THE OFFICIAL MAGAZINE OF **AEROSPACE TESTING, DESIGN & MANUFACTURING EXPO EUROPE**

AEROSPACE TESTING INTERNATIONAL

MARCH 2013

Snow patrol

Investment in climatic chamber technology continues, but Mother Nature still has an important role to play

HYPERSONIC FLOW

Latest research from NASA, AEDC, Texas A&M University, University of Queensland and more...

A350 UPDATE

Interview: Didier Evrard, head of the A350 XWB program, on the virtual first flight (VFF) campaign

ACOUSTIC TESTING

Should acoustic testing be carried out at the start of a test program rather than at the end?

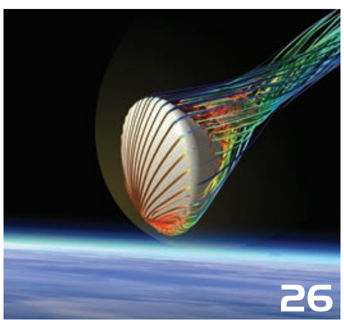
787 BATTERY LATEST • FUTURE VERTICAL LIFT • MISSILE SEPARATION • ULTRASOUND NDT

www.AerospaceTestingInternational.com


Ground
Vibration Testing
Complete structural dynamics solutions
• Classical modal analysis
• Operational modal analysis
• ODS analysis
• Structural dynamics modifications
• Pre-test analysis
• Model correlation and updating
• Vibration testing
ALL FROM ONE PARTNER
Brüel & Kjær has the world's most comprehensive range of sound and vibration test and measurement systems
www.bksv.com/StructuralDynamics
BN 1277–11
HEADQUARTERS: Brüel & Kjær Sound & Vibration Measurement A/S · DK-2850 Nærum · Denmark
Telephone: +45 7741 2000 · Fax: +45 4580 1405 · www.bksv.com · info@bksv.com
Local representatives and service organisations worldwide
Brüel & Kjær
creating sustainable value


A400M
42


14


26


36

In about 450 BC, the Greek historian Herodotus noted, "Not snow, no, nor rain, nor heat, nor night keeps them from accomplishing their appointed courses with all speed." In an almost equally eloquent manner, several millennia later, Tom Cruise, in the film *Top Gun* noted, "I feel the need, the need for speed."

It is intrinsic that humans demand to travel ever-faster: walk, horse, wheel, combustion engine, rocket power. In a huge acceleration over the past 100 years, we have become more and more impatient in our demand to get somewhere faster. In the age of sail it took nearly four months to get from the UK to Australia; by 1913, during the great age of steam liners, the time of travel had decreased to about six weeks. Early air travel would have taken three days. Now, to fly from London to Sydney takes a little over a day. (Admittedly, last time I did it with three young children, it felt more like three years.) However, it could be possible that within the next two decades we could travel half way around the world within four hours. London to New York in under an hour?

How? Through the power of hypersonics – featured heavily in this issue, where we take a look at the latest technologies being developed beyond the ramjet-powered X-51 Waverider.

In 2010 the X-51 flew for a little over three minutes maintaining a speed higher than Mach 5 (3,400mph), and in that short time it covered around 400 miles (London to Edinburgh). The second flight malfunctioned and the third and final craft lost control after separating from its rocket booster and crashed into the Pacific. A statement by the Air Force Research Laboratory indicated a failure of the tail control surface as the cause. The booster could not maintain aerodynamic control and the aircraft lost control before the scramjet engine could ignite.

It is thought that more test flights are planned this year, but nothing concrete is in sight. At the moment, modifications are being made to the X-51 that are designed to strengthen the rear seal area near the engine exhaust nozzles.

In some ways it could be viewed that the US hypersonic program has stalled. As Dr James Pittman, senior advisor of the Fundamental Aeronautics Program, explains to the magazine, the biggest problem is "sustained and sufficient funding – this is the primary issue with the advancing of hypersonics".

However this hasn't stopped a wave of academic research into the technology. Turn to page 26 to read more on a NASA and USAF instigated academic collaboration, begun in 2009, that is now seeing advanced progress on many levels of hypersonic tests spread between two prime universities – Texas A&M and the University of Virginia – and also Teledyne, but also pulling in test and research from a multitude more organizations across the USA, as well as private companies. Other institutions have also picked up the hypersonic baton and started to run. The University of Queensland (see page 30) is at the forefront of hypersonic research with other Australian universities, but this also involves the likes of JAXA and DLR. I can't help think that all this activity is reminiscent of the period just prior to the advent of jet travel.

And while discussing my excitement about hypersonics with NASA, their office suggested I contact 'Mr Hypersonic' himself – Dr Richard P Hallion, a retired USAF historian at the American Institute of Aeronautics and Astronautics. Hallion discusses the first flight of the X-51, which reached Mach 4.87. "I'm inclined to say it was the Kitty Hawk moment for air-breathing supersonic combustion," he says. Given the advancements in the technical understanding of hypersonics, Hallion feels emphatically that it would be remiss not to make the technology a key part of US national security. It is a thought, especially considering that countries such as China, Russia and Iran are developing hypersonic technology too.

The funding might not be there, but by involving and integrating academia in technical hypersonic R&D, hypersonic travel will arrive faster. Some people might not agree. As Woody Allen stated, "It is impossible to travel faster than the speed of light, and certainly not desirable, as one's hat keeps blowing off."

However, it is worth speeding to our cover story on page 42, where we examine the latest harsh weather testing. The cover image is of an A400M, undergoing cold weather testing in Iqaluit, Canada, which included a 24-hour 'cold-soak' at -32°C.

Temperatures are warmer where my sister lives in Australia, and who knows, with the help of hypersonics I could pop over for a cup of coffee and be back home in London in time for supper.

Christopher Hounsfield, editor

PRODUCTS & SERVICES

REGULARS

EDITOR Christopher Hounsfield (chris.hounsfield@ukipme.com)
ASSISTANT EDITOR Bunny Richards (bunny.richards@ukipme.com)

PRODUCTION EDITOR Alex Bradley
CHIEF SUB EDITOR Andrew Pickering
DEPUTY CHIEF SUB EDITOR Nick Shepherd
PROOFREADERS Frank Millard, Kari Wilkin

ART DIRECTOR James Sutcliffe
ASSISTANT ART EDITOR Louise Adams
DESIGN CONTRIBUTORS Andy Bass, Anna Davie, Craig Marshall, Nicola Turner, Julie Welby, Ben White

HEAD OF PRODUCTION & LOGISTICS Ian Donovan
DEPUTY PRODUCTION MANAGER Lewis Hopkins
PRODUCTION TEAM Carole Doran, Cassie Inns, Robyn Skalsky

SALES MARKETING DIRECTOR Simon Hughes (simon.hughes@ukipme.com)
PUBLICATION MANAGERS David Paton (david.paton@ukipme.com)
Cheryl Standley (cheryl.standley@ukipme.com)

CEO Tony Robinson
MANAGING DIRECTOR Graham Johnson
EDITORIAL DIRECTOR Anthony James

The views expressed in the articles and technical papers are those of the authors and are not endorsed by the publishers. While every care has been taken during production, the publisher does not accept any liability for errors that may have occurred. *Aerospace Testing International* USPS 020-657 is published quarterly, in March, July, September, and December by UKIP Media & Events Ltd, Abinger House, Church Street, Dorking, Surrey, RH4 1DF, UK; tel: +44 1306 743744; fax: +44 1306 742525; editorial fax: +44 1306 887546. Annual subscription price is £42/US$75. Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping USA Inc, 155-11 146th Street, Jamaica, New York 11434. Periodicals postage paid at Jamaica, New York 11431. US Postmaster: send address changes to *Aerospace Testing International* c/o Air Business Ltd, c/o Worldnet Shipping USA Inc, 155-11 146th Street, Jamaica, New York 11434. Subscription records are maintained at UKIP Media & Events Ltd, Abinger House, Church Street, Dorking, Surrey, RH4 1DF, UK. Air Business is acting as our mailing agent.
Printed by William Gibbons & Sons Ltd, 26 Planetary Road, Willenhall, West Midlands, WV13 3XT, UK.

Average net circulation per issue for the period 1 January 2012 to 31 December 2012 was 9,663

Published by UKIP MEDIA EVENTS

WORLD TEST UPDATE

HTS900: The HTS900 turboshaft engine has been chosen by Eagle Copters for its re-engine program for the Bell 407 – named the Eagle 407HP. The concept of the Honeywell engine conversion program originated in 2009, and now, after the successful conclusion of integration and ground testing, the Eagle 407HP is in the final steps toward Transport Canada and Federal Aviation Administration certification.
Calgary, Canada

787 BATTERY SYSTEM: Boeing has received approval from the FAA for its plan to test and certify improvements to the 787's battery system. Successful completion of each step within the plan will result in the FAA's approval to resume commercial 787 flights.
Seattle, Washington

LIGHT AIRCRAFT: The Cessna TTx has completed its first production flight. The single-engine composite aircraft took off from the Cessna facility in Kansas. The aircraft features an optional Flight Into Known Icing (FIKI) system and an operating ceiling of 25,000ft.
Independence, Kansas

BOEING P-8 POSEIDON: The US Navy's next-generation maritime patrol aircraft is nearing the end of operational test and evaluation at Patuxent River Naval Air Station. Three test aircraft are flying from the US Navy base and pre-delivery flight checkout will take place at Boeing's Seattle plant as production ramps out.
Patuxent River, Maryland

ALTERNATIVE FUEL: NASA researchers have begun a series of flights using the agency's DC-8 flying laboratory to study the effects of alternate biofuel on engine performance, emissions and aircraft-generated contrails at altitude. The Alternative Fuel Effects on Contrails and Cruise Emissions (ACCESS) research involves flying the DC-8 as high as 40,000ft while an instrumented NASA Falcon HU-25 aircraft trails behind at distances ranging from 300ft to more than 10 miles.
Washington DC

SURFACE-TO-AIR: A Throttling Divert and Attitude Control System (TDACS) qualification testing has been completed by Aerojet with the successful altitude hot fire test for the Standard Missile-3 (SM-3) Block IB program. The SM-3 program is managed by the Missile Defense Agency (MDA) and by prime contractor Raytheon.
Sacramento, California

CSERIES PROGRESS: Bombardier's CSeries aircraft is making excellent progress, according to the company, as the program readies to transition to the flight test phase in order to achieve first flight by the end of June 2013. "We are very pleased with the progress being made on the CSeries aircraft program and we are excited to open our facility and publicly show the world the advances and key milestones we have achieved as we get ready for first flight," says Mike Arcamone, president, Bombardier Commercial Aircraft.
Montreal, Canada

SPACE VERTICAL HOVER: SpaceX's Grasshopper has doubled its highest vertical flight to rise 262.8ft, hovering for approximately 34 seconds and, most importantly, landing safely using closed loop thrust vector and throttle control. This is Grasshopper's fourth in a series of test flights, and each test has demonstrated exponential increases in altitude.
McGregor, Texas

F-35 WING ASSEMBLY: The first F-35 Lightning II with a center wing assembly (CWA) has been flown for the first time. The aircraft, known as BF-25, is an F-35B short take-off and vertical landing variant that will be delivered to the US Marine Corps at Yuma, Arizona. The CWA is a major structural component and represents approximately one-quarter of the aircraft's fuselage.
Marietta, Georgia

A400M: Airbus Military has today received full Type Certification for the A400M new generation airlifter, marking a critical step toward delivery of the first aircraft to the French Air Force. Award of the Type Certificate makes the A400M the world's first large military transport to be designed and certified to civil standards from its inception.
Paris, France

DASSAULT NEURON: The multinational unmanned combat aerial vehicle demonstrator project, Dassault Neuron, passed a major milestone in December 2012 when it made its maiden flight from the Istres test site. Further testing will continue in France during this coming year, before moving to other facilities in Sweden and Italy.
Istres, France

TRANCHE 1 TYPHOON: The installation of the update to the whole Tranche 1 Typhoon fleet has been agreed following the successful delivery and assessment of Drop 2. The enhancement package, developed by BAE Systems' Capability Sustainment Team, provides capability upgrades to a wide range of Typhoon avionic systems covering displays and controls, attack and identification, defensive aids and communication subsystems. It was developed through a mutual support agreement between the UK and the National Support Centre Germany.
Farnborough, UK and Manching, Germany

GRIPEN UPGRADE: Defense and security company Saab has received an order from the Swedish Defence Materiel Administration (FMV) for upgrades to the current Gripen fleet. The changes to the Swedish Armed Forces' existing Gripen fleet will ensure the multirole fighter aircraft remains modern and capable of operating efficiently over the next 40 years.
Stockholm, Sweden

A400M FLIGHT TEST: The first production Airbus Military A400M has made its maiden flight, marking a key milestone in its delivery to the French Air Force. The aircraft, known as MSN7, took off from Seville, Spain, and landed back there 5 hours 42 minutes later.
Seville, Spain

TRAINER AIRCRAFT: Alenia Aermacchi's SF-260TP primary and basic trainer, equipped with new digital avionics, an enhanced multispectral vision system and an upgraded air-conditioning system, has completed its first flight in Venegono, Italy. The aircraft is in final testing stages, and potential customers have requested demonstrations
Turin, Italy

RUSSIAN SUPERJET: The new Full Flight Simulator (FFS) for training on the SSJ100 aircraft from Sukhoi, installed at the SuperJet International training center in Venice, Italy, has been successfully certified by the European Aviation Safety Agency (EASA) and is now ready for training. This SSJ100 FFS is the first simulator for a Russian civil aircraft that achieves certification by EASA.
Venice, Italy

HELICOPTER CERTIFICATION: Hindustan Aeronautics Ltd (HAL) has achieved the initial operational clearance (IOC) for the Advanced Light Helicopter – Mk4 army version of 'Rudra'. It is a major milestone moving HAL into a global group that designs, develops, manufactures and certifies a helicopter as a weapons system to international standards.
Bangalore, India

GE
Measurement & Control

RotoArray

The Power of an Immersion C-Scan System in the Palm of Your Hand

The RotoArray is a portable, manually operated, phased array, ultrasonic inspection device which can be connected to any suitable phased array flaw detection instrument to allow rapid scanning of a wide variety of materials and components.

It is especially well suited for scanning composite and aluminum aerospace components and can provide A, B & C-scan images that are achieved with the simplicity of a handheld probe and with performance rivaling that of a full immersion C-scan system.

Please visit **UTprobes.com** for more information.

GE imagination at work

F-35 JSF IN TROUBLE ONCE AGAIN

When the Lockheed Martin F-35 Lightning II Joint Strike Fighter (JSF) was grounded for six days in February 2013, after cracks were discovered in its engine turbine blades, there was a sense of déjà vu. It had only just returned to flight 10 days before and earlier in the year the annual report into the next-generation combat aircraft's progress, by the Pentagon's director of operational test and evaluation, had identified a raft of problems. This is an aircraft that does not yet appear to be out of the woods.

The report revealed that the flight test program for the next-generation stealth combat aircraft continues to be hit by delays, threatening to lead to more of the knock-on cost overruns that have bedevilled the JSF project since it was launched more than a decade ago. "Up to November 2012, the flight test teams were able to exceed the flight rate planned for flight sciences in the F-35B and F-35C variants, but were slightly behind the plan for the F-35A," said the report. "The program did not accomplish the intended progress in achieving test objectives (measured in flight test points planned for 2012) for all variants. Certain test conditions were unachievable due to unresolved problems and new discoveries. The need for regression testing of fixes (repeat testing of previously accomplished points with newer versions of software) displaced opportunities to meet flight test objectives."

The report said the flight rate of the mission systems test aircraft also exceeded the planned rate during the year. It found that, "Overall progress in mission systems was limited. This was due to delays in software delivery, limited capability in the software when delivered, and regression testing of multiple software versions (required to fix problems, not add capability). Test points accomplished for the year included Block 1 verification, validation of limited capabilities for early lot production aircraft, baseline signature testing, and Block 2 development. No combat capability has been fielded."

The delays in the 2012 flight testing content will defer testing to the following years and this "will contribute to the program delivering less capability in production aircraft in the near term", said the report. The JSF Joint Program Office (JPO) and contractor Lockheed Martin have now revised the flight test program four times, but the report said its latest iteration "contained an unacceptable overlap of development with the start of operational test activity for integrated operation test and evaluation."

"The challenges that are identified in the report are known items, normal discoveries," remarked Steve O'Bryan, Lockheed's F-35 business development director. "When you look at it in a holistic sense, when you really talk about beginning operational testing in 2017, these are known discoveries, known challenges, and the kind of normal discoveries you'd see in a flight test program of this size and complexity." Despite the problems highlighted in the report, O'Bryan said 2012 went very well for the stealthy tri-service fighter: "In my humble opinion, it was our best year on the program."

However, within days of the report emerging in January 2013, the F-35B variant was grounded after a fault emerged with the lift fan fueldraulic system. A production 'quality discrepancy' was blamed after an investigation into the problem found that the fueldraulic line was improperly crimped. "An audit of quality-control records identified six additional non-compliant units, which have been removed from aircraft and returned to Pratt & Whitney for replacement," said the JPO in a statement. The fueldraulic lines on all 25 F-35Bs built to date had to be removed and inspected.

STAYING CENTRAL

The first F-35 Lightning II with a center wing assembly (CWA) built at the Lockheed Martin facility in Marietta, Georgia, USA, has been flown for the first time. The aircraft, known as BF-25, is an F-35B short take-off and vertical landing variant that will be delivered to the US Marine Corps at Yuma, Arizona. The CWA is a major structural component and represents approximately one-quarter of the aircraft's fuselage.

In addition to building the CWAs, technicians also apply specialized stealth coatings to F-35 horizontal and vertical tail control assemblies, and also coat spare and repaired aircraft doors, panels and covers.

For regular news updates: AerospaceTestingInternational.com

RAF CHINOOKS HIT TURBULENCE

Flight testing of the Royal Air Force's new Boeing Chinook HC.6 has been extended by six months to deal with "additional risks surrounding the integration of the Digital Auto Flight Control System", according to the UK's National Audit Office (NAO).

In its annual major projects report published on January 10, 2013, the spending watchdog revealed that the procurement of 12 new heavy lift helicopters, which are modified variants of the US Army's CH-47F, has slipped after problems were encountered during efforts to install similar cockpits on the existing fleet of 46 Chinooks. This first project for the existing RAF Chinook HC.2s and HC.3s, known as the Julius cockpit upgrade, encountered multiple technical problems that delayed its deployment.

Experience with the Thales-made Julius has prompted UK procurement officials to review the work on the new-build helicopters. In its report, the NAO said, "A senior Boeing/MoD independent review took place in March 2012 and concluded that there were additional risks surrounding the integration of the Digital Auto Flight Control System, and that the flight test schedule, although adequate in flying hours, provides limited scope in the scheduled timescale to address any issues identified during flight test. As a consequence, we have now declared a delay in entry into service of six months to November 2014 to accommodate these additional risks."

The NAO described the problems, saying: "In June 2011, during test and evaluation, issues with software, firmware and electromagnetic compatibility surfaced that necessitated a forecast delay of three months to initial operating capability." The report concluded that further design changes were required. Subsequently an intense period of rig and flight testing began to resolve the following primary issues: vertical speed indicator's analogue to digital conversion; electromagnetic compatibility of the multifunction displays; and mission management system functionality. In March 2012 an issue with how the height relative to the surrounding terrain is displayed in the cockpit emerged during Release to Service testing.

END OF THE UPGRADE

According to the NAO, the Chinook Mk4 'Release to Service' was signed by the assistant chief of the Air Staff on May 11, 2012, enabling aircrew to begin training on the aircraft. This training is now underway to support operations, and Initial Operating Capability was achieved on June 15, 2012, against the initial projection of September 2011. It is expected that the upgrade of all the existing Chinook HC.2s and 3s with Julius cockpits will be complete by October 2015.

A400M COMPLETES F&R TRIALS

In March 2013, Airbus Military was finally able to announce that the A400M airlifter had acheived European Aviation Safety Agency certification after successfully completing 300 hours of Function & Reliability (F&R) flight-testing, a step towards final approval.

The European aircraft manufacturer had to stop the F&R tests in June 2012 after only 160 hours of flight tests, prompting a three-month delay to the delivery of the first aircraft to the French Air Force, the A400M launch customer.

A gearbox failure on the first production-representative aircraft – MSN6/Grizzly 5 – caused the tests to be halted, prompting Airbus and the manufacturer of the TP400 TD engines, Europrop International (EPI), to order a major investigation to find the cause of the problem. "EPI discovered that a thin aluminum cover plate in the middle of the gearbox, used to prevent oil from moving from one side to the other, had cracked due to vibration," said Fernando Alonso, Airbus senior vice president for flight and integration tests. "Parts of the plates migrated to an adjacent bearing and damaged it, so the engine had to be removed."

Similar cracks were identified on other production standard gearboxes and EPI had to work on a fix to rectify the problem. A replacement cover plate was delivered and testing began again in November 2012. F&R testing was intended to examine the aircraft's behavior in conditions representative of normal in-service experience, including routine and simulated abnormal operations in a wide range of weather and locations. The F&R testing was completed in just 32 days – aside from the hiatus to rectify the cover plate problem – during which the aircraft made 52 flights and visited 10 airfields. The F&R data is now being examined by the civil and military certification authorities for the A400M – respectively, the EASA and OCCAR, a committee appointed by the European procurement agency.

Having received restricted type certification beginning May this year, the F&R phase of the flight-test program was the last major requirement prior to full type certification. It is expected that the aircraft will receive this certificate and military Initial Operating Capability in the first quarter of 2013 subject to the approval of the relevant authorities. First delivery to the French Air Force, of MSN7, is planned for the second quarter and a total of four aircraft will be delivered during the year.

Alonso added, "During this F&R campaign the A400M has really been put through its paces. It flew an average of two flights and 15 hours per day over 26 days, with only six days devoted to routine maintenance. The crews have been greatly impressed with the performance of the onboard systems and engines, and we are confident that we have a sound basis for completing the civil and military certification in the next couple of months."

For regular news updates: AerospaceTestingInternational.com

Rapid Control Prototyping | Autocoding | HIL Testing

Hardware-in-the-Loop Testing with dSPACE – For Certain Success

With the complexity of today's highly-integrated vehicle systems, testing is more important than ever. In "iron birds," integration test facilities, and model-testbed applications, dSPACE hardware-in-the-loop (HIL) systems, emulators, and model-driven testing tools are best-in-class when it comes to performance, quality, and value. dSPACE products have set the standard for quality for over 20 years. Whether the application is for air, land, sea, or space, dSPACE has provided world class support on programs as diverse as Joint Strike Fighter, the USS Makin Island, Future Combat Systems, and the Joint Polar Satellite System.

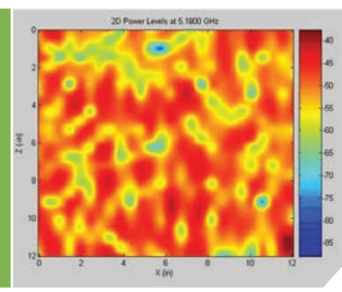
When quality, reliability, and performance are critical, you can rely on dSPACE.

BOEING CHIPS AWAY AT CABIN RF TEST TIME

Today's airline passengers expect a high level of robust cabin wi-fi connectivity for their personal electronic devices, and carriers are working hard to match that expectation. Among the many challenges of bringing this relatively new technology into everyday use, manufacturers have had to investigate optimal antenna positioning and understand the dynamics of the airliner cabin.

Kenneth Kirchoff, a Boeing cabin systems engineer, explains: "Typically wi-fi antennas are positioned above the ceiling panels and oriented to provide maximum coverage in the cabin. Almost any material in the airplane can affect wi-fi signals. Some materials (seat foam, people, luggage) attenuate the signal by absorbing the energy and others (metallic materials, carbon fiber composite) reflect the energy. Moving passengers can attenuate the signal and reflect it, effectively 'stirring' the RF [radio frequency] energy within the cabin. This is not very different from the wi-fi environments we encounter on the ground, such as the office, Starbucks, or your home."

"IT INDICATED THAT IN THE TEMPERATURE RANGE FROM 0°C TO 30°C, PEOPLE AND POTATOES HAVE A SIMILAR RELATIVE PERMITTIVITY"



THE LARGEST WAVE IN THE OCEAN

Boeing looked at its methods for testing RF signal strength in airliner cabins and found the established test process long-winded and costly. Dennis Lewis, a Boeing metrology engineer, says: "Previous methods looked for a peak signal, which was analogous to finding the largest wave in the ocean. Although the inside of a commercial aircraft is much smaller than the ocean, it still required a very time-consuming test methodology that required a large number of measurements. In fact it often needed two shifts of technicians, engineers, flight operations and ground crews." By Boeing's own admission, it could also take up to a fortnight.

The company's new technique, based on "proprietary measurement technology and analysis tools", has reduced that time to just 10 hours. "It's based on a statistical approach in which the main objective is to measure the average signal strength in the cabin," Lewis reports. "This can be accomplished with a relatively small number of measurements. Once the average level is measured, the peak levels can be determined through a statistical process.

"The reduction in the number of measurements greatly reduces the time required to perform the testing. Combined with an innovative new test and measurement system, this greatly improves the quality of the data and gives us a better picture of how the signal behaves in the complex cabin environment. The new system also increases safety by providing a better understanding of the signals and the way they interact with the environment they are operating in," Lewis explains.

Kirchoff is keen to stress the safety implications of the technique. "Boeing's top priority is always the safety of its products. The processes and procedures we use to offer wireless passenger connectivity effectively eliminate any interference concerns that may arise from the use of such technology. The new test technique affords the same high level of safety we have always provided, but in a much shorter time. Dramatically reducing the time it takes to test on an airplane saves the customer and the company money while providing the data necessary to ensure we continue to provide the safest possible products."

Boeing invested a great deal of laboratory time in developing the signal testing technique. Surprisingly a good deal of it was spent looking at potatoes, as Lewis recalls: "One of our team members found *Dielectric Properties of Vegetables and Fruits as a Function of Temperature, Ash, and Moisture Content,* an article by O Sipahioglu and S A Barringer in the *Journal of Food Science,* Volume 68, No 1, from 2003. This indicated that in the temperature range from 0°C to 30°C, people and potatoes have a similar relative permittivity, so we would expect them to have a similar loading effect on the inside of an aircraft. Months of testing were conducted in the laboratory to validate this approach before it was implemented on a full-scale airplane test."

Kirchoff explains more about this seemingly unlikely choice of test subject: "While potatoes and humans are not very similar chemically, they are similar in the way they interact with wi-fi signals at 2.4GHz. A colleague read in a scientific journal how potatoes were discovered to be similar to humans in their absorption of RF energy at certain frequencies, so we decided to try them out."

In fact 20,000 lb of the vegetables were used inside the test cabin, sacked and placed in seats as passenger substitutes. They performed admirably, helping Boeing develop a time-saving, safety-enhancing system that should also provide more effective cabin connectivity. "Once testing was completed," Lewis says, "the potatoes were donated to a local food bank."

For regular news updates: AerospaceTestingInternational.com

GARNET RIDGWAY

TO UPGRADE OR NOT TO UPGRADE?

Two ex-colleagues from the Flight Science and Technology group at the University of Liverpool lock horns over the testing issue of 'clean-sheet design versus incremental upgrades' – and the implications of this on testing

SOPHIE ROBINSON

If a single picture could illustrate the impact of the global economic situation on the defense industry, a strong contender would be one from BAE Woodford, UK, in 2011. Nine years late and £780m (US$1.2bn) over budget, the long-anticipated Nimrod MRA4 project was canceled, and nearly completed airframes were rolling off the assembly line and immediately being demolished.

This situation raises questions. What could have caused the project to go so badly wrong? Surely a simple upgrade of an existing platform is the low-risk option? And perhaps most importantly, what lessons can be learned from this?

From a testing perspective, incremental upgrade projects can be very appealing, primarily because the previous version of the aircraft provides a solid baseline against which upgrades can be evaluated. The phrase "not worse than Mk1" can be extremely useful in expediting the release to service process. However, it can be easy to forget that, just because a system is an improvement on its predecessor, it is not necessarily fit for purpose. This is especially true when working with legacy equipment that has already passed through several upgrade iterations – as was the case with the Nimrod. The inquiry into the total loss of a Nimrod MRA2 in 2006 found that a design flaw in the fuel system, originating in 1969, had passed through two major upgrades without being addressed. The difficulty in tracing such issues can be exacerbated by the fact that the engineers involved in the original design are long-retired, or even that the original design organization no longer exists.

Garnet Ridgway has a PhD from the University of Liverpool. He has designed cockpit instruments for Airbus and currently works for a leading UK-based aircraft test and evaluation organization

The installation of new equipment into legacy airframes can also create new problems. For example, a leaking cockpit window considered unimportant on the original aircraft may now be positioned directly above a new item of electrical equipment. The identification of such an issue in testing can lead to an awkward contractual position: who's responsible for addressing it? The legacy design organization will be reluctant to fix an issue that has previously passed through acceptance testing, and those responsible for the upgrade will claim it falls outside the scope of their contract. A well-designed contractual framework can mitigate against such difficulties, but only if it is in place *ab inito*.

An overall conclusion that can be drawn is that there comes a time when even the longest-serving, most capable aircraft should be retired, rather than upgraded. With this in mind, consider the UK MoD's recent decision to replace the Nimrod R1 with the Boeing RC-135 – a design that first flew in the late 1950s. Maybe this will be the exception that proves the rule; only time will tell. ∎

The alternative to incrementally upgrading an aircraft is one which engineers can find exciting and challenging in equal measure; clean-sheet design. Clean-sheet design used to be the go-to method of developing new capabilities. In the post-World War II era of rapidly advancing technologies and changing capability requirements, clean-sheet design was the norm. Since then, monetary, regulatory and time constraints have seen clean-sheet design become an increasingly rare occurrence. Combine this with the reduced rate of step-change technological advancements, and clean-sheet design becomes a once-per-generation activity.

The RAH-66 Comanche helicopter is a relatively recent example of clean-sheet design. This provided engineers with an exciting opportunity to use all the modern technologies at their disposal – and they seized it. The design of the Comanche featured an all-composite fuselage, main rotor and empennage, stealthy features to reduce its radar cross section, and a sophisticated fly-by-wire control system. These technologies combined to produce a potentially very powerful platform, but also high expectations of its performance.

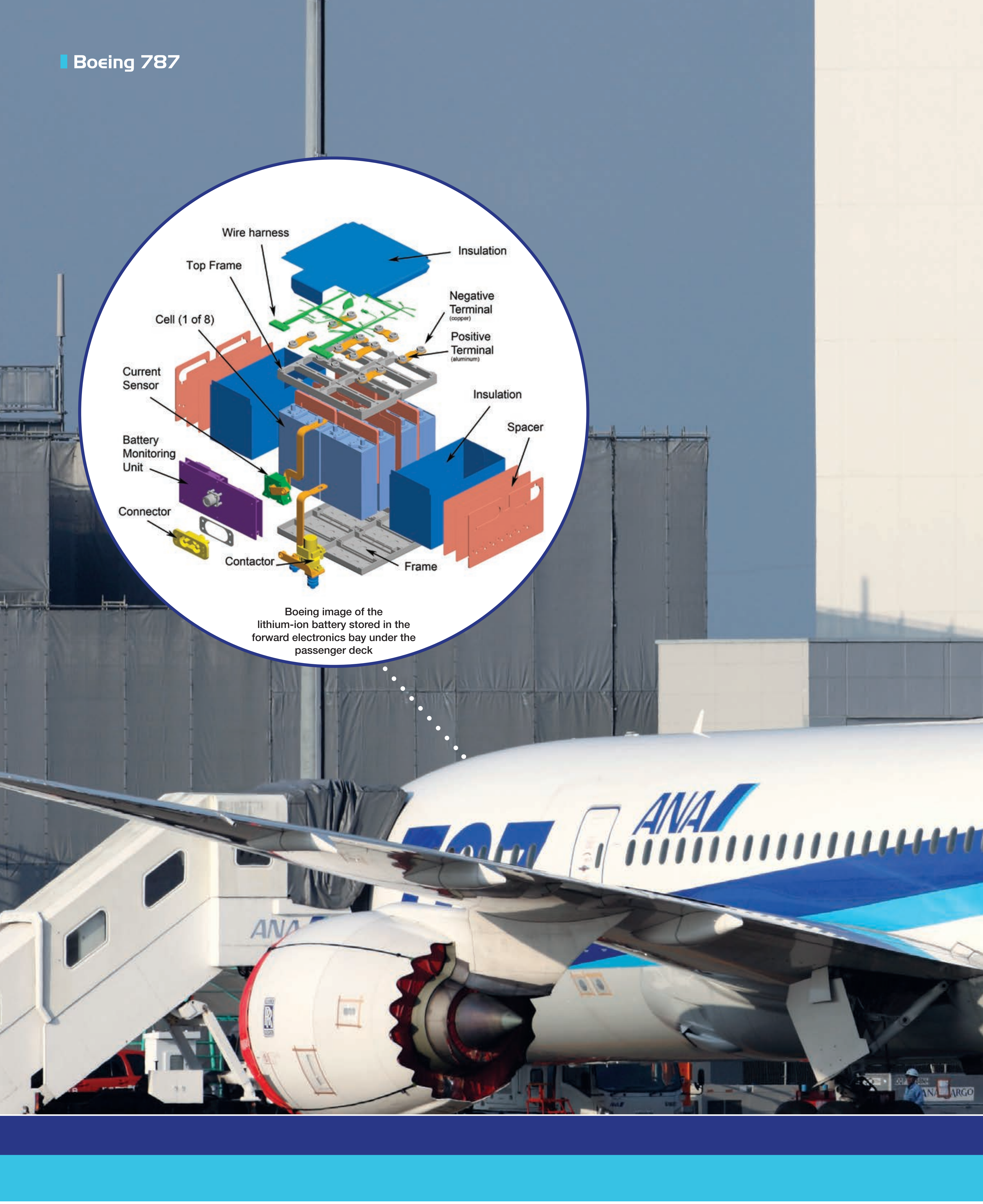
A disadvantage of this is that the resulting aircraft is so far in advance of its predecessors that existing testing methodologies are no longer sufficient to formally assess the aircraft. New testing methods have to be developed, which is both costly and time consuming. There can also be contractual issues associated with the development of these new testing methods – are they the responsibility of the design organization or the customer?

Excessive design and performance targets (for example, being expected to have sufficient range to ferry itself across the Atlantic), and unrealistic over-arching requirements, as well as poor management, resulted in the Comanche project being cancelled in 2004 at a cost of US$7bn. This illustrates another problem with clean-sheet design; engineers see it as an opportunity to showcase the bleeding edge technology in their discipline, often to the detriment of the viability of the design as a whole.

Sophie Robinson is currently finishing her PhD as part of the Flight Science and Technology Research Group within the Centre for Engineering Dynamics at Liverpool University. In the course of her research, Sophie regularly works with test pilots

While US$7bn might be somewhat expensive for a single document, an enduring legacy of the Comanche program is the military handling qualities specification ADS-33E-PRF. This specification is the go-to document for rotorcraft designers and evaluators worldwide, proving that the benefit of clean-sheet design extends beyond the delivery of new aircraft.

As a final ignominy, the money that the US Army would have spent on procurement of the Comanche was spent on incremental upgrades to their existing fleet of aircraft, proving that potential future capability is no substitute for proven performance. ∎



Boeing image of the lithium-ion battery stored in the forward electronics bay under the passenger deck

Shock tactics

Can Boeing get the 787 flying again after its well-documented problems with lithium-ion batteries; and what went wrong with its initial testing?

BY TIM RIPLEY & CHRISTOPHER HOUNSFIELD

There appears to be light at the end of the tunnel for Boeing over its lithium-ion battery crisis after several weeks of intensive testing by company engineers and investigations by regulatory authorities in Japan and the USA.

The latest saga in the troubled life of Boeing's 787 Dreamliner began on January 16, 2013, when All Nippon Airways (ANA) flight NH-692, en route from Ube to Tokyo Haneda, received indications of battery problems. A burning smell was reported while climbing from Ube, about 35 nautical miles west of Takamatsu, Japan. The pilots decided to divert to Takamatsu, where the plane landed and vacated the runway, before all the passengers evacuated via slides. One passenger suffered a serious injury, and two other passengers received minor injuries during the evacuation. Inspection of the battery compartment revealed that there had been a battery fire.

This, along with a similar incident on a parked Japan Airlines 787 in Boston that had suffered a battery fire a few days earlier, led the Federal Aviation Administration to ground all of the 51 Boeing 787s that were flying at the time.

This set in motion a series of events that threatened to cost Boeing hundreds of millions of dollars in

delayed payments for the delivery of new aircraft, lost profits and compensation to prospective customers. The fact that these incidents came after the 787 had been certified safe to fly by the US regulatory authorities added to concerns, leading to fears that there were yet-to-be discovered problems with lithium-ion battery technology. This threatened the roll-out across the industry of the new lightweight batteries, which had been seen as an important step in efforts to reduce the weight of next-generation airliners.

ABOVE: Boeing is confident it can provide a permanent fix for the battery problem

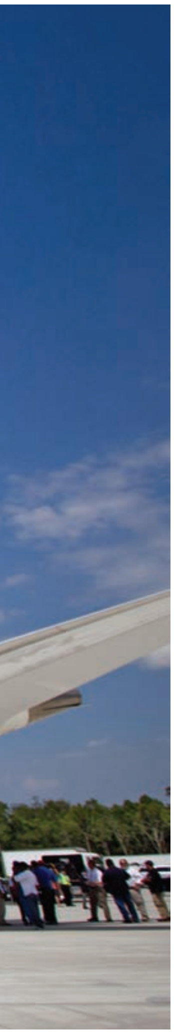
TOP RIGHT: Boeing still aims to double 787 Dreamliner production by the end of the year

Speaking at the time, Mary Schiavo, airplane attorney and former Inspector General of the US Department of Transportation from 1990 to 1996, said, "They've isolated it down to a battery, so that's good news for Boeing. Since it's now down to a battery and they are looking at a battery and how they can contain this problem." She added that Boeing now needed to find a better way to contain those batteries: "Boeing has to change it; that has to be more robust and do the job. They are talking about putting more separation between the batteries, cooling them and building a better containment box, and that should improve safety."

In response, Boeing mobilized a taskforce of experts from across the company and its supply chain to investigate the battery incident. As part of this effort, it was granted permission by the US Federal Aviation Administration (FAA) to begin limited

THE TIMELINE

FEBRUARY 6 2012	Boeing says it has discovered a manufacturing error that requires repairs in the fuselage section of some 787 Dreamliners
JULY 23 2012	ANA says it is having five 787 jets repaired for a defect in their Rolls-Royce engines
JULY 28 2012	A 787 suffers engine failure during testing in South Carolina
JULY 31 2012	US safety regulators announce an investigation into a GE engine failure on a 787 during tests in South Carolina
SEPTEMBER 5 2012	ANA aborts the take-off of a 787 after what appears to be white smoke is seen billowing from the airplane's left engine, believed to relate to the hydraulic system
OCTOBER 4 2012	General Electric (GE) recommends inspections of its GEnx engines, used on some Boeing 747 and 787 aircraft, following the failure of an engine in Shanghai on September 11
DECEMBER 5 2012	The FAA orders inspections of all Boeing 787s in service worldwide following reports of fuel leaks



THE INVESTIGATION

After an exhaustive examination of the JAL lithium-ion battery, which was comprised of eight individual cells, investigators determined that the majority of evidence from the flight data recorder and both thermal and mechanical damage pointed to an initiating event in a single cell. That cell showed multiple signs of short-circuiting, leading to a thermal runaway condition, which then cascaded to other cells. Charred battery components indicated that the temperature inside the battery case exceeded 500°F (260°C).

As investigators work to find the cause of the initiating short-circuit, they ruled out both mechanical impact damage to the battery and external short-circuiting. US NTSB chairperson Deborah A P Hersman says that potential causes of the initiating short-circuit currently being evaluated include battery charging, the design and construction of the battery, and the possibility of defects introduced during the manufacturing process.

During the 787 certification process, Boeing studied possible failures that could occur within the battery. Those assessments included the likelihood of particular types of failures, as well as the effects they could have on the battery. In tests to validate these assessments, Boeing found no evidence of cell-to-cell propagation or fire, both of which occurred in the JAL event.

The NTSB learned that as part of the risk assessment Boeing conducted during the certification process, it determined that the likelihood of a smoke emission event from a 787 battery was less than once in every 10 million flight hours. Noting that there have been two critical battery events on the 787 fleet with fewer than 100,000 flight hours, Hersman says, "The failure rate was higher than predicted as part of the certification process and the possibility that a short-circuit in a single cell could propagate to adjacent cells and result in smoke and fire must be reconsidered."

"THEY ARE TALKING ABOUT PUTTING MORE SEPARATION BETWEEN THE BATTERIES, COOLING THEM AND BUILDING A BETTER CONTAINMENT BOX"

787 flight test activities using ZA005, the fifth flight test airplane. This flight test activity was to allow the conduct testing of the inflight performance of the airplane's batteries.

For further precaution, Boeing said it had implemented additional operating practices for test flights, including a pre-flight inspection of the batteries, monitoring of specific battery-related status messages, and recurring battery inspections. The US National Transportation Safety Board (NTSB) also began a detailed examination of an undamaged 787 battery at a US Navy laboratory, hoping to "uncover signs of any degradation in expected performance".

Speaking to *Aerospace Testing International* about the test program, Richard Aboulafia, vice president, analysis at Teal Group Corporation, points the finger at outsourcing: "The cause of the problems remains a mystery. If they can't figure out the cause in a few months of post-incident testing, it was probably too elusive a problem to have shown up in testing." He continues: "The best way for Boeing to have avoided this problem would have been for them to keep more design and integration work inhouse. Instead, much of this work was placed with contractors, with reduced prime contractor oversight."

FAULTY WIRING

The investigations appeared to be getting to the bottom of the mysterious fires by February 2013, with Japanese

JANUARY 7 2013
A fire breaks out on board an empty Japan Airlines 787 Dreamliner in Boston

JANUARY 8 2013
A Japan Airlines 787 flight to Tokyo is grounded in Boston following a fuel spillage

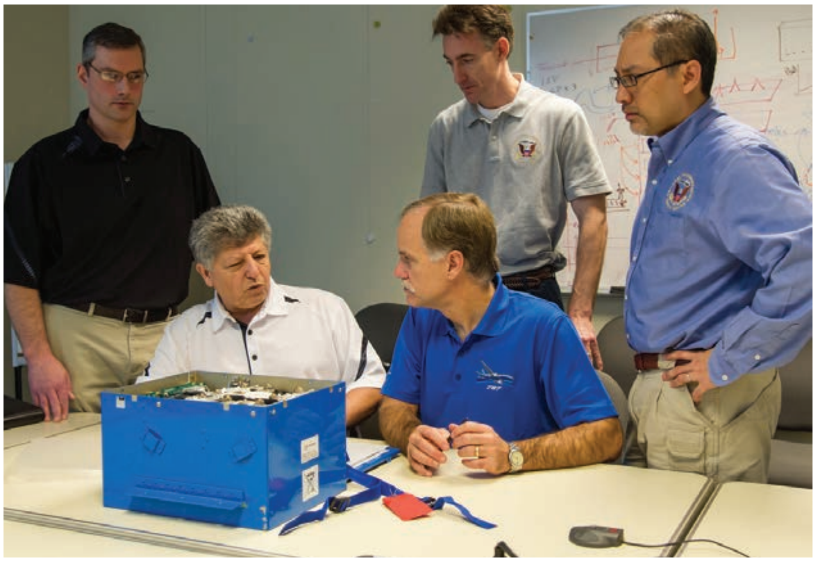
JANUARY 9 2013
ANA cancels a 787 flight because of a brake problem

JANUARY 11 2013
US regulators announce an in-depth safety review of the Dreamliner after several incidents. A crack in a cockpit windshield grounds an ANA Dreamliner in Japan, and another ANA 787 experiences a delay due to an oil leak

JANUARY 13 2013
A Japan Airlines 787 suffers a fuel spill for the second time in a week

JANUARY 14 2013
Japan's transport ministry says it has begun examining the Dreamliner that suffered two fuel leakages in less than a week

JANUARY 16 2013
ANA Dreamliner passenger airplane makes emergency landing in Japan after smoke is reportedly seen inside the cockpit. ANA said a battery problem triggered a cockpit error message



LEFT: NTSB investigators and Boeing engineers in Seattle examine the type of lithium-ion battery used on the Boeing 787 to start the auxiliary power unit and to provide back-up power for flight critical systems

ABOVE: NTSB investigator Mike Bauer inside the Boeing 787 under investigation at Boston's Logan Airport

transport ministry investigators identifying faulty wiring of the battery as the likely cause of the fumes that led to the emergency landing of the All Nippon Airways 787. They reported that the aircraft's auxiliary power unit was incorrectly connected to the main battery.

On February 7, the US NTSB announced that the battery in the Boston aircraft fire "showed multiple signs of short circuiting, leading to a thermal runaway condition, which then cascaded to other cells. Charred battery components indicated that the temperature inside the battery case exceeded 500°F [260°C]." The board, however, had yet to find a cause for the initial short-circuiting.

Boeing sources were also reported as saying that the company was proposing to increase the space between the lithium-ion battery cells.

"The gaps between cells will be bigger. I think that's why there was overheating," a company source was reported to have told the Reuters news agency.

Boeing is expected to present its 'fix' to the US FAA by the end of March (for updates, see our website at www.aerospacetestinginternational.com), in the hope of getting its aircraft back in the air by April 2013.

The company is believed to be proposing insulating the battery's lithium-ion cells to separate them from one another and thereby prevent fire spreading, encasing the battery in a fire-proof shell and installing sensors. It is also proposing a venting mechanism to remove fumes of the type that led to the emergency landing in Japan. Japanese transport minister Akihiro Ohta says, "It's too early to say we are over the hump." US transportation secretary Ray LaHood has warned that the 787 will not fly again until the FAA is "1,000% sure" the batteries are safe.

BATTERY TECHNOLOGY

Lithium-ion battery technology has had a controversial history which has seen it blamed for fires in home computers, cell phones and electric cars. Boeing's extensive use of this new type of battery in the 787, in a bid to reduce its weight and so increase fuel efficiency, received heavy criticism from battery experts.

"Unfortunately, the pack architecture supplied to Boeing is inherently unsafe," wrote Elon Musk, founder of SpaceX and owner of electric car maker Tesla, in an email seen by *Aerospace Testing International*.

"Large cells without enough space between them to isolate against the cell-to-cell thermal domino effect means it is simply a matter of time before there are more incidents of this nature," he added.

The batteries used by Tesla in its electric cars contain thousands of smaller cells that are independently separated to prevent fire in a single cell from harming the surrounding ones. Moreover, when thermal runaway occurs with a big cell, such as the ones used by Boeing, a proportionately larger amount of energy is released and it is very difficult to prevent that energy from then heating up the neighboring cells and causing a domino effect that results in the entire pack catching fire, said Musk.

In mid-February 2013, Boeing's great rival Airbus seemed to step back from lithium-ion technology when it announced it would be reverting back to the proven and mastered nickel-cadmium main batteries for use on its A350 XWBs when they enter production.

As a result of making this decision, Airbus said it did not expect recent events to impact the A350 XWB entry-into-service schedule.

Throughout the crisis, Boeing continued to stand by lithium-ion batteries despite Airbus's decision to remove them as a power source on the A350 XWB family.

THE NIGHTMARE BEHIND THE DREAM

Since the Boeing 787 project was launched more than a decade ago to produce an airliner with 20% more fuel efficiency than current-generation aircraft, the Dreamliner has been dogged by technical problems and delays.

As the aircraft moved toward its flight test program, these issues snowballed, with the first flight being put off twice in the space of a month in 2007 after problems emerged with software and fasteners. A further four delays to the first flight were announced by Boeing in 2008 as it grappled with supply chain problems and a strike by machinists. It was not until December 15, 2009, that the Dreamliner took to the skies on its maiden flight. The flight test program ran for just over 18 months and progressed relatively smoothly, with the aircraft surviving a lightening strike with little damage, while an electrical fire was blamed on foreign objective debris. Deliveries, however, had to be delayed by three months to allow modifications mandated during the test program to be incorporated into production aircraft.

The aircraft received US Federal Aviation Administration and European Aviation Safety Agency type certification on August 26, 2011.

The great outdoors

It's designed to save fuel, is made from advanced materials and provides a whole new family of civil aircraft… The A350 XWB is out of the hangar, on the tarmac and ready for *Aerospace Testing International* to take an exclusive look at the progress of this revolutionary aircraft

BY CHRISTOPHER HOUNSFIELD

The A350 XWB is the all-new mid-size long-range product line comprising three versions and seating between 270 and 350 passengers in typical three-class layouts. The new family will bring a step change in efficiency compared with existing aircraft in this size category, using 25% less fuel and providing an equivalent reduction in CO_2 emissions. Scheduled for entry into service in 2014, the A350 XWB has already won 617 firm orders from 35 customers worldwide.

A350 systems testing has been taking place almost since the outset of the A350 XWB program. Throughout the development phase, various demonstrators have been created to validate the technology and efficiency of each system. A second level of testing then looks at how different systems can be integrated and what degree of interaction there can be between them. The ultimate level of systems testing before flight testing is performed in full-scale facilities, with each focusing on different systems. Airbus test pilots perform 'flights' in a simulator connected to the test benches. In February 2013 the A350 XWB Aircraft Zero testbed started its virtual first flight (VFF) campaign, a key step in the final preparation for the actual first flight of MSN001 by the middle of this year.

Aircraft Zero is the association of the Iron Bird electric, hydraulic and flight control test bench with a flight deck integration simulator. This provides the closest core system test environment to the effective first flight of MSN001. For this campaign, Aircraft Zero is equipped with a standard of equipment fully representative of MSN001's first flight.

The campaign, set to last for several months, has two main objectives: the first is to prepare for first flight by simulating normal and abnormal operational scenarios, verifying the aircraft systems and handling aspects. The second is to ensure maturity by detecting and resolving potential issues as early as possible. The VFF campaign will also enable the flight crew to fully prepare for the first flight and the subsequent flight test program.

AIRFRAME STATIC TESTS

Another aspect of testing focuses on the A350 XWB static airframe test specimen, known as ES (Essai Statique). At the time of writing it is being prepared for major static testing.

The specimen – an entire A350 airframe structure dubbed MSN5000 – has been constructed to be representative of the serial aircraft structure. The static test has been developed to check that under critical loads the specimen's behavior meets Airbus engineers' predictions, and it is a mandatory part of the aircraft's first flight clearance and certification.

Speaking exclusively to *Aerospace Testing International*, Didier Evrard, head of the A350 XWB program,

ENGINE TEST AND CERTIFICATION

On February 7, 2013, Rolls-Royce achieved the European Aviation Safety Agency's (EASA) award of the engine type certification of the Rolls-Royce Trent XWB turbofan. This certification covers Trent XWB engines, which will power the A350-800 and A350-900 variants. A higher-thrust version of the Trent XWB is currently under development for the A350-1000.

Since February 2012 a Trent XWB has been fitted to a flight test A380 FTB (Flying Test Bed) and has undergone numerous tests including hot weather trials in the Middle East. Most recently, cold-weather testing was conducted in Iqaluit, Canada. These tests will help ensure a high level of powerplant integration, maturity and reliability. Mounted on the A380's inner-left pylon (replacing one of the aircraft's Trent 900 engines), this engine had been specially fitted with test sensors to measure hundreds of parameters.

Overall this part of the engine-test program accumulated 175 flight hours – some three times more airborne flying hours than on previous programs. It also tested the advanced nacelle and thrust reverser system provided by Goodrich. The overall objective of these flight tests was the early and systematic validation of all performance aspects of the engine and also the associated systems. This has contributed to considerably 'de-risking' the A350 XWB's development well ahead of entry into service.

A notable milestone in 2012 was the successful fan blade-off test. Blade-off testing is designed to prove that the powerplant will withstand the loss of a high-energy fan blade by containing any debris, preventing damage to the wing or other aircraft structures. The test was performed on November 29 and was a major milestone toward engine certification.

The engine test program, both on the ground and in the air, on the A380 FTB has been a global program: including the environment tests, there have been altitude and crosswind tests in the USA, endurance tests in Spain and performance tests in the UK. The program is on track. As Evrard states: "Overall, so far so good, but there are still some critical steps ahead and everyone is concentrating on the work."

explains, "For the static tests on MSN5000, due to start in the very near future, the inspection program will last more than 8,000 hours and use 12,000 synchronous measurement channels. The program has been designed to help shape and optimize the aircraft's future inspection program in service. At its peak, the team preparing and completing the specimen ahead of testing will number as many as 200 people. These activities will include the connection of 253 loading lines, 197ft of hydraulic pipes and 66ft of cables. Moreover, 235 hydraulic jacks will be used, with the biggest being able to lift four A320s at maximum take-off weight."

After the 1.25 limit load campaign, Airbus will conduct the ultimate load campaign, with 1.5 times the limit load being applied, ahead of the aircraft's type certification. The test specimen is designed to withstand the ultimate load for at least three seconds without failure. After this phase, in 2014 comes the residual strength phase on MSN5000, followed by the margin research cases, which make up the final part of the test. During these final phases Airbus will check the real limit of the aircraft and then load maximum wing bending up to failure.

For the A350 XWB, the ES testing will be Airbus's most detailed yet, benefiting from techniques such as ultrasonic inspection, where ultrasonic pulse-waves are launched into materials to detect any internal flaws or to characterise materials. Additionally, carbon fiber-reinforced plastic (CFRP) requires some different loading concepts. The ES test supplier is Intespace (ITS) for the project management for Airbus, while DGA's Toulouse Aeronautical Test Centre (formerly CEAT) has been selected by ITS for the overall (technical) test integration and performance.

ABOVE: Airbus has devised its A350 production plan to enable output levels of up to 10 aircraft a month, with the final assembly line capable of ultimately delivering up to 13 a month

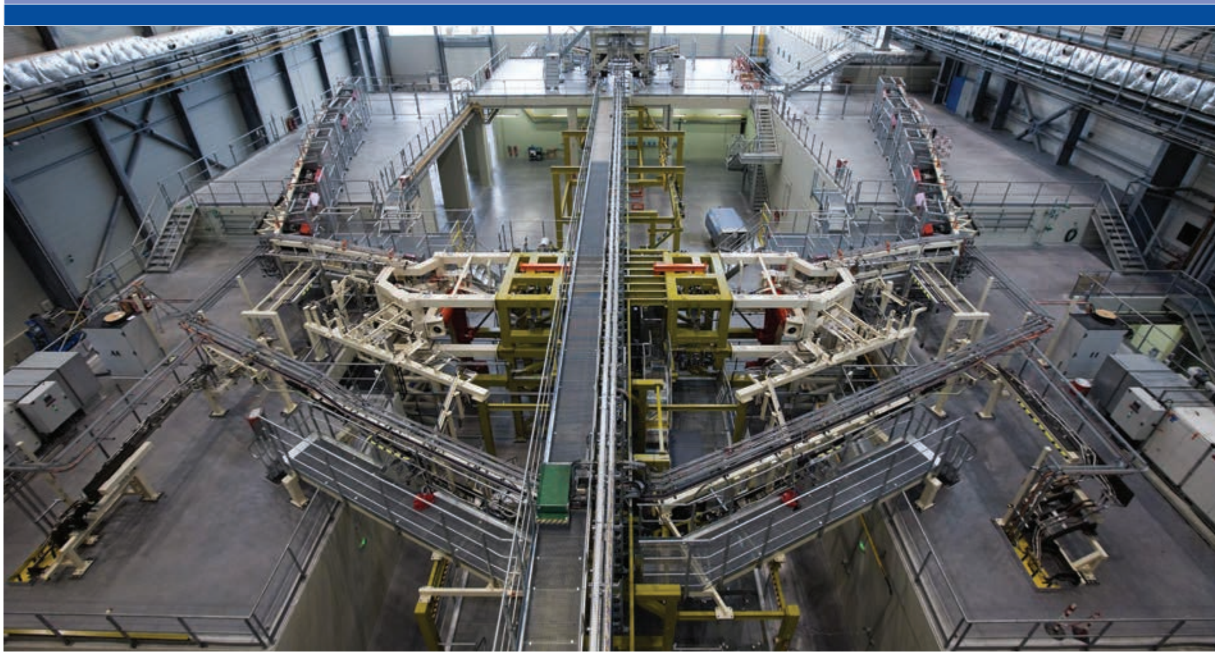
STRUCTURAL AND FATIGUE TESTING

In addition to the ES static tests with MSN5000, additional testing that encompasses the fatigue testing will also deliver important results. The results will form a significant component of the overall A350 XWB certification campaign. These tests are: EF1 (Essai Fatigue 1) – a nose fuselage fatigue test (mostly for the metallic components of the primary structure). EF1 will be installed and performed in DGA's facilities in Toulouse, Balma. As with ES, Intespace (ITS) is also project-managing EF1, working with DGA (CEAT).

EF2 (Essai Fatigue 2) – to evaluate a center fuselage fatigue specimen including a wing boxes fatigue test (mostly for the metallic components of the primary structure). The test supplier is IABG (prime contractor), in Erding, Germany.

EF3 (Essai Fatigue 3) – this encompasses a rear fuselage fatigue test (mostly for the metallic components of the primary structure). The test will be managed in-house, installed and performed at the Airbus Finkenwerder site in Germany.

EW (Essai Wing) – a combined static and fatigue test for a left-hand wing box for wing-specific interfaces and material interactions; for example, for main landing gear attachments and pylon attachments. This test will also be used as the testbed for the '1g wing bending test' (a function test of the moveables). As with EF2, the test supplier will be IABG (prime contractor) in Erding.



ABOVE: the A350 XWB Iron Bird test rig, the ground-based engineering tool used to incorporate, optimise and validate vital aircraft systems, including electrical and hydraulic generation, and flight controls

"THE INSPECTION PROGRAM WILL LAST MORE THAN 8,000 HOURS AND USE 12,000 SYNCHRONOUS MEASUREMENT CHANNELS"

GROUND TRIALS ON FIRST AIRCRAFT

Having completed the structural assembly of the first flying aircraft, MSN001, a series of indoor ground tests are already being run on the aircraft – now situated in Station 30 at the Toulouse A350 FAL – to ensure that all the systems are fully functional and meet the level of maturity Airbus has set prior to the maiden flight.

To this end, ground testing on all types of systems – including hydraulic systems, air conditioning systems and electrical harnesses – has produced successful results. The extension-retraction of the main landing gear also went smoothly, and the wing spoilers, ailerons, elevators and rudder were seen moving for the first time. For the fuel pipes and tank, functional tests were performed indoors both with air and with a special liquid. They will be completed with tests with real fuel when the aircraft moves outdoor. A series of other trials, such as for pressurization validation, will be conducted outdoors too.

Following the indoor tests, MSN001 moved to its next phase of ground testing on February 26, 2013. At this point the aircraft showed the installed winglets for the first time, as well as its belly fairing panels and main landing gear doors. The next step is outside at Station 18 and includes three planned types of tests: fuel tank testing with real fuel to verify levels, flows, sealing and internal fuel transfer functions; pressure testing of the fuselage; and radio equipment testing. "The radio equipment tests need to be done outside because inside there could be electromagnetic interference from the building," says Evrard. "Results are good so far and the tests analysis process is ongoing."

Subsequently, the Trent XWB engines (currently being prepared for powerplant integration in Toulouse) will be fitted prior to outdoor engine run-up tests. "Fuel and pressure tests have already started on MSN001 and will continue until load calibration tests take over," Evrard continues. "The next important steps will be related to the engine. Thanks to our partner Rolls-Royce, another major milestone paving the way to first flight clearance was passed: the Trent XWB turbofan was awarded engine type certification by the EASA. The engines that will power the A380 MSN1 are now being prepared prior to installation of the integrated powerplant on the aircraft's pylon at the end of March.

"Another important stream relates to preparation for major structural tests, and very good progress has been made, which puts us on track to start static and fatigue tests at the end of March. On systems side, the VFF campaign with the Iron Bird coupled to the development simulator has continued." In the coming weeks, the movements will be pushed to their limits for the stability tests, a testing phase following the standard functioning tests. ∎

NEXT STAGE

From the start of flight tests to entry into service will take slightly more than a year from March 2013. Much of the flight testing of the engine has already taken place on the A380 MSN1 flying testbed.

The A350 program will have five flying test aircraft – Airbus's largest flight test fleet (A380 had four flying):

- MSN001 – for first flight, including flight envelope clearance.
- MSN002 – full cabin for testing all cabin-related systems, including evacuation tests on the ground, early long flights, IFE, cabin hot and cold tests, and some flight test installation.
- MSN003 – production starting in early 2013. No cabin, heavy flight test installation for high altitude, hot and cold weather and other situations.
- MSN004 – light flight test installation, external noise tests, lightning test, head-up display (HUD), pilot training for first customers and training for maintenance teams.
- MSN005 – full cabin installation, dedicated to route proving which will also include some flight test installation.

The science of very fast

Hypersonics is hitting the headlines as more projects and designs propel test programs forward across the globe. NASA instigated one such academic collaboration that is now seeing advanced progress

BY CHRISTOPHER HOUNSFIELD

In 2009 NASA and the US Air Force designated three universities and other industry partners in California, Texas and Virginia as national hypersonic science centers. Their task was to advance research into air-breathing propulsion, materials and structures, and boundary layer control for aircraft that can travel at more than Mach 5. Hypersonics is being re-energized, and with programs sporting names like HySET (Hypersonic Scramjet Engine Technology), IHPRPT (Integrated High Payoff Rocket Propulsion Technology), Blackswift and HyperSoar ebbing and flowing in research and development, it is only a matter of maybe a decade before regular manned operations will be a reality.

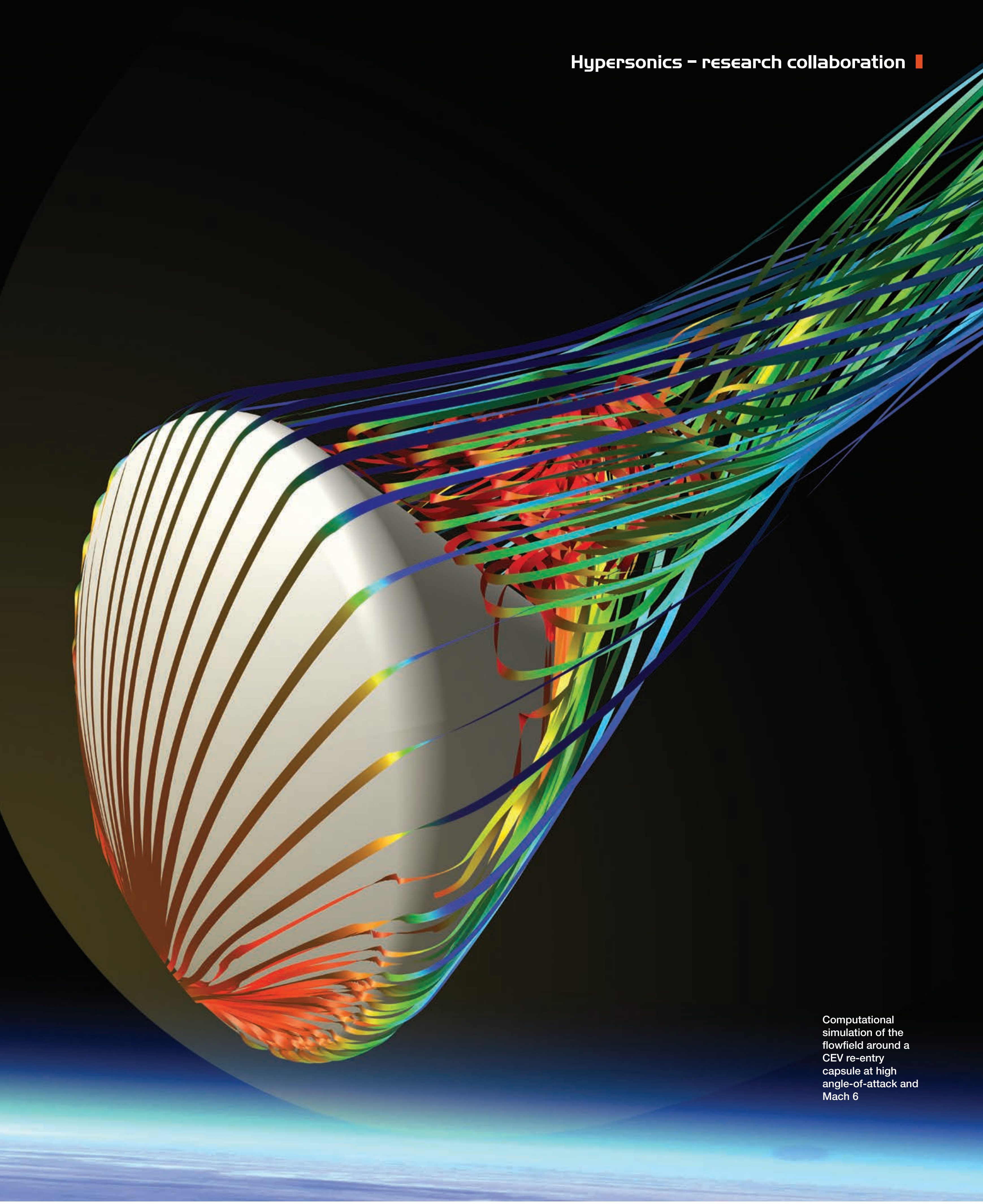
NASA is the organization arguably most involved in hypersonic research development and test, which dates back to shortly after World War II, as technically it is only NASA's vehicles that have achieved this speed manned (the X-15), and not just through re-entry.

The chief characteristic of hypersonic aerodynamics is that the temperature of the flow is so great that the chemistry of air molecules must be considered. At low hypersonic speeds the molecular bonds vibrate, which changes the magnitude of the forces generated by the air on the aircraft. At high hypersonic speeds the molecules break apart, producing an electrically charged plasma around the aircraft. Large variations in air density and pressure occur because of shock waves and expansions.

Strictly speaking, hypersonic flight is any flight faster than Mach 5, which is 3,300mph at a high altitude. So all objects that achieve orbit must achieve hypersonic flight. Hypersonic flight therefore goes back to the 1950s, with almost every instance of hypersonic flight to date being achieved by a rocket-powered vehicle.

MAN BEHIND THE SPEED

Dr James Pittman has over 35 years' experience as an aerospace engineer at NASA. He has worked in the fields of hypersonic, supersonic and subsonic air vehicle concepts, computational tools and technologies, and in technical and program leadership positions. Pittman has contributed to numerous hypersonic programs including the X-24C, a Mach 5 reconnaissance aircraft concept, the National Aero-Space Plane (NASP) Technology Maturation



Computational simulation of the flowfield around a CEV re-entry capsule at high angle-of-attack and Mach 6

Program where he led the US government effort on hypersonic propulsion airframe integration, the X-43A, the X-51A, and the HIFiRE programs.

He is now the senior advisor for the NASA Fundamental Aeronautics Program. He puts the organization's involvement into perspective: "The term 'hypersonics' has evolved to be associated with air-breathing propulsion-powered flight, while the rocket community has evolved to use the term 'EDL' standing for entry, descent and landing. All re-entry into the Earth's or another planet's atmosphere will occur at hypersonic speeds, which is the entry phase of EDL. Remember that these orbital vehicles must also achieve hypersonic speeds on ascent in order to achieve orbit or escape the Earth's gravity.

"The history of hypersonics and air-breathing propulsion dates back to circa 1960. This is when the supersonic combustion ramjet, or scramjet, was first conceived along with scramjet-powered hypersonic vehicle concepts. There was a scramjet program in the 1960s – the Hypersonic Research Engine or HRE. The program was cancelled prior to flight test. There was a US Air Force/NASA X–24C program in the 1970s, also canceled prior to flight test, and NASP in the 1980s and 1990s, which suffered a similar fate."

"THE US DEPARTMENT OF DEFENSE MAY BUILD A SMALL OPERATIONAL HYPERSONIC VEHICLE IN THE 2020S"

CURRENT PROJECTS

The first scramjet-powered vehicle flight test was the NASA Hyper-X or X-43A program. It achieved its first successful flight on March 27, 2004 at Mach 6.91, and its second flight on November 16, 2004 at Mach 9.68.

Pittman, who was responsible for leadership of the 8ft-High Temperature Tunnel after its conversion to a propulsion facility and for the first scramjet test in the HTT, which was the NASP Concept Demonstrator Engine, explains that air-breathing hypersonic travel is very much alive: "NASA continues to develop scramjet technology, primarily in partnership with the US Air Force. The objectives of this work are to mature small scramjets to a Technology Readiness Level (TRL) of 6, which is the point at which the technology is considered sufficiently mature for use as part of an operational vehicle, and to develop larger-scale scramjets than the current sizes.

"The Air Force continues to pursue TRL 6 flight tests of a scramjet powered vehicle, the X-51, with plans for a new flight test program being developed. NASA is supporting this effort. The community has learned how to build a scramjet that can provide sustained, controlled hypersonic flight when properly integrated into a vehicle.

ABOVE: Dr James Pittman has recently managed the $450m NASA Hypersonics Project

RIGHT: The SJX61-2 engine that powered the X-51A simulating Mach 5 flight conditions

BELOW RIGHT: Graphic of the X-51 Waverider, which has already achieved more than two minutes of flight

X-51 WAVERIDER

An engine first validated in one of NASA's wind tunnels made the longest supersonic combustion ramjet-powered hypersonic flight off the California coast as recently as 2010.

The air-breathing scramjet engine, built by Pratt & Whitney Rocketdyne, burned for more than 200 seconds to accelerate the US Air Force's X-51A vehicle to Mach 5. It broke the previous record for the longest scramjet burn in a flight test, set by NASA's X-43 vehicle.

Pittman explains that NASA test involvement is going through a subsonic, or lean period as other organizations do their research: "Hypersonic ground testing at NASA is focused on developing more efficient scramjet combustors and supporting US Air Force scramjet development."

Tim Marshall, director, aeronautics test program office at NASA, backs up this view: "NASA has not made much investment in hypersonic test technologies over the past five years, and none is on the horizon. As a result,

NATIONAL CENTER FOR HYPERSONIC COMBINED CYCLE PROPULSION

The Center, located at the University of Virginia, is making use of data from two experiments in two facilities. Specifically, the IMX (Inlet Mode Transition) rig in the NASA Glenn 1 x 1ft Supersonic Wind Tunnel and the L-IMX (Large Inlet Mode Transition) rig in the NASA Glenn 10 x 10ft Supersonic Wind Tunnel.

The IMX and L-IMX test program is an excellent source of data. Measurements include high- and low-frequency wall static and dynamic pressures, flowfield rakes, mass flow measurements and schlieren. Boeing and NASA have conducted detailed steady RANS CFD analysis of the test configurations, which are being used as a baseline for comparison with more sophisticated analysis methods. Working with NASA, the team is closely monitoring the data generated by this test program and the data is being used it to validate advanced numerical methods.

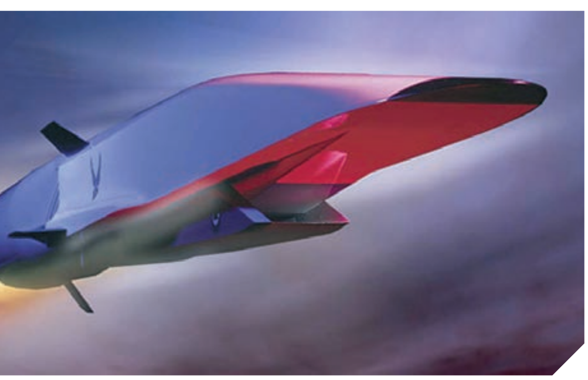
The initial entries into the programof IMX and L-IMX will be followed by entries to develop the control schemes for the turbine-to-ramjet transition as well as the integration of an actual turbine engine in the low-speed flowpath. It is anticipated that the numerical models developed will enable more advanced and accurate control strategies to be developed.

test capability improvements have only been incremental in basic test technology systems such as data acquisition and instrumentation."

But it is not over with the X-51: "The X-51 achieved 143 seconds of scramjet powered flight. The X-51 program goal is 300 seconds of sustained hypersonic flight. The US Department of Defense may build a small operational hypersonic vehicle in the 2020s," says Marshall.

USING ACADEMIA

Pittman and Marshall are keen to emphasise that with concerns over funding, it is the next generation that matters and can take hypersonics to the next level. It is for this reason that considerable investment has been made in testing and research with US universities: Pittman describes further: "NASA and the Air Force Office of Scientific Research (AFOSR) are both involved in understanding the basic science of hypersonic flight. To this end, NASA and AFOSR have entered into a 50/50 partnership to delve into the basic physics of hypersonics in three specific areas: hypersonic boundary



layer transition, high-temperature materials and structures, and air-breathing combined cycle propulsion.

"Each National Hypersonic Science Center leads a consortium of 18 universities, and other organizations, for the purpose of increasing our understanding of hypersonics and to train the next generation of hypersonic engineers and scientists."

Marshall indicates that the next stage of hypersonic testing is currently away from flight tests: "One area of interest has to do with non-vitiated flow and another with the ability to perform ground testing by varying the Mach number on the fly. The US Air Force has been doing engineering studies and analyses of new hypersonic test capabilities addressing these concerns."

NATIONAL SCIENCE CENTER FOR HYPERSONIC LAMINAR-TURBULENT TRANSITION RESEARCH

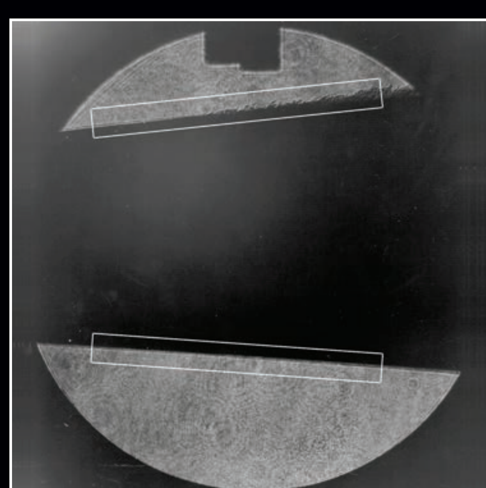
Laminar-turbulent transition is a fundamental scientific problem that affects many aspects of aerodynamics, from drag reduction in transport aircraft to surface heating in re-entry vehicles.

The National Center for Hypersonic Laminar-Turbulent Transition Research ('the Center') was established as a five-year program in 2009 to specifically address issues of transition in hypersonic flows (generally over Mach 5).

The US Air Force has critical mission requirements for space access and rapid global strike. NASA Strategic Goal 3 seeks to: "Develop a balanced overall program of science, exploration and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration."

Key enabling challenges toward achieving these national capabilities are to accurately predict and effectively control the transition from laminar to turbulent flow. Transition affects high-speed vehicle and weapons-system performance, as it may critically drive system drag, thermal load, propulsive efficiency and stability. For example, a hypersonic vehicle experiencing turbulent flow and designed to reach low-Earth orbit would experience about five times more viscous heating and be double the weight of an equivalent vehicle in laminar flow.

The goal of the Center is to develop a physics-based understanding of the basic building blocks required to estimate the onset of transition and testing in hypersonic flight relevant to Air Force and NASA missions. The approach consists of an integrated series of experimental, computational and theoretical studies. The work has already advanced basic knowledge and engineering practice in the areas of unstable mode interactions, receptivity and initial conditions, nonequilibrium chemistry and thermodynamics, ablation and transition control. A balanced team of qualified researchers has been assembled in unique facilities to meet the Center's goal. For example, the NASA-Langley Mach 6 Quiet Tunnel at Texas A&M is the only long-duration, quiet-flow hypersonic test facility in the world, and this capability is imperative to make measurements of instability-mode growth suitable for model validation. This is complemented with Purdue University's short-duration, quiet flow, Mach 6 Ludwieg Tunnel. Together these facilities can accomplish a great deal because it is well known that conventional (noisy) facilities can give trends contrary to flight.



ELEMENTS OF THE PROGRAM

There have been a large number of contributions to the program over the past four years. Focused schlieren is one such element, used in combination with a small-diameter fiber optic and a photodetector to measure second-mode instabilities on a Mach 6 flared-cone model. At a freestream unit Reynolds number coinciding with the loss of the test tunnel's quiet-flow environment, the redistribution of the available energy in the interacting modes eventually involves frequency components throughout much of the spectrum. With regard to testing and development it is important that computations and theory are shown to motivate experimental work. Computations and theory work hand-in-hand with the experimental activities within the Center to identify the instability mechanisms in all regions of the hypersonic-flight parameter.

VENOM

Vibrationally Excited Nitric Oxide Monitoring (VENOM) is a laser-based diagnostic technique under development at Texas A&M University. The goal of the diagnostic is simultaneous and instantaneous velocity and temperature to quantify heat flux in a hypersonic boundary layer.

The operating principle is based on a combination of molecular tagging velocimetry and planar laser induced fluorescence of nitric oxide (NO). The unique and enabling feature of the VENOM technique is that the probe molecules, NO, are prepared in the flow through laser photolysis of seeded trace amounts of nitrogen dioxide NO_2. This process produces vibrationally excited NO, where 40% of the molecules are in the first excited vibrational state. The laser 'writing' process is used to introduce a 'grid' of NO molecules that are probed via the planar laser induced fluorescence. Two sequential 'reads' are accomplished to quantify the motion of the grid and hence the flow velocity.

Texas is currently developing a dual-plane extension of this system to enable measurement of density, pressure and simultaneous rotational and vibrational temperature.

Professor William S Saric is senior director, George Eppright '26 Chair in Engineering, Texas A&M University

Space – such a drag

Australia has played a lead role in scramjet research for Mach 8+, in which the work has laid a platform that is crucial to bringing hypersonic, airbreathing vehicles to reality

BY RUSSELL BOYCE

MAIN: One of the generic scramjet flow paths in the T4 test section

RIGHT INSET: This full-scale THAAD missile tip and IR seeker window assembly recently underwent aerothermal testing at AEDC's Tunnel 9 Hypervelocity Wind Tunnel Facility

FAR RIGHT INSET: Schlieren image of 1/30 scale model of the aeroshell configuration for AEDC'S Mars Science Laboratory

The most promising way to achieve safe, secure, economical and reliable access to space and space-based technologies is through the development of scramjet-based launch systems. Australian universities have played a lead role in scramjet research for Mach 8+, enabled by key capabilities such as shock tunnels and associated diagnostic techniques, and the achievement of milestones in first demonstrations of positive net thrust in the shock tunnel and supersonic combustion in flight.

Building on this heritage and these capabilities, the Scramjet-Based Access-to-Space Systems (SCRAMSPACE) project is currently tackling the science of scramjet flight in the Mach 8-14 range, and building capability for future flight programs and a future Australian space industry through the performance of a free-flying scramjet flight experiment, SCRAMSPACE I.

SPEED AND JAPANESE COOPERATION

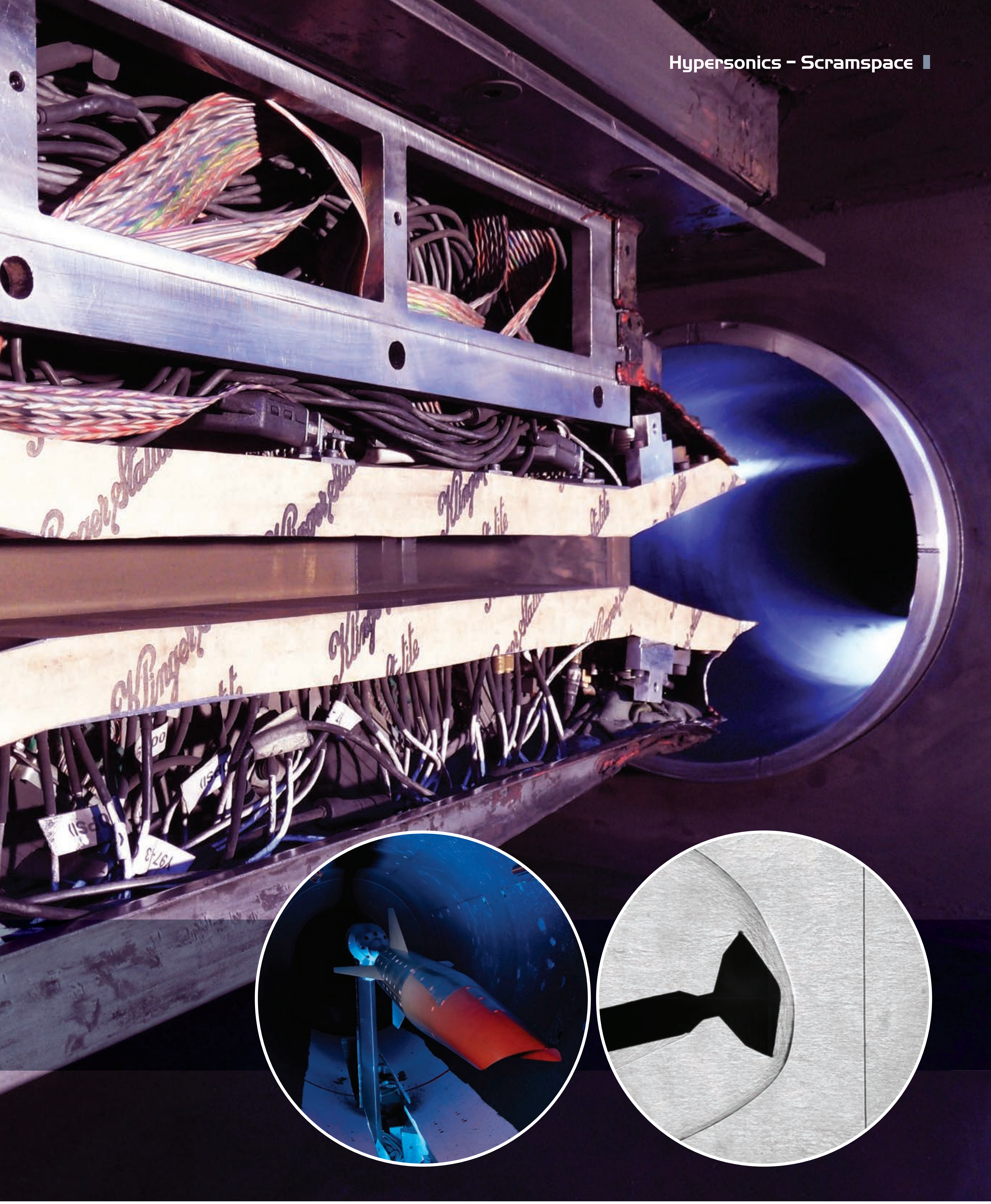
Hypersonics has, for over 40 years, been a world-class niche research strength for Australia. Hypersonics in Australia was started in the 1960s by Dr (now Emeritus Professor) Ray Stalker. He dramatically increased the maximum velocity limits on the ground-based testing of hypersonic flow by developing the free-piston-driven hypersonic shock tunnel at the Australian National University (ANU) in Canberra.

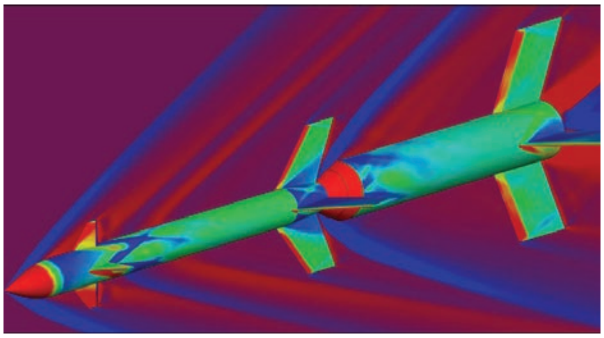
With the T3 tunnel in particular, Stalker and colleagues made major in-roads into the understanding of hypersonic flows with high-temperature effects. These results have proved critical to the design and operation of reentry vehicles. In 1977 Stalker moved to the University of Queensland (UQ) and continued his activities in hypersonics, focusing specifically on testing scramjets. He developed the T4 shock tunnel for that purpose and it is that tunnel, and its associated diagnostic techniques – for example the stress wave force balance capable of measuring aerodynamic forces within the few milliseconds of useful test time.

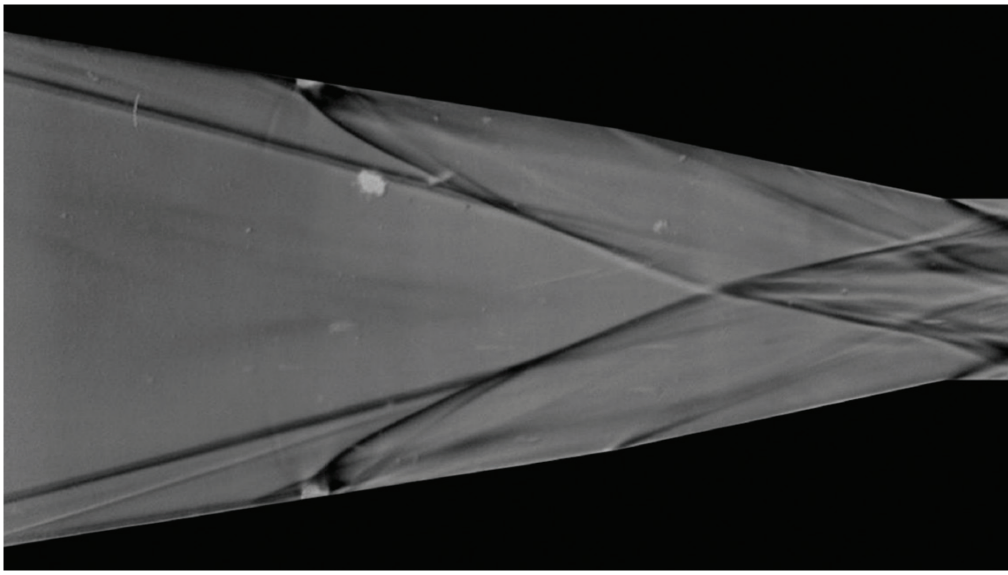
Building on over a decade of fundamental experimental and analytical studies in supersonic combustion and scramjet phenomena in T4, a milestone was reached in 1995 when for the first time positive net installed thrust was demonstrated for a complete scramjet configuration. However, the mounting body of research being generated in the Australian impulse facilities was accompanied by the question of whether the same results would be achieved in longer duration facilities or indeed in flight.

The answer to this question with respect to facility comparisons was provided through another milestone, in which supersonic combustion was directly and favorably compared between the T4 shock tunnel and a long-duration combustion-heated blowdown scramjet test facility at JAXA's Kakuda Research Center. This work provided considerable confidence in the scramjet research being conducted in T4 and was a precursor to answering the second part of the question – comparison with flight.

To provide this answer, and therefore validate of the use of the university's short-duration ground-test facilities for this research, the HyShot scramjet flight experiment program was developed at UQ. The







configuration was not designed to produce thrust, but rather to produce direct comparison between pure supersonic combustion in T4 and in flight. The trajectory was ballistic, with Mach 7.6 obtained at the test point during the descent. Post-flight data analysis of HyShot II confirmed the presence of supersonic combustion during the approximately three-second test window at altitudes between 35km and 29km, and reasonable correlation between flight, pre-flight T4 tests and CFD was observed.

ABOVE: Simulation demonstrating the stability of SCRAMSPACE flight. The colors represent Mach number

ABOVE RIGHT: An experimental image of the flow and combustion initiation in one of the scramjets in the T4 shock tunnel

VELOCITY – 13KM/S

The HyShot II flight experiment was a major milestone for international scramjet research and has opened up opportunities and methodologies for cost-effective scramjet R&D. In particular it opened the door to collaborative hypersonic flight experiments such as those between Australia and the UK (HyShot III), Australia and Japan (HyShot IV) and Australia and USA – the Mach 10 HyCAUSE scramjet flight experiment and the current HIFiRE flight experiment program. The aim of HIFiRE is to undertake fundamental in-flight research of hypersonic phenomena using the HyShot sounding rocket approach.

An extension of the piston-driven shock tunnels that have been developed at UQ is the piston-driven expansion tunnel, capable of research into super-orbital velocities for planetary entry. Such tunnels employ an additional low pressure tube – the expansion tube – between the shock tube and the test section.

As a result of the rapid unsteady expansion of the test gas through the expansion tube, flow velocities up to 13km/s and total pressures of the order of 10GPa have been measured in these tunnels. Their total pressure capability is extremely attractive for scramjet testing, and recent major upgrades of the large tunnel X3 now enable Australia to test full-flowpath scramjets along complete scramjet access-to-space trajectories.

Australian hypersonics has embarked on an effort to build the technologies, capacity and capability for the development of future scramjet-based access-to-space systems.

FAST FLOW

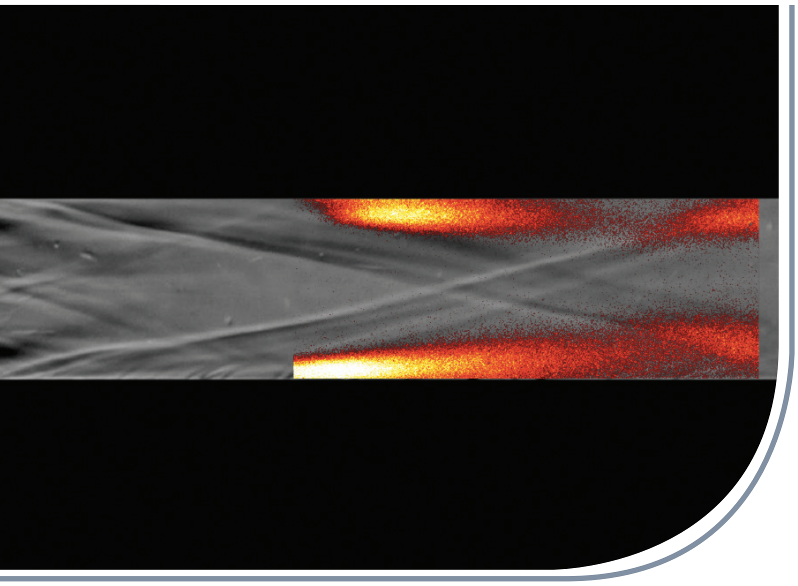
The Arnold Engineering Development Complex (AEDC) based in Tennessee, USA, manages some of the world's highest-performing hypersonic facilities. Forged in an era when strategic priorities included long-range ballistic strike and travel to and from space, several large capabilities provide replication of the most critical parameters important for the design and development of hypersonic vehicles.

The suite of wind tunnels includes the VKF wind tunnels A, B and C (providing continuous-flow testing up to Mach 10), the Hypervelocity Wind Tunnel 9 (the world's highest-pressure blow-down facility operating in the Mach 7 to 14 corridor), Arc-Jet facilities H1, H2 and H3 (producing realistic reentry heating environments for testing thermal protection systems), and the Aerodynamic and Propulsion Test Unit (providing ram/scram engine data to Mach 8). Together, this suite of high-speed test capabilities provides evaluation of flight control, thermal protection and propulsion efficiency. Ballistic ranges, space chambers and rocket cells also provide system testing related to hypersonic vehicles, and AEDC maintains expertise in all scientific and engineering disciplines related to high-speed flight.

Recent developments in technology, combined with advances in computing power and physics-based analysis, have enabled a class of non-ballistic reentry glide vehicles to become feasible. Programs rely on AEDC to help unlock the secrets of high-temperature gas dynamics, chemistry and physics. Vehicles associated with the US Conventional Prompt Global Strike (CPGS) program, such as DARPA's Hypersonic Technology Vehicle-2 (HTV) and the US Army Advance Hypersonic Weapon (AHW), are the first of the candidate CPGS vehicles to undergo stringent testing at AEDC.

While AHW and HTV are being tested in some of the very same facilities that perfected ballistic re-entry vehicles in the 1970s and 1980s, the test techniques in use today represent considerable advances in the state of the art. Today's high-performing vehicles demand orders of magnitude greater accuracy in determining the aerodynamic forces and moments, far more detailed understanding of the aerothermal and surface pressure and heating conditions, and much more confidence in thermal performance.

Responding to this, the AEDC complex of hypersonic test capabilities has revolutionized the test data product. As an example, the data being obtained today at Tunnel 9 exhibits extremely high accuracies in force measurements, highly detailed characterization of surface-



SCRAMSPACE is an Australian Space Research Program funded project that represents the first phase of this effort. It is a three-year, US$14 million international project led by UQ, with consortium partners including the University of New South Wales (UNSW), the University of Adelaide (UA), the University of Southern Queensland (USQ), the Defense Science and Technology Organization (DSTO), BAE Systems, Teakle Composites, AIMTEK, the Japanese Aerospace Exploration Agency (JAXA), the Italian Aerospace Research Center (CIRA), the German Aerospace Center (DLR), the University of Minnesota (UMN), and the Australian Youth Aerospace Association (AYAA).

The project is centered on an affordable, expertise-building flight – SCRAMSPACE I – at the Mach 8 point on the access-to-space Mach range. The flight, to be launched in late 2013, will address scramjet performance, materials and instrumentation, supported by ground-based performance and vehicle control developments in this Mach range.

FLIGHT TEST PURPOSE

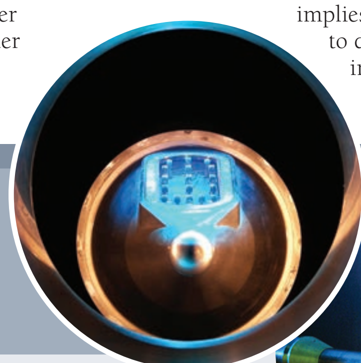
What is the motivation for flight testing in this process? To build capacity and capability for a future scramjet-based access-to-space industry, Australia's ground-based research must be leveraged and extended to provide answers to key scientific questions. Yet this is not enough. For several reasons, flight tests are needed if the team is to successfully develop these systems.

Firstly, for access-to-space, the high thrust of a scramjet vehicle must exceed its high drag to produce net positive thrust. The UQ's shock tunnel net-thrust measurements, CFD and other analysis provides confidence that this can be achieved. However, the fact that scramjet net thrust is a small difference between two large numbers implies that flight testing is required to determine the thrust achieved in practice.

Secondly, the limited test time in the facility's tunnels prevents us from observing the effects of sustained flow and sustained heating. Establishing the heating loads is critical to successfully designing a scramjet vehicle.

The team regularly makes point heat-flux measurements in the tunnels, but they must be extrapolated with CFD to complete a vehicle design. To ensure that we understand the heating environment sufficiently accurately, we need to make measurements in flight. Furthermore our scramjet test models in the shock tunnels are made from steel – the flow duration in a shock tunnel is so short that the metal remains relatively cold. In sustained flight, advanced materials such as high-temperature composites and ultra-high-temperature ceramics are required. Their performance under sustained heat loads can be examined in certain high-enthalpy facilities but must be tested in flight in order for confidence to be placed in our ability to understand them and design vehicles with them.

Thirdly, the short test time in a shock tunnel does not allow ground testing of flight control strategies. This can only be done in long-duration facilities, none of which are able to test scramjets at these flight speeds. Furthermore, the control strategies must be capable of handling changes in the vehicle shape as it heats up.



RIGHT: Full-scale THAAD missile tip and test engineers Joe Norris and John Lafferty ready a Hypersonic Technology Vehicle-1 model prior to a Hypervelocity Wind Tunnel 9 operation

heating profiles and interrogation of boundary-layer transition using high-frequency microphones and pressure sensors. Taken together, this data product is being used to explain anomalies in flight and to reduce risk for upcoming flights.

Looking to the future, these boost-glide re-entry vehicles must be evaluated with the same rigor as our fielded systems and a class of air breathing cruise missiles and platforms using supersonic combustion ramjet engines will have to be proved.

Since computers have yet to send test facilities to the graveyard, AEDC hypersonic capabilities are busy increasing reliability and availability of our continuous flow tunnels. We are extending our hypervelocity tunnel to Mach 18 where pull up is severe, developing new arc jet environments that will bridge the current gaps in test environments driven by tomorrow's systems, and integrating more analysis into the test product to increase our understanding of the salient physics.

On an equally important front, AEDC is giving attention to developing a future workforce able to take full advantage of the technology and innovation required to mature systems by teaming with academia and research agencies and reinventing how we think about testing. These enhancements are sure to maintain the high level of value required of the USA's T&E infrastructure and will assure that the next century is ushered in hypersonically.

The SCRAMSPACE vehicle up in space, during the several minutes of exo-atmospheric ballistic flight

Finally, experience gained from HyShot, HyCAUSE and HIFiRE has shown our scientists and engineers how extreme the hypersonic flight environment is, and that it is only by taking our science to the air that we truly understand the realities of flight and thus develop the critical experience and expertise required for industry-based operational systems. Therefore the SCRAMSPACE I flight experiment is designed to contribute to developing the talent pool, the human capacity and capability, for this purpose and for an Australian space-related industry in general.

GETTING AWAY FROM EARTH

SCRAMSPACE I takes the ground-tested science to the sky and will measure the changes induced when H_2 fuel is switched on in a simple axisymmetric inlet-fueled shock-induced combustion scramjet flowpath. The elegantly simple flowpath has been tested in shock tunnels at UQ, DLR and JAXA. The vehicle, being a hypersonic free-flyer, is equipped with fins to ensure vehicle stability along the whole re-entry flight.

These fins are provided by DLR Institute of Structures and Design, Stuttgart, and are constructed from ceramic-matrix composite (C-C SiC). Additional high-temperature materials on board are an ultra-high-temperature ceramic (UHTC) experimental winglet provided by CIRA, and a filament-wound carbon-phenolic thrust nozzle manufactured by Teakle Composites. The flight will be conducted by SCRAMSPACE partner DLR's Mobile Rocket Base (MORABA) at the Andoya Rocket Range in Norway in late 2013.

The main secondary experiment on the flight is a new, Australian-developed tunable diode laser sensor, installed in the scramjet inlet and capable of measuring key inlet flow parameters. This experiment, including miniaturization and flight hardening, is provided by UNSW. A further piggy-back experiment is an onboard camera positioned inside the vehicle to observe temperature sensitive paints on the back surface of the combustion chamber.

The development of the flight vehicle has passed its critical design review and is currently in the assembly and pre-flight test phase. To achieve this, a core flight-experiment team has been assembled at UQ, supported by training, reviews and access to flight subsystems from DSTO, as well as the hardware- and software-in-the-loop expertise and capabilities of BAE Systems. ∎

Professor Russell Boyce is chair for Hypersonics at the University of Queensland in Australia

TOO COOL FOR SCHOOL

A UK-based company has successfully demonstrated a range of technologies for the Mach 0-25 capable SABRE 1 aircraft engine as part of a program designed to elevate the engine's Technology Readiness Levels to 4-5.

The 85% commercially funded program from Reaction Engines included the demonstration of technologies such as contra-rotating turbines, combustion chambers and lightweight heat exchanger manufacturing, however the main focus has been on the testing in 2012 of a SABRE air pre-cooler in a working environment.

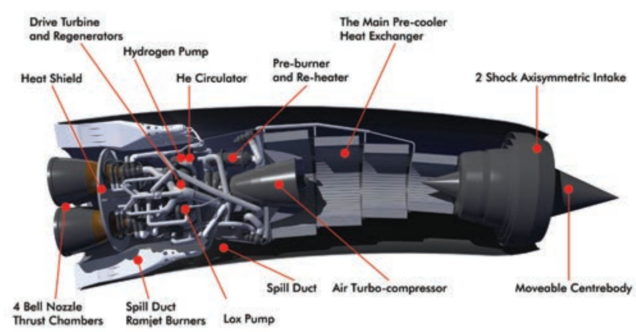
The air pre-cooler is a special heat exchanger designed to deeply cool the incoming air to allow it to be compressed and injected directly into a rocket combustion chamber to create an air-breathing rocket engine capable of much higher speeds than a jet. This is a demanding task; at Mach 5 the air must be cooled from 1,000°C to -150°C in 1/100th of a second. Without this air pre-cooling the engine will not work.

The European Space Agency (ESA), which is providing independent validation of the testing, stated in a November 2012 REL press release: "The pre-cooler test objectives have all been successfully met and ESA are satisfied that the tests demonstrate the technology required for the SABRE engine development."

The pre-cooler tests, undertaken at Reaction Engines' facility in Oxfordshire, UK, integrated the pre-cooler technology with a jet engine and a novel helium cooling loop in order to demonstrate the crucial elements of the new technologies in the SABRE engine. The key SABRE pre-cooler demonstration objectives included:

- heat exchanger structural integrity;
- aerodynamic stability and uniformity;
- freedom of vibration above and beyond the flight envelope;
- steady state cooling of incoming air to -150°C;
- prevention of frost build up during low temperature operation.

The next step in development will include a ground demonstration of the SABRE engine. Dr Mark Ford, ESA's head of propulsion engineering, said: "One of the major obstacles to developing air-breathing engines for launch vehicles is the development of lightweight high-performance heat exchangers. With this now successfully demonstrated by Reaction Engines, there are currently no technical reasons why the SABRE engine program cannot move forward into the next stage of development."



Amicable separation

Weapons separation testing is among the more prosaic but essential stages in combat aircraft trials work. The US Navy and Lockheed Martin are deeply entrenched in weapons testing for the P-8 Poseidon and F-35 Lightning II programs

BY PAUL E EDEN

In the complex world of integrated combat aircraft, some of the obvious factors in the delivery of air power are easily overlooked. Warplanes rely primarily on expendable weapons, generally carried externally, sometimes in bays, and these weapons have to 'come off' cleanly, predictably and consistently, throughout their performance envelope.

The job of ensuring this is the case generally falls to the airframer, working closely with weapon manufacturers and the customer, through a series of trials from form and fit, through ground release to captive carry, separation testing and finally live fire against a target.

POSEIDON PROGRAM

The US Navy's Boeing P-8 Poseidon is the replacement for the Lockheed P-3 Orion. Given its anti-submarine and anti-surface vessel roles, the P-8 is being tested for compatibility with a number of weapons systems, including the Mk 54 torpedo and AGM-84 Harpoon anti-ship missile.

Captain Scott Dillon (see overleaf) manages the US Navy's Maritime Patrol and Reconnaissance Aircraft (MPRA) program office (PMA-290) at Naval Air Station Patuxent River, Maryland, and looks after development, test, acquisition and budgeting for the P-8 Poseidon program. He explains a typical weapons test schedule: "The majority of integration and form/fit work is conducted on the ground. Form/fit for weapons being tested today began several years ago. Integration is an ongoing cycle of software development and lab testing, followed by aircraft ground tests.

"Once separation tests begin, we look for the store to eject safely and clear the aircraft environment as modeled, and for the aircraft to respond as expected. We mitigate risk by incrementally expanding the release envelope."

Speaking in late March 2012, Dillon provided an overview of the P-8 weapons testing effort. "Mk 54 torpedo testing is complete and a flight clearance for fleet employment has been issued. Harpoon [Block] IC testing is underway. Several separations have been successfully completed and the release envelope is being expanded. Upcoming weapon integration flights will pave the way for several live fire events in 2013, using free-flight exercise missiles."

The test campaign has been flown from the US Navy's Atlantic Undersea Test and Evaluation Center at Patuxent River, Maryland, typically employing T-2C Buckeye or F/A-18 Hornet chaseplanes for safety reasons and to secure video and still images of stores releases. PMA-290 works closely with the weapons program offices (PMS-404 for Mk 54 and PMA-201 for Harpoon), as well as the weapon manufacturers (Raytheon and Boeing, respectively).

Despite the P-8's large cabin and multiple operator positions, Dillon says that the number of test personnel airborne is kept as low as possible. "Test team size varies according to the type of store and complexity of the program. Teams are a mix of contractor, military and government service aircrew and engineers. Typical roles include a project officer/engineer group from the test team, contractor subject matter experts, associated NAVAIR [Naval Air Systems Command] and contractor engineering staff, control-room test conductors, range support and safety personnel, photographers and maintenance personnel, who upload and download the weapons and verify loading procedures for the fleet. Aircrew size is typically limited to the personnel essential for a safe separation test."

The subject aircraft is modified with camera installations as Dillon explains: "Aircraft are modified and equipped specifically for each task and sometimes configured with unique instrumentation and recording equipment that has been specifically tailored for a certain type of test. Aircraft, pylons and weapon racks are instrumented for the collection of various types of weapons release information, and data and video are

METEORIC LAUNCH FOR TYPHOON

Last year's MBDA Meteor launch was a key point in the evolution of the European Typhoon. Test pilot Steve Long and flight test manager Andy Pegg describe the successful trial

On December 4, 2012, a Eurofighter Typhoon launched an MBDA Meteor air-to-air missile for the first time. Released at Mach 0.9 and 5,000ft (1,524m), the weapon's ramjet engine fired successfully, propelling it on a 20-second guided, telemetered flight. BAE Systems test pilot Steve Long flew the trial from BAE Systems Warton facility, over the Aberporth Range off the Welsh coast.

The two-seater IPA1 carried the Meteor in its starboard aft recessed fuselage station, with high-speed camera pods underwing and a flight test observer in the rear seat.

"The firing sortie was the final step following a series of work-up and rehearsal flights," says Andy Pegg, BAE Systems flight test manager – Typhoon.

Long continues, "We did captive carriage and four jettison trials, three of them straight and level and one at around 3*g*, vaguely representative of a real-world launch." These confirmed that the weapon fell clear of the aircraft in accordance with computer models and simulation.

"Right now the Typhoon is an AMRAAM shooter, so we had to get an iteration of the Tranche 1, Drop Two software load that could talk to a Meteor – it uses a very different data uplink from AMRAAM. We flew three sorties with a telemetered round and practiced firings. A trick in the system made the airplane think the missile was airborne and the radar started trying to uplink. This enabled us to check that when we came to fire the missile, we'd have a good uplink signal coming out of the radar and that the missile could see it.

"The first sortie wasn't a great success because we lost a lot of the datalink messages. A software tweak fixed it and on the second sortie the missile got every message. Then we flew a third to make sure the cameras were working."

TEST SYSTEM

Pegg explains the camera and telemetry systems employed: "The camera pods are standard supersonic fuel tanks modified to hold high-speed cameras and their associated windows. The cameras' field of view can be adjusted internal to the pod and they form part of the flight test instrumentation [FTI] system, controlled from the cockpit.

"Calibration markings on the missile were used in conjunction with the camera pod footage to determine the missile near field [proximal to the aircraft] relative positions, and hence the trajectory. This information is compared with the predicted model to confirm safe separation and aid clearances for future, more demanding firings.

"The Warton-based team is in contact with the aircrew from crew-in until arrival at the range, when the BAE Systems MGS [mobile telemetry ground station] team has contact," he continues. "BAE Systems flight test engineers and MBDA specialists were at Aberporth to monitor telemetry data and work with the QinetiQ range personnel. Aircraft instrumentation data was recorded by IPA1's comprehensive FTI system and a subset was transmitted via telemetry to a BAE Systems MGS located at Aberporth for the trial. The missile also transmitted data to a separate telemetry ground station at Aberporth."

TEN-SECOND WINDOW

"With two thumbs-ups from MBDA and the same from our radar guys, after the third

LEFT: This January 4, 2013 sortie assessed F-35C handling with open weapons bays and AIM-120 missiles in place. The AAMs are attached to the inner bay doors

collected onboard the aircraft and downloaded for post-flight analysis."

Poseidon carries its weapons on underwing pylons and in an aft fuselage bay. When asked about assessing weapon separation from a bay, Dillon notes: "In general the use of weapons bays simplifies testing by providing internal carriage that alleviates the need to gather store flutter test points. The main problem we might encounter in any testing would be if a separation did not go according to our modeling. The flight test is really a validation of all the modeling and ground ejections that took place previously. There have been no concerns with any stores separation testing on P-8A."

STEALTHY SEPARATION

With its F-35 Lightning II, Lockheed Martin faces similar challenges as the US Navy with the P-8, with weapon testing on an aircraft equipped with wing pylons and bays. However, the F-35 is also supersonic, comes in three versions and is stealthy. Lockheed Martin is of

CAPTAIN SCOTT DILLON, US NAVY

As well as his role on the P-8 program, Captain Scott Dillon has responsibilities for the P-3C Orion and its variants, including the EP-3E Aries electronic intelligence gatherer and S-3B Viking, as well as the power and propulsion systems for the P-3, EP-3, S-3B, C-130 Hercules, C-2 Greyhound and E-2C Hawkeye.

A former P-3 Tactical Coordinator and Mission Commander, Dillon joined the US Naval Test Pilot School/Naval Postgraduate School Cooperative Program before moving on to Air Test and Evaluation Squadron Two Zero (VX-20) to lead developmental testing on the P-3 Block Modification Upgrade Program.

Subsequent postings saw him working on P-3 upgrades at PMA-290 before serving as acquisition officer for the Marine Corps Presidential Helicopter, H-1 Huey upgrades, V-22 Osprey, CH-53K Super Stallion and AV-8B Harrier II programs, and leading the MH-60R Integrated Product Team. He was assigned to the P-8A in June 2011.

sortie we were ready for the money shot," says Long. "We had the camera pods on and the nature of the imagery we wanted meant that we couldn't wear a centerline tank, so we went down to Aberporth quite light on fuel. We had sufficient for two attempts, but the first was scheduled as a dry pass for the range controller to check telemetry and signal strengths. On the day the weather was pretty awful, but we had a maritime patrol aircraft over the range and they said it was okay. In the event the clouds parted and the telemetry was good.

"Typhoon can produce a synthetic target at 50 miles and 20° left for training, and we took advantage of that for the test. The missile was equipped with a takedown system, which was activated five seconds beyond the 15 seconds that was initially planned.

"There's a safety trace for each trial that decides the length of the launch box. It describes an area that has to be clear of aircraft, shipping, trawlers and so on. The box worked out to be about 10 seconds long. Once you're in the box, you have to wait for the call that you're clear to arm and clear to fire. Then you have to arm and wait while the cameras run up.

"With the cameras running, take one last look around to make sure everything's right, then pull the trigger and wait. Time compresses as your heart beats faster and all of a sudden that 10 seconds is pretty tight.

"In terms of feel, the launch is invisible. There's a clunk, but I can't imagine the flight control system has to work hard at all, especially with the missile coming off a station close to the centerline. There's a long pause before the weapon launches, just as there is with every missile. You pull the trigger and for just over two seconds all kinds of handshaking goes back and forth between computers as they agree that they're happy to release, know where they are and know where the target is. I pulled the trigger, watched the missile go whoosh and saw it break up."

LEFT: Meteor Firing 041212 cinestill 1, Meteor Firing 041212 cinestill 2 and Meteor Firing 041212 cinestill 3

ABOVE: Dan Levin flew the first ever F-35 weapon separation test, on August 12, 2012. He dropped a 1,000 lb GBU-32 JDAM from an F-35B

TYPHOON TRIALS

BAE Systems made considerable use of real-time data analysis during its recent Meteor trials, which built on extensive work already done with the missile on Saab's Gripen and QinetiQ's Panavia Tornado F3.

Given the success of the Typhoon/Meteor separation trials, the launch might have been considered straightforward, but as test pilot Steve Long reports, there were some minor concerns: "It really was a case of 'go to the range, pull the trigger, missile falls away and whoosh', but there had been a couple of instances on the Tornado where a small plug in the back of the missile motor came out and caused some minor damage. But the nature of iterative development cycles is that MBDA will modify or replace the plug."

> "IN THE WORST CASE THERE COULD BE STORE-TO-AIRCRAFT CONTACT. SO FAR, THE TEST DATA MATCHES PREDICTIONS"

course circumspect in the information it is willing to share about the jet's stealth, but when asked whether separation testing is complicated by stealth features, a spokesperson delivered a simple 'yes'.

However, the company did say: "Last year we initiated our separation program with CTOL releases of AIM-120 [Advanced Medium-Range Air-to-Air Missile, AMRAAM] and GBU-12 [Paveway], and STOVL release of GBU-32 [Joint Direct Attack Munition, JDAM]."

Lockheed Martin follows very similar procedures to the US Navy, as the spokesperson explained: "Every flight test jet has a physical fit check with the actual weapons prior to a flight clearance being issued. Captive flights are only required to clear the separation envelope for loads, flutter and flying qualities. The number of flights is envelope dependent.

"The size of the test team for any particular trial is wholly dependent on the number of weapons to be cleared. F-35 is clearing 10 weapons in SDD [the system design and development phase of the program], with five dedicated analysts based at Fort Worth. There is also a separation engineer at each test site. Key roles for the test engineers include wind tunnel testing, aero-database development, trajectory pre-flight predictions, flight clearance, control-room support, and separation trajectory and miss-distance analysis.

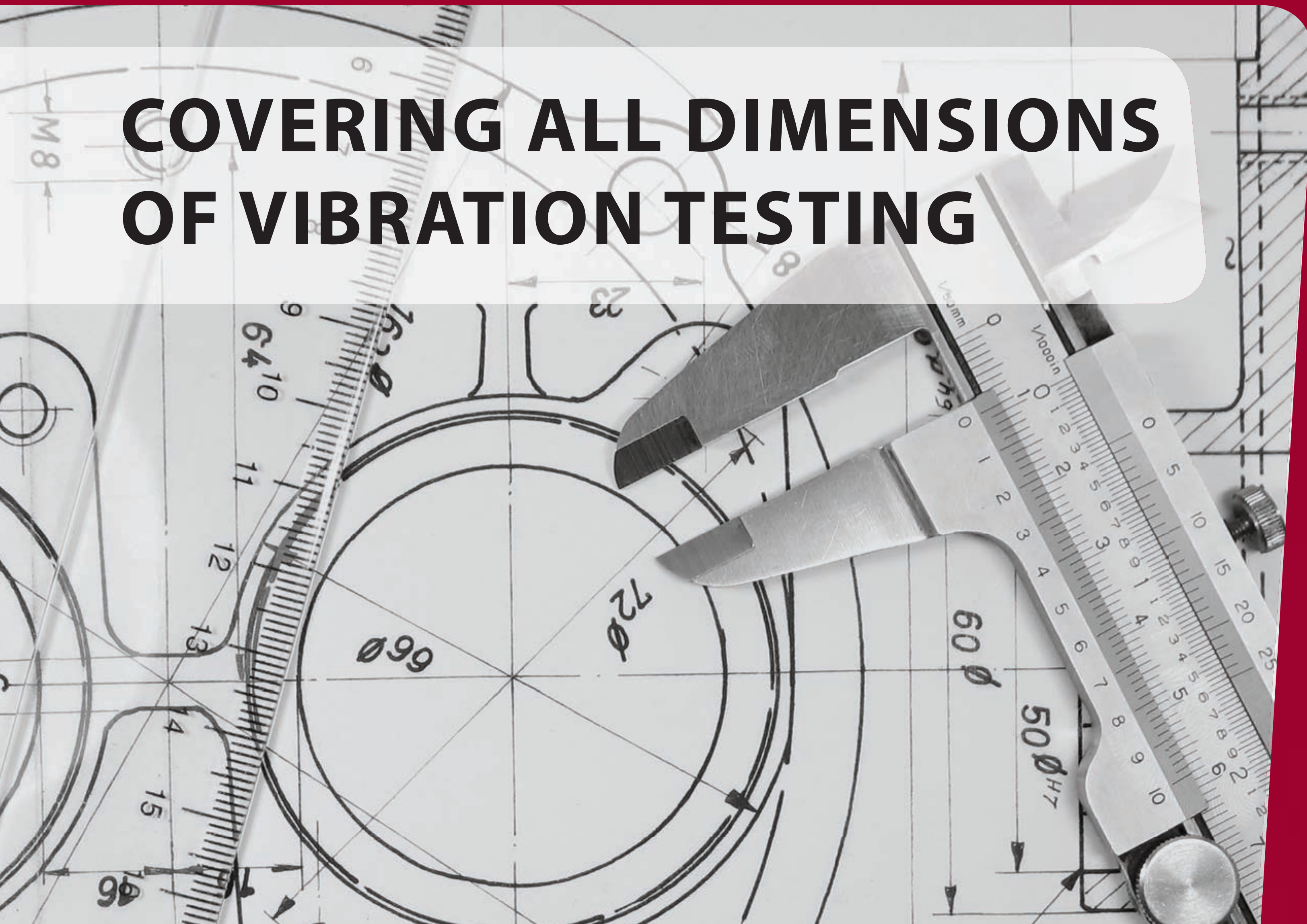
"Lockheed Martin has direct contracts with the weapon suppliers for integration support. The suppliers and weapons program offices are involved in the test planning, but the test sites execute the work. The weapon suppliers are provided with separation data and analyze it to determine if the separation characteristics fall within their requirements for acceptable separation. The basic parameters and test points that we look for are roll, pitch and yaw rates, accelerations and miss distance."

COMMON PROGRAMS

Another similarity between the P-8 and F-35 weapon separation test campaigns is the choice of base, with both programs using Patuxent River, although Lockheed Martin also uses Edwards Air Force Base, California.

Aircraft involved in separation testing are equipped with cameras, specifically the Digital Store Separation Analysis System (DSSAS) and the jet and store are both photogrammetrically targeted. It is surprising that neither the Lightning II nor the Poseidon campaigns make use of aircraft datalinks for real-time data analysis, in contrast to BAE Systems' practice with Typhoon, for example. In addition to DSSAS, however, the weapons themselves are equipped with a six degrees of freedom telemetry kit, whose data is used in the control room and recorded for post-flight analysis.

Selected flight test points are examined to validate weapon separation models and to clear the entire envelope. In terms of potential problems, Lockheed Martin looks out for: "Rates, accelerations and miss distances that may not match predictions," says the spokesperson. "Rates and accelerations may exceed the weapon's definition for acceptable separation and in the worst case there could be store-to-aircraft contact. So far, the test data matches predictions." ∎



Blowing hot and cold

As climatic chamber technology evolves and continues to be the subject of much investment, don't underestimate the industry's reliance on Mother Nature. *Aerospace Testing International* looks at future developments in hot and cold aircraft and subcomponent evaluation

BY JOHN CHALLEN

The latest A400M cold tests in Iqalui, Canada in February 2013 – with Aurora Borealis clearly visible

A combination of new regulations and the need to balance the books when it comes to development costs are indirectly changing the landscape for environmental testing in aerospace.

Offering something of a halfway house is Canada's Global Aerospace Centre for Icing and Environmental Research – or GLACIER (pictured overleaf). This outdoor testing facility, used primarily for icing certification for large engines, comprises a 30ft-diameter wind tunnel, which sprays cooled water mist, recreating the conditions that could be encountered and cause unusual icing patterns. The capacity of the unit allows for engines with up to 150,000 lb thrust – more than any engine out there. In addition, GLACIER's data acquisition system – proDAS from MDS – can measure more than 2,000 separate parameters at varying frequencies, ensuring that all of the information test engineers need can be garnered from testing out in the open.

As these engines cannot be tested in a test cell at NRC's Ottawa base, the Manitoba site was set up to take advantage of the natural conditions that the area has to offer. "Normally testing is done in a warmer environment, and you have to cool a large amount of air that the engine can breathe in to create the icing condition," explains Ibrahim Yimer, director, gas turbines, NRC Aerospace.

"But GLACIER uses the cold natural weather of the region (the northern part of Manitoba, Canada), where the average temperature means we can have two icing windows in one winter." Both windows are 40 days, and temperatures can drop to below -22°F (-30°C), he says, and between the two windows is an even colder period where even icing testing is not possible.

"In the long winter seasons, we use the middle window for icing certification tests, and also cold start or cold soak tests on a variety of engines," explains Yimer. "In the warmer seasons, it can be used for endurance testing, and injection testing."

The two main customers for the site are Rolls-Royce and Pratt & Whitney, the most recent engine to take the stand being the former's Trent XWB, destined for the A350. For these two engine manufacturers, there are huge advantages in using the site, the biggest one being cost savings. "If you want to put the engine in a climatic chamber, the engines breathe in thousands of pounds of air a second, so if you represent the environment that the regulation demands, you have to chill the amount of air at a faster rate, and you have to pay for it," says Yimer. "Use the natural cold weather – you just rely on mother nature to chill the air – and I believe there is more than a 10:1 cost saving in doing it."

A popular facility then, which is one of the reasons that expansion is on the horizon.

"We plan to add in a second stand, which will be offered to third parties for testing," reveals Yimer. "We plan for it to be similar specifications. The existing test stand can accommodate the largest engines in the world, but I

"WE'VE LEARNED A LOT ABOUT CALIBRATING THE SPRAY MASS, AND HOW WE CAN BE MORE EFFICIENT WITH THE TESTING"

ABOVE: The 9m-diameter wind tunnel at the GLACIER facility in Canada can test engines with up to 150,000 lb thrust

THIS IMAGE: Boeing 787 Dreamliner undergoing extreme weather testing at Elgin Air Force base

UNDER PRESSURE

Evaluation of aircraft components at different temperatures under low pressure has been a big part of the flight test facility at Fraunhofer, the research organization based in Holkzkirchen, Germany.

The development options are set to be boosted in 2014, when a new thermal test bench is due for completion. "The test bench comprises a number of different elements, but the main one is the aircraft calorimeter, which is integrated into the low-pressure chamber of our flight test facility," explains Gunnar Grün, project manager of the thermal test bench. "We can simulate environmental conditions inside the aircraft, as well as external conditions on the ground or in flight, and see how the equipment copes."

"As we have more electric aircraft developments, we came to the conclusion that the whole thermal balance of the whole aircraft was very important if we want to save energy during flying," explains Grün. "We have a lot of thermal loads, which are increasing with hot spots from the electronic equipment on board."

An existing bench at the flight test facility has a temperature range of -40°F (-40°C) to 140°F (60°C), but the new calorimeter will offer -85°F (-65°C) to 176°F (80°C), with Grün confirming that some test-piece temperatures could reach 230°F (110°C). "Equipment will be tested under different thermal conditions – under low pressure and under different rates of humidity," explains Grün. "We can also identify the curve on which the equipment is losing its heat, which enables us to distinguish between the convective heat loss, and conductive heat loss of the equipment. Then we are able to advise customers on which cooling system would be most beneficial."

Typically, the work done by Fraunhofer is low pressure testing, but Grün says that investigations are continuing in the area of overpressure testing, and looking more closely at reproductive compression testing. "Because of our huge pressure vessels, we have a large pressure sink," he says. At 7ft wide, 8ft high and 16ft long, Grün says the chamber won't be able to accommodate fuselages, but equipment can be connected to the fuselage, meaning tests would be possible on items such as the avionics power system.

"THE FLUID TEMPERATURE RANGE SPANS FROM -4°C TO 100°C"

think there will be some improvements because we have learned lessons. The capacity will be around the same, but our icing component will be improved – we've learned a lot about calibrating the spray mass, and how we can be more efficient with the testing."

KEEPING IT COLD INSIDE

For Boeing, real-world testing locations have become a necessity – largely due to space requirements – and Captain Raymond Craig, Boeing's chief pilot on the 737 program, says that this poses challenges for the testing teams. "When I was the lead test pilot on the 787 program, we used the cold weather climate hanger at Eglin Air Force base in Florida, where we conducted cold starts down to -40°F (-40°C)," he admits, but adds that this approach is the exception to the rule. "While the 787 fitted in, on 747 programs, the airplane is too large for the climatology lab there."

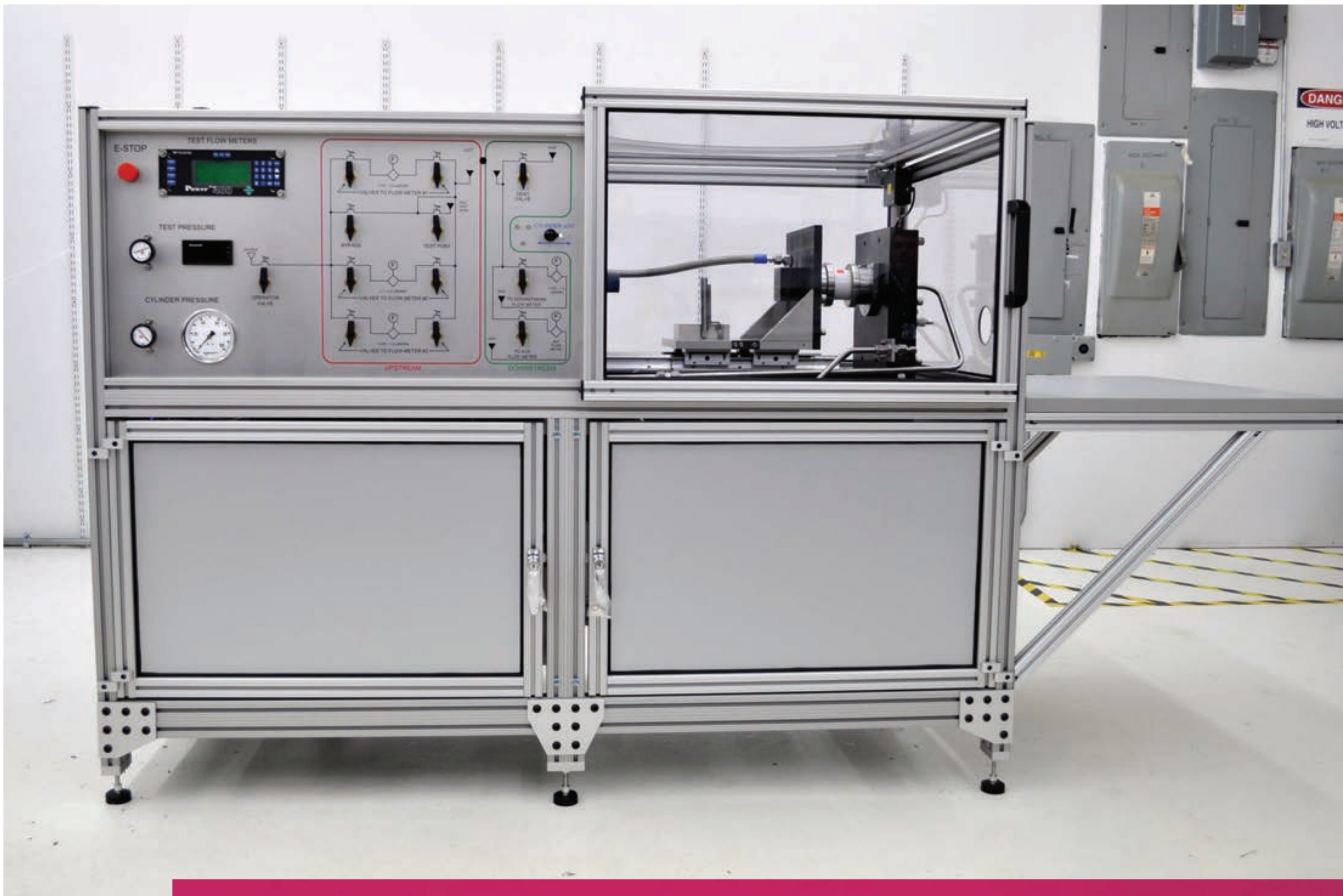
However, the ideal cold-soak and take-off process is difficult to achieve if testing is not completed in the natural environment, believes Craig. "For some of the most recent testing I've been involved in – the 787 program and the next-generation 737 – we've gone to Russia. There we take it down to -58°F (-50°C) and let it cold soak, before going flying straight away. The big problem in Florida is that the airplane starts to fog when you leave the lab," he reveals.

But while Craig says there are no plans for Boeing to invest in environmental testing, he and his teams still value testing inside. "I am working on the 737 MAX program right now, and I think we will be doing some lab work at Eglin. While we haven't defined the test program to that level of detail yet, because the model enters service in 2017, that airplane is small enough to get into the lab and do a good portion of the test work."

HOT WEATHER SCENARIO

A similar scenario exists for hot weather testing for Boeing. "You want to be able to cold- or heat-soak the airplane and then transition into the flight environment straight away," explains Craig. "If you have a climatology laboratory that is different to the outside environment, then you have to add in a transition period. We did the hot weather testing for one of the 787 programs at Yuma, and we

BELOW: Fraunhofer will soon offer a thermal test bench for aircraft component pressure testing



RIGHT: Valve tester at Kaney Aerospace, which also offers a thermal chamber with an ambient air temperature range of -75°C to 100°C, originally used to develop the 787's power electronics cooling system

"WITH THE TRENDS IN ELECTRIC AIRCRAFT, THE ANTI-ICE SYSTEMS ARE BECOMING MORE AND MORE ELECTRIC"

FACE THE ELEMENTS

Cold weather testing of the A400M (the opening image of this article) took place in three basic phases, starting with preliminary tests in the relatively gentle conditions of Hamburg in December 2010 a year after first flight. In February 2011 aircraft MSN2 and then MSN3 went to Kiruna, Sweden, for a test program centered first on the performance of the new TP400 turboprop engines and where temperatures dropped as low as -6°F (-21°C), and then on systems such as electrics and hydraulics. Finally, when MSN6 was available with production-representative hardware, including the upgraded engines and the onboard cargo system, the A400M went to Iqaluit, Canada, in February 2013 for a week's tests in temperatures down to -25.6°F (-32°C).

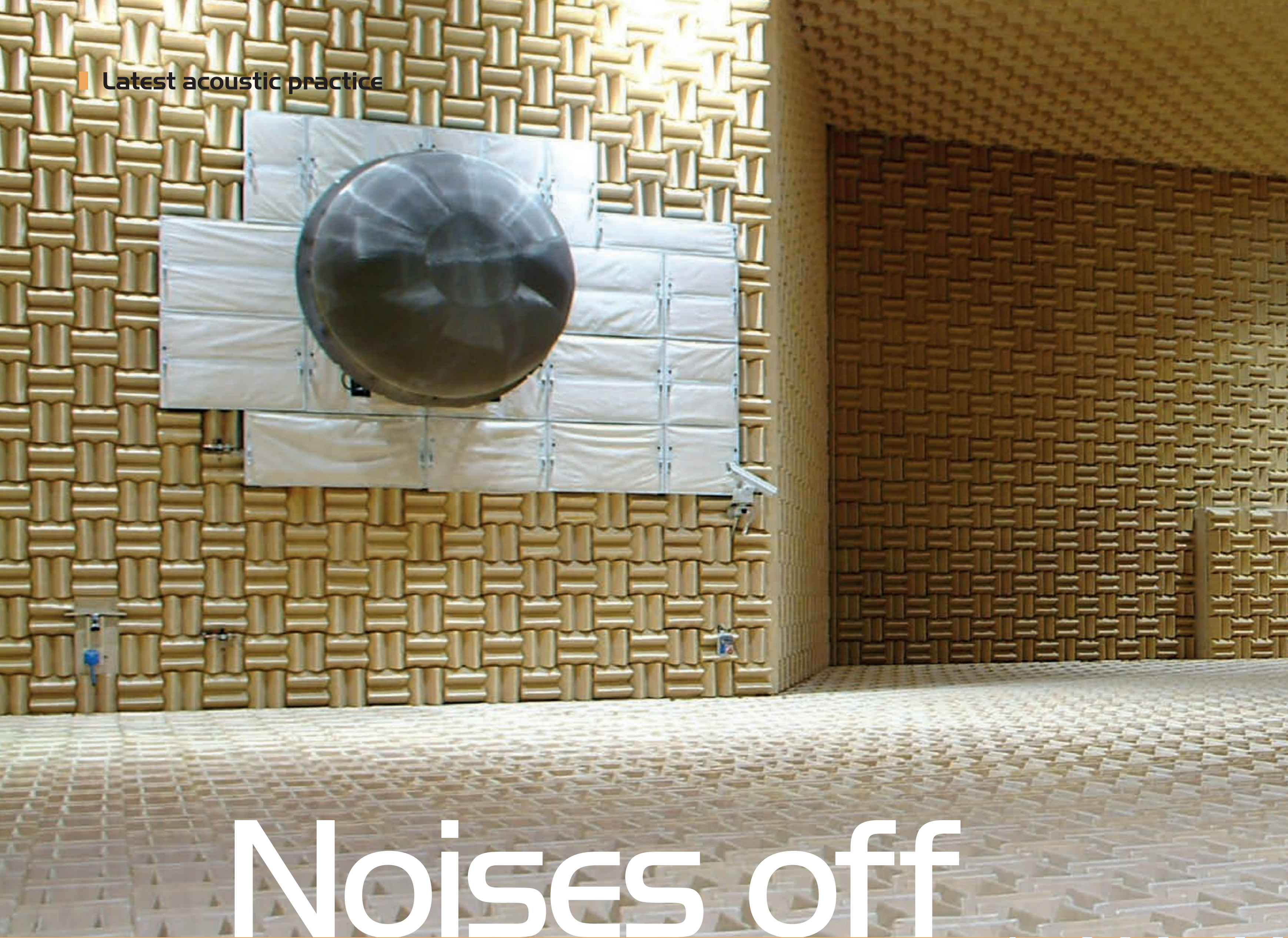
were able to heat-soak the airplane, and then take the instrumentation down when it was still hot, and then go fly and get the data."

When the lab is not available or suitable, it can mean chasing the seasons around the world, as Craig found when testing the 767-400. "On that program, we wanted to do the hot weather testing in February, so we had to go to Alice Springs, Australia, because that was the only place we could find the temperatures we needed for that testing. There we heat-soaked the aircraft all day long, and then just before it got dark, we would start up the airplane, taxi and take off. If we tried to do that in the laboratory, we could technically invalidate the data."

Originally designed to test the cooling equipment on the Boeing 787, Illinois-based Kaney Aerospace's 12ft-wide x 20ft-long x 10ft-high thermal chamber provides a valuable service for aircraft suppliers when it comes to environmental testing. "The fluid temperature range spans from 24.8°F (-4°C) to 212°F (100°C) and we test for performance in thermocycling, and looking for any anomalies at extreme temperatures," says Ron Soave, president, Kaney Aerospace. "Since the conclusion of the 787 work, the chamber runs ambient air tests at anything from 103°F (-75°C) to 212°F (100°C), simulating everything beyond the hottest day in Arizona, to anything you would encounter at altitude.

"We primarily use the facility for development tests, as it is not rated for certification," he continues. "We test pieces of electronics, cooling systems, and subsystems such as the compressor, heat exchanger or refrigeration loop. We are also working with a local customer on anti-ice testing on aircraft wings and flaps."

In the future, Soave hopes to get involved in the anti-icing regulations, and the company is planning investment in that area in the future. "With the trends in electric aircraft, the anti-ice systems are becoming more and more electric, to the point where they are essentially fully electric. That will require a lot of development testing, and while currently the work is completed on 787 wings, and helicopter blades, we think there will be opportunities to increase the capabilities of our cell, and we would like to get involved in certification, because it can get expensive and it is difficult for air framers to do." ■



Noises off

There is a growing school of thought that says acoustic testing in aviation should be carried out at the start of a test program rather than at the end

BY SAUL WORDSWORTH

The area of acoustic testing has evolved considerably in the past decade. New regulations have meant increasing pressure on aircraft designers to reduce fuel consumption and emissions, along with noise at take-off and landing. The demand to lessen engine noise is greater than ever.

"When I created the company in 2002, acoustic testing was only just becoming a vital part of the testing scenario," says Dr Edmund Ahlers, founder and managing director of AneCom AeroTest, one of the world's leading centers for aero-engine testing. "People were becoming more frustrated by aircraft noise, and public regulations were changing. The industry set itself targets. In 2000 it decided to reduce noise by 20dB – a factor of 10. When you design an engine that is less noisy than the competition you have an immediate advantage, possibly translating to extended landing slots at airports."

While it may have grown in importance, acoustic testing has also become more complex. Aircraft structures and systems are now more integrated. The use of composites and more electrical systems may have solved some problems, but they have created others. Meanwhile demand for improved passenger comfort is played out, in particular, in the growing market for smaller business jets. To cope with these heightened requirements, acoustic testing as a whole has shifted from being a trouble-shooting approach at the end of development, to a process that is woven in from the beginning.

"In the past, acoustic issues were addressed once the aircraft was certified," says Lars Enghardt, head of the Institute of Propulsion Technology at DLR in Germany, Europe's largest privately funded aerospace research establishment. "Testing today is an integral part of the development process, from the start when targets are set, right up until the end. Simulation and testing are integral parts of the process. Both technologies are evolving and a good aircraft integrator uses both to reach acoustic targets."

CHANGING MARKET

A competitive landscape means faster time to market, fewer prototypes, and less time and budget for expensive flight-testing. Such a scenario demands speedy, high-quality solutions.

"When you look into specific noise inside the cabin, there is a greater need for hand-held and portable measurement systems that can provide

rapid insight into where a certain noise comes from," says Thierry Olbrechts, director of the Aerospace Competence Center at LMS, a world leader in acoustic testing and simulation that was recently acquired by Siemens. "We invest considerably in creating small systems such as SoundBrush, which gives engineers a very fast insight into where the noise comes from, whether it be the ventilation opening of the Environmental Control System (ECS) or a bad seal at the emergency exit."

LMS, together with MicrodB, has recently been working with Airbus on sound source localization and quantification. Its solution to this issue is a 3D acoustic camera that provides a full 3D view of the interior cabin sources. Many flight conditions can be tested, and because of its one-shot capability, even transient noised can be captured. "In one short measurement you can acquire a full 3D contribution of the acoustics," says Olbrechts. "This is a big difference because during the flight you do not need someone inside operating a probe. It's really about localizing sources that radiate into the interior of the aircraft and can disturb passengers. Although this technology was developed in close cooperation with Airbus, we expect a growing potential for the smaller jets."

ACQUISITION AND DIGITIZATION

One of the principal ways in which acoustic testing is changing is in the acquisition systems. The number of channels that can be squeezed into the same size of system has increased, as has the data acquisition quality. "The complete acquisition chain has been miniaturized," says Olbrechts. "Today it is much more compact and reliable. The signal conditioning has been integrated, so with a much smaller system you can acquire different types of data."

Dr Ahlers adds, "People want to know more detail to further reduce noise. In our rigs we can have up to 500 microphones for detailed investigations into all the different noise sources. Ten years ago we looked at big sources and took relatively simple measurements. Today there are more and more channels, all synchronised and digitized for greater accuracy to delve deeper into the noise details. We are continually asking for more channels at our facility."

"Acoustic testing used to use dBSIL," says Hans-Peter Keller of Happich, an advanced engineering firm with 10 years' experience in aviation acoustics. "That means only taking certain frequency bands into account. This is changing toward the more common dBA methods. The industry has realized the noise received by the human ear is over a wide range and it doesn't make sense to only look at a couple of frequency bands. Although this is mostly at the VIP end of the market, it is slowly coming into play for commercial airplanes."

BIG FAN

At Dr Ahlers' facility, the focus is on just one component in the engine: the fan. This is one of the main noise sources in the aero-engine – and the aero-engine is one of the main noise sources in an aircraft. Rolls-Royce is AneCom AeroTest's principal customer. The companies are trying to improve fan aerodynamics, and thus the acoustics.

"Ten years ago, engine fans had straight blades," Dr Ahlers says. "Now everyone has 3D-shaped fan-blades. This has improved aerodynamics and always means less noise. We have designed a universal test unit for fan testing that is adaptable for any project that a customer might have. We can install a fan, but we can also change the acoustic lining installed in the engine wall, as well as the aerodynamic shape of the bypass duct."

NEW MATERIALS

Acoustic liners – a type of noise-dampening device – are sometimes manufactured from composite materials. There are still some uncertainties as to how composites behave in operational use. Olbrechts explains, "One cannot yet rely on the 50 years of operational experience one has with metallic aircraft. Composite structures change how noise and vibration are transmitted through structures: the physics of the transfer through the composite structure changes."

Keller is more direct: "Less weight means more noise. Composites are not a good trend for noise behavior." Both may be correct. However, the use of composites creates new opportunities for the application of acoustic testing. Different types of measurement techniques exist including fiber Bragg grating, whereby an optical fiber measurement is embedded in the composite layers and the local strains recorded. With the application of new materials, these techniques will mature over the coming years.

ROLLS-ROYCE AND THE FUTURE OF SOUND TESTING

"We have ambitious targets to reduce aircraft noise even further and this has to be achieved while also fulfilling other performance and environmental requirements," says Joe Walsh, senior project engineer of noise at Rolls-Royce. "The development of more advanced analysis and design tools will enable us to focus acoustic testing even more on validating behaviors, and to spend less time sifting through designs. Microphone arrays will produce detailed breakdowns of the acoustic field both inside and outside of the engine, which in turn will enable us to further develop our tools.

"The link between acoustic and aerodynamic testing will strengthen as we continue to develop our physics-based modeling of how noise is generated and how to reduce it in the most efficient and effective ways."

> "LESS WEIGHT MEANS MORE NOISE. COMPOSITES ARE NOT A GOOD TREND FOR NOISE BEHAVIOR"

OPEN ROTOR

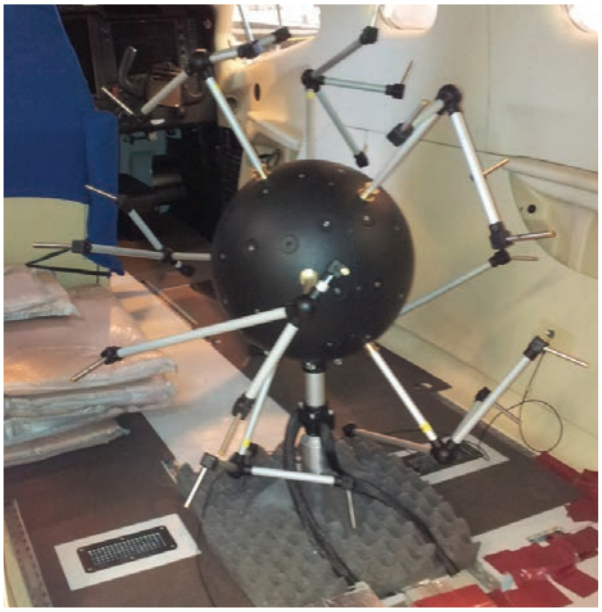
The revival of an all-propulsion technology, the open rotor engine, has come about due to its low-pollution track-record, and because the current family of civil aircraft such as the Airbus 320 and the Boeing 737 have reached a certain age and will need to be replaced soon. "What they should do is develop a whole new airplane, but this is expensive and time consuming," says Enghardt of DLR. "That will probably happen in a few years. In the meantime it looks like the open rotor may come into play."

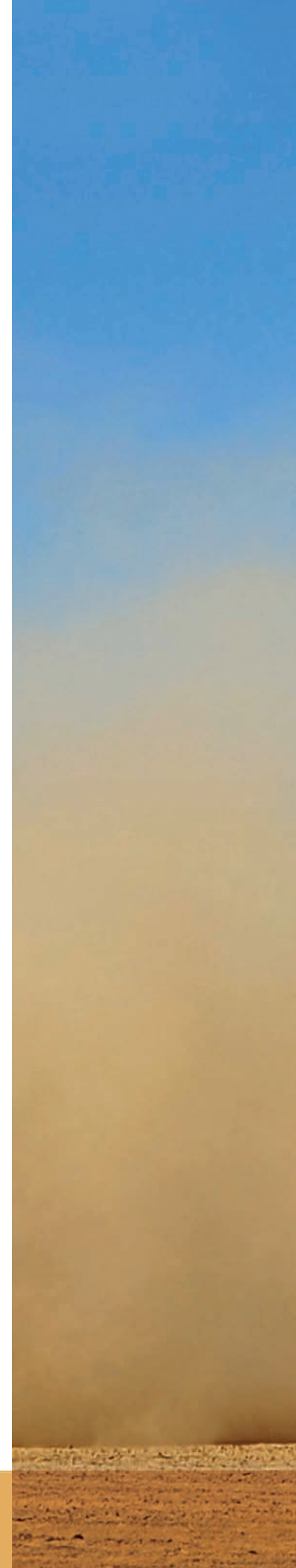
There is little doubt that the use of open rotor engines will affect the way simulation and acoustic testing is done, impacting as it does the way that the source transfers its energy toward the receiver. "One of the big challenges is better understanding aero-acoustic sound sources across the engine," says Olbrechts. "Both for exterior and interior noise, the physical characteristics of the noise changes. For instance, the engine-on-aircraft installation will drastically change the vibro-acoustic transfer toward passengers as well as the exterior acoustic radiation toward communities. Hence the behavior toward the passenger and environment will change. For instance, today's typical engine-under-wing installation filters out a lot of unbalanced noise toward the aircraft cabin because of the flexibility of the wing. Open rotor-technology will need rear-fuselage installation, affecting the vibro-acoustic phenomena. The characteristics of the noise will change in all parts of the cabin. The rear part will suffer from more structure-borne engine noise. In the front part there will be less engine noise, but the turbulent layer noise and internal sources such as ECS systems might become very apparent." The message is clear: in order to address open rotor engine technology it is necessary to understand the source-transfer-receiver model to engineer the aircraft.

CHALLENGES AHEAD

Acoustic testing is still in its infancy in many ways. There may be challenges ahead with new types of engine that require different tests. It is important to remember, however, that the answers do not reside purely with the tools, but in the order in which a solution is sought from first principles and built into early targets, rather than at the end of the cycle. ■

An LMS Test.Lab 3D acoustic camera combines the advantages of both rigid and open spherical arrays. (Source: Société Des Ingénieurs De L'Automobile)





You lift me up

Unique computer tools, simulators and test helicopters make the US Army Aeroflightdynamics Directorate a bastion of basic and applied vertical flight research

BY FRANK COLUCCI

Toward the end of 2012, a one-of-a-kind Black Hawk helicopter wound its way hands-off through 23 miles of mountainous terrain and came to a hover over a landing zone it chose for itself. The US Army Aeroflightdynamics Directorate (AFDD) developed, integrated and demonstrated the autonomous low-level flight capabilities for an optionally manned Future Vertical Lift (FVL) aircraft in service around 2030. "If FVL truly goes optionally piloted, this is the kind of homework you have to do to get there," explains AFDD director Dick Spivey. "Some of the things that we're doing go beyond FVL. We're working a lot of 6.1 [basic research] programs that won't be ready for FVL but for the next generation."

Resident at the NASA Ames Research Center and at the NASA Langley Research Center, AFDD concentrates experimental and intellectual resources to address current and next-generation needs of US Army aviation program managers. The Virginia component just completed, with NASA participation, a major wind tunnel test of a 38% scale model of the Army Kiowa Warrior with a new chin-mounted sensor payload. Other work to be done on behalf of the armed Scout helicopter program manager aims to improve the Stability Control Augmentation System (SCAS) of the veteran scout for safer brownout landings. According to AFDD deputy director Barry Lakinsmith, "We're not going to get real fancy, but it will be better than the legacy rate-response SCAS on the OH-58D. We are developing more advanced control laws that work with the existing partial authority hardware to provide an attitude-command/attitude-hold capability. These improved control laws are being looked at as part of the OH-58F solution in a Degraded Visual Environment [DVE]."

In a collaborative effort with NASA, this summer the Army Directorate will use the Ames Vertical Motion Simulator to evaluate the benefit of the improved handling and control laws for the near-term OH-58F upgrade.

WIND TUNNEL EVALUATION

With a longer view, wind tunnel experiments in the Langley 14 x 22ft wind tunnel will evaluate active flow control to reduce drag on future rotorcraft. "We're trying to understand if there's a way to control the flow," says Spivey. Air jets, piezoelectric actuators and plasma ionization all promise to cut rotor hub drag. "There are several ideas out there, mostly university-generated. Whether they migrate onto the airplane depends on how good they are."

The huge 40 x 80ft and 80 x 120ft National Full-scale Aerodynamics Complex (NFAC) tunnels managed by the US Air Force enabled AFDD researchers to survey air loads on an instrumented Black Hawk rotor.

The data continues to be analyzed to better understand the physics of rotors and airflow in forward flight. Wind tunnel tests of the DARPA/NASA/Army/Boeing active-flap SMART Rotor assessed flap rotor modeling and direct acoustic calculations. In support of FVL/JMR activities, industry will test coaxial, tilt rotor and, probably, compound rotor systems in the Ames wind tunnels. "In the next three or four years, there could be four or five rotor tests in NFAC," notes Spivey.

One ongoing international agreement for the Smart-Twisting Active Rotor ties AFDD to DLR in Germany, ONERA in France, DNW in the Netherlands, the Korea Aerospace Research Institute, Konkuk University, the Japan Aerospace Exploration Agency, and other contributors, to build a database from the DNW wind tunnel test of a variable-twist rotor. "The idea is to find out what that will buy you," explains Spivey.

AFDD is one functional directorate of the US Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC) headquartered at Huntsville, Alabama. Together with the Aviation Applied Technology Directorate (AATD) in Fort Eustis, Virginia, AFDD helped define the Future Vertical Lift initiative and its Joint Multi-Role (JMR) technology demonstrations.

The Army-led FVL Medium is a joint-service rotorcraft concept designed to replace the Black Hawk and Apache, Navy Seahawk, and Marine Yankee Huey and Zulu Cobra. AFDD and AATD are now aligned under the Aviation Development Directorate (ADD) led by Dr Bill Lewis in Huntsville to support industry contractors building JMR demonstrators for FVL technology. "It's a virtual organization," notes Spivey. "So far, it's working well."

AFDD at the two NASA research centers has about 80 government employees and 45 contractors in its aeromechanics, advanced design, flight control, and crew systems integration divisions. "We bring them in as contractors first and, if appropriate, convert them into federal employees," explains Spivey. Most AFDD staff are engineers, scientists, PhDs and PhD candidates. "We've tried to fill holes and gaps," he adds. The current roster

"WE'VE NOW COMBINED THE ROTOR CFD WITH THE FUSELAGE CFD TO BUILD TOWARD A TOTAL UNDERSTANDING OF THE LOCAL FLOW FIELD AROUND THE AIRCRAFT"

ABOVE: AFDD director Dick Spivey shows the RMAX unmanned helicopter used to develop autonomous flight algorithms and the RASCAL Black Hawk used to demonstrate autonomous flight

ABOVE INSET: AFDD uses the big wind tunnels of the National Full-scale Aerodynamic Complex to test rotor performance. Here, the 40 x 80ft wind tunnel hosts the rotor test apparatus

now includes two experimental test pilots who fly a small helicopter fleet based at Ames Moffett Field.

RASCAL ON ITS OWN

The JUH-60A Rotorcraft Aircrew Systems Concepts Airborne Laboratory (RASCAL) gives AFDD a fly-by-wire testbed for advanced flight control experiments supervised by a safety pilot. (See *'Wired Workhorse', Aerospace Testing International*, March 2012.) Last November, the modified Black Hawk used a 3D-LZ laser radar (ladar) to fly through the Diablo mountain range outside San Jose, California, at 200 – 400ft altitude and come to a 60ft hover over an unsurveyed landing zone identified by a computer algorithm. RiskMinOFN (obstacle field navigation) and SLAD (safe landing area determination) algorithms written by AFDD engineers were first demonstrated on small unmanned Yamaha RMAX helicopters and then ported to the RASCAL.

The RASCAL testbed received two new computers for the autonomous low-level exercise, one hosting autonomous flight control laws, and the other running the RiskMinOFN and SLAD algorithms. RiskMinOFN generates velocity commands sent to the autonomous flight control system. SLAD meanwhile generates coordinates for a safe landing location. For safety monitoring, the autonomous flight control laws sent their commands through the existing JUH-60A flight control computer to the FBW actuators.

The 3D-LZ ladar borrowed from the Air Force Research Laboratory flew on AFDD's EH-60L Black Hawk in 2009 to test DVE landing technology at Yuma, Arizona. In the Yuma brownout test, processed ladar returns gave the pilot a visual display. For autonomous terrain awareness, the returns passed through the RASCAL flight control and OFN/SLAD computers. The RASCAL pilots watched a moving map with overlay to show the intended flight path and risks.

During March 2013, RASCAL will have flown a longer autonomous route to include dead-ends, ridge lines, simulated threats and possibly power lines. SLAD and OFN will be coupled more tightly. According to AFDD program manager Matt Whalley, "The

VERTICAL LIFT FOR THE FUTURE

Led by the US Army, the FVL concept aims to give the joint US armed services next-generation rotorcraft with greater speed, range, and survivability than today's helicopters. The two-phase JMR science and technology demonstrations will design, fabricate and test two air vehicles and establish an avionics architecture for mission systems. The AMRDEC Advanced Design Office, including AFDD engineers and scientists, completed concept design studies to help government and industry understand FVL capability and size expectations. JMR advanced design, flight control, and aeromechanics technical support work done at the AFDD was sponsored by the JMR program office at the Aviation Applied Technology Directorate. AFDD remains heavily involved with both the FVL program and the JMR technology demonstrations.

The Phase 1 JMR test aircraft expected to fly in Fiscal 2017 are not FVL prototypes. They will demonstrate and verify platform performance to shape the specification for an operational aircraft. Phase 2 architecture demonstrations on the ground likewise will not represent a specific mission equipment package, but provide tools and information to design an avionics suite.

The FVL configuration is supposed to be scalable to replace a range of helicopters. JMR Phase 1 air vehicle will be sized based on development cost and schedule. They will be representative of, and inform the design of, an FVL Medium rotorcraft around 30,000 lb gross weight in service in about 2030. Design studies now look at advanced helicopters, compound helicopters and tilt rotors, all using technology from the Improved Turbine Engine program. JMR Phase 2 architecture will address the attack helicopter to accommodate the most challenging mission systems. The Army expects to award several JMR initial design contracts depending on funding and proposals. A down-select for flying demonstrators will be made after the preliminary design phase.

goal computed by SLAD will be passed off to RiskMinOFN, which is then recalibrated on-the-fly to operate at finer resolutions, thus enabling us to get into tight LZs while avoiding any trees or poles surrounding the site."

Also based at Moffett Field, the AFDD EH-60L has nearly completed an extensive external load survey hauling CONEX containers and other sling cargo with stabilizing fins and other stability enhancements. Engineers found several different methods to increase safe airspeeds with external loads. Cable angle feedback, meanwhile, allows the EH-60L flight control system to damp load oscillations at low airspeeds for quicker, more precise load placement.

NEXT PHASE

The electronic warfare helicopter will begin the next phase of the Air Force 3D-LZ Joint Capabilities Technology Demonstration this summer. A follow-on test in 2014 will try a Raytheon FLIR/LADAR sensor. In conjunction with the US Air Force DVE effort and the army utility helicopter program manager, the EH-60L is also flying Modern Control Laws (MCLAWS-2) to improve fleet UH-60M handling qualities at low altitude at night and in poor weather. Lakinsmith explains, "They would like to do something with partial authority control much like was done with the Chinook in the CH-47F Digital Automatic Flight Control System. That's an initiative with our EH-60L that could show improvement in handling qualities for the UH-60 fleet, and that technology will be included in what we take to Yuma for the Air Force." Key to the control law development was a modern integrated toolset that generated an aircraft response model and isolated discrepancies between the simulation and the real aircraft.

Manned-unmanned teaming (MUM-T) is a vital US Army focus, and AFDD researchers continue to work on schemes that will enable a single operator to control multiple unmanned aircraft systems (UAS). "If you can get the workload down, you can get to the point of putting that in the cockpit," notes Spivey. MUM-T simulation tools and commercial RMAX helicopters are AFDD assets, but experiments and demonstrations at Fort Ord and Fort Hunter-Liggett in California have included real as well as virtual Shadow, Scan Eagle, Gray Eagle and other UASs. "We borrow them and bring them in. We don't own them, but we use them in the tests," explains Spivey.

TOOLS AND MODELS

Computational fluid dynamics and computational structural dynamics (CFD/CSD) are powerful tools to model and improve next-generation rotorcraft. The AFDD High-Performance Computing Institute for Advanced Rotorcraft Modeling and Simulation recently released its Helios Version 3 software for higher-fidelity aeromodeling. According to Spivey, "We've now combined the rotor CFD with the fuselage CFD to build toward a total understanding of the local flow field around the aircraft." He adds, "Once we correlate that with flight tests or wind tunnel tests, this can get really detailed because you can track vortices coming off the rotor blades and where they hit the fuselage. We're looking at very complex things around the flow field." Data from an AMRDEC small-scale advanced dynamics model in the 7 x 10ft wind tunnel were used to assess CFD/CSD aeroelastic stability calculations.

Helios V.3, funded by the Army and the Computational Research and Engineering Acquisition Tools and Environments Air Vehicles Project under the DoD includes multiple rotor and fuselage combinations relevant to FVL concepts. AFDD researchers used CFD/CSD analyses to explore active flap rotors, direct acoustic calculation, and aeroelastic stability for improved engineering modeling and simulation tools. "These high-speed computers are the only way we can get our arms around this complex flow field," says Spivey. "Our goal is to use this CFD-CSD program to enable the contractors on FVL to better design the airframe and rotor systems they're working on. It's hard to design a rotor if you don't understand the flow field in which the rotor is operating."

The FVL initiative now looks at advanced configurations to extend the speed and range of the next-generation of rotorcraft.

AFDD representatives in the ADD Advanced Design Office have participated in working groups to address the FVL capabilities definition, science and technology planning, and acquisition planning. "We played a big role in the beginning, doing the lead design work on what we think these aircraft should look like," says Spivey. ∎

Set the course

Helicopter test pilot Stephan Carignan, based in Canada with the National Research Council, received two prestigious awards from the Royal Aeronautical Society in 2012. Here, he talks about his exceptional career and what's next for the rotorcraft industry

BY CHRIS HOUNSFIELD

STEPHEN CARIGNAN

Stephan Carignan has earned his wings. Throughout his 32-year career, he has flown more than 6,700 hours on 45 different types of aircraft. His résumé includes serving as a pilot for the Royal Canadian Air Force and working as a flight test engineer for Bell Helicopter.

Carignan's international collaborative work to improve fly-by-wire control laws and vision systems has garnered several awards, including from the American Helicopter Society and the Technical Cooperation Program (TTCP). Most recently, he was recognized by the Royal Aeronautical Society with a Bronze Medal for contributing to major advances in aeronautics, and the coveted Alan Marsh Medal for outstanding international achievement in the testing, development and operational evaluation of rotorcraft. Currently group leader for the National Research Council Canada's (NRC) Flight Mechanics and Avionics Program, Carignan is a leading light in worldwide rotorcraft advancements.

TEST: NRC IN THE NEWS

In January 2013, results from the world's first civil flight powered by 100% biofuel were released by the NRC; they showed that the biofuel used in the flight is cleaner than, and as efficient as, conventional aviation fuel. Information collected in-flight and analyzed by a team of experts revealed an important reduction in aerosol emissions (50%) when using biofuel compared with conventional fuel. Furthermore, additional tests performed on a static engine show a significant reduction in particles (up to 25%) and in black carbon emissions (up to 49%) compared with conventional fuel.
The tests also show a comparable engine performance, but an improvement of 1.5% in fuel consumption during the steady state operations. The jet's engines required no modification as the biofuel tested in-flight meets the specifications of petroleum-based fuels.

Q: WHAT MADE YOU DECIDE TO BECOME A TEST PILOT?

A: From a very young age, I knew I wanted to fly. I got my glider's licence before I learned how to drive. My father was an airplane mechanic in Bagotville, Quebec, which of course made an impression on me. Then I joined Cadets Canada when I was 12 years old, and they took us flying and the bug just bit me early on. A couple of years later, I attended a high school that was located on the military base where my father worked. There wasn't a bus system in place, so when my father couldn't drive me home, I'd get rides from other military personnel.

One day, I got a ride home from a test pilot. He told me about what he did for a living, and after that, I knew what I wanted to do. I was really intrigued by the idea of being able to test aircraft and systems and make them better, and figure out the engineering aspects and how the equipment worked. So even before I got my aircraft wings, I knew I wanted to become a test pilot.

Q: WHERE DID YOU TRAIN?

A: I studied mechanical engineering at the Royal Military College, Canada. After graduating in 1984, I spent about a year and a half training to be a military helicopter pilot, before going to Halifax, Nova Scotia, to train with my operational squadron until 1989. Then the Canadian Forces sent me to the École du Personnel Navigant D'essais et de Reception (EPNER) test pilot school in Istres, France, where I trained for another year. The forces typically send one helicopter pilot a year, so it was a privilege and an honour to be chosen.

Q: WHERE WERE YOU FIRST POSTED AFTER COMPLETING YOUR TEST PILOT TRAINING?

A: In 1990, I was posted to the Aeronautical Engineering Test Establishment (AETE) squadron in Cold Lake, Alberta, where I worked for four years. It was an exciting time to be there, because the forces were developing several different ships and trying new securing systems to assist with the recovery of helicopters on board ships. So although I was posted in Cold Lake, I spent a lot of time doing trials at sea. I did First of Class Flight Trials (FOCFT) for the Halifax-class and Iroquois-class ships (then called City and Tribal-class). Qualifying a new ship is quite an endeavour and takes several months of work; it was definitely a highlight of my time at Cold Lake. I also tested new navigation systems, the use of night vision goggles and automatic approaches onto ships – technologies that are only now being introduced to the Canadian navy, almost 18 years after I conducted the trials. It's exhilarating to get to test those technologies so far in advance.

Q: WHAT TOOK YOU FROM THE MILITARY TO YOUR CURRENT POSITION AT THE NATIONAL RESEARCH COUNCIL OF CANADA (NRC)?

A: I left the military in 1995, as a captain, and took a position as a flight test engineer with Bell Helicopter. I got to be part of the team that certified the Bell 407, which was an incredible experience. After a year at Bell Helicopter, a Research Test Pilot job opened up at NRC's Flight Research Laboratory (FRL), so I jumped at the opportunity. I'm now Group Leader for the FRL's Flight Mechanics and Avionics Program.

> **"IT WAS NICE TO BE ABLE TO DISCOVER THE EUROPEAN TECHNOLOGIES, BECAUSE THEIR GRASP OF THE IMPORTANCE OF TECHNOLOGY IS DIFFERENT THAN IN NORTH AMERICA"**

LEFT & BELOW: **Stephan** Carignan, test pilot and the NRC Bell 412 helicopter

ABOVE: Carignan receives two prestigious awards from the Royal Aeronautical Society from RAeS president Phil Boyle

Q: WHAT ARE YOUR MAIN RESPONSIBILITIES WITH THE FLIGHT MECHANICS AND AVIONICS PROGRAM?

A: In testing aircraft, we're concerned with the crew member and how he or she interacts with the aircraft. We examine what the cockpit looks like, from a user interface perspective, and how the aircraft itself performs. We have several different streams: there's an aviation medicine stream that looks at neurosciences and human factors; an aerodynamics stream that tries to model helicopters to better understand how they respond without augmentation; and control law and system development streams that aim to make it easier to fly the helicopter in all weather conditions.

I'm also part of a team that is involved in several initiatives that are aimed at reducing aircraft certification times. We train test pilots from schools in four countries – Canada, England, France, and the USA. Our work involves improving their abilities as evaluators, and enhancing how a flight test engineer plans and executes testing. That largely entails exposing the pilots to a range of aircraft deficiencies and teaching them how to evaluate those deficiencies. In addition to the training we offer, we have a research stream that aims to develop smarter flight test engineer software that will expedite testing. We're looking at better calibration techniques that would automatically alert pilots to things like a failed aileron deflection sensor. Our team is also exploring video-based data recognition. For example, instead of installing sensors to measure torque, we could have digital software transfer a video image to the torque gauge, giving us an instant reading with just one glance at the gauge. All of these flight research developments could help us greatly reduce certification times.

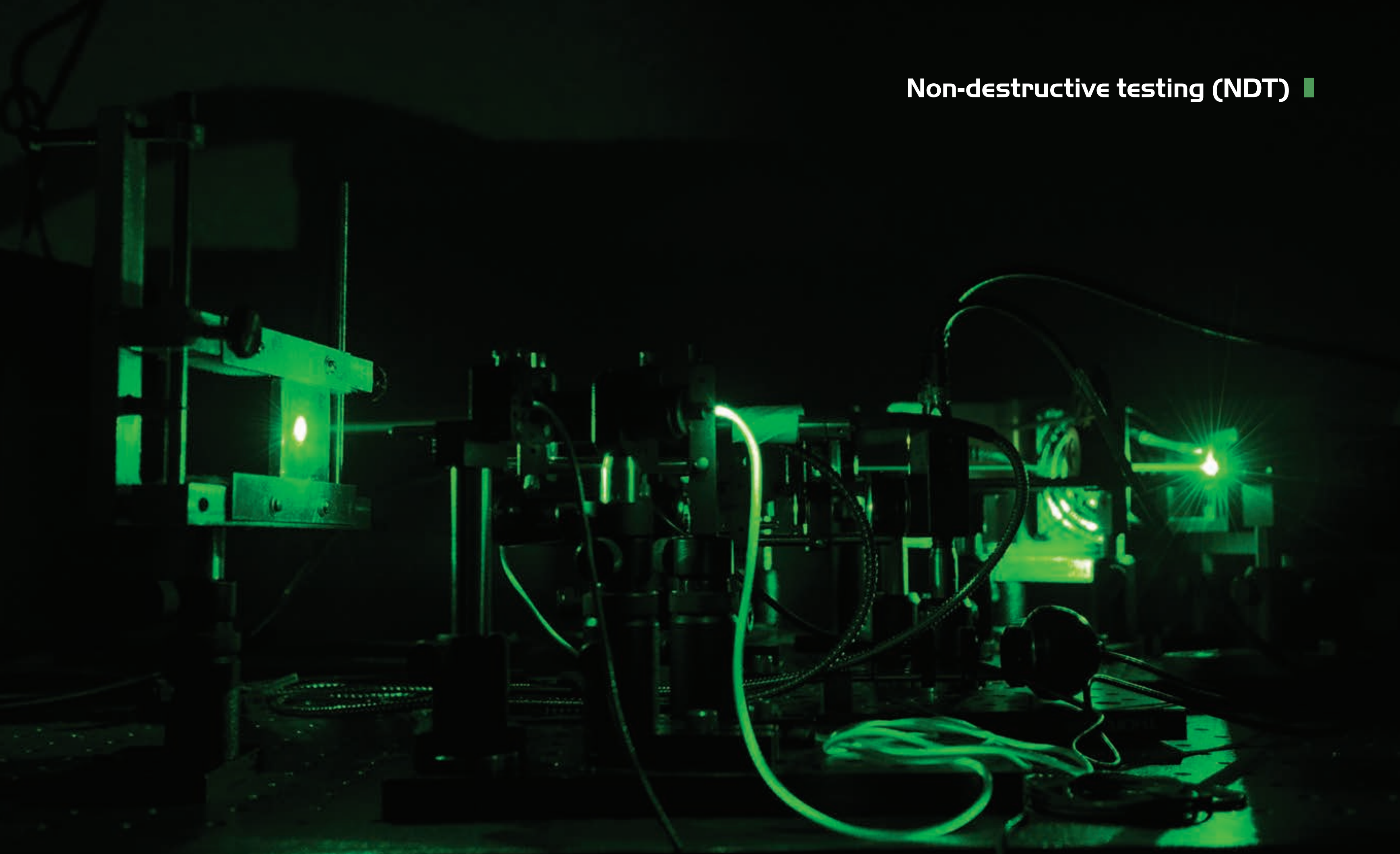
Q: WHAT ARE SOME OF YOUR PROUDEST CAREER ACCOMPLISHMENTS?

A: Winning The Technical Cooperation Program (TTCP) group award for Enhanced Synthetic Vision and the Royal Aeronautical Society (RAeS) awards were two big highlights. The TTCP award was more specific; it was given for my collaborative work in developing up-and-coming technologies, such as better night vision goggles – for example, color goggles or goggles that offer improved peripheral vision.

We also developed synthetic vision systems that could be coupled; you'd have a simulator view of the world, but also a penetrating display that would synch up to it, offering improved visibility in even the most challenging flight conditions. On the other hand, the RAeS awards represented the culmination of many years of hard work. In particular, I was recognized for my involvement in establishing design criteria for maritime helicopter manufacturers; commissioning the Flight Research Laboratory's 4th generation fly-by-wire helicopter; improving fly-by-wire control laws with Sikorsky and Bell Helicopter; gathering the flight data package required to satisfy Level D simulation modeling requirements for a wide range of helicopter types; and training a large majority of western helicopter test pilots and engineers in handling quality evaluations and flight test techniques.

Q: WHERE DO YOU SEE THE NEXT FEW YEARS TAKING YOU AND THE ROTORCRAFT INDUSTRY?

A: We have to improve the ease of handling of the helicopter and provide the pilots with an ability to see through bad weather. This is where improved control laws and enhanced vision and symbology come in. We are at a threshold where we could essentially hit a button and have the aircraft fly and land itself. Once we achieve that, we could apply the technology to shipboard landings, which is one of the most difficult things to do. We're moving towards implementing those technologies within the next five to ten years. So we're on a pretty exciting path.



Hot to CHOT

Turning light into ultrasound could revolutionize NDT. Researchers at the University of Nottingham have developed a new approach to ultrasound-based NDT

BY DR THEODOSIA STRATOUDAKI

Using ultrasound for the non-destructive testing (NDT) of components is a simple yet powerful technique. Ultrasound propagates into the inner structure or surface of the test component and its detection provides information about its properties, thickness and possible defects.

The devices traditionally used for ultrasonic generation and detection are the piezoelectric transducers, and although they have been used successfully in the industry for non-destructive testing, they have several limitations.

Piezoelectric testing is a technique that requires an ultrasonic couplant and the ability to be able to get within close proximity of the component being tested. It also uses wires, which makes it difficult to reach certain parts of the aircraft and engine. In addition, these transducers are of a size and weight that makes them unsuitable for permanent applications or for testing components of unusual geometry. Added to this, they are also expensive, with each costing several hundreds of dollars, which makes it impractical to use them extensively on aircraft.

A NEW BREED

At the University of Nottingham in the UK, a team has been developing a new breed of ultrasonic transducers, the CHOTs (CHeap Optical Transducers), which overcome all of the limitations of the traditional technology.

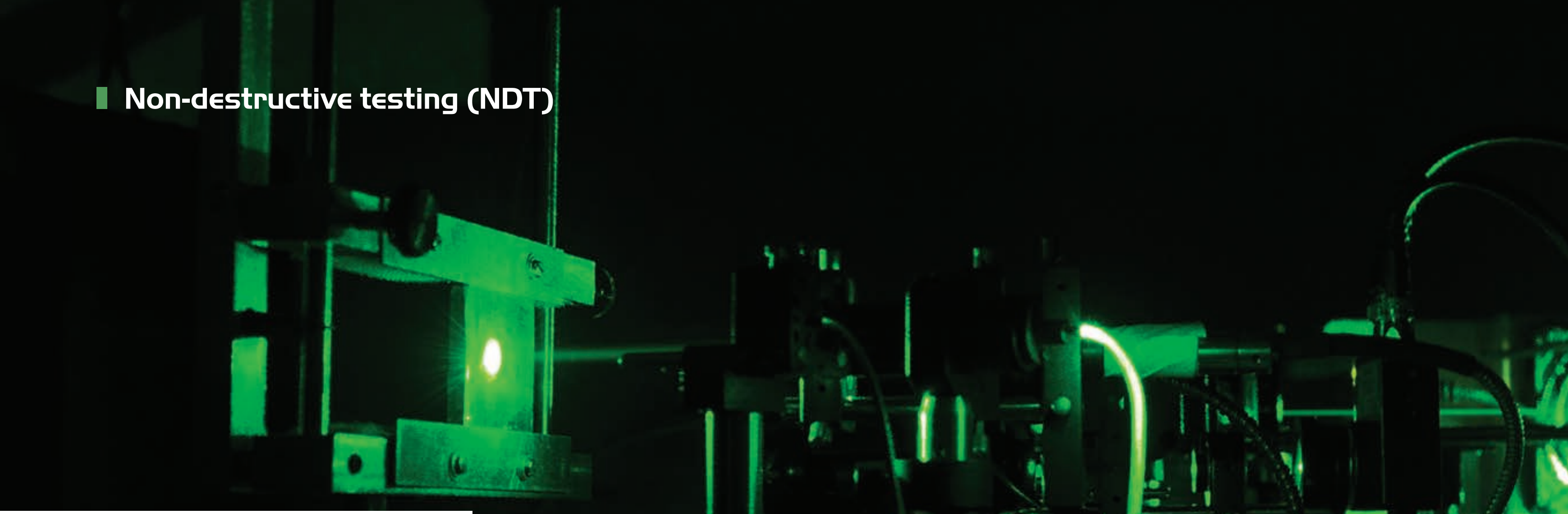
CHOTs are structures attached to the surface of the test component that are optically excited using a simple laser set-up to either generate or detect ultrasound. The use of lasers allows for remote and wireless operation, and in addition, CHOTs are also very cheap (potentially less than 1p (US$0.015) each) so they can be used in great numbers. They are also extremely small with minimal impact on the inspected component, which allows them to be permanently attached; and robust, meaning they can survive in environments with extreme temperatures, high pressures and vibration.

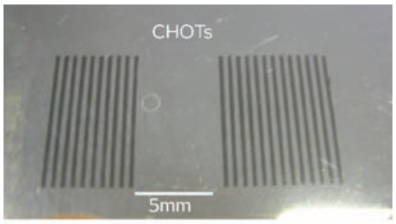
Due to all of these advantages, CHOTs are ideal for low cost, reliable, in-situ and remote NDT, and the university team is currently developing a portable CHOTs system for endoscopic NDT in partnership with the aerospace industry.

HOW DOES IT WORK?

The CHOT is a 2D structure that is deposited, etched, attached or in some way drawn onto the surface of the test component that is optically excited using lasers to either generate or detect ultrasound. There are two types of CHOT: one for ultrasound generation (g-CHOT) and one for ultrasound detection (d-CHOT), and each part can work independently of the other.

ABOVE: A prototype endoscopic CHOTs pulser (All images: Lewis Stainer/ University of Nottingham)





ABOVE INSET: Image shows the CHOT printed onto aluminum

COMMERCIAL PARTNERS

To date, the development of CHOTs at the University of Nottingham has largely been supported by the UK's Engineering and Physical Sciences Research Council and the European Union Framework program. The university is very excited about the potential uses of CHOTs in the aerospace sector and beyond, and is actively seeking partners in industry who can help it to further develop this technology and find new applications and testing opportunities for it.

However, each offers the user full control of the excited/detected wave mode (type of ultrasonic wave), its directivity, and the ultrasonic frequency content. This is achieved through the appropriate design of the CHOT structure.

Both types of CHOT are operated remotely by directing a laser onto the surface of a CHOT. For the generation of ultrasound a pulsed laser is required, while a CW laser is used to detect an ultrasound signal. Aligning these lasers onto their respective CHOT device is a simple task ('point and shoot') and, provided the CHOTs are illuminated by part of the laser beam, the ultrasound signal will be generated or detected as appropriate. Thus only simple, low-cost optics are required for this process.

The CHOTs themselves can be produced using a range of methods, for example contact printing, laser etching and photolithography, or attached as printed stickers and left in place. These methods of production mean that the CHOTs themselves are cheap to produce and can be regarded as disposable. This opens up a whole new range of potential markets for ultrasound testing that have yet to be explored.

AERO APPLICATIONS

CHOTs have the potential to result in a significant increase in aircraft and passenger safety, while contributing to substantial cost savings through a decrease in maintenance and operating times.

One of the great advantages of CHOTs over piezoelectric transducers is that they have the potential to be used for in-service, continuous monitoring. The small size and cost of CHOTs systems will mean that multiple CHOTs can be placed on components, enabling multipoint defect detection or scanning. The fact that CHOTs are so small also means that they have minimum impact when installed onto a test component. They can also cope with testing components of unusual shapes and can also produce a range of ultrasonic waves.

For example, it is entirely feasible for CHOTs to be used to test turbine blades while they are in service. This provides a good example of their benefits where other systems wouldn't work. A CHOT system with a chosen frequency could be placed in the positions where failure of the blade is most likely and could constantly monitor the component throughout its lifetime. Such an application would be particularly appropriate in the example of a turbine blade, which operates in a difficult-to-reach, high-temperature environment, and here CHOT's robustness comes to the fore and demonstrates its benefits over other transducers that cannot be placed.

The low cost and volume of the CHOTs system could also potentially see its deployment in future as part of an active monitoring system of the airframe. A large number of CHOTs could be placed on the airframe, enabling quick, regular, scheduled testing over a large area in a cost-effective way that would not be possible with other transducers. This could potentially provide an alternative to passive condition monitoring and help to identify local damage in the form of microcracks or delaminations, weakening of adhesive bonds, and thermal and chemical damage to the airframe, as well as overcoming some of the inherent data analysis challenges of condition and health monitoring.

These attributes mean that, as well as in-situ testing, CHOTs can also be used to improve quality and check for manufacturing defects on the production line, enabling aerospace manufacturers to quickly and cheaply assess the quality of components during machining and assembly processes. CHOTs are so versatile that they have the potential to be used in industries as diverse as food and drink or pharmaceuticals, where they could form part of the packaging; or the energy industry, where they could monitor offshore wind turbines. ∎

Dr Theodosia Stratoudaki is a specialist in the department of electrical and electronic engineering at the University of Nottingham in the UK

Sowing the seeds

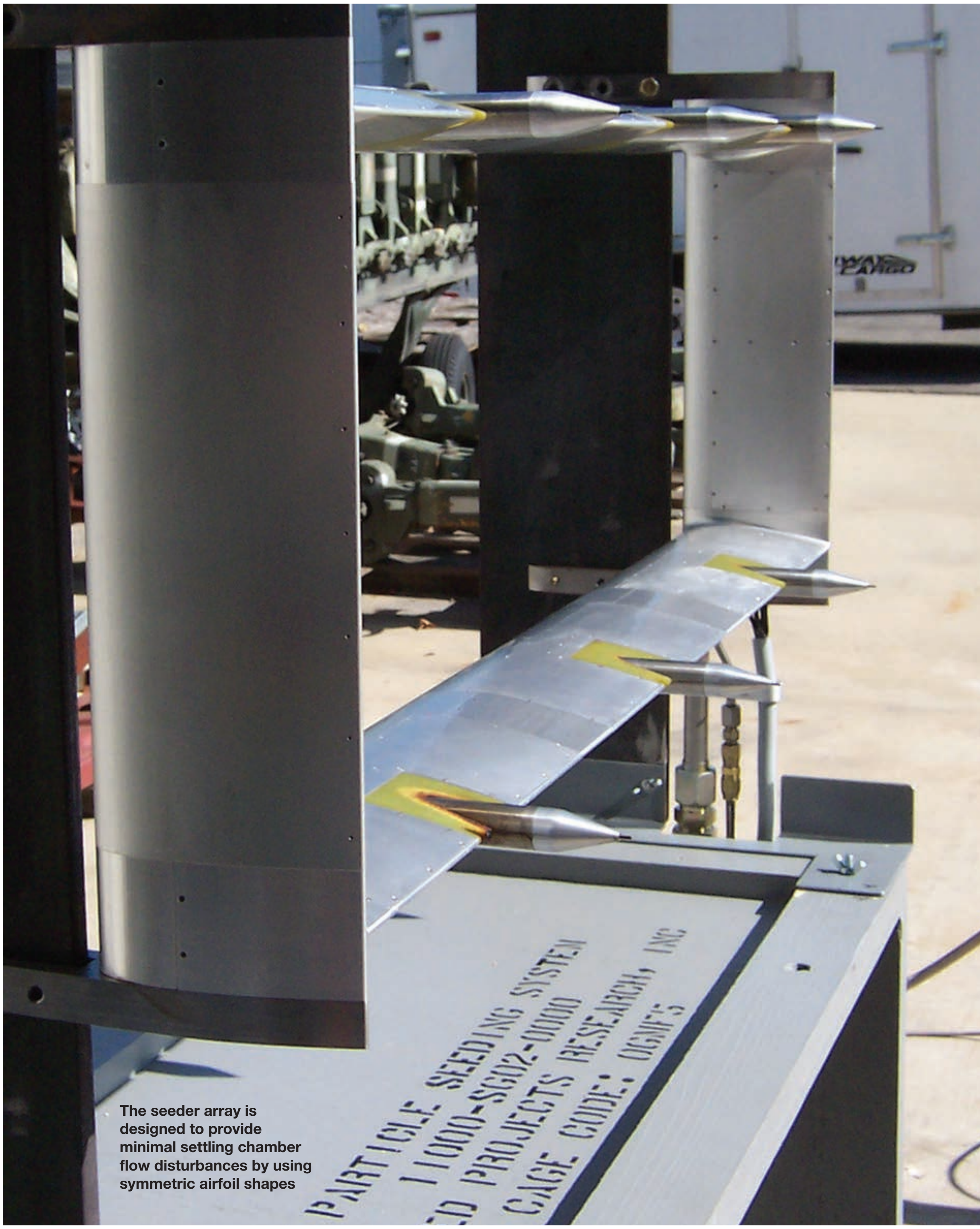
When Arnold Engineering Development Complex needed to update and improve its particle seeding system, or 'smoke' generator, it turned its back on traditional technology and took on a multi-injector system

BY SETH BASS

Located at the Arnold Air Force Base in Tennessee, USA, the Arnold Engineering Development Complex (AEDC) is the largest and most advanced complex of flight simulation test facilities in the world. Since 1961, AEDC's propulsion wind tunnel (PWT) facility has been devoted to the aerodynamic and propulsion integration testing of large-scale aircraft models, providing customers in both the military and private sectors with complete testing and analysis capabilities.

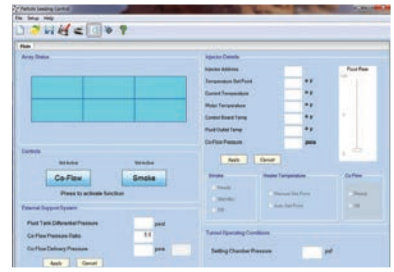
AEDC has used the best available particle seeder technology in the 4ft transonic wind tunnel, 4T, at the complex. This has happened despite the system's inability to direct flow seeding of known size distribution into a desired region of the tunnel, the excess humidity, and the resulting difficulty in collecting acceptable test data. A new seeding system was needed to address these drawbacks, as well as to provide simple operator-control. Tyler Neale, project manager for the PWT ground test complex, explains, "AEDC needed a seeding system that would enable it to complement laser-based flow measurement and diagnostic techniques. This would enable flow fields around regions of interest of test articles to be visualized. This would be a relatively new capability."

When the US Air Force solicited proposals through the Small Business Innovation Research (SBIR) program, several proposals were received. Fred Heltsley, senior engineer at AEDC, explains, "This solicitation was submitted to enable innovative designers to apply modern materials and technologies to develop an elusive 'simple' solution to an old industry need, knowing full well that the result would probably be complex, possibly prohibitively expensive, or maybe even unobtainable." An SBIR Phase 2 contract was ultimately awarded to Advanced Projects Research Inc. (APRI), a California-based company that specializes in aero propulsion, power system engineering and laser diagnostics. AEDC said it was impressed with the hardware that APRI produced for the



The seeder array is designed to provide minimal settling chamber flow disturbances by using symmetric airfoil shapes

"THE NEW SYSTEM HAS A POTENTIAL OF UP TO 100 INJECTORS IN A LARGER TUNNEL"



Phase 1 contract, with Heltsley calling it "well designed and precisely constructed". As it turns out, in its selection of APRI, the US Air Force hadn't found just a contractor, it found an empathetic partner.

THE WAY IT WORKS

On a basic level, most smoke generators work the same way. A seed fluid is vaporized when heated to a temperature above its boiling point. When this vapor is injected into the cooler airstream of a wind tunnel, the fluid condenses into tiny droplets that make up what is commonly referred to as 'smoke'. Technically, these droplets are called 'seed particles'.

With no viable, commercial options available, the contractor commenced development of a custom-designed solution to offer a robust, reliable and easy-to-use system with precise controls and a high degree of automation. Describing APRI's new system, Joe Wehrmeyer, engineer at AEDC, says, "The equipment is computer-controllable, so each of the six 'seeders' can be individually and remotely controlled using a desktop computer." Thomas Sobota, CTO at APRI, explains, "Even with just one injector, the old technology demanded a high degree of human attention. Though configured with six injectors for the 4T wind tunnel, the new system has a potential of up to 100 injectors in a larger tunnel, so it was critical that we engineer a system with the utmost control and automation."

At the top of AEDC's wish list was the ability to direct a singular high-density stream of seed particles within larger flow with lower density seeding. Engineers at APRI approached this request from both a user's and a contractor's point of view. By devising independently controlled, multiple injection points, the size of the particle stream is minimized, while still meeting test requirements. Additionally, each injector in the new design includes mass flow control, enabling the manipulation of seed particle densities.

INNOVATION PROVIDER

Other APRI innovations include heating control of the working fluid up to the tip for each injector, as well as the metering of co-flowing air jets to control the mixing and spreading of the injected droplets. Safety and transient control were essential, leading to minimal settling times, no burned fluids, no burned-out heaters, no sputtering and no leaking – deficiencies well documented in older technology. The new system's features eliminated these frustrations and now present a huge step forward in particle seeding technology.

"APRI's proposed conceptual designs for the full-scale seeder positioning system were innovative and designed to minimize installation time and to reduce the adverse impact of tunnel downtime," Heltsley explains. That need to reduce downtime was critical to both AEDC and APRI.

TURN IT ON/OFF

Another key issue was the ability to turn the seed stream on and off quickly. In response, APRI's team engineered a means by which to efficiently control and minimize the amount of seed material introduced into the tunnel. Among other potential benefits of the new APRI system, AEDC's Heltsley lists: lack of impact
on tunnel humidity; extended Mach number operation range; more precise adjustment and monitoring of system operation; controllable stream tube size, shape/position; as well as constant and quantifiable particle size density. Final

CLEAN-UP

Because many seed generators use a mineral-oil-based fluid, clean-up is notoriously difficult and frequently results in unplanned equipment shutdowns.

Using water might seem like a common-sense solution as far as clean-up is concerned, but it presents its own challenges in terms of humidity. In fact, as Heltsley explains, "The most important consideration was to acquire a non-water-based system to provide seeding for flow visualization, as well as advanced optical diagnostics applications."

ABOVE LEFT: Particle seeding system undergoing validation testing in the settling chamber of an open loop wind tunnel to demonstrate individual injector control with only five of the nine injectors operating

ABOVE RIGHT: APRI developed a custom user interface for controlling the seeder system. The test engineer has easy control over each injector, as well as multiple elements of information while the system is operational

testing will be conducted at AEDC when the new seeder is installed into the 4T wind tunnel for the combined pressure, flow rate, and temperature conditions. Jay Marsh, vice president of engineering at APRI, expects a positive outcome: "APRI anticipates success with this final testing based on validation tests conducted on a thermal heat transfer test model in an altitude test chamber." Before delivery to AEDC, the entire six-injector system array was functionally tested at APRI at ambient pressure and room temperature conditions.

Additionally, a single injector module was delivered to AEDC for mounting into a low-pressure test system and was successfully tested for functionality, including ambient flow rates. The system also demonstrated no leakage in low-pressure operations.

If final testing approval is granted for this initial array in the 4T wind tunnel, APRI's goal is that a larger configuration of up to 100 injectors can be installed in the larger 16T wind tunnel. If there is an opportunity for it to be installed, APRI's new particle seeder should set a new standard for a heightened, state-of-the-art aerodynamics testing experience. Delivering greater precision and more detailed information for AEDC customers, as well as ease of use and simple clean-up for test engineers, this new seeder system promises to help advance the technology of wind tunnel testing well into the 21st century. ∎

Based in Los Angeles, California, Seth E Bass is a writer for multiple media platforms including film, television, magazines and website content

ULTRASONIC INSPECTION

Recent advances in ultrasonic technology for aircraft inspections are contributing to improved safety and more efficient servicing and maintenance

In-service inspection of operating aircraft is essential to ensure continued airworthiness in both the civil and military sectors. Many inspection techniques are employed, from eddy current inspection to detect near-surface or surface-breaking cracks in aluminum structures, to radiography to provide volumetric inspection. Remote visual inspection is regularly applied to provide images of the insides of difficult-access aircraft parts such as engines, and ultrasonics is the technology used to detect flaws in both metal and composite aircraft structures and components.

PORTABLE DIGITAL RADIOGRAPHY

Recent advances in digital radiography have seen the development of detectors as small as 8 x 8in. These extremely portable units can be wirelessly connected or tethered to a convenient industrial laptop computer. A portable wireless router is available to extend connectivity range. Power supply to the new DXR250C-W can also be tethered with mains supply or battery-connected with only a data cable. With no chemicals and with reduced shooting times, and therefore reduced exposure, the new detectors can find application in aircraft on-wing inspection, producing DICONDE-compliant images for instant review via appropriate software.

Remote visual inspection can now offer an innovative measurement technique that provides 3D imaging to increase accuracy and productivity in aerospace and rotating equipment applications. Based on an existing optical metrology technique, it involves projecting line patterns onto a surface, capturing the patterns in a video camera with high-quality viewing optics and processing the images using proprietary algorithms to produce a point cloud, 3D map of the entire surface. This provides accurate three-dimensional surface scans using a single probe tip, streamlining the inspection process. Prior to 3D Phase Measurement, videoprobe measurement was based on stereo or shadow techniques, which are complex techniques, and the tip of the probe had to be changed from a viewing tip to a measurement tip, adding time to the inspection process.

COMPOSITES WITH ULTRASONICS

Ultrasonics is perhaps the most versatile of all inspection techniques and one of the most important recent developments has been the introduction of ultrasonic phased array technology. Today, portable phased array instruments are being successfully used to drastically reduce inspection times and improve probability of detection. Offering the capability for rapid, large surface area inspection, phased array also affords better, clearer visual imaging.

Ultrasonics is also suitable for the inspection of composite materials, to detect disband, material flaws and discontinuities. This capability has been used to great effect in the development of instruments such as the one used by major aircraft manufacturers to allow flightline and ramp crews at airports to quickly and easily evaluate possible damage to composite structures caused by accidental collisions with baggage loaders and other vehicles.

The latest introduction into the composites inspection toolkit is a manually operated, phased array, ultrasonic inspection system, which enables rapid scanning and can be connected to any suitable, phased array flaw-detection instrument to provide results in C-scan and B-scan format. It can complement or replace full immersion C-scan systems in the manufacturing environment, while being equally functional when inspecting aircraft on the ground for collision damage, post-repair and other inspections.

This new system, from GE Measurement & Control, consists of a linear, 64-element ultrasonic transducer array, contained in a tire, which is inflated with a fluid to create the ultrasonic couplant. The tire is fitted within a scanning cart and the complete assembly is rolled along the surface to be inspected to carry out a scan for flaws or delaminations. An innovative magnetic encoder, which operates without belts, pulleys or gears, provides positional data and is connected to a suitable phased array flaw detector, which displays the results.

CONTACT

Thierry Laffont
GE Oil & Gas
Measurement & Control Solutions
Tel: +44 1925 604095
Fax: +44 1925 604096
Email: david.jervis@ge.com
Web: www.ge-mcs.com

Go to online reader enquiry number 101

INTEGRATED GVT PACKAGE

A complete software system, combined with all the necessary hardware for GVT testing, enables an intelligent and efficient workflow

While the structural dynamics testing regimes for aircraft and their components must follow well-established procedures and protocols, closer integration of test results with modeling can reduce time, errors and costs. Further value is available through the economies that result from having a single supplier and contact for all structural testing software and equipment requirements –backed up by a dedicated, 24/7 service organization.

Brüel & Kjær supplies everything needed for structural dynamics testing of aircraft, combining proven data acquisition hardware with a vast selection of high-quality transducers and the LDS range of vibration shakers.

But that's just the hardware. Brüel & Kjær also provides structural dynamics testing software for every stage of aircraft vibration testing that seamlessly integrates with the proven PULSE Reflex post-processing environment. Their finite element correlation software then updates finite element (FE) models with actual test results, so the entire testing workflow is encompassed in one integrated environment.

The mature multi-analysis platform PULSE has more than 11,000 systems in operation globally, and is known throughout the sound and vibration testing world as a powerful workhorse that is at home in demanding test requirements. Perfectly suited to large-scale experimental modal testing, and to determining the low-frequency modes of an aircraft structure, PULSE is, according to the company, ideal for ground vibration test applications.

The Brüel & Kjær GVT system consists of special equipment including structural exciters, vibration sensors, and data acquisition and analysis tools. PULSE Modal Test Consultant (MTC) is an application wrapper around the PULSE multi-analyzer system that tailors the system expressly for hammer and shaker testing. MTC takes care of the modeling and measuring, and seamlessly integrates with the PULSE Reflex (post-processing) structural dynamics suite for curve fitting and modal model validation, where verification and updating of modal models is performed, prior to flutter testing.

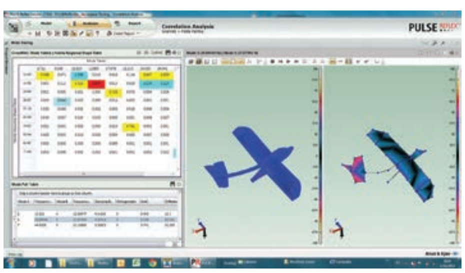
As the modal shakers excite the aircraft during GVT testing, the vibration response is measured at numerous points on the structure, potentially using hundreds of vibration transducers – so the data acquisition system is capable of simultaneously acquiring the response data from many hundreds of channels. Efficiency and accuracy are the core requirements here, and are designed into the system to minimize crucial test time on the fully assembled physical prototype.

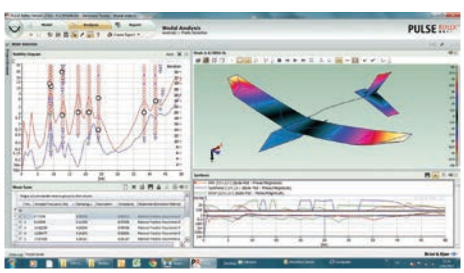
PULSE MTC provides an intuitive drawing package that enables users to create wire-frame models of the test object, and add measurement DOFs directly to this geometry.

Here, the setup of the PULSE LAN-XI data acquisition front-ends, transducer mounting, and the measurement sequencing of the FRFs, is automated to lead users efficiently through the measurement process. Validation of measured FRFs is carried out via tools such as coherence, reciprocity and by studying Operation Deflection Shapes (ODS) at different frequencies. MTC then seamlessly exports the geometry and measurement data for post-processing in PULSE Reflex Structural Dynamics, which uses a targeted set of best-in-class mode indicator functions, curve-fitters and analysis validation tools. A preview of pole locations in selected frequency domains is given, and results are validated using animated mode shapes, modal assurance criteria and complexity plots.

By logically grouping features and displays of results, PULSE Reflex Structural Dynamics enables users to perform a complete modal analysis in just four main steps. The measurement validation step checks the quality of the measurement data prior to performing the modal parameter extraction, then the parameter estimation step prepares and executes the curve-fitting. Mode selection is then used to show the modal results in terms of natural frequency, damping ratio, mode shape animation and synthesis of FRFs, before analysis validation is used to further investigate the obtained modal results, giving maximum confidence in the modal model.

Completing the feedback loop, FE correlation software compares the actual measured response of the structure with the FE model, with the object of correcting the values of the variables in the FE model. Data can be imported from various leading FE modeling programs such as NASTRAN, ANSYS, ABAQUS, or as UFF files. Accurate correlation is quickly obtained by following an intuitive yet flexible workflow process that guides the user efficiently through geometry alignment, DOF mapping, comparison, vector comparison, mode pairing and reporting.





Modes selected are shown in the mode table, animated, and the FRFs synthesized Below them is a practical set-up for measuring FRFs on a remote-controlled aircraft

CONTACT

Brüel & Kjær Sound & Vibration Measurement A/S
Tel: +45 77 41 20 00
Web: www.bksv.com

FAST FRAME FORWARD

High-speed cameras for airborne applications can be adapted to suit any environment or aircraft type

High-speed cameras recording store separation or any event during test flights are a commonly used form of measurement system for current aircraft development and techniques. The data collected by the camera systems delivers important feedback for design and test engineers for improvement or validation of systems.

Since the traditional 16mm film-based cameras were replaced by first-generation digital high-speed cameras, new requirements to deliver high-speed video data have quickly become apparent. New-generation cameras must be network operational in a COTS standard network, or alternatively work reliably for standalone operations. The demands of mechanical and electrical 'fit-the-aircraft cameras' initiated a different approach for a semi-customized camera system.

CAMERA DESIGN

With a complex system such as a fighter aircraft, it is important that the camera adapts to the aircraft and not the aircraft to the camera. This is true for the electrical and control interface, as well as the mechanical outlines of the camera. An application may require that a camera be designed so that the connectors come straight out of the back of the body. Other mounting positions require the system to have the connectors coming out sideways for a 90° view. Some positions may require recessed lens-mounting due to space limitations in the mounting area.

With this in mind, it was felt that it was important to have three separate designs. Of course, all designs must meet environmental and EMI specifications to be aircraft-ready. Sometimes it is much better to have aircraft-specific connectors on the cameras for ease of integration.

Camera designers must deal with these bespoke requests, and one approach is to have a semi-customizable camera platform where the functionality and identical operation of each camera is assured, the cameras perform reliably under the given environmental conditions, and the cameras are commercially attractive to the user.

To achieve this goal, the camera design must first meet a high degree of flexibility in terms of electronic design. Such modules satisfy the highest possible adaptation to mechanical design demands to make the camera fit in the space required. Interface parts must be easy to adapt to given connectors and power requirements coming from the aircraft.

Such a design approach is highly beneficial to the user. The camera sensor element is always equipped with the same sensor, giving the same optical performance for all views and making later image analysis more efficient than taking data from different types of sensors with new parameters.

SMART FEATURES

With a camera design such as this, the question of how to operate such systems taking into account different scenarios under different conditions must be addressed. Smart features in the camera may be used to give the camera a maximum standalone operation that does not interfere with the flight operation, but provides the precious image data required. These features are pre-programmed on the ground by flight engineers and, once the camera powers up, it takes the recordings according these parameters.

NETWORKING AND COMMUNICATION

For cameras intended to work in a network environment, it is important to standardize communication. A recent idea in flight video data capturing is to network cameras via a central control unit. In such a case, the captured sequences are downloaded to the control unit and new commands are sent to the camera for the next take. For this approach, an easy-to-implement and versatile communication protocol is the GigE Vision standard, which enables enhanced video data collection during the flight. For instance, during certain periods a live stream with a standard 30 frames/sec is recorded directly within the control unit. When the test requires a high-speed recording, the data is buffered in the camera and sent to a control unit on demand or transferred to the internal non-volatile camera memory.

DATA FORMAT

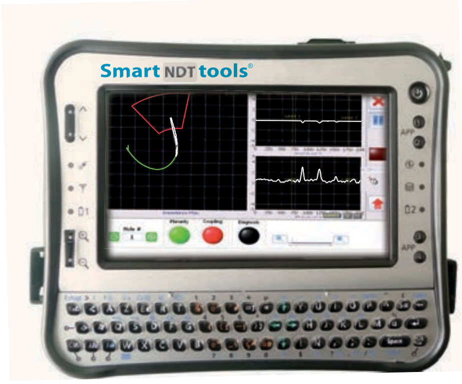
For later analysis of test data, easy-to-achieve correlation between video and other data is important. Synchronization to IRIG-B or GPS signals is now standard. Until recently, users had to cope with many data formats, sometimes including manufacturers' proprietary formats, making exchange of data complicated. Here, the IRIG-106 data format seems to be a viable base for all data-gathering and later analysis. A common data format eases the use of analysis tools and a secure correlation of measurements – taking into account different sensors and cameras – is achieved. In the end, it is a very economical way to produce results and gain insight information and, maybe even more importantly, it makes the comparison between measurement data simpler.

From aircraft store separation tests to mechanical stress tests, high-speed cameras provide a technical insight into the events

CONTACT

Stephan Trost, managing director
AOS Technologies, Taefernstrasse 20
5453 Baden, Switzerland
Tel: +41 56 4833488
Email: info@aostechnologies.com
Web: www.aostechnologies.com

Go to online reader enquiry number 103


Smart NDT tools

DIVE BACK TO EARTH

An essential alternative to an expendable space test vehicle. A look at a space lab that comes back to Earth

The Centro Italiano Ricerche Aerospaziali (the Italian Aerospace Research Center, or CIRA) is using an unmanned space vehicle (USV) to research technologies that are vital to the development of future space transporters. The onboard computer used in the test flights previously underwent comprehensive testing.

CIRA is using the USV as a 'flying laboratory' for research into all the important aspects of developing the reusable space transporters of the future, such as thermodynamics, elasticity, heat shield technologies, navigation techniques and flight mechanics among others. The USV has already performed two test flights and on both occasions provided valuable data on factors such as the pressure, force and temperature conditions on the outer shell.

NOSE-DIVE, DESCENT 25KM

The second test flight took place on April 11, 2010, when the USV was first lifted to an altitude of 25km by a stratospheric balloon. After undocking from the balloon it executed a two minute-long glide, during which it carried out a measurement program, and finally parachuted into the sea off the coast of Sardinia. Its speed was mostly around Mach 1, but for a while it was approximately Mach 1.2. During the flight the USV constantly collected all the data (flight altitude, speed, acceleration, etc) that was necessary for the onboard computer to guide it safely. The computer itself had previously undergone an intensive test program using a dSPACE system.

FLIGHT GUIDANCE SYSTEM FOR AUTONOMOUS GLIDING

To control gliding flight right up to splashdown, the USV uses various sensors to collect data on its position, attitude, speed, acceleration, etc, which inlcudes:

- Magnetometer (this determines the USV's attitude relative to the earth's magnetic field);
- Acceleration sensors (MEMS acceleration meters, i.e., micro-electric mechanical systems);
- Fibre-optic gyroscope (to determine the USV's attitude relative to its trajectory);
- GPS sensors to measure position and speed);
- Air data system (for example, to determine the Mach number via back-pressure sensors).

The onboard computer processes the measurement data from all these systems in real time and uses it to compute the commands needed to adjust the control surfaces and ensure that the USV's autonomous gliding flight goes according to plan. The USV is studded with all sorts of sensors, such as the more than 300 piezo sensors that measure the pressure distribution on the outer shell during flight. Engineers can use this data to optimize aspects such as the shape of the USV.

FUTURE: HEAT SHIELD TESTS

Following the two flights already performed by the USV1, the aim of the future unmanned system the USV3 is to perform a re-entry mission from orbit to ground landing. In order to do this, the European VEGA rocket will lift the USV3 from the European spaceport in Kourou into a low-earth orbit (200-300km altitude).

After completing a few orbits, the USV3 will execute a de-orbit to start its re-entry at hypersonic speed and fly through the atmosphere autonomously from hypersonic down to supersonic, transonic and subsonic regimes to land on a conventional runway. The long-term objective of CIRA's USV program is to develop a space transporter that takes off from the ground like an aircraft, reaches its orbital altitude, and can land on any airfield in the world. ∎

FTB_1

Flying Test Bed 1 represents an available national experimental capability able to offer the typical conditions an RLV could encounter in high subsonic, transonic and low-supersonic regimes (0.6 < Mach < 1.4 extendable to about 2.5). Other flights of FTB_1 can be defined on the basis of different trajectories to be properly designed and optimized.

CONTACT
dSPACE GmbH, Rathenaustrasse 26
33102 Paderborn, Germany
Web: www.dspace.com

Go to online reader enquiry number 104

FEEL THE POWER

How to plan an electrical power rack profile for reliable automated test equipment

Electrical power is often taken for granted, but automated test equipment (ATE) systems are only as good as the accuracy of their test program set (TPS) results and the reliability of the voltage/signal sources they use.

The cost of downtime, no-fault-found and test result anomalies can cause the user to lose confidence in the automated processes, and end up costing more than expected. They can even cost more than it would have cost to have a technician at a workbench performing the tests. Most of these demons that plague both new and old systems come from such mundane incidents as common mode power line noise, transients and ring pulses from substation switching and adjacent system noise that comes from a neighbor's facility or the ATE system in the next aisle. Proper mitigation of these issues usually comes from integration of a power conditioning rack that is designed to house all the ATE equipment.

An effective power/rack design will save hours of troubleshooting hardware and software, and assure you of continuous operation through most power line anomalies that can break down semiconductor junctions.

A STARTING POINT

Most ATE developments start with the required programmable voltages and loads, then signal injection and/or measurement is defined along with the operational envelope and acceptable levels. Too often, however, little thought is given to the effect on results from power line and adjacent equipment noise, although EMI/RFI considerations are considered in the specification for the racks. Generally the need to operate in multiple countries with various voltage standards is the driving force behind adding a transformer on the front end, although most system managers have difficulty understanding why they need a 400 lb transformer in the age of gigabit memory chips.

Establishing an electrical noise mitigated baseline for your system is easy to do with isolation transformers, high power, low pass filters, voltage transient suppression devices and proper power distribution. Despite all the more complex systems required, many companies no longer have a power engineer on their staff, and often pass this over without understanding the need for a power plan that is designed to meet your particular needs.

OPERATION AND APPLICATION

The complications and consequences of poor power conditioning and distribution design are many, and they are defined by the operation and application of the particular ATE. When testing actuators, high power in-rush can drive down voltages through the transformer if not designed with very low impedance. A high-quality transformer design can save you 50% or more in peak rating and weight, and enable accurate ATE performance.

The placement and design of electrical filters in the distribution circuit can make a difference in terms of how harmonics enter your equipment or get back out onto the line from it. A well-designed filter will reduce the energy contained in the harmonics. The unfiltered harmonics usually result in losses from the 'current squared x resistance' heating that can cause localized overheating of components or connections, and break down semiconductor junctions, helping equipment die a slow death with no apparent cause.

Power distribution can help with convenience of equipment connection and localized control of power for various pieces of the ATE. Rating and placement of circuit breakers and contactors are often driven by safety and agency requirements. However, power distribution can be easily designed into the power conditioner to supply your specific equipment needs or maintain system flexibility.

CABLE ROUTING

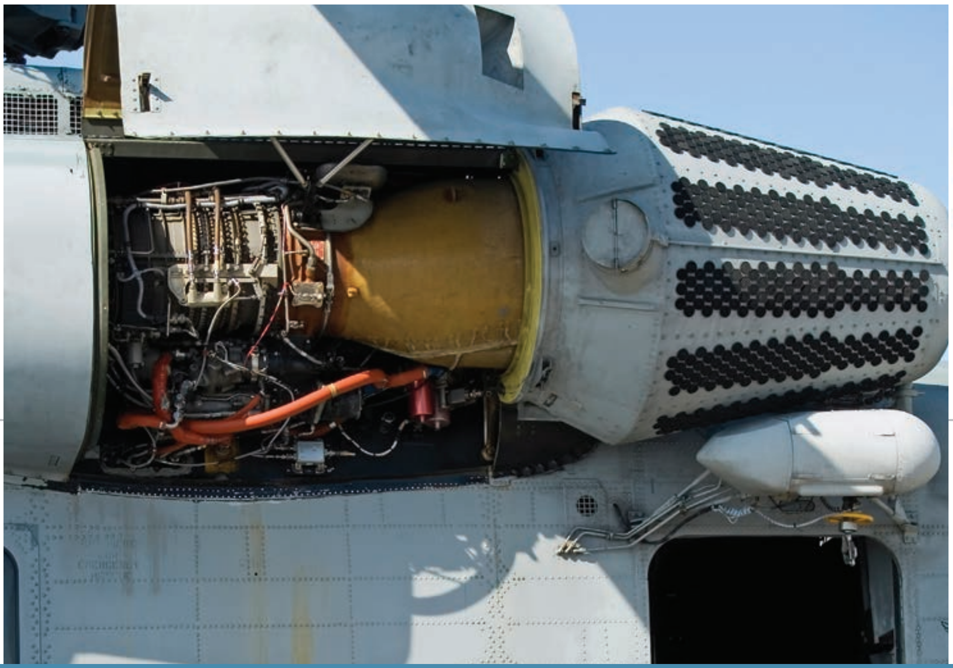
Last but not least, improper cable routing and grounding/shielding of distribution circuits can wreak havoc. Improperly routed or grounded/shielded cabling becomes an easy point-of-entry for unwanted noise and signal cross-talk, and can even cause ground-loop problems that may take days to troubleshoot.

CLEAN POWER

The technology associated with modern, highly computerized automated test equipment and motion simulators for defense and aerospace applications demands clean power. Input power quality is one variable in the process equation and can have a significant effect on the results.

Equipment exposed to harsh electrical environments will fail more often than equipment provided with clean, stable power.

Modern ATE and motion simulators require a very quiet 'noise floor' and a stable zero volt (ground) reference to ensure accuracy.



CONTACT

TEAL Electronics Corp
Bob Close, rclose@teal.com
Tel: +1 858 366 7606
Kevin Harris, kevin.harris@teal.com
Tel: +1 858 366 7601
Web: www.teal.com

Go to online reader enquiry number 105

FLAW DETECTOR

A new portable ultrasonic flaw detector provides powerful tools for conventional ultrasonics – and can be easily upgraded

Building on the success of the its range of portable digital ultrasonic flaw detectors – the D Series, Sitescan and Masterscan instruments – Sonatest has now launched the Prisma ultrasonic flaw detector, which comes in two different versions: conventional UT, or conventional UT plus phased-array. Both can be offered with TOFD (time-of-flight diffraction). Its typical applications are broad, but include weld inspection, corrosion mapping, aerospace and composite inspection.

The Prisma UT is an advanced portable ultrasonic flaw detector that shares many of the basic ultrasound performance characteristics of the popular Sonatest Masterscan series. But unlike the Masterscan, it also has two independent ultrasound channels with full waveform data recording and two-axis encoding. True to Sonatest's design and product principles, the Prisma offers a simple-to-use interface, with additional features to further enhance operational ease. The unit's design and construction ensures long and reliable use in the harshest of environmental conditions. In addition to the Prisma instrument, which incorporates powerful onboard reporting capabilities, there is UT Studio, PC-based documentation and post-inspection analysis software for even greater offline capability.

THE SYSTEM

Prisma can be easily placed in awkward spaces and uses a multiposition stand and hook, as well as a tripod mount and harness attachments. All removable covers are designed to be accessed, without tools, by gloved users.

In terms of performance, the Prisma has interface-triggering capability with a fast PRF to enable use in high-speed immersion, C-scan applications. This provides state-of-the-art imaging, which allows A-, B- and C-scan displays to be viewed simultaneously, with a multiple choice of display layouts taking advantage of the 8192 display resolution.

The Prisma UT can also be made into a TOFD-capable instrument simply by adding the TOFD software option, enabling even greater inspection and imaging capability with no pre-amp required and lateral wave straightening and lateral wave removal featured. In addition, the 16/16 phased-array option can be selected, which increases the probability of detection and also improves productivity significantly.

SYSTEM OPERATION

In terms of imaging, the Prisma UT/PA can show A-scans, B-scans and C-scans in UT or PA. The user can then add S- and L-scans in PA, as well as end view and true top view. Other views available are weld overlay, skip cursors and ray tracing, which are highlighted in S-scans. The 3D scan-plan feature, which includes part, weld, wedge, probe and scan coverage, assists with the setup and assessment of the results in a clear and easily understood manner.

Body-material construction in the Prisma is carefully optimized, resulting in the lightest product of its kind on the market. All plastic components are marked to ISO standards for recycling. Designed for long life and durability, Prisma offers users advanced technology and analytical capability in a compact, rugged, user-centric product. The Prisma occupies a significant place in the world of ultrasonic flaw-detection equipment. It provides powerful tools for conventional ultrasonics, but can be upgraded to provide the many benefits of PA and TOFD in a simple format that is ideal for those new to the benefits of these technologies and techniques.

INSPECTION PROBE

The new Veo 16:128 enables the end user technician to use 128 probe elements for inspection and makes it possible to connect to larger single probes or multiple probes.

This increase in power and capability is important for weld inspection applications, where a linear scan from both sides of the weld is needed. The Veo 16:128 can use a pair of 64-element probes, which means inspection can be carried out in a single pass, improving both the speed of inspection, and positional accuracy since the two probes are linked together. Efficient and effective scanning can also be achieved when the new Veo is partnered with Sonatest's large wheel probe, which is capable of scanning a strip of up to 100mm in a single pass. The system is ideal for large area scanning applications and corrosion inspection.

Ultrasonic phased-array inspection techniques are becoming the leading method for advanced NDT inspection. Applications typically include weld inspection, corrosion mapping, and aerospace and composite testing.

CONTACT

Corinna Cuciureanu
Sonatest Ltd
Tel: +44 1908 525904
Email: corinna@sonatest.com
Web: www.sonatest.com

Go to online reader enquiry number 106


prisma
Sonatest
Digital & Phased Array Flaw Detectors
Thickness Gauges
Ultrasonic Transducers
Coating Thickness Meters
Ultrasonic Scanning Systems
MPI Solutions & Dye Penetrants
Ultrasonic Couplant, X-Ray Film & NDT Accessories.
Contact us to discuss your NDT & Inspection applications.
Tel: +44 (0)1908 316345 Email: sales@sonatest.com
Applications include:
Manufacturing Defects, Delamination Detection, Composite Inspection, Impact Damage Assessment, Corrosion Inspection, Large Area Scanning & WheelProbe Technologies
twitter follow us @sonatestltd
Sonatest
www.sonatest.com


From the publishers of Aerospace Testing International magazine
transportation weight loss diet conference 2013
TURN OVER FOR FULL PROGRAMME
The Transportation Weight Loss Diet Conference is a unique event that will bring together key innovators from across the automotive, aerospace and rail industries, as well as leading academics, to highlight major breakthroughs in mass reduction.
OVER 70 SPEAKERS AND 250+ DELEGATES EXPECTED!
If weight reduction, fuel efficiency or environmental impact matter to you, then you need to attend this conference!
5-6 JUNE 2013 MESSE STUTTGART, GERMANY
GO ONLINE NOW TO BOOK YOUR PLACE!
www.TransportationWeightLossDiet.com

transportation weight loss diet conference 2013

2-DAY PASS ONLY €1,350

about

The Transportation Weight Loss Diet Conference will bring together designers, engineers, program leaders and heads of industry from the global aerospace, automotive and rail industries for a two-day conference dedicated to cutting-edge research and technologies aimed at reducing weight and decreasing carbon footprint, without compromising safety, efficiency or operational ability.

The Transportation Weight Loss Diet Conference is a two-day conference that will operate using three separate conference rooms in order to accommodate the amount of content and discussion available. Every care has been taken to avoid certain content being scheduled together, but on occasions unfortunately choices will need to be made. To avoid disappointment we will issue conference proceedings and, with the consent of the speakers, make the slides of all sessions available to all registered delegates.

Speakers include

Ingo Wuggetzer vice president, Cabin Innovation and Design, Airbus Operations GmbH, GERMANY
Jacques Belley director R&D Standardization and Innovation, Bombardier Transportation North America, CANADA
Gulsen Oncul senior expert, Turkish Aerospace Industries Inc., Turkey
Jody Shaw director, Technical Marketing and Product Development, United States Steel Corporation, USA
Ian Donaldson director R&D, Auburn Hills Tech Center & Materials Engineering Americas, GKN Sinter Metals, USA
Dr James Njuguna lecturer – Transport Lightweight Structures, Cranfield University, UK
Prof. Santiago Hernandez professor, University of Coruna, Spain
Dr Alexander Kling head of Structural Mechanics Department, DLR, Institute of Composite Structures and Adaptive Systems, Germany

BOOK ONLINE NOW!
www.TransportationWeightLossDiet.com

DAY 1, WEDNESDAY JUNE 5, ROOM 1

Opening keynote session

Aerospace vs automotive – perspectives on composites needs and requirements
Dr Robert Yancey, senior director – Global Aerospace, Energy, and Marine, Altair, USA

DAY 1 ROOM 1 – MORNING

Increasing composite potential: affordability, lifecycle and thermal properties

This session will look at the developments in composite materials to make them more useful to OEMs. Some of the limiting factors have been the cost, issues concerning lifecycle, as well as thermal properties that limit their application. session will look at developments in processing techniques aimed at reducing the cost, recycling and using recycled composites, and increases in thermal resistance that enable them to be used in new applications.

The development of processing techniques for affordable carbon composite materials
Prof. Nicholas Warrior, head of Polymer Composites Research Group, University of Nottingham, UK

Cradle-to-cradle use of carbon fiber
James Stike, president and CEO, MIT LLC, USA

Thermo-impact resistance of PA66 composites for automotive structural application
Ian Butterworth, researcher, Automotive Polymer Composites, Cranfield University, UK

Competitive lightweight structures with increased thermal stability
Patrick Weichand, researcher Fiber-Reinforced Materials, Institute for Manufacturing Technologies of Ceramic Components and Composites, University of Stuttgart, Germany

DAY 1 ROOM 1 – AFTERNOON

Designing and creating composite structures

This session will investigate developments in optimizing composite structures using examples from aerospace and motorsport to demonstrate how composite structures can be improved and the potential the composite structure has for weight reduction by incorporating electrical conduction into the structure.

Weight reduction by optimized reinforcement structures
Fredrik Ohlsson, product development director, Oxeon AB, Sweden

Effect of fiber treatments on mechanical properties of flax/tannin composites
Dr James Njuguna, lecturer – Transport Lightweight Structures, Cranfield University, UK

Composite honeycombs for weight savings in aerospace and ground transportation
Mikhail Levit, global technical leader, Aerospace and Mass Transportation, DuPont Protection Technologies, USA

Low-density thermoset composites for transportation
Vincent Banton, Thermoset Development Technical Support, IDI Composites Europe, France

The relative value of weight: how much is a kilogram reduction actually worth?

Panel
- *Ingo Wuggetzer, vice president, Cabin Innovation and Design, Airbus Operations GmbH, Germany*
- *Jacques Belley, director R&D, Standardization and Innovation, Bombardier Transportation North America, Canada*
- *Nicolas Meilhan, senior consultant, Frost & Sullivan, France*

DAY 1 ROOM 2 – MORNING

Challenges in aerospace mass reduction

The highest value gain for mass reduction has been in aerospace. Unsurprisingly this sector has been where most investment and innovation in mass reduction has occurred. Challenges still remain, and this session looks at some of them.

Cabin Concept 2050 based on a bionic structure
Ingo Wuggetzer, vice president, Cabin Innovation and Design, Airbus Operations GmbH, Germany

Advanced methodologies for weight minimization of aircraft structures
Prof. Santiago Hernandez, professor, University of Coruna, Spain

Design solutions to reduce weight during assembly operations
Gulsen Oncul, senior expert, Turkish Aerospace Industries Inc., Turkey

Validation approach for robust primary thin-walled CFRP structures
Dr Alexander Kling, head of Structural Mechanics Department, DLR, Institute of Composite Structures and Adaptive Systems, Germany

DAY 1 ROOM 2 – AFTERNOON

Lightweight electric vehicle design and materials

This session will look at the challenges of designing and building actual modern lightweight electric vehicles.

BMW i3: a battery electric vehicle from the beginning
Oliver Walter, responsible product manager BMW i3, BMW, Germany

transportation weight loss diet conference 2013

Strategies of global OEMs to reduce future car weight
Nicolas Meilhan, senior consultant, Frost & Sullivan, France

Advanced light architectures specifically designed for electric vehicles
Javier Romo, project manager, Cidaut Foundation, Spain

Automotive solar applications changing the rules in car design
Norman Starke, CEO, Proof Technologies, Germany

Half-weight vehicle with new materials: chassis, body and driveline
Mogens Løkke, CEO, ECOmove ApS, Denmark

DAY 1
ROOM 3 – MORNING

Optimizing manufacturing processes

This session will look at the process developments needed for mass reduction to be a key driver in the design and manufacturing process of volume production vehicles.

Automated multidisciplinary optimization (MDO) process development for vehicle weight reduction
Giri Nammalwar, head of Global CAE Strategy Planning, Ford Motor Company, USA

A multidisciplinary stochastic optimization (MDSO) approach to reduce vehicle weight and meet performance targets
Dr Simon Xu, engineering group manager for Vehicle Optimization, General Motors, USA

High pressure meets lightweight
Jens Winiarz, product manager Lightweight, Hennecke GmbH, Germany

DAY 1
ROOM 3 – AFTERNOON

Growing lighter: how to benefit from additive manufacturing techniques

Additive manufacturing enables a parts manufacturer to 'grow' high-value, custom-designed parts layer by layer – enabling the manufacture of complex shapes from a wide range of materials without the need for new tools or machinery. Even using extremely lightweight materials, additional mass reduction can be achieved by minimizing the use of those materials. This is an exciting technology for mass reduction and this session will look at case studies to demonstrate its value.

Additive manufacturing technologies for producing innovative lightweight structured components
Dr Stéphane Abed, CEO, Poly-Shape 3D Generative Manufacturing, France

Lightweight design and laser additive manufacturing: exploiting new potentials
Jannis Kranz, researcher, Lightweight Design for Laser Additive Manufacturing, Technical University Hamburg-Harburg, Germany

Lightweight fiber- and particle-reinforced Al-metal matrix composite structures
Richard Adams, CTO & senior vice president, CPS Technologies Corporation, USA

Powder metallurgy delivers weight savings in automotive powertrain applications
Ian Donaldson, director R&D Auburn Hills Tech Centre & Materials Engineering Americas, GKN Sinter Metals, USA

DAY 2 – THURSDAY JUNE 6
ROOM 1 – MORNING

Will steel still be relevant? Futuresteelvehicle – special presentation

FutureSteelVehicle: innovative development and mass-reduction strategies
Akbar Farahani, vice president, Engineering, ETA Inc, USA; Jody Shaw, director, Technical Marketing and Product Development, United States Steel Corporation, USA

Mixed material design challenges

This session will look at the practical experience of integrating different materials into the design of a vehicle in order to fully exploit and optimize the mass reduction potential of each material.

Daimler hybrid transmission: making it better through weight optimization
Gaurav Kumar, senior lead engineer, MBRDI, India

Lightening the way ahead
Phil Hall, managing director, Caterham Composites, Germany

Achieving 40% BIW mass reduction through mixed material design
Peter Morgan, senior product manager - Lightweight Vehicles, Lotus Engineering, UK

DAY 2
ROOM 1 – AFTERNOON

Innovations for lighter interiors

Silicone foam allowing weight reduction through thinner cushion
Tom Winters, market development manager Mass Transit High Performance Foams, Rogers Corporation, USA

Big windows, light weight
Phillip Bell, product line manager, Corning Incorporated, USA

Low-weight, low-energy infotainment
Ashutosh Tomar, senior research engineer, Jaguar Land Rover, UK

Suspension fabrics – a new era in seating
Jeffrey Gross, director of product development, The Acme Group, USA

BOOK NOW!

2-DAY PASS ONLY €1,350

GO ONLINE NOW TO SECURE YOUR SEAT!

BOOK ONLINE NOW!
www.TransportationWeightLossDiet.com

Intelligent design: lighter materials are a requirement but not all that is necessary

This session will consider some of the more philosophical issues concerning the lightweighting of vehicles. As well as the question of whether the change is best achieved incrementally or through a complete paradigm shift, it will also focus on the need for designers to think less about using lighter materials merely to replace vehicle structures and components and more toward appreciating the potential of new materials to completely change the way vehicles are designed and assembled.

Automotive body-in-white mass reduction philosophy
Dr Donald Baskin, senior associate, Exponent, USA

Lightweight – the paradigm shift
Sébastien Stassin, managing partner, Kiska GmbH, Austria

Composite structure is not making a black sheet metal structure
Andrew Rich, president, Element 6 Consulting, USA

Truck of the future – evolve or leap?
Jörn Buss, partner, Oliver Wyman, USA

DAY 2
ROOM 2 – MORNING

Innovative uses of composite materials

This session will look at innovations in the uses of composite materials for major reductions in mass, for example to replace heavy components such as engines, springs and bearings.

PM2 engine concept – a composite innovation
Hendrik De Keyser, technology officer, Vyncolit NV, Belgium

Weight-loss potential of composite spring elements
Richard Zemann, head, Fiber-Reinforced Polymers Activities, TU Vienna, Austria

Using plastic bearings in automotive applications
Mark Watkins, automotive plastic bearing development manager, BNL (UK) Limited, UK

GFC leaf-spring: approved technology in a new form of appearance
Dr Anna Schwarz, general manager, Danto Invention, Germany

Conductive connection of carbon structures for failure detection safety and repair
Walter Kiersch, CEO, Carbon Conduction Technologies (CCT) GmbH, Germany

DAY 2
ROOM 2 – AFTERNOON

Advances in bonding/ joining technology

The use of new materials in lightweight vehicles requires a revision of bonding and joining techniques for efficient and cost-effective vehicle assembly as well as consideration for aftermarket repair. This session will look at advances in bonding and joining materials and techniques.

Adhesives for composite assembly
Terry Gordon, epoxy development chemist, Permabond, UK

Durability testing for adhesive joints in the vehicle industry
Dr Isabel Van de Weyenberg, research engineer, Flanders' Drive, Belgium

Shedding weight while ensuring maintainability and recyclability with threaded fasteners
Michael Mowins, president, Global Licensing, Phillips Screw Company, USA

Sustainable laser surface cleaning for joining preparation in lightweight production
Edwin Buechter, CEO/president, Clean-Lasersysteme GmbH, Germany

Coating and painting developments for composites

This session will look at developments in the techniques and materials that will enable composite vehicles to be coated and painted effectively and affordably, making their use by OEMs easier to integrate.

Lightweight fiberglass composites for automotive
Robert Langlois, CEO, Powder Coating Solutions, Canada

SMC composite material for automotive on-line painted body panels
Guillaume Cledat, key market developer, CCP Composites, France

DAY 2
ROOM 3 – MORNING

Advances in lightweight metals

Heat treatment of light alloy structural castings for automotive applications
Dr Dan Dragulin, head of R&D, Belte AG, Germany

Weight savings with castings in iron, aluminum and magnesium
Klaus Decking, product segment manager Lightweight, Georg Fischer Automotive AG, Switzerland

Stable inlay aluminum tubes for HPDC and other casting processes
Frank Heppes, head of Research & Development, Drahtzug Stein Combicore GmbH & Co. KG, Germany

Replace die-cast in control modules for dramatic weight savings
Randall Wilburn, global manager Automotive Sector, Molex Inc, USA

DAY 2
ROOM 3 – AFTERNOON

Advances in lightweight metals 2

A new stainless-steel material for weight reduction
Quaranta Lorenzo, development manager, Sandvik AB, France

New material concept for weight reduction
Armin Schneider, product applications manager, Carpenter Technologies GmbH, Germany

Enabling lightweight high-load bearings
Sarah Banfield, research manager, Tecvac Ltd, UK

Titanium extrusion, fatigue and fracture behavior
Gail Hite, market development director, RTI International Metals Inc, USA

Magnesium/MnE21 lightweight solutions: the eco-friendly solution of the future?
Dr Stephen Rudzewski, head of Technics and Innovation, Semcon Holding GmbH & Co. KG, Germany

Q&A

UNDER PRESSURE

The latest hydraulic servicing trolley is now multifunctional and can also be used in the harsh environment of a hostile military situation

Wherever aircraft are in service, ground support equipment is indispensable. For example, hydraulic servicing trolleys supply the energy to maintain hydraulic pressure in aircraft when the engines are not turning. The hydraulic pressure is sometimes necessary for the mechanics when they perform certain tests or checks on the aircraft.

As well as serving aircraft with hydraulic pressure, the Test-Fuchs hydraulic servicing trolley achieves a number of other tasks – cleaning, water removal, filtering and degasification of the hydraulic medium – and performs leakage tests and function tests on the ground.

MILITARY VERSUS CIVIL

The trolleys are necessary in civil as well as military aviation. However, military use of this equipment requires more features than civil use and the trolleys have to resist and endure much more than standard circumstances.

Test-Fuchs, the specialist for highly challenging developments, has already designed and delivered 145 military hydraulic servicing trolley units incorporating a number of features that are difficult to find in any similar device. For the last decade the trolleys have successfully been in use on the Panavia Tornado, Eurofighter Typhoon, BAE Systems Nimrod, Boeing Sentry, McDonnell Douglas F/A-18 and F-16, Vickers VC10, Lockheed Tristar and Bombardier Global Express (Astor).

In the near future the trolley will also be in service with the coming Airbus A400M, with the necessary adaptations already having been carried out on many of the delivered units. Due to the fact that the A400M will not be operated with MIL oil, this special trolley is available for use with either traditional MIL oils or Skydrol/Hyjet IV/V.

As a servicing device for military use, the trolley has to withstand harsh environmental conditions. Therefore the device had to undergo extreme stress tests to prove its flawless operation in even the most inhospitable circumstances.

HOW THE SYSTEM WORKS

The hydraulic servicing trolley operates without difficulty between -25.6°F (-32°C) and 131°F (55°C) up to an altitude of 5,000ft (1,500m) and is compact and rugged enough to be transported by train, ship or aircraft to remote places. The engineers have equipped the trolley with numerous fixation points and it is possible to pack it into a standard 20ft shipping container.

It is electromagnetically compatible and does not interfere with any other appliance. The noise level even in the diesel-powered models is extremely low – an important feature when it comes to a combat mission. During mission use it is particularly important – essential, in fact – that the device operates without problems in extreme wind and on uneven ground, and can even be trailed through water if necessary.

Test-Fuchs engineers did their best to solve all these problems, for example by placing the exhaust pipe on top of the trolley to enable operation even in shallow water.

The trolley is operated via a tethered touchscreen panel that can be removed, enabling the operator to execute tasks from a place other than next to the trolley. The tethered panel, a mobile PC interface, also resists extreme environmental conditions, being cooled in hot environments and heated when it is too cold for normal operation.

The Test-Fuchs hydraulic servicing trolley is in fact a fully automatic test device where the operator selects the aircraft type, presses the start key and is presented with 'OK' or failure results after the automatic test run. Whenever needed, it can also be operated manually.

DIFFERENT VERSIONS

Another feature of the trolley's versatility is that depending on the circumstance and environment in which it is used, it is available in an electrically driven version for indoor use or a diesel-powered version suitable for use outside the hangar or while on a mission, where there may be no established infrastructure such as power supplies or water connections available. The six cylinder 7.1 liter displacement diesel engine is powerful enough to satisfy all the necessary requirements.

Also available with the Test-Fuchs hydraulic servicing trolley are a number of other useful devices designed to be used in combination with the trolley. These include a water separation system, an automatic calibration appliance and various spare part kits.

CONTACT

TEST-FUCHS GmbH
Test-Fuchs Strasse 1-5
3812 Gross Sieghart, Austria
Tel: +43 2847 9001 0
Email: office@test-fuchs.com
Web: www.test-fuchs.com

Go to online reader enquiry number 107

AGREEMENT FOR AIRBUS-DEVELOPED AFDX TECHNOLOGY

By signing a licensing agreement with Airbus and its EADS parent company, Vector is extending the application range of its CANoe and CANalyzer development and analysis tools to include AFDX (Avionics Full-Duplex Switched Ethernet) networks. Multibus capability will enable developers to analyze multiple aerospace bus systems – such as AFDX, CAN and ARINC 429 – synchronously using a single tool.

"In signing the license agreement for AFDX with Airbus and EADS, we are creating a foundation for use of this technology and are supporting it at its full depth," explained Martin Litschel, managing director of Vector Informatik. "As the global market leader in tools for networked systems in automotive electronics, we can already offer a multitude of proven tools that can be applied to AFDX networks as well. This considerably simplifies the simulation and analysis of complex networks in airplanes, and potential design errors are detected much earlier."

Litschel added, "The very good cooperative relationship we have had with Airbus for many years will be further strengthened by taking this step. We are convinced that we will be making a major contribution toward improving the development process for achieving reliable networked electronics in airplanes."

Jürgen Klüser, director of avionics tools at Vector, said, "Electronics developers in the aerospace field will benefit from Vector's 20 years of experience in the development, analysis and testing of embedded systems. As multibus tools, CANoe and CANalyzer are able to analyze AFDX communication synchronously with other networks such as ARINC 429 and CAN. Development and test engineers at airplane manufacturers, system suppliers and component manufacturers can use the CANoe software tool throughout the development process. Potential tool applications range from network design to comprehensive analysis and systematic testing of electronic units."

The AFDX option for CANoe and CANalyzer provides detailed access to the exchanged data, down to the level of individual Ethernet frames. If the network description is available in the form of an interface control document (ICD), the communication is decoded in detail. This permits representation of virtual links not only as numeric values, but means they can additionally be referenced by their names too. Similarly, the transported data can also be accessed by predefined signal names. Signals are displayed – simply and conveniently – in data or graphic windows. User-defined panels, which may contain pointer instruments or animated graphics, enable an especially user-friendly representation of values.

FURTHER INFORMATION

Web: www.avionics-networking.com/afdx
or go to online enquiry card 108

GAPMAN GEN3 NOW IN USE

The Gapman Gen3 was introduced to the industry in the March 2011 issue of Aerospace Testing International in the technology profile section with the headline *Filling The Gap*. The article covered the Gapman Gen3 electronic gap measurement system for aircraft applications, delivering a higher resolution, longer battery life and an extremely easy-to-use interface. Gapman was also featured in the November 2011 issue under the headline *Gap Measurement System*, where it was revealed that the Gapman Gen3 was undergoing final approval at two major new commercial aircraft programs.

Since then Gapman has been fully approved on these two programs and dozens of units are in use, accelerating the shimming process at over eight assembly plants throughout Europe. These sites are responsible for shimming junctions between a variety of metal and CFRP surfaces in applications ranging from VTP, aircraft wings and fuselages, to engine pylon mounting brackets and final assembly.

Gapman Gen3, in conjunction with a Capacitec spring contact wand, has recently been designed in as a standard measurement tool to measure the length of individual fan blades on the new LEAP-X mid-sized commercial aircraft engines. The existing traditional contact method go/no go mechanical step gages have now been replaced with the new Capacitec digital system, which offers a fully portable, battery-operated precise gap-measurement system. The spring-contact gap wand design eliminates the need for normally required grounded targets.

FURTHER INFORMATION

Bryan Manning, director of marketing and business development
Tel: +1 978 772 6033
Email: marketing@capacitec.com
or go to online enquiry card 109

LEADING BY EXAMPLE

Jacobs provides technical, professional and construction services globally, ranging from on-site support to the delivery of advanced technical facilities and specialty systems.

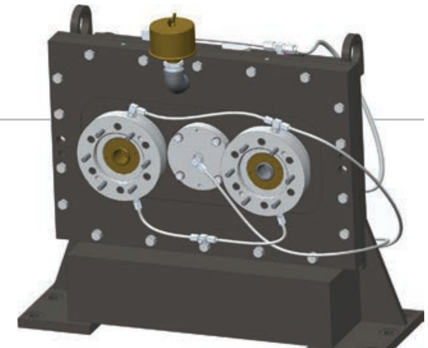
The company's consulting services covers areas from facility planning and use studies, to the latest modeling and simulation techniques, including aeroacoustic predictions, finite element stress analysis and computational fluid dynamics analysis. Jacobs also provides the automated test and measurement software, Test SLATE, as a proven solution for integrating diverse hardware, managing test configurations and transforming data into meaningful results.

As a core example it recently designed and constructed modifications to the Icing Research Tunnel (IRT) at NASA's Glenn Research Center in Ohio, providing enhanced capabilities for aircraft testing. This project included the installation of a modernized refrigeration plant and an innovative low-loss wind tunnel heat exchanger through a fixed-price design/build project. This new refrigeration system enables the IRT to lower the minimum operating temperature from -25°C to -40°C (13°F to -40°F), thereby expanding the testing envelope.

The new integrated system also enables an increase in the maximum test section velocity to 350kts (400mph), along with improved flow quality and temperature uniformity that was previously unattainable. The new refrigeration system includes modern chillers, automated controls and a secondary cooling fluid pumping system. The automated refrigeration plant offers a reduction in the required operational manpower and an improvement in the overall test productivity of the IRT.

FURTHER INFORMATION

Rich Wakeman, vice president
Tel: +1 931 393 6383
Email: Rich.Wakeman@jacobs.com
Web: www.jacobstechnology.com
and/or www.testslate.com
or go to online enquiry card 110



HIGH-SPEED TRANSMISSION FOR MAXIMUM STAND FLEXIBILITY

USA-based Cotta has developed a new high-speed transmission that provides maximum application flexibility for repair depot and multi-unit test stands. The dual output SN2291 high-speed gearbox features a nominal power rating of 300hp, 25,000rpm output speed, and ratios up to five with the option for different output ratios. It has a horizontal shaft design, single stage gearing, and comes with a lubrication system. The high-speed transmissions are used extensively for R&D and production testing of components such as generators, constant-speed drives and pumps in the automotive and commercial and military aircraft industries.

Cotta also designs and manufactures precision-engineered transmissions for a wide range of specialized mobile and stationary applications. Models are available in a variety of output speeds up to 80,000rpm. Modified-standard and custom models are also available to meet specific requirements.

FURTHER INFORMATION

Cotta Transmission Company
1301 Prince Hall Drive, Beloit, Wisconsin, USA 53511-4439
Tel: +1 608 368 5600
Fax: +1 608 368 5605
Email: sales@cotta.com
Web: www.cotta.com
or go to online enquiry card 111

VIBRATION – MULTIPLE SHAKER, SINGLE AXIS

Vibration testing in the laboratory is an essential part of the product evaluation and qualification process. Qualification of large test articles such as satellites requires high force levels. This requirement is typically met with a very large electrodynamic shaker that has the force capability required to excite a large test article to the specified acceleration. In some cases the force required cannot be met with a single shaker and multiple shakers must be used. Other situations, such as testing of large or long articles, may require multiple shakers to balance the input of force and load.

In addition to a higher obtainable force level, the use of multiple shakers has other advantages over a single large shaker.

A single large shaker is often limited in frequency bandwidth and displacement due to the design of the armature. In contrast, the dual shaker configuration can be separated to be used as two individual shakers testing smaller articles to higher-frequency bandwidths.

Multishaker single-axis testing requires a vibration controller capable of compensating for the dynamic response of the fixture and test article. The SignalStar Matrix from Data Physics Corporation uses continuous control to adapt to the dynamics of the system under test. By compensating the cross-coupled dynamic responses to the multiple inputs simultaneously, control accuracy is kept high. The SignalStar Matrix is capable of multishaker single axis vibration for random, sine, classical shock, shock response spectra, mixed mode and time waveform replication tests.

FURTHER INFORMATION

Data Physics Corporation
Tel: +1 408 216 8448
Web: www.dataphysics.com
or go to online enquiry card 112

UPDATED MICROPHONE HANDBOOK

PCB Piezotronics has announced the release of its newly updated Microphone Handbook. Product manager Mark Valentino said, "We are excited to offer this complimentary Microphone Handbook. In its 30 pages our team of acoustic scientists and engineers share over 30 years of microphone manufacturing experience. Inside you will find answers to many of the common applications questions that customers submit on a daily basis, including information on IEC compliant 61094 prepolarized microphones, which are built around the ICP technology pioneered at PCB Piezotronics."

The handbook provides technical information in a user-friendly, easy-to-read format complete with pictures and formulas that will benefit entry level as well as intermediate acousticians. Topics include acoustic technology fundamentals, microphone types, and how to select the proper acoustic sensor. The handbook also discusses the most common standards, interface and setup configurations, along with proper care and maintenance for microphones and preamplifiers, as well as providing a preview of trends for the future. A digital version can be viewed and downloaded at www.pcb.com/microphonehandbook.

FURTHER INFORMATION

For a hard copy, contact PCB
Tel: +1 800 828 8840.
or go to online enquiry card 113

TOOL FOR TUBES

Proving the integrity of tubes and tubular assemblies is critical for aircraft manufacturers. A variety of tests, such as proof testing, helium leak testing, line flushing and pressurization to rupture, are frequently used to qualify parts before they go into service. Tests are performed from vacuum point up to and beyond the component working pressure. Helium, nitrogen, de-ionized water, and Skydrol hydraulic fluid are commonly employed in the testing process. Manufacturers often prefer testing with the same media that is used for operation.

The TestMaster LPHE hydrostatic test tool provides the versatility desired when performing tests at a wide range of pressures using various test media. These tools typically grip and seal the outer diameter of plain-end, round tubes without damage. The LPHE tool is pressure-compensated with the clamping and sealing force increasing at higher test pressures. Hydrostatic loads are contained within the tool, requiring no external fixtures for a safe test. To ensure leak-free performance in critical applications, dual seals are integral. preserve the original finish on tube ends, low-marking collets are available, eliminating the need to leave additional length on tubes for rework. Connecting the tool to the tube is fast with handle and air-operated versions.

FURTHER INFORMATION

Airmo Inc.
Tel: +1 800 394 0016
Email: airmo@airmo.com
Web: www.airmo.com
or go to online enquiry card 114

CLOCK TECHNOLOGY FOR FLIGHT TEST APPLICATIONS

Today's flight test engineers can take a new approach to making a wide range of measurements, with less equipment, easier setup and better results in a shorter time.

Dewetron measurement instruments have the ability to measure every kind of analog sensor output plus digital states, counters, multiple videos, GPS, IRIG, CAN bus, ARINC and 1553. And everything is synchronized to a high accuracy clock that runs on Dewetron instruments, ensuring deterministic data timing. This proprietary technology is called the Sync-Clock.

Thanks to Sync-Clock technology and high-isolation input amplifiers, it is easy to monitor, for example, the power bus, vibration, strain and temperature fully synchronized to ARINC data, video feeds from onboard cameras in NTSC and PAL formats and higher-speed videography to analyze actuators. All data is synchronized from the very beginning to eliminate the need to laboriously time align multiple files later.

But the real power of Sync-Clock is shown in the analysis of the data. Since everything is already recorded in sync, analysis can be performed immediately – even online during the test. This prevents the need for expensive retesting, as well as better overall test results. A single instrument covers a wide range of measurements and provides easy setup and powerful online and offline functions and screens. Dewetron makes portable, bench-top and 19in rack-mounting systems that enable today's busy flight engineers to get the most from their time in the air and on the ground.

FURTHER INFORMATION

Dewetron, Parkring 4, 8074
Grambach bei Graz, Austria
Tel: +43 316 3070 0
Fax: +43 316 3070 90
Email: info@dewetron.com
Web: www.dewetron.com

or go to online enquiry card 115

INDEX TO ADVERTISERS

Fly by tire

The Transition is a car and an aircraft rolled into one, and it could be coming to a garage near you

BY RICHARD GERSH

At the end of October 2012, Terrafugia demonstrated the Transition flying car in action to 300 employees, customers, investors, FAA and other government personnel at Lawrence Municipal Airport, Massachusetts. Chief test pilot Phil Meteer put the vehicle through its paces, demonstrating the Transition driving, converting and then flying, before converting back and driving again – the first true flying car.

In 2012, Terrafugia CEO/CTO Carl Dietrich closed a US$2.7m Series D1 investment round, and Terrafugia successfully completed its contribution to Phase II of the DARPA TX program with the delivery of three-quarter-scale hardware and test data. In the meantime, Terrafugia COO Anna Mracek Dietrich has been actively participating as an industry representative on the FAA Aviation Rulemaking Committee to analyze and provide recommendations for the revamp of FAR Part 23, which has given the company tremendous insight into the evolution of the light aircraft certification process. The new developments have led Terrafugia to initiate a new internal program.

THE TEST PROGRAM CONTINUES

The company says it is actively flight testing and drive testing to evaluate the durability of the Transition airframe in real-world environments. Any issues that are discovered in this phase of testing are either noted as items for evaluation and potential redesign on the next vehicle, or are modified in place on the current prototype.

Once the engineering team is satisfied that the majority of the field issues have been identified from this prototype, the team will evaluate if the number and magnitude of potential modifications warrant the construction of another prototype prior to final compliance testing for certification.

Although the team says it is very pleased with the vehicle's flying and driving characteristics, it also agrees that there is always room for improvement. Recent flight testing has resulted in some aerodynamic improvements to the Transition. The most substantial modification has been the extension of the leading-edge strake at the root of the wing. The primary purpose of this modification is to reduce the magnitude of the wing-fuselage interference drag. A secondary benefit of this modification has been the stiffening of the doors. The team has also received positive feedback on the resulting aesthetic improvement.

The Transition must meet the US Federal Motor Vehicle Safety Standards of the National Highway Traffic Safety Administration as part of the automotive certification process. Drive testing has moved from the organization's corporate parking lot to the New Hampshire Motor Speedway.

Recent testing has determined that the Transition is capable of stopping from a speed of 60mph in only 110ft on a dry pavement. This remarkable braking performance is due to the combination of the Transition's powerful all-wheel disc brakes, its low weight, and tires that provide excellent grip.

The test drivers have been impressed with the Transition's ground performance. "It handles really well – especially considering it's an airplane. It's fun to drive!" said vice president of engineering Andrew Heafitz. ∎

STATEMENT OF INTEREST

In a statement to *Aerospace Testing*, Terrafugia said, "Although we continue to make significant progress toward production, we do not have a specific date for certification and initial production at this time. We're not at the finish line yet, but we can see it from here."

COO Mracek Dietrich added, "We are confident that production is on the horizon, but the final schedule will be substantially informed by the necessary actions that result from the ongoing testing program."

The company was unwilling to give much more away. "While we appreciate that there is substantial interest in knowing when production will begin, the current endurance testing must be completed to determine if an additional design refinement cycle may be warranted prior to initial production," the statement explained.

In 2012, the order backlog for the Transition passed the 100 customer mark and it now represents approximately US$30m of product.

The statement continued, "We look forward to the day when you can experience flying and driving the Transition yourself. We know that within the aviation and automotive media, interest is high. However, the general public and mass media remain fascinated by this concept as well. Terrafugia YouTube videos have been viewed more than 5,000,000 times."

Richard Gersh is vice president of business development with Terrafugia, based in Massachusetts, USA

TEAL
We Power Technology™

Simplify Your Automated Test Equipment or Simulator Installation with TEAL



TEAL Provides ATE and Simulator Power That Is:

CLEAN - Electrical noise and harmonics filtered out.

RELIABLE - High quality designs & construction ensure longevity.

BUILT TO LAST - For the life of your equipment or simulator.

FLEXIBLE & EASILY CUSTOMIZED - Our modular power architecture enables a single platform for all your Automated Test Equipment or Vehicle Simulators, with integrated power and controls. COTS and custom products available.

1-800.888.8325 - www.teal.com

We Power Technology™