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

JUNE 2010

AEROSPACE TESTING INTERNATIONAL

Polar air

Flight trial program of the RNZAF 757 as next generation Antarctic carrier

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The X-37 space rocket launches. The X-51 hits record Mach time

Early warning signs

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WHAT MOVES YOUR WORLD

MOOG

It is a Sunday, April 18, 2010: I am attempting to drive around the London ring road (M25, biggest car park in the world). Myself and my three children are just passing under the flight path of the biggest airport in Europe: Heathrow, London, UK. We are going for a picnic in Windsor on the 'Long Walk'. My son points to a phenomena that makes me gasp: 'Benjamin, get a pen out of the glove compartment and write on the back of that old supermarket receipt', editor tells new 13-year-old sub ed. 'I will dictate, write this down son.'

This is what he wrote verbatim, as I drove and dictated: 'Driving along the M25, on a bright and sunny day just short of Windsor, where we are about to have a picnic, my son points up from the passenger seat and says, "Dad can you see something strange, in the sky?" Expecting to see a UFO or meteorite but instantly disappointed, I reply with a 'no', until he says, "There isn't a single plane, white fluff lines, or any sign of any air 'stuff' above us." I am four miles from Heathrow, and just 25 miles from Gatwick (40 miles from Stansted) and the sky is empty. It really is amazing.

"I have spent time in very, very remote parts of the world, the Sahara, the Arctic Circle, northern Canada, Siberia, and yet in all of these places, you still see aircraft flying overhead; you just can't get away from contrails… My dad is a complete and total idiot." (His surprise addition) There ended the dictation. Benjamin, you're fired.

It was truly enlightening to see an empty clear blue sky above the west of London. Normally it can be quite cloudy, and it is now becoming clear why. There are new investigations only announced this month into 'contrails'. Reading University's Professor Keith Shine, an expert in clouds, said that those formed by aircraft 'fumes' could linger 'for hours', depriving those areas under busy flight paths, such as London and the local areas of summer sunshine.

"People from abroad are amazed by the number of vapour trails in the skies over London,' he said. 'When the air is wet enough, the cloud formed by contrails can last for hours.'

Experts have warned that, as a result, the amount of sunlight hitting the ground could be reduced by as much as 10%. Professor Shine added: "Over the busiest areas in London and the south of England, this high-level cloud could cover the sky, turning bright sunshine into hazy conditions for the entire area. I expect the effects will get worse as the volume of air traffic increases."

Reports said that in a 2009 a Met Office study into the effects of contrails, scientists from a number of UK institutions used a weather satellite to track a large military aircraft as it circled over the North Sea. The team expected high-level winds to disperse its contrails without trace. But instead they helped to form clouds, which the researchers were astonished to find eventually covered a massive 20,000 square miles.

In the USA, there are even conspiracy theories regarding airplane created cloud cover: One scientifci blog states: "Ordinary condensation trails from the jet airplanes are produced when the exhaust water vapor condenses on dust particles at high altitudes then turns into ice crystals and dissipates within 20 minutes. However, the new phenomenon of contrails has a vast visual difference and longevity. The term chemtrails was coined to explain the condensation trails which persist in the sky for hours, spread wider than in the past and eventually multiple 'chemtrails' form milky veils or create cloud like formations. Various unusual chemtrail patterns can be observed daily in many parts of the North America. They appear to be denser, have an off white color and different hues can be created when the sunlight goes through one of the chemtrails.

"Furthermore, there is evidence pointing to the fact that the new type of contrail has a different chemical composition and no longer consists of mere water vapor," was just one view, which went on to suggest that the chemicals that fall to the ground could be a health hazard. I could not possibly comment.

There is an article on the effects of the volcano on aviation and the reaction on page four. However, I am slightly startled by what I think is a knee-jerk reaction to the ash cloud. BAA, which owns Heathrow and Stansted airports, said the total impact of the ash cloud, along with the BA strikes was expected to be £40 million. However, aircraft sent into the cloud had minimal detrimental readings.

Who needs ash clouds to block out the blue sky, when aircraft vapor trails do it all by themselves.

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Aerospace Testing International is published four times per year by UKIP Media & Events, Abinger House, Church Street, Dorking, Surrey, RH4 1DF, UK. Tel: +44 1306 743744; fax: +44 1306 742525; editorial fax: +44 1306 887546. 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. Distributed by US Mail Agent, Clevett Worldwide Mailers LLC, 7 Sherwood Ct, Randolph, NJ 07869, USA. Periodicals postage paid at Dover NJ, 07801. POSTMASTER: Send address changes to: Aerospace Testing International, 19 Route 10 East, Bldg 2 Unit 24, Succasunna, NJ 07876, USA. Printed by Nuffield Press, 21 Nuffield Way, Ashville Trading Estate, Abingdon, Oxfordshire, OX14 1RL.

ANNUAL SUBSCRIPTION £42/US$88

COVER IMAGE: RNZAF Boeing 757 lands at McMurdo Sound, Antarctica

ABC Average net circulation per issue for the period 1 January 2008 to 31 December 2008 was 10,462

Published by UKIP MEDIA EVENTS

Cloud busting

A REPORT ON HOW THE AIRBORNE THREAT FROM ICELAND'S VOLCANO WAS MONITORED AND CHECKED BY EUROPEAN RESEARCH AIRCRAFT

BY DAVID OLIVER & TIM RIPLEY

In the first week after Eyjafjallajökull spewed a giant ash plume into the sky, the temporary closure of large portions of European airspace resulted in a US$4.7 billion loss to air travel disruption, with further flights canceled through to May 24, 2010, adding to that figure.

During the European-airspace shutdown there were conflicting reports of not only the spread of the ash, but the amount of potential damage to aircraft, and more crucially, engines, that it would cause. There were initial reports of NATO Typhoon jet fighters suffering airframe and engine damage after flying through the ash plume, but these later proved to be unfounded. In the meantime several European airlines flew test flights within the exclusion area with the post-flight inspections showing no damage. However, it was the reports from a few specialized research aircraft that should have paved the way for the flight ban to be lifted.

The UK Met Office was accused of over-reliance on computer modeling, but it was hampered by the fact that its only large atmospheric research aircraft was grounded during the crucial period prior to maintenance and a repaint. This was the Facility for Airborne Atmospheric Measurement's (FAAM) BAe-146 Atmospheric Research Aircraft (ARA) which is owned by BAE Systems, operated on its behalf

The FAAM BAe-146-300 Atmospheric Research Aircraft (ARA) was grounded during the shutdown of Europe's airspace (BAE Systems)

Above: The NERC Dornier 228 flew more than 30 hours, monitoring the Icelandic ash plume over the UK (David Oliver)

Right: Digital Globe satellite imagery of icelandic volcano (Digital Globe)

One aircraft: case study

In April, British Airways sent up one of the first test aircraft to check the effects of the cloud. Prior to the flight, and to formally establish its condition, BA Engineering at London Heathrow conducted a full survey of the aircraft structure and engines.

The inspections included the aircraft radome, wing, and stabilizer leading edges, flight-deck windshields, passenger windows, sensors and probes, landing lights, and engine inlets. Digital images of each of these items were taken to ensure a full comparative assessment of the hardware could be conducted once the flight had been completed.

Borescope inspections of each engine, including the compressors, combustor, vanes, and turbine were also conducted on each engine position. A number of engine-oil and fuel filters, together with aircraft recirculation fan and equipment-cooling filters were also replaced.

To assess fully the performance of the aircraft in the suspected area of contamination, the flight was conducted at various altitudes and geographic locations. At each condition and after a period of stabilization, the performance of the aircraft was closely monitored by the flight crew and observers.

Particular attention was paid to the performance of the engines, the presence of any acrid odor build-up within each zone of the cabin, the condition of the wing and aerofoil surfaces, together with the condition of the windshields and passenger windows. No deterioration or odors were detected or observed during the flight. From their base in Derby, the engine manufacturer, Rolls-Royce, also monitored the performance of the engines in real time.

Following the successful conclusion of the flight, the aircraft returned to BA's aircraft-maintenance facility in Cardiff for detailed after-flight checks. All the checks showed no deterioration from the condition previously recorded at London Heathrow. Playback of the aircraft flight-data recorders was carried out at the engineering base in London. Analysis of this data indicated that all four engines performed without fault and that they had not suffered any deterioration as a result of the flight.

by Directflight Ltd, organized and tasked by the FAAM which is a joint structure owned by the Meteorological Office and the Natural Environment Research Council (NERC).

The BAe146-300 ARA is a converted regional airliner extensively modified to provide a versatile sensor-fitted platform to the FAAM. Capable of extended operations up to 1,800 miles, a ceiling of 35,000ft and a duration of 5.5 hours, it carries a crew of three and up to 18 scientists.

With the ARA unavailable, FAAM had to reply on NERC's twin-turboprop Dornier Do 228 research aircraft. Leased from the German Aerospace Research Institute (DLR) the Do 228 is normally used for low-altitude remote sensing of the land and atmosphere, using instruments such as radar and the light detection and ranging (LiDAR) system. The aircraft has six hardpoints below the cockpit-area for external loads such as SLAR-antennae and atmospheric samplers, plus two underwing pylons for lighter loads. The Dornier is also fitted with a storm scope and weather radar that are standard in any commercial aircraft, but which are not able to detect the volcanic ash clouds. Although unpressurized, there is on-demand oxygen for the aircrew and a constant-flow system for up to three scientist/operators which allows flights up to 25,000ft and a maximum endurance of five hours.

Locating the cloud

The aircraft operated several test flights from Cranfield airport between April 15-19, which initially proved negative. However, on its second flight, the Dornier located and tracked the edge of the plume at 8,000ft over East

Set the safe limit

A month after the Icelandic volcano burst into life, large tracts of European airspace were closed. Over subsequent weeks, the eruption continued to spew ash and other noxious gases into the atmosphere and regular closures of airspace were instituted by aviation authorities across Europe.

With hundreds of thousands of passengers stranded around the world and airlines drowning in compensation claims from disgruntled customers, the airline industry demanded an end to the 'zero tolerance' safety-regulation regime that, in the past, prevented aircraft flying through ash-contaminated airspace. The prospect of the volcano continuing to erupt for several months, with a major part of the global aviation industry effectively being closed down, was just too much to contemplate.

In a dramatic turnaround, in response to pressure from the industry and traveling public, the regulatory authorities across Europe rushed to introduce a new regime that set 'safe' limits of ash densities, allowing aircraft to fly in contaminated airspace. Since then the regulatory authorities, meteorological agencies, airlines and aerospace industry across Europe have worked to fine tune this new safety regime.

The UK Civil Aviation Authority (CAA) has led these moves, and at its meeting with those with an interest in the volcano crisis on May 17, 2010, set up a new concept of operations. This introduced a system of zones, with a Time Limited Zone (TLZ), a black, No Fly Zone (NFZ) and a red, Enhanced Procedures Zone (EPZ).

According to the CAA, aircraft and engine manufacturers, basing their decisions on additional research and analysis, agreed that it was safe to allow operations in the new zone for limited periods of time, at higher ash densities than were previously permitted.

To operate in the new zones, airlines have to present the CAA with a safety case supported by their aircraft and engine manufacturers. The UK airline, Flybe was the first to achieve this, and was able to use the new zone from midday on May 18. Areas of UK airspace that would have previously been closed, could now safely open, further minimizing flight disruption.

"I'm pleased that the huge efforts we're all making across aviation to keep flying safe while minimizing the disruption from the volcano have resulted in further progress, said Civil Aviation Authority, chief executive, Andrew Haines, who announced the change. "Unprecedented situations require new measures and the challenge faced should not be underestimated.

"Firstly, because the standard default procedure for aircraft that encounter ash, to avoid it completely, doesn't work in our congested airspace. Secondly, the world's top scientists tell us that we must not simply assume the effects of this volcano will be the same as others elsewhere. Its proximity to the UK, the length of time it is continuously erupting and the weather patterns are all exceptional features.

"The answer can only come, therefore, from aircraft and engine manufacturers establishing what level of ash their products can safely tolerate," he stated. "At an international aviation conference we held (on May 13), attended by all the leading airline operators this approach was welcomed and supported.

"The manufacturers are cooperating fully and urgently in this task and the new zone is an excellent example of how the industry should be working to move the issue forward and I commend Flybe for its work. It's the CAA's job to ensure the public is kept safe by ensuring safety decisions are based on scientific and engineering evidence; we will not listen to those who effectively say, 'let's suck it and see'."

The introduction of the TLZ is based on measurements collected from test flights through the ash cloud over the last months, as well as on data and evidence compiled and analyzed from previous volcanic ash incidents, combined with additional analysis from manufacturers. Operations in the newly established zone may be subject to time limits and increased maintenance practices. The new zone's area is established using Meteorological Office forecasts, and will be approved by the CAA before operations are allowed within it.

This is uncharted territory for all parts of the aviation industry, as well as the regulatory authorities and traveling public. Most experts agree that the low density of ash found over central Europe is unlikely to cause a catastrophic incident, such as that experienced by a British Airways Boeing 747 Jumbo Jet over Indonesia in the 1980s.

However, the long-term impact on aircraft and engines has yet to emerge. The worse case is that some unforeseen chain of events leads to a fatal crash. The best case is that a new regime of intensified engine maintenance and inspection becomes the norm. Who pays for this will become interesting in an era where many engine companies and their maintenance arms provide their products under 'pay by the hour' deals to airlines. This new environment changes the economic terms of trade in a major sector of the airline industry.

This also puts increased pressure on the meteorological and other scientific research communities to come up with higher quality predictions of where the ash cloud will be and its density. Only with greater levels of fidelity will the airline industry be able to operate effectively in this new environment. This includes a lot more detailed forecasts of airspace contamination, drilling down into detail of multiple blocks of airspace.

The eruption of Eyjafjallajökull has been a wake-up call for the aviation industry and rendered the previous policy of just flying around clouds largely obsolete. The prospect that the Icelandic volcano could go on erupting for several more months, and that three neighboring volcanoes could also blow, is just too horrendous to contemplate for the aviation industry.

Easy ash trial

The world's first airline to trial a new technology called Airborne Volcanic Object Identifier (AVOID) will be easyJet. The system, essentially a weather radar for ash, was created by Dr Fred Prata of the Norwegian Institute for Air Research (NILU). AVOID places infrared technology onto an aircraft to supply images to the pilot and an airline's flight control center.

The images enable pilots to see an ash cloud up to 100km ahead of the aircraft and at altitudes of 5,000-50,000ft, enabling them to make adjustments to the aircraft's flight path to avoid any ash cloud. The concept is very similar to weather radars, which are standard on commercial airliners today.

On the ground, information from aircraft with AVOID technology would be used to build an accurate image of the volcanic ash cloud using real-time data. The first test flight is to be carried out by Airbus on behalf of easyJet by the end of July 2010, using an Airbus 340 test aircraft. Subject to the results of these tests, easyJet intends to trial the technology on its own aircraft, with a view to installing it on enough aircraft to minimize future disruption from ash.

The interior of the FAAM BAe-146 ARA, which can carry up to 18 scientists (BAE Systems)

Anglia and the North Sea toward the Dutch coastline.Different layers of the ash plume were identified when the aircraft flew between 6,000 and 20,000ft over southern England and Wales before descending to 1,500ft and then climbing to 20,000ft over Scotland. Results from these flights revealed the presence of sulphur dioxide and a number of layers of volcanic ash of varying sizes between ground level and 20,000ft.

During the six-day closure of UK airspace, the NERC Do 228 flew a total of 10 hours in the center of the ash plume and another 22 hours around the cloud's periphery. Since then dedicated Honeywell engineers have been disassembling its two TPE331 turboprop engines looking for any irregularities in any of their components.

At the same time, scientists from the German Aerospace Center (DLR), which operates Europe's largest fleet of civilian research aircraft, successfully completed a three-hour test flight to measure the ash plume over Germany. Using its highly modified Falcon 20E, DLR scientists detected volcanic ash with its LIDAR system at 30-36,000ft over southern and central Germany. After this, and subsequent flights, the Falcon's twin General Electric CF700 turbofans were thoroughly inspected, and no damage was detected.

Other test flights were undertaken by Airbus with an A380 flight-test aircraft that flew for nearly four hours in French airspace and an A340-600 that flew for five hours in French and German airspace. The flight-test crews observed nothing abnormal while airborne and the post-flight airframe and engine inspections showed no irregularities.

Questions were subsequently asked if the blanket ban had been necessary, but the answer from the civil aviation authorities was that they needed the time for testing to see what the impact of the ash was, before permitting the airlines to operate safely within European airspace. As this involved 10 separate airspaces within European jurisdiction, there is now a call for a unified European airborne atmospheric research organization, bearing in mind that Iceland's Eyjafjallajökull volcano could remain active for many months, or even years, to come.

In the meantime, the budget airline easyJet is investing £1 million in the development of the Airborne Volcanic Object Identifier and Detector (AVOID) system, created by atmospheric scientist, Fred Prata. Described as an ash radar, that would be mounted on a plane's tail fin, the technology uses infrared radiation to detect airborne ash particles up to 100km away and would enable aircraft to fly round any ash clouds, in the same way that pilots currently change their flight paths to avoid thunderstorms. ∎

JSF faces new cost crisis

Just when it seemed that the Lockheed Martin F-35 Lightning II Joint Strike Fighter was making progress, following the first successful vertical landing at Patuxent River Naval Air Station in Maryland on March 18, 2010, a new row has emerged about the projected cost of the program.

"The vertical landing onto a 95ft^2 pad showed that we have the thrust and the control to maneuver accurately both in free air and in the descent through ground effect," said Graham Tomlinson, F-35 lead short take-off/vertical landing (STOVL) pilot.

Tomlinson performed an 80kt (93mph) short take-off. About 13 minutes into the flight, he positioned the F-35 150ft above the airfield, where he commanded the aircraft to hover for approximately one minute, before controlling the descent to the runway.

"The low workload in the cockpit contrasted sharply with legacy STOVL platforms," said Tomlinson, a retired Royal Air Force fighter pilot and a BAE Systems employee since 1986.

"Together with the work already completed for slow-speed handling and landings, this provides a robust platform to expand the fleet's STOVL capabilities."

The same month, the Pentagon released details of the F-35 Selected Acquisition Report (SAR), by the Capabilities Assessment and Program Evaluation spending watchdog, that estimated the price tag of the basic 'A' model variant aircraft had surged to US$138 million and the total program cost was at US$917 billion, if each aircraft had a 8,000-hour service life.

This took into account a swath of cost overruns, including the requirement for US$3.3 billion in additional risk funding, US$1.5 billion cost overruns by prime contractor Lockheed Martin and engine manufacturer Pratt & Whitney, US$9.2 billion in cost rises due to changes in the aircraft's wing design, US$8.6 billion increases in raw material costs, US$6.7 billion in cost overruns due to changes in user requirements, US$3.9 billion in additional labour costs and more than US$3 billion in program-cost increase, due to the delivery schedule being stretched.

This latest report comes hard on the heels of previous Pentagon investigations into the JSF effort that led US Defense Secretary Robert Gates to sack the program manager and Lockheed Martin to restructure its JSF management team.

Lockheed Martin disputed the findings of the F-35 report and said it expected to deliver JSF aircraft at "far below the costs laid out in the SAR".

The Lexington Institute think-tank, however, was less impressed with the way the report was portrayed in the media, noting that the report in fact said the F-35 was "meeting all of its performance goals, passing all of its tests, and setting new standards for quality". The institute said the JSF program had "progressed more smoothly than any other fighter development programme in modern times – even though it is considerably more complicated".

"But that is not the message Congress and the public are hearing. Instead, they are awash in a continuous stream of misleading information about rising costs and schedule delays," added the institute. "The high-water mark in this flood was reached last week, when an anonymous defense official told the website InsideDefense.com that each F-35 would end up costing between US$133 million and US$158 million."

The Lexington Institute described these numbers as ridiculous and said the SAR estimates were based on historical data from the F/A-18 and F-22 programs and upon assumptions about the future that are "unknowable and untestable".

"Based on what the prime contractor has actually charged the government to date for three successive lots of fighters, the unit recurring flyaway cost for the most common version of the F-35 will be about $60 million in today's dollars," commented the institute. "That's roughly what the latest variants of the F-16 and F/A-18 fighters cost, and less than half what an F-22 costs."

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British Army buys throw-away drone

British soldiers in Afghanistan are soon to be armed with a 21st century version of the Second World War 'doodlebug'. The low-cost, disposable Fire Shadow drone will be capable of monitoring Taliban fighters for 10 hours before firing a salvo of deadly missiles at them.

The Fire Shadow drone is called a 'loitering munition' by the British Army, which says it will give it the same fire power as the RAF's airliner-sized Reaper drones – at a fraction of the cost.

British engineers at guided weapons company MBDA in Stevenage, Hertfordshire, are working on the revolutionary design in cooperation with French experts. The former UK defense secretary, Bob Ainsworth, gave the go-ahead for production of the first batch of drones last month to ensure troops in Afghanistan have the weapon by 2012. The drone made its first test flight at Aberporth, Wales, in 2008. This is the first time the British military has ordered disposable drones; Israel is the only other country that has this type of weapon in frontline service.

Fire Shadow is to be light enough to be fired from a small trailer. Once in the air it will patrol, or 'loiter', over battle zones for up to 10 hours at a time, watching for enemy activity. Television cameras will alert an operator at the control station, who will then give the order to launch the drone's onboard weapons. It carries a pack of miniature guided missiles inside an internal weapons bay.

If a target is not found, Fire Shadow will be directed to fly to an uninhabited area, where it will be crashed and its warhead detonated, so it does not become a danger to civilians. One of the British Army's requirements is for Fire Shadow to be light and compact enough to be carried inside a Chinook battlefield transport helicopter so that it can be deployed from remote areas, where it is impossible to build the runway needed to launch bigger UAVs such as the RAF's Reaper.

The initial version of Fire Shadow is expected to have a range of 100km. MBDA plans to develop versions with longer ranges and more advanced onboard weapon packs beyond the basic fragmentation warhead. These could include warheads designed to kill enemy troops in the open, to destroy static or moving vehicles and blast hardened bunkers. This would give Fire Shadow operators the ability to engage different types of targets on a single mission.

Army chiefs hope Fire Shadow will cost less than £100,000 each, once production is running at full pace, compared with the US$6 million US-made Reaper.

"As well as being cheap and deadly, Fire Shadow is designed to put the frighteners on enemy troops by buzzing around over their positions for hours at time, until they are too scared to do anything for fear of getting a missile heading their way if they break cover," said a Ministry of Defence expert involved in the project.

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Antisubmarine torpedo trial

Airbus Military has announced the successful launch of a torpedo from its C295 Maritime Patrol Aircraft (MPA) during a test firing off the coast of Spain on May 7, 2010. This is an important milestone in the development of the antisubmarine warfare (ASW) version of the C295 MPA, enabling the aircraft to enter a market dominated by veteran aircraft such as the Lockheed P-3 Orion, and the Dassault Atlantique, and new-build 'high-end' products such as the Boeing P-8 Poseidon and BAE Systems' Nimrod MRA4.

The tests are part of the company's effort to mature the design of the C295 and give it a wider suite of weapons. To date, the aircraft has been used predominantly as a surveillance and search and rescue (SAR) aircraft, rather than as an offensive ASW platform.

Airbus Military has not yet confirmed whether the torpedo capability is being developed for a specific customer or is a company-funded venture, nor did it reveal the type of weapons involved in the test. Subsequent tests are expected to include live firings against submerged targets.

The trial is clear evidence that many nations and companies are still investing the development of ASW technology and products, although purchasing equipment for land-based counter-insurgency warfare has dominated the defense procurement policies of many NATO countries over the past decade.

The C295 MPA/ASW includes two under-wing pylons for the installation of torpedoes and other external loads. It also incorporates a store management system, integrated with the Airbus Military Fully Integrated Tactical System (FITS), to control the deployment of sonobuoys for submarine detection and torpedoes.

The C295 MPA has a flight endurance of more than 11 hours and is employed for a wide variety of missions, including SAR, control of the Exclusive Economic Zone, law enforcement, and marine pollution detection, as well as defense roles.

According to the aircraft manufacturer, the C295 offers high maneuverability and excellent qualities for low-altitude flying. In addition, it has been extensively tested in all kinds of aerial deployments, such as the launch of chains of SAR rafts, emergency equipment, and parachutists.

To date, a total of 82 C295s have been sold to 12 operators. Nine countries have contracted 47 CN235/C295 MPAs. Airbus Military has sold more than 800 C295/CN235/C212s to more than 120 customers.

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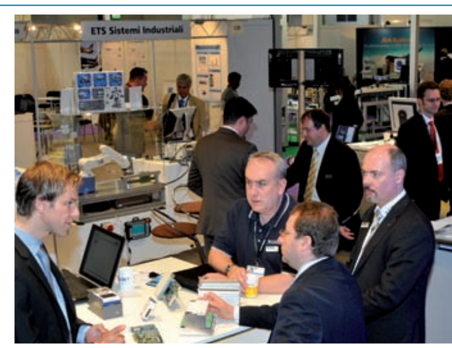
New light at old locations – Testing EXPO 2010



Aerospace Testing Expo 2010 successfully marked its return to Hamburg after a four-year break by welcoming more than 1,500 engineers from some 40 countries.

Co-located with Aircraft Interiors Expo 2010, which itself attracts more than 10,000 senior aerospace attendees, exhibitors and visitors at Aerospace Testing Expo were extremely happy with the move. "Right place for us… the co-location is a great addition to the show," said a representative from IMA.

Commenting on the new location, exhibition director Jonathan Heastie said, "Our move to Hamburg has opened the doors to a whole new 'crowd' of engineers that our exhibitors haven't met before; this was the main motive for coming to Hamburg and we are delighted that it worked. I am also very pleased with the quality of attendees this year, with senior engineers visiting with real requirements and active budgets. We had more than 125 testing suppliers on hand to help them, so I am confident that they will have sourced the right solution to meet their needs."

Testek Inc said, "Aerospace Testing in Hamburg has once again proven to be the test event in Europe. The quality of contacts is excellent… a must for the test community."

The quality of the free educational program was once again a key factor in attracting the right audience to the show, with more than 60 technical seminars presented on the show floor to visiting engineers. Twelve key disciplines were highlighted during the three-day program, with the 'Materials and Composites Testing' sessions proving the most popular. Other successful seminars included the 'Flight Testing' sessions presented in association with the Society of Flight Test Engineers.

Aerospace Testing Expo 2010 also welcomed back the European Telemetry Conference (ETC), which takes place every two years and had previously co-located in Munich in 2008. This conference focused on the most recent telemetry innovations in methods, systems, and instrumentation, with delegates and industry speakers attending from all around the world.

Summarizing, Heastie added, "The combination of a new location, and the additional visitors from both Aircraft Interiors Expo and ETC, has provided an excellent platform for us to build upon for next year. We look forward to returning to Hamburg for another successful event in 2011."

With in-house engineering, modification, and testing expertise, the US Army CERDEC Flight Activity at Naval Engineering Center Lakehurst flies battlefield electronics for paying customers. Frank Colucci visited the test organization with its rotary- and fixed-wing fleet

Inside the megabase

> Resident in a cavernous blimp hangar in south-central New Jersey, the Flight Activity of the US Army Communications-Electronics Research Development and Engineering Center (CERDEC) tests technology for government laboratories, army program managers, industry, and academia. The activity averages 40 modification programs a year on its mixed test fleet.

The spread of C4ISR (command, control, communications, and computers – intelligence, surveillance, and reconnaissance) projects flown in recent years has included foliage-penetrating radar, hostile fire indicators, and sensors to spot improvised explosive devices (IEDs). One industry contender will demonstrate its common infrared countermeasures (CIRCM) technology on a CERDEC Black Hawk this summer.

"If an experiment or R&D effort needs to get something in the air, we can fly it on a target or objective platform, or on some surrogate platform," explains Flight Activity director Charles Maraldo. "To see if something works in the air, you've got to put it in the air."

Under the US Army Research, Development, and Engineering Command, CERDEC is the C4ISR Center of Excellence for information, power, and sensor Science and Technology (S&T). The Lakehurst Flight Activity is within the CERDEC Intelligence and Information Warfare Directorate (I2WD) and supports research, development, test, and evaluation. "The S&T folks use our capabilities frequently," says Maraldo. Although CERDEC laboratories and administration are moving from Fort Monmouth, New Jersey, to Aberdeen, Maryland, the Flight Activity at Joint Base McGuire-Dix-Lakehurst remains within easy flying distance of both locations. Testers also continue to leverage the real-estate and resources of a US military 'megabase'.

McGuire Air Force Base, Army Fort Dix, and Naval Engineering Center Lakehurst, now under unified command, provide a secure, contiguous testing area with runways, laser ranges, parachute drop zones, and other special facilities. "We're uniquely postured with our airspace and geographic location," says Maraldo. Restricted airspace over and around the joint base gives testers safe low-flying areas, and the Atlantic Ocean provides high altitude routes only 25 miles away.

The 1.1 million acre megabase is also located between the electronically 'quiet' area over the New Jersey Pine Barrens and the dense signal regions around New York and Philadelphia. "We're in a sweet spot of sorts," notes Maraldo. "We have a very varied electronic environment."

Much of the technology flight tested at Lakehurst aims at communications and navigation systems. Fort Dix hosts the Army's annual C4 On-The-Move events that link ground units with aircraft, and the Flight Activity often modifies and operates the airborne platforms. In support of the 2009 event, CERDEC engineers and craftsmen designed and integrated a new common datalink antenna on a test aircraft in just a day-and-a-half.

Lakehurst, the one-time blimp hangar, accommodates the CERDEC Flight Activity and large-scale post-production modification lines

Recently repainted with a clean, white test finish, the CERDEC C-23 Sherpa continues to provide a large, easily modified sensor platform

Test team; test fleet

Hangar 5 at Lakehurst opened in 1943 and remains one of the largest free-standing structures in the world with nearly 170,000ft^2 of working space. The building can accommodate airborne warning and control system (AWACS)-size aircraft and contains avionics, metal, and fiberglass shops; electromagnetic interference/compatibility test areas; and a painting facility. Despite the spacious accommodations, the hangar housing the CERDEC Flight Activity is old, and a new, smaller-but-expandable hangar is budgeted to open in 2013.

The Army Flight Activity currently has about 30 government civilians and

“To see if something works in the air, you’ve got to put it in the air”

150 support contract workers from URS Corporation to operate, modify, and maintain its test fleet. Within the highly experienced team are 13 research-and-development pilots, some with more than 15,000 flight hours to their credit. Five of the pilots have logged combat time in Iraq and Afghanistan. "They make excellent test pilots," observes Maraldo. "They understand what they bring to the fight."

The CERDEC-assigned test fleet currently includes two UH/EH-60 Black Hawks, five UH-1H Hueys, one C-12C and three RC-12D Hurons, a C-23B Sherpa, and a few small unmanned aircraft systems.

Most of the aircraft have been modified to accommodate research and development payloads easily. Power and navigation systems and equipment racks can be reconfigured readily to test different devices and subsystems. CERDEC RC-12Ds are now receiving MIL-STD-1553 databus provisions for quick-change test payloads. One Black Hawk has a precision navigation suite with differential GPS, a small lightweight GPS receiver, and other aids to validate new navigation systems under test.

The unpressurized C-23 multisensor testbed is easy to penetrate with test equipment, and according to Maraldo, "It is just a big, flying boxcar that by virtue of its simplicity and space makes a good platform for sensor integration."

The Sherpa was equipped with the IED sensors used by C-12R aircraft assigned to Task Force ODIN in Iraq and accommodated a half-dozen workstations in the cabin to train operators for the combat theater.

CERDEC test aircraft 'owned' by the Army Materiel Command can be supplemented with special types to suit test plans. The Eurocopter UH-72 Light Utility Helicopter with US Army radio suite, unmanned Boeing A160T Hummingbird with foliage-penetrating radar, and a microlight with developmental electronics have all flown at Lakehurst.

Airworthiness authority

In-house engineering, fabrication, and qualification expertise enable the CERDEC Flight Activity to integrate one-off test hardware and fly with limited airworthiness authority.

"We will be able to fly it prior to the army being able to fly it because of our airworthiness authority," explains Maraldo (full airworthiness authority for the broader army fleet resides in the Aviation Engineering Directorate at Redstone Arsenal, Alabama).

The Lakehurst Activity is also responsible for airworthiness releases on test aircraft operated by the CERDEC Night Vision Electronic Sensors Directorate (NVESD) at Fort Belvoir, Virginia. The VADER synthetic aperture/ground moving target indicator radar flown previously on a leased aircraft will be integrated on an NVESD Twin Otter with Lakehurst authority.

CERDEC engineers and craftsmen frequently work with army program managers to field quick reaction capabilities (QRCs) for operational fleets. The RC-12D test aircraft at Lakehurst, for example, often mature QRCs for the Guardrail Signals Intelligence fleet in Afghanistan, Iraq, and Korea. CERDEC engineers also integrated the Sledgehammer QRC electronic warfare suite aboard a UH-60 using commercial off-the-shelf equipment (COTS). The follow-on Air Hammer demonstration will add active jamming capability.

In addition to their usual test work, the Lakehurst team routinely performs post-production modifications for army

"Five of the pilots have logged combat time in Iraq and Afghanistan"

The CERDEC RC-12 was used to fly the FOPEN foliage-penetrating radar

CERDEC UH-60s have received a range of antenna and equipment modifications in the course of development programs

The CERDEC C-12 is used for test and transport missions

“Typically, on any army aircraft, if we add a radio, we add an antenna; we’re looking to cut that”

program managers, other US armed services, and foreign military sales customers. US Army Black Hawks and Apaches have long received mission kits at Lakehurst for combat deployments. Brand-new UH-60M and HH-60M Black Hawks now pass through the hangar for anti-erosion rotor blade coatings, engine dust filters, and equipment kits specific to their assigned units.

“The final stop the UH-60 Mike model makes prior to fielding is here,” notes Maraldo. Skilled CERDEC pilots perform rotor track-and-balance flights required before delivery.

Paying customers

Army science and technology efforts often require surrogate aircraft for testing. Hostile fire indicator (HFI) tests for the I2WD electronic warfare air/ground survivability (EWAGS) initiative integrated a dual-band infrared detector on a UH-1 Huey to detect muzzle flashes.

Maraldo explains, “Not only is it a solution that tells the aircraft crew that they’re being shot at; we demonstrated it can give situational awareness data to the ground commander.”

Army doctrine to use such timely networked intelligence is still in development. “We tried to show some of the technology is there before the doctrine,” says Maraldo.

The foliage-penetrating radar – FOPEN – flown on a CERDEC RC-12 will be followed by TRACER. The Northrop Grumman Artemis radar meant for the now-cancelled army version of the Fire Scout unmanned helicopter was test flown on a CERDEC UH-60. Government users and contractors alike buy CERDEC test capability, and Lakehurst pilots, engineers, and craftsmen can work with sensor designers through all stages of integration. “The same crew that worked with the project from the start then takes it up and flies it,” says Maraldo.

ITT Avionics is under contract to integrate a CIRCM solution aboard a CERDEC Black Hawk that will fly past laser missile launch simulators to demonstrate its capabilities. CERDEC also has cooperative research and development agreements (CRADA) with numerous industry partners. Under a CRADA, the Lockheed Martin Airborne Multi-INT laboratory integrates C4ISR technologies on a Gulfstream G3 jet.

CERDEC also works with university researchers. The New Jersey Institute of Technology is studying ways to consolidate communications antennas on aircraft. Maraldo notes, “Typically, on any army aircraft, if we add a radio, we add an antenna; we’re looking to cut that.” Successful laboratory work may go to flight test.

In its new hangar, the Flight Activity will remain a busy test asset for CERDEC. With US Army Aviation totally modernizing its fleet, director Maraldo meanwhile wants to update CERDEC test assets with the UH-60M, RC-12X, and other modern platforms.

He concludes, “We hope to have more new aircraft that are directly applicable to the aircraft that are in the fight.” ■

For specific test programs, the Flight Activity fleet has been supplemented with unmanned microlights and other unusual test aircraft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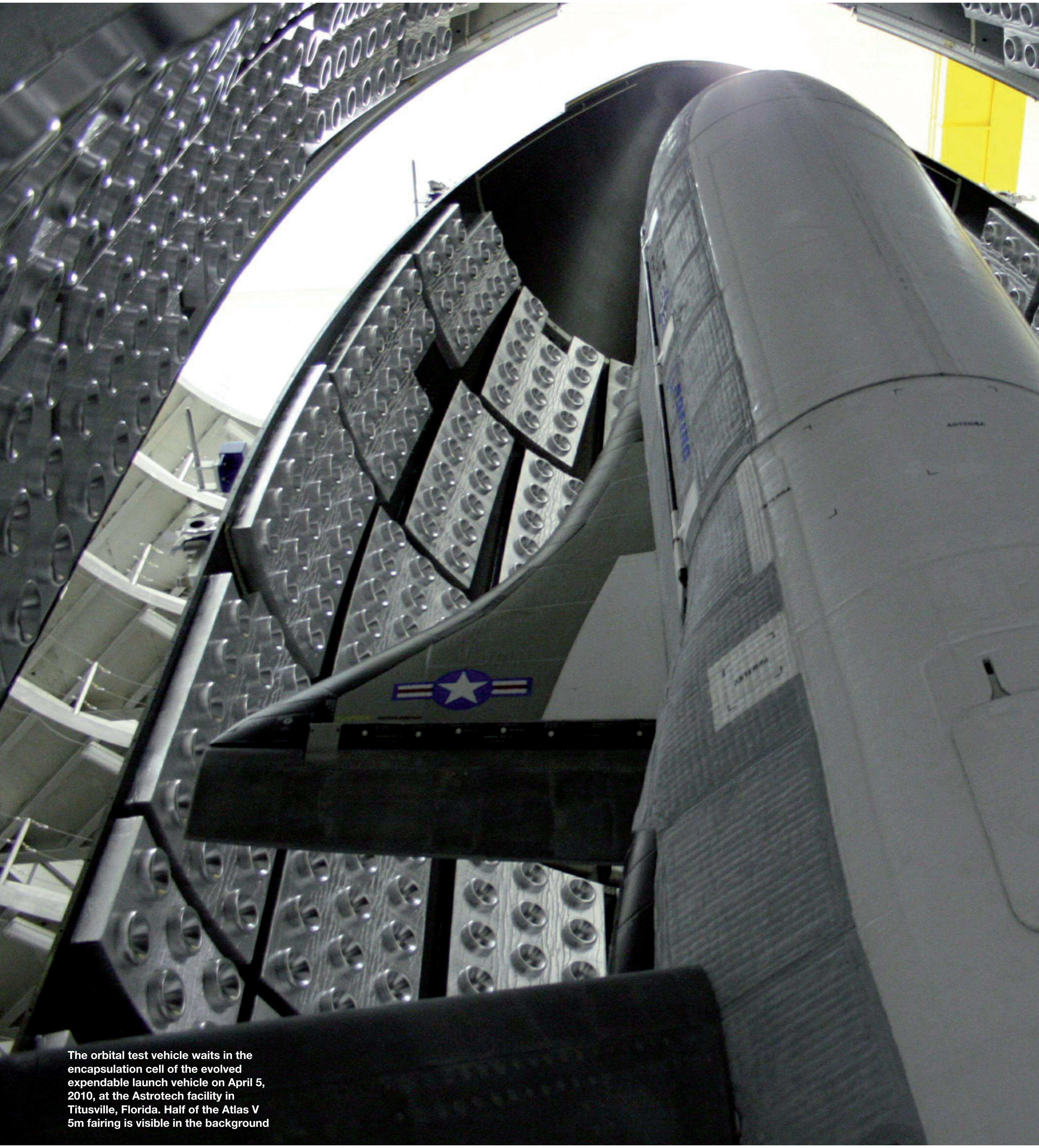


The orbital test vehicle waits in the encapsulation cell of the evolved expendable launch vehicle on April 5, 2010, at the Astrotech facility in Titusville, Florida. Half of the Atlas V 5m fairing is visible in the background

The X-men

ARNOLD ENGINEERING DEVELOPMENT CENTER TEST TEAM REACTS TO THE FIRST ORBITAL FLIGHT TEST OF X-37, AND THE X-51 HITS MACH 5

BY CHRISTOPHER HOUNSFIELD

The US Air Force-Boeing X-37B orbital test vehicle (OTV) launched into space for the first time perched on the top of the Atlas V booster from Cape Canaveral, Florida, on April 22, 2010. The launch caught the attention of engineers, technicians, and craftsmen at Arnold Engineering Development Center (AEDC), who have supported the X-37 program over the years.

"It's great to see the data we provided from Tunnel 9 on the X-37 directly supporting the upcoming hypersonic flight test," says Joe Coblish, projects group team leader at AEDC's Hypervelocity Wind Tunnel 9. "It's an exciting time in the field of hypersonics. In the flight regime of hypersonics, we test cutting-edge experimental configurations that do not always make it to flight," he continues. "Flying at hypersonic speeds can present extreme design challenges to system developers and developing cost-effective solutions in today's economic environment can be difficult on shrinking budgets."

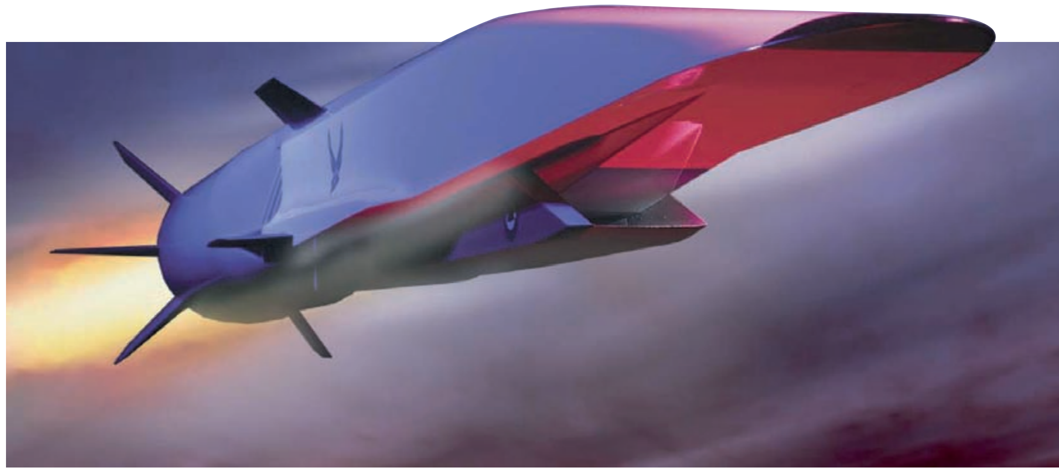
Tunnel 9 supported the X-37 twice while it was a NASA program, first in 1999 and again in 2003. "Both tests looked at high alpha – up to 60º angle-of-attack, re-entry aerodynamics," Coblish says. "This required the Mach 14 capability at Tunnel 9 – the highest Mach number wind tunnel in the USA capable of collecting integrated force and moment data."

John Hopf, a senior project engineer at AEDC, explains the role he and his co-workers performed in testing the X-37 in the von Karman Gas Dynamics Facility Tunnels A, B, and C in 2001 and 2004. "I consider the X-37 jet interaction test my favorite test during my 24-year career at AEDC because it served as a valuable learning opportunity for me by offering numerous technical challenges," he says. "I relied heavily on the expertise of a very experienced and dedicated core test team at the von Karman facility to meet and exceed the customer's expectations by achieving all of the test objectives with a minimal number of delays or problems."

According to air force officials, the X-37B is similar to the space shuttle, except it is about a quarter the size and unmanned. The OTV, at 27.5ft long and with a 15ft wingspan, will operate in low Earth orbit, like the space shuttle, and employ a suite of next-generation technologies.

Major Angie Blair, secretary of Air Force Public Affairs, says, "The first flight of the X-37B Orbital Test Vehicle focuses on checking out the vehicle on orbit and proving technologies for long-duration, reusable space vehicles with autonomous re-entry and landing capabilities. Major milestones for this mission include launch and initialization, on-orbit testing, return operations, and post-landing refurbishment. After mission objectives are

Ride the wave to M5



An X-51A Waverider flight test vehicle has successfully made the longest ever supersonic combustion ramjet-powered hypersonic flight soaring off the coast of southern California.

The more than 200-second burn by the X-51's Pratt & Whitney Rocketdyne-built air-breathing scramjet engine accelerated the vehicle to Mach 5. The previous longest scramjet burn in a flight test was 12 seconds in a NASA X-43.

The flight is considered to be the first use of a practical hydrocarbon-fueled scramjet in flight.

"We are ecstatic to have accomplished the most significant of our test points on the X-51A's very first hypersonic mission," says Charlie Brink, X-51A program manager with the Air Force Research Laboratory at Wright-Patterson Air Force Base, Ohio. "We equate this leap in engine technology as equivalent to the post-World War II jump from propeller-driven aircraft to jet engines."

The X-51 departed from Edwards Air Force Base, carried aloft under the left wing of an Air Force Flight Test Center B-52H Stratofortress. Then, flying at 50,000ft over the Point Mugu Naval Air Warfare Center Sea Range, the Waverider was released. Four seconds later, an army tactical missile solid rocket booster accelerated the X-51 to about Mach 4.8 before it and a connecting interstage were jettisoned. The launch and separation were normal, according to Brink.

Then the X-51's SJY61 engine ignited, initially on a mix of ethylene, similar to lighter fluid, with JP-7 jet fuel, then exclusively on JP-7, the same fuel that powered the SR-71 Blackbird before its retirement. The flight reached an altitude of about 70,000ft and a peak speed of Mach 5.

"Onboard sensors transmitted data to an airborne US Navy P-3, as well as ground systems at Point Mugu, Vandenberg, and Edwards Air Force Bases," Brink adds. "After about 200 seconds of engine operation a vehicle anomaly occurred and the flight was terminated. Engineers are busily examining the data to identify the cause of the anomaly. However, because of the overwhelming success of the test, this will be one of the key points to examine in the analysis of several months' worth of data derived from today's flight."

Four X-51A cruisers have been built for the Air Force and Defense Advanced Research Projects Agency by industry partners Pratt & Whitney Rocketdyne and Boeing. The Air Force intends to fly the three remaining X-51A flight test vehicles later this year, each on virtually identical flight profiles, building knowledge from each successive flight.

Brink says the heart of the aircraft is its SJY61 Pratt & Whitney Rocketdyne scramjet engine, which is capable of producing 400-1,000lbs of thrust. Like a conventional jet engine, the SJY61 is capable of adjusting thrust throughout the X-51's flight envelope.

George Thum, Pratt & Whitney Rocketdyne X-51 program manager, reveals the key technical challenge for X-51 has been integrating a fuel-cooled scramjet, where the JP-7 fuel runs through the walls of the engine, cooling it in flight, into a compact flight vehicle capable of hypersonic flight. The X-51's fuel-cooled engine design serves both to heat the JP-7 to an optimum combustion temperature and to help the engine itself endure extremely high operating temperatures during the long burn.

Boeing's Phantom Works in California oversaw vehicle systems integration and assembly. Beyond scalable scramjet propulsion, other key technologies the X-51A will demonstrate include thermal protection systems materials, airframe and engine integration, and high-speed stability and control.

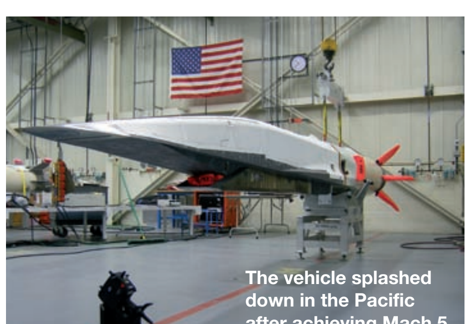
"This first flight was the culmination of a six-year effort by a small, but very talented AFRL, DARPA, and industry development team," Brink says. "Now we will go back and really scrutinize our data. No test is perfect, and I'm sure we will find anomalies that we will need to address before the next flight. But anyone will tell you that we learn just as much, if not more, when we encounter a glitch."

Program officials claim the scramjet motor's great advantage is the ability to capture and burn oxygen in the thin atmosphere, rather than having to carry it in a large tank like the space shuttle or other rockets do. Not having to carry the oxidizer needed for combustion means payload capability is increased.

Joe Norris, AEDC White Oak project engineer, puts the finishing touches on the X-37 model prior to testing at Mach 14 in Hypervelocity Wind Tunnel 9

satisfied, we look forward to a successful re-entry and recovery at Vandenberg Air Force Base, California."

The X-37B will provide a flexible space test platform to conduct various experiments and allow satellite sensors, subsystems, components, and associated technology to be efficiently transported to and from the space environment where it will need to function.



The vehicle splashed down in the Pacific after achieving Mach 5

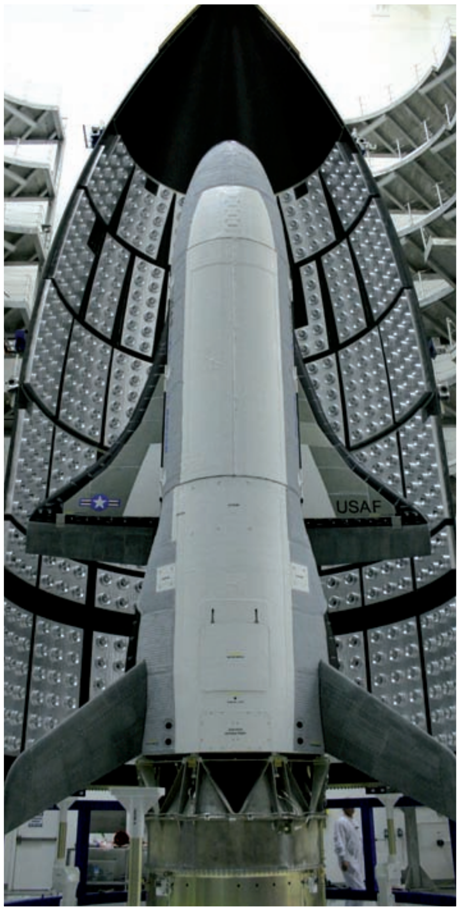
Latest technologies

A number of new technologies will also be tested on the X-37 itself. "If these technologies on the vehicle prove to be as good as we estimate, it will make our access to space more responsive, perhaps cheaper, and push us in the vector toward being able to react to warfighter needs more quickly," says Gary Payton, the Air Force deputy undersecretary for space programs.

"This launch helps ensure that our warfighters will be provided the capabilities they need in the future," says Col Andre Lovett, the 45th Space Wing vice commander and launch decision authority for the mission. "The 45th space Wing [members are] proud to launch this historic mission and continue our commitment to assuring access to the high frontier."

The mission marked a number of important firsts. "As the first US unmanned re-entering space vehicle, the first of its kind, it has been remarkable easy to work with," says Lt Col

Orbital test vehicle (OTV) launches from its Space Launch Complex-41 launch pad on April 22, 2010



Erik Bowman, the 45th Launch Support Squadron commander. "Processing and preparations went extremely smoothly and there were absolutely no delays in the vehicle processing. Overall there was great cooperation between the Air Force officials and industry teams of Boeing (United Launch Alliance) and Astrotech, where we process the spacecraft, to make sure everything went smoothly."

Breaking boundaries

The mission was also the first launch of an Atlas V with the 501 configuration, requiring no solid rocket motors, and the first launch in five years to involve a 5m class fairing. Bowman says, "This vehicle is light enough to launch without the solid rocket motors, even with the larger fairing, making this a rather unique configuration."

Based on NASA's X-37 design, the unmanned OTV is designed for vertical launch to low Earth orbit altitudes where it can perform long duration space technology experimentation and testing. Upon command from the ground, the OTV autonomously re-enters the atmosphere, descends, and lands horizontally on a runway. The X-37B is the first vehicle since NASA's Shuttle Orbiter with the ability to return experiments to Earth for further inspection and analysis.

Technologies to be tested include advanced guidance, navigation and control, thermal protection systems, avionics, high temperature structures and seals, conformal reusable insulation, and lightweight electromechanical flight systems. In addition, the X-37B Orbital Test Vehicle will demonstrate autonomous orbital flight, re-entry, and landing. ∎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Early warning signs

A HUGE MODERNIZATION PROGRAM HAS KEPT NATO'S E-3C MISSION SYSTEMS AT THE CUTTING EDGE OF MILITARY CAPABILITY FOR THE PAST 28 YEARS

BY MAJOR CRAIG GILES

The E-3A Component, NATO's first multinational flying organization, is a truly unique military unit, operating from the Main Operating Base (MOB) at Geilenkirchen Air Base in Germany and flying the Airborne Warning and Control System (AWACS).

For more than 28 years the 'Component' has blended the capabilities, cultures, and leadership styles from 16 member nations' Air Forces. The position of E-3A Component Commander rotates between a German and an American Brigadier General. The Component has a multinational workforce of about 2,200 military and civilian personnel, plus another 700 in internal and external support functions like contractors, national support units, and morale and welfare activities.

The three operational E-3A squadrons and the Aircrew Training Squadron have 30 multinational aircrews assigned from 16 of the 26 NATO member nations. In addition to the MOB at Geilenkirchen AB, the Component has three Forward Operating Bases (FOBs) in Greece, Italy, and Turkey, and a Forward Operating Location (FOL) in Norway.

However, as unique as the Component is, some of the challenges it faces are the same as any other military flying operations. Specifically, the need to modernize the aircraft capabilities while simultaneously addressing the problems associated with ageing aircraft. Here we highlight the recent fleet modernization test programs and discuss challenges associated with maintaining the ageing fleet.

Operational deployment

In the second half of the 1970s, the requirement to detect high-speed combat aircraft capable of low-level penetration made it essential to augment NATO's existing system of ground-based radars with modern airborne detection capabilities. In December 1978, NATO's Defence Planning Committee approved the joint acquisition of 18 E 3A AWACS aircraft to be operated as a NATO-owned early warning system. The Component was officially activated on June 28, 1982, and reached full operational capability by the end of 1988.

The primary mission of the NATO AWACS fleet was originally to provide a multinational, and immediately available, airborne surveillance, warning, and control capability in support of NATO objectives during the Cold War. However, challenges emerging since then have dictated that NATO had to adapt to a new environment. Failed states, terrorism, and weapons of mass destruction pose borderless threats and therefore require an expeditionary approach involving 'Out of Area' operations, potentially with non-NATO partners. The Component is currently tasked to provide full-spectrum air battle management to support effects-based operations worldwide for nominated NATO Commanders. The E-3A aircraft are able to transmit data directly to command and control centers on the ground, at sea or in the air.

The system also provides a warning and detection capability that improves NATO's air and maritime surface picture, essential for surveillance operations. Operating from the FOBs/FOL and

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Component parts

The NATO Airborne Early Warning & Control Force (NAEW&CF) was established in 1980. Force Command Headquarters is located with Supreme Headquarters Allied Powers Europe (SHAPE) in Mons, Belgium, and is commanded either by a US Air Force or German Air Force Major General. The Deputy Commander is always an RAF Air Commadore.

The NAEW&C Force consists of two operational elements called Components – the multinational NATO E-3A Component at Geilenkirchen, Germany, operating 17 Boeing NATO E-3A AWACS aircraft as well as three trainer cargo aircraft, and the RAF e-3D Component at Waddington in the UK with seven Boeing E-3D AWACS aircraft manned and operated exclusively by RAF personnel.

In May 2010 corrosion on the E-3A was detected. After repair work to the nose landing gear door and tests, the aircraft were back in the air within a week

other allied airfields allows the E-3A fleet to execute its mission in an area of responsibility that covers all NATO member countries.

The E-3A Component has participated in numerous operations since the break-up of the Soviet Union. Following the Iraqi invasion of Kuwait in 1990, aircraft from the Component were deployed to eastern Turkey to help reinforce NATO's southern flank during the subsequent war. Their specific mission included monitoring air and sea traffic in the eastern Mediterranean area and providing airborne surveillance along the Iraqi-Turkish border. From 1992 until 1997, aircraft from both the NATO E-3A fleet and the UK's E-3D fleet operated extensively over the Balkans, supporting United Nations resolutions in the former Yugoslavia and NATO missions in Bosnia and Herzegovina, and later in Kosovo, providing around-the-clock coverage. Shortly after the September 11, 2001 terrorist attacks, NATO launched Operation EAGLE ASSIST, deploying seven E 3As to the USA to help defend North America against further attacks. This was the first time in history that NATO deployed assets in support of the defense of one of its member countries.

Most recently, the E-3A Component has become an ongoing participant in Operation ACTIVE ENDEAVOUR, NATO's naval operation designed to prevent the movement of terrorists and weapons, as well as to enhance the security of maritime shipping routes. As the mission and deployment concept of NATO's airborne early warning capability has changed, so the E-3A aircraft have had to be modernized in order to adapt to the changing requirements.

The update

Almost immediately after NATO received its last E-3A aircraft, plans to update the aircraft electronics and mission systems were developed. The initial upgrade, the 'Near-Term' program, was followed by the most significant upgrade to the aircraft, the NATO 'Mid-Term' (NMT) program. This program, initiated in 1997, consisted of nine integrated system enhancements including modern software architecture for future growth.

The NMT upgrade yielded a number of capability improvements resulting in expanded command and control, intelligence, surveillance, and reconnaissance capability. Among many major updates the NMT included Multi Sensor Integration (MSI), automated digital communications switching utilizing fiber optics, new Identification Friend and Foe (IFF) capabilities, five additional display consoles, satellite communications, and wide spectrum Very High Frequency (VHF) radios. Additionally, new flat-panel displays replaced the antiquated CRT scopes, thus allowing user-friendly set-up providing crew members with improved situational awareness. The NMT program was completed in December 2008, with a total cost of US$1.6 billion, making the NATO E-3A the most advanced airborne early warning and control system platform in the world.

While the NMT upgrade provided the operators with more information from more sensors, it quickly overwhelmed the processing power of the existing onboard computers. In response, NATO launched the Computer Upgrade Program (CUP), installing new dual-processor cards with 4GB memory. The program resulted in a 500% increase in processing speed and ultimately enabled full functionality of the NMT upgrade to be achieved. This marked the point where we can really start to fully exploit the system's capabilities , a process that has barely started.

Other recent upgrades to the E-3A fleet have also made the aircraft more effective and increased the system's interoperability. The Aircraft Instant Messaging System (AIMS) capability allows real-time data transfer over secure satellite and HF and UHF (high frequency and ultra high frequency) radio communication channels. For their operations in Afghanistan the US AWACS fleet originally introduced this system, known as 'Chat'. It provides chat rooms focusing on different operational aspects. The advantage of the system is that numerous users, including ground (CAOCs) and other users (aircraft), receive the same message at the same time, making communication faster and more

The Radar System Improvement Program (RSIP) was a joint US/NATO development program

The original E-3 airframe is a modified Boeing 707-320B Advanced commercial airframe

accurate. CHAT marks the entry into network-enabled capabilities, and other assets for this could be integrated in the future.

Finally, the Automatic Identification System (AIS) is a commercial capability contributing to the E-3A's ability to build a detailed surface picture of maritime activity. In the aircraft the information used provides identification of ships. This capability is being utilized in the Mediterranean Sea for conducting counter-terrorism activities during Operation ACTIVE ENDEAVOUR.

Surveillance and maintenance

These recent mission system upgrades significantly enhance NATO's ability to provide an immediately available airborne surveillance, warning, and control capability. Yet no matter how advanced the mission systems are, the aircraft has to remain operational in order to perform the mission. This is ensured by our maintenance and logistics experts.

The E-3A is a modification of the Boeing 707 airframe originally designed and tested in the 1950s. Boeing delivered more than 1,000 707s and 707 variants between 1958 and 1994. The oldest E-3A aircraft in the fleet rolled off the assembly line in 1981 and the Component faces logistic challenges associated with operating an ageing fleet.

The aircraft are into their fourth cycle of depot level maintenance. During the third cycle, which ended in 2005, schedulers planned for each aircraft to spend 93 days undergoing depot level maintenance. During the fourth cycle and beyond, an average of 197 days are scheduled for each aircraft in depot level maintenance. This extra time is essential for two increments of sustainment in response to the age and condition of the aircraft. In the first increment, depot maintainers are replacing all upper wing fasteners (literally thousands of rivets per wing), the front wing spars, control cables, and wiring harnesses. The second increment, scheduled to begin in 2012, includes replacement of both upper and lower rear wing spar chords, lower wing fasteners, fuel bladder overhaul, and additional stabilizer inspections.

> "The aircraft are into their fourth cycle of depot level maintenance"

This maintenance schedule requires aircraft to be out of operations longer, but it ensures that the primary concern of flight safety is always kept in proper focus.

The logistics challenges are not limited to depot level maintenance. Maintainers at the base level are engaged in a never-ending process of inspecting and rectifying corrosion and structural cracks. Parts and components are exceeding their projected life expectancy, and in many cases the original equipment manufacturer is no longer in business. This requires the supply technicians and item managers to find alternative sources of supply and/or repair.

The depot maintenance cycle and the requirement to inspect and repair equipment and locate supply sources are imposing additional time constraints that reduce the availability of the aircraft for performing their primary mission. We therefore have a proactive logistics management program to forecast, schedule and accomplish the additional maintenance associated with our ageing aircraft. Moreover we have highly skilled and responsive maintenance workers enabling us to meet these challenges head-on and mitigating the impact of maintenance work on aircraft availability.

The E-3As at Geilenkirchen NATO Air Base will be watching over member nations until 2035 and possibly beyond. The role of NATO's airborne early warning capability has evolved as the world has changed, and a robust modernization program has kept the aircraft's mission systems at the cutting edge of military capability for the past 28 years. Even though the E-3A Component is a truly unique operational flying unit, some of the challenges faced are the same as any military flying organization. ∎

Major Craig Giles is the Maintenance Squadron Commander for the E-3C, based at Geilenkirchen NATO Air Force Base, Germany

Gaining integrity

A LOOK AT THE SPECIFIC CHALLENGES OF COMPOSITE MATERIALS TESTING AS IT CONTINUES TO SPREAD ACROSS AIRCRAFT DESIGN

BY DR TIM ROBERTS

Recent years have seen a notable increase in the use of composite materials in new developments of both military and civil aircraft. For instance, the first flights of the Airbus A400M and the Boeing 787 at the end of 2009 saw aircraft take to the sky and achieve step changes in the use of composite materials.

In the case of the 787 these make up 50% of the aircraft structure. There are many requirements for the testing and inspection of structures throughout the development, production and in-service support of new aircraft. The challenge to achieve the full potential of more composite aircraft is significant and there are considerable developments in terms of both design methods and testing required to realize the full benefits that they offer and to support them economically when they are in service.

The use of composite materials in new applications requires a generation of appropriate design allowables to enable structural design to be undertaken. The data, known as non-specific design data, is generated by undertaking a series of mechanical tests on standard, and as appropriate, on more specialist test machines.

As well as generating design allowables, testing is also required to qualify the integrity of more representative structures. This activity, known as specific design testing, is part of the qualification and certification process and its purpose is to confirm that the structures perform as per the intent of the design. Such test structures can range from small substructure components up to large primary structures, such as the wing, empennage and even the complete aircraft structure.

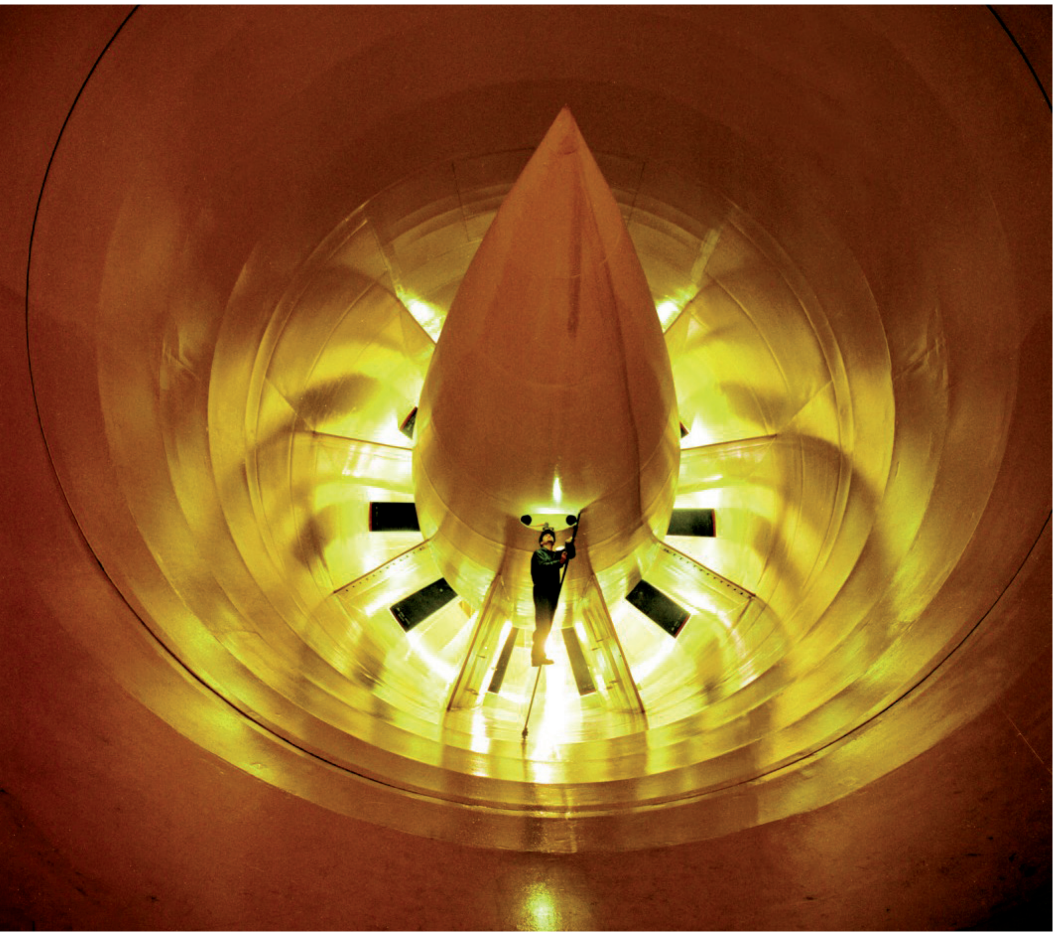
The testing to generate non-specific design data is undertaken at an early stage of the aircraft development whereas the testing for specific design to support qualification, especially fatigue testing, can go on well beyond the first flight of the aircraft. This combined testing methodology is a process that has been developed over many years of aircraft development.

However, the level of experience in understanding the behavior of metallic structures under static and fatigue load is significantly higher than for composites. Hence, the challenge going forward will be to devise test matrices that efficiently generate the data needed to provide the necessary level of confidence for the design and qualification of composite structures.

QinetiQ has provided a wide range of structural test services for a number of commercial and government customers, including Airbus on the A350 XWB and A380, Boeing on the 787, and the Australian Defence Dept on the F111 and P3 Orion. This experience has highlighted the challenges in providing an integrated supply chain of test partners that are cost-competitive and fit for purpose in delivering a solution that, in its level of technical complexity, will vary greatly between different tests.

Non-Destructive Evaluation

Having matured and frozen the design of the aircraft, the next stage of structural inspection focuses around the manufacturing phase of the first and subsequent articles. At this



QinetiQ's 5-m pressurized low-speed wind tunnel has been used by Boeing for aircraft development testing since 1987

stage it is necessary to ensure that the manufactured components are free from any significant defects and are of a sufficient quality for integration into the assembled aircraft. The traditional approach here is to use a range of different Non-Destructive Evaluation (NDE) techniques.

For traditional metallic aircraft, this is a relatively straightforward process, since potential damage is generally visible. The ductile nature of metal is such that certain types of damage caused by manufacturing errors or mild impacts may deform the structure, but as long as they do not generate cracks that exceed an acceptable size they are unlikely to be of great concern.

Composite materials present a more challenging problem in that impact damage can potentially cause internal ply delaminations within the structure that are not visible from the surface. Also, the manufacturing of composite structures poses a number of challenges in ensuring that the components are free from defects, such as ply wrinkling, excessive fiber waviness, resin rich areas and porosity. QinetiQ, working in partnership with Airbus, has made developments in the area of improving 3D characterization of the internal quality of composite structures so that these types of defects can be detected and characterized.

New NDE techniques for composites will be important not only during the production phase, but also for in-service inspection of the aircraft. For an in-service aircraft, it will be necessary to characterize any potential damage rapidly following an incident and quickly undertake an appropriate repair. High quality NDE techniques for composites offer the potential to assess damage quickly and ensure that the ideal repair is devised if remedial action is required.

Structural Health Monitoring

A technology area that has been researched for many years and is now starting to emerge as a genuine contender for incorporation into aircraft structures to support in-service inspection is that of Structural Health Monitoring (SHM). This technique involves the permanent fixing of passive or active sensor systems on the aircraft which can provide real-time, or post-event, interrogation of the state of the structure. This technique can potentially deliver a number of advantages to both the aircraft operator and the aircraft manufacturer.

For the operator, SHM can provide an immediate status indication on a part of the structure where damage may be expected. While conventional NDE techniques may work perfectly well for most areas of inspection, the real advantages of SHM are realized by applying such a system to an area that would require considerable strip down time to access using NDE.

The ultimate advantage that SHM potentially offers is realized by applying it as a fully integrated system across the entire aircraft structure, thereby delivering a high level of real-time monitoring that would provide assurance at all times of the aircraft's integrity

However, there remain a number of important practical issues which SHM technology

Stitching robot. produced by KSL Keilmann Sondermaschinenbau GmbH. Robot unit type: KL502 in linear axis configuration

First flight of the GE 787

The first Boeing 787 Dreamliner with General Electric (GE) engines – the airplane referred to as ZA005 – has completed its first flight, following a nearly four-hour trip over the state of Washington.

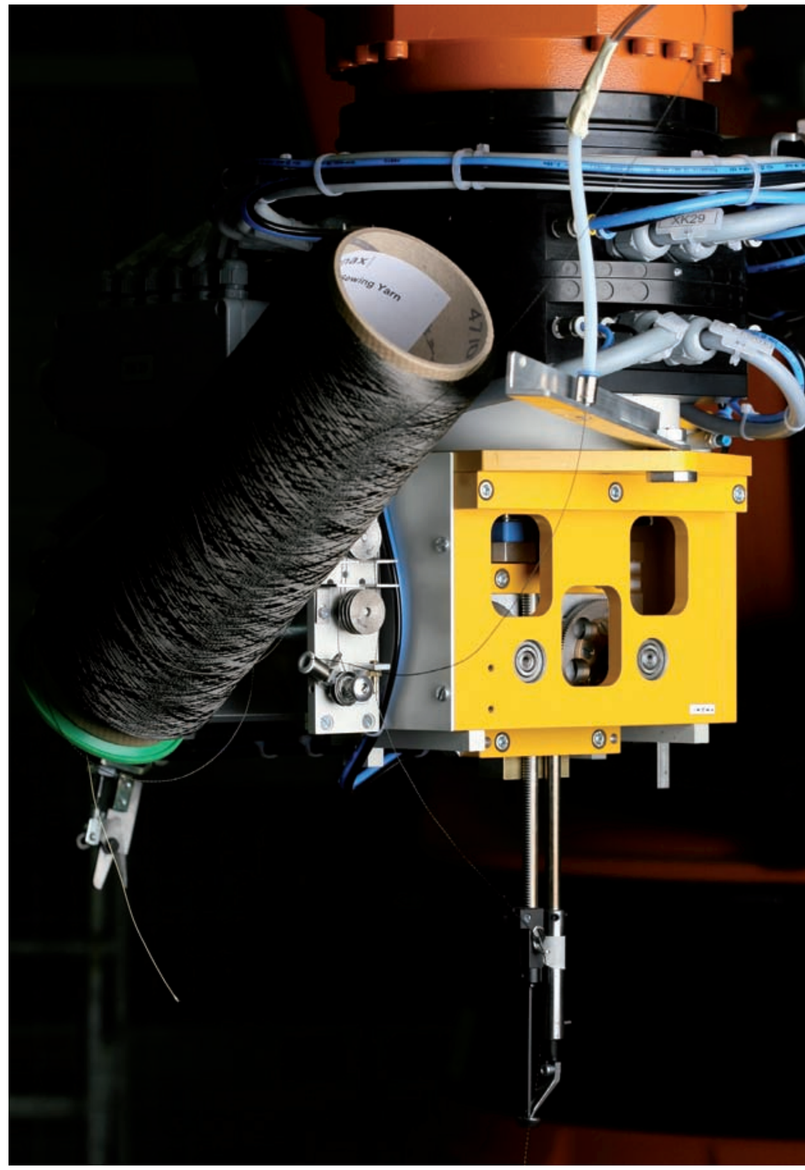
The GEnx engine is the second of two engine types offered to customers on the 787 Dreamliner. The four airplanes already in the flight test fleet are powered by Rolls-Royce Trent 1000 engines.

ZA005 will be used to test the General Electric engine package and demonstrate that the changes made with the new engine do not change the airplane's handling characteristics.

"The airplane handled just like I expected," said Bryan, who captained the flight. "It was just like every other 787 flight that I've flown in the last several months – smooth, per plan and excellent."

"We're pleased to introduce the fifth Dreamliner to the flight-test fleet and to start flight testing with GE engines," said Scott Fancher, vice president and general manager of the 787 program for Boeing Commercial Airplanes.

The sixth, and final, 787 to join the flight test program is expected to fly before the end of July 2010.



The electronic tufting head is a RS522 2-needle head with a RS530 blind stitch head RS510

system will only test the structure immediately underneath the transducer, an SHM system will propagate guided waves through the structure, providing monitoring of whole areas at a time.

QinetiQ has been working on the development of this type of SHM technology for more than a decade. Its approach is based on the use of a particular type of transducer, which is ideally suited to meet typical aerospace requirements. In particular, these transducers are low weight and low cost, and provide a high degree of flexibility in terms of how the system is configured to meet the requirements of different applications.

The most effective SHM approach in the near term will be to use the technique in tandem with conventional inspection methods. This would provide more continuous monitoring to enable more intelligent scheduling of maintenance, thus increasing aircraft availability and avoiding costly and unscheduled downtime. This could represent a smaller but important step towards seeing SHM start to bring real benefits to aircraft operators. ∎

Dr Tim Roberts is strategic business manager for Aerospace from Qinetiq based in the UK

Shear genius

NDT FOR NEW COMPOSITE DESIGNS WITH LASER SHEAROGRAPHY

BY KIM HALLQVIST

The urge to save weight on aircraft has never been more in focus, due to the demand for greener transportation and lower CO_2 emissions and also to the fact that oil prices are shooting through the roof. To save fuel you need to save weight, and to save weight you need to build with composite materials, mainly carbon fiber.

To save even more weight, sandwich structures need to be used everywhere that is applicable. Because of this, many new and exotic designs for sandwiches, including low-cost design sandwiches and foam materials are cropping up. This is not only a feature for the aerospace industry but is also showing up in the automotive and other transportation industries, giving a real boost in terms of ingenuity and new design creation.

This latest phase of design causes headaches for NDT experts who need to come up with inspection methods for each of them. The latest materials need to be 'inspectable', during the engineering and design stage, and this is easily forgotten.

Sandwich materials have always been a problematic material for traditional inspection methods, due to their physical properties. The background behind the monolithic skin is almost all air and only a very small area is the actual honeycomb cell wall.

However, a lack of bond in this small area has a vast influence on the structure. With shearography the strength of the panel is measured under a small load, with this small variation causing large weaknesses to show up. The main reason that shearography exists as a prime NDT method is in its unique capabilities to find unbonds/disbonds in sandwich materials.

To keep up with the larger use of composite materials, the inspection methods need to be optimized to keep up with the higher production speed. The throughput with Shearography is up to 2m² per minute.

The sensor used is a interferometer shearography CCD camera that looks at the surface. It has a very large field of view in comparison with traditional NDT methods. Up to 1m² large 'shots' will be recorded, producing a greater inspection speed.

Automated robot shearography system and a vacuum hood shearography system

System training

The Shearography technology reached a fundamental milestone in industry acceptance with inclusion in ASNT SNT-TC1A for Level III Shearography Certification in 2006. Over 300 NDT professionals have received shearography NDT training to ASNT Level II. Since 2008 Shearography has also been incorporated in the standard document, NAS 410, 2008 Rev 3, which is used for the European EN4179 certification

Shearography is used in the whole chain of NDT, not just from production facilities to in-field and service inspections, but also in the early-stage development of composites. For in-field systems the UK Royal Air Force uses five shearography systems with one application to inspect the 50m² E3D Sentry's Rotodome during service.

The Shearography systems are either used as an in-field system, with a hermetically sealed integrated vacuum hood which evacuates air and pulls the surface on sandwich structures to detect unbonds and weak spots. Such systems performance is about 300 x 200mm/10 seconds.

Composite manufacturing is also constantly developing automated production lines. In parity with this trend, robotic shearography equipment is also available as a standard industrial product. It can inspect up to 2m² per minute for arbitrary geometries, absolute cutting-edge performance in worldwide NDT. The system operates in a production environment, inside a vacuum chamber and excites the production parts with a vacuum, and can also load the material with up to 3kW of heat, if necessary. Objects are illuminated with eight laser diodes and the shearography sensor reads out real-time phase-stepping results. The system's interface is constructed to be easy to operate and it harmonizes with a company-written practice standard, in accordance with SNT-TC-1A. The robot system can also be equipped with a software-integrated sound excitation mode for vibration shearography through a piezo shaker or loudspeaker.

For current and future innovative industrial composite structures, shearography offers special detection capabilities in contactless large-area rapid inspection. Shearography technology is industrially mature and is excellently suited to sandwich or foam applications, and it is certified to all the main post-2008 Aerospace NDT standards. ∎

Kim Hallqvist is product manager with Dantec Dynamics, based in Denmark

Eye moored in the sky

RECENTLY TRIALS OF THE AEROSTAT RADAR SYSTEM TO COUNTER MISSILE THREATS TOOK PLACE AT THE USA's DUGWAY PROVING GROUND IN UTAH

BY AL VOGEL

The first Utah flight of a system that uses radar, mounted on aerostats, to detect cruise missiles and other threats was recently conducted about 80 miles west of Salt Lake City.

The US Army's Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System, or JLENS, made its first integration and developmental test flight above the US Air Force's Utah Test and Training Range (UTTR), north of US Army Dugway Proving Ground (DPG). The JLENS system is managed by the US Army's Cruise Missile Defense Systems Project Office, at Redstone Arsenal in Huntsville, Alabama.

Raytheon, was awarded the development of the aerostat-borne radar and communications system. In 2007, the army and Raytheon finalized a US$1.4 billion contract modification for the JLENS project.

In addition to giving battlefield commanders greater situational awareness, it will give them earlier warning and more time to assess a situation for a proper response. The advantages of aerostat-mounted radar and communications are many, compared to today's conventional systems that employ ground- or aircraft-based radar and communications.

The 74m (242ft) long aerostats are less costly to operate than aircraft-mounted radar, and can stay aloft much longer. Maintenance and repair is easier. Because the aerostats are unmanned, risk to human life is greatly reduced. They may be raised, lowered or moved in weather conditions that would ground conventional aircraft. No airstrip is required; they may be placed nearly anywhere they are needed, including tethering to ships at sea.

The Utah test and partners

The Utah test was conducted through the cooperative efforts of the army at DPG and the air force at Hill Air Force Base. Test support for the JLENS program is based at DPG.

"Dugway is proud to lead and support this important test, that will protect American warfighters, civilians and their allies around the globe," said Col William E. King IV, commander of Dugway Proving Ground. "Not only will it expand the view well over the horizon, but do so at the least cost to the taxpayer. This is a critically needed capability, as we continue to prosecute the global war on terrorism." The vast UTTR and DPG, totaling

The dirigible stayed aloft for about three hours before it was pulled back down. Raytheon was awarded the US$1.4 billion contract 2007 to build and test the aerostats

3,927m^2 (10,170km^2), were selected for testing because of their remoteness and resemblance to the mountainous, arid geography and climate of Afghanistan, where US and allied troops are fighting the Taliban and other terrorists.

The JLENS system consists of two aerostats with radar and communication equipment, tethered to mobile mooring stations that are, in turn, connected to ground-based communication and processing equipment. Each aerostat carries a specific radar system, one for fire control and the other for surveillance, and may be aloft for up to 30 days.

The aerostats are inflated at a pressure not much more than the exterior air pressure, making them difficult to shoot down. With such low pressure, even when perforated, they take some time to deflate, giving operators ample time to retrieve, patch and raise them again.

The equipment is designed to detect and track possible threats from aircraft, ballistic missiles at their boost phase (minutes after launch, in the lower atmosphere, when they cannot maneuver to evade ground vehicles and cruise missiles). These are notoriously difficult to detect, as they fly at high speed, hugging the ground contours.

The JLENS system, now under test, gives the modern warfighter a long-term, bird's-eye view over the horizon to detect such threats, and provides elevated communication capabilities.

The first flight of JLENS was in Elizabeth City, North Carolina in August, 2009 and limited to 3,000ft. In Utah, the aerostats will reach 9,000-10,000ft above the UTTR, which has restricted airspace to 58,000ft. The system is designed to rise up to 10,000ft when used at sea level.

Integration and operational tests are now underway. Later operational tests through 2013 will train army soldiers to become the nation's first JLENS battery.

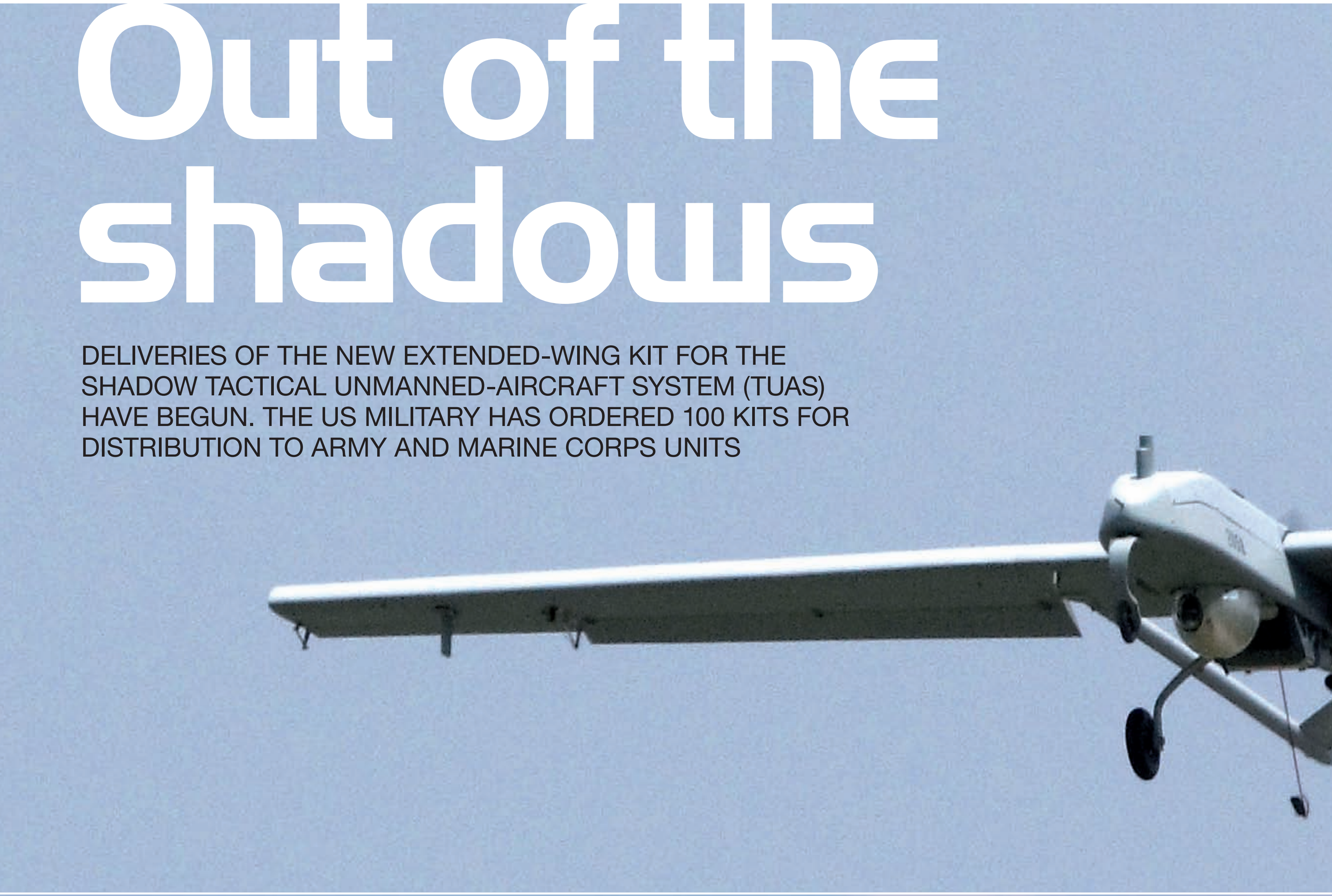
"This is one more heroic step forward as we transition the platform from the controlled environment of contractor facilities to a site which emulates tactical conditions," said Lt Col Steve Willhelm, JLENS product manager.

The JLENS program is an excellent example of joint-service testing, involving army, air force and navy, noted Willhelm. ∎

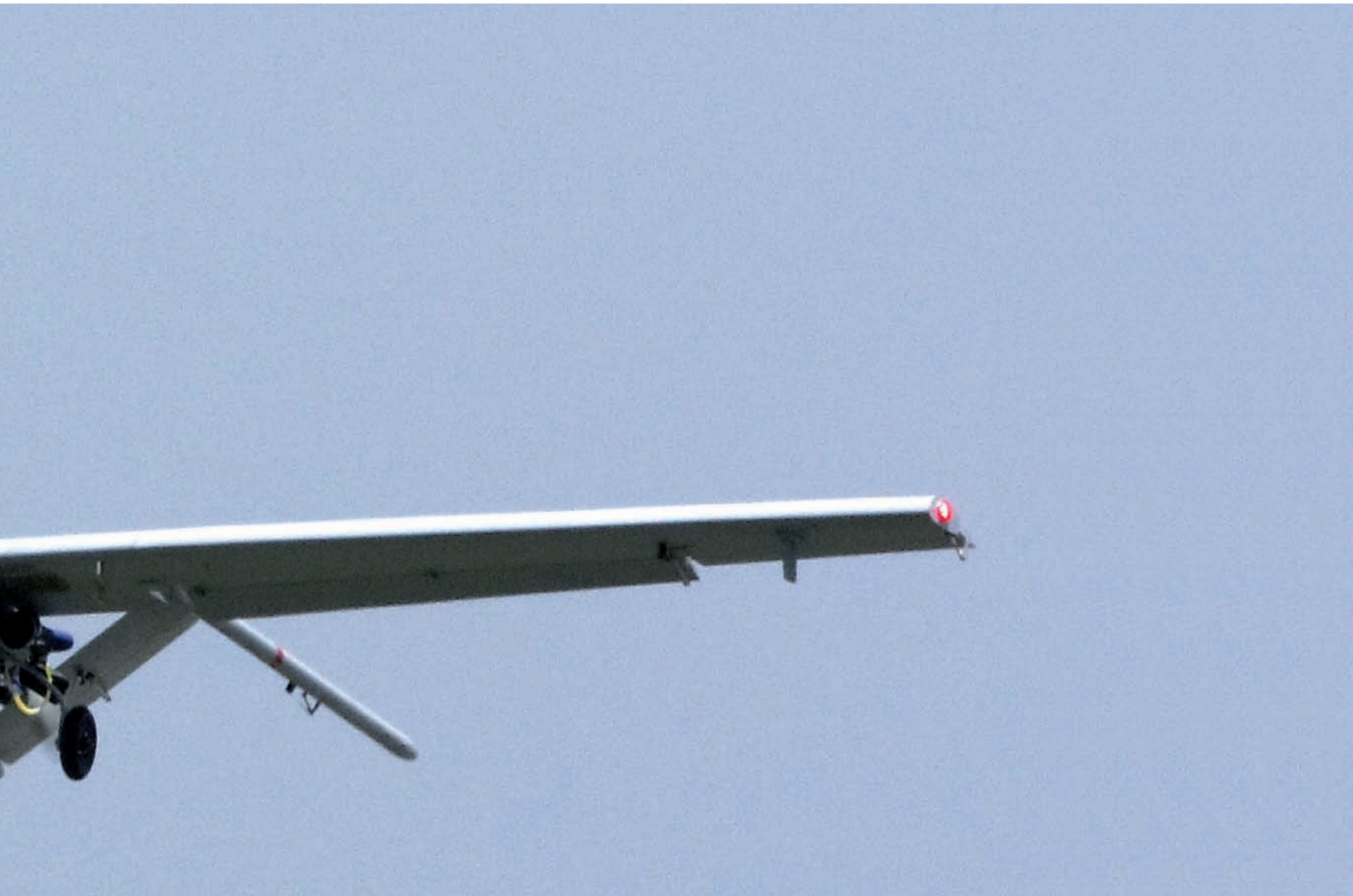
Al Vogel, public affairs specialist, Dugway Proving Ground, Utah, USA

Out of the shadows

DELIVERIES OF THE NEW EXTENDED-WING KIT FOR THE SHADOW TACTICAL UNMANNED-AIRCRAFT SYSTEM (TUAS) HAVE BEGUN. THE US MILITARY HAS ORDERED 100 KITS FOR DISTRIBUTION TO ARMY AND MARINE CORPS UNITS



The aircraft can see targets up to 125km away from the tactical operations center, and recognize vehicles from 8,000ft



BY DR MICHAEL GUTERRES

The US Army and Marine Corps have ordered 115 Shadow Tactical Unmanned Aircraft Systems (TUAS), each including four aircraft, since AAI Corporation won the program in December 1999. By May 2010, Shadow systems had amassed more than 500,000 flight hours, approximately 90% of which were in support of combat operations in Iraq and Afghanistan.

Along with its original intelligence, surveillance and reconnaissance role, the Shadow system is now equipped to handle a communications relay function and the laser designation of targets. The addition of new equipment onboard the aircraft increased its weight, and gradually reduced its capacity for continued growth.

A new wing design was proposed to customers that would address several objectives, such as increased mission endurance and the ability to mount external stores. The modification would also enable system growth and increase reliability. The new wing would extend endurance from six to nine hours, and allow a significant addition of internal and external equipment and maintain critical system-performance parameters like maximum operational ceiling, and launch altitude.

Initial concept design

Several constraints defined the path of the project. With Shadow systems in the air 24/7, the US Army could not afford to wait long for a new capability, limiting the available development time. In order to provide the greatest benefit in the least amount of time, the customer agreed that only the wing and tail set could be modified. Off-limits were the fuselage, propulsion system, launcher and aircraft transport.

In short, the aircraft could not undergo any significant fuselage changes. Also, the new wing needed to be implemented as a retrofit to a current Shadow aircraft-production configuration. After an initial design trade-study phase, Engineers were clear that a new wing and tail set could provide the required benefits within the agreed constraints.

The project began with detailed exploration of system requirements and analysis. To advance the project as quickly as possible, a multidimensional optimization (MDO) design approach was employed. MDO methods can be utilized for any complex system that has multiple, unconnected parameters that impact the final objective. When modeled and executed properly, MDO offers two distinct advantages: First, time efficiency – after initial set-up to design and implement a multidisciplinary system model, MDO makes it possible to run thousands of possible scenarios within just a few days, enabling engineers to identify an optimum in an automated way.

Secondly, a verifiable optimum – typically, several engineers would be assigned to run and evaluate design cases. Within the available timeframe, the team would need to identify a best-in-time solution. However, it would not necessarily be possible to verify that the solution was the absolute system-design optimum. Use of MDO helped to identify the best among the domain of feasible solutions, subject to system, aircraft and programmatic constraints, and enabled aircraft and system-design solutions to be optimized quickly and concurrently.

Preliminary design

The team then moved on to a preliminary aircraft-design phase. Inherent to this process is making key risk mitigation decisions, by choosing structural concepts consistent with the performance and time constraints of the project. For example, the Shadow aircraft incorporates complex composite ribs in the wing. Were the wing cord in the section including those ribs to change, the complex rib tooling would need to be redesigned.

The Shadow aircraft's wingspan increases from 14ft to 20ft

Shadow Tactical Unmanned Aircraft Systems have amassed a record 500,000 flight hours

Engineers chose to slightly alter the ideal aerodynamic plan of the wing to include this consideration and maintain the same internal ribs, then incorporate taper into the remaining structure. The team verified that this would yield the required aerodynamic performance and avoid a redesign of the rib tooling. This resulted in increased program performance to schedule.

The wing was modeled and designed to include all of the necessary aircraft equipment including the data link, antennae, fuel tanks and new hard points for external stores, as well as a new structural design as dictated by the growth in loads. Aerodynamic and structural performance were evaluated using computer-aided engineering (CAE) methodologies such as finite element analysis (FEA) and computational fluid dynamics (CFD), as well as experimental investigation of both structural and aerodynamic performance.

Initial structural analysis identified that the new loads would stress critical composite bonds to below the normal design margins for the aircraft industry. Bonding strength is vital to aircraft structural performance. AAI applied a new technology that more than doubled the shear force of the bonds. To verify this technology insertion in a fast-paced program, the team conducted comprehensive coupon and full-scale testing. Design modifications were made to enable the landing gear to accommodate the additional loads.

While modeling and analysis enhance confidence in the design, CAE tools like FEA and CFD rely upon the quality of the models and the input data. Physical testing was used to verify the accuracy of the models with quantifiable data. For aerodynamic performance, extensive flight testing verified predictions before a commitment was made to manufacturing tooling. For structural performance testing, a wing was constructed for destructive testing. Instrumented testing enabled engineers to verify the structural failure modes, quantify the failure points, and use measured data to calibrate the FEA predictions.

Each iterative decision was made after determining whether the design could be built in a feasible and achievable way, within cost and schedule limits.

"Bonding strength is vital to aircraft structural performance"

Putting it all together

The team implemented a parallel effort to design and build both a prototype and a production model of the new aircraft. This key decision enabled AAI to mitigate technical risk in the design of the objective wing, while allowing engineers to collect valuable data with a prototype.

Although their external shapes were identical, the prototype and objective, or production-realistic, aircraft were structurally dissimilar. The prototype was built in-house by the rapid-prototyping experts in a few weeks, enabling the team and the customer to verify that the new wing design would perform according to predictions and meet agreed-upon specifications.

Manufacturing and aero-mechanical engineers simultaneously worked the complex tooling required to implement the updated aircraft on the production line. Because of the time and cost involved with building new tooling, the engineering needed to be right the first time. Emphasis was placed on verifying tolerances and evaluating materials through extensive modeling, analysis and the use of Federal Aviation Administration certified composite systems.

Both aircraft were tested extensively, including ground testing, calibration testing, structural testing and flight testing, in addition to all of the CAE modeling and analysis done throughout the project. The production wing completed acceptance testing and loads testing as the first wing mock-up had done. The team also focused on other areas of the aircraft that had been modified. The landing gear was subjected to extensive drop testing and dynamic analysis to verify that it would perform successfully with the added weight of the aircraft. Also, both the in-flight autopilot and the auto-landing solution were integrated and tested for flight performance, for although the fuel system had not changed, the size and shape of the actual fuel bladder had changed drastically.

The company completed the Shadow TUAS extended wing project in 18 months and began deliveries to the customer in early 2010. The success of this effort was a testimony to the skilled team that took on the challenge, as well as sound program management and engineering methodologies, risk mitigation and comprehensive modeling and testing at every stage to verify that the customer would receive the best possible solution, in the shortest amount of time. ∎

Dr Michael Guterres is the aircraft engineering manager, AAI Corporation, based in the USA

New ice age

THE ROYAL NEW ZEALAND AIRFORCE B757 COULD BE A MORE EFFICIENT AND EFFECTIVE WAY OF TRANSPORTING PASSENGERS AND CARGO THAN THE C-130 OR C-17. THE AIRCRAFT ARE CURRENTLY BEING POLAR TESTED. THE NEXT STAGE WILL BE THE POST-TRIAL FLIGHT ANALYSIS

BY CLINTON BARNES

In December 2009, the Royal New Zealand Air Force (RNZAF) conducted a successful trial flight to Antarctica on a Boeing 757-200 aeroplane. The flight itself was the culmination of months of planning and preparation from the RNZAF's technical team and operational community.

The Antarctic destination presents its own unique challenges, most notably the weather. The weather can be notoriously changeable with high winds and low visibility which can arrive very quickly. And then of course there is the cold itself; a serious consideration if the aircraft has to remain parked on the ice for any length of time. The RNZAF has been operating the C-130 Hercules to the Antarctic for many years, but the RNZAF had never operated a twin engine commercial jet to an ice runway before, let alone to an airfield whose latitude is beyond 70 degrees south.

The idea of conducting Antarctic operations using the RNZAF's 757 aircraft was first mooted many years ago, but feasibility studies at the time concluded that the standard aircraft navigational performance, and the lack of a TACAN approach capability, meant the aircraft was unsuitable for polar operations. Over the last three years however, the RNZAF's two 757's completed a significant upgrade program.

The upgrade program installed a main deck cargo door and palletised deck system allowing the aircraft to be configured for either cargo or passenger operations or, a mix of the two. In addition though, the flight deck was also updated with dual integrated GPS, a satellite communications system, and other military upgrades. The addition of these systems coupled with the aircraft's existing suite of navigation and communication equipment meant that some of the earlier obstacles to Antarctic operations were no longer present.

“Weather planning played a crucial role in the test”

In 2007 both 757s were fitted with an upper deck cargo door to facilitate an 11-pallet cargo capability, internal air stairs, upgraded engines and flight deck

The addition of integrated GPS was pivotal. Firstly, the GPS improved Actual Navigation Performance (ANP) for long duration flights over water. In general, inertial reference units suffer from drift error which increases with flight time. Without correction this error reduces the ANP markedly for long duration flights. When flying over land the error is corrected from updates from ground-based radio beacons and acceptable ANP is maintained, unfortunately there are no such corrections available en route and in Antarctica itself.

The addition of the integrated GPS provided the necessary corrections to the Flight Management System (inertial and GPS total solution) and retained an acceptable ANP throughout the flight to Antarctica and, as importantly, the return leg to Christchurch in New Zealand. Secondly, a 757 specific Required Navigation Performance (RNP) approach was developed allowing the aircraft to operate into the Antarctic, McMurdo airfield without the need for the ground-based systems such as TACAN or MLS. The addition of satellite communications during the upgrade program also provided additional redundancy to the existing HF radios. Given the importance that the GPS played in the trial flight, consideration was given to a dual GPS failure en route.

Point of safe return

The flight planning included a Point-of-Safe Return (PSR) which was approximately two thirds of the distance south to Antarctica (this distance varies as a function of aircraft performance on the day). At this point the aircraft could be turned around and returned safely to New Zealand.

A GPS failure prior to the PSR would require the aircraft to return to New Zealand, if however a dual GPS failure occurred after this point then ANP would begin to reduce. An analysis of the drift error was calculated to determine the magnitude of the error from a dual GPS failure at PSR and showed that although the ANP was not optimal, it was still acceptable for an approach into McMurdo airfield.

The permanent ice runway was also assessed for suitability with the 757, particularly around braking performance without the use of thrust reversers. As the runway is mechanically grooved as part of its preparation, the coefficient of friction was suitably high and allowed for adequate aircraft performance both in normal and emergency conditions (up to certain strict crosswind limits). The assessment also included pavement calculations (bearing capacity) to ensure the aircraft wheel loadings were not high enough to cause localised sinking.

In terms of a twin engine operation, the Antarctic falls outside the normal FAA ETOP’s latitudes and is more akin to polar ETOP’s operations. During the planning phase however, it was determined the flight operation is within standard ETOP’s 180 planning.

Further consideration is given to the use of a PSR which falls outside the 180 minute ETOPS rule. The PSR is identified to enhance greater flexibility of the unique operation and as stated

Next time around

The project to fly a 757 to the Antarctic required a considerable amount of research and a number of risk mitigation plans to be implemented. The points discussed within the article are but a few of the many issues that required careful consideration before any certification to approve the 757 for an Antarctic trial was granted. The first trial was ultimately successful and a second, equally successful, trial flight was carried out in February 2010.

Currently, analysis from the flights continues especially around operational testing and evaluation and airworthiness. Depending on the outcomes of the study, the Air Force will look to develop the capability further during the next Antarctic operations support season.

The Mission Commander, Squadron Leader Richard Beaton, says the work done in the lead up to the first flight meant it went smoothly. "There was a lot of planning involved around the various operational, technical, and logistical issues before the flight could get underway."

Air Component Commander, Air Commodore Steve Moore, said the modernization of the navigation system, as part of Boeings' recent upgrade, removed many of the limitations of the aircraft to operate into the high latitudes of McMurdo.

"With the upgraded Boeings we were able to look more closely at a trial flight to Antarctica.

"The aim of the flight was to look at the suitability of the B757 to carry passengers to McMurdo, and the availability and suitability of passenger handling facilities, ground support equipment, and engineering support equipment required in the event the aircraft requires any maintenance," said Air Commodore Moore.

Currently, the New Zealand Defence Force operates around 12 C-130 Hercules flights to McMurdo Station each year during the Antarctic summer months between October and April.

"Depending on the outcome of the trial flights, it could be that the B757 would be a more efficient and effective way of transporting passengers than the C-130 Hercules or United States Air Force C-17, enabling these aircraft to be more effectively utilised to carry cargo. The next stage will be the post-trial flight analysis," Air Commodore Moore concluded.

previously is the maximum distance point of safe return to New Zealand given all of the associated variables, such as quick changes in weather. Operations outside the ETOPS 180 minute rule are not planned on, however the PSR is identified as the last point to return to New Zealand with all required fuel reserves, etc.

Weather planning played a crucial role in the test and was rigorously monitored before departure and throughout the flight with a final assessment of the destination weather made at the PSR. Weather updates were able to be received over ACARS using a satellite communications channel direct from McMurdo.

Although the aircraft was only parked on the ice for approximately two hours during the trial, the engineering team carried out considerable analysis on the effects of cold soaking on the aircraft should it have stayed on the Antarctic ice due to weather or aircraft unserviceability.

Polar inspection procedures

A collaborative study between Boeing, Rolls-Royce, FAA, and a former Soviet Union airline operator had been undertaken in 1995 in Yakutsk, Siberia, to study the 757 at extremely low temperatures. This study provided the basis to the 757's maintenance manuals cold weather procedures.

These procedures were varied and included additional inspections and warming techniques for avionics systems and engines. On the exterior of the aircraft ice can build up in numerous locations, including on control surface hinge joints, flaps, main and nose landing gear, radome, wing upper and lower surfaces, engines, and the tail plane.

> "The integrated GPS provided the necessary corrections to the Flight Management System and retained an acceptable ANP"

Engine oil temperatures may also be below operational limits resulting in unacceptably high viscosity and any start attempt with such cold oil can potentially damage bearings. As a consequence, warm up procedures from the maintenance manual were reviewed together with an assessment of the specialist equipment required to remove ice and warm the aircraft, also noting that Antarctic rules do not permit the use of de-icing fluids.

Simple considerations, such as having an appropriate stand to reach the refuelling point on the aircraft, all become critical elements of the assessment. So too does qualifying the ice inhibiting compounds in the fuel and even the refuel pressure itself. Furthermore, a moderate wind, as low as 20kts, can cause the aircraft to slide on an ice surface so planning how the aircraft can be moored was also necessary.

Other contingency planning was also undertaken in case of an aircraft unserviceability that would keep the aircraft on the ice for a day or more. This included a review of ETOP's 180 critical dispatch items, the level of spares to be carried in New Zealand, what spares were to be carried on board and the tooling/support equipment requirements for each. Human factors for maintenance personnel were also considered should they be required to repair aircraft in the cold conditions; after all there is no hangar at McMurdo. ∎

Engineering Officer Flt Lt Clinton Barnes is from the Royal New Zealand Air Force

“We develop ground test equipment primarily for aircraft within the defence market”

Alex Mattos and Steve Uhrmacher

Head of engineering and head of sales, Ultra Electronics Test Solutions

Ultra Electronics is an internationally successful defence, security, transport and energy company with a long, consistent track record of development and growth. Ultra businesses constantly innovate to create solutions to customer requirements that are different from and better than those of competitors. By applying these differentiated solutions to a wide range of international platforms and programess, Ultra has built an exceptionally broad range of niche market positions. Alex Mattos and Steve Uhrmacher are head of engineering and head of sales, respectively.

Can you please give your names, job titles and a brief description of what part you play in the company?

Alex Mattos and Steve Uhrmacher, head of engineering and head of sales, respectively for the Test Solutions business unit of Ultra Electronics, Electrics. Ultimately we are responsible to the MD of Electrics for the performance of the Test Solutions business. Alex is responsible for all technical activity within the business and Steve ensures that new business is secured and the customer base is developed. Ultra offers support to its customers through the design, delivery and support phases of a program. Ultra businesses have a high degree of operational autonomy so that they may provide exceptionally agile and responsive support to customers and partners. Operationally, the Group is organized into three divisions: Aircraft & Vehicle Systems, Information & Power Systems And Tactical & Sonar Systems.

Can you give a very brief overview of Ultra, specifically with regard to aircraft systems?

Ultra is a diverse Group providing many systems and products across the defence, security transport and energy sectors. As a Group we provide global expertise with operations in the UK, the USA, Australia and the Middle East. Focusing on aircraft systems, Ultra provides solutions ranging from safety-critical de-icing, electronic controls for landing gear and cargo-handling, power management, situational awareness, high-integrity harnessing, to HMI equipment and engine components, as well as on-ground system test solutions.

Test Solutions fits under the Aircraft and Vehicle Systems division located in Cheltenham, UK. Customers include the US Navy, US Army, UK MoD and most global OEMs including BAE Systems, Lockheed Martin, Boeing and Sikorsky.

Could you describe the Test Solutions business unit in some more depth?

Ultra Electronics, Electrics - Test Solutions is the new name for BCF Designs, which was acquired by Ultra Electronics in 2007. We develop first and second line ground-test equipment, primarily for aircraft within the defence market. We are also, however, seeing increased demand from the commercial aviation market. Our fuel system-test product is general purpose test equipment that is in use across a range of UK MoD and US Navy aircraft. We are currently exploring the test-equipment requirements for military land systems, as they become increasingly more complex.

Electrics supplies automatic portable test equipment and harnesses for integrity validation, safety testing and calibration of fixed and rotary-wing aircraft fuel, databus and electronic filtering systems. Ultra Electronics also supplies systems for the detection and monitoring of structural anomalies, including cracks, in various types of material. These systems are used in a ground-based test environment, or fitted to aircraft to provide continuous monitoring of structural integrity

What does Ultra see as the latest prime development in aerospace testing and also your part in it?

Collation, analysis and interpretation of test data is the next big step. Once you are testing multiple platforms using intelligent test equipment with the ability to record the results, collating and analyzing this data allows platform operators to reap the benefits of system prognostics. It enhances understanding the operational parameters of the system to the extent that maintenance can be performed at the optimal interval to ensure platform availability, whilst reducing maintenance and logistics costs.

What portable test facilities have you recently put to the industry?

The latest product to be introduced to the testing market is our upgraded fuel-system test set, the DE8491EX. The product gives the front line aircraft maintainer the ability to verify the performance of the aircraft fuel system from in-tank probes, including all of the aircraft-harnessing and signal-conditioning units through to the cockpit gauges. This is a first line, ATEX (Explosive Atmosphere) approved piece of equipment that has enhanced features and performance benefits from our previous fuel system test set.

What are the latest systems on the Ultra Electronics – Test Solutions drawing board?

Aged-wiring is a significant problem for the aerospace industry; we are currently working with a UK university and our sister company in the USA, Ultra Electronics, Flightline Systems, to develop effective preventative solutions for an issue which is becoming increasingly problematic as military platforms remain in operational service for longer timeframes than were ever originally anticipated.

What message would you like to give to the aviation test industry?

We are a business unit actively investing and developing our product capabilities and service offerings, which has lead to an increase in the availability of our customer’s platforms.

"You hit the igniter and you're in the air in four short seconds, making the X-Racer look more like a rocket with wings"

BY MICHAEL D'ANGELO

It was in 2006 that *Aerospace Testing International* magazine first wrote about the Rocket Racing League (RRL) concept, and it was a concept. It is now about to become the newest phenomena in sports and entertainment, but fundamentally, it's a canard-style aircraft powered by a rocket engine. You hit the igniter and you are in the air in four short seconds, making the X-Racer look more like a rocket with wings.

Pilots fly the Rocket Racers through a virtual Raceway-In-The- Sky (RITS) superimposed on their helmet displays, a system called TargoRacer. Spectators see the RITS via JumboTrons or giant screens, and the use of an RRL-developed ground and air-augmented reality system. Four cameras strategically placed in each aircraft give fans the sensation that they are flying the X-Racer right alongside the pilots.

As of summer 2010, the RRL has built, tested, and flown three versions of the

Flying the inside groove

THE LATEST ROCKET-POWERED TEST AIRCRAFT TAKE JUST FOUR SECONDS TO GET IN THE AIR FROM IGNITION. THE BRINK OF TAKE-OFF OF THE RRL

X-Racer, and has demonstrated this flight capability in three public exhibition events: the 2006 New Mexico X PRIZE Cup, Oshkosh Air Venture 2008, and the 2010 Tulsa Air and Rocket Racing Show. Currently the RRL is flight testing two of the three designs, the Mark-II and Mark-III. In more than 50 flights, we have totaled more than 350 in-flight re-lights, mostly in aerobatic but more recently in duo-racer tandem formation.

What have we learned?

The major building blocks of a Rocket Racer are the airframe, the rocket propulsion module, the avionics package and the ground support equipment necessary to operate the vehicle, and of course a highly skilled pilot.

The current Rocket Racer airframes, derived from experimental aircraft manufactured by Velocity Aircraft in Sebastian, Florida, have been through three design iterations to better configure the airframe for the dedicated purpose of rocket racing. Along the way, we have incorporated lessons learned from flight tests, ground tests, public exhibitions and analysis.

The Mark-III design, which had its public debut at the April 24, 2009, Tulsa QuikTrip Air and Rocket Racing Show, contains a number of major improvements over previous designs:

First is a fighter-style canopy which now replaces the traditional gull-wing doors, providing pilots with enhanced visibility for close-in operation, and when competing multiple Rocket Racers are in close proximity. The two-seat, side-by-side configuration has been replaced with a single center seat, adding to the enhanced visibility now possible with the canopy top.

The cockpit was redesigned to reinforce ease of single-pilot operation, which also eliminated the need for a flight engineer to accompany the primary pilot. Design changes in this configuration allowed equipment to be moved to side consoles to free up the front instrument panel. The aft-engine cowling was redesigned for better pressure recovery to reduce overall vehicle

The current Mark-II and Mark-III designs are limited to 300mph

drag for better conversion of velocity to altitude. This involved elongating the aft-engine cowling, also requiring an aft extension on the engine thrust chamber.

Also, the key load-bearing structural components of the airframe have been reinforced and strengthened, enhancing the performance potential for higher g flight and off-nominal operation. Reinforced areas include the fuselage area surrounding the main propellant tanks, the main wing spar and the landing gear.

Finally, to enhance yaw stability, fins were added to the aft section of the aircraft. These fins, along with the canopy top, are perhaps the most 'visual' of all the upgrades. The Mark-II design was retrofitted with the same aft fins and canopy top.

Propulsion

X-Racer engines are now being developed and tested by Doom and Quake creator John Carmack and his team at Armadillo Aerospace. The Armadillo propulsion module, a LOX-Ethanol film-cooled, pressure-fed blow-down engine, is well-designed to best suit the needs of the RRL X-Racer. Generating in excess of 2,500 lb of thrust at lift-off, the newest generation of X-Racer lifts off in four seconds; whereas previous versions of the Rocket Racers took 15 seconds. This improvement in performance means that in just a blink of the eye the X-Racer is in the air, after the pilot fires the engine. No one gets off the ground this quickly.

The propulsion module has the capability to dye the rocket plume with a variety of colors, by injecting into it a mixture of water and a specific chemical that when heated emits color in desired spectra. This 'plume seeding' has been demonstrated in green (barium), red (strontium) and yellow (sodium) to allow for a more exciting visual display and to make it easier for fans to follow their favorite team's Rocket Racer.

Similar to the airframe, the engine has undergone several iterative design improvements, better suiting it to the needs of the Rocket Racing League in the areas of safety, reliability, and performance, all based on actual runtime experience in ground and flight testing. The current propulsion module contains four major upgrades over previous designs, retrofitted into the two Rocket-Racers currently in the air:

First, flight test showed that restarting the engine multiple times while aloft, at different attitudes, loading and in different atmospheric conditions proved to be a challenge for a variety of reasons. By redesigning the igniter to eliminate the possibility of igniter plume impingement on the face of the injector manifold, the life of the engine overall was greatly enhanced.

Second, an enhanced thrust-containment system was incorporated to eliminate the introduction of a destabilizing side-thrust event following an unlikely certain mode of engine failure. Third, a so-called burn-through sensor system for early detection of a certain combustion chamber anomaly was installed, enabling the safe shutdown of the engine and return home. And, lastly, the injector manifold for higher performance and longer life was redesigned. The injector manifold is the component that mixes fuel and oxidizer in the combustion chamber.

> "The propulsion module has the capability to dye the rocket plume with a variety of colors"

The pilots are selected and include aerobatic pilot Sean Tucker, Len Fox, Dave Morss and Jim Bridenstine. They typically possess backgrounds in aerobatics and military fighter jet domains

Raceway avionics

Whether for a demo exhibition or an actual race competition, RRL pilots navigate their Rocket Racers within a three-dimensional track in the sky. RRL's RITS can be created in an unlimited number of race formats, shapes and locations. The raceway consists of a course created through a simulations tool that is then uploaded to the RRL's custom avionics package – melding the real world with the virtual, and presenting to the pilots and spectators a real-time depiction of the virtual raceway, navigation metrics and safety aids. Rocket Racer pilots are able to navigate the

raceways using a variety of displays from in-panel to helmet-mount. Each Rocket Racer vehicle draws from precise differential GPS tracking with an integrated inertial navigation system, providing spatial accuracy within a few meters.

In 2009 RRL partnered with Elbit Systems to migrate our raceway avionics from the instrument panel to the pilot's direct line-of-sight. What this specifically means is that previously, we projected the raceway on an in-panel cockpit display, HDD, for heads-down-display. This required the pilots to look through the windscreen with his head 'up' in order to see the outside world (specifically, his Rocket Racing competition, and the earth), and then quickly look down, in a heads 'down' position to orient himself in the RITS – a cumbersome task at best.

Now, though our partnership with Elbit, we provide RRL pilots with specialized helmets that project the RITS on the pilot's visor. This puts the raceway, and race-critical information directly on the pilots line-of-sight, negating the need to look anywhere except at the outside world to navigate the track.

The HMD, or helmet-mount display, designated as TargoRacer, is built, tested, and under flow and operational test and evaluation. The foundation containing the hardware, firmware and software to enable the projection of the raceway onto the pilot's line-of-sight is complete and in a refinement phase to perfect it for the purpose of Rocket Racing.

As of summer 2010, we have completed our initial flight-test program with excellent results,

The engines burn liquid oxygen (LOX) and ethanol, producing a maximum of 2,500 lb of thrust emitting a brightly, colored, 10-15ft long flame

Virtual race

Rocket Racing League's gaming platform has been designed to combine the virtual and real world, and the spectrum of game coverage is real-time to offline. Participation is expected to range from single user to multiplayer and from hand-held to console to arcade games. Through games, fans can design and fly their own Rocket Racers and also network online with other virtual 'owners' and 'pilots' for a year-round gaming platform. Games will enable fans to fly in real-time against the actual Rocket Racers with combinations of virtual and live action and it is further contemplated that gaming finalists may come to actual races to compete with real Rocket Racers in cockpit-based gaming modules.

RRL's iPhone game, released on June 16, 2010, and available through Apple's iTunes online store, should help promote the RRL vision/brand and create immediate opportunities for sponsors. At its core, RRL's iPhone game is a rocket-racing simulator, allowing players to sit in the pilot seat and race against both the computer and other gamer opponents. Beyond the first release of RRL's iPhone game, an evolving family of iPhone games is envisioned to include tournaments and other advanced features. RRL's iPhone game will represent the leading edge of applications thus far developed for the Apple mobile platform.

"RRL plans to develop next-generation versions of the Rocket Racer based on lessons learned"

The RRL will work carefully follow all air show regulations set by the FAA, airport authorities, the RRL safety board and other governing bodies

The events will be held at selected venues across the USA and select overseas locations

validating that the raceway projected on the pilot's line-of-sight not only tracks with the movement of the rocket racer itself, but also with the movement of the pilot's head within the Rocket Racer.

Operationally what this means is that no matter where the pilot looks when flying a Rocket Racer, he or she will see the raceway in that portion of the sky within their line-of-sight. The TargoRacer is a major development for the RRL, bringing to the mix of enabling technologies a capability that permits safe, engaging, head-to-head racing in a form previously available only to military organizations with many millions, and perhaps billions of dollars to spend in the acquisition process.

Augmented reality

The various augmented reality systems being deployed within the RRL are designed to provide a rich, immersive viewing experience, from the perspective of pilots in the sky to the fans on the ground, deployed live and remotely to television and web audiences. These augmented reality systems enable end users to experience the nexus of the real world with the virtual world.

The groups of end users include, but are not limited to: fans on-site at events (large screens stationed around the grandstands, hand-held devices); remote fans (broadcast on television and internet). Both live-action and remote fans can tap into RRL's virtual world with streaming video. Such categories include: gamers, FAA (safety), race officials (scoring, safety, control), race teams (real time monitoring) and archives (repackaging to end-users).

At its simplest level, the virtual world consists of the RITS. At the next level, it contains a means to recreate for fans and other end users, exactly what is happening in the cockpit of a Rocket Racer as, for example, one pilot attempts to overtake another pilot in the final lap of a head-to-head race to the finish.

The progress that has been made in the past 12 months with viewer-based augmented reality systems is significant. A capability to create for end users a RICS where ship-raceway interaction occurs based on the performance of a pilot through the track has also been developed. If a pilot flies perfectly through a designated gate that is part of a more expansive track, the gate will undergo a change in appearance to reflect positive scoring; likewise if a pilot misses a key part of the raceway, or violates a rule, the gate will alter its appearance to reflect a penalty.

This proximity-aware raceway is at the core of RRL augmented reality, delivering to the fans and other end users, a highly interactive, intuitive depiction of the race that combines real-world live imagery and video streams with virtual effects to visualize the raceway and other race metrics to create an unprecedented vantage-point experience for fans.

Future Rocket Racers

Beyond the initial 2009-2012 flying schedule, RRL plans to develop next-generation versions of the Rocket Racer based on lessons learned during the first racing season to increase speed and maneuverability, safety and performance. RRL plans to roll out different Rocket Racer designs to meet different performance specifications, ultimately building a vehicle from the ground up, deliberately designed for the sole purpose of rocket racing.

2010 is a year of enhanced development and testing for the RRL. In the next two years, multiple teams will compete at airfields, spaceports and skyways all over the planet. ∎

Michael R. D'Angelo is chief operating officer of the Rocket Racing League in the USA

Air gel

THE DEVELOPMENT AND TEST OF ROCKETS WITH THE NEW CLASS OF GELLED PROPELLANTS

BY DR KARL WIELAND NAUMANN

Rocket motors that burn gelled propellants (GRM – gel propellant rocket motor) are a new class of rocket motors. They combine the advantages of both solid propellant rocket motors (SRM) and liquid propellant rocket motors (LRM). The propellant is essentially solid in the tank and liquefied upon injection into the combustion chamber. The result is a variable-thrust rocket motor that is safer than SRMs or LRMs. Bayern-Chemie's propulsion system has now been demonstrated in two successful flight tests.

Burning gelled propellants

The fact that a rocket motor can burn gelled propellants yields an innovative combination of interesting features and advantages. The thrust of a GRM can be controlled like that of a LRM, either by throttling the propellant flux or by intermittent operation, dependent on the chosen motor concept.

A GRM also has a high degree of insensitivity, because, on the one hand the propellants do not act explosively like solid propellants, and on the other hand, unlike liquid propellants, the gelled propellants cause no spillage in case of leakage or perforation of the tanks. In addition, gels have a much lower vapor pressure than liquid fuels and hence a significantly lower evaporation rate in case of destruction of the tank and subsequent spillage. This significantly reduces the fireball risk compared with LRM.

Also the energy content of the propellants may be increased by adding metal particles without any tendency for the particles to form sediments.

In principle, almost all liquid propellants and oxidizers can be gelled. The GRM itself, like a LRM, consists of an injector array, a combustion chamber, an igniter, and a nozzle. The injectors have to provide a very high shear rate in order to liquefy the gel and to create small droplets which are a prerequisite for a good and efficient combustion.

An inherent shortcoming of a GRM compared to a SRM is that the propellant has a lower density, requiring a larger volume tank. The fact that the GRM needs more components than a SRM adds to the mass of the propulsion systems, but provides inherent safety against unwanted operation because cumulatively the operation of the igniter, the pressurization of the tank and the opening of the propellant flow control valve are needed to generate thrust.

GRM demonstrator program

The development of rockets that burn gelled propellants was initiated in Germany in 2000 as a joint program of institutes (FhG-ICT, DLR-IRA), the company, Bayern-Chemie and the German MoD/BWB as the funding agency.

The technology demonstration phase was successfully completed in 2006, proving the function and the key parameters of all components of a GRM on the Bayern-Chemie static-test facilities. December 2, 2009, on schedule, two successful flight tests were carried out jointly by Bayern-Chemie and the German Armed Forces Test Centre at Meppen, using a GRM-accelerated missile. Currently, full-scale insensitivity tests are ongoing in Meppen to verify the behavior of a GRM under different stimuli.

A key element of the German test program is to avoid, as much as possible, toxic, carcinogenic, corrosive or other aggressive or hazardous components in the gel propellant. Another requirement is that the gels have to be chemically stable over long periods to enable the design of maintenance-free propulsion systems that can be stored for many years, yet are instantaneously ready for use, if needed.

The GRM technology that has been demonstrated is a monopropellant GRM that, in addition to the above-mentioned benefits, has stable burning and thrust-modulation characteristics. It also has a measured specific impulse (Ispe) that meets the prediction of 2,250m/s for the propellant at sea-level ambient pressure. This is better than the effective Ispec of SRMs with minimum smoke double-base propellants which are mostly in the range 2,000-2,200m/s. With an optimized configuration and higher combustion pressure, an even higher Ispec should be achievable.

The fuel is an environmentally-friendly propellant and exhaust gas (with the exception of carbon monoxide), and has little primary and no secondary smoke, with a low plume signature.

A peculiarity of gels is that they have to be pumped by pressure. Verified solutions to pressurize the tank by inert gas or a solid fuel gas generator are available. For applications that require mission-dependent thrust levels, a method to design the gas generator grains and to predict the tank pressure has been developed and verified. This enables the team to keep the tank pressure within the limits for good motor operation, without the need to vent excess gas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Bayern-Chemie successfully carried out two gel demonstrator test flights at the German Armed Forces Test Range in Meppen in December 2009

in periods when low thrust (which equals low propellant flux) is demanded.

The price that has to be paid for the insensitivity of the GRM is that an igniter is needed. Both ignition by solid propellant igniters and an external gas lancet igniter have been verified.

The demonstrator test missiles had a caliber of 135mm, a length of 3m, solid propellant gas generator and igniter, and carried out ballistic flights over a distance of about 7km. The propellant-flux control was pre-programmed to start with full thrust of 5,5kN, throttle down after a given time, and return to full thrust until all propellant was used up. Onboard safety devices secured depressurization of the tank after the propellant had been burnt or upon impact or on command from the ground control station as long as the umbilical wire provided contact between the missile and the firing controllers. The firing control station controls the start-up sequence, including the pre-programmed start interruption schemes should the sequencing go awry.

Follow-on actions of the development program have started to further improve the functions and the performance parameters.

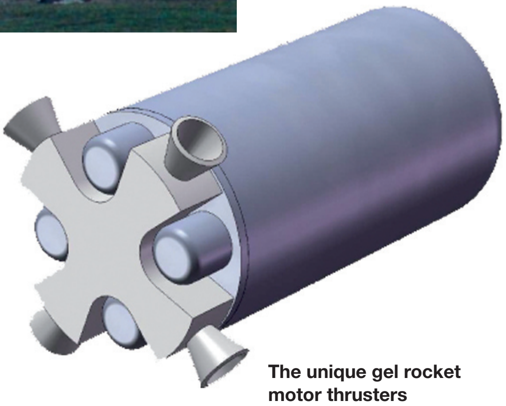
Applications for GRM

Taking into account the present status of German GRM technology, which allows for its inclusion in early applications, the use of a GRM propulsion system should be considered if the following requirements dominate: insensitivity, thrust adaptation, easy handling, transport, storage, and operation – in short, an easily manageable logistics chain and easy operational modes.

It is, in general, an environmentally friendly propellant, for the systems are also non-toxic, non-acidic and non-carcinogenic. GRMs have a long burn time of more than 60 seconds, which is difficult to realize for tactical SRM. However, to achieve long burning times, the tank is, of necessity, much larger than the combustion chamber. This reduces the mass penalty of a GRM compared to a SRM and does mean the propulsion system can be re-used.

In the short term, GRM technology would ideally benefit launch motors for drones, UAVs and cruise missiles.

"If many launches should be required, a re-usable GRM could be a promising option"



The unique gel rocket motor thrusters

If many launches should be required, a re-usable GRM could be a promising option. Furthermore, a GRM can be adapted to different drone types, take-off mass and atmospheric conditions (wind, altitude) by adaptation of the propellant load and/or setting of the thrust level. It is also perfectly possible to integrate the tanks, combustion chamber and control elements according to the available space, such as, within the launch canister of cruise missiles.

Other related applications for a simple low-cost GRM are target rockets with the ability to adjust the total impulse and the thrust according to the specific payload and range.

In the medium term, systems that would benefit from the specific features of a GRM could be missiles designed to engage a variety of land and maritime targets. They could be fired from static platforms (ships, ground stations/platforms or airborne platforms, such as attack helicopters, or fixed-winged aircraft). They would need to comply with a few, or more, of the following mission characteristics: subsonic cruise velocity, a launch-dependent acceleration phase that covers the velocity difference between the velocity of the launch platform and the cruise velocity, a final-acceleration phase to increase the impact velocity of a penetrator warhead, or to increase the maneuverability of the missile if it engages heavily defended or agile targets, and some thrust variation in the cruise phase, for example to enable climb or descent phases after launch to make a terrain-following trajectory possible in mountainous terrain, or to fly tracks with significantly changing headings for deception purposes.

Adaptability

A specific advantage of the GRM is that each flight phase can be adapted to the demands of each specific mission. If the missile is launched from a fixed-wing aircraft at high subsonic cruise, the boost phase may be very short, leaving more fuel for an extended cruise phase. If the target is not at the range limit, the residual fuel can be used for the terminal acceleration or to increase the average cruise speed.

The thrust modulation capability may also help to separate the airspace between aircraft and the missile after launch, because the variable-thrust capability of a GRM permits it to fly very low-level trajectories, enabling engagements without the need to ensure the clear airspace that would be needed for a ballistic trajectory. In principle, similar thrust-management capabilities, say initial-boost thrust, adaptable-cruise thrust, perhaps terminal-boost thrust, should be useful for underwater rockets or super-cavitating torpedoes too.

The technology to build rocket motors that burn gelled propellants has reached a state of maturity that permits a positive engagement in development tailored to specific applications. In the longer term, more and more applications will be possible, including general-missile propulsion and gas generators. ∎

Dr Karl Wieland Naumann is head of business development strategy, Bayern-Chemie, MBDA Missile Systems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To run the structural and the fatigue tests, a complete Airbus A380 airframe was set up in a test hangar in Dresden, Germany

In the CAN

THE DISTRIBUTED AND SYNCHRONOUS ACQUISITION OF THOUSANDS OF MEASURING POINTS

BY DIRK EBERLEIN

Strain gauges (SGs) are frequently used in experimental structural and stress analysis applications for measuring the stresses on mechanical structures. With huge structures, such as an aircraft fuselage, several thousand SGs can easily be required. The challenge involved in this type of application is to synchronize the reading out and recording of the signals of all the strain gauges. Distributed data acquisition has many advantages here.

At 72m long, 24m high, and with an 80m wing span, the Airbus A380 is the biggest passenger aircraft ever built. With the usual division of the cabin into three classes, it can hold around 550 passengers, and has a maximum take-off weight of 560 tons. During development and the approval process, the aircraft has to meet some extremely strict requirements, such as those in fatigue testing, which are needed for approval. The forces acting on the aircraft, as well as the strains that occur, are measured at as many as 7,000 measuring points distributed over the entire aircraft.

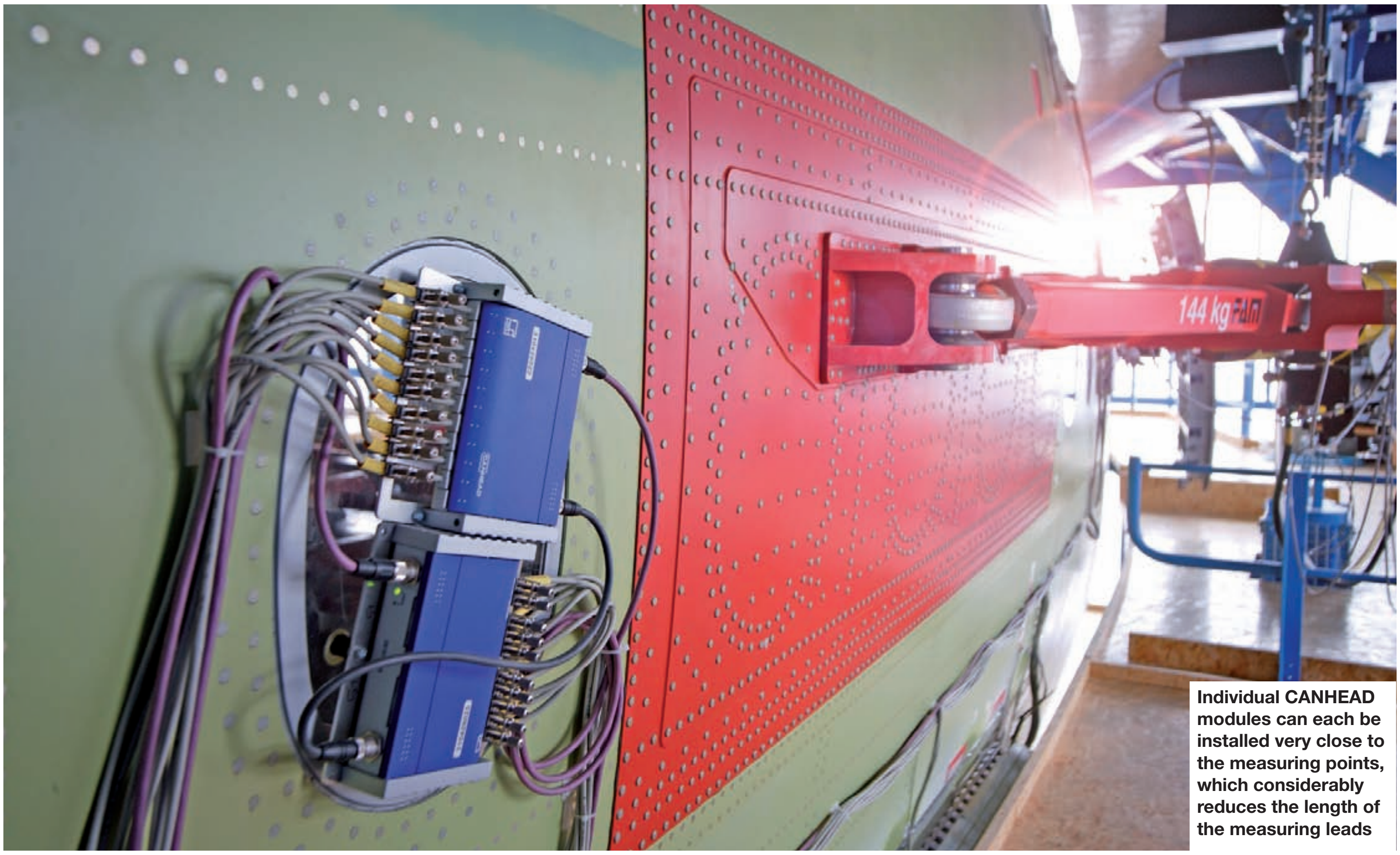
Challenge to measurement

With such a large and complex structure, the measurement technology involved has some stringent requirements to meet. For example, the acquisition of a total of 7,000 measuring points has to be absolutely synchronized. Because of the size of the aircraft, the measuring points are also relatively far away from one another. At IAB GmbH, the decision was made to use HBM measurement electronics and software. Distributed CANHEAD amplifiers are used to record the signals of the various measuring points. One module can read out as many as ten different measuring points and is mounted right next to the strain gauges. In this way, the measuring leads can be kept short, therefore virtually excluding the interference that often occurs with longer leads. Using less cable for this not only has a positive effect on measurement quality, it also means that a lot less cable is used overall, which in turn leads to savings in time and cost.

As many as 10 SG quarter bridges can be connected to one CANHEAD module, which is about the same size as a paperback book. The modules house all the signal conditioning and the A/D conversion at 24 bits, with a separate A/D converter available for each channel. The individual strain gauges are connected in regulated 3-wire circuitry. Because a 600Hz carrier frequency is used, measurement has good interference immunity. The compact and lightweight modules are easily fitted on the aircraft and do not affect its mechanical properties. As base modules with strain gauge connections can be disconnected from the amplifier modules, it is very easy to replace the amplifiers with just a flick of the wrist.

The digitized signals are transmitted through a standard CANbus, which interconnects the individual modules. Cable lengths up to 250m are possible with this extremely robust bus system. An ML74 module for HBM's MGCplus system operates as the communication master. A maximum of 12 CANHEAD modules can be connected for each module that is on a CANbus line making a possible total of 120 measuring points for each MGCplus communication master.

As many as four CANbus lines can converge in one 19in module. In turn, these are interconnected



Individual CANHEAD modules can each be installed very close to the measuring points, which considerably reduces the length of the measuring leads

and networked with a primary measurement data acquisition PC, via Ethernet. With this architecture, it is then very easy to implement the required 7,000 measurement channels. It is particularly important for these measurements that all channels are acquired synchronously, however many there are. The individual CANHEAD modules are synchronized through the CANbus, the communication master within a module through the MGCplus system, and the different modules via Ethernet.

The software package

The catman enterprise software package used to parameterize the system and for data acquisition, is noted for its easy, user-friendly operation, even when the channel count is extremely high. The software is ideal for applications with larger measurement systems. Convenient and simultaneous acquisition of up to 20,000 channels is possible. At the same time, the software is very easy to operate and allows the user to quickly and easily set up a measurement.

It is possible, for example, to automate checking for the SG measuring points and to set up the amplifier efficiently. During measurement, data is acquired by a four channel data server. Thanks to the system's client/server architecture, different clients can then access data simultaneously online, and visualize them in real time.

Extensive trigger functions allow functions that have previously been set up to be triggered. These range from starting a fast measurement to sending email. Special online calculations for experimental structural analysis are already implemented in the software. The open architecture allows users to integrate their own, additional functions. There is an integrated script language, as well as an ActiveX interface available for this purpose.

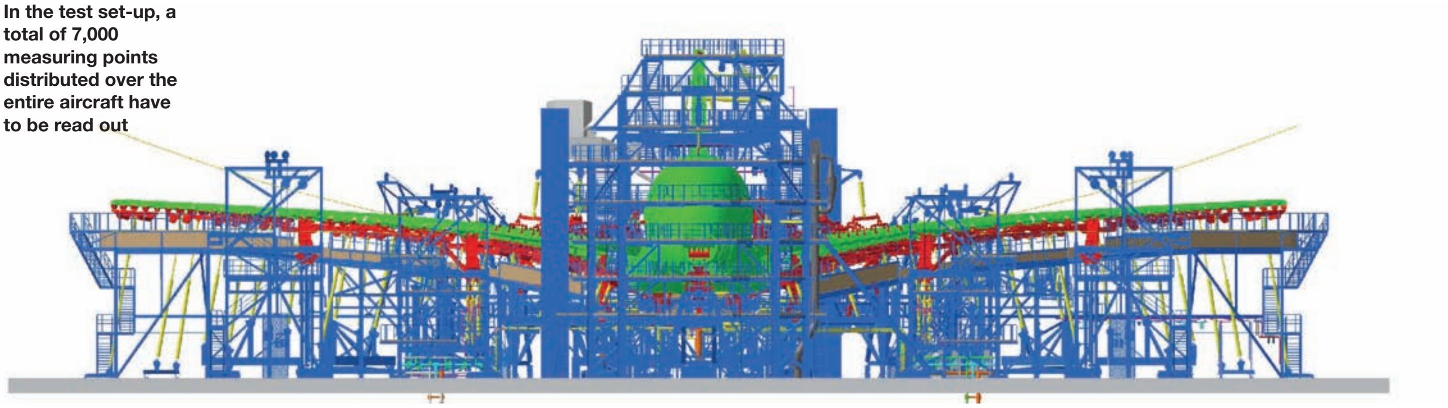
Other applications

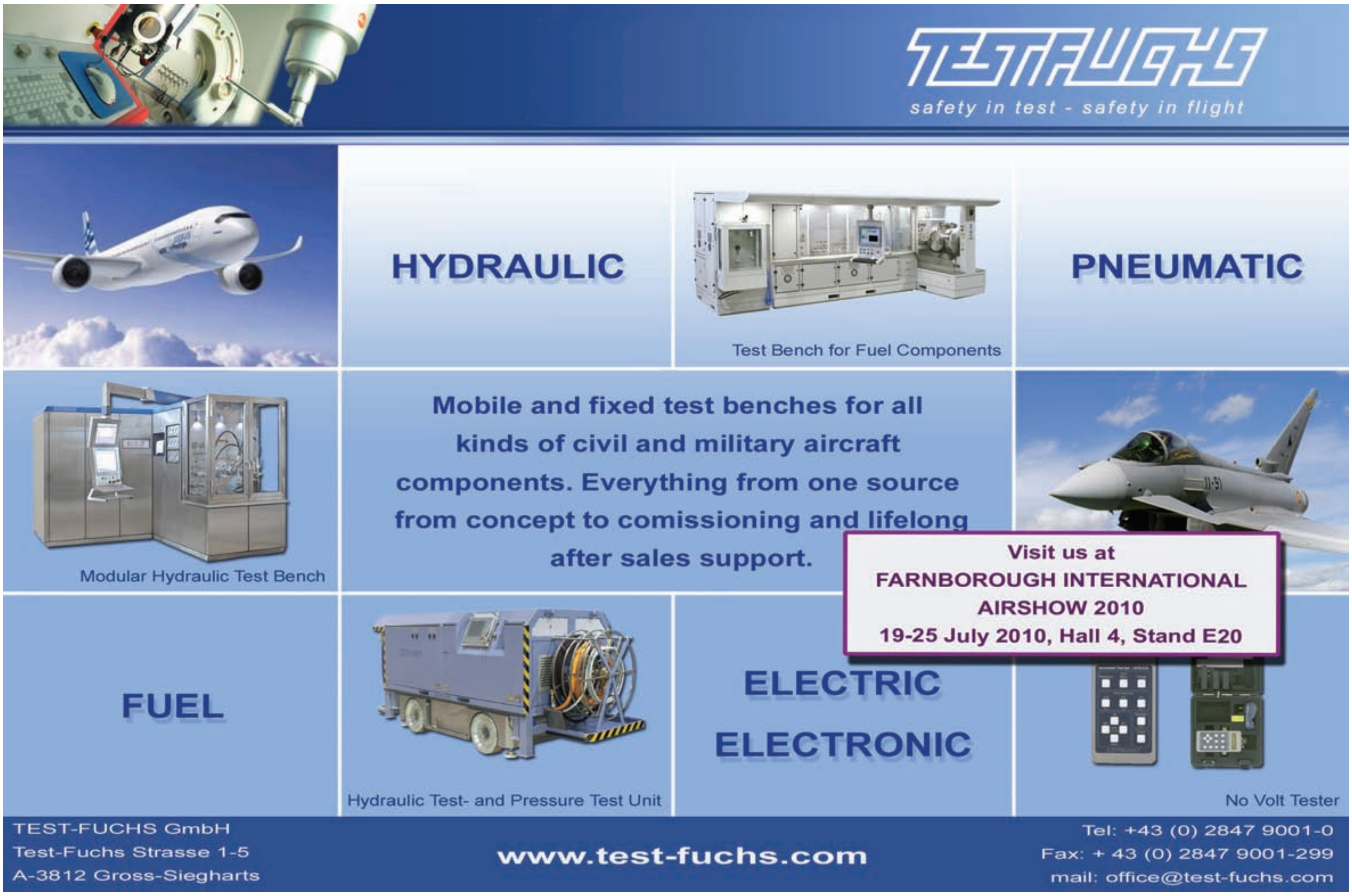
The architecture described for synchronous acquisition of several thousand measurement channels is suitable for many different applications in experimental structural and stress analysis. Such applications include general structural mechanics measurements in wind turbines, in rail vehicles, or in the components of machine construction. This technology has already been used to perform measurements on major bridges.

"IABG decided to use CANHEAD for A380 fatigue testing because centralized data acquisition has considerable advantages when major structures are involved," says Detlev Bauer, the technical consultant with IABG With 7,000 SG measuring points to deal with, we were able to reduce installation costs and time, improve interference immunity, and obtain easy expansion, each of which are highly persuasive arguments," he concluded. ∎

Dirk Eberlein is the product and applications manager with HBM Strain Gauges & Optical Sensor Technology

In the test set-up, a total of 7,000 measuring points distributed over the entire aircraft have to be read out

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Random thoughts

SHOCK ON RANDOM TESTING, USING THE KURTOSION SYSTEM

Have you ever asked for shock on random software? You should have! It all started with customer requests saying, "We need shock on random". What were they trying to do? Customers would explain that they had used sine on random, and random on random, but had never seen shock on random software. Why did they need it? Was there a standard? What were they trying to do? Technicians would take actual accelerometer data from the product in the field. This data would result in a spectrum definition, which they would use to run a random test.

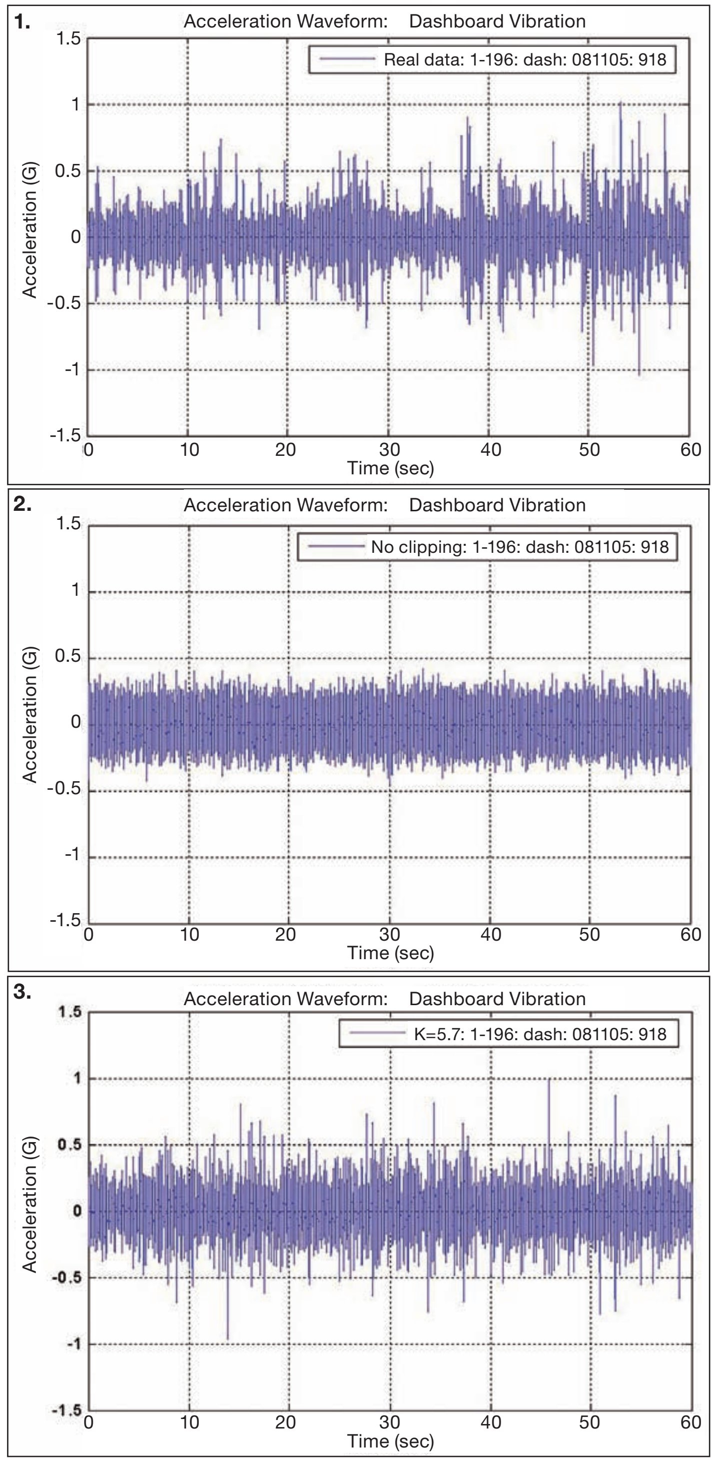
Technicians understood perfectly that this custom random-spectrum profile was supposed to mimic the environment in the field. However, they often were disappointed that field failures could not be reproduced in the lab with random testing. It was observed that peak *g*s, seen in the field, sometimes never occurred during a random test. So, technicians needed a way to put the peak *g*s back into the product under test.

For example, data recorded in the field resulted in a 10*g* RMS test, and it was noted that there were quite a few 100*g* peak pulses seen in the field. Running a 10*g* RMS random test will result in three or four times RMS levels for peak *g*s. Usually test labs would assume four times the RMS level for the peak *g*s seen. So, the 10*g* RMS test produced 40*g* peaks. How to get to 100*g*s, that was the question. The only way technicians could do it was to increase the 10*g* RMS level to 25*g* RMS – a much harsher test, tough on the product and perhaps past the shaker capacity too.

One day, the head of research and development at Vibration Research said, "I think we need kurtosis control." Kurtosis, a statistical parameter, the fourth standardized moment of a data set, describes the 'peakiness' of the data.

Gaussian data, as random vibration controllers implement, has a kurtosis of three. To get the bigger spikes, or shocks, in the data set, the kurtosis of a random data set can be increased. This technique was developed by Vibration Research, and it was discovered that the trick is to get the kurtosis into the resonances. This requires VR's patented Kurtosion algorithm. Resonances in a product are typically where the product fails. The higher peaks into the resonances increase the failure rate substantially.

To promote this concept, a series of half-day seminars were held on a USA-road tour. The introduction included the question: "Who has heard of kurtosis?" For the first year, fewer than 5% of the attendees had heard of the term. Now, only four years later, when asked, "Who has heard of kurtosis?", you will find a 95% affirmative response. If you design random profiles with data from the product, then it is absolutely necessary to also measure the kurtosis of the data. After all, if the kurtosis is higher than three, then you can be assured that the random test you have designed will under-test the product. In testing, it has been demonstrated that 40% of the field environments measured have kurtosis levels higher than three. Kurtosis of 5-9 is quite typical.



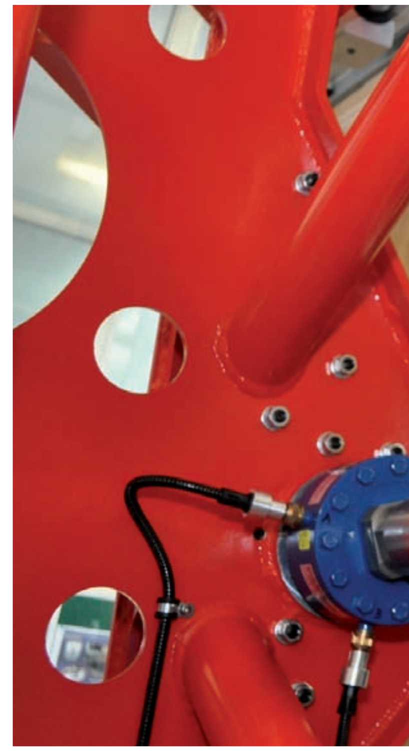
Top: 60 seconds of actual field data – the kurtosis equals 5.7. Middle: 60 seconds of random test data, spectrum generated from data in first figure – the kurtosis equals 3. Bottom: 60 seconds of random test data, spectrum generated from field data in first figure – kurtosis equals 5.7

By visual inspection, it can be seen, from the diagrams, that the 60 second snapshot of the last figure much more closely approximates the data in the second, although the spectrum and the RMS levels of all three figures are identical.

Fatigue rates have not been discussed, but data now shows that products fail 10 times faster with a Kurtosion setting of nine, compared to conventional random test methods. ▮

John Van Baren, is president of Vibration Research Corp


Comar technicians during final assembly of the A350 TRAS test rig



Iron Bird rigs

THE A350XWB AIRBUS THRUST REVERSER ACTUATOR SYSTEM PUSHES BRITISH COMPANY COMAR ON THE PATH TO SUCCESS

BY GRAHAM MARTIN

In the competitive world of aircraft economics, techniques for reducing the direct operating costs of aircraft are in great demand. The current focus is on the 'more electric aircraft' resulting in the inclusion, for the first time in civil aviation, of an electrical thrust reverser system on the Airbus A380. This style of system has now been chosen for inclusion on the new A350 XWB family of aircraft, a long-range, mid-size, wide-body family of airliners which will be the first Airbus with both fuselage and wing structures made primarily of carbon fiber-reinforced plastic.

Using electromechanical actuation, which replaces traditional hydraulic systems, this environmentally friendly design removes the need for hydraulic fluid, increases efficiency and is easier to maintain. The thrust reverser actuator system (TRAS) consists of three actuators per cowl; each of the three units being linked through a mechanical flexible transmission, two locking actuators – one with positional feedback and a central non-locking actuator with manual drive capability. The unit consists of an input shaft which receives rotational mechanical power from its associated electric motor. The input torque is translated through an integrated gearbox to the actuator torque tube which rotates the ball nut with the ball screw rotationally earthed, this results in a linear motion to the translating cowl.

The testing of TRAS when hydraulically powered has been achieved by many differing methods to achieve flight simulation. The change to electric powered TRAS brings about a growing complexity that requires extensive testing to be performed on dedicated test rigs to gain the necessary flight clearance and to provide troubleshooting of the problems that may arise during prototype flight trials.

Having a virtual platform during the design evaluation stages has become a necessity to enable the integration with the customers OEM models into the final test rig design.

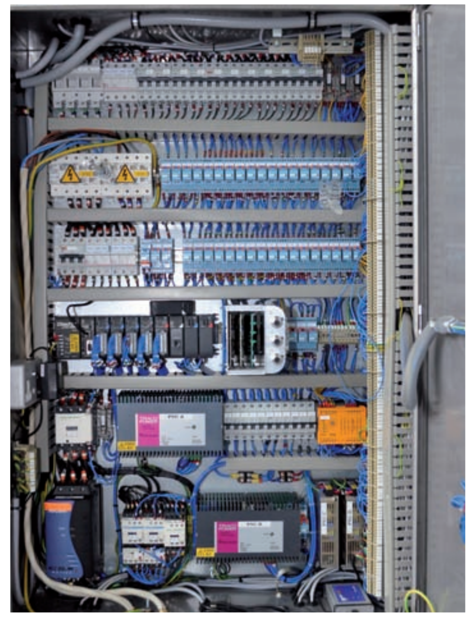
Comar Engineering Services, with its partner RTC Electronics, utilized the Dymola system of modeling techniques and Solidworks 3D CAD with associated stress analysis programs. The hydraulic loading system was also simulated using 'Automation Studio' to complete the overall simulation and modeling package.

Comar were tasked with designing and manufacturing two test rigs, one to be used as part of the Iron Bird (Aircraft No.1) and therefore simulating a complete TRAS integrated into the aircraft control system, and a second rig to be used as a qualification test rig for the development program of the aircraft units.

Essentially the two test rigs were identical with the exception that the qualification test rig had to perform over a temperature range for environmental testing as well as being able to conduct individual testing of each type of actuator. This gave the system the flexibility required to allow troubleshooting and fault conditions be carried out on the Iron Bird system, but in a development environment.

Electric actuators

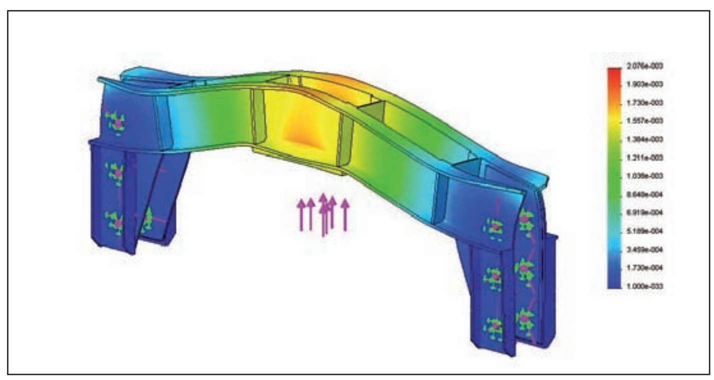
Testing fault tolerant control and diagnosis systems for electric actuators under operating conditions that closely resemble the actual application is an important part of control system verification. Modeling and simulation across multiple systems means that all components can be tested to their limits before the rigs are actually built, this saves time on site and effectively de-skills the commissioning process.



Above: a typical electronics cabinet.

Above: the hydraulic loading system connected to a translating cowl.

Right: an example of stress analysis works



The extensive use of hardware-in-the-loop (HIL) simulation replaced the traditional static testing where functionality of a particular component is tested by providing known inputs and measuring the outputs, today there is more pressure to get products to market faster and reduce design cycle times. This has led to a need for dynamic testing, where components are tested while in use with the entire system, either real or simulated. Because of cost and safety concerns, simulating the rest of the system with real-time hardware is preferred to testing individual components in the actual real system. Dynamic testing also encompasses a larger range of test conditions compared to static testing. The most evident advantage of HIL simulation is that real-world conditions are achieved without the actual risks involved.

Running the tests in Dymola and matching the results obtained by the customer in Simulink then allows us to see all systems working together, including hydraulics, mechanical, electrical and control systems.

Test rig

The purpose of the test rig is to mount and operate the TRAS system for various aircraft operational sequences. As such the aircraft loads have to be simulated in response to positional movement of each cowl. To achieve this, servo-operated hydraulic loading cylinders were used, these were attached to the translating cowl with feedback of load and position monitored dynamically and fed back into the control loop. This in itself is quite conventional, but adding to the complexity of design and modeling are the fact that inertia, system stiffness and unequal load sharing between the actuators have to be considered.

The loading system has to have a high bandwidth as the rate of change of load, (particularly during rejected take-off (RTO) tests) is very large, the dynamic response of the system has to be such as to eliminate the potential of load overshoots. This is achieved by developing control algorithms against the system model.

The Iron Bird system had to be commissioned in the UK prior to integrating into the Iron Bird at Airbus, Toulouse, and as such, aircraft supplies with adjustable voltage and frequency outputs were supplied to enable data logging and error monitoring on a Full Authority Digital Engine Controller (FADEC) simulation PC system, this allowing manual and automatic operation of the TRAS via an Avionics Full-Duplex Switched Ethernet (AFDX) bus to the electric thrust reverser module. The AFDX is a data network for safety critical applications that utilizes dedicated bandwidth while providing deterministic quality of service. It is based on IEEE802.3 Ethernet technology and utilizes commercial off-the-shelf (COTS) components, giving full duplex redundancy, high speed performance, switched and profiled network.

Manufacturing, designing, and testing of the test rig itself brings into play many disciplines, none more so than project and program management. At the request of our customer we ran in parallel a 'least waste way' system, basically a lean product development process to minimize lead time and reduce costs. Integrating this with our customer's top-level process allowed us to deliver the two test rigs on time ready for testing and commissioning.

A350XWB is set for first delivery in 2013. It is hoped a significant part has been played in ensuring the thrust reverser system operates efficiently and effectively as designed. ∎

Graham Martin is the managing director of Comar Engineering based in the UK

Low frequency accelerometer

Piezoresistive (PR) flight test accelerometers have traditionally been specified due to their high accuracy, low frequency and DC response capabilities within extreme environments. As PR sensor designs can also include an undesirable tendency toward excessive zero and sensitivity shifts over a wide temperature range, variable capacitance (VC) sensing technologies are also used. Unlike PR accelerometers, the high-level, low impedance output sensitivity of a typical VC sensor is not dependent upon applied excitation voltage. VC accelerometers are also inherently more rugged than PR devices and can withstand 10kg shock levels without sensor damage.

Specified VC accelerometers must be highly rugged for continuous-use conditions and offer stable performance. Quantity requirements per test can vary according to aircraft, ranging anywhere from less than a dozen, to up to several hundred. Accelerometers may be subjected to high frequency vibrations of up to 50g rms at frequencies of up to 1,200Hz. Since frequencies below 50Hz are relevant for this type of testing, accelerometer damping and natural frequency characteristics provide much of the low-pass filtering. Additional electronic filtering at the input amplifier is also desirable and anti-aliasing filters may be required.

For aircraft flutter measurements on control surface locations, such as wingtips, VC accelerometers experience low temperatures at most measurement points. The sensors are also used to measure vibrations originating from struts, axles, brakes, as well as gear shimmy. This is the most hazardous area for accelerometers, because they will be exposed to mud, splash, icing and moisture. To prevent water ingress during hose down, an RTV potting, like DC3145 is recommended, which is easily peeled off for accelerometer removal. When braking, temperatures can meet or exceed the maximum VC accelerometer operating temperature. In addition, engine load-cycle measurements require flight-test sensors to be mounted at locations encircling the engine inlet fan case, providing six-degrees-of-freedom acceleration data for the engine's rigid body motion during flight cycles.

The Endevco model 7290A VC accelerometer has been used in thousands of industry flight test applications because of its flat frequency response, inherent stability over wide temperatures and low frequency measurement capabilities down to Zero Hz. The sensors operate from 9.5-18.0V and offer a high-level, low impedance output. Sensor frequency response is controlled by near-critically gas-damped sensors, resulting in very small thermally-induced changes. Incorporation of mechanical internal over-range stops enables the sensor to withstand very high shock and acceleration loads. Design of model 7290A requires use of several accelerometers with special modifications for hot and cold aircraft zones. These provide combined thermal zero and sensitivity shifts of 5% over a temperature range of -25°C to +75°C.

Latest generation

Its next generation, the newly released model 7290E, employs integral digital temperature compensation for improved stability over a wide operating temperature range with reduced thermal errors. Available in ranges from 2-150g, model 7290E incorporates a patented, optimally gas-damped VC sensing element which controls sensor frequency response for negligible changes over temperature. These accelerometers provide accuracy in demanding, extreme temperature environments, broadband high-amplitude vibrations and severe weather conditions.

In addition, the extended range of model 7290E allows for use of the same accelerometer at all aircraft measurement points, with a combined thermal zero and sensitivity shift of 2% over a temperature range of -40°C to +100°C. One accelerometer model will operate within specification if exposed to cold temperatures at altitudes up to 13,000m, or if tolerating heat from the engine fan case and landing gear brakes. The standard model 7290E also will operate from a wide range of supply voltages, from 9.5-36V DC. Available in a range of excitation voltages and choice of differential or single-ended output and cable length, model 7290E offers +0.2% FSO typical non-linearity and hysteresis for most ranges, with superior frequency response, for the highest level of available measurement accuracy in the industry.

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Web: www.meggittsensingsystems.com

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Long look down

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

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

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

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

ETS, as the operator of the ESTEC Test Center, was contracted to perform the environmental test campaign on the Herschel spacecraft. The spacecraft was delivered in several subassemblies and final integration was performed at the ESTEC test center by EADS ASTRIUM, the prime contractor for the launch vehicle. For mechanical testing purposes the spacecraft was equipped with accelerometers to measure acceleration and strain gauges to measure stress. In addition, the spacecraft was installed on load cells (ESTEC force-measurement device) to measure and control the forces and moment introduced at its base.

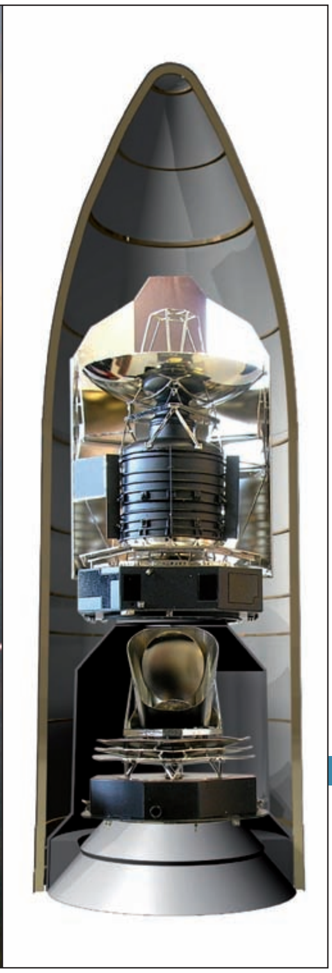
The LMS SCADA III system was used to acquire more than 300 acceleration, 72 load-cell and 60 strain channels during the mechanical tests. ETS uses LMS mobile-acquisition rigs and patch panels. Five years ago, the ESTEC Test Center upgraded their in-house system to a LMS installation consisting of state-of-the-art LMS SCADAS III hardware and viibration-control and data-reduction software in the form of the LMS Test.Lab Environmental Test software. In close collaboration with ESA staff, these standard items were fitted into a customized package for optimal deployment.

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

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

To ensure that the satellite structure was surviving the vibration test without damage, low-level sine excitation sweeps were performed before and after applying large loads. The specimen acceleration responses, and in particular, their resonance frequencies were compared to see if any changes had occurred. In addition to the base vibration, it was also verified that the spacecraft will survive the acoustic loads generated by the rocket. The noise generated by the rocket and airflow at the fairing of the rocket during launch was simulated in the frequency range from 25-2,500Hz. Then, the Herschel team simulated the performance of the spacecraft in the thermal and vacuum environment of space for more than two weeks. The environmental tests were completed with an electromagnetic compatibility (EMC) test performed in the large anechoic chamber of ESTEC.

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



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Hydraulic ground-test unit

ABC specializes in ground-support and test equipment for the aerospace industry. ABC has developed a new range of solutions based on its extensive aircraft-test experience. ABC hydraulic ground test units (HGTU) are suitable for: AMM/ATA29 maintenance and overhaul tests on an aircraft hydraulic system; filtering the system for decontamination, and refilling and draining it.

The HGTU is designed for all aircraft categories, such as wide-body civil aircraft, regional and bizjets, or helicopters. For many years ABC developed key experience in supplying test systems for defence purposes all over the world. These test systems can be supplied to military standard. These HGTU replace the aircraft-hydraulic power unit, enabling it to perform on ground-maintenance operations. It is designed for outdoor/indoor applications with a focus on simplicity of operation and maintenance. The HGTU can perform preliminary tests by supplying an adjusted hydraulic power, driven by an electrical motor, or a thermal engine.

ABC has designed a standard series of mobile HGTU with a capacity ranging up to 60 US gallons per minute. In addition ABC proposes tailor-made solutions according to specific customers' requirements, such as military applications. ABC also supplies hydraulic hangar-housed test installations, using centralized hydraulic power packs with several distribution centers.

All HGTU are designed and suitable for mineral fluids such as MIL-H-5606/MIL-PRF-83282 standards, and for phosphate-ester based fluids such as Skydrol/Hyjet. With several suggested options, each customer can manage the HGTU as per its use and need. All HGTU are designed in compliance with ergonomic requirements for easy use of operation.

ABC is involved in continuous research and development and has been enlarging its field of activities in aerospace. ABC's mission is to support its customer's activities by supplying relevant and quality solutions. But the mission is not only supplying a product, but to give effective and daily technical support through training, spares, advice, support, and expertise delivered by qualified and experienced engineers. The company remains in contact with each customer for prompt and efficient support whenever necessary.

For further information contact
ABC, www.abc-essais.com
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or go to online enquiry card 103

Expansion of HUMS accelerometer family

Dytran Instruments has recently expanded its line of airborne accelerometers, designed for use in Health and Usage Monitoring Systems (HUMS) as well as Active Vibration Control (AVC) applications typically found on commercial and military aircraft. The Dytran 3232A series is a new family of IEPE-type biaxial accelerometers incorporated into a mounting bracket. They are offered in sensitivities of 10mV/g and 100mV/g and have a radial 3-pin 'Mighty Mouse' connector. For rotor track and balance applications, the model 3077A, weighing just 11g, is offered with a sensitivity of 10mV/g and a 10ft integral cable, with bracket style mounting. With an upper frequency response of 5,000Hz, the model 3077A is ideal for use in helicopter structural health monitoring applications, as well as for use within aircraft locations which are typically subjected to higher frequencies. The distinguishing feature is their integral mounting bracket design, which facilitates improved sensor performance, and eliminates the cost associated with separate mounting brackets. Both the 3232A series and 3077A series are hermetically sealed, for reliable operation within high-humidity and dirty environments.

For further information contact D2T
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The missing link: MIL-STD-1553 to Gigabit Ethernet

The conflict between the needs of the military for network-centred communication and the current situation where the vast majority of basic military equipment interconnects via MIL-STD-1553 can be easily resolved by the use of 'network bridges'. These are now available from MBS Electronic Systems, Germany, which offers autonomous connectivity between MIL-STD-1553 and Full Duplex Gigabit Ethernet. This FPGA-based standalone module is one of a family of Gigabit Ethernet interface modules, referred to as ÆSyBus modules, which provide a low-latency connection to a range of military and aerospace databuses using UDP/IP protocol. The open source nature of this solution, combining Ethernet and UDP/IP protocol, enables these devices to be easily accessed by any networked computer and operating system, without the need of any additional drivers or software infrastructure. Furthermore, these devices can be accessed simultaneously by up to 10 separate computers, which can individually log on to the module, configure and control its resources and automatically receive status and data messages, periodically or as needed.

The MIL-STD-1553 ÆSyBus Module can be configured to operate as a bus controller, remote terminal, or passive monitor. In all cases, terminal/bus status is collected with receive data for automatic transfer to the applications, in accordance with the configured requirements of the user. A configurable hardware scheduler is also provided for accurate scheduling commands, when operating as a bus controller. The modules are available in a robust conduction-cooled enclosure, with build options to meet various environmental conditions, or as interface cards which slot into a VME I/O-type enclosure.

With a view to platform independence and to minimizing system development time, the API and all example software are provided in source code.

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or go to online enquiry card 105

Graphical error report

Traditional wiring test reports present results in text format, one row of text after another. DIT-MCO's TestExecutive test software now offers a better way. Its Graphical Display feature lets you view test results as an image. The graphic display helps you quickly find the fault, shorten repair time, and improve throughput. TestExecutive uses your wiring data and raw test-result data to generate a streamlined graphic that displays the circuit under test, showing all the connections that should be in the circuit, and highlighting any opens and shorts found during testing. You can still view the results as a text report. With hypertext links embedded in that report, you can click through the report to display corresponding images – better pictures, a better test process.

For further information contact
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Eurofighter mobile fuel system

It was a privilege to be selected to develop a new mobile fuel-testing system for the Eurofighter/Tornado programmes. The MFTR1500 was specifically designed to provide a mobile solution to fuel-system testing. The complex fuel system of the Eurofighter Typhoon aircraft consists of 17 single tanks separated into three groups. Three additional tanks with a capacity of 900 kilos each can also be fitted to the aircraft.

The mobile fuel-test rig was designed to meet all of the post production and in-service testing requirements. The advanced testing procedures range from the initial filling of all tanks within a maximum filling pressure of 3.45 bar and also providing confirmation that the safety of the aircraft system is not compromised. Advanced electronic systems adjust critical measurements and also integrate with the safety systems.

Testing is performed by comparing the indications of the aircraft systems with the test rig's indications. Measurement devices need to have the highest accuracy and also provide long-term reliability. Test-Fuchs worked with the fuel system designers to develop this test facility. It delivers benchmark systems design with reliable, highest precision, measurement systems. In addition to the standard testing processes, this test system also simulates the fuel consumption of the engines. Flow and pressure are regulated via a speed controlled screw spindle pump and two pneumatically powered control valves. The entire facility is explosion proofed and can therefore be operated within the explosive atmosphere around the aircraft. Easy operation is assured by a touch-screen control panel.

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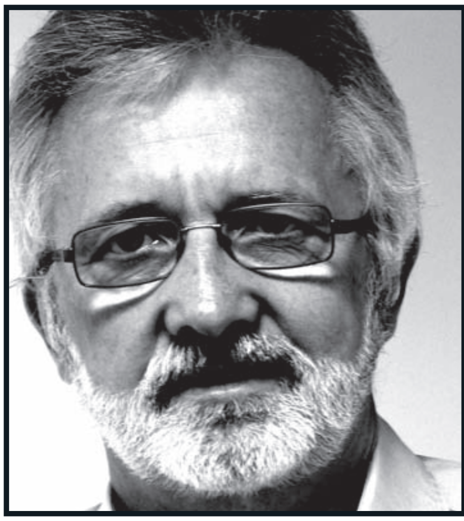
"We have developed a complete family of intelligent interface cards"



Hansjoerg Frey

Managing director and founder AIM GmbH

Hansjoerg Frey, managing director and founding partner of AIM GmbH explains the roots and focus of the company during the last 20 years. His career in the avionics test and simulation business started back at LITEF, before forming AIM with his partners in 1989. Having had significant experience with avionics test and simulation systems in Europe and North America for projects such as Eurofighter/Typhoon, A400M, A380/A350 and B787, he now drives new developments to support new and exciting aircraft developments in Europe/ North America, Asia, Russia and South America.

What has been your core focus over the last 20 years?

Our core focus has been to design and manufacture high-performance, quality databus test and simulation cards, databus analyzer software and customized systems.

The goal is to provide a compatible family of products for a diverse range of aerospace and defence applications, deploying communications buses and networks such as the legacy MIL-STD-1553 and ARINC429, but also for new standards embraced by the industry including AFDX/ ARINC664, GigE, ARINC825 (CANbus) and MIL-STD-1760.

What changes have you seen to the avionic developer's demands over this time?

We have seen increased complexity of the onboard avionics systems over the past two decades. In many cases hundreds of onboard LRU's (Line Replaceable Units) have needed to be integrated and tested during design, right through to production, and finally in service support.

Now, rotary-wing and fixed-wing aircraft such as the A400M military/civil transport aircraft can have a mixture of databuses or networks integrated onto the platform (Hybrid avionics systems) with gateways bridging between the various buses/networks on board.

So how has this driven the company's product development?

We have developed a complete family of intelligent interface cards based on a 'common core' hardware design. This design easily propagates to the various databuses and host-computer formats and for future bus and host-computer standards. With such diverse and differing requirements for our cards to work with various operating systems, we have built an extensive knowledge base and capability to draw upon and give first-class support for our clients.

Our databus analyzer and analysis software has implemented a unique approach with scalable and component based design, known in the Industry as PBA.pro. This gives our clients the flexibility to select the required interface modules and software components to meet a very basic testing requirement right up to a complex avionics test bench, supporting hybrid avionic systems.

How does AIM set itself apart in aerospace the market?

We have some very specific technical advantages designed into our hardware and software solutions, but more than this, AIM has a broad customer appeal whereby we offer anything from an embedded interface card right up to a complete systems solution. This is of great value to our clients when they look to us for a solution.

Responsive and expert pre- and post-sales customer support is paramount. We can offer training courses with the developers, which enables us to target the customer's specific application and maximize the transfer of knowledge to support the efficient use, and significantly shortens development time. This underlines what sets us apart as a full service provider and here for the long term.

What are your future plans to support new and emerging databus technologies?

In the area of databus testing, we have been invited, and participated, in databus standards committees, working groups and European technology programmes. We continue to monitor the aerospace market to look for new and emerging technologies where we feel we can become a mainstream supplier.

We have invested internally to fund the revolutionary common core-hardware design and the highly modular-and-scalable analyzer software to quickly adapt to emerging standards. As a board supplier, we stand ready to support upcoming platforms and technologies used by our customers for the implementation of systems and solutions. We are right in the middle, so our challenge is to be up-to-date on both sides, the 'front end' to support new databus and communication standards and the 'back end' with new host backplane and interface standards.

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