AEROSPACE TESTING INTERNATIONAL

APRIL 2015

LANDING GEAR

Discover the latest testing developments from a leading undercarriage systems supplier and the head of landing gear integration at Airbus

NASA ORION

Chief engineer Julie Kramer White reveals her dedication to the next generation of deep space exploration

SURVIVABILITY TESTING

Exclusive insights from the US Army Test and Evaluation Command's Redstone Test Center

ELECTRIC AIRCRAFT

The move towards More Electric Aircraft is irreversible, but full electric and hybrid aircraft remain a challenge

AIRBUS CHIEF TEST PILOT • FIRE SCOUT MQ-8 • V-22 OSPREY WEAPONS TRIALS • NDT AUTOMATION

www.AerospaceTestingInternational.com


12


32


38


64

Outside it is quite dark – and it is getting darker. The birds are roosting and cars have their headlights on, but it is 09:30 on a spring morning… Friday, March 20, 2015, saw an amazing partial solar eclipse across northern Europe. A poignant reminder of the power and majesty of our solar system. Perhaps it was fate, then, that ensured this issue of *Aerospace Testing International* includes an exclusive interview with Julie Kramer White, the senior engineer for the deep solar system manned Orion project.

On December 5, 2014, Orion launched atop a Delta IV Heavy rocket from Cape Canaveral: a two-orbit, four-hour flight that tested many of the systems most critical to safety, including launch and high-speed re-entry systems such as avionics, attitude control, parachutes and the heat shield. In the future, Orion will launch on NASA's new heavy-lift rocket, the Space Launch System. The test flight marks a new era of space travel. It shows a hugely important commitment to go that further step. "I joined NASA in the shadow of the 1985 Space Shuttle Challenger tragedy," says Kramer. "I saw first-hand people's dedication to resolving what went wrong that day, and to making sure it never happened again. From that point forward, the passion for what NASA strives to achieve – engineering excellence and integrity – became the touchstone for everything I have done. I know these life lessons aren't unique to NASA. But take the ability to take these values, add a focus on teamwork and persistence, and you can see why NASA truly excels and continues to draw some of the best and brightest young people into the adventure of human spaceflight." Turn to page 12 to discover the depth of Kramer's dedication to the field of manned spaceflight.

We also have an interview with Peter Chandler, the chief test pilot for Airbus, on page 26, where he discusses his own milestones and the hugely important role test pilots still have when it comes to new aircraft development.

I'm sure both Kramer and Chandler would have been aghast at the news from just over a year ago (March 8, 2014) that flight MH370 had gone missing without a trace. I wrote a detailed foreword describing my own thoughts and those of others within just a week or so of the tragedy, fully expecting the truth to be revealed in a matter of days or weeks at most. How wrong I was. It is just over a year since the Boeing 777 disappeared somewhere in the Indian Ocean. Since then, conspiracy theories have gone bonkers, while evidence remains scant. However, some new details have emerged about the circumstances surrounding MH370's disappearance. Chief among them is the revelation that the battery on the underwater locator beacon attached to the missing airplane's black box had expired in December 2012, 15 months before the doomed aircraft took off.

However, this does not explain anything regarding the crash. The latest investigation states that the aircraft's final nine voice transmissions came from Captain Zaharie Ahmad Shah. This includes the final communication "Goodnight Malaysian three-seven-zero" at around 1:19am (local time), a minute or so before the aircraft's transponder ceased transmitting.

The Australian Transport Safety Bureau (ATSB), which is leading the search, has scoured 26,800km^2 of the ocean floor, 40% of the designated search area, but has so far found nothing.

A year on, it would seem the disappearance of MH370 remains one of aviation's biggest mysteries. At the time, I speculated that the pilots were overcome by a cockpit fire caused by an electrical fault, which left them with enough time to change route, but not to save the plane. I think I stand by that – but the victims and families of all those touched by this tragic event deserve more than theories.

Christopher Hounsfield, editor

All in a name

There has been some debate about what 'drones' should be called. To settle this: 'drone' is the civilian and media term for unmanned air systems. The latter term, often shortened to UAS, covers all systems, ranging from small (even toys), to larger types, and tends to refer to civilian versions, rather than large military types such as Predator or Taranis. This leads us to the military acronym RPA, or remotely piloted aircraft – those which still need a pilot (according to the military), just not on board. The industry term for these is UAV (unmanned air vehicle), which seems the most straightforward. Clear? Yes, as mud! And of course there's UCAV… an unmanned combat air vehicle, etc, etc…

EDITOR Christopher Hounsfield (chris.hounsfield@ukipme.com)

PRODUCTION EDITOR Alex Bradley
CHIEF SUB EDITOR Andrew Pickering
DEPUTY PRODUCTION EDITOR Nick Shepherd
PROOFREADER Christine Velarde

ART DIRECTOR James Sutcliffe
ART EDITOR Louise Adams
DESIGN CONTRIBUTORS Andy Bass, Anna Davie, Craig Marshall, Nicola Turner, Julie Welby, Ben White
HEAD OF PRODUCTION & LOGISTICS Ian Donovan
DEPUTY PRODUCTION MANAGER Lewis Hopkins
PRODUCTION TEAM Carole Doran, Cassie Inns, Robyn Skalsky, Frank Millard

PUBLICATION DIRECTOR Tom Eames (tom.eames@ukipme.com)
PUBLICATION MANAGER Jag Kambo (jag.kambo@ukipme.com)

CEO Tony Robinson
MANAGING DIRECTOR Graham Johnson
EDITORIAL DIRECTOR Anthony James

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

Printed by William Gibbons & Sons Ltd, 26 Planetary Road, Willenhall, West Midlands, WV13 3XT, UK.

 ISSN 1478-2774 *Aerospace Testing International*

COVER IMAGE: trekandshoot/Shutterstock

Average net circulation per issue for the period 1 January 2014 to 31 December 2014 was 9,685

Published by UKIP Media Events

WORLD
TEST UPDATE

1 ADVANCED HAWKEYE MAIDEN CARRIER DEPLOYMENT

Five E-2D Advanced Hawkeyes assigned to Carrier Airborne Early Warning Squadron (VAW) 125 will make their maiden deployment as part of Carrier Air Wing (CVW) 1 aboard the aircraft carrier USS Theodore Roosevelt (CVN 71). The E-2D Advanced Hawkeye is set to replace the E-2C Hawkeye in its primary mission to provide airborne early warning and command and control capabilities for all aircraft-carrier battle groups. While the primary mission for the E-2 has not changed, the Advanced Hawkeye is able to gather and process data more precisely and efficiently, thanks to state-of-the-art radar and communication equipment.

Norfolk, Virginia

2 SOLAR-POWERED RECORD

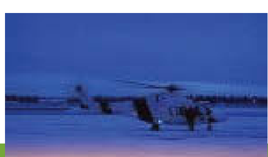
Solar Impulse, the fuel-free airplane, has successfully completed the second leg of its historic attempt to fly around the world and is currently on course with its third leg. Project chairman Bertrand Piccard, piloted the vehicle from Muscat in Oman to Ahmedabad in India, crossing the Arabian Sea in the process. The journey, on March 11, took just over 15 hours. The distance covered – 1,468km – set a new world record for a flight in a piloted solar-powered airplane. The vehicle has another 10 legs ahead of it over the course of the next five months. Included in that itinerary will be demanding stretches when the craft has to fly over the Pacific and Atlantic oceans.

Varanasi, India

3 UK MOD INVESTMENT IN HELICOPTER FLEET UPGRADE

In the past 12 months, the Puma Mk2, Merlin Mk2, Chinook Mk6, and both the Royal Navy and British Army Wildcats, have all been declared ready for operational use. As a result, UK forces now have new military capabilities that can be deployed around the world. The Merlin Mk2 is currently delivering vital support in Sierra Leone to tackle the spread of Ebola; the Puma Mk2 is preparing to contribute to NATO's training and assistance mission in Afghanistan; and the Royal Navy Wildcat is deploying for global maritime operations.

London, England



4 AW169 COLD WEATHER TRIALS IN ALASKA

The AW169 arrived at Heli-Expo straight from Alaska, where it successfully completed extreme cold weather trials in the framework of civil certification. Performance and system reliability were demonstrated at temperatures down to -40°F/C. The latest testing followed a series of hot and high trials in Arizona last year, which confirmed the aircraft's performance in demanding environmental conditions.

Alaska, USA

5 FIRST SOUTH CAROLINA-BUILT 787-9 DREAMLINER

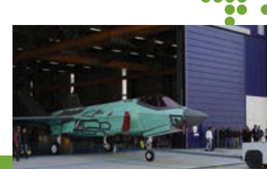
The first 787-9 Dreamliner assembled at the North Charleston, South Carolina, facility has been delivered to United Airlines. As the 250th 787 to be delivered, the airplane marks a milestone for the 787 program. In the first quarter of 2013, Boeing South Carolina teammates began fabrication, assembly and integration of the aft and mid fuselage sections for the first Boeing 787-9.

South Carolina, USA

6 KOREAN HELICOPTER

Airbus Helicopters will join with Korea Aerospace Industries in developing two 5 metric ton class rotorcraft that meet South Korea's requirements for its next-generation light civil helicopter (LCH) and light armed helicopter (LAH). As the LCH and LAH competition winner, Airbus Helicopters will continue its relationship with Korea, including the joint program that developed the Surion twin-engine transport helicopter.

Seoul, South Korea



7 FIRST ITALIAN F-35

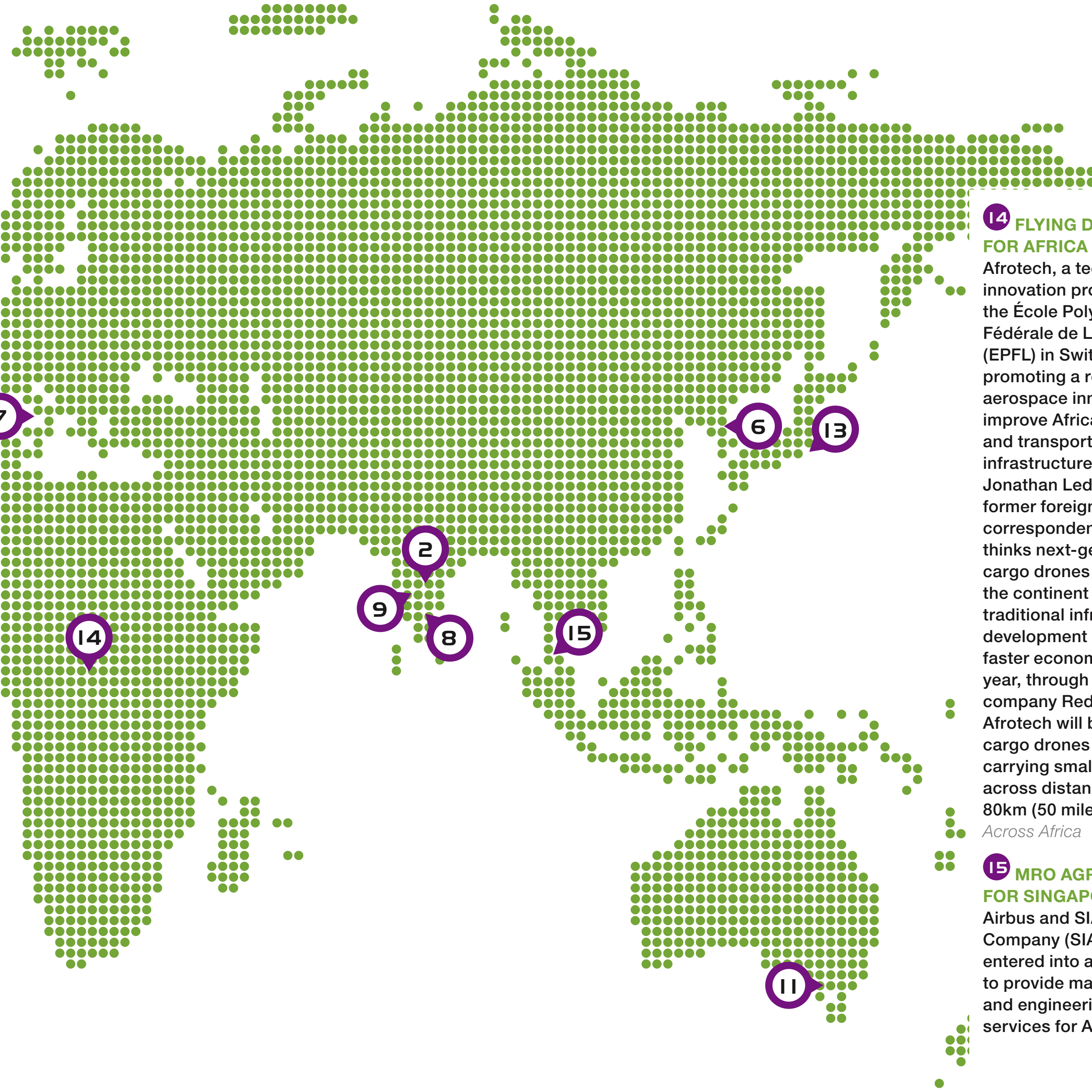
The first Italian F-35A rolled out of the Cameri Final Assembly and Check Out (FACO) facility, marking the first F-35A assembled internationally, and the first of eight aircraft currently being assembled. The aircraft will now proceed to additional check-out activities before its anticipated first flight later this year. The roll-out is a partnership between the Italian Ministry of Defence, Finmeccanica-Alenia Aermacchi, and Lockheed Martin.

Cameri, Italy

8 MRO DEAL FOR INDIA DORNIER

HAL's civil aviation business got a boost with the Directorate General of Civil Aviation (DGCA) according an approval to HAL's transport d ivision at Kanpur for maintenance and repair of Dornier (Do-228) and Avro (HS 748) aircraft. In February, HAL bagged a major defense contract for supplying 14 Do-228 aircraft to the Indian Air Force. HAL has so far produced 125 Do 228 and 89 HS 748.

Kanpur, India



14 FLYING DONKEYS FOR AFRICA

Afrotech, a technology innovation project set up by the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, is promoting a revolutionary aerospace innovation to improve Africa's economy and transport infrastructure. Director Jonathan Ledgard, a former foreign correspondent in Africa, thinks next-generation cargo drones will enable the continent to leapfrog traditional infrastructure development and grow faster economically. Next year, through its spin-off company Red/Blue, Afrotech will begin testing cargo drones capable of carrying small packages across distances of up to 80km (50 miles).

Across Africa

15 MRO AGREEMENT FOR SINGAPORE

Airbus and SIA Engineering Company (SIAEC) have entered into an agreement to provide maintenance and engineering training services for Airbus aircraft in Singapore. Through the collaboration, SIAEC, one of the world's leading aircraft engineering and maintenance groups, will deploy Airbus standards, dynamic tools and teaching techniques to provide aircraft manufacturer-backed maintenance training capabilities to its personnel and to third-party personnel in the region.

Singapore

16 RE-ENTER THE DRAGON

SpaceX's Dragon cargo spacecraft splashed down in the Pacific Ocean on February 10, 2015, 259 miles southwest of Long Beach, California, with nearly 3,700 lb of NASA cargo, science and first-of-its-kind technology demonstration samples from the International Space Station. The Dragon spacecraft will be taken by ship to Long Beach, where some cargo will be removed and returned to NASA. Dragon will then be prepared for a return trip to SpaceX's test facility in Texas, for processing.

Pacific Ocean, nr California

9 LCH FACING THE COLD

Cold weather trials of a light combat helicopter (LCH) have been carried out by manufacturer HAL at Air Force Station, Leh, India. "The trials covered engine starts with internal batteries after an overnight cold soak at altitudes of 3,000m and 4,100m," explained T Suvarna Raju, chairman, HAL. The engine starts were satisfactory in the temperature of -18°C at 4,100m. The flights were also carried out to assess high-altitude performance.

Leh, India

10 CSERIES FLIGHT

Bombardier has conducted the maiden flight of the CS300 airliner. The CSeries aircraft will provide a single-aisle mainline jet specifically designed for the 100- to 149-seat market segment. "Results from testing [are] as expected or better. The CS300 airliner will now join the five CS100 aircraft flight test vehicles that have amassed more than 1,000 flight test hours to date," said Rob Dewar, vice president, CSeries Program.

Montreal, Canada

11 3D JET ENGINE

Researchers from Australia are helping develop 3D-printed jet engines, with great expectations for future development. Engineers from Monash University in Australia and Amaero Engineering have created the world's first 3D-printed jet engine. The proof of concept was designed after a challenge from Safran. Researchers disassembled an old engine and began manufacturing a new one, which took about one year to complete.

Victoria, Australia

12 A400M TRIAL REFUELS TWO F/A-18S SIMULTANEOUSLY

The Airbus A400M airlifter has successfully demonstrated simultaneous air-to-air refueling (AAR) of two F/A-18 fighters. Over the course of four flights, the A400M performed 74 contacts and dispensed 27.2 metric tons of fuel to the Spanish Air Force fighters. The A400M has a basic fuel capacity of 50.8 metric tons, which can be increased by the use of the cargo hold.

Seville, Spain

13 JAPANESE AEROSPACE JOINT AGREEMENT

Two independent agencies, the Japan Aerospace Exploration Agency (JAXA) and the Japan Science and Technology Agency (JST), concluded a mutual cooperation agreement on February 19, 2015, for generating unique research and development, accelerating practical development, and delivering results in an effective way to ultimately achieve a greater acceleration of scientific and technological innovation.

Tokyo, Japan

AROUND THE WORLD IN NON-WEIGHTY DAYS

After an 11-hour stop in Muscat (Oman), Solar Impulse's attempt at the first round-the-world solar flight continued onward to India. Bertrand Piccard took the controls from CEO and co-founder André Borschberg, piloting Solar Impulse 2 (Si2) from Muscat to Ahmedabad (India), across the Arabian Sea. In doing so, he traveled 1,468km, setting a straight distance world record (subject to validation by the FAI (Fédération Aéronautique Internationale)). Borschberg had previously held the record for straight distance, pre-declared waypoints (1,386.5km), for the Si1 Across America mission in 2013. At the time of going to print, Si2 had been delayed in India, but had finally completed the fourth leg of its journey to Mandalay in Myanmar (Burma) in its historic bid to fly around the world.

SOLAR IMPULSE FLIGHT-TEST MILESTONES

- Test pilot Markus Scherdel took Solar Impulse 2 (HB-SIB) up for its initial flight at Payerne, Switzerland, on June 2, 2014. The aircraft reached an altitude of 1,670m during a two hour and 17 minutes-long flight. This was followed by a high-tempo test campaign to prove HB-SIB in the run-up to its round-the-world attempt.

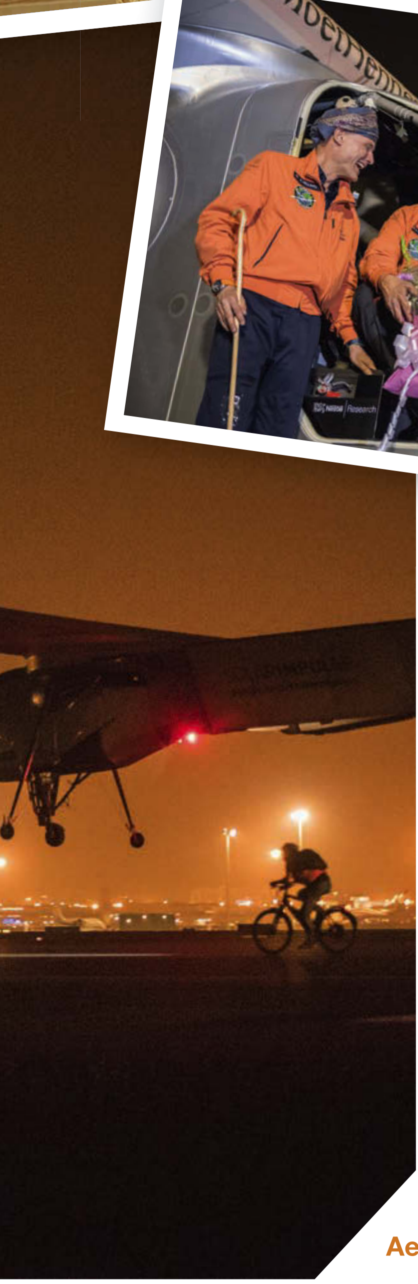
- Scherdel was also in the cockpit when the first aircraft, Solar Impulse 1 (HB-SIA), completed its maiden flight in April 2010. The following month it went on to achieve a first flight using exclusively solar power. The first two all-solar flights completed an initial circuit using energy stored in the batteries, and a second in which the solar panels were activated, allowing the batteries to recharge.

- The next milestone came in July 2010, when HB-SIA carried out the world's first manned 26-hour (day and night) solar-powered flight. André Borschberg was at the controls for the mission, which was flown from Payerne. By now, Solar Impulse 1 was operating at a maximum altitude of 8,700m. At this height the sun's rays supplied the solar cells. During a slow descent, before sunrise, energy stored in the batteries was used.

- In May 2011, HB-SIA flew from Payerne to Brussels, in a 13-hour flight that marked its first international transit. The aircraft recorded an average altitude of 1,800m and an average speed of 50km/h. The flight served to prove operations in international airspace, with the slow-flying aircraft operating below commercial traffic routes. A debut international flight followed in June 2012, from Madrid to Rabat in Morocco.

- While HB-SIA continued to push the envelope, construction was already underway on Solar Impulse 2. Structural tests were carried out between May 2012 and October 2013, but in July 2012 a wing spar broke during torsion tests. A replacement spar arrived later that month and was subjected to further tests, which proved it capable of withstanding the planned 4.9-ton load. The next set of structural tests exposed the spar to bending, at loads up to 3.5 tons across both axes.

- The broken spar delayed the planned round-the-world flight from 2013 to 2015. Instead, a flight across America was scheduled for HB-SIA. This took place in multiple stages during summer 2013.

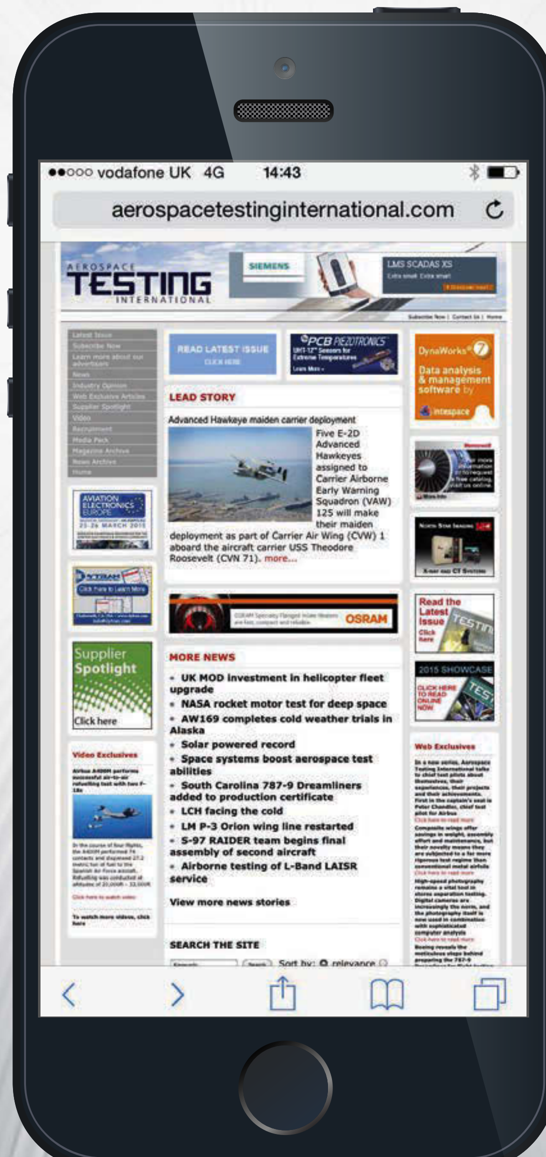


1.3
The size in cubic meters of the cockpit

1,600
Weight in kilograms of entire aircraft structure (without pilot)

63
Wingspan in meters. Greater than a 747

For regular news updates:
AerospaceTestingInternational.com



JSF SKI JUMP TRIAL

In February this year, the Pentagon's JSF Program Office announced that three-month-long ski jump trials had begun at US Naval Air Station Patuxent River in Maryland, kicking off the live flying element of the effort to bring the F-35 to the deck of HMS Queen Elizabeth in 2018. The trials are necessary because British and Italian aircraft carriers all have the famous ski jumps, which were originally installed in the 1970s and 1980s to improve the take-off performance of the old Harrier Jump Jets. By adding the 12° ski jumps, the Harriers could take off with more bombs and did not have to use as much thrust and fuel to get airborne.

British and Italian Harrier operations were transformed by the ski jumps and both countries want their F-35s to continue to benefit from using them. The Royal Air Force sees the ski jump as complementing its shipborne rolling vertical landing (SRVL) concept to enhance the performance of F-35s in a wide range of operating scenarios.

To date, F-35 deck trials have taken place on US Navy flat-tops, which lack ski jumps. Until now, the US Navy and Marine Corps

have opted not to go for ski jumps, claiming they reduce deck space for aircraft parking and flight operations flexibility, although critics have claimed that the US Navy 'cats and traps' lobby has wanted to stop anything that might threaten the case for nuclear aircraft carriers, fitted with catapult-launched fast jets.

The Pax River ski jump was installed more than five years ago under a contract with Williams Fairey Engineering Limited of Stockport in Cheshire. Prefabricated metal sections were built in the UK and then shipped across the Atlantic to be ready by 2012 for the first trials, but the decision by the UK government to switch to the catapult launched F-35C meant it was mothballed. When the UK switched back to the lift fan-powered F-35B jump jet variant, the ski jump suddenly found it was needed again and work had begin to bring it back into use.

INTEGRATED TEST FORCE

The F-35 Lightning II Pax River Integrated Test Force (ITF) partnered with ATR's Geomatics and Metrology team to perform a high-fidelity survey of the ski jump to make sure it was ready for use.

"Launching off our Pax ski jump paves the way to F-35Bs launching off our international partnerships that feature ski jumps," said Bob Nantz, the Pax River F-35 ITF external environment and performance lead. "The significance of the Pax ski jump shape is connected to aircraft loads and performance modeling. Ideally, the loads will never limit the launch weight or speed, thus allowing the maximum performance benefit."

In the run-up to the tests starting, experts from ATR Geomatics and Metrology employed electronic differential leveling and total station measurement techniques during surveys in 2014 to check for drift in construction and determine precise deviations in both vertical and horizontal components of the ramp.

"We captured hundreds of elevation readings, determining the relative vertical difference between points," said Fred Hancock from ATR Geomatics and Metrology. "We also obtained precise angular distance measurements to determine if the ramp edges were parallel to the center line. This helped us to know whether the ramp was at all skewed."

Hancock said that the team achieved readings accurate to within one millimeter.

"The razor-sharp accuracy of the Geomatics team's survey is a key part of the process leading to future ski-jump operations at sea," Nantz said.

Sylvia Pierson, spokeswoman for the Pentagon's F-35 program office, said two British pilots, one from BAE Systems and the other from the British Royal Navy, would use the first F-35B jet to complete the testing through into late May 2015.

BAE Systems' lead test pilot for F-35, Pete 'Wizzer' Wilson, who will take part in the trials, said, "The team at Patuxent River have got more than 2,000 hours of flying under their belts for the F-35B variant and the handling and performance of the aircraft has shone throughout." ∎

MOD SUFFERS AVIATION ENGINEERING RECRUITMENT CRISIS

A shortage of aviation engineers across the UK armed forces could impact on airworthiness inspections and certification, according to the head of the UK Military Aviation Authority, Air Marshal Dick Garwood.

In his annual report for 2014, Garwood raised concerns about shortages of suitably qualified and experienced air engineers across the Royal Air Force and the British Army's Royal Electrical and Mechanical Engineers. He reported that in key areas of both services' air engineering career groups, between 40% and 50% of personnel have less than two years of engineering on their type. Outflows of experienced aircrew, particularly instructors, is also becoming a more frequently voiced concern, he said.

Garwood highlighted a shortage of qualified engineers in the UK procurement organization, Defence Equipment and Support (DE&S), as a particular cause for concern. "MAA assurance activity sees this manifest itself most typically as routine airworthiness tasks not being addressed, which ultimately transfers risk onto operational duty holders [in frontline commands and units]."

He said a strategic challenge program has been set up to address the issue to target recruitment retention efforts. While the recent re-organization of DE&S by increasing its human resources freedoms to bring in more outside management expertise may improve the situation, Garwood expressed worries that "unintended consequences that may flow from the DE&S moving to a pay and grading structure that is different from the rest of the MOD's mainstream science and engineering community; in particular where this affects the ability of the MAA, and other MOD regulators, to recruit civilian staff with experience of procurement and support to ensure that regulation is delivered effectively."

For regular news updates:
AerospaceTestingInternational.com

THE STUDENT ENGINEERING CULTURE

Space has traditionally been the jewel in the crown of the aerospace testing world – the ultimate showcase for a nation's technological prowess. But has the public lost its appetite for extraterrestrial achievements?

GARNET RIDGWAY

In 1969, coverage of the Apollo 11 moon landing was watched by an estimated 125 million TV viewers, representing 93% of the possible audience. The fact that this figure has not been surpassed in the following 46 years demonstrates that the public's interest in space exploration has been in decline ever since.

One of the key issues is the lack of milestones to get excited about that are both tangible and significant. Many would question the value of returning to the moon, and a manned mission to Mars may be decades away. Of the spacefaring nations, the USA is certainly the most credible hope for manned interplanetary travel; however, NASA's current activities appear to be laying the groundwork for potential future missions rather than aiming for specific, near-term goals. The level of support for the US space program ultimately stems from the electorate – if the appetite for space exploration is still present, why isn't this a more significant campaigning point for politicians?

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

Discounting a manned mission to Mars in the near future, are there any other milestones that would ignite public interest? The main focus of many current space programs is to achieve existing capability for less money; while eminently sensible, this is unlikely to set pulses racing. Robotic exploration is technologically astonishing, but simply doesn't inspire the same emotional response as a manned mission; this is potentially due to the lack of risk involved. Additionally, while robotic probes can send back incredible images of their adventures, advances in computer-generated imagery means that comparable vistas can be simulated on a modest home computer, while films such as *Gravity* are all but indistinguishable from the reality. In short, people are a lot harder to impress than they were in 1969.

Looking to broader horizons, while the departure of the Voyager spacecraft from the solar system does inspire an emotional response, it also reminds us of the immensity of astronomical distances. These machines have been hurtling through space for a generation, yet have completed only a tiny fraction of their interstellar journey. While this is certainly thought-provoking, it is hardly the edge-of-seat, flag-waving excitement of the Apollo era.

So, is the future of space exploration entirely bleak? Not necessarily, if we see a resurgence of a key element of the Apollo era that's currently absent: competition. Emerging nations are keen to demonstrate their aerospace industries on the world stage, and are choosing space for this purpose. Imagine, for example, if China was to announce an intention to set foot on Mars within 10 years. Would other nations with prodigious spacefaring pedigrees be content to sit back and watch?

SOPHIE ROBINSON

The Space Age is far from over; if anything, we're entering a bold new era of testing and exploration in which commercial companies, alongside government-funded bodies, will take us outside of our terrestrial confines.

Companies such as SpaceX, headed by Paypal founder and playboy scientist Elon Musk, and Blue Origin, run by billionaire Amazon founder Jeff Bezos, are at the forefront of this revolution in the commercial sector. Both companies seek to develop fully reusable spacecraft, which could reduce the cost of getting into space by as much as a factor of 100. SpaceX first successfully docked its Dragon spacecraft with the International Space Station in 2012, and recent test activities as they tried (and failed, but only just) to recover their Falcon 9 reusable launch vehicle to a floating platform known as the autonomous spaceport drone ship have generated headlines across the world.

Now private companies are well on the way to commercializing the low-Earth orbits, attention is turning further out into our solar system. Privately run projects such as Mars One, the Dutch organization intending to establish a permanent human colony on Mars by 2025, have been criticized for their outlandish goals and unrealistic timescales, but they are pressing on with their mission. Even NASA is starting to prepare a path to send astronauts to Mars, recently carrying out a study involving 55 participants staying in bed for 70 days to study the effects of long periods in space on muscular and skeletal atrophy. Perhaps Elon Musk's intention to retire to Mars isn't so unrealistic.

Looking closer to home (for me here in the UK anyway), Major Tim Peake will become the first Briton in space for more than 20 years, and the UK's

Sophie Robinson works at the front line of aerospace testing as a rotary-wing performance and flying qualities engineer for a leading UK-based aircraft test organization. She also holds a PhD in aerospace engineering from the University of Liverpool

first official astronaut, when he boards a Soyuz rocket for a six-month trip to the International Space Station in November 2015. Peake's appointment has coincided with a renaissance in the British space industry, and has garnered much attention through the use of social media to engage with and excite both the next and the current generations of engineers.

The absence of the element of competition and the excitement it brings, which is so lamented by my co-author, is still present in the space race, but it now comes from private companies, rather than governments and politicians. Imagine how much we will achieve now we are liberated from years of bureaucratic dogma. Space is only becoming more exciting and more enthralling.

The Orion lady

Feted by President Obama and lauded across the space world, Julie Kramer White is dedicated to her leading role as chief engineer on the Orion space program. Her accomplishments have helped put NASA back on the map for deep space travel

BY CHRISTOPHER HOUNSFIELD

OPPOSITE: Orion chief engineer Julie Kramer White waits for the parachute sequence to start after Orion re-entered the atmosphere. The Orion spacecraft orbited Earth twice, reaching an altitude of 3,600 miles above Earth before landing

In December 2014, President Obama stood up and gave a briefing to praise the work of the NASA Orion spacecraft chief engineer. He even joked that he might hitch a ride to Mars himself one day. The chief test engineer was Julie Kramer White, a woman who is utterly dedicated to her work.

Obama said at the time, "Although everybody here is doing remarkable work, let's face it, usually what we do isn't rocket science – unless it is. So Julie Kramer White is helping America launch a new era of space exploration. Julie is NASA's chief engineer for Orion, the new spacecraft that could carry humans further into space than we've ever seen before. I'm sure you were all as proud as I was to see Orion's first successful flight test. America was already the first nation to land a rover on Mars; when an American is the first human to set foot there, we'll have Julie and her team to thank. And at that point, I'll be out of the presidency and I might hitch a ride. So thank you Julie for your great work." High praise indeed, and well deserved.

Even prior to launch, as Orion was slowly rolled out of the hangar toward the launch pad a month before the President's words, Kramer White was reported to have gushed: "Oh man, that's awesome. Me and my 3,000 closest friends did that… it's kind of like sending your kid down the aisle."

DECEMBER 2014

It was on December 5, 2014, that Orion launched atop a Delta IV Heavy rocket from Cape Canaveral Air Force Station's Space Launch Complex Flight Test on the Orion Flight Test: a two-orbit, four-hour flight that tested many of the systems most critical to the safety of the craft for any future missions. It was a huge success.

The Orion flight test evaluated launch and high-speed re-entry systems such as avionics, attitude control, parachutes and the heat shield.

In the future, Orion will launch on NASA's new heavy-lift rocket, the Space Launch System (SLS), which is still under development. More powerful than any rocket ever built, SLS will be capable of sending humans to deep space destinations such as an asteroid and eventually Mars. Exploration Mission-1 (EM-1) will be the first mission to integrate Orion and the Space Launch System.

Johnson Space Center, where Kramer first arrived aged 19, has had a hard decade and has an unsure future. The loss of Space Shuttle Columbia in 2003 shook the USA's faith in human spaceflight. Seven years later, Obama canceled Constellation, NASA's troubled exploration program, and finally, in 2011, the shuttles stopped flying entirely. The Orion and SLS program have reignited an otherwise empty space program, and Kramer has been at the heart since the beginning.

CHIEF TEST ENGINEER

Although Kramer really is the senior person who built Orion (along with others) and chief engineer across the whole program, she is insistent about her title: Orion MPCV, multipurpose crew vehicle program chief engineer.

Kramer hails from Indiana and attended Purdue University, and according to her biography, it was she who owned and treasured her toolbox; she was the one asked to fix the washer or whatever was broken. So, when strong academic talent in math and science became apparent, she was a natural recruit for efforts focused on bringing more girls into math and science fields during the 1970s. Although engineering interested Kramer, she knew she didn't want to design washing machines. Instead it was the challenge of spaceflight that appealed to her – and she set her sights on NASA. At the age of 19, she arrived at NASA's Johnson Space Center in Houston, home of the engineers who designed Apollo and the space shuttle. As a cooperative education student, she began to learn what it took to fly humans in space. It became her career and her passion. During her 25 years working on the space shuttle, she learned a lot about engineering, spacecraft, and ultimately how NASA made human spaceflight look a lot easier than it actually was. But it was the space shuttle that forged her path.

"After the Columbia accident, I worked with the recovery team because of my familiarity with the airframe. I went out in the field and then went to the Kennedy Space Center for about four months during the reconstruction and worked on failure analysis. So I led a big team of folks from across the agency that were doing all the destructive failure analysis to the airframe and looking to support the NASA side of the investigation. After that was all said and done I went on maternity leave, then came back

"OH MAN, THAT'S AWESOME. ME AND MY 3,000 CLOSEST FRIENDS DID THAT... IT'S KIND OF LIKE SENDING YOUR KID DOWN THE AISLE" into another part of the organization – not a lot of people have heard of it – it's called the NASA Engineering and Safety Center."

Kramer moved on through the shuttle program, and is a keen advocate of the spacecraft, despite its demise. "I am kind of a shuttle-hugger. I think they're magnificent. If it were up to me and we'd had the bank account, I would have never retired them. They serve a totally different purpose than what we're able to do now obviously – the massive amount they can lift to low earth orbit. To me, it's like a truck.

"Do you want to own something very practical that can get you further, or do you want to own a truck that can carry a lot? So I think they [Orion and shuttle] serve very different purposes, but also I think in some ways it's a shame we don't have the bandwidth that we can do both, but we don't. The shuttles were aging and they were expensive to operate and, of course, we had our experiences with Columbia that made us nervous perhaps about the reliability or safety, although I think they were quite magnificent, and when you're sitting on that much propellant and that complicated a machine, there's bound to be issues.

"Orion to me is something very different; you know, it's much more about mass optimization and making it as light as possible, because that really governs what you can do with it and that drives all kinds of things in terms of development of avionics and materials. We certainly understand how to go out into lunar space; I mean

4.5

The number of hours spent in space on first test flight in December 2014

8.95

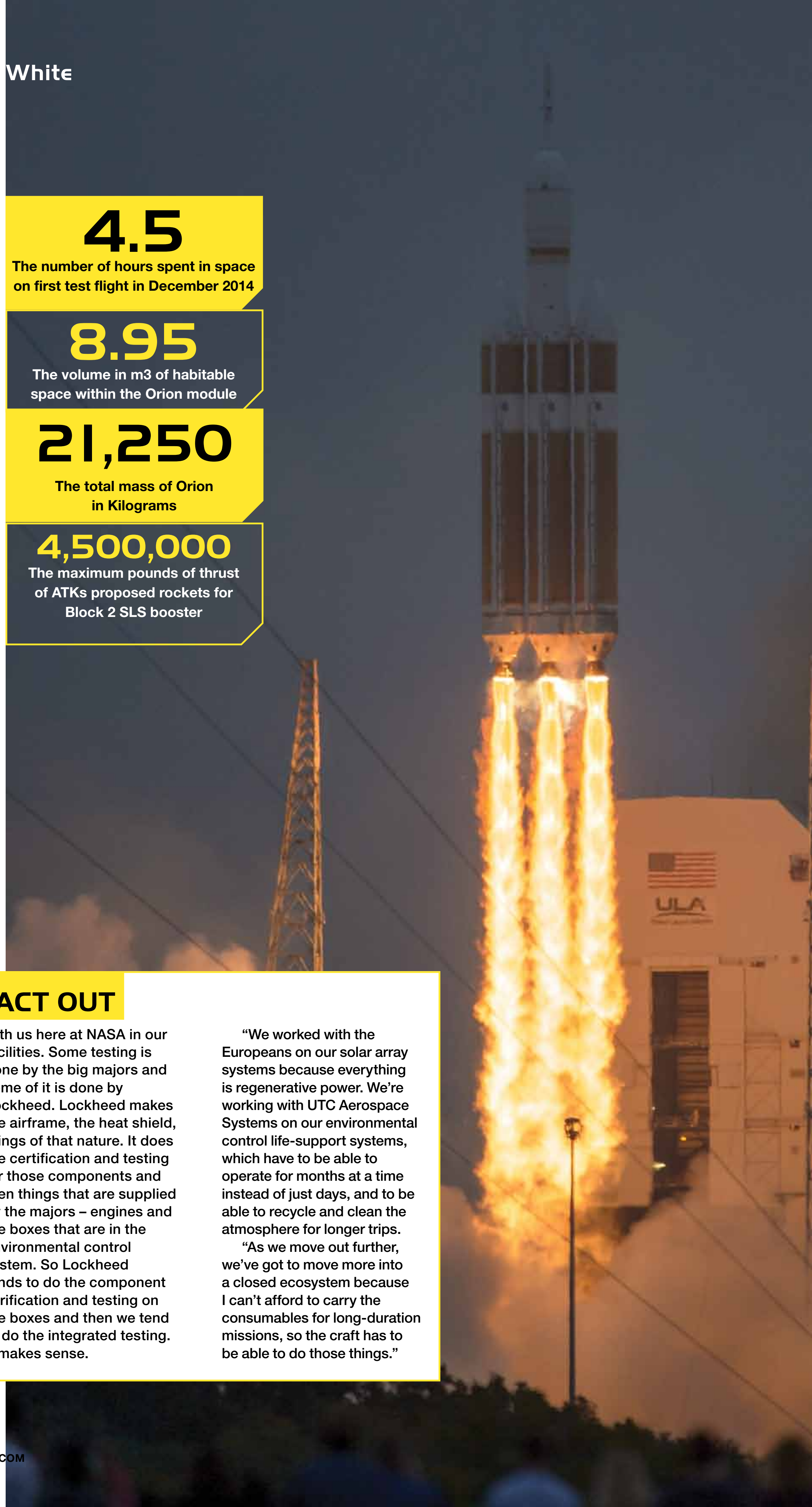
The volume in m3 of habitable space within the Orion module

21,250

The total mass of Orion in Kilograms

4,500,000

The maximum pounds of thrust of ATKs proposed rockets for Block 2 SLS booster



TEST AND CONTRACT OUT

Orion is not just a NASA space program. As with any aerospace project, there are many other subcontractors who also conduct their own component trials at varying levels. Julie Kramer White is keen to highlight the support: "We are at prime contractor level, and then several majors are underneath. We have so many avionics boxes that come from Honeywell; they typically test the box to meet specification requirements and then they pass it to Lockheed, which integrates into the spacecraft and then tests at the spacecraft level with us here at NASA in our facilities. Some testing is done by the big majors and some of it is done by Lockheed. Lockheed makes the airframe, the heat shield, things of that nature. It does the certification and testing for those components and then things that are supplied by the majors – engines and the boxes that are in the environmental control system. So Lockheed tends to do the component verification and testing on the boxes and then we tend to do the integrated testing. It makes sense.

"We worked with the Europeans on our solar array systems because everything is regenerative power. We're working with UTC Aerospace Systems on our environmental control life-support systems, which have to be able to operate for months at a time instead of just days, and to be able to recycle and clean the atmosphere for longer trips.

"As we move out further, we've got to move more into a closed ecosystem because I can't afford to carry the consumables for long-duration missions, so the craft has to be able to do those things."

"IT'S CLEARLY AN APOLLO DERIVATIVE. WE DID IT THAT WAY ON PURPOSE; WE WANTED TO BE ABLE TO LEVERAGE A LOT OF THE AERODYNAMICS AND TESTING AND RE-ENTRY DATA"

LEFT: The United Launch Alliance Delta IV Heavy rocket with NASA's Orion spacecraft mounted atop lifts off from Cape Canaveral Air Force Station's Space Launch Complex

TOP: No one is aboard Orion for the first flight test

ABOVE: Kramer and deputy program manager Mark Kirasich celebrate Orion's successful mission

we did it in Apollo and we've done it on smaller scale with planetary exploration vehicles," Kramer states.

OLD AND NEW

The flight mode, lunar orbit rendezvous, was selected in 1962. This was the beginning of the Apollo program, and was the source of every schoolboy's spacecraft drawing – what the industry calls a 'castle' style of space rocket (as opposed to the shuttle design). The boosters for the program were the Saturn IB for Earth orbit flights and the Saturn V for lunar flights.

Apollo was a three-part spacecraft: the command module (CM), the crew's quarters and flight control section; the service module (SM) for the propulsion and spacecraft support systems (when together, the two modules are called CSM); and the lunar module (LM), to take two of the crew to the lunar surface and support them on the moon, and return them to the CSM in lunar orbit.

Kramer is insistent that the look may be the same, but the technology is wildly different: "The things you see from the outside, the shape of it, was clearly derived from Apollo. Having come out of the shuttles, when you talk about going to another next-generation of vehicle, the debate is always, 'Do you change?' A castle-type vehicle has a lot of positives to it from a mass perspective. It has a lot of positive attributes from a safety and robustness perspective – the re-entry is about as simple as you can get it, and it's easier to protect the vehicle. That's why Soyuz is built essentially in that same castle form. It's why you see Dragon done that way.

"It's clearly an Apollo derivative. We did it that way on purpose; we wanted to be able to leverage a lot of the aerodynamics and testing and re-entry data that had been gathered during Apollo because that all gives us a leg-up on the development. So I don't want to go and reinvent the shape when I have a lot of data on the shape. It would be like comparing a 1960s VW Bug with mine from 2005. They're totally different, the engines are totally different, the electronics are totally different, the computer, everything is 50 years newer on mine. We all joke about how my iPhone has a lot more computational capability than the Apollo capsule had."

LAUNCH-ABORT SYSTEM

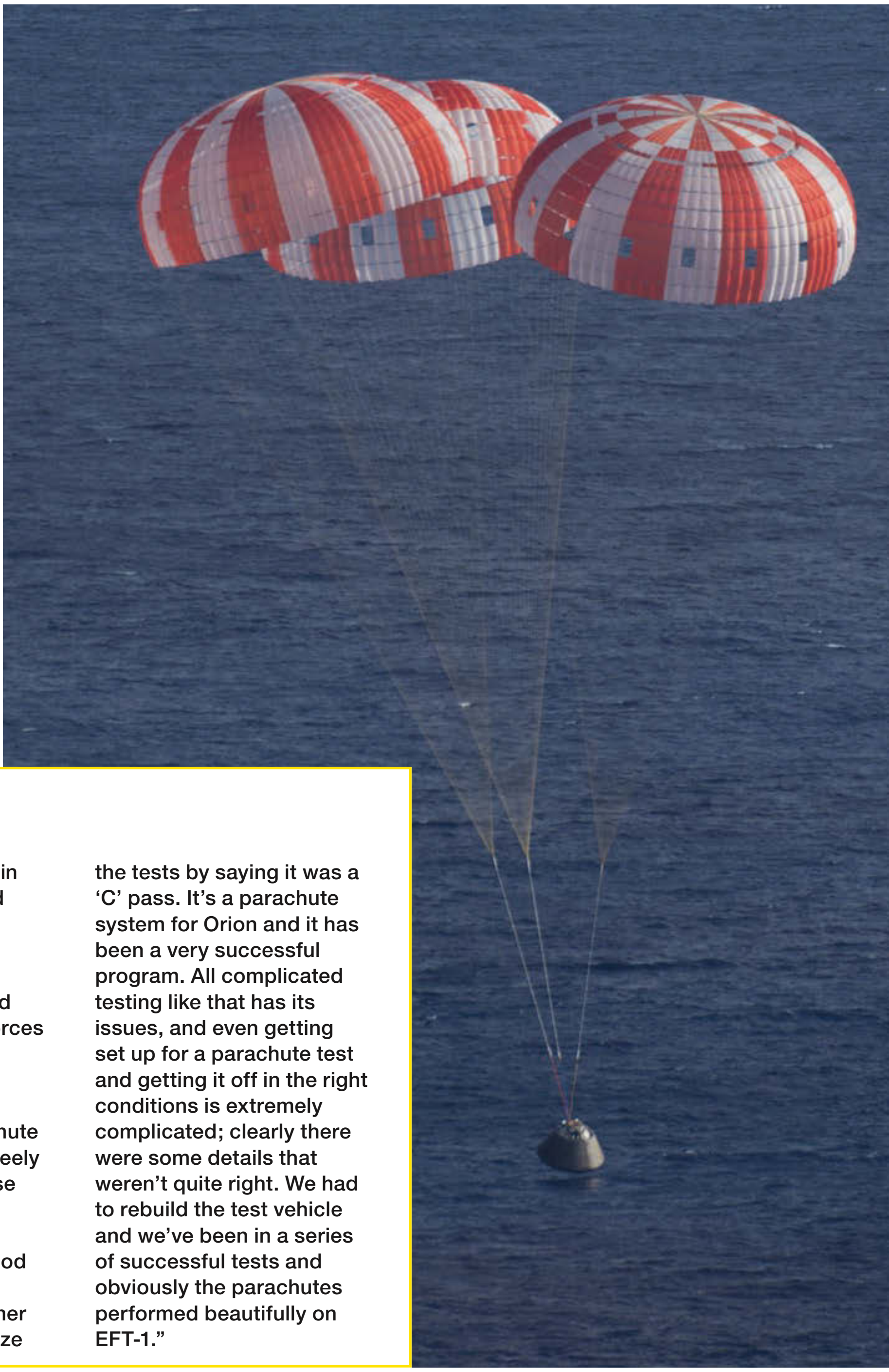
No rocket motor test is complete without serious power. And the motor tests for Orion's launch-abort system (LAS) are no different. With three separate solid motors, the LAS packs a powerful punch, for the sole purpose of providing safety for the astronauts, and getting them off the ground and into the space environment.

"The biggest issue is really the abort system. We have an LAS that's composed of three solid rocket motors. Unfortunately, when you have a solid rocket motor that provides 500,000 lb of thrust, and takes you up to 13g in just a few seconds, you know it provides a very high vibro-acoustic environment," Kramer says. "Some of our environments on the outside of the 'O' drive, on the last faring, are in excess of 175dB, so it's a very high acoustic environment that wreaks havoc with a lot of our components. Obviously we have to test for that, and


TRANSIENT TEST SET

so we had to build a special test facility, as there was no facility in the USA that could test to the level we wanted. There was some similar testing done at Johnson Space Center for Apollo and it was done in our vibro-acoustic chambers here, but they could only go up to about 160dB. So we are going to do our vibro-acoustic testing at Plumbrook, outside of Cleveland [Ohio], so we can get to higher levels than we can here. The plan is to take a castle up there and to carry out what we would call a 'stub' test, meaning the very top is cut off because it's so tall that it will not fit in the generator.

"We will take it up to the maximum facility vibration and acoustics, and then they'll take the 'O' drive off and submit the capsule to those environments, so we'll get a very good understanding of how those acoustic and vibration environments are transmitted through the 'O' drive and into the castle. I believe that the test is actually scheduled for



RIGHT: NASA's Orion spacecraft is seen from an unpiloted aircraft as it descends under three massive red and white main parachutes at 20mph

BELOW: NASA's Orion spacecraft floats in the Pacific Ocean after splashdown from its first flight test in Earth orbit

PARACHUTE TRIALS

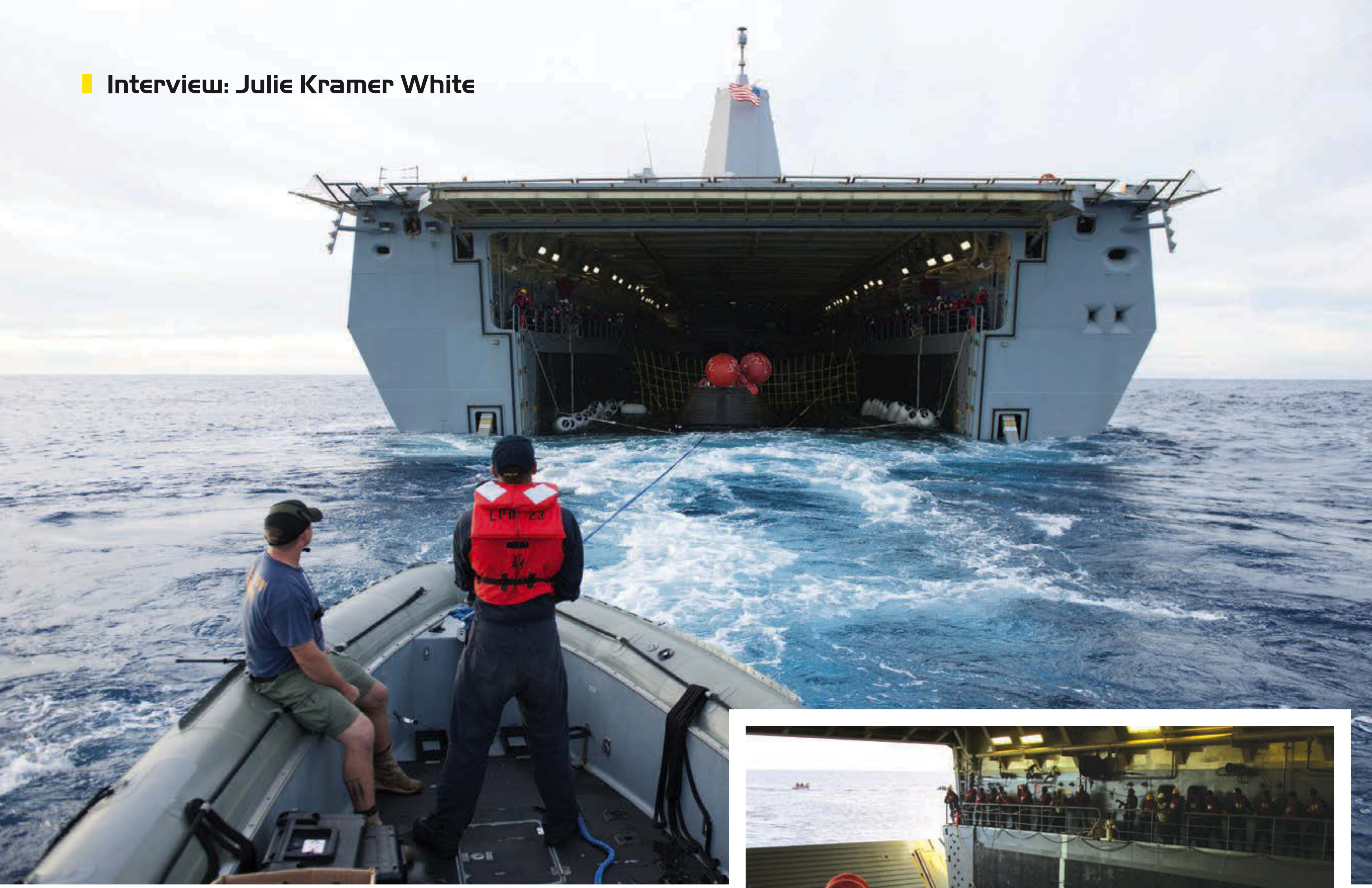
Engineers in Arizona have been testing subscale parachutes for NASA's Orion spacecraft to help improve the safety and reliability of the Orion's landing by investigating ways to make its main parachutes more aerodynamically stable while maintaining drag performance, in preparation for its next mission – Exploration Mission-1.

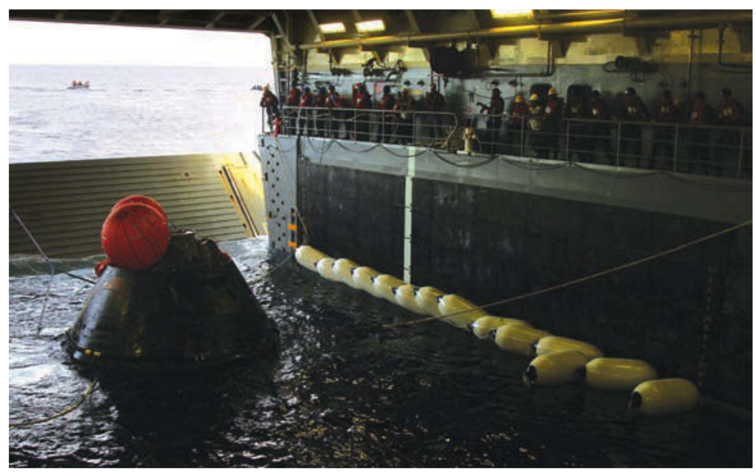
In January 2015, a team from NASA, Jacobs Engineering, Airborne Systems, and the National Full-Scale Aerodynamics Complex, tested 13 different parachute configurations in one of the complex's wind tunnels in California.

During the testing, a tether system was used to hold the parachute and measure aerodynamic forces to help determine which parachute configuration provided the best performance. The parachute was also allowed to fly freely in the tunnel. During these free-flights, data was gathered using photogrammetry, a method of taking measurements using photography. Kramer says, "I would characterize the tests by saying it was a 'C' pass. It's a parachute system for Orion and it has been a very successful program. All complicated testing like that has its issues, and even getting set up for a parachute test and getting it off in the right conditions is extremely complicated; clearly there were some details that weren't quite right. We had to rebuild the test vehicle and we've been in a series of successful tests and obviously the parachutes performed beautifully on EFT-1."

2018 right now; that's the final configuration with the final castle.

"We did what we call the multipoint random vibration tests on the EFT-1 capsule because we wanted to get some dynamic characterization of the system. But EFT-1 was never intended to go through abort load; it was just going to go through normal asset loads and they're quite a bit lower. So we were able to subject the airframe and all the systems that had been installed at that point – the propulsion systems, the acid thermal control systems, all the harnesses, everything had been installed. We actually sent a team down to the facility at Kennedy Space Center where it's built, and they did multipoint random vibration testing with the stingers installed on the flight hardware that drove the whole spacecraft. They were able to get the dynamic responses of the spacecraft to see that everything was responding as we would have anticipated it to, and to help us with model correlation. It's a little bit nerve-wracking to hear the whole thing start rattling, but it was great; it really proved how well the system was built and how well the models were correlated. So we do all kinds of different testing before we attempt to





fly: mechanical testing as well as a lot of electrical and software avionics integration testing in labs. Then we'll do a final four-score certification test here in a couple of years' time on the final configuration."

TESTING THE LAUNCHER

In mid-November 2014, construction of the first SLS began using the new welding system at NASA's Michoud Assembly Facility, where major rocket parts will be assembled. The assembled rocket will be able to remain at the launch pad for a minimum of 180 days and can remain in stacked configuration for at least 200 days without destacking. In January 2015, NASA began test firing RS-25 engines in preparation for use on SLS.

What is incredible is how such advanced technology can face simple and basic testing, right up to the last minute, as Kramer explains: "This is not just a new launch vehicle but a massive launch vehicle – and being able to test that is a bit of a challenge. We've worked really hard with the space launch systems team at Marshall Space Flight Center over the past couple of years to lay out what testing we will be doing at the spacecraft level. So what will happen when I put those two pieces together and what options will I have available to me?

"I don't know if you've seen old pictures of Saturn V, where basically they would take it into the vehicle assembly building at Kennedy, and the guys would go up to the top levels and they would basically push on it to see how it would respond. They did do more sophisticated things, but I just think it was always interesting to see the pictures of these engineers just pushing at the top."

However, testing does not stop when the vehicle leaves the VAB. "What kind of data can we gather while I'm rolling to the pad?" says Kramer. "What a great opportunity – the whole thing is stacked and it's sitting on a mobile launch platform and it's moving, so you can get a lot of information about what's going on with that stack dynamically right there and then."

NEXT STAGE

It has been more than four months since the successful completion of the Exploration Flight Test 1 (EFT-1) mission, and Orion is back at the space agency's Marshall Space Flight Center. The protective component will now be inspected with sections of the heat shield being extracted. The analysis follows the successful test-firing of a five-segment solid rocket booster, which is planned for use on the SLS.

MAIN IMAGE: US Navy personnel aboard a rigid hull inflatable boat help recover NASA's Orion spacecraft following its splashdown in the Pacific Ocean after its first flight test

ABOVE: After splashdown, NASA's Orion spacecraft has been recovered and is positioned on rubber 'speed bumps' inside the flooded well deck of the USS Anchorage

If everything goes according to NASA's plan, an Orion spacecraft will be perched right at the top of an SLS booster for the Exploration Mission 1 in November 2018. This will be the first flight of the SLS, and the second for Orion. The spacecraft will conduct a circumlunar flight around the Moon.

Kramer is pragmatic about the next stage: "NASA is constantly under evaluation by Congress and the Executive Branch, so whether it will continue to play this way, or whether they'll ask us to try to accelerate a manned mission, it's difficult to say. I've given up trying to guess because I'm usually wrong. So we'll continue to build as fast as the budget allows, and to put as much capability into that spacecraft as we can, and at some point the mission will come together with the spacecraft and the launch vehicle will be ready for people."

It's an awful cliché, but only time will tell, and whether we will see the US President onboard a Mars mission…


AVL

Alive firing

Providing cutting-edge test and evaluation support, Redstone Test Center covers aviation, missile and sensors systems, subsystems and components, but one of its prime focuses is on aircraft survivability

BY MAJOR JON MULDER

Army aviation, both manned and unmanned, has played and will continue to play a vital role in the US Army's mission. Through the fusion of trained aircrew, advanced technology and precision systems, Army aviation has brought an asymmetric advantage that enables the movement of troops, delivery of supplies and execution of precision fire throughout the battlespace. While these operations may be conducted in a permissive environment without the presence of enemy forces, Army aviation most often finds itself operating in complex and unknown situations where there are clear threats to the aircraft and crews.

The US Army Operating Concept states that it must be prepared to operate in complex environments with many unknowns and unknowable factors, so aircraft survivability is a key design characteristic. Through the integration of advanced and redundant survivability systems, army aviation platforms and crews can continue to execute their vital mission set and remain a dominant asymmetric capability.

While survivability is always part of an aircraft's initial design, adversaries continue to develop advanced missiles and sensors that require a constant assessment of our survivability systems and a rapid and agile process to design, integrate, and test new capabilities. That's why the testing conducted at the US Army Test and Evaluation Command's Redstone Test Center (RTC), is so vital to present operations and those of the future. Through a rigorous, holistic, yet rapid process, RTC can assess survivability system performance and ensure that soldiers and crew are protected throughout the spectrum of lethal threats.

THE TASK

Aircraft survivability has three major areas of investigation: prevention of aircraft detection; if detected, defeat the threat system prior to impact on the aircraft; and, if that system cannot be defeated, ensure the survival of aircraft and aircrew after impact.

"The ultimate goal of aircraft survivability testing is to ensure that the aircraft and personnel are capable of succeeding against the threat in detection, defeat, or survival tasks," says Justin Powell, RTC assistant division chief of the aviation systems test division.

Over the past decade, aircraft survivability equipment (ASE) testing has dramatically improved to help counter the proliferation of anti-aircraft weapon systems around the globe. "Learning from the past, we've left the days when the extent of available ASE equated to the aircrew placing sandbags at their feet in attempts to shield against incoming fire," says Powell. "In most recent times, fixed- and rotary-wing aircrew must address both low- and high-tech threats alike." Given the array of potential threats, the development of ASE technology and test methodologies must effectively assess passive and active countermeasures against sophisticated weapons systems.

In collaboration with the Project Management Office for Aircraft Survivability Equipment, (PMO ASE), the Redstone Test Center has continued to develop state-of-the-art facilities and assets capable of testing the latest in ASE technologies against live and simulated threats that our forces are most likely to encounter in the future.

"Together we're dissecting the lessons learned from the past decade and focusing on how to counter future unpredictable threats. As the US Army composes itself to support 'Force 2025', we must determine the best way to simulate enemy threats in a test environment, to collect data and determine countermeasure effectiveness against threats we've seen historically, and anticipate in the future," says Powell.

The myriad activities necessary to do this include creating a repeatable process that is not disturbed or influenced by weather conditions.

"Just as our soldiers deploy into different environments around the globe, our test activities must emulate those environments to gain a true understanding of what capabilities need to be assessed," says Col. Patrick Mason, RTC Commander. Consequently RTC test experts created

LEFT: UH-60 interaction testing of flare, chaff, and the volcano mine dispensing system

REDSTONE TEST CENTER

As the US Army's primary test agency for aviation, missiles and sensors, RTC is uniquely suited to the mission of aircraft survivability. Through an array of technical expertise and many advanced facilities, RTC can rigorously test systems from the component level through subsystem testing to full flight test.

"Our workforce is comprised of pilots, engineers and technical personnel working with a fleet of aircraft, laboratories, open-air ranges and component-level test beds on more than 140,000ft² of hangar space and test ranges," says Col. Patrick Mason, RTC Commander.

RTC's state-of-the-art facilities and equipment capabilities include environmentally controlled laboratories housing standard and specialized dimensional metrology equipment, electrical and optical components test labs, a wide range of static and dynamic structural load test stands, hydraulics and pressure test laboratories, and multiple high-bay facilities that can accommodate large test items.

In addition RTC also has extensive modeling and simulation capabilities allowing the integration of hardware-in-the-loop testing with virtual and constructive environments. "Our facilities enable us to leverage simulation to test against varying threats in differing climatic environments similar to what our soldiers would face in the real world," says Mason. "Because of this advanced simulation capability we are able to save costs and reduce test complexity without sacrificing the accuracy of test results."

a self-contained mobile test capability for end-to-end testing against various threat systems.

"In the face of multiple setbacks, challenges and changes in test methodology, a test capability of this magnitude requires cutting-edge technology to keep up with rapidly evolving threats," Mason explains. "Because of this, RTC's repository of threats is updated constantly. This enables us to efficiently, effectively and relevantly test customer test articles at minimum cost, in any location or weather conditions, maximizing the test results we're able to generate."

THE VALUE OF SIMULATION

Military forces deploy around the globe in numerous diverse and austere environments, so it is imperative ASE capabilities are tested in realistic environments. "As our soldiers are globally engaged, we cannot sacrifice testing in real-world locations without sacrificing the quality of the test and the results it would produce," says Powell.

However, executing ASE testing across the vast array of environments creates unique complexities, greatly increases cost and lengthens the test schedule. RTC has therefore created a network of simulated environments in its testing facilities. These facilities allow for tower, in-flight and ground simulation testing. Currently in development, RTC's Aviation Systems Test and Integration Lab, AvSTIL, will have ground simulation capabilities, to stimulate ASE sensors as if the aircraft were actually in flight. This capability simultaneously provides multispectral stimulation of aircraft sensors to imitate threat systems against which the aircraft ASE can react, according to Lt-Col. Richard Bratt, commander for RTC's Aviation Flight Test Directorate.

"The new lab [AvSTIL] will provide for rapid and iterative low-cost stimulations for developmental tests of new ASE with a potential certification capability of ASE with fewer flying hour costs," says Bratt. "In the lab, we'll be able to provide ASE manufacturers with large quantities of data that may otherwise be unattainable due to the relatively high cost of inflight testing when compared with ground simulation."

Powell describes the three categories of ASE threats that RTC test experts test against:

- **Unguided threats:** These may range from rifle fire to a large unguided rocket fired in the general direction of an aircraft. While these threats are basic in concept, they have the capability for effective employment against airborne targets and are therefore an important threat category to build defenses against.
- **Radar-guided threats:** Radar-guided weapons can range from medium machine guns with radar guidance to

14,000
The size in acres of the test site in Alabama

5,000
The number of flight test hours conducted by Redstone annually

64
Aircraft used for test purposes

BELOW: A CH-47 ASE stimulation event

RIGHT: A night-time AH-1 Cobra flare test at Redstone Test Center's Test Area 3 and 6

BELOW: CH-47 flare safe separation testing at Redstone Arsena

large radar-guided missiles capable of reaching high altitudes. While this threat is more prevalent while engaging in combat against established nations with integrated air defense networks, as opposed to small insurgent cells, it remains a major area of interest as the potential for large scale warfare is always present.

• **Optically guided threats:** These threats are grouped without regard for the spectrum in which the optics operate. Threats in this category can range from the traditional infrared seeking missile to wire or laser-guided missiles that may have been developed for alternative purposes.

"Regardless of which category a particular weapon system is in, the most important aspect for RTC is to anticipate the unexpected and have the organic capability to test all three categories of weapons against various types of aircraft survivability equipment. Among our current focuses is testing against optically guided threats, as they are quickly adapting, evolving and are capable of employment by small nation and non-nation states around the world," Powell explains.

"THE MOST IMPORTANT ASPECT FOR RTC IS TO ANTICIPATE THE UNEXPECTED AND HAVE THE CAPABILITY TO TEST ALL THREE CATEGORIES OF WEAPONS"

Countering minor changes in threats can have major impacts on the survivability of the system. To keep up with the rapidly developing processes and changing threats, RTC has reduced the cycle time of testing both new and legacy ASE systems against new threats through live, virtual and constructive test programs executed in rapid succession to ensure the test article can survive. These tests may take from as little as six weeks to as long as six months to ensure a complete data set used to certify a vast suite of ASE. ▮

US Army Major Jon Mulder is RTC experimental test pilot and account manager, aviation systems division, Alabama, USA

LIVE FIRE... SAFETY FIRST

Upon the completion of component level testing and modeling and simulation, live fire events complete the test evolution. Tests to validate the results of the simulation/stimulation tests, many times in partnership with other ATEC test ranges, are often the culminating event and provide the full spectrum of data necessary to ensure system performance, according to RTC's Justin Powell.

Because of the complexity and risk of live fire weapon tests to validate the defense mechanisms, RTC has developed a robust safety program, risk mitigation techniques and approval processes for the conduct of high-risk test events.

"This process is streamlined to move through the risk mitigation and approval processes efficiently with the goal of staying ahead of potential threats, being on time and within budget," Powell said.

"As a body of professional test experts, it is our responsibility to ensure equipment is capable and ready to protect our aircraft throughout all operational phases," says Col. Patrick Mason. "ATEC and RTC will remain focused on performing full-spectrum survivability testing to ensure our soldiers can fight and win in a complex environment."

2,000
Length in feet of a sled used to test warheads against hard targets

10,000,000
The maximum propulsion in pounds thrust at which the center is capable of static testing rocket propulsion systems


Peter
CHANDLER
AIRBUS
FLIGHT TESTS

Principal project pilot

In a new series, *Aerospace Testing International* talks to the industry's leading chief test pilots about their experiences, their projects and their achievements. First in the captain's seat is Peter Chandler, chief test pilot for Airbus, on the latest from the A350 test program

BY CHRISTOPHER HOUNSFIELD

It is nearly two years since the A350 made its maiden flight on a balmy day in Toulouse back in June 2013. The flight was the culmination of a determined effort by Airbus to challenge Boeing's leadership in the long-haul aircraft market. Those efforts continue, with MSN2, one of five A350 XWB test aircraft, most recently appearing at Munich International Airport at the end of February, as it concluded a world airport tour to drive sales. To date, the new medium-capacity, long-range, wide-body aircraft has racked up an incredible 780 orders from 40 customers worldwide.

It was following its maiden flight that Peter Chandler, chief test pilot for Airbus, who was captaining the prototype aircraft as part of a six-man crew, explained: "It just seemed really happy in the air… all the things we were testing had no major issues at all."

I first met Peter Chandler on the inaugural flight of the A380, nearly a decade ago. And although not taking part on the first flight, he was integral to the test flying and development of the aircraft.

THE PILOT

Although not unique, it is still quite unusual to have a career jump like Chandler's: "I started off as a pilot in the Royal Air Force originally flying Buccaneers and then Tornados, and then went to test flying within the RAF. I did the test pilot course with the US Air Force as an exchange pilot. I came back and spent another five years or so test flying and instructing in the Air Force [Empire Test Pilots' School]. Then at the end of my time in the RAF, I left and joined an airline, so I went to Virgin Atlantic just as an ordinary airline pilot and ended up as a captain on A340s and then the opportunity came to go to Airbus and carry on, and go back to test flying, but in a new role with commercial airplanes instead of fighters."

As well as serving in the RAF 20 years, Chandler has now been with Airbus for 15 years and even before then began work on the A340-600 as part of an airline working group. It was then that the development work began on the A380: "I saw the A380 program right through from when it was first launched, through the flight testing and into service. And as that was finishing testing, the A350 was starting in terms of development, so it followed straight on into that. So the major programs for me have been the A340-500/600 and then the A380 and the A350. I have flown a bit on the A400M, but it's not really my main project so I don't know quite so much about that."

THE TECHNOLOGY

The A340-500 cockpit technology Chandler first worked on years ago has moved forward. Now, as a civil test pilot, what are the biggest changes he has noticed 'up front'? Less than might be expected: "In terms of the cockpits and the way that the pilots operate, it has been… I wouldn't say a slow evolution… but it has been a evolutive process because from the [A]320, 330, 340 which had virtually identical cockpits, we put a new cockpit into the 380, which actually retained a lot of the elements from the original airplanes, but it introduced much more intuitive interfaces. So we have, say, a cursor trackball system interface with the flight management systems; most of the functions are done with point-and-click and drop-down menus, rather than little screens with line select keys.

"We have electronic documentation rather than paper documentation, which of course is now coming in on all the aircraft, in many cases just through iPads, but it was fairly revolutionary when it came in with the 380. And then the 350 has basically been another evolution from the 380, so the

A DAY IN THE LIFE…

HOW DOES YOUR AVERAGE CHIEF TEST PILOT DAY PAN OUT?

“I was in for the first meeting at 08:00 this morning, the second meeting was at 09:00. Both of those were actually more management than flight test, which is not typical for the test pilots here, but as the chief test pilot, I have a lot of administration for management to sign, as well as doing the test flying. So a couple of meetings, then some administration, catching up on emails, and preparing a presentation that I’ve got to give next week.

“Then this afternoon I’ve been flying an A330 for two hours, which was just a production flight, so an airplane off the production line that’s about to go into the delivery phase. It was a flight to check various things up at high altitude and landing gear extension times, and things like that.

“I generally work between 11 and 12 hours most days.”

350 has taken all the good bits from the 380 and improved them slightly.

“So the major change I suppose is that the cockpit is much more user-friendly now than it was in the 320, 330 and 340 cockpit layout. Pilots are now required to cope with a much more complex air traffic system than before, so there’s a lot more types of approach. It used to be that you would do an ILS (instrument landing system) approach, or you would do a VOR [VHF omnidirectional range beacon] approach, and that was it. Now, for even small airports, there will be a dozen different sorts of approach including RNP [required navigation performance], others based on GPS, GLS, various noise abatement, complicated routings, and so on. So what the pilots are required to do has become much more complex and therefore the cockpit systems, particularly within the flight management system, have had to adapt to that.”

THE CHANGES

Although test technology does seem to evolve at a relatively slow pace, it has changed the role of the test pilot and the processes in which data is managed with regard to the development of aircraft. Is the test pilot becoming redundant as software design and downloads are increasing in efficiency? Is the test pilot now just the bus driver?

Chandler disagrees, but explains in detail that it is teams’ roles that have changed in a short space of time, not the importance of those roles: “Test flying is still important, but it’s just that the way we work is perhaps different. A lot of the work we do is collecting performance data, or demonstrating and getting data. So a lot of the performance side is basically just flying the airplane very accurately so that we get reliable data. But equally there are quite a lot of things that we do, particularly in the handling qualities of the airplane, where it’s very subjective – we want the aircraft to feel right for pilots. As pilots, we are trying particular maneuvers, seeing if the airplane is responding as we want it to; and when it’s not, then we go back to the data to find out why it’s not and try to work out what to change. So in some areas the data supports us in refining the characteristics and the handling of the aircraft, while in other tests we are there basically just to fly the airplane accurately to get the data. So it’s a bit of a mix.”

“THE MAJOR CHANGE I SUPPOSE IS THAT THE COCKPIT IS MUCH MORE USER-FRIENDLY NOW THAN IT WAS IN THE 320, 330 AND 340 COCKPIT LAYOUT”

So where has the emphasis changed between the computer guys on the ground and the pilots in the air? “I suppose the big change is the amount of data that’s now available. The data collated 20 years ago would be taken by people in the cockpit and pilots actually writing down numbers as they saw them on the dials, which of course doesn’t happen any more because all of that is recorded,” says Chandler. “But the principle behind it is: first, you need to have accurate data to support the flight tests; and second, on some occasions you need the technical data to be able to explain various phenomena. That really hasn’t changed very much; it’s just the amount of data we have and the way we collect it.”

But how involved are test pilots now in the design process from, literally, the ground up? Chandler is emphatic: “The first thing to say is that the test pilots are involved in the design process right from the start. For example, with the A380, right from when the program was launched, virtually all aspects of the cockpit design, and particularly the

A350 XWB MSN1 first flight crew, June 2013

A GOOD DAY

YOU'VE FLOWN SO MANY AIRPLANES. WHICH IS YOUR FAVORITE?

"There have been some fantastic airplanes. For a fighter aircraft just to go and have fun in, the single-seat Hunter was always one of my favorites. The Buccaneer I enjoyed a lot – that was my first squadron aircraft and you always like that. It could be a bit of a pig to fly sometimes, but it gave you a real sense of satisfaction when you could fly it well.

"So the Buccaneer and the Hunter really stand out, but then when you come to commercial aircraft, I think the A380 takes a lot of beating – it just doesn't feel as big as it is.

"For several years, I've done flying displays in the A380 and it's just such a nice airplane to display because, although it's so big, it's so maneuverable; the speeds are nice and slow and it has got a very big efficient wing. I remember the first flight and thinking 'wow that's quiet and looks rather graceful'. It was a good day."

Peter Chandler with Patrick Du Che, flight test engineer and head of the A350 flight test program

layout of the displays, and because of the 'Trapdoor' system [for test aircraft] that we have as an interface, all of that we were involved in," comments Chandler. "I was involved in this personally, right from the start.

"Our involvement starts way, way before the flight test program starts. When it gets to the flight test phase, we have flight test engineers here who specialize much more than the pilots do. So there will be flight test engineers who are specialists in, for example, engines and fuel systems, in performance, in handling qualities, in various systems, in flight management and avionics. They tend to manage the tests much more than the pilots do, and for us, it's good because they're the ones that generally write the reports. Of course, it includes any comments from the pilots.

"So we do have a very close interaction with the design office engineers right from early on in the program in the subjects with which the pilots are concerned, which is mostly cockpit functions and cockpit displays. Then when it gets into the flight testing, the pilot is the main arbiter, for example in handling qualities and tuning the flight controls. It is here that the pilots have a very strong voice. Other things relating mostly to performance, we can't do anything much apart from just fly the aircraft and then let the boffins work out what's either right or wrong with it."

THE A350

The A350-900 is now certified – it got the type certificate in September 2014. The first aircraft was delivered to Qatar in December and is now in service, flying from Doha to Frankfurt.

Chandler was flying the second: "The second one is also going to Qatar – I actually did the first flight on it in February 2015, so that's in the delivery process. Meanwhile, there is still some work to do [on the aircraft program] – software upgrades for various systems, which we will obviously need to test, but the bulk of the testing is all done now," By the March 4, 2015 the second aircraft had been delivered to Qatar "But next we're starting on the 350-1000, which is the stretch version. That starts in 2016, so will get busier toward the end of this year." What will the next generation A350 test entail? "It will go through a test program similar to the 350-900, but a lot of the tests we won't have to repeat. For some things, like checking the handling because it's a longer fuselage, there will be quite a lot of handling to do. A lot of the systems are common, so there will be less systems testing," comments Chandler.

And looking around the corner? "I've never met an engineer who has enough data. As it's possible to get more data, of course people want it, whether it's useful or not. I think what we will have to do in terms of testing is just start looking at what is really necessary to do and what isn't because otherwise test programs are just going to get longer and longer."

DEVELOPMENTAL AIRCRAFT

DO YOU THINK THERE IS A FUTURE FOR UNMANNED OR GLASSLESS COCKPITS IN CIVIL AIRLINERS?

"I think unmanned civil aircraft is a long, long way away simply because of the public acceptance of it. Airline pilots spend 99% of their time actually managing the flight rather than hand-flying the aircraft; whether it's more efficient to manage a flight sitting in the airplane or sitting in a box on the ground is a difficult question. Sure, the technology exists and unmanned air vehicles have almost taken over military roles in some areas, so you can't say that the technology doesn't exist, but I think it's a long way away before it will replace pilots.

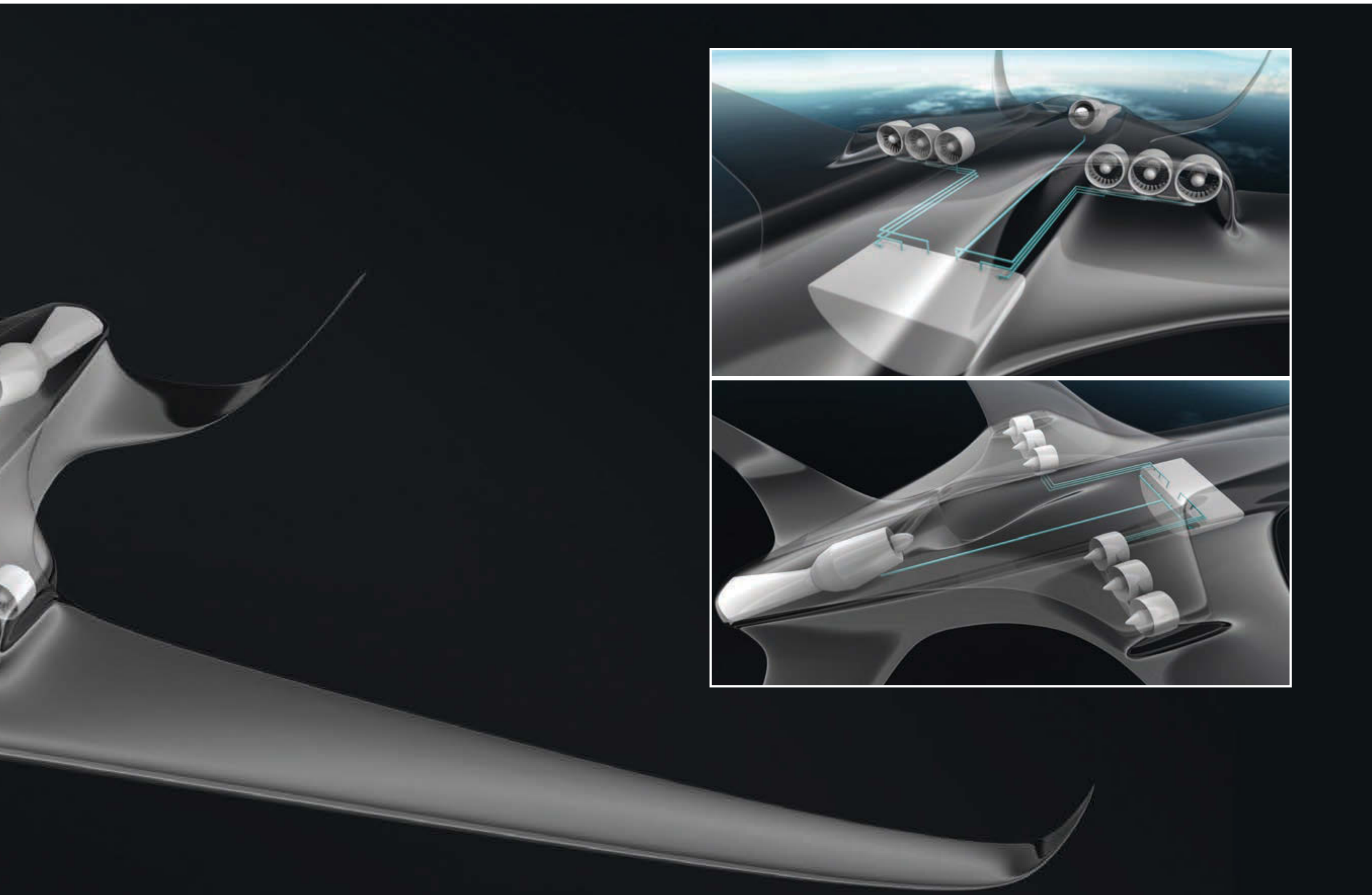
"Assisting pilots is a different thing. The idea of maybe having an extra co-pilot on the ground who you could talk to or who can help out with problems because you've got a permanent data link connection with them – that's a concept that might be worth considering. But in the short term, I don't think anything is going to change.

"The other thing to remember is that even if things do start changing for future designs, we've got around 8,000 fly-by-wire aircraft flying at the moment, from the 320 up to the 350, which are going to be in service for the next 40 years. So even if something new comes along, it isn't going to change the way that those airplanes are being flown."

Plugged-in planes

On every level, aircraft manufacturers are constructing vehicles that increasingly use electrical systems over mechanical. And it's not just avionics – it will be a complete electric aircraft

BY IAN GOOLD



The aerospace future is electric. In partnership with academia, the whole industry, from builders of small single-seat machines to the giants that are Airbus and Boeing, are all exploring greater use of electrical rather than pneumatic or (sometimes) hydraulic systems. Indeed, Airbus and Boeing are involved in research with very small aircraft, sometimes alongside universities. Meanwhile, airworthiness authorities are open-minded, but cautious.

Increasing aircraft electrification is 'irreversible' and will accelerate and intensify, says aerospace supplier Safran. Fully committed to the 'aircraft energy revolution', it describes onboard electrical power as "the order of the day", right up to whole aircraft provision and distribution. Functions such as power-generation management, cabin air pressurization/conditioning, configuration management, and flight control and operations use a lot of power, according to Safran.

The French equipment manufacturer believes that progress in more-electric aircraft (MEA) research and experience with the technology on the Airbus A380 and Boeing 787 foreshadow "a radically transformed onboard energy chain".

As well as saving weight and improving safety through having many fewer parts, MEA technology can improve engine efficiency by deriving power from the low- or intermediate-pressure spools instead of the high-pressure compressor. An MEA also uses fewer hot ducts and inflammable fluids and needs no related fire protection.

> "WE ARE LEARNING MORE EVERY DAY ABOUT THE FEASIBILITY OF THESE TECHNOLOGIES AND HOW THEY COULD BE USED"

ATTITUDE CHANGE

As the major airframe, systems and engine manufacturers move incrementally into MEA technology, the most visible progress is among small aircraft in the GA industry. This sector, accounting for 90% of civil aircraft (except commercial airliners), contains a large element of light, often non-certificated, designs that historically have extended technological boundaries in aerodynamics, materials, propulsion and structures. And as the first certificated all-composites aircraft was the 1969 Windecker Eagle (not the new Boeing 787, nor even the 1980s Beech Starship), GA in fact pioneered electric propulsion with academic or larger aerospace partners.

As an example, late last year, Boeing and University of Cambridge researchers flew a hybrid gasoline/electric-powered aircraft that was claimed to be the first to recharge its batteries in the air. Marty Bradley, Boeing's principal investigator for the Cambridge project, sees hybrid electric as an important element of research: "We are learning more every day about the feasibility of these technologies and how they could be used."

2
The aircraft-generated percentage of all man-made CO_2 emissions – expected to grow to 3% by 2050

2.2
The number in billions of passengers flying each year

Airbus Group has used an electric-powered variant of the minuscule Cri-Cri aircraft and is developing its own small E-Fan test aircraft.

Although reserved about battery technology, US airworthiness authorities are taking a firm interest. "Electric propulsion has the potential to be a real game-changer for GA," according to the FAA aircraft certification service.

The agency's Small Airplane Directorate (SAD) studies new technologies to improve safety and reliability. "We're looking at the total package that electric propulsion can bring. We must first determine if it is safe, economical and practical."

SAD analysis revealed several factors to consider when integrating more electric philosophies into aircraft regulations, such as battery technology and performance limitations. As knowledge and experience increases, officials believe it may be possible to adapt MEA technology to type-certificated aircraft.

An FAA safety document identifies the benefits of electric propulsion systems, including simplicity of design, operation and maintenance. For example, without a reciprocating engine, pilots of electric aircraft would not need to consider carburetor heat, mixture settings or fuel selection.

The agency particularly notes that 'the only two moving parts' with electric power are the motor shaft and the propeller. It envisages aircraft systems that monitor and record motor and battery performance for download at any time: "Your next inspection may involve handing over a thumb drive to a mechanic, or having them connect a laptop to your motor via a USB cable," notes the safety document.

But the FAA also acknowledges that new technologies involve drawbacks and unknowns: "This is particularly true with battery technology. Questions loom, such as how often batteries need replacing and whether their power-to-weight ratios will improve enough to be viable for more than just short hops."

VIEW AHEAD

One man keen to promote MEA technologies, particularly power electronics, is Professor Patrick Wheeler, director of the UK's University of Nottingham Institute for Aerospace Technology and of the EU-funded Clean Sky research project.

He says that, in addition to providing electrical current for avionics, in-flight entertainment and lighting, the

AIRBUS E-FAN

The 600kg E-Fan is the first aircraft with fully electric fan propulsion, claims Airbus Group. Two 30kW electric motors powered by 250V lithium-ion polymer batteries drive ducted variable pitch fans.

Airbus Group anticipates an E-Fan family of aircraft, seen as the first all-electric production machines, and has signed up partners for the industrialization phase of the E-Fan 2.0 two-seat trainer, for service entry in 2017.

Subsidiary Voltair and aerospace supplier Daher will design, develop (including engine and batteries), build, flight test and certificate the E-Fan 2.0, which "will be the first all-electric production aircraft certificated to international standards". The four-seat E-Fan 4.0 is planned for *ab initio* training and general aviation.

ABOVE: The four-engine all-electric Cri-Cri was developed by EADS innovation Works

guaranteed never to jam, it is "not yet possible" to use EMAs for airliner primary controls.

Alternatively, electrohydrostatic actuators (EHAs), driven by local hydraulic systems and with no direct mechanical connection between motor and actuator arm, offer benign failure modes, concludes Wheeler, who sees EHAs as finding readier industry acceptance because of component manufacturer's familiarity with that technology.

Committed to meeting European Commission flight path 2050 targets, including a 75% reduction in aircraft CO_2 emissions (compared with 2000), Airbus, its research network Airbus Group Innovations, and companies like Rolls-Royce and Siemens, are exploring different MEA avenues with myriad 'e' epithets.

E-PLANS

Airbus Group Innovations has flown the E-Fan fully electric training aircraft and its 'e-roadmap' includes the E-Thrust concept study, based on a distributed propulsion system architecture, to develop electric or hybrid technologies for an all-electric helicopter and a 90-seat aircraft. Working as integrator, it has developed

> **"THESE SYSTEMS HELP TO MAKE FUTURE AIRCRAFT MORE FUEL EFFICIENT AND QUIETER, IMPROVING THE ENVIRONMENT"**

larger electrical systems of new aircraft such as the A380 and Boeing 787 also power flight-control and undercarriage actuation systems, protection against airframe icing, cabin environmental control systems and fuel pumping: "These systems help to make future aircraft more fuel efficient and quieter, improving the environment."

In a 2013 Institute of Mechanical Engineers paper, Wheeler explained that MEA concepts assume that a single type of engine-derived power source is more effective and that electrical power provides flexibility and application options. The overall goal, according to Wheeler, is to reduce airlines' operating costs, fuel burn and environmental impact.

GETTING THE CONNECTION

The move to MEA technology greatly increases the electrical energy required: established airliner systems provide 115V AC power at 400Hz, with light aircraft and low-power systems using 28V DC. Wheeler points out that a Boeing 737's typical power rating is around 100kW, while that for the larger 787 is over 1MW. Higher voltages could be used to reduce current and hence cable weight. Many aircraft use mixed supplies, frequently 28V DC for equipment such as avionics, with larger loads supplied from higher-voltage AC or DC systems.

The need for MEAs to be competitive in weight and system reliability has driven fundamental developments in how onboard electricity is generated. For a constant frequency 400Hz electrical supply, most airliners use mechanical gearboxes to create constant-speed drive to a generator from a variable-speed engine input. An alternative way to generate constant frequency supply, according to Wheeler, is to connect the generator direct to the engine, with the resulting output having a variable frequency based on engine speed.

"This can be processed by a suitable power converter to produce a fixed frequency and voltage supply," says Wheeler. "Unfortunately power electronics is not yet reliable enough to make this option viable and it remains a rarely chosen configuration."

To move primary flight control surfaces electrically (typically by motor-driven ball screw, often through a reduction gearbox), the obvious choice is an electromechanical actuator (EMA), according to Wheeler. But because the mechanism must be

COULD BE BUSINESS

Dassault is researching and developing an MEA for a Falcon business jet that could enter service in the 2020 to 2025 timeframe. The company stated that engineers from the company and partners in Europe's Clean Sky initiative are endeavoring to use fewer hydraulics and take less bleed-air from the engines, with the aim of improving overall aircraft efficiency.

The installed electric power would therefore be greater than the 50kW system on the current Falcon 7X. However, the predicted reliability of electric systems, especially for power electronics, is an obstacle. "The right level would be one failure every 10,000 flight hours. We are not there yet," explained Jean-Marc Le Peuvédic, Dassault's onboard energy architect for future systems. Since high temperatures affect component reliability, the validation of a thermal modeling software program is key, even for transient temperatures.

Validation trials are now underway at a Fraunhofer-IBP test facility in Stuttgart. Dassault also uses a testbed operated near Paris by Labinal Power Systems that was recently upgraded to implement a full DC architecture. The need for more electrical wiring might add weight, but choosing aluminum over copper could minimize any increase. Le Peuvédic also singled out the operating noise of electric systems as an issue of specific importance for business jets. Ensuring a quiet cabin will require designers to pay particular attention to this issue.

HONEYWELL SAFRAN EGTS

Honeywell/Safran joint venture EGTS International has developed the electric green taxiing system (EGTS), which it demonstrated on an Airbus A320 at the 2013 Paris Air Show and expects to bring to market in 2016. The APU powers landing gear motors that enable the aircraft to push back and taxi autonomously without starting the engines.

The technology is said to cut fuel consumption by up to 4% per flight cycle while reducing noise and carbon and nitrogen oxide emissions during taxi operations. With short- or medium-range aircraft each spending up to 2.5 hours per day taxiing, the system could save 600kg of fuel daily, say Honeywell and Safran. Pilots control aircraft speed and direction during taxi operations.

its eConcept vision using technologies from the Distributed Electrical Aerospace Propulsion (DEAP) project, a research partnership with Rolls-Royce and Cranfield University.

Other major Airbus Group projects are the DA36 E-Star 2 two-seat hybrid/electric-motor aircraft, developed with Diamond Aircraft and Siemens, and applications in unmanned aerial systems such as the Quadcruiser, which combines hover capabilities with standard aircraft cruising speeds.

After limited MEA technology applications on the A380 (and the military Lockheed Martin F-35 fighter), Boeing has proclaimed its extended use to replace pneumatics and some hydraulics on the 787, whose electrics are seen as easier to diagnose and monitor. Almost everything previously powered by engine bleed-air is electric, according to Justin Hale, formerly the program's chief mechanic.

The US manufacturer says that 787 integrated power generation offers better back-up (via a hybrid ram-air turbine for emergency hydraulics, and lithium-ion batteries). Electric power for brakes, cabin air/pressurization, engine and APU starting, landing-gear actuation, and wing de-icing comes from four 250kVA engine-mounted generators and two 225kVA units on the APU, with engine inlet anti-icing the only remaining bleed system. "More-electric architecture dramatically simplifies the flight deck," says 787 chief pilot Randy Neville. "Remote power distribution permits use of electronic circuit breakers, eliminating hundreds of physical units.

"Crew awareness of system state is enhanced and part count is reduced. For example, the 787 has 13 LRUs for full-flight deck display, communications, navigation and surveillance – about half as many as similar aircraft," concludes Neville. ∎

Ian Goold is a UK-based aviation journalist, specializing in the civil sector

160

The number of AA batteries used to fly an aircraft from Matsushita Electric Industrial Co. for 391 miles in 2006

17,000

The number of solar cells on the Solar Impulse aircraft on its upcoming around-the-world flight

160

Cruise speed in km/h of the E-Fan with a 'possible' range of 100km

AIRBUS CRI-CRI

The four-engine all-electric Cri-Cri was developed by EADS innovation Works, Aero Composites Saintonge and the Green Cri-Cri Association, as a low-cost testbed for electrical technologies system integration. "In all-electric mode, performance during climb and aerobatics is better than a conventional aircraft of this type," according to program head Emmanuel Joubert.

The machine incorporates technologies such as lightweight composite structures (that reduce airframe weight and compensate for the additional mass of the batteries), four brushless electric motors with counter-rotating propellers (which propel it without CO_2 emissions and with lower noise compared with thermal propulsion), and high energy-density lithium batteries.

UOC AND BOEING

University of Cambridge researchers have flown an aircraft powered by parallel hybrid/electric propulsion designed and built with financial support from Boeing. Evaluation flights, which have exceeded 1,500ft altitude, will be used to optimize the system for best performance and fuel economy.

The electric motor and Honda gasoline engine combine when maximum power is required during take-off and climb. Cruising in generator mode, the electric motor can recharge the batteries (not done before in the air). In motor-assist mode, it reduces fuel consumption (said to be up to 30% less than conventional gasoline-engined craft). A power electronics module controls current to and from 16 large lithium-polymer cell batteries.

Fire Scout comes aboard

Testing aboard the USS Dunham included take-offs and landings at different weights up to the full 6,000 lb gross weight of the MQ-8C vehicle (Photo: US Navy/Northrop Grumman)

Shipboard Dynamic Interface testing advances the MQ-8C Unmanned Aircraft System (UAS) toward operational sea deployments

BY FRANK COLUCCI

The US Navy has upgraded its MQ-8 Fire Scout Unmanned Aircraft System (UAS) from its original MQ-8B helicopter for the MQ-8C, with more than twice the endurance and nearly three times the payload. The Naval Air Systems Command (NAVAIR) expects a first operational MQ-8C deployment in 2016, and the endurance upgrade is in accelerated developmental testing to give US Special Operations Command (SOCOM) and US Africa Command (AFRICOM) Rapid Deployment Capability (RDC).

"We're flying every day," observes Northrop Grumman Fire Scout business development manager Tom Twomey. Dynamic interface testing aboard the destroyer USS Jason Dunham in December 2014 included 32 take-offs and recoveries with varying winds and ship motions. By early this year, two MQ-8C Engineering and Manufacturing Development (EMD) aircraft had accumulated 345 flight hours in over 260 sorties. Program engineers had logged 2,397 of 3,157 flight test points. "Those are specifications from the government – things the Navy tells you you have to do," explains Twomey. "In the meantime, we've also delivered four production air vehicles and completed sound production acceptance check flights. We're ahead of ourselves."

NAVAIR plans an MQ-8C operational evaluation later this year and has already increased the planned number of RDC helicopters from 28 to 40. The Fire Scout endurance upgrade integrates the civil Bell 407 helicopter with nearly all the same electronics and software as in the MQ-8B, now on its 10th sea deployment. The MQ-8C also uses the same shipboard control stations, datalinks and operating procedures. The EMD helicopters nevertheless fly with additional instrumentation and flight termination systems. "They're absolutely identical to each other," notes Twomey. "The only real way they differ from the production aircraft is they have orange wire in them."

An RDC aims to rush commercial or developmental products to the fleet. MQ-8C testing nevertheless requires the same engineering rigor as any NAVAIR Program of Record and culminates in a full Safety of Flight certification. Test aircraft consequently re-flew much of the documented Bell 407 flight envelope. "It was really to verify a lot of the Bell data that's already out there. The 407's already an FAA-certified aircraft, and it's got a lot of time," says Twomey. Dynamic interface testing took the autonomous helicopter into a new, complex environment. "Part of the contractual deliverables is to prove this thing is safe to take off and land on the deck of the ship. NAVAIR really doesn't treat an unmanned airplane any different from a manned airplane."

TESTING AUTONOMY

Navy requirements for a Vertical Take-off Unmanned Air Vehicle (VTUAV) for over-the-horizon reconnaissance, targeting and communications relay date back to 1999. (See *Aerospace Testing, Testing Talk*, June 2007.) Programmed through its Air Vehicle Operator (AVO) station, the Fire Scout launches and recovers vertically on air-capable ships and confined land bases. It comes back aboard ship using the Sierra Nevada Unmanned Common Automatic Recovery System (UCARS V2).

A transponder on the helicopter helps shipboard radar determine the aircraft's position, and a Recovery Data Link sends the aircraft accurate range data to the moving deck. Around 10-15ft (3-5m) from landing, the airborne GE Fanuc Vehicle Management Computer (VMC) matches ship motion to put the helicopter on a deck capture grid.

The Fire Scout system, including air vehicles, AVO and MPO (mission payload operator) stations, tactical common datalink, UCARS, deck landing system and related equipment made its first operational deployment aboard USS McInerney in 2010 and deployed to Afghanistan from May 2011 to August 2013. The MQ-8B

12
The rotor system's maximum flying endurance in hours

2,650
The weight in pounds of its extended payload capability

3,000,000
The number of flight hours accumulated by the Bell 407

LEFT: **The MQ-8C endurance upgrade gives the Fire Scout UAS new air vehicle 12 hours' endurance (Photo: US Navy/Northrop Grumman)**

system now on Oliver Hazard Perry-class frigates and the Coast Guard cutter USS Bertholf, uses the 3,300 lb (1,497kg) Sikorsky-Schweizer 333 light helicopter to provide five hours on station with an electro-optical payload 110 nautical miles from the ship. Deployments in the AFRICOM region and Afghanistan drove the MQ-8C Endurance Upgrade.

Northrop Grumman and Bell Helicopter teamed on the Fire-X proof of concept using the 6,000 lb (2,722kg) Bell 407. "We knew the Navy was looking at a larger helicopter," notes Twomey. "We also knew the SOCOM customer was looking for something that would fly more than 4.5 to 5 hours." A bigger helicopter also opens opportunities for 360° search radar and other future payloads. Combined fuel and sensor payload of the MQ-8B is 1,242 lb (563kg); the MQ-8C can carry 3,200 lb (1,451kg).

The Fire-X demonstrator retained Bell 407 cockpit controls, enabling the optionally manned helicopter to be piloted from one test site to another without an FAA Certificate of Authority. Twomey explains: "The unmanned pieces, the boxes, went in the back of the Fire-X. We showed we could easily fly the Fire Scout UAS that flew in the MQ-8A/-8B and put it into another helicopter, and we did it fairly rapidly." The company-owned Fire-X flew unmanned for the first time in December 2010, and all subsequent UAS testing was conducted without a safety pilot aboard.

The Fire-X and a second Bell 407 continued as test assets after the Navy awarded Northrop Grumman the Endurance Upgrade EMD contract in April 2012. The company demonstrator, for example, made initial landings on a variable-slope platform at Naval Base Ventura County at Point Mugu, California. "When the Navy decided to move forward on MQ-8C, we kept flying it for awhile," explains Twomey. "We did a demonstration that showed we could carry cargo unmanned on the hook. We also did a lot of risk reduction until we got on contract with the MQ-8C. We were getting datapoints to help us get ahead of the power curve before the first EMD birds came off the line and started flying from Point Mugu."

Slope testing verified that the Fire Scout flight control system transplanted to the new helicopter could maintain stability at different simulated deck angles. "If the deck of the ship is tipping one way or the other, it provides a little compensation because when the skids hit the deck, it's going to slide a bit," Twomey explains. In previous testing, the MQ-8B maintained a landing dispersion within 18 in of the deck centerline. The bigger MQ-8C stayed within the same margin.

SLOW-BURNING FIRE SCOUT

The Fire Scout system, first flown in 2000, evolved from the RQ-8A, based on the three-bladed Schweizer 300 helicopter and four-bladed MQ-8B, with performance and reliability improvements to today's MQ-8C Endurance Upgrade based on the Bell 407. The US Navy received 30 MQ-8Bs – one was shot down in Libya and three more were lost in accidents. Plans for 168 MQ-8B air vehicles to operate from frigates, destroyers, and the new Littoral Combat Ships have been superseded by the MQ-8C Upgrade. Northrop Grumman has 19 MQ-8C air vehicles on contract, including the two EMD test helicopters. The first operational MQ-8C was delivered in December 2014. The prime contractor has also delivered six new control segments to provide rapid deployment capability.

The first MQ-8B sea deployment aboard the frigate USS McInerney from October 2009 to April 2010 flew just 60 flight hours but provided lessons about shipboard integration. Aboard ship, Fire Scout systems are operated and maintained by helicopter squadrons operating the manned SH-60B or MH-60R Seahawk from the same decks. Blue water operations typically mix two MQ-8Bs with one Seahawk. In 2012 HSL-42 deployed a detachment with four MQ-8Bs and no helicopter aboard the frigate USS Klakring off the Horn of Africa to provide intelligence, surveillance, and reconnaissance (ISR) coverage for up to 12 hours a day. The Endurance Upgrade in the MQ-8C promises 24-hour coverage with three air vehicles.

The MQ-8B Fire Scout was deployed to Afghanistan from May 2011 until August 2013 and provided more than 5,100 ISR flight hours supporting US and coalition forces. Test programs have fired laser-guided rockets and integrated a 180° search radar on the MQ-8B vehicle. The MQ-8C will carry the same weapons and may be integrated with a 360° degree radar. NAVAIR acknowledges foreign military sales inquiries for the MQ-8C. Tom Twomey at Northrop Grumman notes, "There's a lot of foreign customer interest in it as it goes through flight testing. Everyone wants the Navy to pay for the R&D."

The first MQ-8C EMD vehicle flew in October 2013. "The Fire-X does not exist anymore," notes Twomey. "It's been well over a year since we retired the aircraft. We really did everything we needed to do with it. It costs a lot of money out of the company's pocket to keep flying those things."

TEST FOR PRODUCTION

Production representative MQ-8Cs dispensed with optional manned flight controls altogether and relocated the VMC and other UAS elements to the cockpit. "Today, all the gear we had in the back of the airplane is where the pilots would sit," notes Twomey. MQ-8C production starts with a standard Bell 407 built in Mirabel, Canada.

A Faraday cage (a mesh enclosure formed from conductive material to block electric fields) supplied by Summit Aviation protects cockpit avionics from shipboard electromagnetic interference. A 304 US gallon (1,151-liter) fuel tank in the passenger cabin gives the unmanned helicopter 12 hours' endurance. The longest MQ-8C flight so far lasted six hours, and analysis of the remaining fuel quantity verified full endurance.

Northrop Grumman has now taken the helicopter back for UAS completion. "Once the sheet metal and the gas tank are put in the airplane, it's sent to Moss Point, Mississippi, for the electronics." The MQ-8C inherits dual VMCs, flight and auxiliary power

5,900
Hours flown by MQ-8C operationally from ships and on land

17,000
Operational ceiling height in feet

140
Maximum speed in knots

conditioning units, payload and engine interface units, and ARC-210 radios from the MQ-8B. The bigger helicopter also uses control actuators identical to those in the MQ-8B, but the dual-channel full-authority digital electronic control on the Rolls-Royce 250-C47B engine eliminates two of the six actuators on the smaller aircraft. Air vehicle software for the new helicopter, with its hydraulic flight controls, is nevertheless nearly identical to that flying the smaller UAV.

The Fire Scout endurance upgrade benefits from a more reliable, less costly GPS/INS navigator, but carries the same BriteStar II laser-designating electro-optical/infrared sensor payload as on the MQ-8B. Like the MQ-8B, the MQ-8C also carries the automatic identification system for cooperative ship targets, and an undisclosed electronics package, but the new aircraft augments the original MILSTD-1553 databuses with an

RIGHT: At-sea testing was preceded by sloped platform landings at Point Mugu, California (Photo: US Navy/Northrop Grumman)

BELOW: Northrop Grumman and Bell Helicopter flew the Fire-X demonstrator as a risk reduction tool for the Fire Scout Endurance upgrade engineering and manufacturing development vehicles (Photo: Northrop Grumman)

Ethernet bus and router for payload control. "There were a lot of enhancements we did in a rapid fashion," acknowledges Twomey.

The USS Jason Dunham had pilot and sensor operator stations integrated into the ship. The Fire Scout verified the UCARS and TCDL (Tactical Common Data Link) worked out to specified ranges, and showed that the UAS could use the same datalink as the manned MH-60R Seahawk. "It was a full-up system as if it were going to go to sea. We used some of the same things the MH-60R uses." Sensor and aircraft data ordinarily go to the Fire Scout ground stations through the TCDL. The MQ-8B link carries 291 vehicle parameters to the ground. MQ-8C aircraft downlink a little more data from their VMCs, but MQ-8B experience that showed operators actually had more aircraft information than they needed to operate the system. On the MQ-8C test aircraft, most engineering data is stored on the airplane and downloaded to a laptop computer for post-flight analysis.

The five days at sea on the Dunham enabled take-offs and landings at different weights. "You had to take-off lightly loaded and work your way up to 6,000 lb gross take-off weight," notes Twomey. "It's really to verify the stability of the aircraft at all those weights. We did take-offs and landings in different wind conditions over the deck. We're doing 30kts and the thing pops off the deck and lands like a regular helicopter does." Follow-on testing awaits ship availability.

"We have more test points, but we can do those test points on land. We verified on a DDG that we're good to go to take-off and land on that class of ship," Twomey explains. The MQ-8C will be tested on the new Littoral Combat Ships (LCSs) later this year or early 2016. "The LCS will be another dynamic interface test. It won't be as involved, but we're going to have to show we can work on both classes of LCS. It's no different than a manned helicopter, Twomey concludes." ∎

Frank Colucci is a specialist in rotorcraft design, civil and military operations, test and avionic programs

Up and down, round and round

A crucial element in operational safety, landing gear systems must be fully tested before flight. *Aerospace Testing International* learns more from the landing gear test engineers at UTC Aerospace Systems and the head of fuel and landing gear integration test at Airbus, Martin Evans

BY PAUL E EDEN

Of the many aircraft systems proved before a new machine begins even its first taxi run, the undercarriage is perhaps not the first to spring to mind. But extensive and exacting testing processes are applied not only to individual gear legs and their components, but also to the entire complex and interacting system of legs, wheels, tires, brakes, doors, actuators and steering.

In many cases OEMs commission undercarriage components from multiple suppliers who themselves source parts from others, so the whole must be built, integrated and tested to exacting levels. Among the major players in the industry, UTC Aerospace Systems (UTAS) has a landing gear facility at Oakville, Ontario. It is unusual, perhaps even unique, in boasting design, manufacturing and test capabilities under one roof.

According to Tim Whittier, director, government relations – landing systems, this intimate arrangement improves the level of internal communication and cooperation between design, engineering and test personnel. "The test department engineers are very much a part of the overall product development. They're involved right at the early stages of design, identifying what tests need to be completed and what their parameters are."

Oakville produces landing gear primarily for commercial applications. Its smallest equipment is built for helicopters while its largest, heaviest structures are the wing and body landing gears for the Airbus A380. The facility is in the process of expanding its test capabilities, but can already work across the full range of equipment it manufactures.


www.cwc-ae.com
ACRA KAM-500: THE WORLD'S MOST WIDELY INSTALLED FLIGHT TEST INSTRUMENTATION SYSTEM
CURTISS-WRIGHT
New Processor Card Reduces Turn-around Time
+ Low power, rugged and reliable computing module with embedded DSP
+ Addresses custom data acquisition needs quickly and easily
+ Saves time and removes the need for dedicated units
+ Industry standard development tools simplify the task


safety in test > safety in flight
TEST-FUCHS
Test Equipment for Aerospace SSE / STTE
Visit us in Hamburg at the Aircraft Interiors Expo 14 - 16 April 2015
Mobile and fixed test systems for all kinds of civil and military aircraft components
> Mobile Air Conditioner
> Oxygen and Nitrogen Trolley
> Hydraulic Servicing Trolley
> Various Tools
WWW.TEST-FUCHS.COM

A380 LANDING GEAR SYSTEM

According to a 2008 Airbus document, the full A380 landing gear system comprises:

- Nose landing gear with twin wheels;
- Two body landing gears, each with six wheels, four of them braked;
- Two wing landing gears, each with four wheels, all braked;
- Extension/retraction system;
- Braking control system;
- Steering control system (nosewheel and body wheel steering);
- Wheels, tires and brakes;
- Monitoring systems for the tire pressure indication system, brake temperature indication system and oleo pressure monitoring system. The undercarriage doors and their actuation systems must be added to these.

THE TEST PROCESS

Gary Warburton, senior mechanical designer and project leader – test lab at Oakville, explains that although there are variations in test requirements, a landing gear typically goes through a series of standard test procedures. These include dynamic level testing, perhaps more familiar as drop testing, as well as static, durability and component testing. "For drop testing, we take a fully assembled landing gear, place it in a carriage on a drop tower and release it at different descent speeds and surface velocities to simulate its dynamic performance. Static testing is also performed on fully assembled gears and we apply loads up to the maximum they would be expected to see, assessing whether they can withstand them.

"We test two types of load. A gear is expected to recover from yield load without deformation, while ultimate load deforms the gear but it must not fracture. Yield load is actually the maximum load the gear is expected to take, while ultimate load is a factor above.

"In durability testing, the gear is placed under loads to simulate a flight, and that is repeated until it's equivalent to the lifetime of the aircraft. Then we add an additional scatter factor of between three and five additional lives to demonstrate that the gear definitely meets its requirements."

Marco Perrella, director, in-production engineering, explains that additional test processes are applied at component level. "They are typically carried out on smaller items such as actuators and steering manifolds. They go through all the other test procedures, but also undergo a fair degree of environmental testing."

UNDERCARRIAGE FACILITY

Given Oakville's product range, its test facilities vary enormously in capability and it has drop towers capable of handling gear ranging from the size of that installed on the Gulfstream G450 right up to A380 and Boeing 777 legs. It tests over this wide range of dimensions using three towers, specially equipped to vary 'weight over gear' according to aircraft type. A fourth tower is in the planning phase and will facilitate testing across an extended range from 1,500kg to 500,000kg.

Other variations between aircraft types are less immediately obvious, but as Perrella explains, vertical acceleration is another factor that testing has to take into account. "An A380 typically lands at around 5-7ft/s in service, and the maximum we need to meet is 10ft/s at maximum landing weight and 6ft/s at maximum take-off weight. We also perform a case, called the ultimate drop test, at 12ft/s, with the intention of ensuring that the landing gear shock strut does not bottom.

"With helicopters, it's a different situation with a different set of

32
The unique number of undercarriage wheels on the Antonov-225, configured in two bogies with 14 wheels each, and four up front

22
The number of wheels on the A380; just two are on the nose landing gear

BELOW LEFT: UTAS manufactures gear for a variety of aircraft types at Oakville, including the Bombardier CRJ

OFF THE TOP OF YOUR HEAD

How many personnel work in the test department?
Gary Warburton:* *"There are currently around 25."

Is the department busy with research outside its regular test schedule?
Gary Warburton:* *"We have three projects on right now, all scheduled for first flight this year or next."

How long does a landing gear test effort last?
Tim Whittier:* *"Programs typically last three-plus years when they include fatigue testing."

What is the primary function of UTAS's test effort?
Tim Whittier:* *"Our test work is most importantly a validation of our analysis."

How do you think test will change in the future?
Tim Whittier:* *"We hope to improve our analysis and focus on certain parameters, rather than testing entire landing gear."

8
The number of wheels on a Boeing Stratofortress

10
The number of wheels on the Boeing 787, mounted on four bogies (framework/structure)

14
The number of wheels on the A340-500/600

requirements. Their landing gear must be able to absorb 30% of the energy in a vertical landing and their structure the remaining portion. Descent rates can be in excess of 18ft/s, especially in the case of engine failure, so vertical acceleration requirements for helicopters are generally a lot higher than for fixed wing."

All the dressed gear testing includes the aircraft tire or tires, which are integral to undercarriage performance and safety. These are specified and supplied by the OEM. Gary Warburton explains just how important tires are to the test process: "Tires from different manufacturers vary in carcass stiffness and tread, for example, and tire function and inertia may also differ."

Depending on program specifics, there may be an on-site role for UTAS specialists once landing gear has been delivered to the OEM and installed in its prototype aircraft. Perrella says that test personnel might witness preflight shimmy testing on the ground, for example, where the aircraft is taxied over boards and data collected on undercarriage performance for analysis. A proportion of data is telemetered for immediate use, while much is recorded for future use. The latter is especially useful for trend identification if problems should subsequently emerge.

UTC AEROSPACE SYSTEMS

In 2011 United Technologies announced its intention to acquire Goodrich, combining it with Hamilton Sundstrand to produce UTC Aerospace Systems, a deal formally concluded in July 2012. The Goodrich holdings included the undercarriage design, test and manufacturing facility at Oakville, Ontario and its portfolio of landing gear products.

Oakville delivers basic gear structures, individual dressed gears and complete systems across a range of aircraft including the Airbus A380 (it also has a contract for A350-1000); Boeing 737, 747, 767 and 777; Bombardier CRJ700, 900 and 1000, and Q400; and Gulfstream G450, 550 and 650, as well as helicopters.

The 250,000ft² (2,500m²) Oakville plant employs 900 people, including 450 in manufacturing and 120 in engineering.

RIGHT: UTAS tests and manufactures gear for Boeing airliners, including the 777

SYSTEM RIGS

UTAS employs system rigs – similar to the 'iron birds' used for avionics testing – to assess the functionality of the full landing gear systems it creates, but in many cases it supplies only components of a wider system. The A380's wing and body landing gear units are manufactured by UTAS, for example, while Messier-Bugatti-Dowty supplies the aircraft's nose landing gear and several other manufacturers build components of the aircraft's complex landing gear system.

Martin Evans, head of fuel and landing gear integration test at Airbus, explains that all these items are built to detailed Airbus specifications that include definitions of interfaces between elements. "The suppliers are required to verify their compliance to these specifications," he says, "and Airbus then verifies the integration of these system elements, generally through test at increasing levels of physical integration through avionics tests and '0' Test Means to the aircraft."

"TELEMETRY IS EXTENSIVELY USED DURING TAXIING AND EARLY FLIGHTS AS IT PROVIDES REAL-TIME SUPPORT TO THE ENGINEERS AND CREW ON THE AIRCRAFT"

Evans explains that in Airbus parlance, the initial aircraft is MSN001. The Test Means that come before it are therefore numbered '0' and include High Lift 0, Cabin 0 and Landing Gear 0. "All elements of the landing gear systems are integrated into a large '0' Test Means and tested prior to aircraft power-on, when functional tests are performed. The systems are then tested again to assess performance prior to first taxi and first flight."

Within the landing gear system, the gear doors and their actuators are major elements of the extension/retraction system. Evans says: "They contribute to the hydraulic, timing and state control of normal operation and, under gravity extension, need to be assessed to confirm that they do not hinder the safe extension of all the landing gears. Normal extension/retraction and gravity extension performance is confirmed when the aircraft is still on the assembly line."

During subsequent taxi trials, performance, flight warning system and reconfiguration tests are carried out within a wide suite of testing that leads up to rejected take-off performance confirmation. As Evans explains, telemetry is crucial to these challenging, dynamic trials: "Telemetry is extensively used during taxiing and early flights as it provides real-time support to the engineers and crew on the aircraft. Through telemetry, systems designers and specialists are able to investigate a high number of parameters specific to their systems and give direct feedback, via the telemetry controller, to the aircraft. This activity is distributed across the Airbus engineering sites, where satellite telemetry rooms are linked via Toulouse to the aircraft." ∎

Paul E Eden is an aviation writer based in the UK

Sounds ultra advanced

Automating NDT will save time, reduce costs and speed up the test process. Now that systems are becoming more refined, this will be particularly applicable for composite structures

BY BERNARD FITZSIMONS

Non-destructive testing is used extensively at every stage of aircraft production and operation, from raw material evaluation to in-service inspection. Automating the process promises to save time, cut costs and avoid potential production bottlenecks, particularly for composite structures.

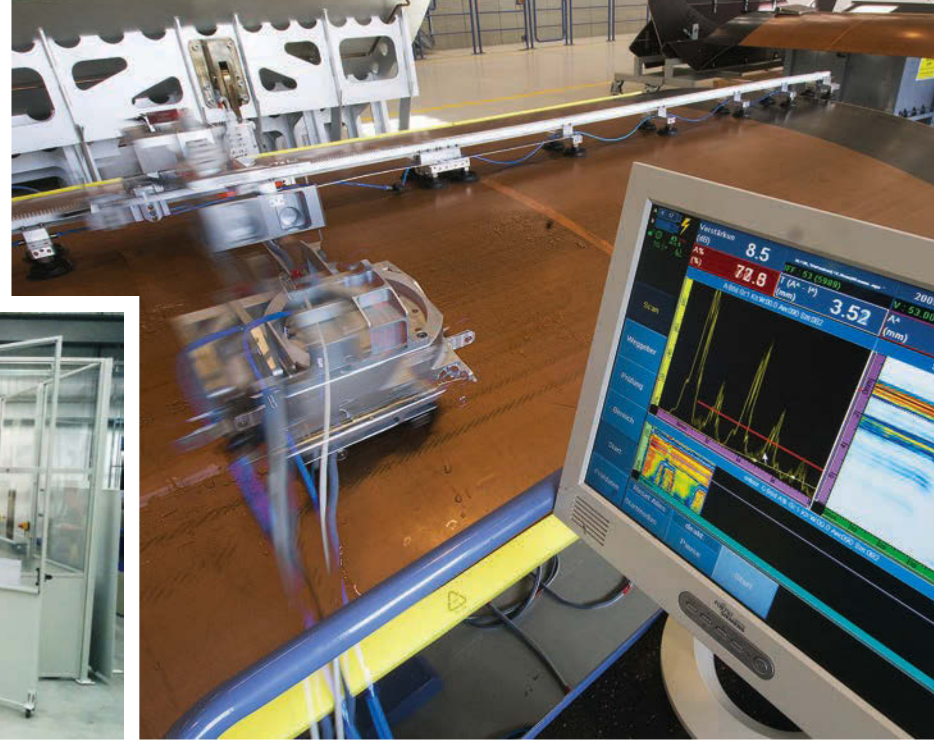
Automated NDT systems are already widely incorporated into the production process of new airliner models. Airbus factories in France, Germany and Spain, for example, use ultrasonic systems from Areva NDE Solutions and its subsidiary intelligeNDT to inspect wing covers and other structural elements of the Airbus A350.

Phased array ultrasound transducers (PAUT) are the only option for examining such large panels at high throughput rates. The arrays' multiple elements mean that the angle and focal depth can be varied by changing the pulse focal laws. For fuselage panels, which are up to 20m long and 6m wide, the center wing box, and keel beam parts, six-axis manipulator systems are used to position the PAUT instrument. For wing covers, dual six-axis tower systems are used: one system inspects the skin side while the other is synchronized and programmed to inspect stringers in a different position to avoid interference with water on the backside.

CLEAN SKY NDT

Exploiting the properties that make composites attractive – including improved stiffness to weight ratios and better resistance to corrosion, impact and fatigue – means fabricating increasingly complex parts that are correspondingly harder to inspect. For

RIGHT: **Robots scan two areas of a large aerospace part simultaneously in TWI's IntACom prototype robotic inspection cell**



FAR RIGHT: Ultrasonic quality control of CFRP fuselage shells for the Airbus A350 at the Nordenham plant of Premium Aerotec

RIGHT: IntACom prototype robotic inspection cell at the TWI Technology Centre in Wales

this reason, the pan-European Clean Sky research program that is pursuing dramatic reductions in the environmental impact of air transport includes work on NDT automation.

In Spain, Tecnatom and the Center for Advanced Aerospace Technology (CATEC) in Seville are collaborating on the €475,000 DIAAMOND (Development of Non-destructive Inspection Approaches for Automatic detection and Monitoring of Damage evolution) project. The aim is to develop new approaches to inspection and automated systems for the detection and online recording of CFRP damage during structural tests. The approach would shorten total test time and reduce the requirement for human presence, particularly for tests running continuously around the clock.

The resulting demonstrator will perform data acquisition and analysis automatically and transfer results to the structural test control system in real time. As well as avoiding the need for human intervention, the objectives are to reduce inspection time, improve inspection quality by providing NDT data positioning and recording, and simplify system automation. Relevant information will be extracted automatically by image processing and data fusion to support structural test follow-up.

DIAAMOND forms part of the Green Regional Aircraft platform. Under another Clean Sky initiative, Sustainable and Green Engines (SAGE), the €500,000 WELDMINDT project is looking at open rotor engine welded parts inspection using miniaturizable non-destructive techniques.

The SAGE 2 project focuses on a geared open rotor engine, which will feature rotating turbine frames. Because the frames are regarded as engine-critical components, they require extremely reliable design, manufacturing and inspection methods, and maintenance and overhaul procedures. NDT methods in particular need to be robust and accurate.

Welded joints are currently examined using techniques such as visual inspection, fluorescent penetrant inspection (FPI) and radiography. WELDMINDT aims to improve both detectability and NDT accessibility in interior semi-closed design elements such as hollow vanes and torsion boxes. It will mean developing non-contact techniques such as optical, infrared camera and others, with the potential for miniaturization and characterizing their capability.

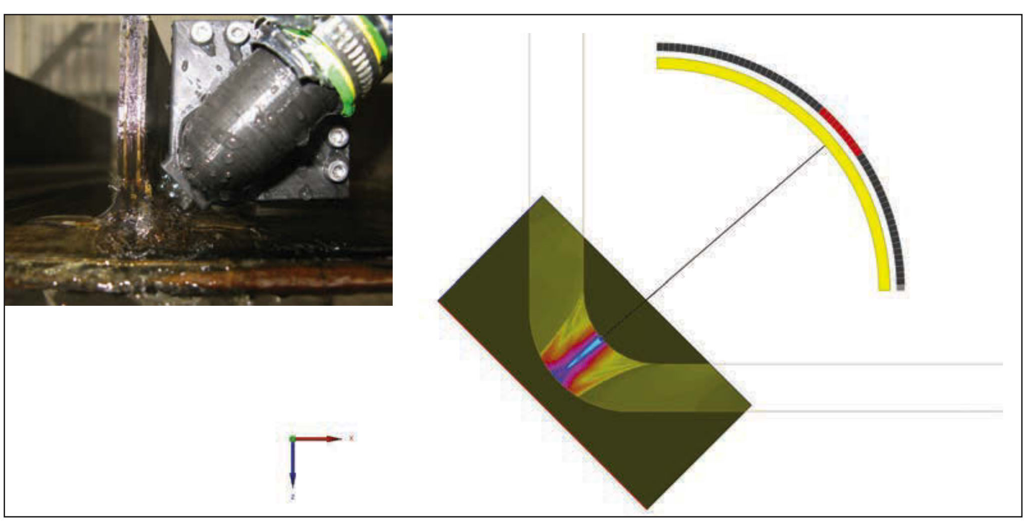
Coordinated in Spain by Lortek, the project aims to integrate shearography, infrared thermography and ultrasonic inspection into a single inspection system, using a laser as the sole excitation source. The combination

INSPECTING COMPLEX GEOMETRY

The prototype system developed by TWI Technology Centre in the UK was designed to be able to inspect all areas of a 3 x 1 x 1m volume. The resulting 5 x 5m robotic cell houses two KUKA KR16 L6-2 robots capable of streaming positional data at high speed and working both independently and cooperatively. The six-axis robotic arms can carry a 6kg payload, have a maximum reach of 1,911mm and position repeatability better than plus or minus 0.05mm. The end-effector on each arm carries a water jet nozzle fed with water at up to 20 liters/min. Multiple nozzles, produced by 3D printing, have been designed to support both flat and concave ultrasonic phased-array probes and generate suitable coupling with high curvature surfaces. A jig table 1.5m wide and 2.5m long mounted on the draining tray between the robots enables accurate positioning of the item under inspection.

Two Peak-NDT Micropulse 5PA phased-array ultrasonic-transducer systems provide 128/128 active channels individually or 256/256 channels when connected together.

BELOW: IntACom uses curved arrays to inspect internal and external radii in a single pass




MU56 TB –
Fully automated quality
assurance for turbine blades
Robot system for serial X-ray inspection of turbine blades
Fully automated defect recognition (ADR)
Fully customizable and adjustable to meet every customer requirement
Visit us at ASNT 24th
Research Symposium
16-19 March 2015
Anaheim, CA
Please contact our sales organization:
Essener Bogen 15, 22419 Hamburg, Germany
Phone +49 40 527 29 - 101 or visit us at
www.yxlon.com
YXLON
Technology with Passion


NEW SITESCAN & MASTERSCAN
FLAW DETECTOR SERIES
Sonatest
Protective Rubber Boot
Now Available
NDT'S PREMIER ROADSHOW
www.ndtroadshow.org
United Kingdom
Feb/Mar/Apr/May/June 2015
Control
Control 2015
Germany
05-08 May 2015
Take a Closer Look
Frequent Applications
Composite Inspection, Delamination Detection
Manufacturing Defects, MRO Inspection, Impact Damage Assessment
Bond Testing, Large Area Scanning, General UT Inspection
UK NDT Equipment Manufacturers
Digital & Phased Array Flaw Detectors
Thickness & Coating Gauges, WheelProbe Technologies,
Ultrasonic Couplant, X-Ray Film, NDT Accessories.
www.sonatest.com
tel: +44 (0)1908 316345
e:sales@sonatest.com

LEFT: The Morfi robot uses active thermography to examine the chemically milled pockets in 737 Classic fuselage skin plates

ABOVE: Lufthansa Technik has developed a prototype robot to inspect Boeing 737 Classic fuselage panels

> **"THE HEART OF THE AUTOMATED INSPECTION SYSTEM IS AN INSPECTION CELL COMPRISING TWO SIX-AXIS ROBOT ARMS"**

of multiple NDT techniques, along with the use of advanced signal processing, is expected to increase the defect detection rate and size precision by more than 20% while reducing the inspection time from minutes or hours – or days in the case of maintenance, which would otherwise involve dismantling the engine to gain access – to seconds.

INTACOM PROJECT

Research is not confined to Clean Sky. TWI in the UK is a participant in the WELDMINDT project, and the TWI Technology Centre in Wales recently completed the first phase of its IntACom NDT automation project with the production of a prototype robotic NDT system.

Backed by Rolls-Royce, GKN, Bombardier and the Welsh government, the three-year project aimed to achieve a fourfold increase in the speed of inspection and analysis of geometrically complex composite components. And it has succeeded to the extent that the industrial partners have opted to back further phases of the project without waiting for a further round of Welsh government funding.

High raw material costs and labor-intensive processes make composite parts expensive to produce, and the requirement to inspect every part means that NDT can be a bottleneck. Exploiting the properties of composites to produce more complex parts exacerbates the problem and demands both faster and more advanced inspection techniques. The alternative is manual inspections that can add variability and cost.

According to project manager Ian Cooper, the research addressed three areas. As well as automating the inspection itself and applying advanced PAUT, it uses advanced software techniques such as assisted defect recognition and scan display management. Automation means areas previously scanned by hand, with results transcribed on to the part and report drawings, are now scanned automatically using scanning paths generated from imported CAD data.

The heart of the automated inspection system is an inspection cell comprising two six-axis robot arms, capable of working independently and cooperatively. The robotic arms deploy end-effectors carrying ultrasonic array transducers that can scan wide areas of the part in a single pass. CAD data imported into the system is used to generate scan paths using commercial or in-house-developed off-line programming software. Mousing over the displayed CAD image enables the user to select surfaces to be inspected and assign tools to each surface, while live imaging allows programming of focal laws and other ultrasonic parameters. The tools and components are protected by detachable magnetic holders. Once the part has been defined, scanning is achieved by simply selecting the part from a menu and pressing the start button.

ULTRASONIC ARRAYS

The replacement of single element transducers with ultrasonic arrays enables curved surfaces, radii and other difficult areas to be scanned at much higher rates than was previously possible. Where possible, large PAUT probes were used to provide maximum area coverage in a single pass. Ultrasonic modeling was used to determine the optimum inspection techniques for difficult areas of geometry. For example, curved arrays were used to inspect internal and external radii in a single pass.

Complex curvatures are addressed by detecting the shape of the surface interface and adapting the focal laws to suit. This can be pre-programmed or done 'on the fly'. Other challenges such as non-parallel front and back surfaces and highly varying thickness are addressed by a combination of relative positioning of transducers when working in through transmission mode, and post-processing of the data.

In enhanced scan imaging, the permanent data record is used together with CAD data to produce 3D imaging of parts and flaws using software developed as part of the project. "Acquiring high-resolution data is great," comments Cooper, "but the job of the inspector can be made much easier if the data is displayed in such a way that flaws are easy to identify, characterize and size."

The 3D images are fully scalable and can be manipulated intuitively by the user to show the area of interest or the whole part. Selectable views include the usual A- and B-scans and the 3D view, and features such as the display of the CAD image with scan data plotted on it. Clicking on the center mouse button normalizes the view at the cursor position on the surface for convenient sizing of flaws using the included suite of measurement and mark-up tools.

Cooper says the next phase of the IntACom project has already begun. So pleased were the partners with the work achieved that the industrial partners have provided funding support for another year, while a proposal for a larger program of work for a further three years is submitted.

In the short term, he says, work will concentrate on the integration of metrology equipment to provide automated part identification and verification: "This will allow parts to be positioned in approximately the correct position and the system will adjust scan paths to suit. It will also detect if parts do not conform to CAD data within set limits and either adjust scan paths or reject the part." Other work will include the inspection of thicker components and the detection of damage under metal fasteners or erosion shields using full matrix capture (FMC) techniques optimized for use on composites.

Looking ahead to the larger project, a larger cell will be constructed with multiple robots on tracks and part translation systems aimed at the inspection of larger components such as wing spars and skins, wind turbine blades and boat hulls. Development scope will be extended to include high accuracy inspection of complex metal parts such as those produced by the latest additive manufacturing methods such as laser metal deposition.

FUSELAGE INSPECTION

Lufthansa Technik is developing the use of active thermography for inspection of carbon fiber composite structures. One project, looking at the optimization of NDT methods for composite materials, also involves industrial image processing specialist Automation Technology and Hamburg University of Technology (TUHH). Another, involving TUHH plus NDT systems manufacturer edevis and joining technologies consultant IFF, has applied the technology in an automated system that uses a robot to carry out inspections of aircraft fuselages.

Active – or heat flux – thermography uses a brief thermal pulse from a heat source such as a halogen lamp to heat the surface of the objects to be measured. As the heat moves from the surface to the interior of the material, any subsurface faults or defect areas with lower thermal conductivity prevent the heat from spreading. The surface above defective areas therefore remains hot for longer, enabling infrared cameras to make the temperature differences visible.

In composite materials, the technique enables concrete indications of damage or of defects such as delaminations to be detected in ribs and stringers. Its advantages include the ability to examine areas of up to 0.5m² in a single pass. The four-year optimization project included the development of software for the automated detection of defects. And while the method is limited so far to materials 4mm or less in thickness, that already covers around 80% of the fuselage of a Boeing 787. ∎

Bernard Fitzsimons is an aviation journalist specializing in the air transport business, technology and operations

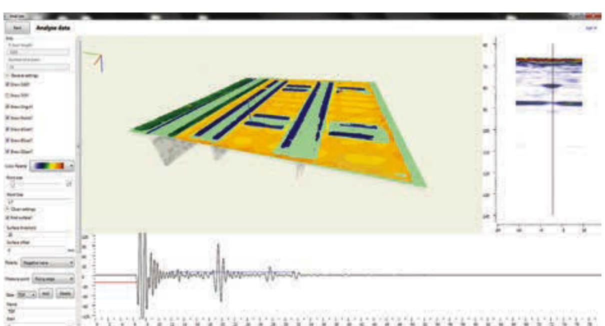
FUSELAGE INSPECTION ROBOT

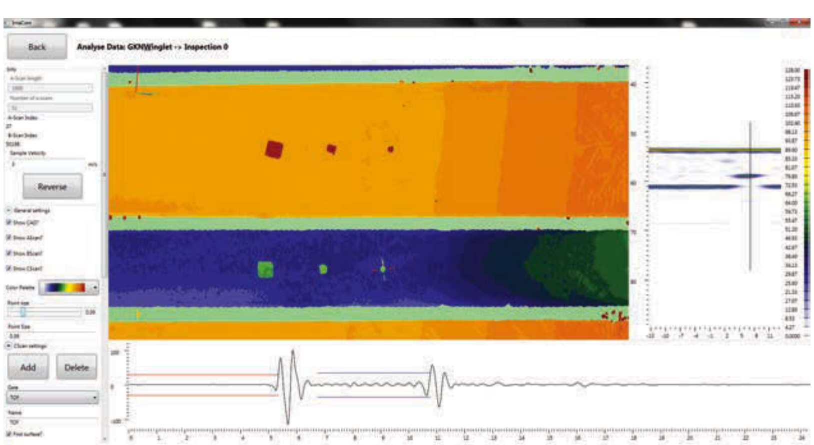
Manual application of NDT procedures to an entire fuselage is time-consuming and expensive, so Lufthansa Technik set out to develop a robot–assisted inspection procedure. The result is a demonstrator named Morfi (Mobile Robot for Fuselage Inspection).

Morfi uses active vacuum pads to move and position itself even on vertical and overhanging surfaces. Two coils induce a brief electrical pulse in the control area on the fuselage surface, heating it by a few degrees, and an infrared camera records the change in temperature. Cracks stand out because they heat up more strongly, exhibiting a distinctive temperature profile, particularly at their tips. The demonstrator was designed to inspect the 10 x 9.6in chemically milled pockets used to reduce the weight of Boeing 737 Classic fuselage plates. During each positioning operation, it gathers data on four control areas, each comprising two pocket edges. The entire inspection cycle, including saving all the recorded data, takes less than 30 seconds.

Follow-up work focuses on reducing the demonstrator's 75kg weight and extending its application to alternative materials used on current production aircraft, such as carbon fiber reinforced composites and glass fiber reinforced aluminum (Glare).

BELOW: The IntACom software enables data to be displayed in a way that makes flaws easy to identify, characterize and size





RIGHT: The IntACom software enables the user to analyze the collected data through visualization of B-scans (right hand side of the screen) and the A-scans


Failure is not an option.
Computed Tomography allows for the detection of internal and external flaws and other defects that can help avoid catastrophic failures in mission critical components. This technology can also reduce production downtime, manufacturing costs and ultimately save lives.
X5000
North Star Imaging has X-ray and Computed Tomography Systems designed for efficiency and repeatability to ensure your equipment functions safely and correctly each and every time.
The Inspection Services Group provides real-time X-ray inspection and 3D CT scanning services to virtually anyone needing to verify the integrity of internal components.
NORTH STAR IMAGING, INC.
NSI
AN ITW COMPANY
www.4nsi.com . 1.800.635.8392 . +33(0) 1 48 17 02 00 . info@4nsi.com

Lightning II ground

As the F-35 Lightning II completes a whole raft of flight test trials, *Aerospace Testing International* takes an exclusive look at the involvement of the Integrated Test Force (ITF) in this stage of the fighter's complex multirole development

BY SYLVIA PIERSON

Since December 2006, the F-35 Lightning II has surpassed 25,000 combined flight hours with 16,200 hours in F-35 military fleet aircraft and 8,950 hours of system development and demonstration testing. Much of that testing has been conducted by the F-35 Lightning II Integrated Test Force (ITF) assigned to Air Test and Evaluation Squadron (VX) 23, based at Naval Air Station Patuxent River, Maryland.

Operating at a high tempo is routine for the Pax River ITF's cadre of military, government and contractor testers. In the span of less than six months, they successfully conducted two high-profile test evalutions on opposite coasts of the USA and began preparations for additional high-visibility testing, yet again on both sides of the country.

On September 29, 2014, the ITF deployed a team of 40 testers to the McKinley Climatic Laboratory (MCL), the world's largest environmental testing chamber. The 96th Test Wing, a US Air Force Materiel Command unit, operates the MCL at Eglin Air Force Base in Fort Walton Beach, Florida. For six months, the Pax River ITF Climatic Test team and key members of the Edwards ITF have capitalized upon the MCL's proven capability to recreate nearly every weather condition on Earth as they assessed the performance of aircraft BF-05, the short take-off/vertical landing (STOVL) variant, in a wide array of temperatures and meteorological conditions. Testers put the aircraft through extremes such as -40°F/C up to 120°F (48.8°C) and featured wind, solar radiation, fog, humidity, rain intrusion/ingestion, freezing rain, icing cloud, icing build-up, vortex icing and snow.

By placing BF-05 onto a purpose-built frame, test pilots were able to 'fly' a standard profile in accordance with defined test sequences. This profile featured a normal start-up, a VSBIT (vehicle systems built-in test) to check the onboard systems, a simulated short take-off, a climb out, full afterburner runs in conventional mode, and a simulated vertical landing. Each meteorological condition was fully tested and featured 60% ground operations and 40% flying, including engine runs and simulated flight in both conventional and STOVL modes. Testers also ensured the collection of accurate and representative data during the icing evaluation by installing additional F-35A and F-35C icing detector probes according to each variant's design.

"This type of testing doesn't happen every day," says US Navy test pilot Cdr Tony 'Brick' Wilson. "What the McKinley team has pulled off at Eglin

LEFT: An F-35B Lightning II short take-off/vertical-landing (STOVL) variant of the Joint Strike Fighter is currently undergoing climatic testing at McKinley Climatic Laboratory (MCL) at Eglin AFB. An icing cloud test calibration fixture has been installed within the climatic chamber

is a real feat of engineering; it's been a very surreal experience to walk from normal Florida weather into the hangar where it's like the Arctic and test the F-35. We'll complete our testing at the end of March 2015 and I'm pleased to say that the findings have been very positive to date."

ABOVE: The F-35C Lightning II carrier variant conducted its first carrier-based night flight operations aboard a US Navy aircraft carrier in November 2014

BELOW: Flight 328 of aircraft BF-02 returns to base at Pax River

INTERNATIONAL EFFORT

The F-35 Lightning II is a joint, multinational acquisition intended to develop and field an affordable, highly common family of next-generation strike fighter aircraft for the US Air Force, Navy, Marine Corps, and eight international partners. The single-seat, single-engine, stealthy strike fighter will incorporate low-observable (stealth) technologies, defensive avionics, advanced sensor fusion, and internal and external weapons. It will also have an advanced prognostic maintenance capability to deliver optimum international security via integrated coalition operations to the UK, Italy, the Netherlands, Turkey, Canada, Australia, Denmark and Norway; and three Foreign Military Sales (FMS) countries – Japan, Israel and South Korea.

The F-35A conventional take-off and landing variant will be a multirole, stealthy strike aircraft replacement for the Air Force's F-16 Falcon and the A-10 Thunderbolt II aircraft, complementing the F-22A Raptor. The F-35B short take-off and vertical landing variant will be a multirole stealthy strike aircraft to replace the Marine Corps' F/A-18C/D Hornet and AV-8B Harrier aircraft. The carrier-suitable variant, the F-35C, will provide the US Navy department with a multirole, stealthy strike aircraft to complement the F/A-18 E/F Super Hornet. Lockheed Martin is the aircraft contractor and Pratt & Whitney is the engine contractor.

ONBOARD TRIALS

While some of their teammates were in Florida, an ITF detachment traveled to Naval Air Station North Island in Coronado, California, to board the USS Nimitz (CVN 68) in November 2014. Led by Cdr Wilson and Thomas Briggs, the ITF's lead flight test engineer for DT-I, their test objective was to conduct a three-week initial shipboard developmental test (DT-I) trial of the F-35C Lightning II, the carrier variant of the Joint Strike Fighter (JSF).

During DT-I, F-35C test pilots and engineers tested both the suitability and integration of the aircraft with carrier air and deck operations in an at-sea environment. The F-35C demonstrated exceptional performance both in the air and on the flight deck, accelerating the team's progress through the DT-I schedule and achieving 100% of the threshold test points three days early. Test pilots and engineers credited the F-35C's Delta Flight Path (DFP) technology with significantly reducing pilot workload during the approach to the carrier, increasing safety margins during carrier approaches and reducing touchdown dispersion.

"The engineers responsible for the aircraft's control laws did a phenomenal job designing this aircraft from the pilot's perspective," Wilson explains. "The control schemes of the F-35C provide a tool for the below-average ball flyer to compete for top hook."

"My major takeaway was that the F-35C is very good at flying behind the ship," notes Lt Cdr Ted Dyckman, a VX-23 test pilot at the ITF. "Any deviation that someone gets themselves into, they can correct fairly quickly and accurately. In fact, it's a three-wire machine," he added, referring to the optimal arresting wire aboard an aircraft carrier.

The DFP capability allowed for 124 arrested landings with zero unintentional hook-down missed attempts to catch an arresting wire on the flight deck, otherwise known as 'bolters'. (Two hook-down intentional bolters were conducted as part of the DT-I test plan.)

"The flight control system is precise, stable and responsive, and provides carefree handling in all flight regimes," says Cdr Christian Sewell, the VX-23 F-35 operational test liaison officer/ITF operations officer. "We've tested right up to the edge of the envelope and the aircraft handles amazingly. In general, the pilot workload required to fly the F-35 is less when compared with legacy aircraft, which allows the pilot to focus on the operational mission."

33
The number of flights during the F-35C's initial shipboard trials (DT-I)

124
Catapult launches and arrested landings

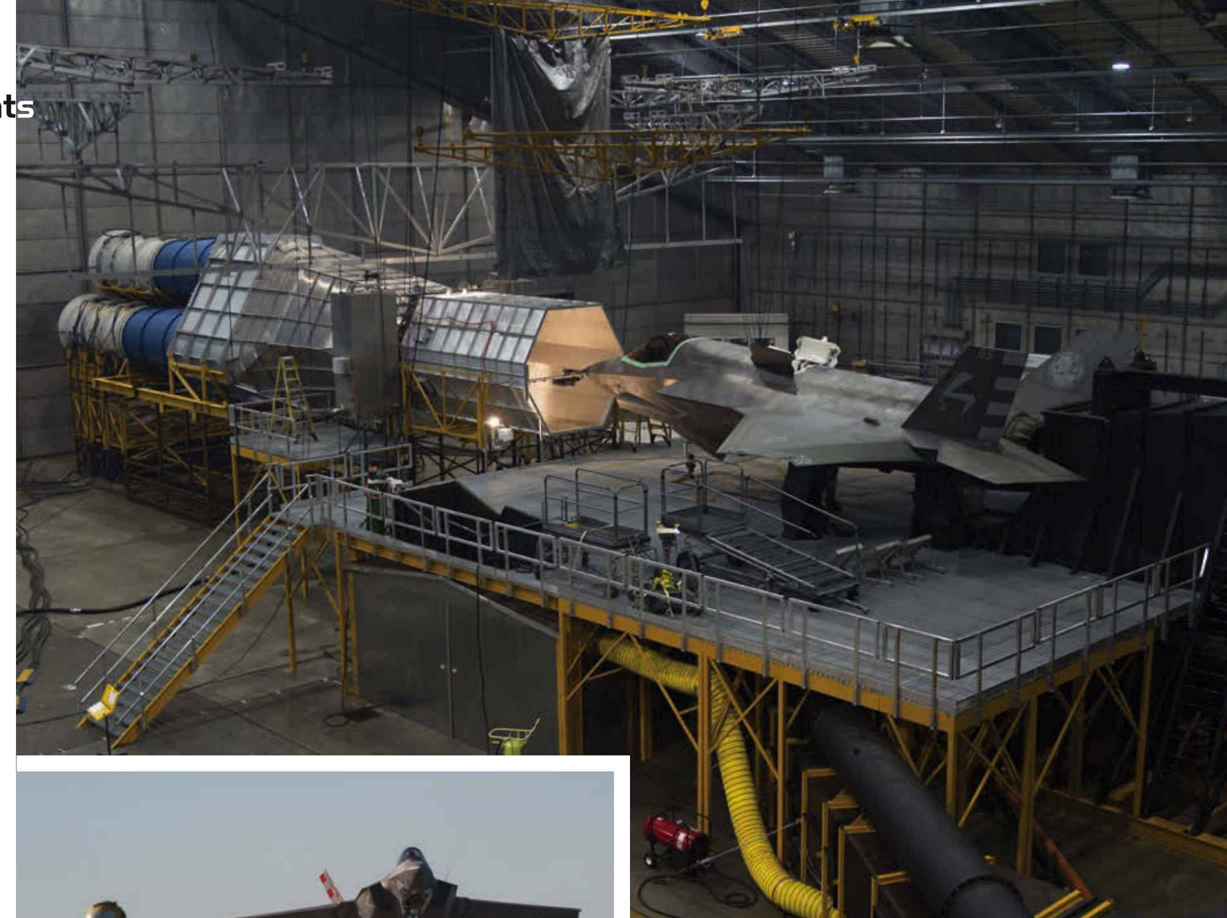
0
Unintentional bolters (unarrested landing)

F-35B CLIMATIC TEST

15°C	Ambient temperature of the chamber
48.8°C	Max. hot soak
-6.7°C	First cold weather engine run
-40°C	Max. cold soak
10°C	Ambient temperature at which all ice on the aircraft melts

TAILHOOK DESIGN

The three-wire landings during DT-I also demonstrated the successful redesign of the F-35C's tailhook and supporting structural interfaces. The joint contractor and government team consisted of engineers from NAVAIR's Systems Engineering, Air Vehicle



RIGHT: **The F-35 Lightning II Pax River Integrated Test Force from Air Test and Evaluation Squadron (VX) 23 has ferried aircraft BF-05 to Eglin AFB to undergo climatic testing**

BELOW: **CF-05 lands aboard the USS Nimitz during the initial shipboard trials. The F-35C performed its first set of arrested landings and catapult launches**

Engineering and Support Equipment & Aircraft Launch & Recovery Equipment departments, the Atlantic Test Range (ATR) and Pax River ITF, and Lockheed Martin Aero, Northrop Grumman, and Fokker Landing Gear.

The tailhook redesign effort, like the flight control system, is an example of the power of collaboration between government and industry engineers. In both cases, industry was able to leverage NAVAIR's decades of experience in carrier-based aircraft design to build an outstanding product for the warfighter.

"Since beginning shore-based carrier suitability testing in January 2014 with the redesigned hook system, test results have been positive, with the ultimate proof coming in the success of DT-I," says Bryan Racine, F-35 ship suitability team lead.

"We had stricter weather requirements when we were here. As we got into testing, the weather started coming down," Dyckman says. "We had such confidence in how the airplane was flying that we lowered the weather minimums to what the fleet is actually using, knowing that when I lower my hook and come into the groove, I'm going to trap."

Dyckman adds that the test team's confidence level in the aircraft was so high that they were ready to evaluate the aircraft for night operations. "It flew very well behind the ship, even on the darkest night," he says. "Two hook-down passes and two traps: that says it all right there. It's unheard of to conduct night ops on the first test detail."

During DT-I, F-35C maintenance and ground operations integrated well with standard Navy carrier procedures aboard Nimitz.

"All of the flight deck crew members involved in DT-I were assigned to Nimitz, some of whom went to NAS Patuxent River in mid-October for training," Wilson explains. "They returned to the ship and prepared the remainder of their crew for the arrival of the F-35C. The initial ship trials of the F-35C would not have been possible without the cooperation of Nimitz."

After all test points are collected, analyzed and assessed, the DT-I data will be used to advise the Navy of any adjustments necessary to ensure the fifth-generation fighter is fully capable and ready to deploy to the fleet.

"Our main testing points were to verify that the approach handling qualities were satisfactory across a variety of wind conditions; to determine the launch characteristic and performance from the ship's catapults across a variety of wind conditions; to look at the integration of the aircraft with the ship, both on the flight deck and in the hangar bay; and to test the ability of the F-35C to use other ships' flight systems to perform inertial alignments, instrument approaches, and basic navigation to and from the ship," says Cdr Shawn Kern, the director of test and evaluation for F-35 naval variants. "We also performed some aircraft functions in and around the shipboard environment, including use of various sensors and fuel dump testing."

3
The number of days ahead of schedule that DT-I was completed

100
Percentage completed threshold test points on DT-I

2
Night ops hook-down passes and arrested landings

2
Intentional bolters for test data

RUNWAY TRIALS

As team members returned to the ITF from their highly successful detachment aboard the Nimitz, they began to finalize preparations for wet runway and crosswind testing at Edwards Air Force Base and Naval Air Weapons Station China Lake in March 2015; and ski jump testing at Pax River in May 2015.

To date, 158 F-35 pilots and more than 1,650 maintainers have graduated from training at Eglin AFB, while the F-35 has completed multiple weapons tests as well as F-35B and F-35C first-life durability testing.

Additionally, the program has conducted two F-35B DT shipboard trials aboard the USS Wasp (LHD 1) and two more shipboard trials are anticipated in 2015 – the F-35B will conduct its first operational test and the F-35C will conduct its second DT event. As the F-35 progresses through all of these test events, the initial operational capability (IOC) milestone dates published in 2013 continue to be on target. The F-35A is set to reach its IOC milestone by December 2016; the F-35B is expected to reach its IOC milestone by July 2015; and the F-35C is anticipated to reach its IOC milestone by February 2019. ∎

Sylvia Pierson is the F-35 Lightning II Patuxent River Integrated Test Force (ITF) public affairs officer

Waltzing unmanned

Australia is proving to be a world leader in the development, testing, regulation and application of specifically civilian unmanned aerial systems

BY NIGEL PITTAWAY

Lockheed Martin's Indago Quadcopter has been used with great success in the monitoring of bushfires in Western Australia

With the ability to take on the dirty, dull and dangerous tasks currently performed by manned aircraft and helicopters, unmanned aerial systems (UASs) are rapidly establishing a large footprint in the military orders of battle across the globe. Although many of these platforms actually had their origins in the civil sector, regulators around the world have been slower to adapt to the new technology; civilian operation of UASs, despite their increasing use, is not as widespread or as accepted as military operations.

However, that is changing, and in Australia, which is well placed from a geopolitical perspective to harness the utility of the UAS, the testing and development of such systems across a broad range of applications is, in some respects, leading the rest of the world.

Given the country's vast size and wealth of resources, its harsh climate and relatively small population, there are many tasks now being undertaken by unmanned vehicles. Applications such as search and rescue, border protection, resource exploration and management, and bushfire monitoring are high on the wish lists of civilian and paramilitary organizations.

FOLLOWING REGULATIONS

Australia's Civil Aviation Safety Authority (CASA) is one of the world leaders in the development of regulations for the civilian use of unmanned aerial vehicles (UAVs) and, together with organizations such as the Australian Association for Unmanned Systems (AAUS), is developing a whole range of systems, from handheld UASs, to the large and high-flying Global Hawk and Predator platforms.

Speaking at the Defence Summit in Darwin in late 2013, then executive director of AAUS Peggy MacTavish noted that Australia is at the leading edge of this work and in some cases more advanced than the International Civil Aviation Organization (ICAO).

"We have to be very careful that we're enabling the domain in the best possible way, and when you are doing that from scratch, you can imagine the opinions and difficulties out there," she said. "The big challenge will be to set those international standards and be involved in the direct shaping of the regulations that we would like to see in place."

The AAUS considers the testing of UAVs with respect to type certification another challenge for the UAS industry, and development work needs to continue, particularly in the manufacture and control of components.

SMART SKIES

A recent example of the testing work being done in the UAS field in Australia is the Smart Skies project, which was a three-year program to explore the research and development of technologies to allow manned and unmanned platforms to share the same airspace.

Smart Skies engaged academia and industry to explore the viability of technology such as an automated separation management system, sense and act systems for manned and unmanned aircraft (collision avoidance

> **"SMALLER UNMANNED PLATFORMS EQUIPPED WITH THERMAL IMAGING SYSTEMS ARE NOW BEING USED BY POLICE FORCES TO SEARCH FOR LOST OR INJURED BUSHWALKERS"**

of dynamic and static obstacles), and a mobile aircraft tracking system (MATS). The testing was carried out by the Australian Research Centre for Aerospace Automation (ARCAA), together with the Commonwealth Scientific and Industrial Research Organisation and the Queensland University of Technology on what was believed to be the first demonstration of 'sense and act' (where the air vehicle can sense another aircraft in the vicinity and automatically deconflict itself) and global automated control of a civil UAS.

The work used a small airfield in rural Queensland, where unmanned vehicles, including an Insitu Pacific Limited (IPL) ScanEagle, shared airspace with a specially equipped Cessna 172. The experiments centered on the use of the UAS in civilian airspace into which the 'intruder' Cessna was flown and demonstrated detection ranges in excess of 10km.

"Smart Skies has researched, developed and demonstrated real technologies, that can potentially open the skies to autonomous aircraft and improve the safety and efficiency of conventionally piloted aviation operations," ARCAA said at the conclusion of the trials.

SEARCH AND RESCUE

Perhaps the best-known example of UAS applications is in the SAR and disaster management roles that occurred in the wake of the Japanese nuclear accident at Fukushima, following the tsunami. UASs with radiation monitors, cameras and other sensors were flown over the damaged reactor to gather data that was far too dangerous to be gathered by other means.

Further south, UASs were used to inspect areas damaged by the Christchurch earthquake in New Zealand, searching for survivors.

Smaller unmanned platforms equipped with thermal imaging systems are now being used by police forces to search for lost or injured bushwalkers in Australia's rugged mountain areas.

ABOVE: The Cessna 172 used in the Safe Skies program to demonstrate UAS use in shared airspace

BELOW: An Indago system is used in the training of first responders and has been acquired by Heliwest, a rotary wing operator in Western Australia

20
The weight of a UAS in kg that requires it to have sensors to detect other aircraft *(UK CAA directive)*

40
The number of US universities that receive grants for UAS research

BORDER PROTECTION

Australia is a vast continent with a long coastline which, particularly in the sparsely populated north and west, is difficult to persistently monitor. This is a perfect application for a UAS and Australian Customs and Border Protection has been required to consider the application of unmanned systems as part of its portfolio since around 2012.

Prior to that, Customs was involved in both real and simulated testing of Global Hawk and Predator large UAVs over Northern Australia.

The Royal Australian Air Force will acquire a number of Northrop Grumman MQ-4C Tritons for the persistent maritime intelligence, surveillance and reconnaissance role in the early part of the next decade and these will fill a large part of the requirement. However, there is a need for a littoral surveillance capability, which may see the use of a smaller UAS, possibly operating off the decks of border protection vessels, in the not too distant future.

MINING AND RESOURCE SUPPORT

Australia is a resource-rich country and has enjoyed the benefits of a mining and resource boom over the past decade; UASs have played a role in both the exploration and support roles in recent times.

IPL, for example, has tested a version of its ScanEagle equipped with a magnetic anomaly detector (MAD) from a merchant ship on a mineral detection research program in the Tasman Sea. The deployment of minerals exploration sensors over the vast and uninhabited regions of central and western Australia has obvious savings in exploration manpower and infrastructure.

The continuous striving for efficiency in the mining sector has embraced automation on a large scale and this has most recently translated to the use of small unmanned systems as well.

Perth-based helicopter company Heliwest has acquired the Lockheed Martin Indago small unmanned

400
Estimate in billions of dollars that the civilian UAS market could be worth in the near future

70,000+
The number of personnel used by the US military to process all the data and information gathered from drones

30,000
The number of drones predicted to be in the US skies by 2020

336
The endurance record in hours performed by the Qinetiq Zephyr in 2010

RIGHT: An Insitu Pacific Limited ScanEagle was operated in Australia's Safe Skies program to develop a system to allow manned and unmanned aircraft to use the same airspace

ABOVE: Lockheed Martin markets the Indago UAS which has both civil and military applications

quadcopter system, and has not only used it on geosurvey tasks but also to inspect powerlines and conveyor belts in the large spaces of northwestern Australia in support of the mining industry.

BUSHFIRE MONITORING

It is perhaps the bushfire monitoring role for which unmanned systems are best known in Australia. It is difficult to monitor and fight bushfires at night, particularly from the air when many of the manned assets are grounded and UASs have been used across Australia to monitor fire activity and identify hot spots for ground crews to deal with.

Back in 2009, the US Air Force RQ-4A Global Hawk had been deployed to monitor fires in California; Australian fire authorities were briefed on the operation shortly after.

In January 2014, IPL conducted a successful demonstration of its ScanEagle to the New South Wales Rural Fire Service, which also employed General Dynamics Mediaware's D-VEX video exploitation system to stream full-motion video alongside accurate geo-location information in near real time.

During the tests, fire commanders used the imagery to assess the movement of the fire front and pinpoint the locations of spot fires ahead of the fire front. This permitted fire crews to respond more rapidly and with greater safety, because their position relative to the location and movement of the fire could be actively monitored from the headquarters of the emergency services.

"Combining the imagery captured by the ScanEagle with D-VEX's next-generation video analytics provided the New South Wales Rural Fire Service with enhanced situational awareness and real-time actionable intelligence to extend the capabilities of firefighting services around the clock," says General Dynamics Mediaware chief technology officer Kevin Moore. "We see this demonstration as the start of a new type of fire response that has the potential to save agencies time, money, and most importantly, lives."

Most recently, Heliwest has used its Indago system to support the Department of Fire and Emergency Services in Western Australia at a fire on the outskirts of Perth in January. "Word had spread through the organization that Heliwest possessed a night-capable UAS, with approvals and crew to meet our operational needs. Faced with a Level 3 incident (that has the potential to threaten lives and property) covering 4,100ha and a situation where no manned assets could assist, the Incident Management Team requested the tasking," Chris Arnol assistant commissioner, Hazard and Response, DFES – Western Australia explains. "The Indago was used as a situational awareness tool directly to the Incident Management Team. The IR camera allowed for hot-spot monitoring, assessment of containment lines, asset and infrastructure monitoring. DFES is currently working to establish procedures for the use of UAS intelligence and to integrate the technology into operations."

Heliwest chief controller Tim Hand says the Indago system had operated for more than 200 hours since being acquired, in all climatic conditions, and over the Perth fire, it was typically flying three missions of 45 minutes duration each night.

"This is the first time in the world that this has been done and to get it over the line with CASA, we had to put quite a robust safety and operating procedure to them," he added. "We have a primary pilot, who is the controller and commander, and he flies from the ground control station. At the same time, we have a safety pilot/payload operator sitting with the laptop in a secondary station. He will monitor from a safety point of view and is able to take control of the system if necessary, but he is also responsible for providing the video feed and ensuring that the downlinks are working as they are supposed to." ■

Nigel Pittaway is a freelance aviation and defense journalist based in Australia

A tale of two aircraft

Pioneering forward-firing weapons trials on the V-22 Osprey and the first carrier deployment of the E-2D Hawkeye are two of the major highlights of the latest US military test programs

BY THOMAS NEWDICK

Two US Naval Air Systems Command programs have reaped notable results recently. The first carrier deployment for the new generation E-2D Hawkeye is the culmination of an intensive test and evaluation program, and pioneering weapons trials for the V-22 Osprey look set to revise the mission set *ok?* of the tiltrotor transport.

OSPREY WEAPONS TRIALS

During a milestone series of flights in the final quarter of 2014, a Bell Boeing V-22 Osprey test article became the first tiltrotor aircraft to launch forward-firing weapons.

The successful demonstration of the Osprey's forward-firing capability took place in November 2014 during an exercise at the US Army Proving Ground range in Yuma, Arizona, and was revealed by Bell Helicopter on December 8.

"The forward-firing demonstration was a great success," says Vince Tobin, vice president and program manager for the V-22 at Bell Helicopter. "We've shown the V-22 can be armed with a variety of forward-facing munitions, and these can hit their targets with a high degree of reliability."

Bell Helicopter began initial design work on the Osprey's forward-fire capability in mid-2013. The aircraft used for the tests was a US Marine Corps MV-22B version, BuNo 165942, which Bell and Boeing employ for test work. The aircraft is loaned from Naval Air Systems Command and wears the civilian registration N204TR. The tests were funded using the two companies' research and development budgets.

First deployed in 2007, the V-22 has seen operational service in Afghanistan, the Persian Gulf and the

ABOVE: Bell Helicopter announced the successful demonstration of a forward-firing capability for the Bell Boeing V-22 Osprey

12

The time in seconds it takes to 'tilt' the propellers 90° depending on which mode???

36

Number of fatalities due to accidents with the V-22

Mediterranean. At the time of the weapons tests, the Bell Boeing partnership had delivered 242 MV-22 tiltrotors to the US Marine Corps and 44 CV-22s for US Air Force Special Operations Command (AFSOC).

EXPANDING ROLES

With the MV-22 now established as the backbone of the Marine Corps' rotary-wing fleet, both the Marines and AFSOC are keen to explore additional capabilities for the Osprey. Now that the V-22 has demonstrated that it can be equipped with forward-firing rockets and missiles, potential missions can be added.

"Integrating a forward-firing capability to the Osprey will increase its mission set," Tobin explains. "These weapons, once installed, will provide added firepower and reduce reliance on forward arming and refueling points (FARPs), which are sometimes necessary to supply short-range attack rotorcraft in support of V-22 operations. Without the need for FARPs, V-22s can be launched more frequently, and at shorter notice." In the concept as outlined by Tobin, the Marine Air-Ground Task Force commander could call upon armed MV-22Bs to provide organic firepower, obviating the need for an accompanying escort provided by lighter, shorter-legged AH-1Z Viper or UH-1Y Venom helicopters.

The Osprey has previously been equipped with guns, but never rockets or missiles. A forward-firing capability is certainly on the Marines' wish list for the Osprey; it has long sought to boost the tiltrotor's firepower. One such effort resulted in the BAE Remote Guardian System, a belly-mounted, remote-controlled 7.62mm (0.3in) caliber GAU-17 Minigun. However, once in theater MV-22 crews have preferred to ditch the heavy gun turret in favor of flying with an armed escort, the Osprey itself typically being armed only with a ramp-mounted tail gun.

Indeed, should an Osprey come under fire, current practice is to apply full power and escape using the aircraft's impressive climb rate.

MODIFICATIONS

The latest work involved design, manufacture and installation of a pylon arm to carry forward-firing weapons. This also required structural modifications of the airframe to support the additional weight. Furthermore, the test aircraft was equipped with new cockpit displays for targeting and control panels for the related instrumentation. Other changes included the replacement of the standard Raytheon AN/AAQ-27 laser targeting/forward-looking infrared (FLIR) sensor with the latest Wescam MX-15Di electro-optical/infrared sensor mounted under the Osprey's nose.

The Bell Boeing team was required to provide an approval to fly in accordance with the Federal Aviation Administration's experimental type certification process. This was carried out as part of an overall safety analysis of the forward-firing modifications.

The run-up to the live firing trials involved the test crews becoming familiar with the aircraft modifications and the three types of weapon to be deployed. This included a limited amount of time in the simulator, weapons training from subject matter experts, and a series of dry-run flights. These early test flights were conducted from the Bell Boeing joint facility at Amarillo, Texas, as well as at Yuma.

The airframe, too, had to be put through its paces before any of the new weapons could be fired. Among others, the work-up period included electromagnetic environmental effects (E3) compatibility testing and captive carriage testing, during which the Osprey was flown with weapons or test 'shapes' installed on the new pylon. These demonstrated that the airframe was able to bear the dynamics and loads involved in the different weapons configurations. Bell has demonstrated the ability to carry more than 136kg (300 lb) on either side of the Osprey's forward fuselage.

In five days of testing at Yuma, the Bell Boeing project team fired a total of 24 unguided and four laser-guided rockets. In all cases, the weapons were

200+

The number of V-22s built as of 2014

36

The amount spent on the program to date, in billions of dollars, with 400+ aircraft planned

BELOW: A V-22 test article fired a 70mm rocket from a launch tube mounted on the aircraft's left side

fired at stationary plywood targets. In 10 of the launches, the weapons used high-explosive warheads. For the remaining 18, the weapons were fitted with inert warheads.

The guided weapons comprised the BAE Advanced Precision Kill Weapon System (APKWS) and the AGM-176 Raytheon Griffin B. Two examples of each type were successfully fired.

Now in its third year of quantity production, the APKWS turns a standard unguided 70mm (2.75in) caliber rocket into a precision laser-guided rocket. Developed in order to provide a low-cost surgical strike capability, the APKWS is the only guided rocket of its size to have been fully qualified by the US Department of Defense.

The Griffin B belongs to a family of lightweight missiles, the B-version being the model intended for forward-firing applications. The Griffin B combines GPS-aided inertial guidance with a semi-active laser seeker. The weapon is equipped with folding fins and is deployed from a tube launcher. A 5.9kg (13 lb) warhead is carried. Like the APKWS, the Griffin is a low-cost precision weapon that makes use of components from existing systems.

Speaking about the Griffin B launches from the Osprey, Mike Jarrett, vice president of Raytheon's Air Warfare Systems, remarks, "This is the first time a forward-firing missile has been launched from the V-22. It's an important aspect of the V-22's capability that integrates a simple to operate, low-cost, precision strike missile – something in which the US Air Force Special Operations Command has shown significant interest."

The third, unguided weapon was the US military's standard 70mm caliber Hydra rocket, as used on a variety of fixed- and rotary-winged platforms. Currently unique as an in-service tiltrotor aircraft, the Osprey's configuration presented the test team with new challenges. In order to ensure adequate clearance of the rotors in forward flight, it was judged impossible to add weapons in the 'waist' position along the lower fuselage. Instead, the weapons hardpoint was fitted below the cockpit on the left side of the fuselage.

"THIS IS THE FIRST TIME A FORWARD-FIRING MISSILE HAS BEEN LAUNCHED FROM THE V-22. IT'S AN IMPORTANT ASPECT OF THE V-22'S CAPABILITY"

BELOW: On March 11, 2015, the Theodore Roosevelt Carrier Strike Group departed Naval Station Norfolk for an around-the-world tour with deployment of the E2-D

For the forward-firing trials, each weapon was launched in two different flight regimes: hover and conversion. In the conversion flight mode, the V-22's engine nacelles are set at 60° and the aircraft was in forward flight at a speed of 110kts. In each case, the weapons were launched at a range of 2-3km from the target.

In order to fire a weapon, the crew on board the MV-22 first set the aircraft's altitude and attitude, and maintained the correct distance from the target. For the precision weapons, the target was then 'lased' using the MX-15Di turret. The weapons were fired using a new control panel fitted to the central console on the flight deck.

An accompanying helicopter gathered video of the firing sequence, supplementing video recorded by cameras on board the Osprey. The Yuma trials have demonstrated that the V-22 can be successfully equipped with forward-firing rockets and missiles. Now that the industry-led phase of testing is complete, the way has been paved for further trials by the military.

E-2D CARRIER TRIALS

On March 9, 2015, the aircraft carrier USS Theodore Roosevelt departed its base in Norfolk, Virginia, with the Northrop Grumman E-2D Advanced Hawkeye early warning aircraft on board for its first operational deployment. The path toward the landmark cruise by Carrier Airborne Early Warning Squadron 125 (VAW-125), the initial operational E-2D squadron, was a long one and has at times been hampered by budget cuts.

The next-generation E-2D made its maiden flight in summer 2007 and began carrier suitability testing back in early 2011. An Integrated Test Team (ITT) within Air Test and Evaluation Squadron 20 (VX-20) completed a first arrested carrier landing aboard the USS Harry S Truman on January 31, 2011. The initial E-2D, known as Delta One, followed this feat with a first carrier take-off from the flat-top on February 2. In the course of a six-day evaluation, around 200 test points were addressed, to ensure the E-2D's effectiveness in an operational shipboard environment.

Externally, the E-2D looks little different from the E-2 as first flown in 1960. The obvious external changes are the new eight-bladed propellers, but inside the airframe fully revised avionics and electronics systems bring the Hawkeye fully up-to-date.

JOINT EFFORT

While VX-20 handled SDD testing, operational testing has been the domain of VX-1, using a combination of two pilot production aircraft and two low-rate initial production aircraft for initial operational test and evaluation. The four aircraft served as a detachment at Naval Air Station Jacksonville, Florida, where they arrived in January 2012.

The IOT&E was run as a joint program between VX-1 and VAW-120. Their activities included four weeks of evaluations aboard the USS Enterprise. "VAW-120 acts as a trusted agent for VX-1. Our job is to determine how well the E-2D compares with what the Navy asked for, and how it operates in the real world as opposed to a controlled test environment," said VAW-120's LCdr Dave Champaigne at the time. The team proved the functions of the E-2D and its systems in large force, strike group, air wing and joint exercises, and deployed to different locations for flight test work. Tests included involvement in air combat training exercises at Nellis Air Force Base, Nevada, during 'Red Flag', as well as a Navy-led counter-UAS (unmanned aircraft system) exercise at Naval Air Station Point Mugu, California.

The test effort was officially concluded in late 2012. Once VX-1 declared the E-2D 'suitable and effective', the way was clear for the Defense Acquisition Board to approve the aircraft for full-rate production in January 2013. However, the spiral development nature of the program means that further modifications have since been made to fine-tune the aircraft.

Next in line to get the E-2D was the Fleet Replacement Squadron, VAW-120, charged with training aircrews at Norfolk, Virginia. VAW-120 received an initial four E-2Ds, the first in 2010. Cdr Paul 'Paulie' Lanzilotta, the commanding officer of VAW-120, explains the effect of the spiral development path on his unit's work: "We are often updating [the E-2Ds] with minor upgrades on an ongoing basis, increasing reliability, sustainment, and meeting regulatory conformance issues. In the E-2D we have an onboard oxygen generation system] and we do not have the need to always be on oxygen, since we have a pressurized cabin. However, we do test the system every flight to keep it exercised."

55
Time in years since first flight of E-2 Hawkeye

2,000
The number of targets that can be tracked simultaneously

8
Number of propellers on upgraded E-2

THE LONG ROAD

The first two E-2D test aircraft, known as AA-1 (Delta One) and AA-2 (Delta Two), or BuNos 166501 and 166502, were used for the system development and demonstration (SDD) phase. Of these two airframes, AA-1, first flown on August 3, 2007, was primarily concerned with air vehicle testing and was equipped with stress sensors and telemetry instrumentation. AA-2, which completed its maiden flight on November 29, 2007, has been used mainly for testing mission systems.

Overheating problems, played down by Northrop, were cited as a reason for funding cuts toward the end of 2008, which slowed the program down and threatened to delay production. The SDD aircraft left the manufacturer's facility at St Augustine for Naval Air Station Patuxent River, Maryland, where they began electromagnetic environmental effects testing. This was followed by carrier suitability assessments between late 2009 and early 2010. Pilot production verification testing was completed in 2010, with the aim of beginning initial operational test and evaluation (IOT&E) in autumn 2011.

One man involved intimately in the test effort was VX-20 air vehicle project officer Lt Cdr Drew 'Balls' Ballinger. "The E-2 is an aircraft you do not want to stall, but we did that intentionally during flight test and it is one of the more demanding and eye-opening tests," Ballinger recalls. "We put the gear down and set the flaps at full, and when you keep pulling back and force it, eventually the Hawkeye rolls onto its back, going inverted, and then you have to pull it out. That is a scenario that is not a real-world likely event, but we must still record the flight characteristics."

SYSTEM IMPROVEMENTS

The different flight characteristics of the E-2D compared with earlier iterations of the Hawkeye were a result of, among other factors, a maximum speed increased to 345kts at sea level and a gross weight 2,500 lb greater than the E-2C. For the operator, the main changes in the E-2D are avionic. Lt Cdr Dave 'Cabbage' Peterson served as lead flight-test Naval Flight Officer attached to VX-20's E-2D detachment. He comments, "In our jobs, after we fly, we will note down the things we liked or things that could be improved, mostly software, and we work side-by-side with the Northrop Grumman engineers in our goal to present the fleet with the best new derivative of Hawkeye. Sometimes we have small user-group discussions and arrive at a consensus before recommending a change."

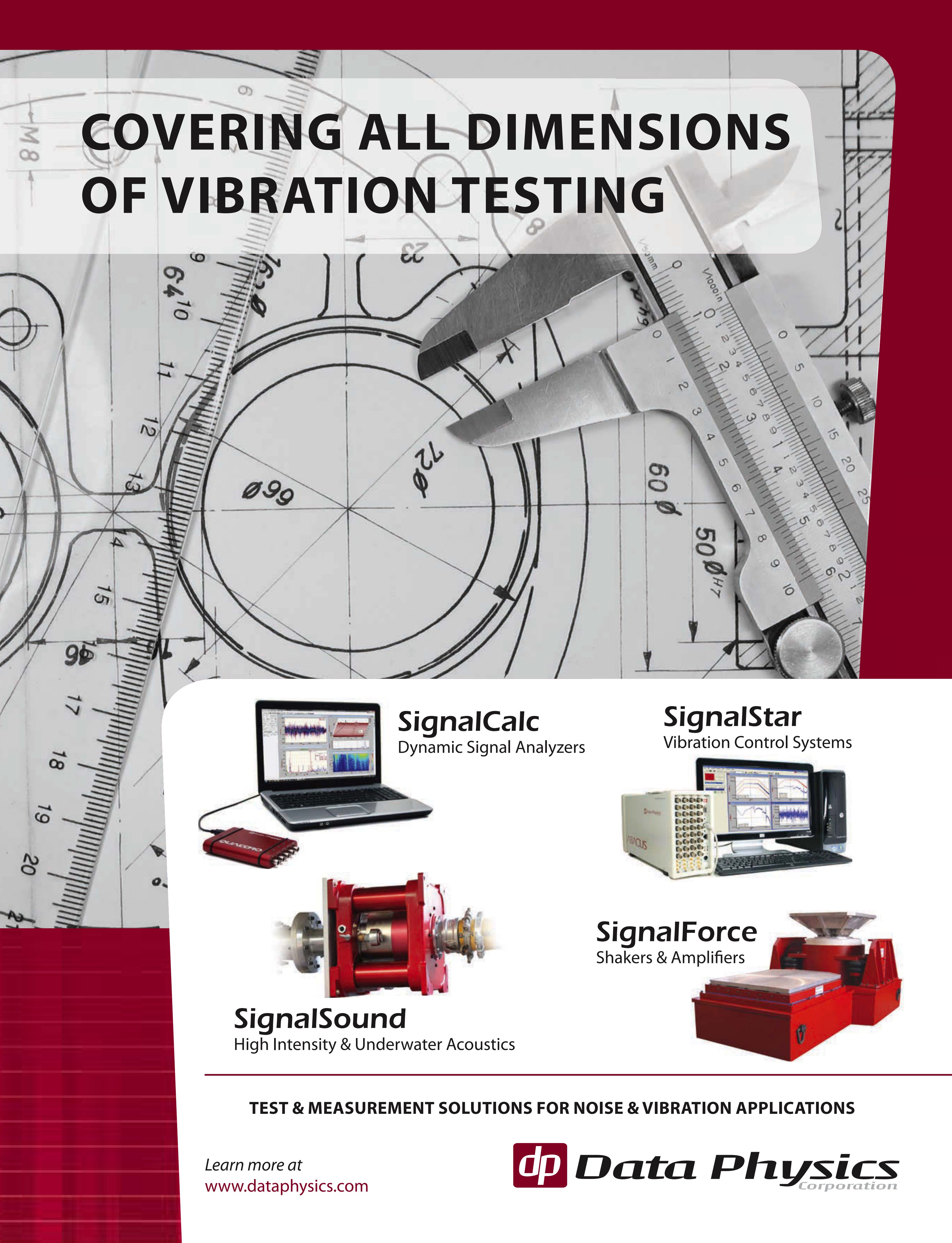
Peterson praises the ITT setup due to the speed with which changes could be effected using on-hand engineers from Northrop: "Changes are made incredibly fast and if we were flying from a remotely located test site, updates would take much longer. While the radar is the most significant change, the plethora of combined smaller changes such as the new communications suite, 'glass' cockpit and smart probes, will make the aircraft easier to fly and to fix."

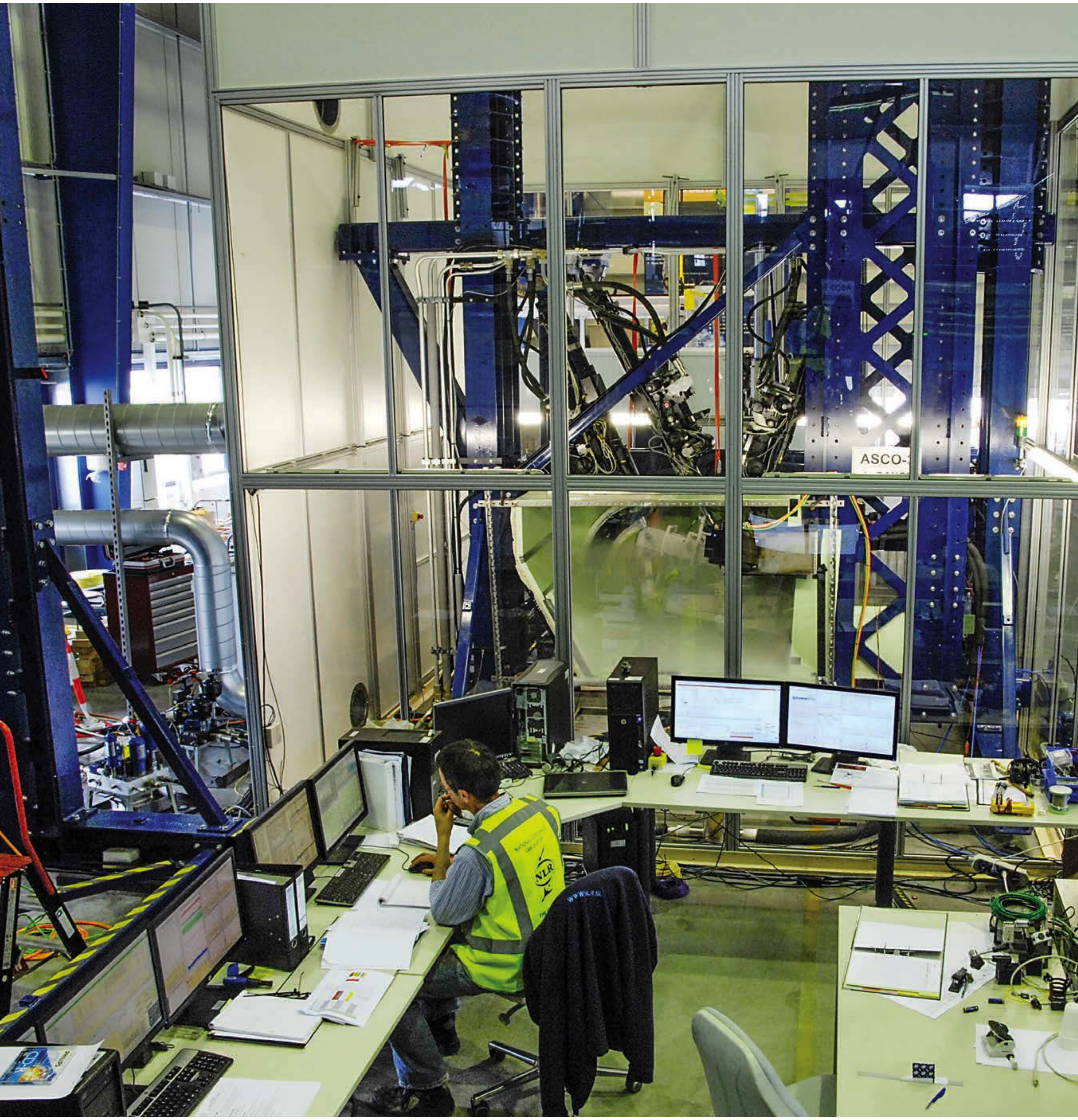
As first operational squadron to get its hands on the E-2D, VAW-125 was declared safe for flight in January 2014, and achieved initial operational capability according to schedule in October 2014.

The US Navy Program of Record calls for a total of 75 E-2Ds to be procured, to replace a current fleet of 62 legacy E-2Cs. As such, the March 2015 deployment was not only the culmination of an intensive period of test work, but the beginning of a new era for the fleet at large. ∎

BELOW: The E-2D Advanced Hawkeye, which features an entirely new avionics suite

Thomas Newdick is an aviation and defense writer based in Berlin


COVERING ALL DIMENSIONS OF VIBRATION TESTING
SignalCalc
Dynamic Signal Analyzers
SignalStar
Vibration Control Systems
SignalSound
High Intensity & Underwater Acoustics
SignalForce
Shakers & Amplifiers
TEST & MEASUREMENT SOLUTIONS FOR NOISE & VIBRATION APPLICATIONS
Learn more at
www.dataphysics.com
Data Physics Corporation


ASCO-

Cold is cool

The Dutch National Research Laboratory has developed a new method for environmental testing at low temperatures, which improves the handling and delivery of liquid nitrogen to save time and lower cost

BY HOTZE JONGSTRA

Strict environmental regulations and a highly competitive market call for affordable and efficient aircraft that are durable and easy to maintain. Fuel consumption and engine emissions are directly related to aircraft weight, and in the design phase, much time and effort is spent on optimizing the structural components and mechanical subsystems that make up the airframe.

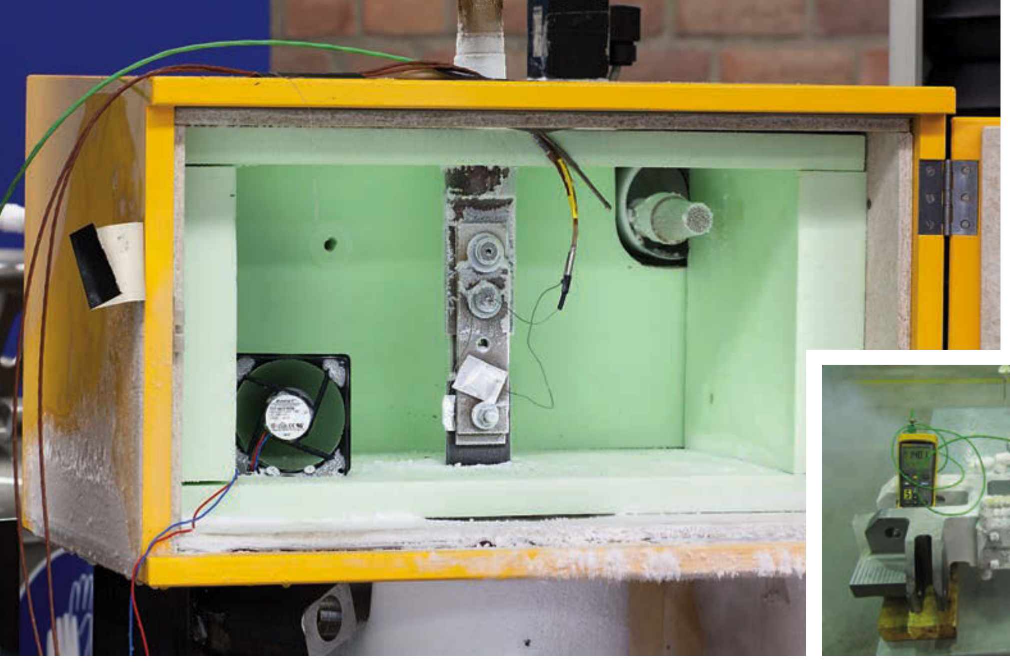
Testing starts in the early design stage, when materials are established. Later, it needs to be done to validate structural design solutions and analysis methods. Finally, full-scale tests on the complete aircraft or on major structural components are needed to generate input for the certification process. In all these tests, attention must be given to the effects of parameters other than loads. Of these, temperature is very important. Material properties are known to change with temperature, and predicting the temperature dependence of specific structural properties, such as buckling behavior and subsequent failure, is not straightforward.

This is why the test house of the National Research Laboratory (NLR) in the Netherlands has developed both modular and specific cooling solutions for use in material and structures testing, based on the use of liquid nitrogen. Attention has been paid to affordability, maintainability, safety, scalability, accuracy and operating temperature range. The developed systems feature a high degree of autonomy, which makes them suitable for 24/7 applications.

It all started some decades ago with the development of a simple system for testing material coupons at low temperatures, typically -55°C. Liquid nitrogen was used to cool a climate chamber that was built around the specimen. A controlled amount of liquid nitrogen was simply poured into the chamber until the temperature of the specimen had stabilized. Manual adjustment in a slow feedback loop was subsequently applied to the flow of liquid nitrogen until the desired temperature level was reached.

At that time, far more advanced cooling methods were in use by NLR's Space Department. For standard mechanical coupon testing in a commercial environment, however, the cost was (and still is!) of crucial

LEFT: Overview of full-scale flap track test setup at -55°C



FAR LEFT: Starting practice of the cooling of material test specimens by pouring liquid nitrogen in the climate chamber

LEFT: Thermal blocks, or heat sinks, are mounted on the LIDs to thermally insulate the test article from the test rig

importance, which precluded the use of these advanced methods.

DISADVANTAGES

The simple 'pouring method' worked all right, at least for relatively small coupons, but there were some disadvantages, the main one being spillage. The amount of nitrogen escaping from the setup was considerable and the area around the test setup – and the operators – was exposed to low temperatures.

A sufficient supply of nitrogen for a static test on a smaller specimen was not a problem, but for larger specimens or longer lasting tests, the supply was problematic. Moreover, the spillage of nitrogen was undesirable and led to unacceptable safety issues. Nitrogen is not poisonous; at sea level the atmosphere contains about 78% nitrogen. However, if sufficient liquid nitrogen is vaporized and the oxygen percentage is reduced from its normal level of 21% to below 19.5%, the risk of asphyxiation greatly increases. Since nitrogen is colorless and odorless, this happens without much warning.

In the meantime, a number of customers and prospective customers had expressed a requirement for low-temperature testing of larger structural items, such as stiffened panels and even full-scale structural components and mechanical systems. The sustained endurance testing of large components at -55°C for the 24 hours a day and seven days a week that some customers desired required the development of a radically new approach.

This new approach still involves the use of liquid nitrogen, but the control system is much more elaborate. Instead of pouring the liquid nitrogen in bulk into the climate chamber that encloses the test article, nozzles are used to evaporate and spray controlled amounts of liquid nitrogen around the test article at specific locations. In this way the test article is cooled very efficiently because of the swirling evaporation near the specimen. This is quicker and more accurate, and by optimizing the number/placement of nozzles, the temperature gradients in the test article can be minimized. This is done empirically, prior to the start of a structural test.

The system is totally modernized for different materials. Client names cannot be discussed, but after a successful series of low-temperature static specimen tests using the new approach, a fatigue crack growth test was performed at -55°C on a specimen made of Glare (aluminum layers interspersed with glass fiber layers, as used in the Airbus A380). This test had to run continuously for several days.

The amount of nitrogen used was relatively small and the multipoint controllability of the temperature over the test article was excellent. Minor problems such as frost on the test article and frozen window panes were easy to solve. Frost on the test article and the inner side of the window pane was prevented by pre-filling the climate chamber with dry nitrogen: no humid air, no water, no problem. The heat from a paint stripper solved the problem of a misted or frozen window pane.

INCREASED SCALE

The next step in the development was increasing the scale: doing panel tests at low temperatures. For this purpose, a stiffened panel was tested at -55°C in an MTS 500 testing machine under

LIGHTNING STRIKES

Wichita State University's National Institute for Aviation Research (NIAR) recently added lightning transient analysis, high-intensity radio frequency (HIRF) and direct effects of lightning testing capability to the wide range of services offered by its specialist Environmental Test and Electromagnetic Effects Labs.

In February 2015, NIAR completed two full-vehicle lightning transient tests. The first was for Garmin's supplemental type certificate on the Beechjet 400, followed by full-vehicle tests for the Cirrus SF50.

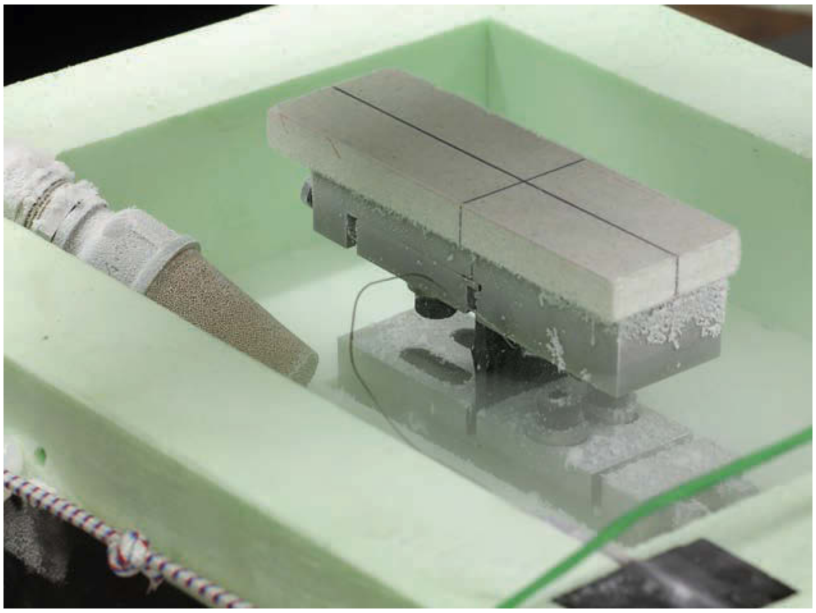
Lightning transient tests are intended to measure the actual transient levels induced into aircraft electrical wiring as a result of lightning attachment to an aircraft. This is done to ensure that the transient level does not exceed the wiring's transient control levels. To measure actual transient levels, a simulated lightning strike at a reduced level is injected onto the aircraft; the field generated by the lightning strike travels the length of the aircraft, inducing voltages and currents on wiring inside the aircraft. These voltages and currents are measured and analyzed to make sure that an actual lightning strike will not damage any critical equipment during flight.

NIAR teamed with QinetiQ to perform HIRF testing for the Cirrus Vision SF50 personal jet, a newly designed composite five-plus-two-seat, single-engine turbofan-powered aircraft. The aircraft was tested using low-level swept coupling to measure the level of induced currents and voltages on system components as a result of radiated fields below 400MHz. It also underwent low-level swept fields testing above 400MHz to determine the transfer function relating the external field to the internal bay fields at specific locations in the airframe.

NIAR will offer direct effects of lightning testing in the second quarter of 2015. With a 200,000A generator, the lab is able to test all common lightning strike levels. Direct effects lightning testing evaluates the aircraft components' ability to resist the possible damaging effects associated with lightning attachment to the aircraft. Effects can include melting; the development of holes at points of contact; temperature rises in metal conductors; magnetic force effects; acoustic shock effects; arcing at structural bonds, hinges, and joints; and the ignition of flammable vapor in fuel tanks.


Fly By Wire . . . Or With Wiring Faults?
Your systems depend on wired interconnections for top performance. Is your wiring up to the task? Make sure with automatic wire harness testing from DIT-MCO International. Find out why for over 50 years the aerospace industry has relied on DIT-MCO's test solutions.
• From simple wire harness to entire aircraft testing
• Open and short fault detection
• High voltage HIPOT tests
• Component verification
• Relay activation
• Data archiving and statistical analysis
DIT-MCO International
Call 800-821-3487 or visit www.ditmco.com for more information.
© 2009 DIT-MCO® International Corporation. All brands and products are registered trademarks or trademarks of their respective holders. All rights reserved. EOE.


AIM
RIGHT ON TARGET
Avionics Databus Solutions
MIL-STD-1553
STANAG3910/EFEX
ARINC429
AFDX®/ARINC664P7
Fibre Channel
ARINC825
ARINC818
Modules – Software – Systems
Solving all your Avionics Testing Needs – Right on Target.
www.aim-online.com
AIM Contacts:
AIM GmbH - Freiburg
sales@aim-online.com
AIM GmbH - Munich Sales Office
salesgermany@aim-online.com
AIM UK Office - High Wycombe
salesuk@aim-online.com
AIM USA LLC - Trevose, PA
salesusa@aim-online.com



640
The number of employees working at two locations for NLR

320,000
The amount of research space at NIAR in square feet

fatigue loading. Again the nitrogen was sprayed around the test article at several locations with the nozzles, controlled by a temperature measuring and control system.

The final step in the development of an advanced cooling system was a considerable one, both in scale and in complexity. It was taken within the context of the certification program of the Bombardier C-series flap tracks. These flap tracks are designed and manufactured by the Belgian company ASCO Industries. NLR has been tasked with conducting the full-scale static, endurance, fatigue and damage tolerance tests that are required by the certification authority, Transport Canada Civil Aviation. This ongoing test program is a milestone in the development of the full-scale structures testing capabilities at NLR.

The test setup consists of three independent modular rigs (one for each of the tracks tested), each combined with an advanced electrohydraulic actuation system.

The loads on each flap track are distributed over its carriage and rear link through a load introduction device (LID) that essentially mimics the flap. Six independently controlled hydraulic actuators per test rig are connected to the LID. Three of the actuators are displacement-controlled and serve to enforce the subtle and complicated out-of-plane (i.e. lateral) movement and orientation of the flap (represented by the LID in the test program) during extension and retraction.

The other three actuators are force controlled and used to apply the complex dynamic loads that are a function of the flap position. The position-dependent actuator loads have been computed using 6DOF vector decomposition and are provided to the Moog/FCS loads control system by means of a lookup table. In this way fatigue loading and endurance loading can be applied in a flight-by-flight manner and possible changes in the test specification can be handled in a very flexible way without having to redesign any hardware. For the endurance test program in particular, this has turned out to be a major technical advantage.

The endurance test program is essentially a full-scale system test in which the tracks are exposed to various contaminants (sand, dust, oil, anti-icing fluid, etc) while operating at the true extension/retraction speed under representative flight loads. A large part of the endurance testing is to be performed at -55°C around the clock for several weeks. The first mandatory part of cold cycling was achieved and testing will continue in 2015.

ABOVE LEFT: Material test specimens are cooled by pouring liquid nitrogen into the climate chamber

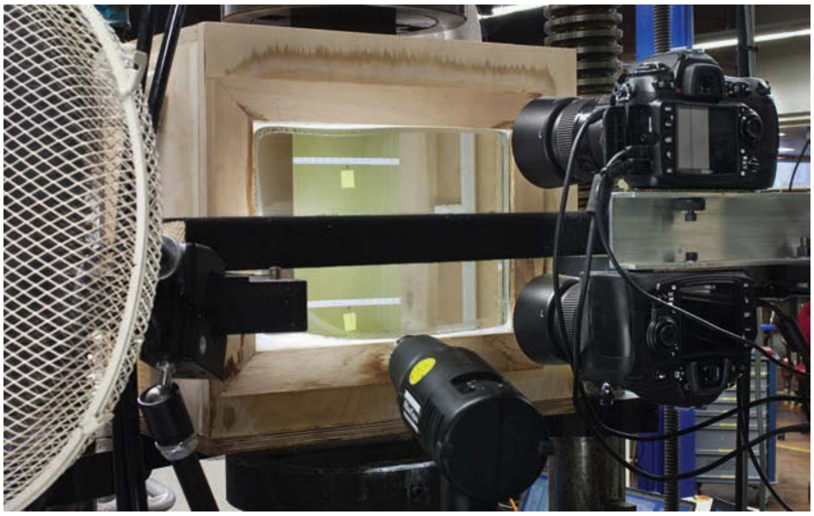
CLIMATE CHAMBERS

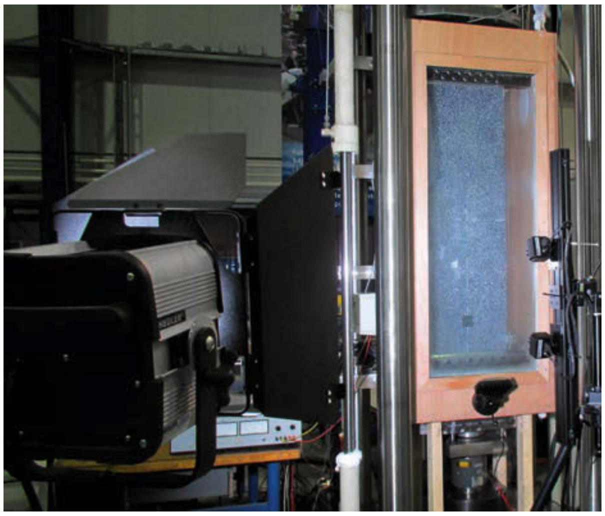
The size and complexity of the test setup necessitated the use of an inner climate chamber measuring roughly 3 x 1 x 1m, and an outer cabinet 5 x 5 x 5m. Prefilling the outer cabinet with dry nitrogen gas is instrumental in avoiding condensation and ice formation in the inner cabinet.

To prevent heat from the hydraulics being transferred to the cold test article, thermal blocks are used to create a thermal barrier. These blocks act as heat sinks and insulate the cold test article from external heat sources. The thermal blocks are cooled down using special thermal pads and liquid nitrogen. The pads are capable of

BELOW LEFT: New approach to cooling a fatigue test specimen: crack growth testing of Glare, 24/7 at -55°C

BELOW: Panel fatigue testing at -55°C, combined with DIC optical measurements





75
NLR's annual turnover in millions of euros

2
The number of laboratory aircraft: a Cessna Citation and a Fairchild Metro

RIGHT: Two experts flush a 33,000 liter liquid nitrogen tank

"THE CIRCULATION OF THE HYDRAULIC OIL IN THE SHUT-DOWN CONDITION TURNED OUT TO BE INSUFFICIENT TO PREVENT IT FROM FREEZING AND BLOCKING THE FLOW"

reaching -170°C within minutes and have been developed in cooperation with experts from a local cryogenic engineering company.

Some developmental problems have been encountered. Since the endurance test is to run 24/7 and unattended at night, a fully automated safety system is in place. One particular night this system was triggered and the test was automatically shut down. The next morning the operator on duty had great problems restarting the test. The circulation of the hydraulic oil in the shutdown condition turned out to be insufficient to prevent it from freezing and blocking the flow. Additional oil heating elements were therefore included and the hydraulic actuators are monitored and electrically heated when necessary. This enables an easier restart after a cold shutdown and it also smooths daily operation.

The development of cold testing at NLR continues. A possible application is the full-scale testing of space structures down to -180°C. To prepare for this, a prototype setup has been built to test an aluminum plate with a thickness, size and geometry equivalent to a segment of the Ariane Engine Thrust Frame (ETF). The test was conducted successfully in October 2014, demonstrating that the system is capable of cooling a representative structural component down to -180°C in a reasonable time. NLR is are now confident that it can affordably perform the actual full-scale static strength test on the ETF, or any similar structure, at this very low temperature. ∎

Hotze Jongstra is the principal project engineer, structures testing and evaluation department, at the National Aerospace Laboratory in the Netherlands

THRUST GOES CRYOGENIC

In 2009 ESA and Arianespace started the Ariane 5 Midlife Evolution (ME) program to prepare the Ariane 5 launcher for future market demands. The upgraded launcher will be capable of carrying heavier satellites. It features a completely new upper stage, equipped with a re-ignitable cryogenic engine, in order to fulfill a broader range of missions. The maiden flight is scheduled for 2018.

The Engine Thrust Frame (ETF) of the new upper stage is required to go through a thorough qualification test program, which includes a static strength test to rupture at a representative temperature level. Since the operational temperature of the ETF top ring is 90-120K, this called for a cryogenic test setup. This requirement triggered the cold testing developments at NLR.

The common test principle at that time was to place the adaptor cone (attached to the ETF top ring) on top of a cylindrical heat sink. It was thought unthinkable to put the entire test setup in a cabinet filled with cold nitrogen as it was too large, too cumbersome and had containment problems. Within this heat sink a contained flux of liquid nitrogen is pumped. This controllable flow ensures that the bottom of the adaptor cone has a temperature of 77K. Toward the end cap, at the top of the test setup, there will be a temperature gradient, depending on the size of the adaptor cone, the heat flux in the cone and the temperature of the end cap.

To analyze the temperature gradient, the conical structure was modeled as an axially symmetric shell with a uniform thickness of 5mm. For the simplified model, the relevant material properties of aluminum 7075 were used. They included the temperature-dependent material density and the conductivity.

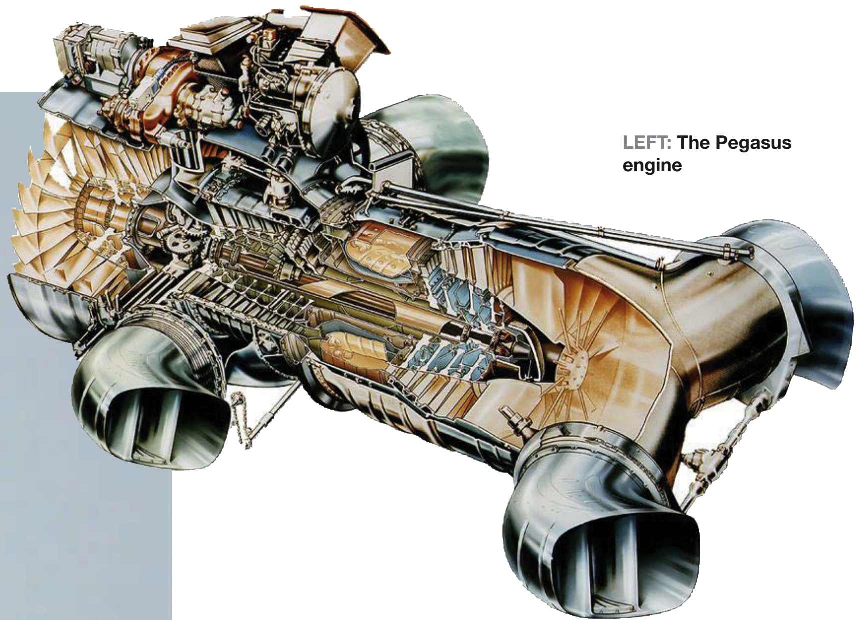
An uncoupled heat transfer analysis was performed to determine the temperature distribution in the ETF as a function of time. In the heat transfer analysis, natural convection and conduction were taken into account. Radiation was not accounted for. The heat transfer coefficient was prescribed with a convective film condition, by defining the heat transfer coefficient h (=1,000W/m^2/K) and the sink temperature of -77K. Also, film conditions were defined far from the other outside and inside surfaces of the ETF for natural convection h (=2W/m^2/K) between the air and the ETF.

The following preliminary conclusions were drawn, based on the (simplified) analyses:

- The heat transfer through the adapter cone is of major importance for reaching the prescribed temperatures at the top ring within a reasonable time.
- When insulated perfectly, the prescribed temperature at the top ring can be reached.
- Due to natural convection, however, the prescribed temperature at the top ring can not be achieved.

The long cooling times are a obstacle to a competitive full-scale test setup. Local cooling with contained use of nitrogen, would not suffice; something drastically different needed to be developed. It was decided to submit the entire test article to a forced cooling mechanism and thereby solve the containment problem on a full-scale level.

Pegasus – flying horsepower



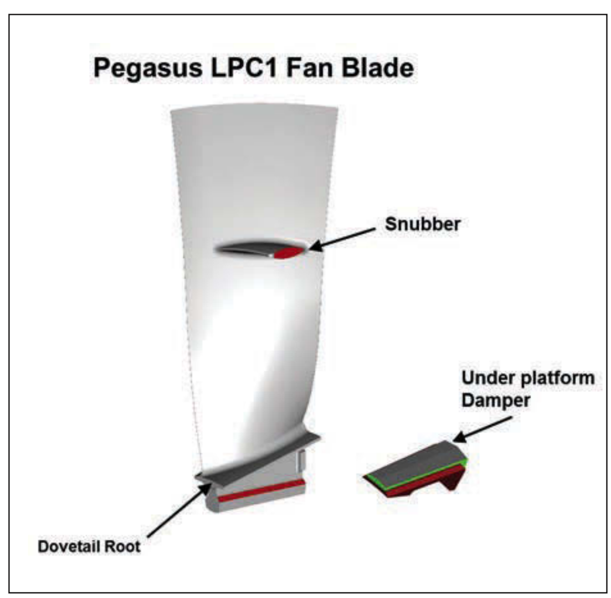
LEFT: The Pegasus engine

Supporting the development of a new Pegasus LPC1 fan blade for the US Marine Corps Harrier upgrade led to the revival of a mothballed testbed

BY TIM WILLIAMS

When the US Marine Corps asked Rolls-Royce to improve the performance of fan blades for its Pegasus engine for the USMC Harrier (see figure above), it set a test challenge that involved some sophisticated vibration modeling and trials, even including the reactivation of a mothballed test facility.

The Rolls-Royce Pegasus engine powers the Harrier aircraft operated by the USMC as well as the Italian, Indian and Spanish navies. In 2012, the USMC awarded Rolls-Royce a contract under the Component Improvement Program (CIP) to develop a modified fan blade to improve the robustness of the engine.



LEFT: Pegasus LPC1 fan blade

PROBLEM CONTROL

Rolls-Royce created a number of finite element (FE) stress models to understand the dynamic behavior of the blade and establish the root cause of some of the problems that had been experienced in initial operations. The fan blade, as shown in the figure on the right, is manufactured from titanium alloy and rotates at in excess of 8,000rpm. It is retained within the engine by a feature commonly referred to as a dovetail.

The blade features a 'snubber' at around two-thirds height, which is intended to control the flap and torsional response of the blade. After the analysis was completed, it was established that issues could be caused by high stresses within the blade,

COALITION DEVELOPMENT

The US Marine Corps (USMC) has flown the first BRU-70/A digital improved triple ejector rack (DITER)-equipped AV-8B Harrier aircraft in support of the US-led coalition campaign against the Islamic State (IS) militants in Iraq and Syria. Deliveries of the DITER production units were originally scheduled for June this year, but were fast-tracked after USMC requested for the systems to maximise current mission capability in December 2014.

LEFT: Friction wear part test rig

which were often exacerbated by damage from material drawn into the engine during operation. From completed analysis, it was determined that the dynamic mode most likely to cause issues was a part speed stall flutter mode, which gives rise to high stress levels at several locations on the blade.

The importance of this mode was further underlined by an analysis of the operating regime of the Harrier aircraft, which indicated that considerable time was spent operating in the speed range at which this mode was prevalent.

Analysis and practical testing was able to show that control of this flutter mode was highly dependent on the tribology of the snubber faces. During operation, the snubbers can become locked due to centrifugal and aerodynamic loads on the blade. Excitation of the stall flutter mode can reverse the loading on the snubbers, leading to a situation whereby higher-order modes become excited due to stick-slip motion as the snubber faces move relative to each other.

The snubber faces are coated with tungsten carbide and a dry film lubricant, and will lock when the critical coefficient of friction, determined by the angle of the snubber face is exceeded. For the existing design, having a snubber angle of 20°, this value is 0.36. It was indicated that loss or lack of lubrication between the two faces can impact the behavior of the mode.

In order to understand this phenomenon, a friction wear test was initiated at the Rolls-Royce sponsored University Technology Centre (UTC) at Oxford University. This test was set up to simulate the relative motion between two snubbers in service and was performed at a frequency in line with what would be seen in service. The rig used is shown in the image on the left.

The results from the rig enabled an understanding of the bedding-in process and indicated that the level of friction between the two faces increases as the dry film lubricant wears away and debris builds up. The

340
The number of Harrier variant AV-8Bs manufactured

20,280
The thrust in pounds generated by the Pegasus engine

company proposed a number of design changes to the blade to mitigate this issue: the angle of the snubber face was increased to 25° to make the adjacent faces slide more easily and an improved under-platform damper was introduced to control the dynamic response of the blade.

900
The maximum range in nautical miles of the USMC Harrier variant

9.25
The wingspan in meters of the USMC Harrier

1,347
The number of Pegasus engines produced

VALIDATION PROGRAM

Having identified the design solution, the company's efforts turned to proving the change. It was established that the design changes would be validated by both rig testing and engine running. The validation process commenced with a frequency survey of the revised blade standard and the results compared with the data previously available from the existing standard. With the results of the frequency survey in line with pre-test FE predictions, the next step was a fatigue test of the new blade. Six sample blades were tested to establish each of their failing fatigue strengths.

Each blade was mounted on a vibration table and restrained at the inner dovetail fixing and the snubber to accurately represent engine conditions. The rig used is shown in the figure below right.

From the testing, it was demonstrated that the basic strength of the new blade was within the scatter of the legacy blades and that no new potential failure modes had been introduced.

ENGINE TRIALS

Rolls-Royce followed a structured process to establish the verification and validation requirements for the revised blade. It was determined by the engineers that a number of engine tests would be necessary to gather all the evidence required to clear the new blade for operational duty.

The last production engine was shipped from the Rolls-Royce Filton factory in 2005 and the testbed was mothballed in 2010. Therefore establishing an engine test capability was the first major challenge. The first of the engine tests, to calibrate the testbed, was completed in May 2013.

With the testbed deemed serviceable, the program to validate the design change could begin in earnest. The first test of the structured validation program was a build of the engine, incorporating its existing baseline configuration, against which the intended design improvements could be assessed. The build of the engine incorporated two systems to measure the dynamic response of the blade.

The first system is the blade tip timing, which uses optical probes to detect the arrival time of the tip of the blade at a number of points around the casing. The system measures the speed of the engine spool and differences in the time at which the tip of the blade passes the probe compared with the expected timing, and can be used to determine the amplitude and frequency of any blade resonance.

The second system is the FM grid, and is similarly used to measure blade dynamic response with a magnet attached to the blade tip and a conductive wire grid around the engine casing. The motion of the blade tip causes a signal to be induced in the grid, which is proportional to the frequency and displacement of the blade tip and from which the blade dynamic characteristics can be deduced. Subsequent engine builds and testing were aimed at understanding the impact of the individual improvements in the proposed design changes.

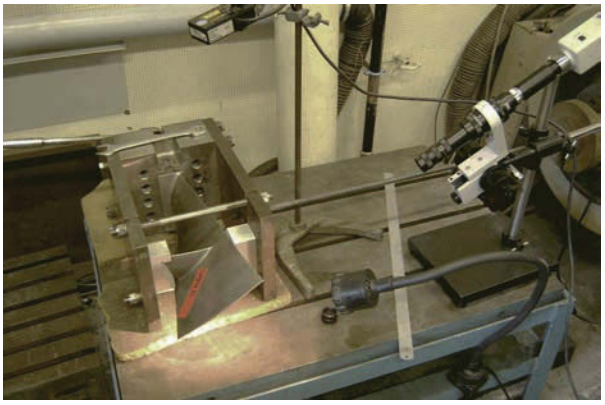
As discussed earlier, the propensity for flutter is dependent on the lubrication of the snubber and other contact faces on the blade. The gap between adjacent snubber faces is also a major contributor to blade lock up. In order to promote flutter during the test, the fan assembly was built with dry film lubricants removed and snubber gaps at the bottom limit of tolerance. Fan blade flutter can be influenced by a number of factors, the two principal being engine inlet distortion and blockage downstream of the fan. During the test program the blockage in the front (cold) nozzles of the engine was varied to further promote flutter.

The first of these tests was completed in September 2013 and featured the existing blade fitted with the revised damper. The purpose of the test was to establish the individual benefit of the damper, with the testing completed in the flutter promoting configuration.

The next test, again in the flutter promoting configuration, featured both the revised blade and the damper. The final test, completed in August 2014, featured the revised blade and damper in the production standard configuration with all surface lubrication reapplied. The results of the test program clearly showed that the redesign of the blade and the incorporation of the new damper led to a great reduction in flutter amplitude of the blade. In the final production standard configuration, flutter has been all but eliminated.

Despite the twin technical and logistical challenges, the Rolls-Royce team compiled a comprehensive understanding of the issue and devised a substantial design improvement, which is currently being evaluated by the customer. ∎

ABOVE: Southern Helmand province, Afghanistan after conducting an aerial refuel



BELOW: (Below) Vibration rig used for blade fatigue strength evaluation

Tim Williams is chief engineer – Pegasus, transport and helicopter engines, with Rolls-Royce plc, based in Filton, UK

Listening post

LMS solutions expert Raphael Hallez highlights the latest tools and trends for the aviation industry

BY CHRISTOPHER HOUNSFIELD

RAPHAEL HALLEZ

With dreams of becoming a mechanical engineer specializing in acoustics and vibration, Frenchman Raphael Hallez started studying at the University of Technology in Compiègne, France, and finished with a Masters of Science from Virginia Tech in the USA. Thirteen years later, he finds himself working for Siemens PLM Software in Leuven, Belgium. As a business development manager for aerospace and defense, he helps customers around the world solve product development challenges on both the simulation and testing fronts.

LMS SOLUTIONS ARE WELL KNOWN ACROSS THE INDUSTRY. WHY DO YOU THINK THIS IS?

Our solutions are centered on testing and simulation tools for very specific noise and vibration engineering applications. On the testing side, we have a complete testing, analysis and report-generating solution including both the LMS SCADAS test data acquisition hardware and LMS Test.Lab software.

We are very active in the aerospace industry with leading solutions for structural dynamics and modal testing, ground vibration testing (GVT) and flutter testing, and acoustics. Our solutions are also greatly appreciated within the space industry, specifically in environmental testing.

WHY DO YOU THINK GVT IS SUCH A CRITICAL TEST?

The GVT campaign is on the critical testing path for an aircraft's first flight. Since this test is typically completed on the actual first flight test vehicle, our GVT solution is much more than a modal test system that extracts resonance frequencies, damping values and mode shapes. Embedded with more than 30 years of aviation customer feedback, it integrates testing and analysis, managing the test setup, data, and analysis results, in a traceable, transparent and, well, rather elegant way.

But GVT is just the starting point. Key players from both the aviation and space industries appreciate the value of the LMS testing solutions from Siemens PLM Software.. And our solutions are just as popular among acoustic testing experts. Customers are using our solutions for all kinds of jobs: inflight operational noise measurements, sound source localization and ranking, and flyover and ramp noise measurements, for example.

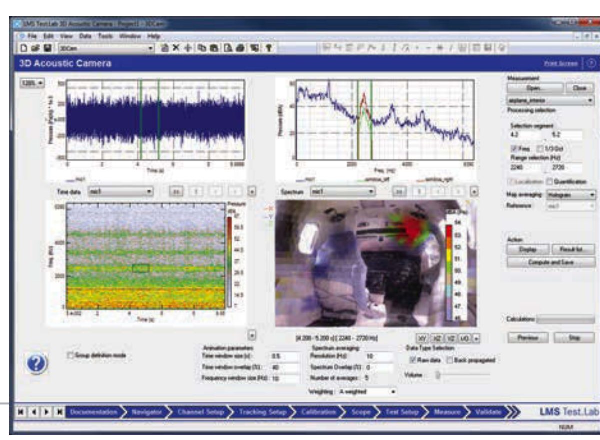
WHY DO YOU THINK THIS IS THE CASE?

I think aviation test teams really like our platform concept. They have an engineering tool with integrated hardware and software to solve all types of noise and vibration issues. This is especially important for teams covering both acoustics and vibration disciplines because acoustic problems typically originate from a vibration problem. Just having to use one uniform tool is crucial for productivity.

WHY IS ACOUSTIC TESTING GAINING GROUND IN AIRCRAFT DEVELOPMENT PROGRAMS?

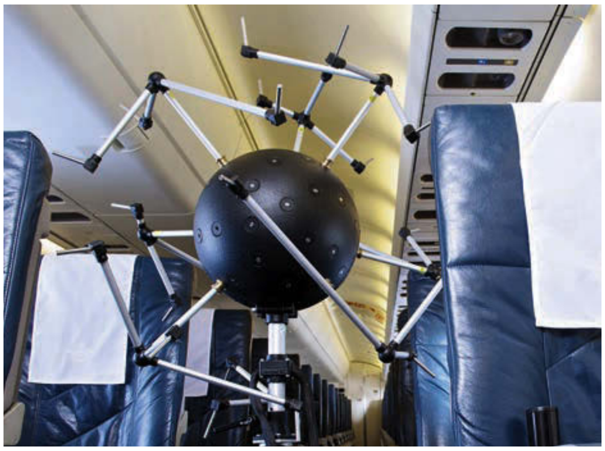
Noise reduction and sound engineering are a continuous challenge in the aircraft design process for both exterior and interior acoustics. Stringent regulations on take-off, flyover and landing noise are forcing manufacturers to limit noise emissions from not only the engine but also the airframe. And, of course, passenger comfort is playing a much bigger role in aircraft design these days, with customers raising the bar for improved sound quality and a more pleasant flying experience.

But there is an issue. Most acoustic requirements are often in conflict with



RIGHT: Detailed analysis of sound fields inside the aircraft cabin

BELOW: **Quick and accurate identification of in-cabin sound sources through array-based techniques (Photo: Belgian Defense)**



the environmental requirements for lighter, greener and more eco-friendly aircraft. For example, the new composite structure definitely reduces the weight, but this weight reduction typically has a negative impact on the aircraft's acoustic performance. Finding the balance between conflicting requirements is a day-to-day issue for acoustic engineers.

"A SYSTEM WITH 12 CHANNELS WAS ATTACHED DIRECTLY TO THE PILOT'S BODY TO ACCURATELY ACQUIRE DATA FROM SEVERAL MICROPHONES"

WHAT TYPES OF NEW TECHNOLOGY ARE AVAILABLE FOR ON-GROUND OR INFLIGHT ACOUSTIC TESTING?

There are some exciting developments to help engineers meet these tough new noise level targets and make the right choices, acoustically speaking. One solution is a specific array-based technique that has been developed in partnership with a major aircraft integrator for interior sound source localization. The system is based on a 3D rigid sphere acoustic camera. The sphere contains numerous integrated microphones, which span the entire 3D space and detect noise sources at any location around the sphere. The results are strikingly fast, yet offer unprecedented insights into noise source localization and source ranking for selected frequencies and configurations. Many customers say it's a real shortcut to optimized cabin comfort. Most only need a few minutes of flight testing, instead of several hours, to create a precise sound profile of the aircraft interior and clearly identify realistic paths for acoustic optimization. It is also a speedy troubleshooting tool and it keeps expensive inflight testing to a minimum.

CAN YOU GIVE SOME MORE EXAMPLES FOCUSING ON ACOUSTIC TESTING?

Well, I can't name names, but we have customers who manufacture small business jets and they have very high expectations regarding acoustic comfort. Low sound transmission from exterior sources, such as the engine and turbulence noise to the cabin, is very important. The acoustic and vibration teams were looking for tools to help identify acoustic weak spots and analyze sound transmission inside the cabin during flight. They also needed a tool to improve and validate the experimental setup for panel transmission loss.

Our high-definition acoustic camera solution has proven to be a superb tool. Its 'point and shoot' functionality delivers quick feedback on the acoustic performance to identify and quantify acoustic weak points inside the aircraft cabin or inside the transmission loss room.

But our acoustic work goes further. Recently, a customer completed an extensive acoustic and vibration study on a US aircraft carrier in compartments under the flight deck to reduce noise levels and prevent overexposure to the soldiers due to aircraft launch operations. On the flipside, we also helped a military aircraft manufacturer quantify pilot noise exposure during various flight conditions. An extra-small LMS SCADAS system with 12 channels was attached directly to the pilot's body to accurately acquire data from several microphones positioned at the pilot's ears and various locations inside the cockpit. It verified that no excessive noise levels occur in the cockpit and that the pilot could operate safely.

Here is another one: flyover noise measurements. These are now a mandatory step in the certification process for a new aircraft. Noise is measured at specific locations on the ground while the aircraft flies over it and follows a well-controlled trajectory. The data acquisition system must be integrated into a fully certified process that is approved by the certification authorities. The SCADAS system has been approved for this type of testing. Based on testing and extensive validation work, the data acquisition, analysis, recording and reproducing system complies with the technical standards of International Civil Aviation Organization Annex 16, Volume 1, Fourth Edition, Appendix 2.

WHERE DO YOU SEE THE FUTURE OF AIRCRAFT TESTING?

Certainly, safety remains the key priority in the aviation industry, but market demands, such as better fuel economy, increased comfort, reduced emissions and noise levels, and lower operating costs, will continue to force the aircraft industry to rethink traditional engineering methods. Successful development programs must deal with new materials such as composites, new technologies, more control systems, and overall much more inter-system complexity. Not to mention staying within budget and on schedule.

The end goal is to achieve the earliest possible aircraft maturity. To succeed, we see a continuous need for integrated simulation and testing throughout the development process. This is why we constantly work on developing faster and better simulation and testing tools to provide more in-depth engineering insight to help OEMs, integrators and suppliers design the best possible aircraft of the future. ∎

BOOSTING V_0

Boosting the velocity of development in the early project phases with suitable test methods saves time and money

The abundance of literature relating to procedure models certainly does not call for yet another V-model. Nevertheless it is apparent that the vast number of projects still do not reach their goals as planned.

Over the past few years, the company TechSAT has been increasingly involved in development projects for its customers. It has had to evolve from a mere supplier of test systems to a partner for the entire development cycle. Consequently the company has devised a wide range of solutions for customers that help accelerate and secure the development process. People working in system development learn early on in their career that errors found late in the development process can be expensive and even disastrous.

This means that clients need help to identify potential problems as early as possible. Although proven methods for this purpose have been around for a long time, such as requirements for engineering and system modeling, most customers are not satisfied with the results achieved so far.

Coming from a background in systems testing, it was only logical for TechSAT to look for ways to implement verification measures right from the beginning of the project's requirement and design phases. Because the symbol for initial velocity is V_0 it was applied – as a play on words – to V-models.

PRACTICAL APPROACHES

From recent discussions with the company's clients, it became clear that many are searching for a partner to take them through their development projects. At the same time, they shy away from the effort it would take to find the right support for each of the phases. For this reason, TechSAT has built up a network of specialists and tool providers, enabling the company to massively scale its portfolio of test system solutions, customized tools and consulting expertise, and adapt it to the needs of its customers. For each project, the company jointly developed the optimum solution for services, tools and test systems.

TechSAT is known for its test systems, I/O boards, and tools for the aerospace industry. Two major trends are on the horizon. As a manufacturer of test systems and tools, the company is having to develop the technology requirements for test environments itself or in cooperation with customer representatives. The times when customers composed their own test systems from a technology platform are definitely over.

The second major trend is the need to supply customers with integrated solutions suitable for the start of a development project. To this end, the company has scaled down its ADS2 platform for use on small systems and can now offer it as a dynamic test platform supplementing the development host, turning it into an integrated model development and verification system.

The next stage of test systems is the Single Device Integration Bench (MAYA-SDIB). It is software-to-software and hardware-to-software integration at the equipment level. The MAYA concept is complemented by software and hardware simulators as well as equipment prototyping.

Excellent development tools are available on the market that combine engineering and design in an integrated system. These tools provide host-based simulations and analysis capabilities, but are usually limited to a single application. In dynamic testing or application intercommunication testing, however, they often reach their limits.

When moving from the host to the target platform, at the very least, discontinuities will appear in the testing environment. The user must therefore be provided with the testing solutions that integrate seamlessly with the engineering and design tools and simultaneously also be supported with automated test systems.

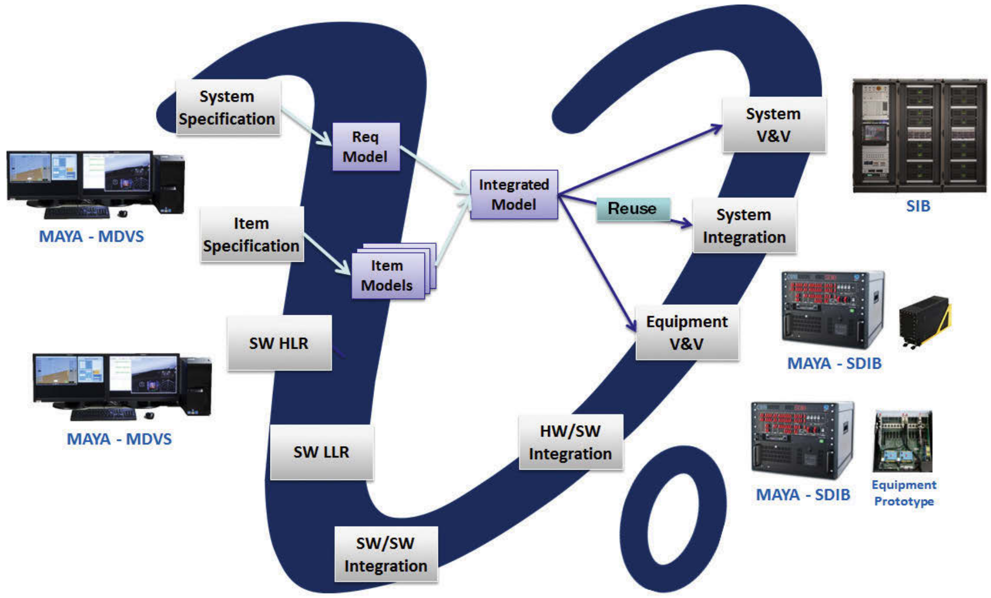
BOOSTED DEVELOPMENT

For some time, TechSAT has been working with the ambitious C919 CDS development project for a Chinese customer. Together the two have faced the challenge of adhering to an almost impossible schedule. It was therefore decided to start verification in parallel to model development.

All the measures described here were taken to accelerate the development to a maximum, right from the start.

Through rigorous test drive development, automated data processing and parallel use of 15 Model Development and Verification Systems (MDVS) plus five Single Device Integration Benches (SDIB), it was possible to create a complete, integrated CDS prototype within nine months.

Later, two Full System Integration Benches (FSIB) will be available for further integration and verification.



TechSAT can accomplish this continuity, as requested by its customers, by using its ADS2-based technology platform. As a logical consequence, a target simulation for the first development steps is provided. This ADS2 virtual target simulation (e.g. for VxWorks 653) is integrated into ADS2 and supports, for instance, dynamic tests between applications on the development host. The applications can therefore use the communication calls or shared memory accesses of the target platform unchanged.

NEXT STAGE

For the next development steps, a target simulator and a test system of the MAYA family are supplied. The target simulator is a small real-time system, which in addition to the target simulation, running on ADS2, also offers I/O support (ARINC 664, ARINC 429, CAN, MIL1553, Discrete, etc).

The target simulator enables testing of both the inter-process communication and the real I/O transfer of the application. With the attached test systems of the MAYA family, the additional possibility arises to create the test procedures for the software-to-software and hardware-to-software integration and test their functionality as early as the development phase.

Therefore, by using model-based development tools with a built-in code generator, development times can be greatly reduced because customers have and can test executable code during the model-development phase. Any change in the model can be directly tested in this way.

CLIENT BENEFITS

In addition to the increase in development speed at the start of the project, the main advantage lies in the reduction of development risks.

Many more errors were found during the project phases in which error correction did not actually increase costs.

Another advantage is that from very early on, information is gathered for system integration and verification. Verification can therefore be managed far more comprehensively and test environments can be set up to be far more efficient. Additionally the design-to-test methodology is much better supported.

At this point the additional measures for development support carry a positive effect right through to the formal verification processes. These measures come under the term ‘boosting V_0’. The numerous but consistent individual measures that are offered as part of a development agreement ultimately allow TechSAT’s clients to save a lot of time and money with their development projects. ▮

A CENTURY OF INNOVATION

Company founder, innovator and leader in the aerospace testing industry Per V Brüel celebrated his 100th birthday on March 6, 2015

Fifteen years into the 21st century, sound and vibration measurement and analysis is an essential component of aerospace product development. The shortening design and development timeframes of modern aerospace programs demand 'right first-time' engineering. Whether the challenge is ensuring structural integrity and product safety, performing exterior noise analysis such as flyover testing, or confirming the integrity of aircraft gas turbines, the technology being used today had its start nearly 80 years ago outside Copenhagen, Denmark. It was the brainchild of Per V Brüel, who has just celebrated his 100th birthday. He can now look back on a century in which he played multiple larger-than-life roles: engineer and inventor, founder of a major global corporation and pilot who personally pioneered new markets.

INITIAL BREAKTHROUGHS

As a young engineer with a recent PhD in acoustics from Danish Technical University and a passion for innovation, Brüel made his initial breakthroughs in the late 1930s and early 1940s with the development of the world's first acoustics analyzer and the first commercial piezoelectric accelerometer (Type 4303). "I was able to make the first acoustics analyzer in the world," he says. "No one had ever made anything like that before. We made two copies, and it became our first commercial instrument when Viggo Kjær and I started Brüel & Kjær."

This early work was the foundation for many of the products that followed. It was new territory, but as a pilot himself, Brüel could see its importance to the future of aircraft development. These insights were the genesis of a global company – Brüel & Kjær's first production site was rented space in a dressmaker's workroom. The company that Per Brüel and Viggo Kjær founded is today the world's largest specialist in sound and vibration solutions. Its product line grew to include transducers, data acquisition systems and data analysis systems, as well as a comprehensive range of electrodynamic shakers designed for vibration testing of devices of practically any size, from a semiconductor component to a complete satellite system.

Even in the early days, a main objective was to use the instruments to measure and reduce vibration and noise levels, both of which are vital concerns in the aircraft industry. "Even then we could see that noise is one of the biggest problems of our time – it affects millions of people every day," says Brüel. It became increasingly clear that sound and vibration instruments could help manufacturers improve the safety and comfort of airline passengers worldwide by enabling them to see how their products would stand up to real-world conditions.

Brüel pioneered the development of products such as a revolutionary sound-level recorder and microphones that set a new standard for accuracy and stability. A single example is the special microphone (Type 4193) developed to measure and analyze the N-Wave generated from Concorde's sonic booms. These products were the forerunners of the complete aerospace testing and analysis systems and comprehensive applied solutions that the company supplies today.

OPENING NEW FRONTIERS

On Brüel's 100th birthday, it is interesting to reflect that one man's passion for overcoming engineering challenges has led to sound and vibration innovations throughout the entire life of aerospace industry products, from modeling an early design, to manufacturing the product and maintaining its operation. Today, sound and vibration testing contribute not only to safer, more comfortable air travel and to reducing airport noise, but also to advancing space exploration. Brüel & Kjær data acquisition and vibration test systems have been used to test NASA's Mars Curiosity rover, Astrium's satellites and the ESA's Rosetta space probe, which recently landed on a comet. Also, Brüel & Kjær accelerometers were present on the legs of the lander, Philae, to 'listen' to its landing on the comet.

It shouldn't be surprising that Per Brüel was the source of sound and vibration advances that continue to help advance aerospace development. His engineering passion was equaled by his enthusiasm for flying. He was licensed in Denmark to fly single- and multi-engine planes as well as gliders. From 1957 to 2000, he logged 9,476 hours of flight in more than 20 aircraft. Many of those hours were on business trips, opening new markets and pursuing new challenges throughout Europe and as far afield as Russia and China, piloting company airplanes that were humorously referred to as B&K Airlines. It seems only right that his engineering insights are playing a part in pushing back the frontiers of space.

Per V Brüel flying (above right), and measuring airport noise in 1971 (right)

SCANNING FOR PROBLEMS

Computed tomography is the most effective way to evaluate the properties of composite materials

The Boeing 787 Dreamliner made headlines for being the first major airliner to use composite materials to construct the majority of its airframe. Long before any aircraft like the Dreamliner took off, scientists and engineers around the world used the 3D inspection capabilities of computed tomography to evaluate the structure, processing and properties of the composite materials. Industrial computed tomography (CT) provides digital 3D x-ray models of test subjects, thereby allowing the analysis of interior structures of composites.

Industrial CT uses a series of 2D images taken at specific intervals throughout a complete (360°) rotation of the test object. A typical North Star Imaging CT system consisting of three principal components: an x-ray tube, an x-ray detector, and a rotational stage. The x-ray tube shoots high energy x-rays through the test object to form images on the x-ray detector. Once anything between 360 and 3,600 2D images are collected, CT calibration and CT reconstruction algorithms reconstruct the images into a 3D volume. The use of visualization software of the 3D volume allows one to slice through anywhere in the object, inspect and look for defects, take accurate measurements, and reconstruct a surface model.

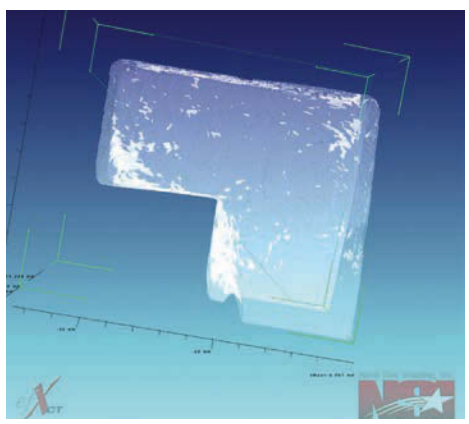
Computed tomography is uniquely suited for composites because they often consist of complex structures of multiple materials and varying densities. Traditional 2D x-ray fails to differentiate between layers in composite structure with intricate geometries. For a given part geometry, the amount of signal received by the x-ray detector decreases as density increases, thereby allowing different materials to be highlighted. The image bottom right shows a composite of lower density plastic surrounding higher density fibers. CT enables one to see the orientation of the fibers, flow lines in the plastic and voids in the material structure.

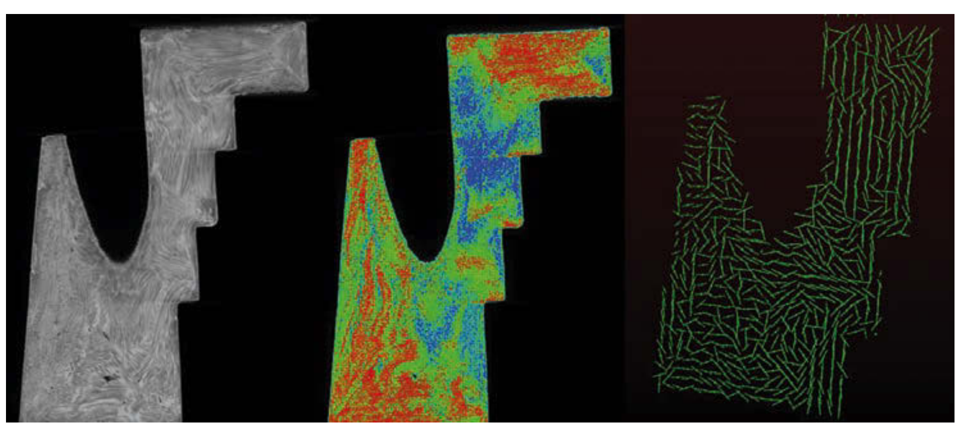
The high level of contrast that CT provides allows for clear identification of delamination, wrinkles, fiber orientation, misweaves, fiber pull-out, cracks and voids. 3D rendering capabilities of CT software, such as efX-CT produced by North Star Imaging, allow for multiple virtual cross-sections through the part in multiple axes. The resolution of industrial CT often allows seeing individual composite fibers that are only a few micrometers in size. High-resolution CT is used to detect delamination, to detect fiber distribution patterns, and to quantify and measure porosity.

Unlike traditional mechanical testing or sectioning, industrial CT is a non-destructive technique that preserves the test object for future use. This non-destructive testing technique is not only valuable throughout a product's lifetime, it also saves money. During research and development, industrial CT may be used to periodically check a part undergoing accelerated testing. In a multi-year test, hundreds of parts are placed in an environmental chamber so that a single part can be pulled out periodically for destructive inspection. CT allows the parts to be inspected and then returned to the test chamber. During production, industrial CT is used to inspect parts before they are shipped. High-value casting houses, including turbine blade manufacturers, have been using industrial CT to measure wall thickness and rib thickness for years. If material that failed incoming inspection accidentally makes its way into a production run, parts are quickly CT scanned to screen for defects. In the event of a field failure, industrial CT provides a 3D model without sacrificing a unique specimen of a failed component.

Industrial computed tomography systems, like the X5000 manufactured by North Star Imaging, are powerful tools that provide precise and automatic material analysis when combined with powerful software. As consumers demand larger and safer aircraft with more amenities, aircraft manufacturers continue their search for low-density materials that are strong, stiff, and abrasion and impact resistant. More and more composites are meeting these needs and industrial computed tomography provides a unique and non-destructive inside view of composite structures and properties.

North Star Imaging designs systems, develops software, and manufactures x-ray and CT equipment, near Minneapolis, USA. The company built its first digital radiography system in 1991. In 2006, North Star Imaging founded the Inspection Services Group offering need-based consulting to anyone needing x-ray and/or computed tomography scanning. In 2010, North Star Imaging was acquired by ITW, a global company with





ABOVE RIGHT: Internal voids are highlighted by creating a transparent shell

RIGHT: Fiber orientation analysis of a composite part. The colors in the middle picture show the angle of the fibers and indicate the orientation strength of the part

IN PRAISE OF SIMPLICITY

Keeping test solutions simple is key to reducing costs. Using a Test Requirements Document keeps the program clear and straightforward for the customer

Test requirements traceability – not a phrase that sets the pulse racing, yet it's the essential thread that runs through all formal test implementations. Making sure that LRU (line replaceable unit) functional test requirements have been correctly fulfilled is the core quality assurance activity for test solutions.

The usual scenario encountered by test solution providers such as Red Earth Systems is that test requirements are set out in a text Test Requirements Document (TRD) created by one or more system designer, hardware designer, or test engineer. The test equipment hardware is provided by an in-house team or by outsourced suppliers and similarly for the software that implements the functional testing. Individual requirements in the TRD are tagged with unique IDs and these are then referenced in the test software and the results files produced by executing the tests.

There are software tools on the market that implement end-to-end requirements management and can do it very well if used correctly by experienced staff; however they typically come with substantial costs in terms of both finance and the amount of training required. Users of such applications may also have experienced the feeling that a significant amount of effort can be spent satisfying the demands of the tool and the original objective of simplifying requirements management can seem to be lost along the way.

However, there are obviously very good reasons to make the process of managing requirements as easy as possible because it's fairly certain that anyone at the start of their working life thinking of making engineering their profession hasn't been attracted by the lure of requirements management. It may not be the interesting part of the job for most people, but it has to be done – and done well.

TRANSPARENCY

Rather than going down the path of attempting to produce another requirements management application, the approach at Red Earth Systems has been to make the test process more transparent by simplifying the implementation of the functional tests. A PC-based test management application has been developed that executes test scripts written using a very simple set of programming commands. A layer of driver code provides the interface to represent test instrument I/O as a set of variables within the script language, e.g. to set a power supply voltage, the command would be of the form 'Primary_DC_PSU_Volts = 28.0;'.

A test evaluation is performed by a single statement that includes a reference to the TRD test ID, the limits for the parameter being measured and a comment to be logged to the results file with the test result. The systems test manager enables the parallel execution of test scripts, making the implementation of tasks such as background alarm monitoring very simple, but the majority of test code will be implemented as a linear series of test steps of the form: 'set inputs to LRU', 'wait', 'measure outputs from LRU'.

The two key points about the use of high-level scripting are firstly that the implementation of the functional tests has an almost one-to-one correspondence between test steps in the TRD and test script statements; and secondly that the scripts themselves are eminently understandable by people who aren't software professionals but, crucially, are those who have the greatest knowledge of the product that is being tested and the equipment being used to test it, i.e. the system, hardware and test engineers. This approach provides the informed oversight of the test solution that is an essential part of driving up quality.

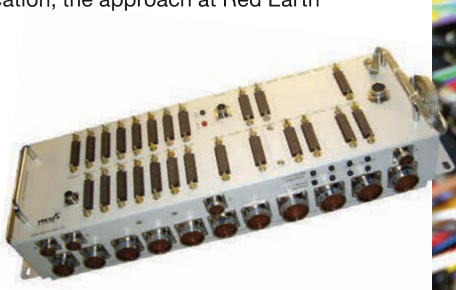
SCRIPTING LANGUAGE

In practice, when test solutions using this approach have been deployed, users have not simply been passive reviewers. Systems and hardware engineers have found that the accessible nature of the scripting language has meant that it's been easy to create variants of formal test scripts and also write separate bespoke tests to aid integration, commissioning and fault diagnosis. The test scripts are plain-text files so it's not essential to have special development environments to create, edit or review them.

This leads on to another key aspect of supporting test solutions – change management. Changes to the functional tests are initiated by updates to the TRD that then drive the requisite changes in the test implementation. Typically, new revisions of the affected source files are raised within a configuration management system, then a new build of software is created, tested, verified and released.

The verification activity will usually consist of a combination of functional test and scrutiny/review of the changes in source files. The high-level, text file implementation of the script files used by Red Earth Systems has the dual benefit of minimizing the number of statements to be changed and enabling the use of freely available, powerful, text file comparison tools. The review process is therefore made much more straightforward in comparison with tracking changes in graphical or database-based test systems.

There are many ways to implement test systems, but by keeping things simple, transparent and maintainable, customers are both engaged and empowered. ∎



HIGH-SPEED DATA RECORDING

If quality measurement, fast reporting and data sharing are accepted norms, why are you worrying about losing critical data?

High-speed measurement and recording of aerospace and defense systems under test in an accurate and timely manner is not a simple engineering task. Management and data security of large files, along with sharing and reporting the results quickly, are only a few challenges engineers are facing as channel requirements increase.

In the 1980s, Müller-BBM connected an IBM PC to a smart instrument to acquire and transfer data, store and load setups and create plots of desired analyses. Since then, the instruments gradually became less intelligent devices as the engineer's interface transformed into a software-based solution. In the light of progress in the programming of user interfaces, the rise of PC's processing power and the decrease of cost utilizing it, the measurement hardware – "frontend" – was stripped of its capabilities. In parallel, the demand for higher sampling rates and more data channels created a weakness: How do we transfer and store real time data continuously without loss?

When a multimillion-dollar product is ready for vibration or acoustic testing, any delay can have great consequences. Optimization of the measurement, analysis and data management processes to quickly provide and share results drives new system requirements.

Working with hundreds of high-speed channels is demanding. Transducer and channel management, accurate signal conditioning, phase synchronization, reporting speed and lab integration are all engineering challenges that can affect downtime.

Data security is paramount; loss of any test results is not acceptable. In the design and delivery of two 528 channel PAK systems to Lockheed Martin Space Systems in Sunnyvale, California, high-speed data acquisition and secure recording was the highest priority. The value this lab provides and the product it delivers is quality data.

SYSTEMS INTO OPERATION

To cure the security problem, technology needed to repeat itself. The measurement hardware required intelligence. Eleven PAK MKII measurement systems, each precisely synchronized with Müller-BBM's SyncLink and connected to the test operation and analysis workstations, a 28TB NAS for shared storage and an automated tape back-up library – two 528 channel systems with a total of 1,056 channels – were successfully integrated, tested and put into operation.

Contained within two standard racks, each system provides 528 24-bit channels, each sampled at 204.8kHz in parallel while maintaining precise phase response across the entire configuration. An embedded controller providing intelligence and local storage to each PAK MKII guarantees data security in the event of communication or power loss.

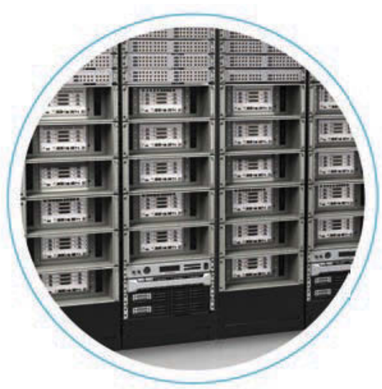
A circular buffer records continuously to assure every event is measured prior to and during the test. Integrated signal conditioning providing a high-powered ICP current for long cable runs, voltage and accurate DC measurements are supported and augmented by buffered analog outputs. An optimized network with transfer rates to 400MB/s supports the automated reporting and data export executed at test completion.

THE USER BENEFITS

Customers benefit from industry-first data management to guarantee measurement security and integrity for both immediate and later analysis in various formats. Data administration from multiple, synchronized mainframes is transparent to the operator.

The industry standard, modular and scalable hardware simultaneously supports a wide range of measurement parameters with precise channel-to-channel synchronization. Voltage, charge, ICP, strain, microphone, temperature and pressure sensors can be combined and sampled at different rates during a single test. The beauty lies in simplicity as the aerospace application-specific software simplifies the operation and provides formatted graphics, reports and quick data availability for review and export.

Simplicity does not have to equal loss of capabilities. The solution seamlessly integrates into existing test environments, cabling, signal conditioning, monitoring and control equipment. A wide range of signal input-output interfaces, buffered outputs and battery back-up has any system configuration producing results quickly. System expandability and reconfiguration are effortless. Multiple mainframe configurations are easily separated into smaller, portable systems or combined for larger test requirements. Again, data administration and synchronization is invisible to the operator.



RIGHT: Measurement test setup

FAR RIGHT: PAK MKII acquisition units in the used 19in racks

FIGHT AS YOU TRAIN, TRAIN AS YOU FIGHT

Since last year, the Swedish Defence Materiel Administration, FMV, has been the operator of Sweden's largest firing and exercise range, Älvdalen, which is situated in a relatively remote region in the middle of Sweden, about 400km northwest of Stockholm.

With an area of 540km², Älvdalen offers a wide range of capabilities: one main feature is the 700 x 1,000m hardened target area, which is an ideal target site for tracked and monitored firings (inert and live). The effective firing range is about 46km; maximum detonation weight at the hardened target area is TNT 1,000kg.

The hardened target area is also an ideal location for testing of dispenser weapon systems. Dedicated monitoring and tracking systems are present, which track every sub-munition until impact and record the exact place of burst. When it comes to general monitoring, recording, measurement and test systems, a wide selection of radars and optical systems are available.

Besides the hardened target area, there are a number of launch and target sites scattered throughout the range. Furthermore, there are three dedicated helicopter landing sites, an 800m airfield and a 1,500m landing strip within the range. Älvdalen base camp is well equipped with accommodation, assembling, course and workshop facilities.

The remote location and vast area makes Älvdalen a perfect place for the firing of guns, missiles and rockets from helicopters. It is also very well suited for bomb runs with fixed-wing aircraft.

As the place is unpopulated and the radio spectrum is open, Älvdalen works very well for training and exercises with live EW systems and threats. For example, trials with GPS jamming and other electronic attack techniques such as noise and deception jamming and deployment of live expendables (chaffs, decoys and flares) can be successfully implemented. Another aspect of the remote location and low population is the night sky. Älvdalen is almost totally unaffected by artificial night sky brightness (light pollution), which is very prominent over mainland Europe and the British Isles. This feature makes Älvdalen a perfect place for night-vision goggles evaluation and training, as well as for night-vision operations. The operational conditions achieved in Älvdalen are very similar to the conditions present in recent operational areas, such as Afghanistan, Iraq and Libya.

The winter climate at Älvdalen sees outdoor temperatures down to -30°C. The peak temperature during summer is about +30°C. The vast area makes Älvdalen a natural choice for large-scale exercises (up to and including brigade level), for example joint operations between fast jets, helicopters and ground forces. Through using GBAD and other threat systems, very realistic training and exercise scenarios can be designed, such as SEAD and DEAD. The target catalog includes static ground targets and remotely controlled ground and aerial targets, all are available for hard kills. Targets can also be furnished in accordance with customer specification.

AERO-ACOUSTIC AND POWERED MODEL WIND TUNNEL TESTING

Aero-acoustic capabilities have been introduced by RUAG Aviation to its wind tunnels to help customers to efficiently identify and quantify noise sources generated, for example, by high-lift devices or landing gears during aerodynamic testing.

The company's facilities include the Large Wind Tunnel Emmen (LWTE), one of the largest subsonic wind tunnels in Europe, and the Automotive Wind Tunnel Emmen (AWTE), where car models up to 50% scale can be tested on an accurate moving ground simulation.

In 2012, RUAG Aviation teamed up with Dassault Aviation to carry out a demonstration test using an array of 144 microphones to measure the acoustic noise source maps of a business jet. During this one-day test, 60 aero-acoustic datapoints were measured for various model configurations, wind speeds and angles of attack, thus confirming the suitability of the LWTE for aero-acoustic studies. The LWTE is also often used for conducting tests with powered models. A demonstration in the open section of the Experimental Wind Tunnel Emmen (EWTE), with a hydraulically driven counter-rotating open rotor (CROR) propulsion setup, confirmed that no significant noise from the motors masks the acoustic sources of interest.

RUAG Aviation continues to quickly respond to customers' changing requirements. In recent years, demand for propeller and open-fan-powered aircraft has grown due to economic and ecological constraints. As a consequence, RUAG Aviation has recently upgraded its hydraulic power supply, which is now capable of generating a total of 1MW of power. The pumps are used to drive up to four independent high RPM model propellers/rotors, or can be combined to power a single full-scale propeller. In-house hydraulic motor technology is under constant development to fulfill the customer-specific high-torque/high-RPM requirements in this field.

RUAG Aviation's wind tunnel status as a leading European aerodynamic testing facility is largely due to the team's experience, flexibility, cost-efficiency and focus on customers' requirements. Whenever standard wind tunnel tests, powered models or acoustic measurements are needed, RUAG Aviation provides the necessary high-quality data.

GAPMAN GEN3 MEASURES COMPOSITE GAPS

A portable non-contact electronic gap tool from Capacitec Gapman Gen3 can replace feeler gauge measurement methods in aircraft shimming applications at Airbus, Boeing, Bombardier and Embraer, as well as military aircraft such as JSF.

A Gapman and 'thin wand' (0.2mm) design is important because it measures small entrance gaps that transition to larger internal gap locations. Feeler gauges can fail at this job and create a manufacturing process.

It can greatly speed up electronic measurements when there is a non-parallel part relationship. Increased aircraft use of very rigid CFRP materials has made the Gapman very popular due to the multiple composite part interfaces creating unwanted air gaps, especially on new aircraft builds, such as wing skins. New gap technology particularly benefits aircraft assembly, quality and throughput when semi-automated shimming operations are added for CFRP/CFRP and CFRP/metal assemblies.

To date, the Gapman has achieved a gap measurement/shimming operation build-rate improvement amounting to five times faster than with manual feeler gauges. Additional benefits are: reduced overall shimming scrap cost, enhanced structural integrity of aircraft components, and a shim gap database to assist users in process improvements.

Datalogged gap values can now be communicated from the Gapman via the wireless to customer-driven template data programs for direct control of the gap-filling process.

FREE READER INQUIRY SERVICE

Capacitec

READER INQUIRY 109

To learn more about this advertiser, visit www.ukipme.com/info/tea **NOW!**

R&D INITIATIVES FOCUS ON LATEST TECHNOLOGIES

Two important R&D initiatives have been sponsored by the Spanish Centre for Industrial Technological Development (CDTI).

TARGET was a four-year project that was concluded in November 2014, with the objective of investigating new intelligent and environmentally sustainable technologies for a generation of structures using composite materials. In particular, the research focused on materials and new techniques necessary for the development of new machinery concepts. Tecnatom, the Spanish engineering company, participated by applying advanced NDT, a critical activity when producing structures based on these materials. Tecnatom has demonstrated the efficiency of NDT-improved methods and algorithms in the inspection of composite complex geometries and their influence in the optimization of the manufacturing phases.

The second initiative, ESTENEA, another new project, has the objective of achieving cost-effective and high-productivity technologies in the manufacturing of composite parts. The NDT industrialization objective includes the implementation of inspection of aero-parts by using air-coupling ultrasonics (ACUT), laser ultrasonics (LUS) and thermography, in an automated way. These use contactless techniques that avoid the use of water when scanning the parts, and in particular ACUT and thermography allow scanning of large areas in one single sweep. Meanwhile, LUS is an advanced technique that is very useful when scanning small parts, and difficult and integrated geometries.

FREE READER INQUIRY SERVICE

Tecnatom

READER INQUIRY 111

To learn more about this advertiser, visit www.ukipme.com/info/tea **NOW!**

X-RAY ROBOT SYSTEM FOR TURBINE BLADES

The inspection of turbine blades is an essential and extremely sophisticated task because of their complex design. Currently, x-ray technology is the most reliable inspection method, and the Yxlon MU56 TB has been designed especially for this type of challenging application.

The system, in combination with the proven Yxlon software PXV5000 and imaging software Yxlon Image 3500, is the established tool for automated defect recognition in the foundry industry for aircraft parts. It creates superior image processing, providing objective, repeatable image analysis and automatic archiving. It is ideal for serial inspection within the production line and supports the process optimization. With the combination of the Yxlon MU56 TB and these software options, the Review Workstation allows an operator to evaluate the results independently from the continuous, full-automated inspection process.

The Variofocus x-ray tube, together with the state-of-the-art digital flat-panel detector, provide the best image quality. The variable focal spot is the ideal solution for applications with high demands for detail recognition, as well as applications requiring high-power operation.

Yxlon MU56 TB is perfectly suited for the inspection of vanes and various other components in the aerospace sector.

The precondition to fulfill the high safety standards in the aerospace industry is optimal detail resolution, and is the basis for raising efficiency and quality improvements in the production process. Yxlon MU56 TB is compliant with industrial standards like ASTM and MAI, and also fulfills the Nadcap requirements.

FREE READER INQUIRY SERVICE

Yxlon International GmbH

READER INQUIRY 110

To learn more about this advertiser, visit www.ukipme.com/info/tea **NOW!**

Q-MIZE FH – A HIGH-SPEED CAMERA WITH A VIEW

High-speed cameras are often used in store separation recordings and provide essential insight into the mechanical and aerodynamical processes taking place. An increasing demand to mount cameras in remote locations on a test aircraft has lead to the development of a compact, small camera with a sensor that is positioned to provide a 90° view from the camera axis.

The Q-MIZE FH is an ideal instrument for mounting on AIM-9 pods or similar models. The diameter of the camera matches the inner dimensions of the pods. When mounted, the camera can record the scene directly without the need for 90° mirror optics, where only a limited resolution of the 3MP sensor can be used. This is made possible by using the compact micro four-third optics. The dimensions of the lenses mean the camera is ultra-compact and few mechanical precautions have to be taken when mounting the Q-MIZE FH in the proper positions.

The Q-MIZE is designed and certified to withstand *g*-forces in excess of 100*g*, and spikes of up to 200*g*. Certified according to the MIL810 standard for vibration and environmental conditions, the camera optionally comes with MS27473 series standard plugs. Semi-customized housing is available to fit existing structures for ease of integration.

FREE READER INQUIRY SERVICE

AOS Technologies

READER INQUIRY 112

To learn more about this advertiser, visit www.ukipme.com/info/tea **NOW!**

SERVICING TROLLEY FOR THE GERMAN AIR FORCE

Hydraulic servicing trolleys have the task of suppling the energy to keep up the hydraulic pressure in an aircraft when the engines are not turning. Apart from supplying the aircraft with hydraulic pressure, the Test-Fuchs hydraulic servicing trolleys can also conduct various other tasks which include: rinsing tasks such as cleaning, water removal; filtering or degasification of the hydraulic medium; leakage tests or function tests on the ground.

These trolleys are necessary in civilian as well as military aviation. However the military use of such equipment requires many more features than the civilian applications and the trolleys have to resist much more than just ‘normal’ circumstances in harsh environments.

Test-Fuchs has already designed and delivered 145 military hydraulic servicing trolley units incorporating a number of features that are difficult to find in any other devices. Recently the Test-Fuchs hydraulic servicing trolley has been put into service for the first time in the German Air Force for the Airbus A400M. The training for its use and maintenance has been successfully carried out in the German region of Wunstorf.

The device had to undergo extreme stress tests in order to prove its operation in even the most inhospitable circumstances. The hydraulic servicing trolley operates without difficulties between temperatures of -32°C and +55°C, up to an altitude of 1,500m, and it is compact and rugged enough to be transported by train, ship, or even via aircraft, to remote areas.

The trolley is electromagnetically compatible and does not interfere with any other appliance. The noise level, even in the diesel-powered models, is extremely low – an important feature when it comes to a combat mission.

The trolley is operated via a tethered touchscreen panel that can be removed, allowing the operator to carry out tasks even when he is not next to the trolley.

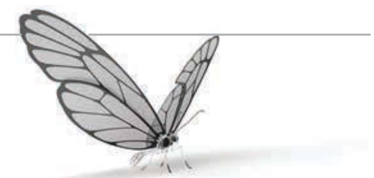
FREE READER INQUIRY SERVICE

Test-Fuchs GmbH

READER INQUIRY 113

To learn more about this advertiser, visit www.ukipme.com/info/tea **NOW!**

INNOVATIVE DESIGN CAN MAKE ANYTHING LIGHTER



Altair develops and implements intelligent simulation technologies that allow users to significantly reduce the weight of their products, saving cost, fuel and CO_2 emissions. Instead of taking a product that’s already been designed and just shaving off material, the company takes a different approach, called ‘simulation-driven design’, where CAD and CAE are deployed in parallel.

Using optimization technologies, clients can define a design space, an area where the component must fit in the structure, including data of any holes or access points required. Loads are applied to the design space along with manufacturing constraints and other variables, allowing the technology to suggest the best-possible material layout, for the component which meets the predetermined performance targets set out.

Over the last two decades, Altair has pioneered simulation-driven design to generate innovative design solutions for its clients. This has resulted in products that exhibit minimum weight and outstanding performance in industry-leading timescales.

Altair’s software solutions enable users to design high-performance, weight-efficient structures, starting in the concept design phase. Designers and architects can use ‘solidThinking Inspire’ to generate and explore structurally efficient concepts in a friendly and intuitive environment.

Moving to product engineers and analysts, HyperWorks offers optimization solutions for both concept studies and design fine-tuning stages. OptiStruct, Altair’s award-winning integrated analysis and optimization tool, along with HyperStudy, Altair’s design exploration software, enable a multidisciplinary product design cycle even for the most complex of structures.

FREE READER INQUIRY SERVICE

Altair

READER INQUIRY 114

To learn more about this advertiser, visit www.ukipme.com/info/tea **NOW!**

INDEX TO ADVERTISERS

Celtic thunder

Martin Rowe-Willcocks, head of future combat air systems business development for BAE says that the UCAV Taranis project has moved UAV development for the UK's forces rapidly forward

BY CHRISTOPHER HOUNSFIELD

AT WHAT STAGE IS THE TEST PHASE OF TARANIS NOW?
We have just completed two phases of flight testing and are currently undertaking further ground-based testing, with plans for a further phase of flights later this year.

WHAT DATA HAS BEEN COLLATED FROM THIS PHASE OF TESTS?
We have now completed two phases of flight trials. The main difference between the two sets of trials was that in the second phase, Taranis flew in a fully 'stealthy' configuration. The aircraft was able to gain those vital air data measurements in a way which did not impact on its low observable characteristics. Taranis successfully used a conformal air data system which allowed these parameters, along with others already embedded in the system, to generate a full set of flight data without the use of an external probe or boom.

WHAT NEW TECHNOLOGY HAS MADE THE AIRCRAFT DIFFERENT?
From the outset, Taranis has been designed to utilize the most advanced means possible of achieving low observability. This includes both the systems and technology inside the aircraft and the shape, design and finish of the exterior. It does mean, however, that there are aspects of the exterior design of the aircraft which remain classified.

WHAT NEW TECHNOLOGIES HAVE SET THE TARANIS APART?
Taranis has been developed to demonstrate the potential of an unmanned, stealthy combat aircraft ultimately capable of delivering weapons to a battlefield, able to undertake sustained surveillance. It will be able to: mark targets, gather vital intelligence, deter an adversary, carry out strikes in hostile territory, and assess the impact of any strike.

WHAT PROBLEMS HAVE YOU FACED IN THE PROGRAM?
Technical demonstrator programs by their very nature are demanding and contain risk. Prior to first flight trials, the system was comprehensively and extensively 'flown' on the ground over many hours. This thorough and robust testing activity allowed us to ensure that the system progressed into its flight testing phase in a safe and low-risk manner.

HOW DOES SYSTEMS INTEGRATION WORK WITH YOUR PARTNERS?
The Taranis project is a tremendous example of UK industry and MoD working and investing together to secure advancements in technology and capability to meet the anticipated future requirements of the armed forces. A project charter was signed by DE&S, BAE Systems, Rolls-Royce, QinetiQ and GE Aviation, whereby they agreed to work together to design, manufacture, test and fly an experimental mission representative UAV system.

DOES THIS PUT THE UK AHEAD WITH UAV COMBAT DEVELOPMENT?
Taranis is designed to provide the MoD with critical knowledge on the technical and manufacturing challenges and the potential capabilities of Unmanned Combat Air Systems. The project aims to contribute to the understanding of strategic UCAS, through the demonstration of relevant technologies and their integration into a representative UAV system. Taranis will provide the UK MoD with experimental evidence on the potential capabilities of this class of UAV. Taranis is being designed to explore the feasibility of developing the next generation of unmanned combat aircraft, suitable for significantly higher threat environments than the current generation of UAVs in use today.

WHAT IS NEXT IN THE TEST PHASE?
MoD answer: We will continue to gather data and complete additional test points as per the requirements of the current test program and any future test or technology de-risking programs agreed with the MoD or UK Industry.

SPECIFIC ROLES

BAE Systems: Design, final assembly and test, flight systems, flight control system, ground station, system performance measurements, integration, qualification and trials, airframe and aero, comms, intake, sensors and mission avionics and autonomy

Rolls-Royce: Engine and exhaust systems plus systems performance measurements

GE Aviation & Triumph Group: Flight systems

QinetiQ: Comms and high-level mission autonomy

Cobham: Comms antennas

APPH: Undercarriage

Claverham: Flight control systems (actuation)

DSTL: System performance measurement, MoD technical advisors

GE Intelligent Platforms: Mission avionics hardware.