DECEMBER 2017

Aerospace TESTING INTERNATIONAL

Inside this issue

Behind the scenes at Vidsel

Exclusive interview with the man in charge at Sweden's Vidsel Test Range, Europe's largest overland weapons testing site

WWW.AEROSPACETESTINGINTERNATIONAL.COM

THE FUTURE OF YOUR PRODUCT DEVELOPMENT IS CLOSER THAN YOU THINK

Prepare for change with invaluable insights delivered by The Beyond Tomorrow vision study. Access real-world scenarios developed by experts to help prepare your business for 2030.

Join our visionary journey today, to transform your innovations tomorrow. **www.beyondtomorrow.dk**

Brüel & Kjær

BEYOND MEASURE

CELEBRATING **75** YEARS OF PROGRESS

www.beyondtomorrow.dk

BN 2088 – 12

14
32

40
64

48

Global briefing

Inside this issue

// Best job in the world?

The stunning photo on the cover of this issue of *Aerospace Testing International* shows a pair of Swiss Air Force Cougar helicopters and Swedish Air Force Gripens during electronic warfare training at Vidsel Test Range, Sweden – Europe's largest overland range.

As Jonas Malmquist, project manager in the testing department at the test range, tells us in an exclusive interview on page 50, Vidsel is not your average workplace: "What is unique about Vidsel is that we have a huge restricted ground area, uninhabited and far away from the public eye, with an extensive test range infrastructure including roads, electric power, fiber network, radars and other range instrumentation."

Vidsel's remote location isn't just ideal for top secret, military testing – it's also a haven for wildlife and nature to flourish, largely undisturbed by man, give or take the odd explosion! As a result, the range often makes a lasting impression on visitors, as Malmquist explains: "For many of our foreign customers, the test campaigns in Vidsel are the first encounter with northern Scandinavia and quite exotic," he says. "Large parts of the range are part of a nature reserve and many encounter reindeer and moose. Some lucky ones even see bear, lynx or wolverine. One test team heading back on a helicopter got front-row seats, hovering by a cliff where a lynx and her young cubs were playing, totally oblivious to the helicopter. The restricted access to the range actually helps to preserve the environment for future generations."

In fact, some visitors are clearly keen to be invited back to the remote range, going the extra mile in providing provisions during testing for their hosts. "The Italian army set a standard of excellence last year, during the MLRS-I validation," says Malmquist, "bringing in a container of Italian food, with their own cook providing espresso, homemade cookies and pastries during the three weeks we spent out on the range. They really spoiled us with that and we tend to mention this to all customers we have out on the range, hoping for a repeat performance!"

I have to admit to feeling a strong pang of jealousy, sat here in a rather dreary office, where the view from my window is of a car park... with not a mouse, let alone moose, to be seen. Fortunately there is a very good coffee shop nearby, so at least the catering is sorted – and certainly no explosions, although the odd verbal volley from the production department as we approach deadline is not unheard of.

But I'm not complaining – after all, we at least get to share in some fascinating testing programs and grill the expert minds behind them, while exploring the latest technologies that help to bring it all together.

This issue is no exception, with an exclusive report from the US Air Force's light attack demonstration at Holloman AFB, New Mexico, on page 14, where four different light attack aircraft competed to prove their suitability to take out targets on the ground while operating in harsh desert environments. Next? A live combat demonstration in the Middle East. Maybe this desk job isn't so bad, after all...

Anthony James, *editor-in-chief*

// Contributors

PAUL EDEN
Editor of the *Official Royal Air Force Annual Review* magazine and *Salute* historical journal, Paul is a dedicated aerospace writer, editor and blogger.

IAN GOOLD
A former air-transport editor at *Flight International*, Ian began his freelance writing career in 1993, specializing in non-military aerospace and aviation.

ROB COPPINGER
Rob is an engineer turned journalist, who has been writing about aerospace technology for approaching 20 years. He has recently relocated to Brittany in France.

NIGEL PITTAWAY
Nigel is an experienced freelance journalist for aviation and defense publications worldwide. He is also a qualified aircraft maintenance engineer.

// The team

Published by UKi Media & Events, a division of 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

Average net circulation per issue for the period January 1, 2016 to December 31, 2016 was 9,669

Aerospace Testing International USPS 020-657 is published quarterly, in March, June, September, and December. Annual subscription price is £80/US$104. 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 UKi Media & Events, 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: Swiss Air Force Cougar helicopters and Swedish Air Force Gripens during EW training at Vidsel Test Range

www.dspace.com

dSPACE MicroAutoBox II – Perfectly Launching Your Ideas

Whether in the laboratory, on a test bench, or directly on board an aircraft – the compact and robust dSPACE MicroAutoBox II makes model-based control function development quicker and easier. With many years of experience and thousands of our units used across various industries, we know what really matters when it comes to prototyping systems. The MicroAutoBox II provides powerful advantages to successfully create an application and shorten the development times:

- Intuitive software environment with smooth Simulink® integration
- High processing power, flexible I/O, and bus interfaces
- Shock- and vibration-resistant hardware according to DO-160
- Mechanisms for operation monitoring and a wide range of possible extensions

Put your ideas into practice with dSPACE MicroAutoBox II.

Embedded Success dSPACE

WORLD *test update*

// FIRST FLIGHT OF JAPAN'S E-2D ADVANCED HAWKEYE

Northrop Grumman Corporation has completed the first flight of Japan's E-2D Advanced Hawkeye (AHE) at the company's Aircraft Integration Center of Excellence in St Augustine, Florida.

Japan's Ministry of Defense has selected the E-2D Advanced Hawkeye to fulfill the country's airborne early warning requirements. Northrop Grumman began production in 2016 on two aircraft that are now in the final production phase. The largest Hawkeye operator outside the US Navy, the Japan Air Self Defense Force (JASDF) has had 13 E-2C aircraft operating since 1983.

"The augmentation of the JASDF's current Hawkeye fleet with the E-2D AHE further strengthens its ability to meet Japan's evolving security and intelligence needs," said Jane Bishop, vice president, E-2D Advanced Hawkeye programs, Northrop Grumman.

St Augustine, Florida, USA

READ MORE ON OUR WEBSITE

// SUCCESSFUL FREE FLIGHT TEST FOR DREAM CHASER

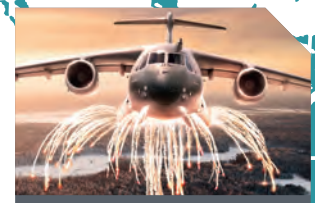
Sierra Nevada Corporation (SNC) has confirmed that its Dream Chaser spacecraft has successfully completed an atmospheric free-flight test, as it moves closer to orbital operations. The full-scale Dream Chaser test vehicle was lifted from a Columbia Helicopters Model 234-UT Chinook helicopter, before being released and flying a pre-planned flight path followed by an autonomous landing on Runway 22L at Edwards Air Force Base, California.

The test verified and validated the performance of the Dream Chaser spacecraft in the final approach and landing phases of flight, modeling a successful return from the space station. Most critically, by flying the same flight path that would be used when returning from orbit, this free-flight proves the landing attributes needed to bring back research and experiments from the station.

The first orbital vehicle is scheduled to go to the International Space Station as soon as 2020 for at least six missions as part of NASA's Commercial Resupply Services 2 contract (CRS2).

Sparks, Nevada, USA

WATCH TESTING VIDEOS ON OUR WEBSITE!



// EMBRAER KC-390 STARTS US FLIGHT TRIALS

The new Embraer KC-390 multi-mission military transport and tanker jet has started a series of flight trials in the USA as part of its flight test campaign for certification. Two flight test aircraft left Brazil in November to begin testing at Embraer's facility in Jacksonville, Florida.

They will spend two to three weeks performing tests on the aircraft's avionics systems, while measuring external noise and operations with cross wind.

Since the start of the flight test campaign in October 2015, both KC-390 prototypes have demonstrated high rates of availability, accumulating more than 1,450 flight hours. Initial operational capability should be achieved by the end of this year and first delivery is scheduled for 2018.

"The flight test campaign is progressing extremely well and matching the aircraft design goals," said Jackson Schneider, president and CEO of Embraer Defense & Security. "We are very satisfied with the maturity that this product has already reached and confident that certification will be achieved as scheduled."

Jacksonville, Florida, USA

SEE MORE NEWS ON OUR WEBSITE

// AIRBUS A350-1000 ACHIEVES EASA AND FAA TYPE CERTIFICATION

Following an intensive flight test campaign performed in less than a year, the A350-1000 has received Type Certification from EASA and the FAA. The certified aircraft is powered by Rolls-Royce Trent XWB-97 engines.

Type certification followed an intensive series of flight test trials using three A350-1000 flight test aircraft powered by Rolls-Royce engines. Over 1,600 flight hours were accumulated during flight testing.

"Receiving the A350-1000 Type Certification from EASA and the FAA less than a year after its first flight is an incredible achievement for Airbus and for all our partners who have been instrumental in building and testing this superb widebody aircraft," said Fabrice Brégier, Airbus COO and president of commercial aircraft. "We now look forward to delivering the first aircraft to Qatar Airways by the end of the year."

Toulouse, France

// A400M: PRE-FLIGHT RADAR THREAT SIMULATION

Leonardo will provide the UK's MoD with equipment that simulates radar threats to the RAF's new A400M transport aircraft prior to take off. The threat simulation equipment uses special radio-frequency (RF) emitting hoods that will cover the A400M's sensors while the aircraft is still on the ground, stimulating its RF sensors with real radar energy. It will also de-risk and reduce the cost of the aircraft's flight trials, prior to entering RAF service, by ensuring that as much testing work as possible is carried out on the ground.

Most defensive aids suites, including that on the A400M, come with built-in test equipment (BITE), which signals to the pilot that the equipment is working as designed. However, throughout the life of an aircraft problems can emerge undetected as the aircraft is maintained and operated. For example, RF antenna head sensitivity can degrade, or they can be installed incorrectly by being wired into the wrong aircraft quadrant. Such problems cannot be picked up by BITE, leaving a gap where the equipment is technically operational, but could still endanger the crew as the installation is not operationally effective and could provide limited or incorrect information to the pilot. Leonardo's 'capability assurance' equipment and training closes this gap.

Rome, Italy

// ANSAT HELICOPTER HIGH-TEMPERATURE TESTS

Russian Helicopters (part of Rostec State Corporation) has begun testing its multipurpose Ansat helicopter in Pakistan. "The objective of testing is to prove the ability to use the machine in high temperatures," said the company's deputy CEO for marketing and business development, Alexander Shcherbinin.

"The helicopter has already started test flights. It is planned to expand Ansat's temperature range from -45°C to +50°C [-49°F to 122°F].

"Ansat is a very attractive helicopter due to its flight performance characteristics, which make it ideal for customers in [climates such as in] Asia and the Middle East. In addition to the extension of the temperature range we have several other upgrades planned. I hope that positive test results will turn the interest of potential buyers into firm orders."

Islamabad, Pakistan

FIND BACK ISSUES ON OUR WEBSITE

// INTERCITY FERRY FLIGHT FOR CHINA'S C919 JET

COMAC has confirmed that the C919 test aircraft AC101 completed its first intercity flight. The aircraft took off from the fourth runway of Shanghai Pudong International Airport at 11:38 in the morning on November 10, 2017, and arrived at Yanliang airport in Xi'an at 14:02 after a flight of 2 hours and 24 minutes. During the flight the aircraft flew at a maximum altitude of 25,600ft and cruised at Mach 0.74.

The ferry flight was performed by COMAC Flight Test Center test pilots Cai Jun and Wu Xin, Observer Zou Lixue, and flight test engineers Dai Wei and Liu Lisu.

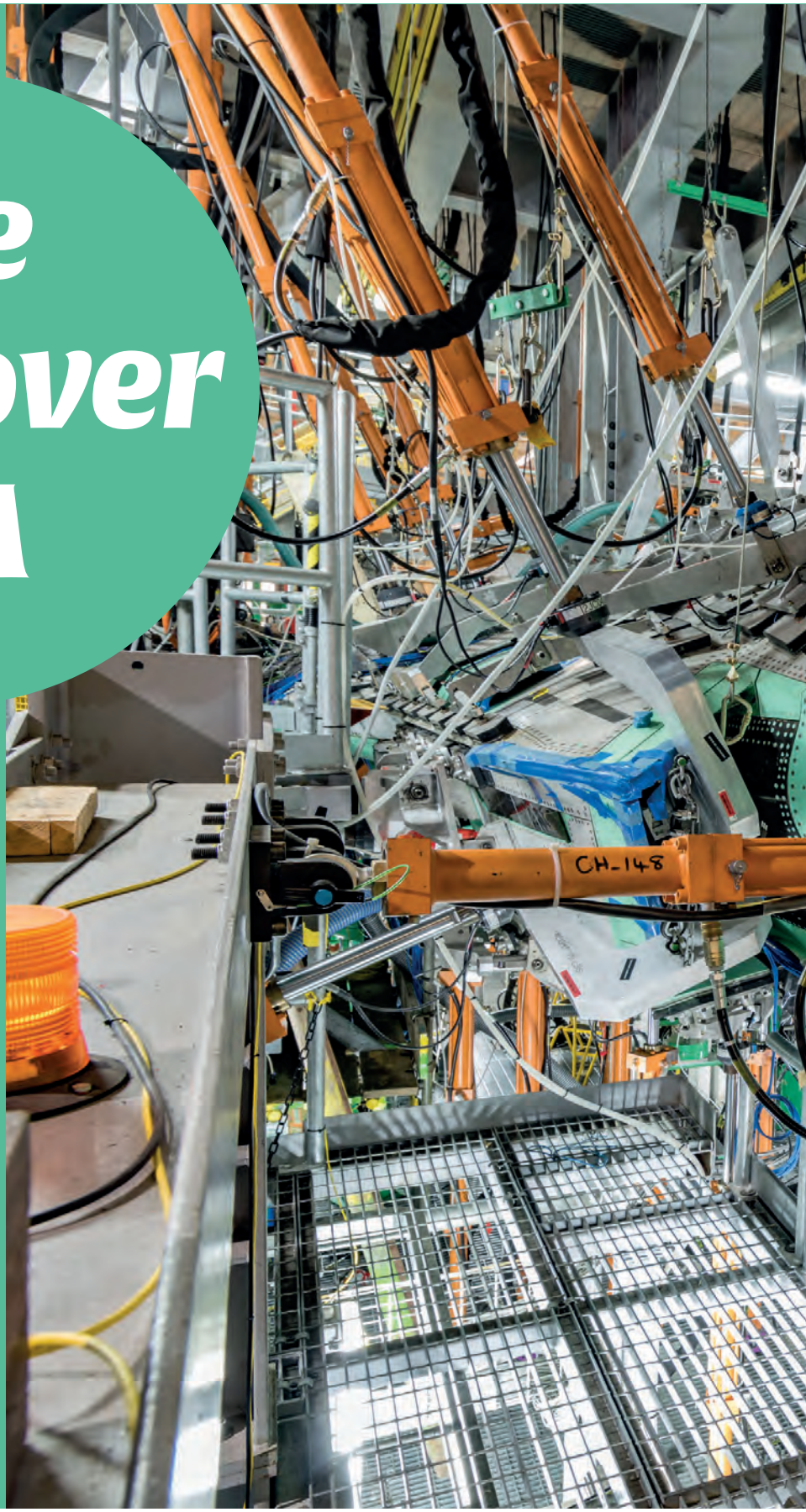
Previous to the ferry flight, COMAC had issued a statement confirming that AC101 had conducted its third flight test on November 3. The airplane took off from Shanghai Pudong International Airport at 07:38, flying for 3 hours and 48 minutes and achieving an altitude of 9,840ft before landing at 11:26.

Shanghai, China

For regular news updates:

AEROSPACETESTINGINTERNATIONAL.COM

Third life testing over for F-35A

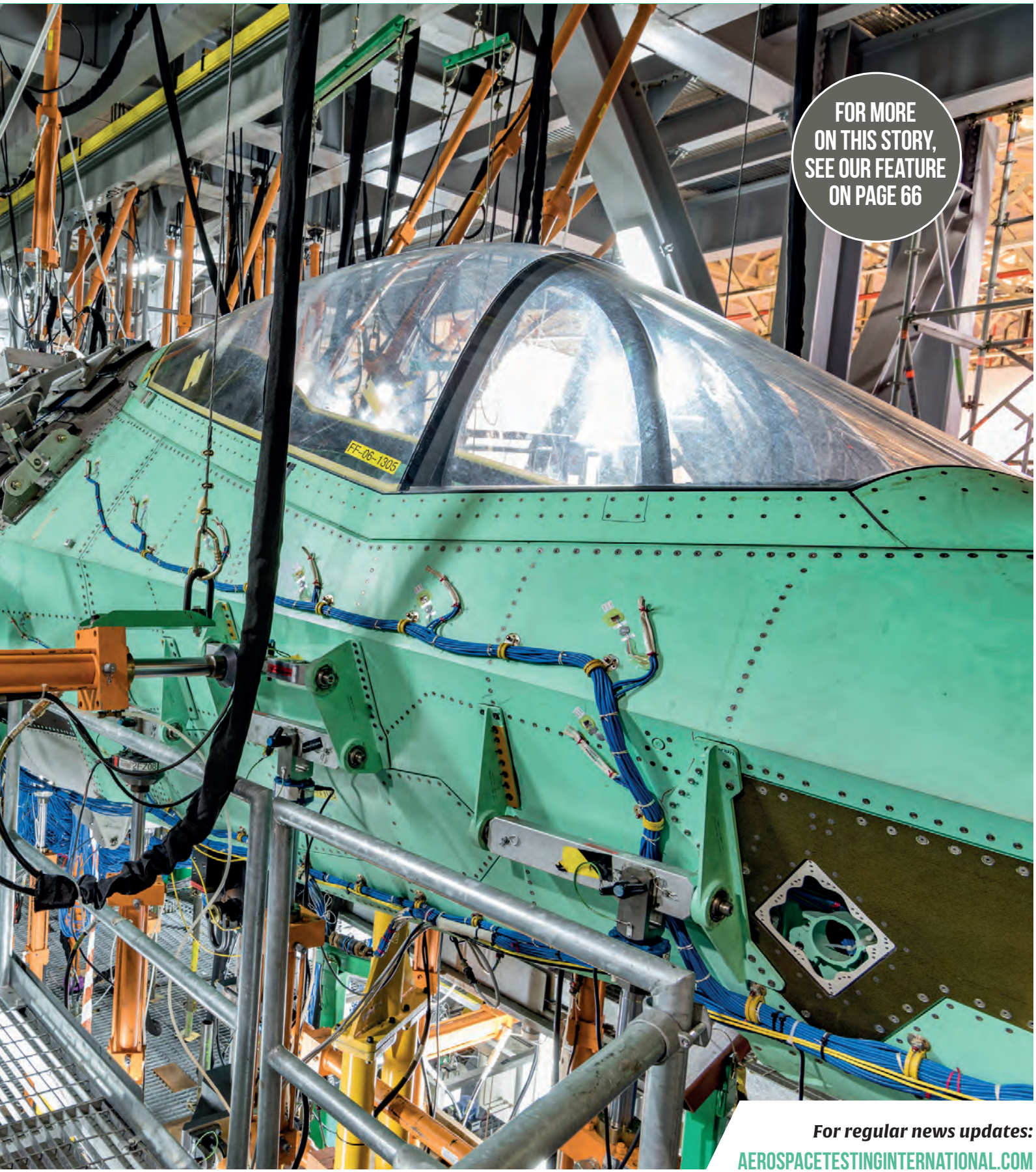


A full-scale durability test airframe of the F-35A aircraft has successfully completed its third life testing, equivalent to 24,000 hours of 'flying', in a unique testing facility at BAE Systems' site in Brough, East Yorkshire, UK. The airframe, known as AJ-1, is representative of the F-35A conventional take-off and landing variant of the jet. While in the 350 metric ton structural test rig, it has been subjected to and tested on the range of loads it would experience in actual flight, with durability tests carried out to simulate real-life fleet usage based on projected operational requirements.

BAE Systems' durability test rig is the only one of its kind in the UK and it has supported the testing of AJ-1 since it arrived in Brough in 2009. It is fitted with more than 20 miles of wiring, 2,500 strain gauges and 160 loading actuators, which are attached to the airframe during testing. The F-35A durability test airframe will now leave the rig and travel to the USA, where it will undergo further detailed inspections.

Kathy Nesmith, F-35 Joint Program Office Airframe team lead, said, "The F-35 program requires a service life of 8,000 flight hours. This is verified through durability testing to two lifetimes or 16,000 hours. Completing third life testing on the F-35A durability article will provide us the data to enable the warfighter to maintain and sustain this aircraft beyond 2050."

The F-35 is the latest in a line of aircraft to have been tested at Brough. These include the Buccaneer, Harrier, Hawk and, most recently, the Eurofighter Typhoon, which continues to be tested at the site. \\



FOR MORE ON THIS STORY, SEE OUR FEATURE ON PAGE 66

For regular news updates:
AEROSPACETESTINGINTERNATIONAL.COM

OLYMPUS

Your Vision, Our Future

Elevate Your Inspections

EPOCH® 6LT Ultra-Portable Flaw Detector

Don't compromise on comfort and nondestructive testing capabilities. The EPOCH 6LT instrument combines the functionality of a powerful ultrasonic flaw detector with an ergonomic design that thrives in high portability applications.

Comfortable One-Handed Operation: Weighs just 1.95 pounds (890 g) with a grip-oriented weight distribution for minimal wrist fatigue

Easy to Use: Rotary knob and simple button design make it easy to navigate the menu with just your thumb

Connected and Cloud Enabled: Optional Wi-Fi for on-the-go data backups, system downloads, and powerful cloud applications through the Olympus Scientific Cloud

Tough and Reliable: Engineered to IP65/67 and drop tested

Learn more at **www.olympus-ims.com/epoch6lt**

// The E-Fan X hybrid-electric demonstrator will see a 2MW electric motor installed on a BAe 146

E-Fan X test aircraft to fly in 2020

Airbus, Rolls-Royce and Siemens are partnering to develop an E-Fan X hybrid-electric technology demonstrator. Following a comprehensive ground test campaign, the test aircraft is anticipated to fly in 2020, with a BAe 146 used as a flying testbed, with one of the aircraft's four gas turbine engines replaced by a 2MW electric motor. A second gas turbine will be replaced with an electric motor once system maturity has been proven.

"The E-Fan X is an important next step in our goal of making electric flight a reality in the foreseeable future," said Paul Eremenko, Airbus's chief technology officer. "The lessons we learned from a long history of electric flight demonstrators, starting with the Cri-Cri, including the e-Genius, E-Star, and culminating most recently with the E-Fan 1.2, as well as the fruits of the E-Aircraft System House collaboration with Siemens, will pave the way to a hybrid single-aisle commercial aircraft that is safe, efficient and cost-effective. We see hybrid-electric propulsion as a compelling technology for the future of aviation."

The E-Fan X demonstrator will explore the challenges of high-power propulsion systems, such as thermal effects, electric thrust management, altitude and dynamic effects, on electric systems and electromagnetic compatibility issues. The program also aims to establish the requirements for future certification of electrically powered aircraft, while training a new generation of designers and engineers to bring hybrid-electric commercial aircraft one step closer to reality. \\

For regular news updates:
AEROSPACETESTINGINTERNATIONAL.COM

350 kN Water Cooled Shaker

Latest Addition to IMV's Product range

IMV CORPORATION has added a new water cooled shaker to the impressive K-series range, with a force rating of **350 kN**. The world premium K-series class K350 has a displacement of **76.2 mmp-p** and a shock velocity rating of **3.5 m/s**. This makes the K350 capable of a 100 g, 11 ms shock pulse with exceptional force rating. The K350 is available with IMV' s award winning **eco-technology**.

74 kN Air Cooled Shaker

Latest Addition to IMV's Product range

IMV CORPORATION' s latest addition to the A-series range has already achieved significant success with many blue chip companies taking advantage of this industry leading system. The world leading A-series class A74 has a displacement of **76.2 mmp-p** and a shock velocity rating of **3.5 m/s**. This makes the A74 capable of a 100 g, 11ms shock pulse with an exceptional force rating of 74 kN sine and random. The A74 is available with IMV' s award winning **eco-technology**.

IMV CORPORATION

Head Office (Japan)
kaigai-1@imv.co.jp

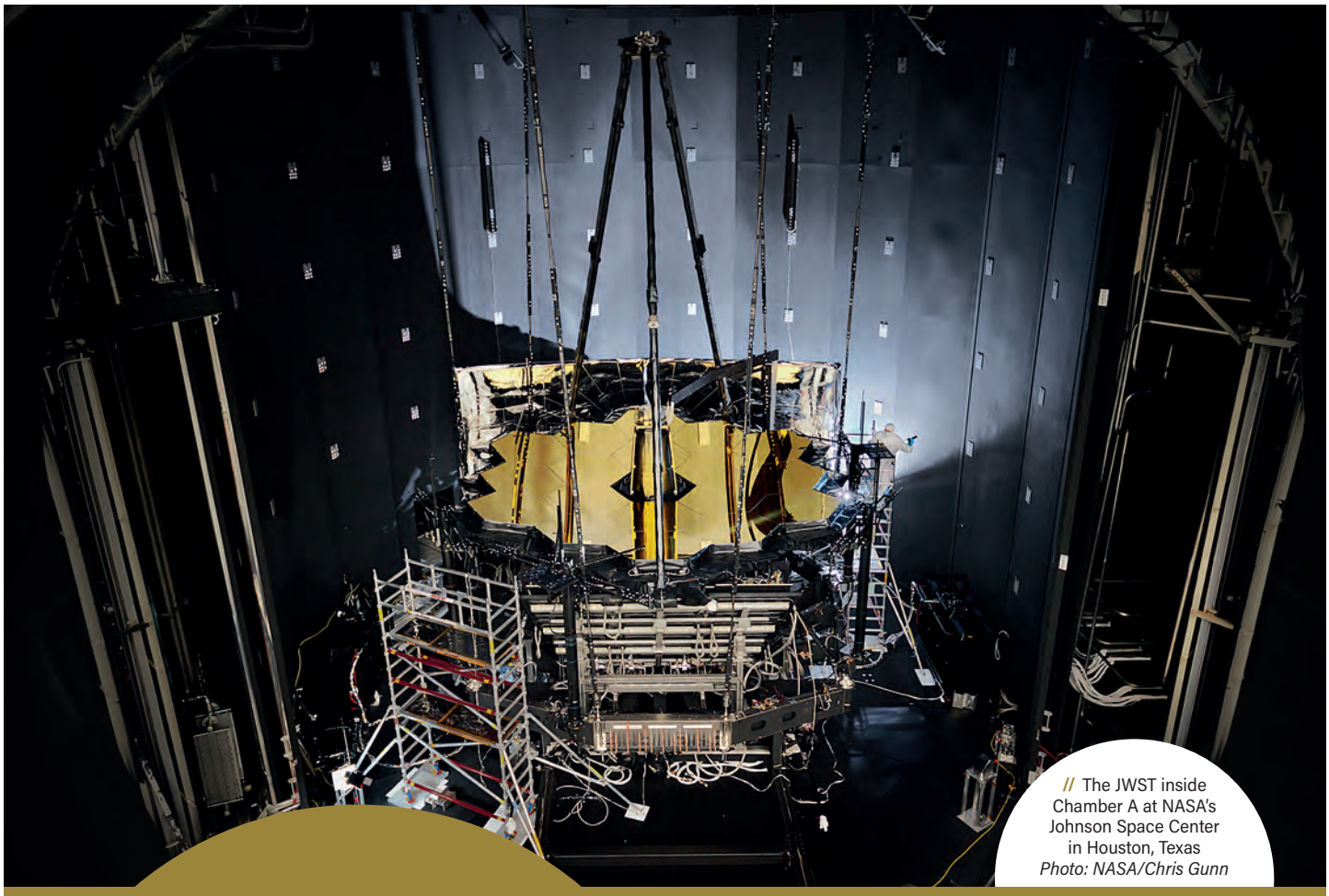
IMV America, Inc.
info@imv-usa.us

IMV EUROPE LIMITED (UK)
info@imv-tec.com

IMV (THAILAND) CO., LTD.
service@imv.co.th

IMV EUROPE LIMITED (Germany)
martin.engelke@imv-tec.com

IMV CORPORATION
Shanghai Representative Office
kaigai-1@imv.co.jp



// The JWST inside Chamber A at NASA's Johnson Space Center in Houston, Texas
Photo: NASA/Chris Gunn

JWST completes cryogenic testing

Cryogenic testing for NASA's James Webb Space Telescope (JWST) concluded on November 18, when the gigantic, 40ft-diameter, 40-ton door of Chamber A at NASA's Johnson Space Center in Houston, Texas, was opened, having been sealed shut since July 10, 2017. The cryogenic vacuum test ensured that Webb's optical telescope and integrated science instrument module (OTIS) functioned as expected in an extremely cold, airless environment akin to that of space.

"After 15 years of planning, chamber refurbishment, hundreds of hours of risk-reduction testing, the dedication of more than 100 individuals through more than 90 days of testing, and surviving hurricane Harvey, the OTIS cryogenic test has been an outstanding success," said Bill Ochs, project manager for the James Webb Space Telescope at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "The completion of the test is one of the most vital steps in the march to launching Webb."

The tests included an important alignment check of Webb's 18 primary mirror segments, to make sure all the gold-plated, hexagonal segments act like a single, monolithic mirror. This was the first time the telescope's optics and its instruments have been tested together, though the instruments had previously undergone cryogenic testing in a smaller chamber at Goddard. Engineers from Harris Space and Intelligence Systems, headquartered in Melbourne, Florida, worked alongside NASA personnel for the test at Johnson. \\

For regular news updates:
AEROSPACETESTINGINTERNATIONAL.COM

Rolls runs the rule over new core

Rolls-Royce has achieved a new milestone in the development of its next generation of civil aerospace engines with the first run of its Advance3 demonstrator. The demonstrator will test a new engine core that will deliver maximum fuel-burn efficiency and low emissions. The core forms a key part of the Rolls-Royce Advance and UltraFan engine designs, both of which form part of the engine manufacturer's future technology program.

The completed demonstrator engine began testing at the company's plant in Derby, UK, in November. Testing will initially confirm operational parameters, with future tests designed to gather data on the performance of the engine across more than 2,800 parameters.

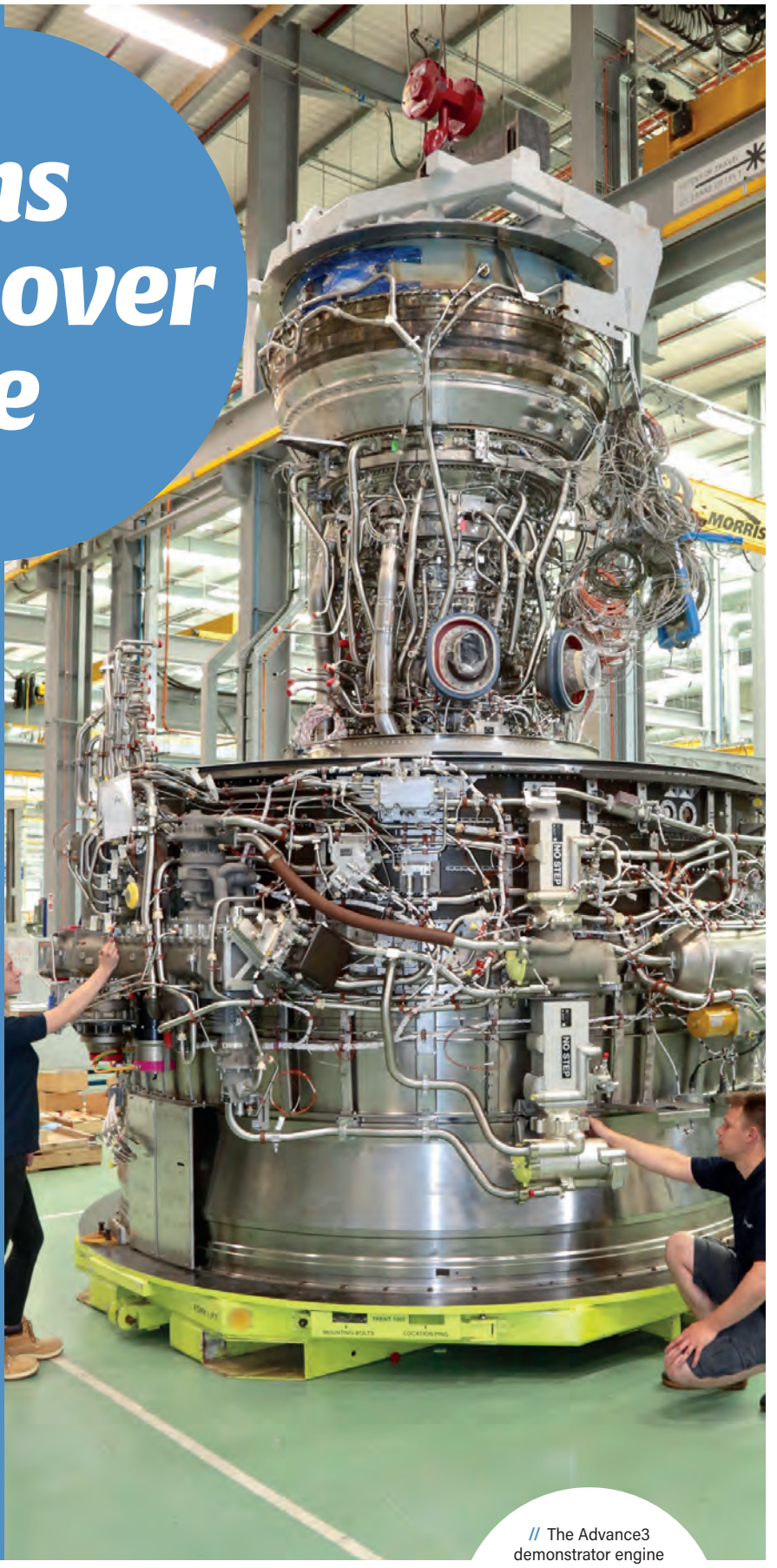
The Advance3 core features a new 'work split' with a two-stage, high-pressure turbine and a single-stage intermediate pressure turbine. Engineers have attached the core to a Trent XWB fan system and a Trent 1000 low-pressure turbine to create the completed demonstrator engine. The engine also features a high-power gearbox, designed to deliver efficiency at high bypass ratios, which earlier this year achieved 70,000hp while on test in Dahlewitz, Germany – a new record in the aerospace industry.

Rolls-Royce says UltraFan will offer a 25% fuel efficiency improvement compared with the first generation of Trent engine and will be available for service from 2025.

Advance3 receives funding and support from Clean Sky 2, the Aerospace Technology Institute and Innovate UK. \\

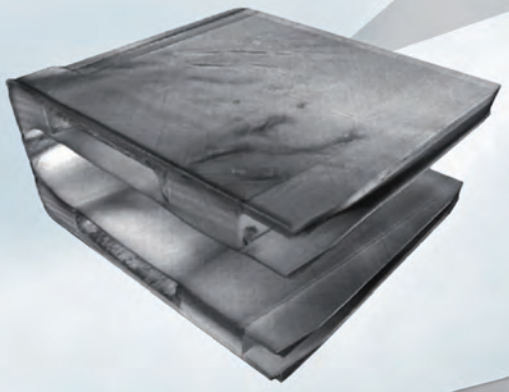
For regular news updates:

AEROSPACETESTINGINTERNATIONAL.COM



// The Advance3 demonstrator engine

See beyond the surface



CT scan of a
rotor spar

We build World Class Industrial Digital X-ray and 3D Computed Tomography Systems so you can develop the world's best products.

NORTH STAR IMAGING
NSI
AN ITW COMPANY

4nsi.com/ati | +1 (866) 754-4902 | sales@4nsi.com

// PAUL E EDEN

Fant

stic

In just six months, the US Air Force publicly announced and flew its Light Attack Experiment, pitching four platforms against a series of demanding mission objectives

1 // These Scorpions were flying during the production aircraft weapons separation test campaign in July 2017. Both aircraft have underwing rocket pods, while N534TX also mounts a pair of laser-guided bombs (*Photo: Textron Aviation Defense*)

2 // The Wolverine, armed with rocket and gun pods *(Photo: USAF/Ethan D. Wagner)*

TEXTRON AVIATION DEFENSE

Textron Scorpion
The Scorpion test team had completed its production aircraft weapons separation testing on July 18 (2017). Thanks to its twin 4,000 lb st (18kN) Honeywell TFE731 turbofans, the Scorpion was the fastest of the LAE aircraft with a maximum speed of 450kts, considerably more rapid than the turboprops but somewhat short of fast jet speeds. Textron supplied the second production Scorpion for the trial and its IPs trained USAF pilots for the LAE campaign.

Beechcraft AT-6 Wolverine
The AT-6 is a fully missionized version of the well-proven T-6 training aircraft. Like the Super Tucano, full frontline crews flew the Wolverine during the LAE process, and, in parallel with the Scorpion and A-29, it employed weapons over the ranges around Holloman.

Over the past 15 years or so, the US Air Force has flown thousands of combat hours in permissive environments, against enemies offering little or no threat to fixed-wing air power. Including regular visits to the air refueling tanker, missions require fighters – typically F-16s or F-15Es – to loiter as they await the call to deliver precision effect.

When a commander requires ordnance on a target at range and quickly, nothing delivers capability more effectively than a fast jet, but targets vary and where persistent air power is required over an unpredictable battlefield, fast jets may not be the most economical or suitable option. Remotely piloted air systems (RPAS) offer persistence and precision, but lack the flexibility of eyes in a cockpit, suggesting a potentially important place for a low-cost, efficient light-attack aircraft equipped with precision-guided weapons.

At least this was the conclusion reached by USAF planners and formalized as a memorandum issued by Air Force Chief of Staff General David L Goldfein to the Air Force Strategic Development Planning and Experimentation (SDPE) office at Wright-Patterson Air Force Base (AFB), Ohio, on March 8, 2017.

The SDPE was tasked with coordinating the Light Attack Experiment (LAE), linked in media releases to the

3 // Up close with the AT-802L, Secretary of the Air Force Wilson discusses the aircraft's participation in LAE *(Photo: USAF/Airman 1st Class Alexis Docherty)*

3

4
Aircraft types

3
Contractor teams

3
Turboprops

1
Jet

AIR TRACTOR/L3 AT-802L

Working with Moog, Air Tractor/L3 employed its fully armored Pratt & Whitney Canada PT6A-powered AT-802L demonstrator. The aircraft had previously been equipped with mission systems and received its airworthiness certification and military flight release on July 31, 2017, simultaneous with the announcement that it would participate in LAE. It completed its first of 17 LAE flights on August 7. Air Tractor instructor pilots (IP) primarily flew from Holloman as WSOs, while simultaneously serving as IPs, but also flew from the front seat with USAF WSOs. The aircraft was not certified to employ weapons during LAE, although the AT-802L is proven with the Mk 82, GBU-12 and a 50-cal gun pod. It's worth noting, however, that the AT-802L, in intelligence, surveillance and reconnaissance configuration, has a US Military Type Certificate and has been delivered under the Foreign Military Sales program.

"Three contractors supplied the four aircraft types, all but one of them turboprop powered"

OA-X concept. Industry participated, providing four platforms for test missions from Holloman AFB, New Mexico, during August.

Three contractors supplied the four aircraft types, all but one of them turboprop powered. Textron's Scorpion was the exception, with its twin-jet powerplant, the company also offering the AT-6 Wolverine, a weaponized version of the T-6 Texan II. An Embraer/Sierra Nevada Corporation (SNC) team furnished the A-29 Super Tucano from the Brazilian manufacturer's Jacksonville, Florida, production facility, while Air Tractor/L3 fielded the Air Tractor AT-802L Longsword.

The experiment was largely without precedent in recent times, aimed neither at proving an experimental aircraft nor testing a new configuration of an established type; there was also no contract available to the winner, since there would be no winner.

The USAF is very familiar with the basic T-6, since the majority of US military pilots have trained on the type, while the A-29 has been operated and procured against foreign military requirements. The opportunity for inadvertent bias toward the familiar platforms was eliminated through careful, mission-focused operations.

Colonel Anthony Thomas, Air Force Life Cycle Management Center advisor to SDPE and a USAF Test Pilot's School flight-test engineer graduate, explained LAE's construct: "The work differed from normal test and evaluation, where we'd use a build-up approach

m+p INTERNATIONAL

www.mpihome.com

Technical Leader in Vibration Control and Analysis

Innovative engineering solutions for the aerospace test community.

m+p international supplies advanced software supporting high-performance instrumentation for shaker testing, noise & vibration analysis, data acquisition and monitoring.

Our products combine convenience, flexibility and test safety with training, consultancy and support to ensure successful outcomes for all your applications.

- **Vibration Control incl. Force Limiting**
- **Multi-Shaker Testing**
- **Vibration Monitoring and Overtest Protection**
- **Data Reduction and Throughput to Disc**
- **Acoustic Control in Reverberant Chambers**
- **Vibration Measurement and Analysis**
- **Structural Testing and GVT**
- **Modal Analysis**
- **Acoustics incl. Sound Quality**
- **Rotational Dynamics**
- **Data Acquisition and Monitoring**
- **Strain Measurements and Experimental Stress Analysis**

Airbus Defence and Space, Germany

USA
m+p international, inc.
Phone: (+1) 973 239 3005
sales.na@mpihome.com

United Kingdom
m+p international (UK) Ltd
Phone: (+44) (0)1420 521222
sales.uk@mpihome.com

Germany
m+p international
Mess- und Rechnertechnik GmbH
Phone: (+49) (0)511 856030
sales.de@mpihome.com

France
m+p international Sarl
Phone: (+33) (0)130 157874
sales.fr@mpihome.com

China
Beijing Representative Office of m+p international
Phone: (+86) 10 8283 8698
sales.cn@mpihome.com

applicable to a clean-sheet design. In this case we used a very disciplined and rigorous process to help gain knowledge on the systems.

"We were looking for off-the-shelf solutions and began the experiment with an air-to-ground mission set, examining what the airplanes could do and what their potential might be. None of them had been configured to match the specific set of criteria the government had provided, and they did the same things in different ways."

OA-X?

LAE also wears an OA-X label, denoting 'Observation, Attack-Experimental' in US military parlance, suggesting a dual role capability – in modern times, observation generally equates to forward air control (airborne). Thomas explains, "The OA-X designation comes from an Air Combat Command enabling concept from around a decade ago. The Light Attack Experiment was similar, but also very different, examining what a light attack platform might be, but LAE and OA-X, one an experiment, the other a concept, may never actually cross paths."

On the subject of bias, especially toward the AT-6, Thomas says, "The test rigor we applied took into account the potential for natural human bias. We also used line aircrew [pilots and weapon systems officers (WSO) brought back from the frontline] as well as our own experimental test pilots, WSOs and flight-test engineers.

"The frontline aircrew often had multiple deployments behind them and expert knowledge in air-to-ground work; their expertise and insight were invaluable. Crews were instructed in the aircraft and became comfortable operating them, so in the execution phase they could focus on their assessments. We used contractor instructor pilots, but during the experiment, full 'blue suit' [frontline USAF] crews flew the A-29 and AT-6.

"We've used the T-6 for undergraduate pilot training for many years, but it was the specific air-to-ground systems of the missionized AT-6 that we assessed. Since it's the mission system that delivers the capability, the issue of bias really isn't there."

4 // It may have been the only jet in the experiment, but the Scorpion still managed to look very different from anything the USAF has on its frontline today

4

SAFETY STANDARDS

"This concept of experimenting is something we haven't done in depth since Vietnam. Since the first Gulf War [1991], the Air Force has been at a very high ops tempo and that's stretching our equipment and people. Our mandate is to find ways of relieving that stress while still delivering the capability the combatant commanders need – experimentation is a great way to do that.

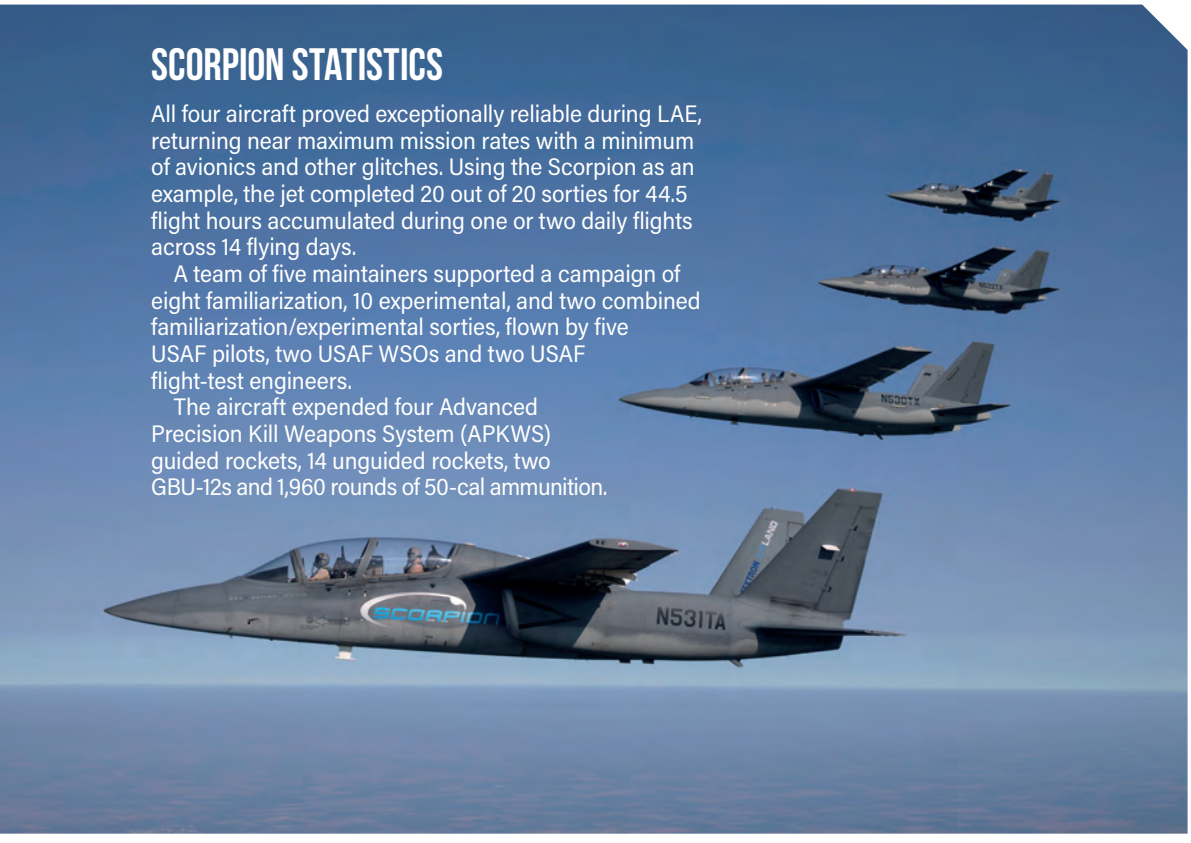
"But we didn't do everything differently. We retained much of our well-proven test process and rigorous safety standards. Here in the Life Cycle Management Center we have the Air Force Technical Airworthiness Authority, which looks through a very technical lens to ensure systems meet Air Force safety and design requirements. They applied some of the world's leading experts to subsystems the contractors had already been using and from that came the risk assessment. We were able to identify risk and ways to mitigate it, and present those risks to the appropriate decision authorities, which helped define the

SCORPION STATISTICS

All four aircraft proved exceptionally reliable during LAE, returning near maximum mission rates with a minimum of avionics and other glitches. Using the Scorpion as an example, the jet completed 20 out of 20 sorties for 44.5 flight hours accumulated during one or two daily flights across 14 flying days.

A team of five maintainers supported a campaign of eight familiarization, 10 experimental, and two combined familiarization/experimental sorties, flown by five USAF pilots, two USAF WSOs and two USAF flight-test engineers.

The aircraft expended four Advanced Precision Kill Weapons System (APKWS) guided rockets, 14 unguided rockets, two GBU-12s and 1,960 rounds of 50-cal ammunition.



5

boundaries of what the experiment personnel could do.

"The Air Force Flight Test Center at Edwards [California] has the 704th Test Group at Holloman, expert at evaluating airplanes in a safe, auditable manner. Their safety processes also kicked in, applying their knowledge to what our subject matter experts had proposed. As a result, we completed a significant review of the aircraft in a very short period, examining their design and maintenance requirements, and applying a build-up approach to the flight testing."

None of the aircraft were specially equipped with cameras, telemetry or other trials systems, but Thomas says the comprehensive test plan was built around data from head-up display (HUD) recordings, the data recording capabilities of the baseline aircraft (typically used for mission debriefing and system monitoring), and information gathered by flight-test technicians.

Gunfire, rocket launches and GBU-12/58 laser-guided bomb delivery were included for some types, but where weapons clearances had not been gained, platform compatibility had been demonstrated and no weapons integration/clearance work was undertaken under LAE. Similarly, targeting capabilities were assessed off the shelf, and Thomas reports, "It was a great knowledge gain for us, seeing how the manufacturers had used systems in different ways."

He also expresses surprise and delight at the extent of the team involved in the experiment. Air Education and Training Command helped formulate the conversion syllabus, while the line crews were pulled from Air Combat Command and Special Operations Command. Air Force Reserve Command personnel were also involved, and maintenance personnel were drawn from a similarly deep pool.

With only four weeks available for the experiment's execution, Holloman's proximity to weapons ranges and the maintenance crews' ability to turn the aircraft rapidly between sorties were critical to its success.

"Thorough planning and understanding of range requirements enabled the team to put together a great data-collect program. And they were pushing the aircraft on turn time, collecting critical data on maintenance per flight hour. Each type typically flew twice a day and one time I saw multiple aircraft parked, taxiing and in the pattern.

"The experiment wrapped up at the end of August, and data analysis is ongoing. We've got preliminary results, then there's a quick look, followed by a final report that'll really get into the detail." \\

6

5 // Embraer builds the combat-proven A-29 in Florida *(Photo: USAF/ Christopher Okula)*

6 // The A-29 over the White Sands Missile Range, armed with a GBU-12 laser-guided bomb

EMBRAER/SIERRA NEVADA CORPORATION A-29 SUPER TUCANO

The A-29, extracted from Embraer's regular inventory, was at Holloman through July and August, completing around 60 sorties from the base. The only LAE participant with a US Military Type Certificate in the attack role and already combat proven, the Super Tucano expended 50-cal ammunition, rockets, and guided and unguided bombs during the trials.

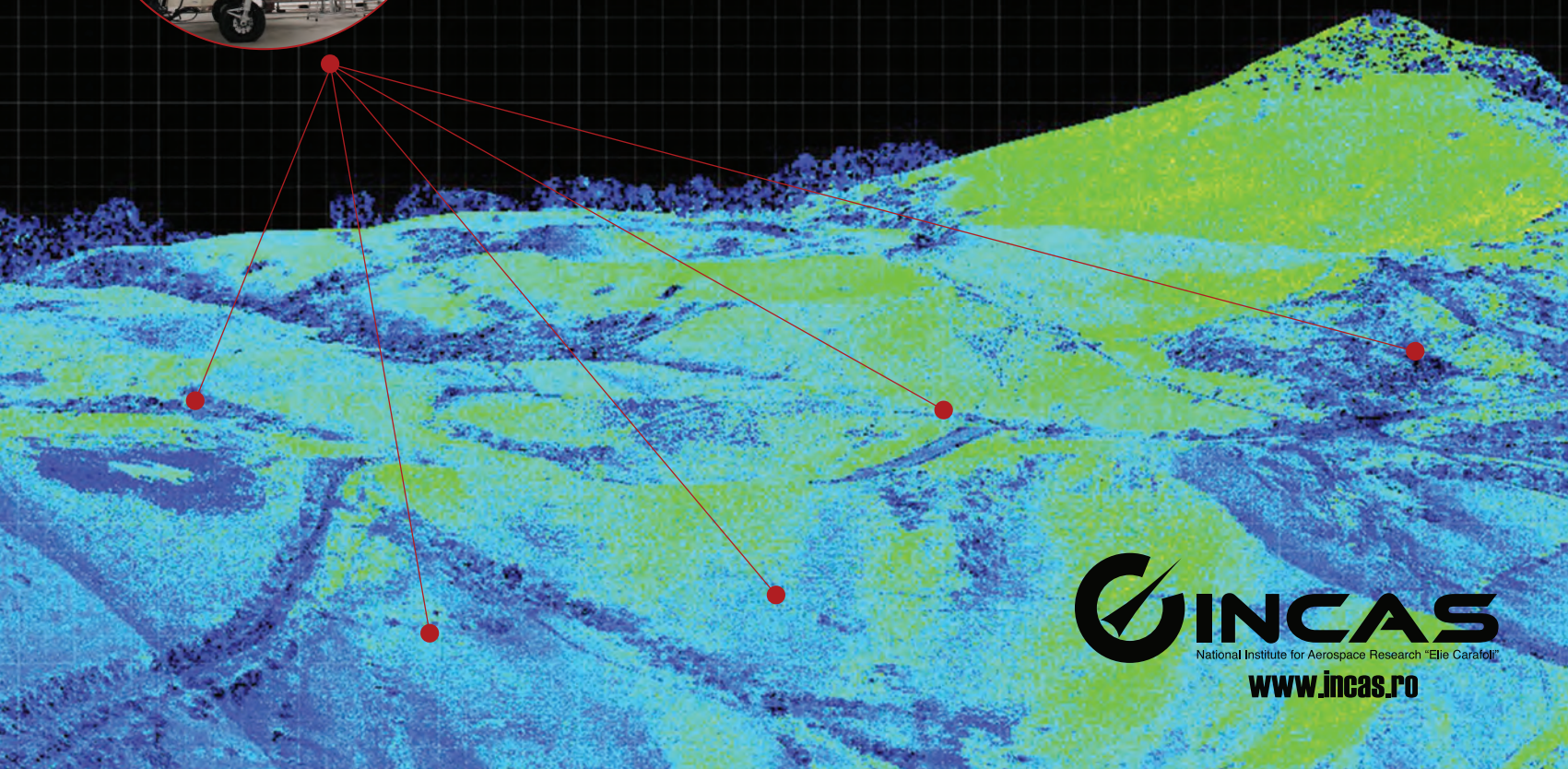
Embraer/SNC IPs helped train USAF test pilots for LAE, although complete frontline crews flew some test missions. In keeping with the AT-802L and AT-6, the Super Tucano takes its power from a PT6A turboprop.

Member of ACTRiS ROMANIA

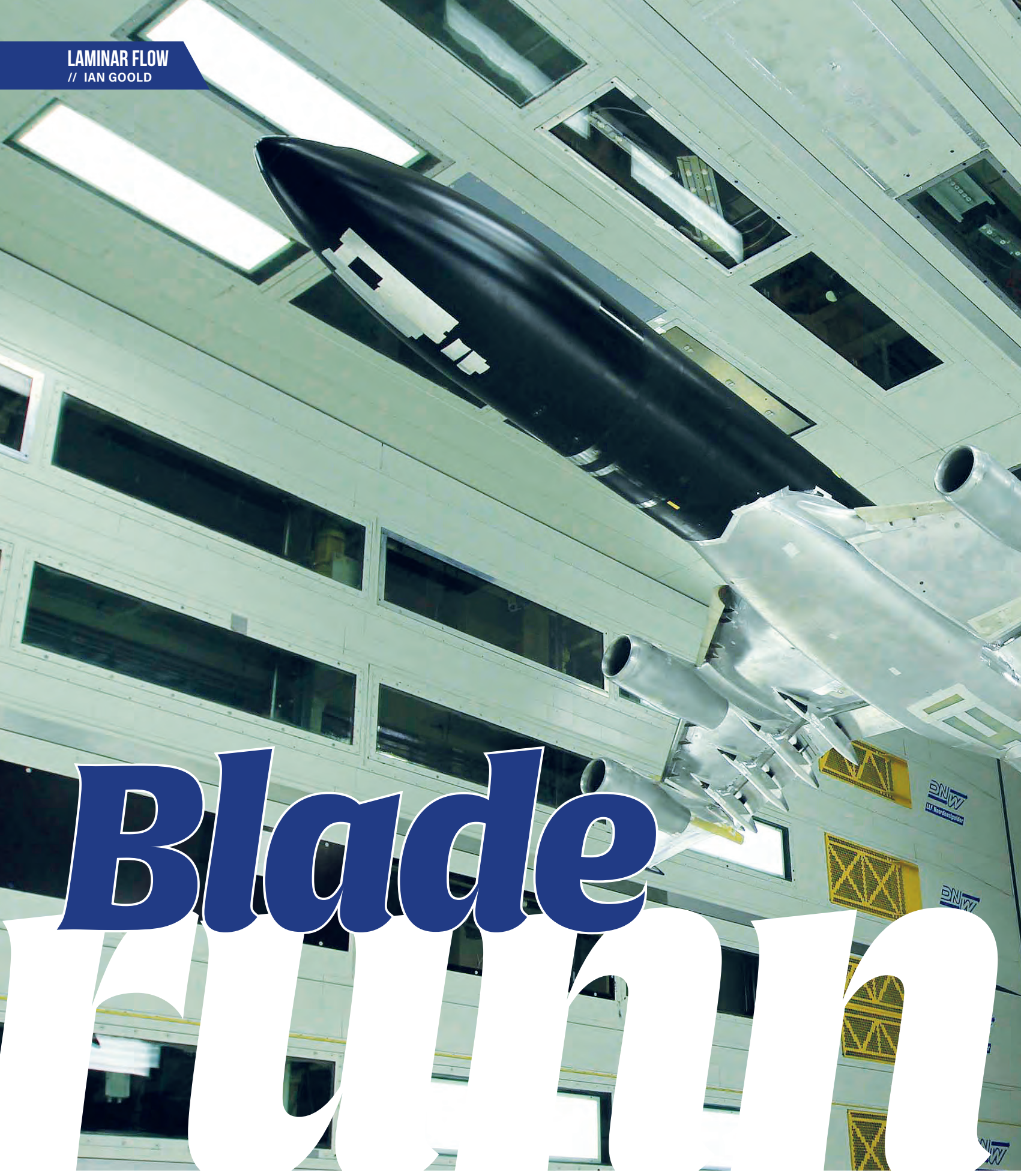
ATMOSLAB

ATMOSPHERIC RESEARCH LABORATORY

State-of-the-art atmospheric and topographic flight base



INCAS
National Institute for Aerospace Research "Elie Carafoli"
www.incas.ro



Blade runner

1 // Low-speed aerodynamic tests were performed on a 1:10.6-scale A340 model in the closed 8 x 6m (26 x 20ft) test section of German-Dutch Wind-Tunnels' large low-speed facility (DNW-LLF) in Marknesse, Netherlands

er

A new flight test project led by Airbus spearheads an EU effort to see if laminar-flow wings can be produced on an industrial scale

2 // The A340BLADE during its maiden flight, from Tarbes, France to the Airbus Flight and Integration Test Centre in Toulouse

Airbus is busy performing the first element of a 150-hour flight test program with an A340-300 modified with natural laminar-flow (NLF) outer-wing sections that could lead to a significant reduction in drag and consequent fuel consumption. After a September 26 first flight, the manufacturer planned to fly the A340BLADE (Breakthrough Laminar Aircraft Demonstrator in Europe) test aircraft two or three times a week in October and slightly less often in November.

Ahead of the 3 hour 38 minute first flight, from Tarbes in southern France (where the aircraft had been modified) to the Airbus Flight and Integration Test Centre in Toulouse, a 10-strong team of pilots and test and flight test engineers spent several months training in a simulator to familiarize themselves with planned flight test instrumentation (FTI). A much larger working party of 70 performed the 16-month FTI cabin installation in Tarbes, while Airbus teams from Bremen, Germany, and Broughton, UK, worked to fit the A340BLADE demonstrator's outer wings.

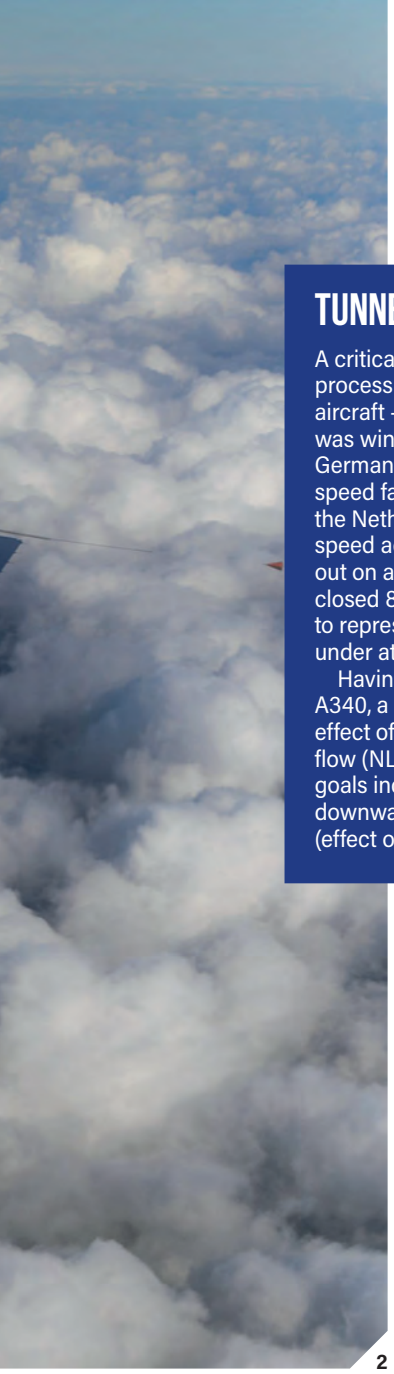
6,500
Parts in A340BLADE modification

150
Hours projected flight testing

Another German team installed an infrared camera pod on the fin.

The A340BLADE is "the first test aircraft to combine a transonic laminar-wing profile with a true internal primary structure", says Airbus. Laminar – or streamline – flow relates to the boundary layer of air that follows the shape of the aerofoil until disrupted by surface contaminants and other factors that generate turbulence, reducing lift and increasing drag.

During the first test flight, engineers were able to observe areas of laminar flow on both new wings during what was mainly a shakedown flight for aircraft and instrumentation. The flight saw the A340BLADE achieve



2

TUNNEL VISION

A critical step in the flight-clearance process for the BLADE demonstrator aircraft – Airbus A340-300 MSN001 – was wind-tunnel measurements in the German-Dutch Wind-Tunnels large low-speed facility (DNW-LLF) in Marknesse, the Netherlands, in early 2014. Low-speed aerodynamic tests were carried out on a 1:10.6-scale model in the tunnel's closed 8 x 6m (26 x 20ft) test section to represent the flying demonstrator under atmospheric conditions.

Having gathered data for the standard A340, a main objective was to check the effect of an installed natural laminar-flow (NLF) outer-wing panel. Other goals included: studying ground effect, downwash and handling qualities (effect on longitudinal and lateral control and stability from the use of ailerons, flaps, spoilers and rudder); examining wing airflow and stall behavior to obtain information on boundary-layer transition (using infrared thermography); and using optical techniques to measure deformation to establish local attitude changes due to wing torsion.

Anticipating the technology now being employed on the real aircraft, the testing used infrared thermography to locate the boundary-layer transition point on the NLF panel. The exercise also yielded valuable knowledge on the use of techniques such as stereo-pattern recognition for deformation measurements in such wind-tunnel applications.

a speed of Mach 0.78 and cruise and maximum altitudes of 32,000ft. "We achieved our objective to fly at the design Mach number, at a reasonable altitude, and check everything was fine," reports flight test engineer Philippe Seve. "We checked that the FTI was working as expected, to identify further fine-tuning for the next flights."

By mid-October, the machine – which is the company's original A340-300 prototype (MSN001) – had made two more flights to confirm the low- and high-speed flight envelope, including stalls and flutter.

Initial flying scheduled for completion this year includes assessing aircraft-handling qualities, extending the flight envelope, and taking first measurements of laminar-wing performance, according to Airbus Research and Technology senior vice president Axel Flaig. A second round of flights in 2018 is planned to "extensively test and characterize laminarity robustness in representative operational conditions".

The campaign is primarily intended "to validate the area of laminarity that can be achieved for a large variety of cruise-flight conditions with respect to altitude, Mach number and wing loading", according to the Clean Sky joint undertaking, an EU research program that aims to reduce aircraft CO_2, gas and noise emissions.

FATEFUL EIGHT

Clean Sky's swept-wing future aircraft (SWFA) integrated technology demonstrator program, of which BLADE is a part, addresses integration of related new technologies for large aircraft. The JU says that demonstrating an NLF 'smart' wing with associated advanced FTI equipment represents the first of eight technology streams in the SFWA flight-demonstration work package.

"For a typical short- to medium-range aircraft, the calculated drag benefit is up to 8% at typical Mach 0.75 cruise flight, which translates to around 4.5% fuel-burn reduction for a typical mission," says Clean Sky.

Airbus hopes to confirm a 50% lowering in wing-friction drag, which will translate into "up to 5% block-fuel and CO_2 emission reduction" if the technology is applied to short-range aircraft flying up to 800 nautical miles.

21
Design, manufacturing, research and testing partners

20
Degrees of sweepback on outer-wing laminar-flow sections

8
Possible percentage drag benefit at typical Mach 0.75 cruise flight

The new NLF wing sections are close in size and configuration to a possible future wing for a short-range, single-aisle airliner, says Airbus. Initial thoughts had envisaged a complete wing for testing on a smaller aircraft, but BLADE project leader Daniel Kierbel explains that using a smaller proportion of a larger wing reduces the potential for loss of control while exploring the limit of laminar flow.

Rapid recent development of numerical flow-simulation tools has enabled the aerospace industry to design, build, demonstrate and validate an optimized NLF wing, according to Airbus, which has defined (and validated through ground testing) "aerodynamic flight-control laws related to the specific shape of the natural laminar wing".

The BLADE project intends to test the robustness and sustainability of natural laminarity in operational service so that – by specifying production-tolerance requirements – manufacturers can properly specify and design laminar components (including wings) for future commercial aircraft.

The program's primary aim is to accelerate future industrialization (or mass production) of laminar wings,

The conference dedicated to

SAVING FUEL, LOWERING EMISSIONS, REDUCING NOISE

electric & hybrid aerospace TECHNOLOGY SYMPOSIUM

The two-day conference will cover all aspects of aerospace activity, from commercial aviation to military applications. In 2018 it will once again feature a dedicated stream for general aviation manufacturers. Its purpose is to highlight the ever-growing research into the increased electrification of aircraft and the possibilities and challenges that brings.

NOVEMBER 8-9, 2018 COLOGNE, GERMANY

Image: ©newFACE Consortium

BRAND-NEW PAPERS!

From the publisher of *Aerospace Testing International* magazine

BOOK NOW! SEE WEBSITE FOR DETAILS

Over 200 delegates participated in 2017 Join the debate in 2018!

www.electricandhybridaerospacetechnology.com

3 // The A340BLADE combines a transonic laminar wing profile with a true internal primary structure

3

4 // Flight test instrumentation (FTI) is a challenging and innovative aspect of the BLADE project

4

BLADE RUNNER

Airbus leads the BLADE program and with Saab co-leads the SFWA-ITD, which is funded by the EU Horizon 2020 program. SFWA-ITD addresses integration of passive and active flow, and load-control technologies for large aircraft and business jets, aiming to demonstrate that innovative capabilities, concepts and technologies can contribute to a step-change in reduced fuel consumption and noise.

Ultimately the SWFA project will use on-ground or inflight demonstration vehicles aimed at reducing aircraft drag by 10% by lowering wing drag using laminarity, cutting aircraft fuel burn by 20% by integrating advanced engines, and reducing aircraft noise by up to 10dB by engine noise shielding configurations.

Airbus led the structural and fuel, hydraulic and electrical system modifications, which involved 21 design, manufacturing, research and testing partners. It emphasizes that the A340-300 BLADE exercise – "the largest flight test demonstrator ever launched in Europe" – has "no link to any possible future aircraft program", although "maturity of this technology could possibly be considered for a future aircraft program."

for which previous technology has been insufficiently mature for commercial aviation application and has not been fully validated in flight. "The past 50 years have seen more than 70% improvement in relative fuel-burn per seat and 90% in noise emissions, but a practical application of laminar flow has not been achieved," says Flaig.

Pointing out that natural (or passive) laminarity can be achieved through aerofoil shape while hybrid (active or passive) laminar flow can be generated with, say, boundary layer suction, Kierbel outlines the many factors that influence the presence of NLF on an industrial wing.

First come external considerations outside the wing. These include leading-edge and wing contamination (such as de-icing fluids, dents, dust, erosion, grease, insects and scratches); atmospheric disturbances; and acoustic disturbances and vibrations.

Secondary (or internal) factors can comprise such considerations as system integration, deformation of fastener heads and joints, gap-filler material, and local and global wing deformation.

"The calculated drag benefit is up to 8%"

SPLIT DECISION

A340-300 MSN001 is being used because it is available and has a natural wing split that permitted replacement of the outer sections. The biggest external change following modification is the introduction of the two representative transonic laminar outer-wing sections.

Clean Sky says that experiments to better understand and control the laminar-to-turbulent flow transition, which is influenced by (for example) isolated surface gaps, steps and holes, prepared the groundwork for full-scale wing design and flight testing – "the first time such realistic test data has been available for future aircraft design".

The 8m-span (26ft) NLF sections were designed and manufactured with partners Saab of Sweden and GKN UK for two different solutions, each complying with stringent accuracy, stability and tolerance requirements to maintain laminarity in all flight regimes.

Kierbel says that NLF wing architectures involve two options – one with a one-piece carbon fiber-reinforced plastic (CFRP) wingskin and leading edge (supported by integrated wing-rib feet and spar cap) on Saab's port outer wing, and the other with a mechanically fastened CFRP wingskin and metallic leading edge, interrupted by a joint at the forward spar, on GKN's starboard outer wing.

Airbus had to design a wingbox to interface the existing wing with the NLF sections, which are very evident because they feature a 20° sweepback (about 10° less than that of the original unit). Inside the aircraft, a specialist FTI station has been installed.

Kierbel says that replacement of the outer wings and modification of the A340 tailfin to accommodate a camera pod (to confirm wing behavior) involved "a combination of experience and a technology bridge". Overall, the Tarbes engineering work involved "21 European partners, 500 contributors and 6,500 parts".

5

5 // The A340BLADE achieved a maximum speed of Mach 0.78 and cruise and maximum altitudes of Flight Level 320 (32,000ft) on the first test flight

Major steps in developing the A340BLADE demonstrator included the manufacture of several special components, according to Clean Sky: large aero-fairings to separate the new outboard NLF wing sections from the original turbulent inboard wing; wingtip pods to ensure a defined flow pattern at the outboard end of each NLF section and to contain flight test equipment (with optical access close to the laminar wing), with a diffusion zone passing wing loads and torque from the NLF section to the datum wing structure; and a digital mock-up of the NLF wing outboard of the datum wing's number-one (port outer) engine.

Wind-tunnel tests (see *Tunnel vision*, p25) were conducted to check low-speed performance and to test a Krueger leading-edge anti-contamination device used to influence airflow over about 20% of the new NLF section span. Flight testing is "intended to demonstrate the device's potential to shield the upper wing surface from contamination", according to Kierbel.

He points out that laminar flow is "much better at lower speed, but requires transonic airflow". As well as containing infrared cameras, the tailfin pod provides mounting for an altitude/airspeed-calibration trailing cone and two cone-flow cameras.

FTI was a challenging and innovative aspect of the BLADE project, according to Airbus. In addition to standard inflight measurements of acceleration, pressure and temperature, the program partners needed to measure: laminar-flow transition location on the wing (using surface-mounted heat-sensitive film and infrared cameras); NLF wing-surface quality and deformation (reflectometry); NLF wing-shape in flight (with loads and inertial sensing); and NLF wing deformation (via an internal mechanical sensor).

To this end (and using such testing on an aircraft for the first time), Airbus says there are "hundreds of points to measure the waviness of the wing surface" to help ascertain its influence on airflow laminarity. "Airbus will simulate every type of surface imperfection in a controlled manner, so that the tolerances for building a laminar wing will be fully known."

The manufacturer says the project also represents the first use of pod-mounted infrared cameras to measure wing temperature and of an acoustic generator to measure the influence of acoustics on laminarity. The wingtip reflectometry system that gauges overall inflight deformation in real time is also said to be innovative. As viewed through transparent apertures, the latter record reflections on the upper wingskin of a diagonal-striped pattern on the wingpod where the NLF outer wing is attached, concludes Kierbel. \\

FLIGHT LAB LOG

The A340-300 BLADE demonstrator campaign, which originated in 2008, is part of a broader program using several aircraft to test new technologies in Airbus Research & Technology's Flight Lab department. A dedicated hangar was erected at Tarbes in southern France to house the A340-300 (and other Flight Lab projects) during its conversion.

Started in 2008, the following steps have been successfully accomplished by the BLADE team.

2010: Wind-tunnel testing, concept freeze, and natural laminar-flow wings maturity review

2013-2014: NLF Wings maturity-closure reviews

2015: Start of NLF upper cover (wingskin) manufacture and assembly

2016: Start of BLADE working party in Tarbes (jigs and platforms installation), removal of A340-300 original outer wings, assembled NLF wings delivered to Airbus for painting, and completion of NLF wing-panel join up to original wing

2017: Aircraft "power on", completion of systems and flight test instruments installation, testing and calibration, and first flight.

"Wind-tunnel tests were conducted to check low-speed performance"

The conference dedicated to

THE PATH TOWARD ELECTRIC FLIGHT!

Volt future aircraft: ©NASA/BOEING/SCIENCE PHOTO LIBRARY

electric & hybrid aerospace TECHNOLOGY SYMPOSIUM

The conference that brings together aerospace industry R&D engineers and heads of design and engineering to discuss, debate and analyze future possibilities for the hybridization of aircraft and even the possibility of pure electric-only commercial flight. New sessions in 2018 will focus on electric propulsion for general aviation and supersonic possibilities for the commercial aviation industry.

NOVEMBER 8-9, 2018 COLOGNE, GERMANY

©DLR

BRAND-NEW PAPERS!

Image: ©newFACE Consortium

From the publisher of *Aerospace Testing International* magazine

BOOK NOW! SEE WEBSITE FOR DETAILS

www.electricandhybridaerospacetechnology.com

Over 200 delegates participated last year Join the debate in 2018!

The conference dedicated to

SAVING FUEL, LOWERING

electric & hybrid aerospace

TECHNOLOGY SYMPOSIUM

THE FUTURE OF AIR

BRAND-NEW PAPERS!

From the publisher of *Aerospace Testing International* magazine

www.electricandhybridaerospacetechnology.com

EMISSIONS, REDUCING NOISE

CALL FOR PAPERS NOW OPEN!

In 2018 the conference will also discuss electric and hybrid propulsion for general aviation and personal aviation vehicles. **PLUS** additional sessions on creating highly efficient and quiet high-speed passenger aircraft.

NOVEMBER 8-9, 2018 COLOGNE, GERMANY

H series future aircraft | NASA/BOEING/SCIENCE PHOTO LIBRARY

CRAFT PROPULSION

Electric & Hybrid Aerospace Technology Symposium 2018 | Contact: Sam Gee
UKi Media & Events, Abinger House, Church Street, Dorking, Surrey, RH4 1DF, UK
Tel: +44 1306 871209 • Email: sam.gee@ukimediaevents.com

Over 200 delegates participated last year Join the debate in 2018!

// PAUL E EDEN

Field

1 // Not Typhoon in concert, but actually BAE Systems' DCI rig, which employs concert staging equipment to suspend cables around the aircraft *(Photos: BAE Systems)*

trip

BAE Systems has developed the industry's first transportable direct current injection rig for high-intensity radiated fields testing. Currently supporting Typhoon P3E trials, it's an exciting alternative to traditional, fixed-base techniques

2 // The rig is surprisingly resilient and although an indoor installation might be an improvement, little time was lost to weather during the recent Typhoon trials

High-intensity radiated fields (HIRF) testing has long been essential to proving that aircraft electrical systems are not susceptible to electromagnetic interference from external sources. HIRF tests have traditionally involved unwieldy fixed equipment, but BAE Systems is pioneering a transportable direct current injection (DCI) rig for the work.

Geoff South, lead technologist, electromagnetic hazards (EMH) at BAE Systems Military Air & Information, explains: "If you look at how airplanes are traditionally cleared in the HF band, up to 30MHz or thereabouts, where we're predominantly looking, the process involves large antennas with hugely powerful amplifiers.

"The antenna is pointed at the plane and it's subjected to an electromagnetic field. There are lots of reasons why it's not ideal – 100+kW amplifiers, for example, are very expensive and dangerous. So we looked for a quicker, cheaper, safer and transportable alternative.

"The direct-injection test itself isn't new. BAE gained its first experience with it during the 1980s on the Jaguar fly-by-wire airplane and then on the Experimental Aircraft Program. It continued to evolve, but hadn't been used with the complexity or refinement of our recent tests."

13
Hours of Typhoon testing per day

8
Engineers monitoring test data

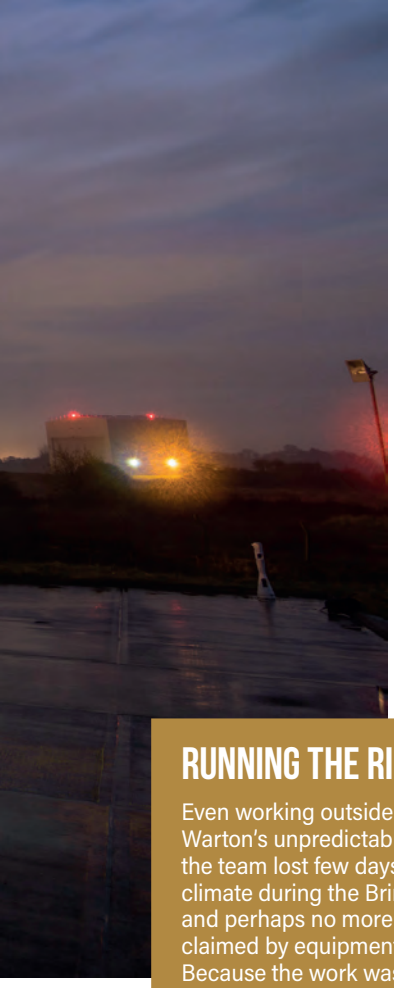
2018
When Project Centurion is scheduled to transfer all RAF Tornado GR4 capability to Typhoon

150kW
Amplifiers associated with traditional low-level HIRF testing

Stuart McCafferty, Typhoon electromagnetic lead engineer at BAE, says, "We're using less power and creating a test facility that's less cumbersome and logistically difficult. Over the past few years the effort we've put into the technique has been more detailed and concerted. We did tests on Tornado P15 shortly before it retired, and Typhoon development aircraft IPA5, to refine and fine-tune the technique."

James McLaughlin, contract delivery manager, Phase 3 Enhancements (P3E) on Project Centurion, notes, "Now we've used it as the basis of an operational Typhoon production electromagnetic clearance for the P3E software and Brimstone missile and it's supporting work for ASRAAM Block 6."

McCafferty continues, "The ambition for the work we've just done on P3E was to go through a production test and clearance, based on the DCI rig, rather than having done any of the traditional HIRF testing over the same frequency range. Facilities capable of achieving the levels our customers require are rare – there isn't one in the UK."



3 // The rig initially supported Brimstone work under P3E. This BAE Systems development aircraft mounts two Brimstone triple launchers under its wings

RUNNING THE RIG

Even working outside in BAE Warton's unpredictable weather, the team lost few days to the climate during the Brimstone trials and perhaps no more than were claimed by equipment failures. Because the work was done at Warton, UK, suppliers quickly solved the rare equipment issues, while on-site personnel attended to aircraft or weapons problems even more rapidly.

The aircraft's APU runs during the test, avoiding the need for a ground input and keeping the jet electrically isolated, since it is effectively part of the rig's circuit. The team developed a remote APU shutdown system, using fiber optics and compressed air. For safety reasons, the cockpit is left unoccupied. Measurement and control of the rig and aircraft is through fiber-optic cables, with a suite of electromagnetically hardened fiber-optic cameras watching aircraft systems.

Currents on looms and at electro-explosive devices on the aircraft and in the Brimstone weapon were measured via fiber-optic signaling. Data was monitored in real time, including what McCafferty describes as "a hit list of safety measurements. These current measurements were spread across the airframe and monitored as indicators of how much energy was on the airframe and key looms as we increased power. We'd already done a full suite of low-level measurements and extrapolated them up, so we knew what to expect at the higher levels and we cross-checked with those results in real time as the power increased.

"We used thermal imaging cameras to monitor the airframe, reassuring us we weren't getting hot spots or energy concentrations. The theory of the technique is that the energy is on the aircraft's skin and then conducted into the looms. We wanted to ensure we didn't have unusual concentrations that might indicate a problem with the process. We had systems that triggered alarms at certain temperatures.

"Once we'd reached our targets we took measurements from multiple other looms and that data was recorded for subsequent analysis. Alongside this, cameras recorded the cockpit displays, and we had a team monitoring databus traffic, via fiber-optic tap. In total we had three people monitoring the aircraft operation and seven or eight engineers monitoring the test, sitting in a screened chamber in a brick building. The screening prevents the rig's own inevitable RF transmissions affecting the measuring equipment."

Taylor concludes: "We worked on a shift system, working 13 hours a day, six days a week, including around eight hours' testing every day."

He says, "A primary issue with traditional methods is that they require a high-power transmitter on-site. It's not ideal for an airfield because it can affect operations and creates 'radhaz' [radiation hazard] safety issues. We've effectively cut out free-space transmission and connected the amplifier direct to the aircraft. It enables us to create energy across the aircraft's surface, simulating flight in a free-field electromagnetic environment."

CONNECTION PROCESS

The configuration of rig and test subject creates an arrangement similar to that of a coaxial transmission cable, with an outer conductor – the rig – surrounding an inner conductor – the aircraft. After extensive computer modeling defined the optimal rig setup, commercial concert staging equipment was used to build a robust framework holding it firmly in place around the Typhoon. The rig comprises a network of copper pipes surrounding the aircraft and never touching the ground.

South explains the connection process. "We used a reasonably high-powered, 50Ω-output amplifier and an input device to match it to the input of the transmission line – it's been nicknamed the cheese grater, because it has lots of holes to make it lighter. These devices are placed at the wingtips, nose and tail, and connected to the airframe. As much power as possible must be passed from the amplifier to the rig, then on to the aircraft, hence the rig's very specific design."

4 // The Brimstone DCI tests were completed in support of Project Centurion, which is transferring capability from the RAF's Tornado GR4 on to Typhoon

> *"We were achieving the correct levels of energy in the correct parts of the aircraft"*

South says, "To gain maximum benefit from the amplifier it was crucial to optimize the match between amplifier and rig. We did it pretty well. The VSWR [voltage standing wave ratio, a numerical parameter defining the match between antenna impedance and that of the transmission line] was not quite as good as we'd hoped, but it was enough to achieve our targets."

Roger Taylor, BAE Systems' technical manager, aircraft trials, says, "We spent a lot of time at the end of 2016 proving the technique's equivalence to the free-field model."

"The result of that," McCafferty notes, "is that we were able to do a P3E test that achieved equivalent levels to a free-field test and went an extra step. We measured the energy conducted on key weapons system looms and used it in the same way you would use the information gathered in a traditional BCI [bulk current injection] test.

"This meant we'd effectively also gathered data from a low-level free-field test, and because we were seeing the same amount of energy conducted onto these key looms through both techniques, we were confident we'd achieved, and in some cases surpassed, the levels required of an equivalent HIRF test. We knew that at each of our test frequencies we were achieving the correct levels of energy in the correct parts of the aircraft."

PRACTICALITIES

The essential test requirement that aircraft systems be powered and access granted to change weapons inevitably caused compromise between the ideal rig configuration and the practicalities of servicing the jet. However, since the rig surrounds the test subject, compared with the old technique there's no requirement to move the aircraft or antenna to ensure overall coverage.

Completion of low and high-level Brimstone testing took a little under four weeks, which McCafferty says was barely faster than with the old technique. "But now we're more confident and I think we were faster the second time, on ASRAAM, and we'll continue to get more efficient as

5 // BAE Systems envisages future roles for the DCI rig, including work with the Typhoon's nascent E-Scan radar

we learn the techniques and logistics of using the rig. However, if you factor in that without the rig we'd have to take a jet and deploy somewhere that has a high-power HF HIRF facility, then the timescales ramp up and you see the real benefits."

"The aircraft under test are generally new," McLaughlin adds, "and generating the clearances to fly them somewhere for tests is very difficult."

Looking to the future, the rig offers possibilities for trials 'on the road'. McCafferty notes: "It covers the lower frequency ranges between about 2MHz and 100MHz and our testing capability above that range is already portable, so in theory we could take the system to a customer. The rig and its logistics pack away into a pair of containers. The amplifier is the most difficult item to transport. It's a case of making certain we have the correct crates and anti-vibration transport mounts. It's something we intend to develop.

"Because the testing has to be performed outside, we're also at the mercy of the weather, but we're working on taking the technique indoors, perhaps into our electronic warfare test facility. It poses further logistical challenges – how do we power it and can we run the APU indoors?"

What's the next phase in for the Typhoon? "We initially focused on the rig's benefits to Project Centurion and P3E, and it was clear the weapons stations would be a relatively easy target," McLaughlin explains. "Going forward, we expect there'll be plenty of iterations of weapons on the aircraft, but we also took advantage of having it in the rig to take measurements from a host of systems. The next area we want to look at, and we did some investigation during the testing we've just done, is possibilities for exploiting the rig during the E-Scan radar program." \\

GLOBAL LIGHTNING

Full vehicle testing - now realizable with full threat parameters

New modular test equipment is enabling testing on large scale structures with full current and energy according to relevant industry standards.

Testing & Verification

Over the years, GLPS test engineers have performed a wide range of verification and certification tests. Nothing is too small and nothing is too large for the application of realistic lightning impacts.
GLPS operate the world's largest mobile test facility for direct lightning effects testing, utilizing full threat testing in accordance with various industrial, military, and aerospace standards.

Lightning is predictable, controllable and the risk is preventable.

Full-Scale Testing is now Mobile! Let us come to you!

www.glps.dk • +45 7026 0211 • contact@glps.dk

AS 9100 BUREAU VERITAS Certification

We are certified to Masterclass – **AS/EN 9100,** which also includes ISO/EN 9001.

GLPS

Night

To chase and record a total eclipse, NASA used modified high-definition television broadcast cameras attached to the nose of a military jet aircraft designed in the UK in the 1940s

1 // A total solar eclipse, as seen on August 21, 2017, from on board a NASA Armstrong Flight Research Center's Gulfstream III, 25,000ft above the Oregon coast *(Photo: NASA/Carla Thomas)*

vision

2 // Two of NASA's WB-57F research aircraft were used to observe the solar corona during the 2015 total solar eclipse, here seen from the Faroe Islands

2 3

The next full eclipse of the sun by Earth's moon will be visible from Chile and Argentina in 2019, but NASA-funded researchers were ready to collect terabytes of data with a special airborne high-definition camera on August 21 this year, when the celestial event was visible in North America.

"By flying the airplanes in the direction of the [moon's] shadow motion, instead of getting only two and a half minutes of totality [full solar eclipse], which is what you'd get from a stationary point, we were able to extend that for about four minutes," Dr Amir Caspi told *Aerospace Testing International*. Caspi is the principal investigator of the eclipse-observing mission and he is a senior research scientist at the San Antonio-based Southwest Research Institute, but he works in Boulder, Colorado. He adds, "Because we had two airplanes that we flew in tandem, we were able to get about seven and a half minutes of a contiguous totality between both of the aircraft."

The camera used, an HDL-F30 broadcast camera manufactured by Ikegami, is defined as high definition because its pictures are made up of 1925 lines by 1080 lines. "We are in the midst of trying to apply our [data] calibrations now [October 2017]. We got the science data in hand a couple of weeks ago. It was delayed in Houston after the hurricane [Harvey]. We had to wait a little while to get the data in our hands, but we have it now," Caspi explains.

The camera instruments bolted to the aircraft's nose are called the airborne imaging and recording (AIR) system. The AIR has a 32in (812.8mm) ball turret with a four-axis gimbal to help ensure a stable image. The gimbal system, Caspi explains, "allows the operator of the camera to essentially track a source regardless of which way the airplane happens to be pointing".

The turret can be operated in both an automatic tracking mode and a manual mode. Within the AIR, the cameras and their anti-jitter rigid fixing structure is called the optical bench. The payload of cameras used for the eclipse study is called Dynamite, which has the visible light camera, the Ikegami HDL-F30, and also a mid-wave infrared (IR) camera.

The IR camera is a FLIR scientific camera with a custom lens. The cameras are aligned so they are both pointing at the same point at infinity. They are located

3 // Note the instruments mounted under the silver casing on the nose of this WB-57F jet as it is readied for a test run at NASA's Johnson Space Center

within the turret's ball to be operated with what NASA describes as "an 11in-diameter, 4.2m fixed-focal-length [telephoto] lens," which was built by Fujinon.

Both the IR and broadcast cameras have their uncompressed data recorded, but compressed data is also saved. Compressed data is transmitted by satellite back to the mission control room to enable managers to monitor progress. On board the aircraft, an engineer acts as an instrument operator. "[As] our primary science is coming from the visible light camera, which is this broadcast TV camera, we did upgrade it with lossless quality video recorders and [with] a special filter that passes only a narrow band of green light, which is something that we needed for our science," Caspi says.

"The Dynamite cameras were built for imaging the [NASA Space] Shuttle," NASA's WB-57 High Altitude Research program office manager, Charles Mallini, told *Aerospace Testing International* (see sidebar, *Space Shuttle Legacy*). The aircraft that carries the turret for all that data collection is the English Electric Company B-57 Canberra. This type of aircraft first flew in 1949. NASA's Canberras are former United States Air Force aircraft retired from active service in the 1970s and later. When serving NASA, they have a different name – the acronym WB-57F. The 'W' stands for weather because the aircraft typically carry out high-altitude weather research. The 'F' indicates it is a version that was created in the 1960s.

5
Terabytes of data

7
Minutes of eclipse filming

30
Frames per second

1080
Lines make up a video picture

Mallini works at NASA's Johnson Space Center, where the agency manages its Ellington Field, Houston-based WB-57F fleet. A long-range aircraft, the WB-57F can fly for 6.5 hours, has a range of up to 2,500 miles (4,023km) and a maximum altitude of 63,000ft. The two WB-57F flew over Missouri, Illinois and Tennessee to observe the total eclipse for about 3.5 minutes each.

To avoid the distortion of the visible light caused by the atmosphere, the aircraft flies high in the stratosphere at 50,000ft, its cruise altitude. The stratosphere begins at almost 33,000ft and extends up to 164,000ft. According to NASA, at 50,000ft, the sky is up to 30 times darker than when seen from the

4 // Initial analysis of the data has begun, with results expected to be available over the coming months

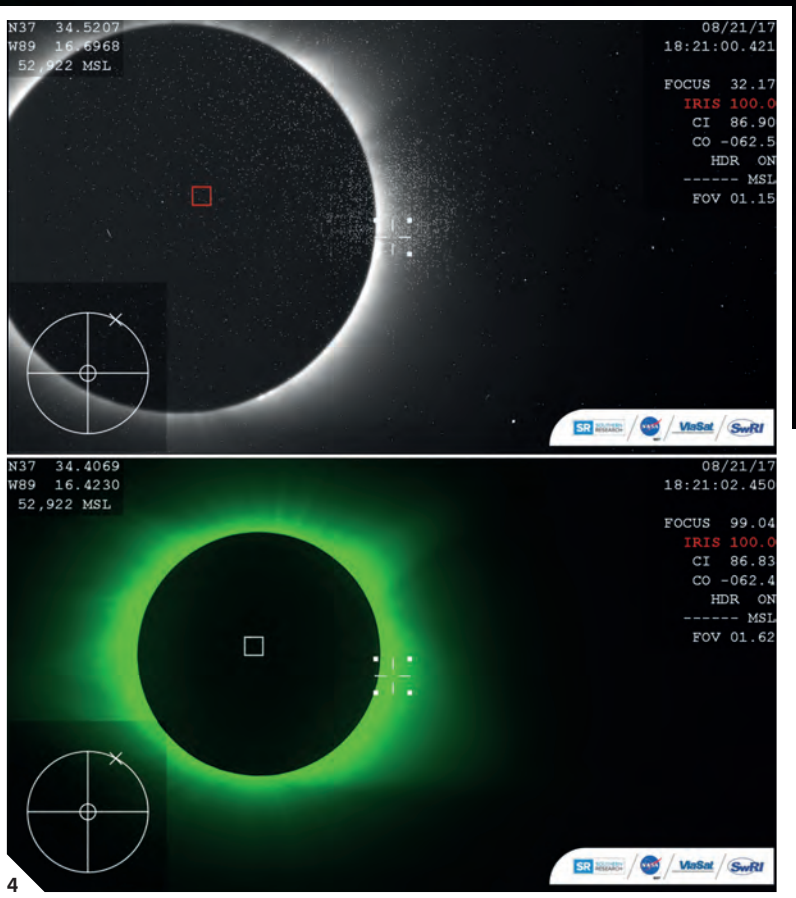
ground and with the reduced atmospheric turbulence, finer structures and motions in the sun's corona can be recorded.

Before the eclipse work, Mallini explains, "NASA Langley Research Center used our infrared cameras and other aircraft to record the descent [of Space Exploration Technologies' Falcon 9 first stage]". NASA's interest was in studying the plume of the first stage's propulsive descent because, at a particular altitude above Earth, it would be similar to a retrorocket landing on Mars. "They used that data to validate their propulsive landing software and modeling," he adds. The eclipse, corona work is a new area of study for the WB-57F aircraft.

SOFTWARE FROM SCRATCH

"We're not trying to analyze all five terabytes of data at once. In principle, it should all be doable with standard desktop computers. Granted it does take a while," says Caspi, but first his team has to write the software they need. The code they write will be in the interactive data language (IDL) used by the astronomy community. Caspi expected another computer language, Python, to be used, and possibly other languages. "Basically, all of the software has yet to be developed. We're writing a lot of custom software to do the analysis."

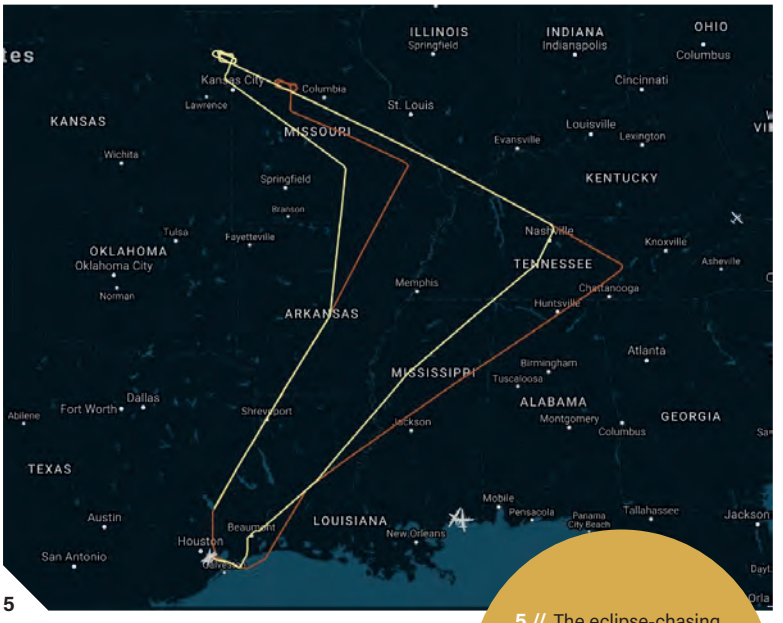
"We're writing a lot of custom software"



4

The bulk of that data to be analyzed is not actually from the eclipse. "From the seven minutes themselves, I think we got, between the two airplanes, probably about a little bit less than a terabyte of data [from the eclipse]," Caspi says. The other four-and-a-bit terabytes are from observing Mercury for about an hour using the FLIR camera and taking calibration observations of stars before and after the eclipse.

All that star-based calibration data will allow scientists to learn about the sun's corona, which is the outermost part of its atmosphere. The calibration is important because the noise from inaccuracies in the instrumentation has to be removed. The high-definition camera's pictures, which capture an image 30 times per second, will be examined for corona wave motion. Scientists want to know how large and how strong the waves are and whether they move toward or away from the sun's surface.



5

5 // The eclipse-chasing flight path – the two jets observed the total eclipse for about 3.5 minutes each as they flew over Missouri, Illinois and Tennessee

Caspi explains, "The corona is heated to millions of degrees, yet the lower atmospheric layers, like the photosphere, the visible surface of the sun, are only heated to a few thousand degrees. Scientists aren't sure how this inversion happens."

Scientists think that magnetic waves generated by the sun, and called Alfvén waves, convey energy into the sun's outer atmosphere, where it is then dissipated as heat. Another hypothesis is that micro explosions, nanoflares, that are too small and frequent to be detected individually, have a large collective effect, releasing heat into the corona.

"Due to technological limitations, no one has yet directly seen nanoflares, but the high-resolution and high-speed images to be taken from the WB-57F jets might reveal their effects on the corona," continues Caspi. "Even though this [camera] is on a pointed stabilized platform, there is still quite a bit of jitter. For our purposes, a jitter can actually make the difference between seeing certain [coronal] structures and dynamics in those structures or not."

The Mercury observation is for other science work to map the variation of temperature across the surface of the small planet, closest to the sun.

With the calibration achieved, Caspi says that it means their data is "instrument independent", when the signal noise from the broadcast camera or the FLIR is gone. "We can get calibration information and we're going to then use that to process all of the solar and planetary images." As the eclipse data is a "few hundred gigabytes", Caspi expects that will be something that can be processed with a "standard desktop" computer.

NASA also operates, in conjunction with the German Aerospace Center, the Stratospheric Observatory for Infrared Astronomy (SOFIA) airborne observatory. A telescope built into a Boeing 747, SOFIA carries a reflecting telescope with a diameter of 100in (254cm). Caspi says that his team's software would have to be adapted for use with SOFIA generated data. "The issue is, of course, that you have to adapt it to the format of the data that you're taking. SOFIA's data depends on what instruments are mounted behind its telescope. Different instruments take data in different ways. Now, they do have essentially a finder camera and that pretty much just takes data in a standard fashion. If we wanted to analyze data from SOFIA's finder camera, we could, using this technique."

Detecting previously unseen nanoflares causing convection in the sun's atmosphere with a TV camera flying in Earth's stratosphere at 50,000ft is an unlikely use for instruments originally designed to help stop another Shuttle accident. Whether it is further examination of returning rocket stages or the eclipse of 2019 and beyond, the Dynamite cameras can be expected to have many more uses than was first envisaged. \\

SPACE SHUTTLE LEGACY

On February 1, 2003, the Space Shuttle Columbia broke up on re-entry into Earth's atmosphere due to thermal protection tile damage caused during its launch. After this, NASA put plans in place to monitor its shuttles during their ascent. One of the methods used was to install high-definition television broadcast cameras in the noses of NASA's high-altitude aircraft, English Electric Company WB-57F. The 'W' stands for weather and the 'F' indicates it is the last version, which was created in the 1960s.

The first time they were used was for Space Shuttle Discovery's STS-114 mission that returned the fleet to flight. To create the monitoring system, NASA's Marshall Space Flight Center in Huntsville, Alabama, and industry partners, developed the cameras and integrated them into the aircraft nose. The work was called WB-57 Ascent Video Experiment (WAVE) and the camera payload is now called Dynamite.

Previously, the aircraft had been used by NASA for high-altitude weather research. WAVE created a swiveling, nose-mounted video recording system designed to capture visible-light and infrared imagery of the Shuttle for 150 seconds, until the spacecraft's solid rocket boosters separated and fell back to Earth. During the launch, the aircraft flew at a distance of 15-20 miles (24-32km) from the ascending shuttle.

Photron

Photron provides a wide range of high-speed cameras with exceptional light sensitivity for slow motion analysis. Our FASTCAM series offers megapixel resolution to 21,000fps and 4-megapixel resolution, producing true HD images at up to 2,000fps.

KEY AERONAUTICAL APPLICATIONS

Combustion Studies
Fluid Dynamics and PIV
Rocket Burn
Materials Testing and DIC
Turbine Failure Testing
Impact Testing
Aerodynamics
Wing Deformation

PHOTRON OFFERS A WIDE RANGE OF CAMERAS WITH POWERFUL FEATURES:

Megapixel resolution to 21,000fps
Reduced resolution to 2.1Mfps
Unparalleled light sensitivity
Minimum exposure to 159ns
128GB of internal memory
Fast download to PC or SSD
Extremely rugged design
Standard 2-year warranty

WWW.PHOTRON.COM

PHOTRON USA, INC.
9520 Padgett Street, Suite 110
San Diego, CA 92126
USA

Tel: 858.684.3555 or 800.585.2129
Fax: 858.684.3558
Email: image@photron.com
www.photron.com

PHOTRON EUROPE LIMITED
The Barn, Bottom Road
West Wycombe, Bucks. HP14 4BS
United Kingdom

Tel: +44 (0) 1494 481011
Fax: +44 (0) 1494 487011
Email: image@photron.com
www.photron.com

PHOTRON (Shanghai)
Room 20C, Zhao-Feng
World Trade Building
No. 369, JiangSu Road
ChangNing District
Shanghai, 200050 China
Tel: +86 (0) 21-5268-3700
Email: info@photron.cn.com
www.photron.cn.com

PHOTRON LIMITED
Kanda Jinbo-cho 1-105
Chiyoda-ku, Tokyo 101-0051
Japan

Tel: +81 (0) 3 3518-6271
Fax: +81 (0) 3 3518-6279
Email: image@photron.co.jp
www.photron.co.jp

The outd

MEET JONAS MALMQUIST, PROJECT MANAGER AT THE SWEDISH DEFENCE MATERIEL ADMINISTRATION'S VIDSEL TEST RANGE

loor type

// WHEN DID YOUR INTEREST IN AEROSPACE BEGIN?

As a boy, I accompanied my uncle who was a flight engineer with the Swedish Air Force [now at the Flight Test Center in Linköping] and dreamed of being a fighter pilot. However, instead I began my military career in the army, at the Ranger Regiment in Kiruna, in the northernmost part of Sweden. I have had 20 fantastic years as an army officer, spending roughly half of them in the infantry and half in the Air Defence Artillery. The last years in active service, I worked as a project manager for the Swedish Armed Forces Unit for Cold Weather Operations and among other tasks coordinated cold weather testing of army equipment, working closely with the Swedish Defence Materiel Administration. I was still fascinated by and interested in military aviation, so when Vidsel Test Range was looking for a project manager with a background in the Air Defence Artillery and electronic warfare, I applied for the job and got it.

// TELL US MORE ABOUT YOUR CURRENT ROLE...

I work as a project manager in the testing department at the test range. My job is to manage the assets and the people at the test range and make sure that we provide the means for our customers to conduct their tests and deliver the required data to them. The job involves planning, together with the customer, who can be national or international, government or industry, from

1 // Swiss Air Force Cougar helicopters and Swedish Air Force Gripens during EW training

1

the early phases to final planning. Then comes the actual testing, where my job is to coordinate the test range assets and handle all unexpected events. Finally, of course, there is making sure we deliver the data, evaluations and that the budget adds up.

// WHAT WAS YOUR FIRST TEST AT VIDSEL?

My first testing job at Vidsel Test Range was supporting a joint venture by the Flight Test Center and the Swedish Defence Research Agency. The tests were conducted in order to study the atmospheric abatement on the laser from the Laser Designator Pod on the Swedish JAS-39 Gripen. We did a number of tests with stationary lidar equipment, but also flight tests with the Gripen at different altitude and ranges. We knew that the air up here in northern Sweden is clear, but were surprised to learn how extremely clear the air was with very few particles, providing very little abatement.

// WHAT MAJOR PROGRAMS ARE YOU CURRENTLY WORKING ON?

I'm currently involved in the planning for several tests of GBAD systems, including the new Swedish SHORAD, IRIS-T SLS, and some A-A missile tests. I also run a long-term project to improve the electronic warfare testing capabilities of Vidsel Test Range. Our major challenge is keeping up with the development of modern weapon systems; the range and performance of modern weapons is constantly improving and we need to adjust to that by improving our range infrastructure and acquiring new systems and capabilities.

"Vidsel Test Range is Europe's largest overland range"

// WHAT ARE VIDSEL'S UNIQUE FACILITIES FOR WEAPONS AND ELECTRONIC WARFARE TESTING?

Vidsel Test Range is Europe's largest overland range. What is unique about Vidsel is that we have a huge restricted ground area, uninhabited and far away from the public eye with an extensive test range infrastructure including roads, electric power, fiber network, radars and other range instrumentation. Furthermore, together with the Air Force we operate a military airbase from where we also fly our target drones. The restricted airspace is 8,000km^2 [3,100 square miles] from ground to unlimited [altitude]. This makes it possible to conduct tests like firing the Meteor air-to-air missile or jamming global navigation satellite systems or radars.

// YOU RECENTLY HAD THE NEURON UAV THERE. WHAT DID THE TESTING INVOLVE?

Neuron is one of several UAVs tested at Vidsel. We had 11 flights using different sensors like the Gripen with its PS-05A radar, the ASC 890 Swedish airborne early warning radar and other ground-based radars and IR-sensors to document the Neuron's radar and electro-optical signature. We also conducted tests with

air-to-ground ordnance, which is thrilling to watch live on the feeds from our radars and cinetheodolites.

// WHAT OTHER UAVS HAVE UNDERGONE TESTING THERE?

Looking back to the early 2000s we had the verification flights for the Swedish Army with the Sagem Sperwer and later the AAI RQ-7 Shadow. Saab tested the SHARC and Alenia flew the UCAV Sky-X and Sky-Y. We have had other UAVs in later years as well and Vidsel Test Range is the perfect place to test them since we can provide a safe environment where we don't put people at risk and we have the necessary infrastructure and instrumentation.

// WHAT ABOUT MANNED TESTING PROGRAMS?

The majority of our tests are manned aircraft weapons testing, both air-to-ground and air-to-air. One of the most recent trials was the Luftwaffe Eurofighter GBU-48 testing. Having a man in the loop is both an advantage and can be a challenge at times. An experienced pilot can adjust to the situation or make a judgement call. The most important thing when having international customers is to agree on the procedures and iron out any risks of misunderstanding each other – the language can be a barrier sometimes. I recently got a funny text message about a transport from a customer, obviously using Google Translate: "Good evening, excuse her late problem. Trucks for forwarding are now rocket launchers. These are driver ID-cards. Enter to wake."

// HOW LONG IS A TYPICAL WEAPONS/EW TEST AND WHAT DOES IT INVOLVE?

Normally we are just a small part of the test program. The actual tests done in Vidsel can vary from just a few days of verifications to a large number of tests over the span of several years. A typical test campaign comprises of a week of build-up with ferry flights and instrumentation setup, a couple of weeks of testing, and then a week of evaluation and packing up. We are a service provider in the sense that our customers do the actual tests, and we provide a safe environment and the data needed. We will normally provide Time-Space-Position-Information data from our range instrumentation radars; and cinetheodolites for aircraft, weapons and targets collect telemetry signals from the different test subjects for analysis, and record high-speed videos and meteorological data. When testing missiles, they are often equipped with telemetry packs that send encrypted signals containing information from the missile avionics or with flight termination systems that enable us to fire long-range weapons safely.

"Having a man in the loop is both an advantage and a challenge at times"

2 // Swedish Gripen above Vidsel Test Range

3 // Gripen, Erieye and the Neuron UAV

// WHAT HIGH-SPEED RECORDING EQUIPMENT DO YOU USE?

Different types of digital HS-video cameras. Normally we use ≤1,000 frames/s. The speed can be increased with reduced resolution and recording time. It can be quite a challenge to position and trigger the high-speed cameras to capture the impact of a weapon. A perfect example is the video sequence, taken from one of our target drones, of the European BVRAAM meteor passing by at Mach 4.

// WHAT IS THE MOST IMPORTANT PIECE OF EQUIPMENT USED IN EW TESTING?

It's impossible to say because EW spans the entire electromagnetic spectrum, from radio and radar frequencies to visible or UV light, but our latest addition, providing new capabilities, is a system for GNSS jamming.

// HOW HAS WEAPONS TESTING CHANGED OVER THE YEARS?

Except for the increasing performance of modern weapon systems, we definitely see a recent change with regard to the security situation in Europe, which leads to requirements

4 // A laser-guided bomb strikes a target during weapons testing at Vidsel Test Range

5 // BQM-167i being launched at Vidsel Test Range

for better test range instrumentation and also electronic warfare capabilities. We've invested in a new air traffic control tower and new aprons at the air base, which will increase our capacity. We are fielding two new types of target drones, the BQM-167i and the MQM-178, are procuring new radars, and will also look at getting a new C2I system for range control.

// AND HOW HAS EW TESTING CHANGED DURING THE SAME PERIOD?

There has been a recent shift in military testing, from focusing on fighting low-tech insurgents to preparing for a high-tech adversary. We see increased demands for incorporating EW in weapons testing, which has for instance led to investments in jamming systems. I'm very pleased that thanks to our international partners we have been able to invest in an EW system that will be beneficial for the Swedish Armed Forces and partners, and will increase our operational capabilities.

// HOW HAVE YOU HELPED TO IMPROVE TESTING EFFICIENCY?

A tight schedule/test program, in combination with bad weather, can be a nightmare for our customers. We always try to be flexible and try our hardest to make the tests happen, making suggestions for adjustments in the setup, working late or weekends, whatever it takes.

// WHAT DOES IT COST TO CONDUCT A TEST, AND WHAT IS CURRENT AVAILABILITY?

We don't have a fixed rate, but prepare quotations based on the actual test requirements. We have had a few free slots this year, but judging by all requests for 2018 and 2019 it will be a challenge to accommodate all customers. Our customers are both defense organizations and industry.

// ANY PARTICULAR TEST STICK IN THE MIND?

For many of our foreign customers, the test campaigns in Vidsel are their first encounter with northern Scandinavia and quite exotic. As well as providing great testing facilities, we live and work in a beautiful environment. Large parts of the range are part of a nature reserve and many visitors encounter reindeer, moose and some lucky ones may even see a bear, lynx or wolverine. One test team heading back on a helicopter got front-row seats, hovering by a cliff, where a lynx and her young cubs were playing, totally oblivious to the helicopter. The restricted access to the range actually helps to preserve the environment for future generations.

The actual test range area is quite far from civilization and especially for ground-based air defense or artillery tests you spend a lot of time out there. The Italian Army set a standard of excellence last year, during the MLRS-I validation, bringing in a container of Italian food, with their own cook providing espresso, homemade cookies and pastries during the three weeks we spent out on the range. They really spoiled us with that and we tend to mention this to all customers we have out on the range, hoping for a repeat performance!

// HOW DO YOU SEE WEAPONS AND EW TESTING CHANGING IN THE FUTURE?

Of course we see that simulation advances replace some live tests. However, in the foreseeable future I firmly believe that there is still a place for physical testing. Our operations span from the early stages to OPEVAL – and also military exercises and training.

Furthermore, Vidsel Test Range is in what NATO refers to as a 'C2 climate area', where the cold and snowy winters put extra strain on equipment and personnel. Environmental test chambers can only simulate the harsh environment to some degree and in a static scenario. The need to test military equipment and weapons in a realistic tactical environment – for our military personnel to have confidence in the state-of -the-art systems they operate – means live firings and EW tests will be required as long as there is a man in the loop. \\

Measuring Equipment for Demanding T&M Applications

960-535e-11.16

Sensors that Push the Limits

Drawing on a wealth of experience, Kistler supplies pressure, acceleration, acoustic emission, force, strain, and torque sensors with corresponding signal conditioning solutions for the Test & Measurement market. Kistler provides engineers, researchers, measurement technicians and students in the aerospace industry with reliable high-quality measuring equipment.

For more information please visit www.kistler.com/t&m

KISTLER

measure. analyze. innovate.

www.kistler.com/t&m

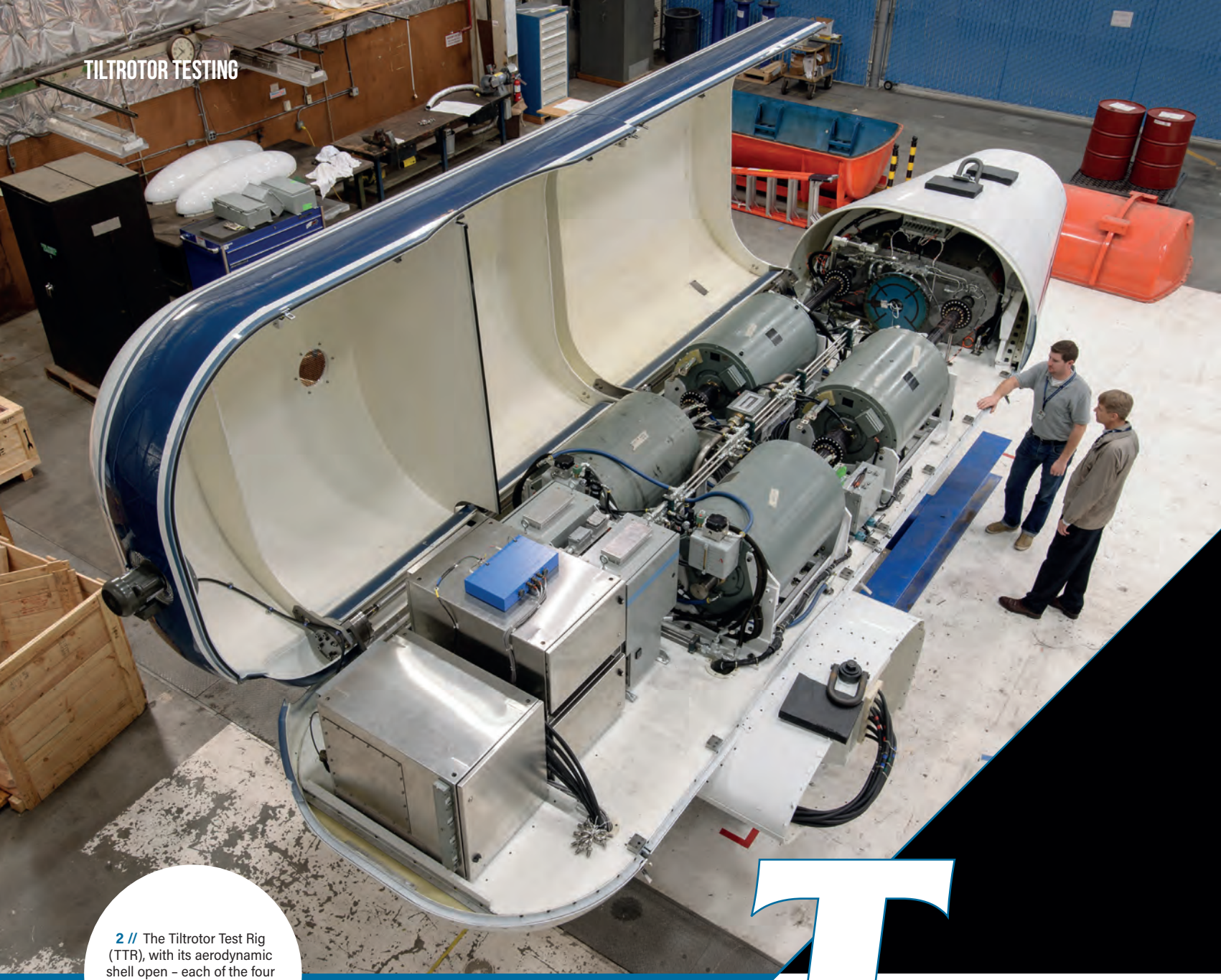
// ROB COPPINGER

Shape shift

er

With the US Army and Air Force's help, NASA has built a test rig for a range of rotorcraft whose proprotors tilt from the vertical to the horizontal, enabling it to fly like a helicopter and fixed-wing aircraft

1 // The Bell V-280 Valor prototype aircraft has successfully achieved ground run testing at 100% rotor rotations per minute

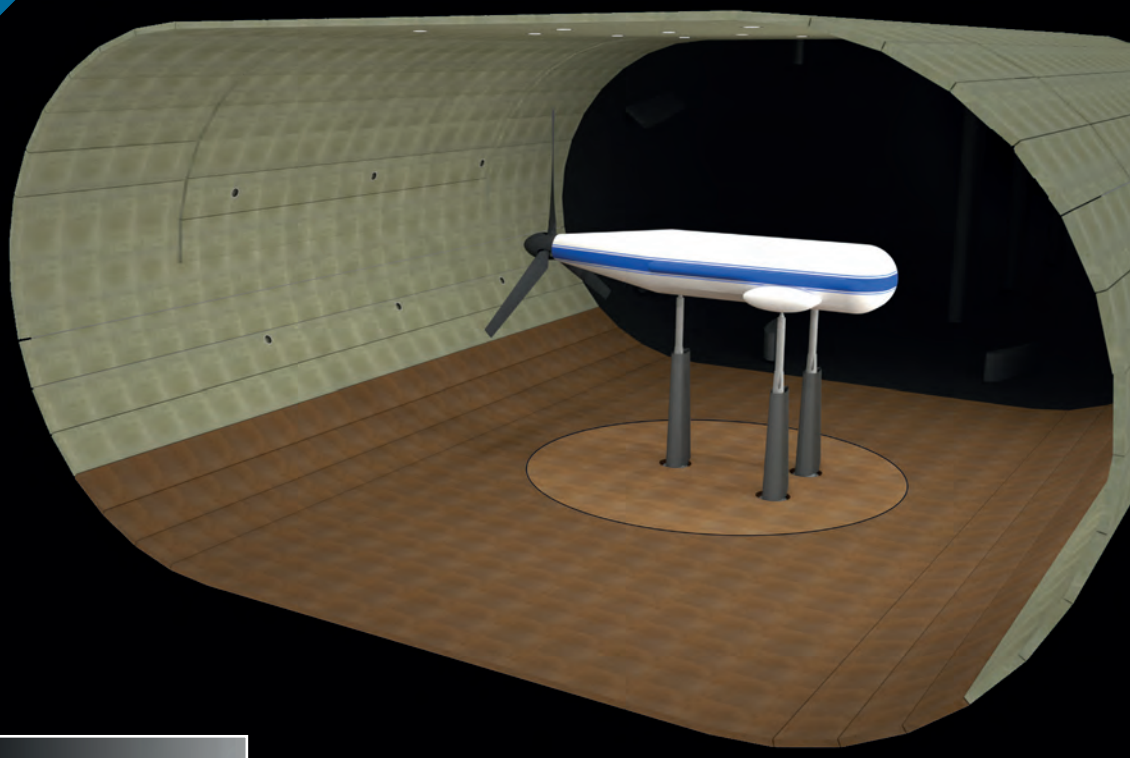


2 // The Tiltrotor Test Rig (TTR), with its aerodynamic shell open – each of the four gray cylinders is a 1,250hp electric motor

Tiltrotor aircraft can move the proprotors on their wings from a helicopter-like orientation to an aircraft-like horizontal position, and back – proprotors being the rotors on a tiltrotor aircraft. Pointed upward, like a helicopter, they allow vertical take-off, landing and hovering, while the aircraft operation delivers a high forward speed capability.

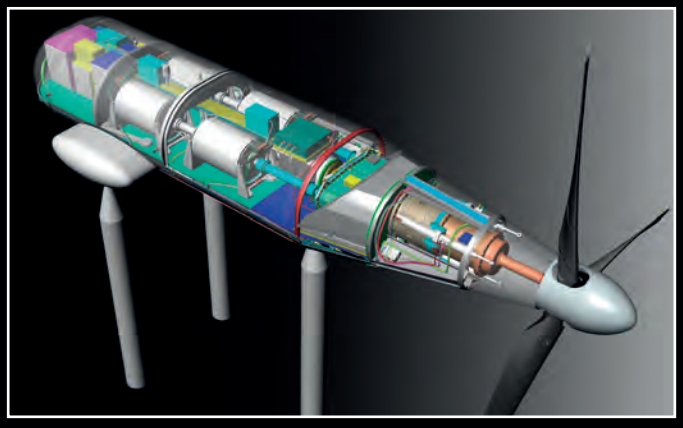
NASA Ames Research Center's new Tiltrotor Test Rig (TTR) will handle proprotors up to 26ft (7.9m) in diameter and windspeeds of up to 300kts (345mph or 555km/h) inside Ames's National Full-Scale Aerodynamics Complex (NFAC) wind tunnels. The TTR is designed for use in both the NFAC's 40 x 80ft (12.2 x 24.4m) wind tunnel and the 80 x 120ft (24.4 x 36.6m) tunnel.

TTR program director Wally Acree is confident that a range of tiltrotor aircraft can be developed from Ames's test rig data. "If you are a reasonably confident rotorcraft engineer, you will be able to take our data and



3 // Computer rendering showing the TTR once installed in the huge wind tunnel

4 // Design concept for the TTR, showing internal components of the control system, motors and gearbox



"NASA simply bought one of those rotors because it was flight tested"

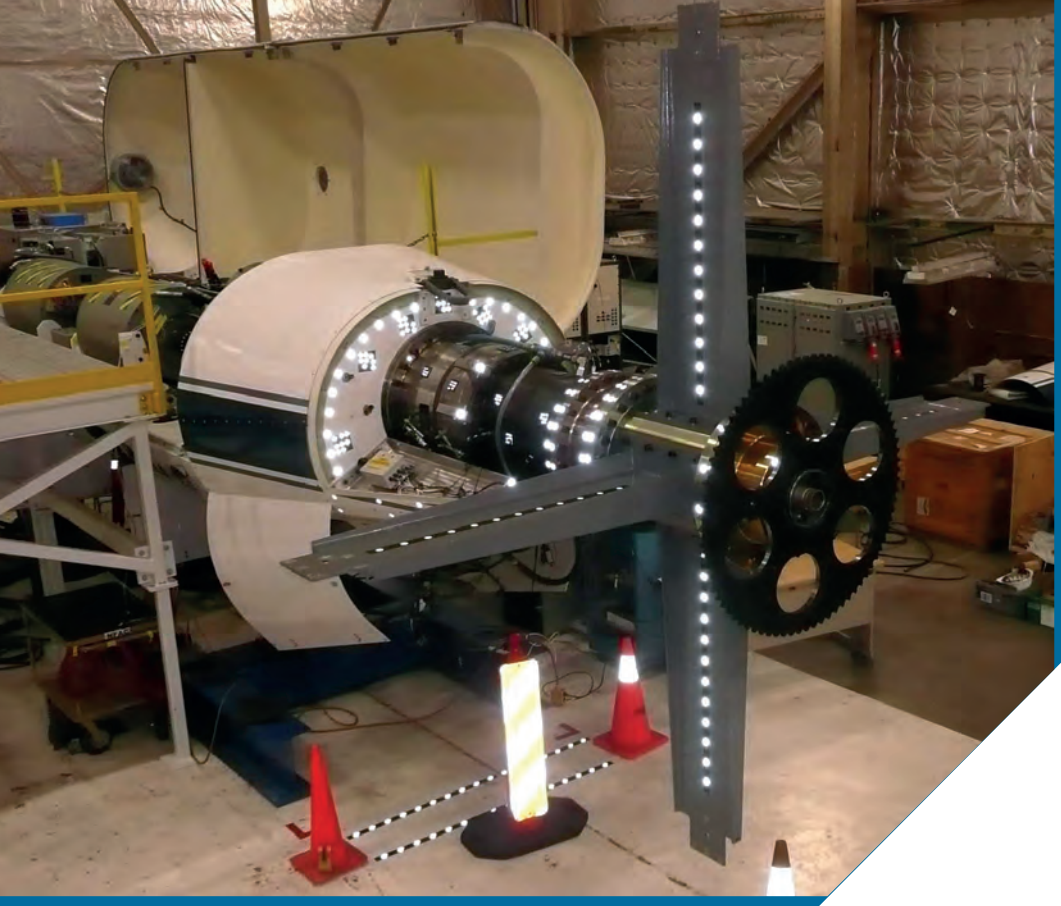
deduce from it all kinds of things that apply to different aircraft," he says. "There are some fundamental characteristics with a tiltrotor that don't change between the XB-15, the 609, [and] the V-22. They scale pretty straightforwardly." The XB-15 was an experimental rotorcraft created by NASA in the 1970s and was the beginning of tiltrotor work in the USA. "That [the XB-15]... really proved the concept of a tiltrotor."

In the 40 years since NASA created the XB-15, the military V-22, developed jointly by Bell Helicopter and Boeing, has become operational, while the civilian 609 Acree refers to, the Leonardo AW609, could be certified for commercial use in 2018. In operation since 2007, the V-22's first flight occurred in March 1989. The production aircraft, the V-22B, also called the Osprey, entered into service with the United States (US) Air Force, the US Navy and its Marine Corps in 2007.

The AW609, originally called the BA609, was a joint venture between Finmeccanica subsidiary AgustaWestland and Bell Helicopter in 1998. Finmeccanica was rebranded Leonardo in 2016 and wants to start delivering the AW609 to customers from 2018. Acree points out that the AW609's proprotors are built in the US and that it is one of those proprotors that is being used in the TTR. "NASA simply bought one of those rotors because it was flight tested. It's available. It was by far the simplest way of getting a large-scale rotor ready for testing," he explains.

RIG SPECIFICS

The TTR is a joint project, between NASA, the US Army and the US Air Force, to develop a large-scale proprotor testing system for use in the NFAC. A horizontal axis rig, it rotates on a turntable in the wind tunnel to face the proprotor, either straight into the wind or at any angle up to an edge-wise orientation.



5 // TTR with rotor calibration hardware – the gray arms apply moments, and the black sprocket applies torque

However, there is a windspeed limit of 100kts for the edge-wise orientation. The rotation – left to right, rather than up and down – allows for the emulation of the proprotor transitioning from the vertical lift position to a horizontal configuration for forward flight.

"The [rig's] measurement system was designed to try to get higher accuracy and more capability for larger rotors that had been tested before, larger proprotors I should say," Acree explains. The rig will provide data to validate the analysis and design tools companies like Bell Helicopter Textron use. The rig was designed and built by Bell Helicopter Textron and Triumph Aerospace Systems. They also provided a calibration rig.

Designed to accommodate a variety of proprotors, the TTR has four 1,250hp electric motors. Electric motors are used, rather than the turbines that power tiltrotor aircraft, as they are more efficient when carrying out wind tunnel work. This is because, as Acree explains, "You can control your rotor speed over a very wide RPM [rotations per minute] range, much wider than you can with any piston or turbine engine. And they don't produce any significant exhaust."

Proprotor forces will be measured by a balance installed between the gearbox and the proprotor, while the proprotor torque is to be recorded by an instrumented drive shaft. Acree describes a balance as "a big chunk of metal that's been machined in such a way as to allow you to put strain gauges in the best possible place to measure the loads coming from the rotor".

"Getting a rig and rotor, and control system, all balanced properly is a bit tedious, especially since you want to have everything really spot-on for a good quality research data. But we're working our way right through that," Acree says. He points out that a challenge for the measurement system is how it measures the rotor loads when it cannot rely on the wind tunnel's scales because they are 30ft (6.1m) away. "You don't want to get the loads on the TTR body mixed up with the loads on the rotor."

One solution is for the proprotor itself to have extra instrumentation, with many strain gauges along the blades to measure the loads. "As a wind tunnel test article, we have extra strain gauges. There's nothing terribly new about the instrumentation. There's just

VALOR GROWS BY DARING

The Bell V-280 Valor prototype aircraft has been undergoing ground run testing at Bell Helicopter's Amarillo Assembly Center this year. The Valor technology demonstrator is part of the multiservice effort, led by the US Army, to replace the US military's helicopter fleets. With a top speed of 280kts and a range of more than 2,100 nautical miles, the Valor has more than twice the range and speed of current helicopter platforms, according to Bell.

The Valor has four crew and can carry 12,000 lb of cargo or 14 troops. The Valor, and the rival design, the Sikorsky Boeing SB-1 Defiant (a helicopter), are being developed under the Army's joint multirole technology demonstration effort. This is a parallel effort to the Army's future vertical lift work, which, for example, has identified five capability sets that equate to specific aircraft types that meet the military's requirements.

In little more than a year, future vertical lift could become a formal acquisition program to buy a new rotorcraft. Between now and then, the Valor prototype will continue its testing at the Amarillo center, where its aircraft systems and flight controls will be tested before the first flight, which is expected before the end of 2017.

300KTS
Maximum windspeed the TTR will experience inside the AMES NFAC wind tunnels

120FT
Width of the largest NFAC wind tunnel

"You don't want to get the loads on the TTR body mixed up with the loads on the rotor"

a little more of what you would normally get on a flight test article," says Acree.

The first proprotor will be 26ft (8m) in diameter. "Our rotor is a modified version of the [Leonardo AW]609 rotor," Acree explains. "We call it the Bell 609 because it is not quite identical to the one that's flying on the 609 aircraft. Ours is built for us, for NASA, by Bell, and it is modified for use in a wind tunnel." And this proprotor is smaller than the Osprey's, being "almost exactly two-thirds scale".

If the TTR is moved to the large wind tunnel section, the maximum proprotor diameter could go up to about 40ft (12.2m). However, Acree points out that better data can be obtained with a smaller proprotor. "The size, if you want to be picky about it... it's driven by the quality of the data that you want. Different customers have different desires, so if you want to be spot-on with your data, then you keep your propeller pretty small." The data on the small proprotor design can then be extrapolated to a larger version of the same design.

RIG VALIDATION

Acree and his colleagues resumed their testing in October after a hiatus due to damage caused to the wind tunnel earlier this year by an unrelated project. The TTR had been in testing since February 2017 to determine that it is functioning and balanced and calibrated correctly. He expects that the testing to validate the rig will be finished in the second quarter of 2018. "We are hoping that we will be finished in the spring.

"What we plan to do is to run the TTR at a variety of different angles to the flow. For the initial check-out, we will try to follow more or less the velocity and angle that the actual aircraft would when it goes through conversion from hover to forward flight," Acree explains. This test program was decided upon because, "we already know that's the safe thing to do. That's our baseline," he adds. The testing will then increase the velocity and the air speed as progress allows.

The TTR has more than 100 data channels that feed the data to the wind tunnel collection system. "We pretty much saturated the system. We're getting a lot of data," says Acree. This data will be analyzed with existing software that he describes as state-of-the-art, adding that it is being upgraded continuously.

Because the TTR continues to be evaluated and calibrated, the data that has been collected so far will help the engineers understand that the rig is behaving properly. It will also include pressure and temperature information that is not about the proprotor performance. Once this TTR check-out testing has been completed, during the second quarter of next year, Acree's team will carry out "deep diagnostics for the behavior of the rig". He adds: "There is a program underway to build a new CFD [computational fluid dynamics] model of the [Leonardo AW]609, but it's just barely gotten started. That's something in the future."

1,250HP
Power output of each of the TTR's four electric motors

100+
Number of TTR data channels

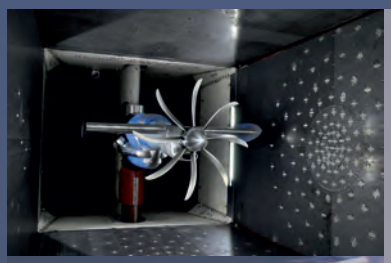
Another potential application, Acree suggests, is the use of TTR data by the US Army for its future vertical lift work. This seeks to realize replacement rotorcraft for the Boeing Apache and Sikorsky Blackhawk, among others, in the 2030s.

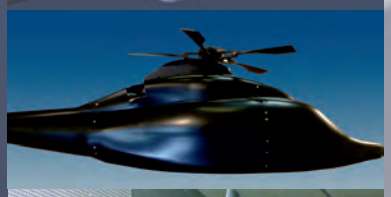
Whether it is a civilian tiltrotor, a manned military rotorcraft or an unmanned aircraft operated by a company or the armed services, the investment by NASA and the US Army and Air Force in TTR demonstrates that the helicopter now has a long-term competitor when it comes to vertical lift. Concepts for all of the above uses have been proposed by aerospace firms, including quad tiltrotor aircraft that could replace transports such as the Lockheed Martin C-130 Hercules. While these aircraft may be large, with blades spanning tens of meters, the TTR data with the potential to realize them will come from smaller proprotors; small is still beautiful in the wind tunnel. \\

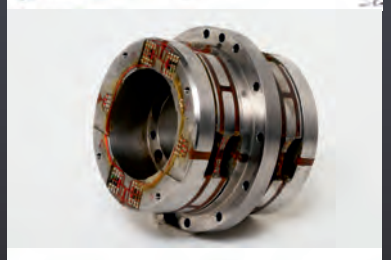
6 // The Bell V-280 will continue ground run testing at the Bell Helicopter Amarillo Assembly Center in preparation for its first flight, scheduled before the year end (2017)

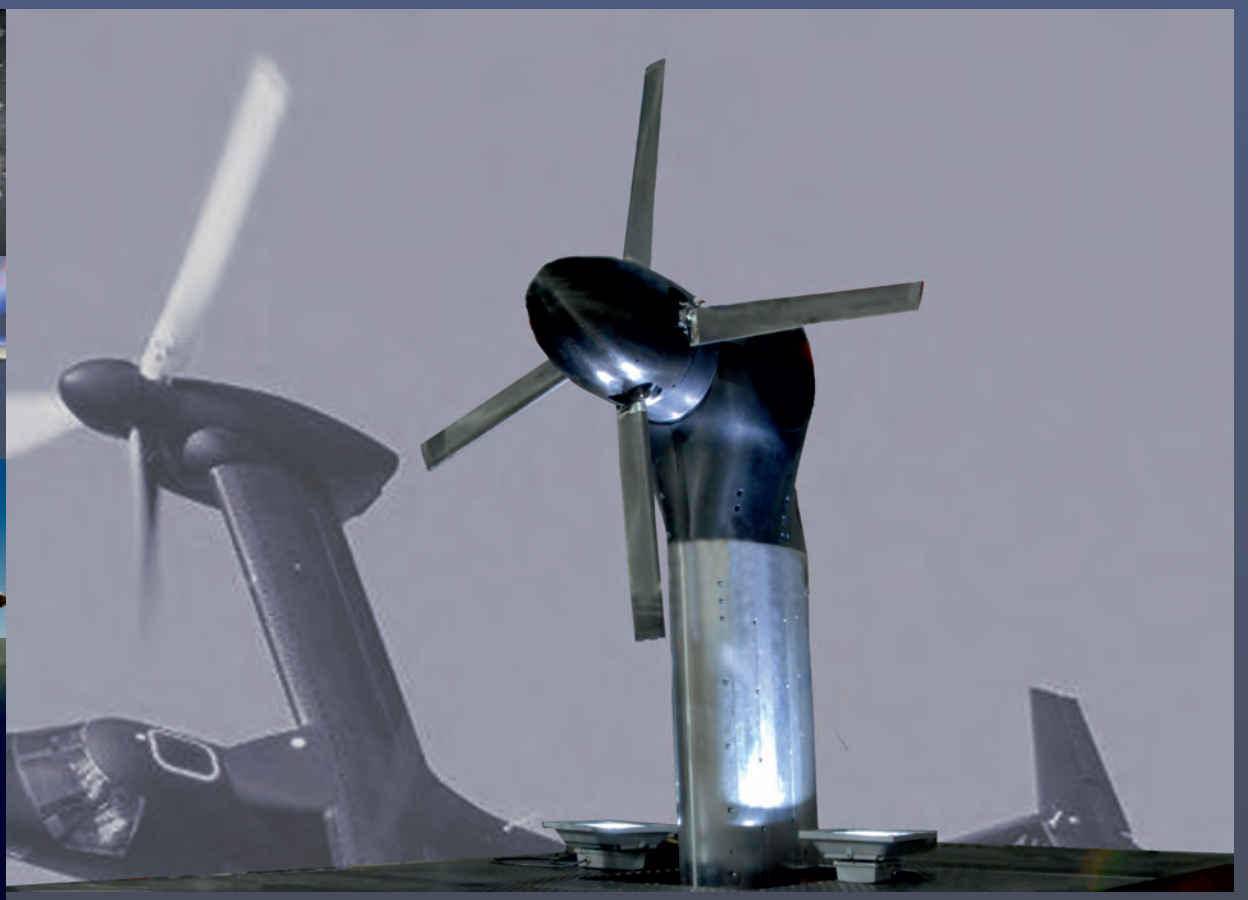
Aircraft Research Association Limited

Providing Rotary Aerodynamic Design, Analysis and Wind Tunnel Testing







From propeller blade design, manufacture of rotating balances, to wind tunnel testing of helicopter rotor blades, ARA provides a full service for rotary aerodynamics.

- Computational Fluid Dynamics
- Precision Design & Manufacture
- Rotary Balance Design & Manufacture
- Test Rig Design & Manufacture
- Transonic Wind Tunnel Testing
- Innovative Measurement Techniques

To find our how ARA can provide the data your programme demands visit www.ara.co.uk or contact business@ara.co.uk

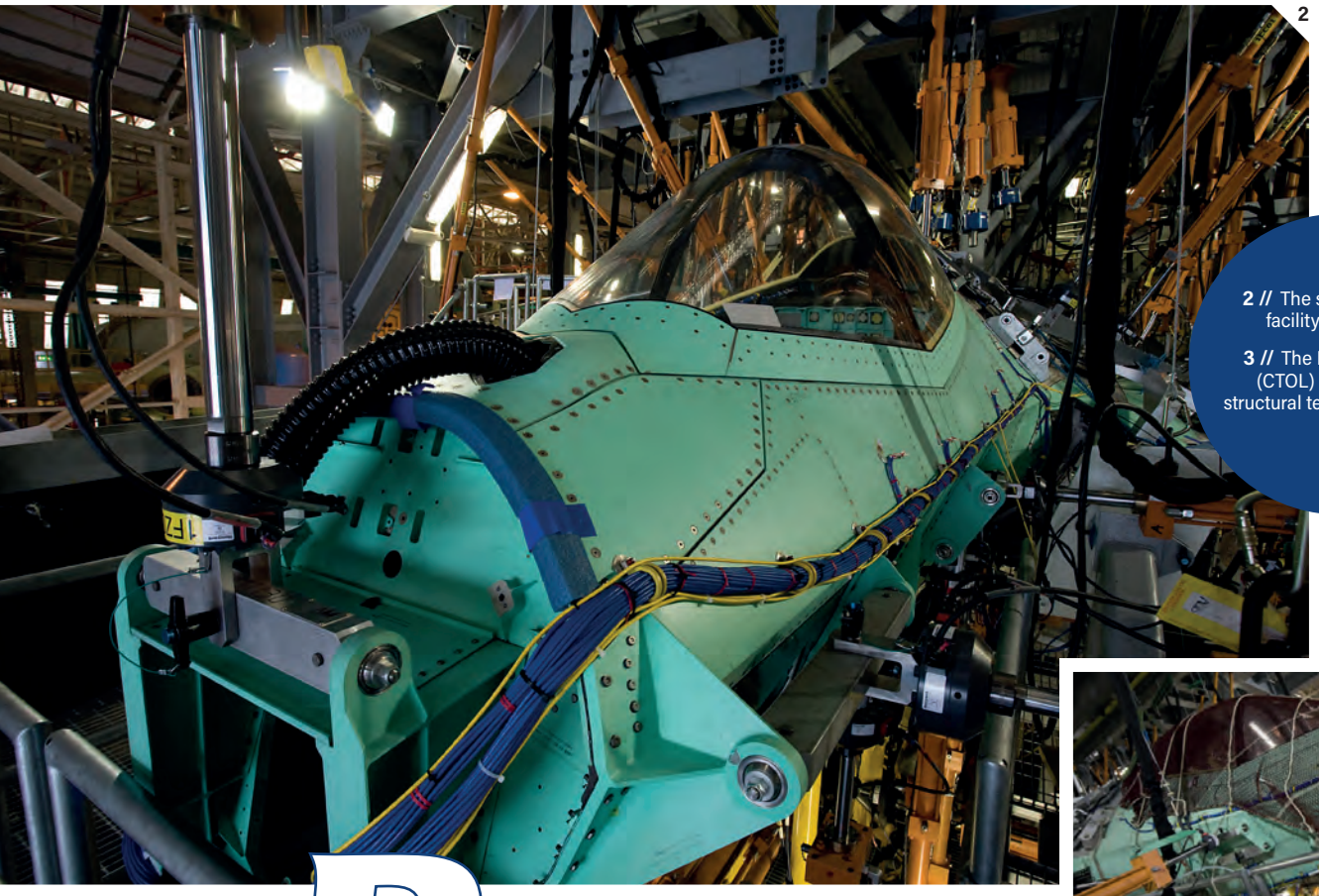
Lightning strikes thrice

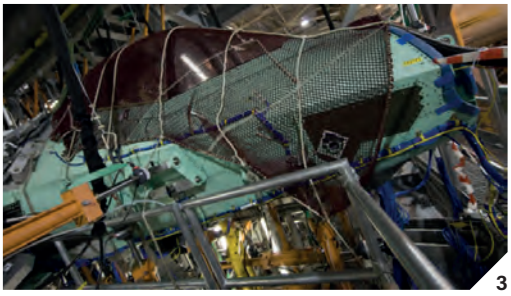
BAE Systems' structural test team at Brough has now completed a third cycle of F-35A fatigue testing

1 // An F-35 CTOL airframe is winched from a barge at BAE Systems' military aircraft site in Brough, East Yorkshire, UK, to be installed within its structural testing facility

1

ng





2 // The structural test facility at Brough

3 // The F-35 airframe (CTOL) undergoing structural testing at Brough

BAE Systems has just completed the durability testing of the conventional take-off and landing (CTOL) variant of the Lockheed Martin F-35A Joint Strike Fighter.

The F-35A test article completed its third lifetime in the test rig at BAE Systems' Military Air and Information (MAI) facility at Brough in East Yorkshire, UK, in November (2017). The Structural and Dynamic Test Department is the center of excellence for the testing of military aircraft in the UK.

The CTOL variant of the Joint Strike Fighter has an anticipated life of 8,000 flying hours and therefore when the durability tests were completed, the test article had carried out 24,000 hours of 'flying' representative flight profiles.

After the completion of testing over two normal lifetimes, or 16,000 flight hours, as required by the System Design and Development (SDD) phase of the international F-35 program, testing for the third and final life began at Brough in February 2016.

BAE Systems is the structural test lead for the F-35A and Lockheed Martin is responsible for testing the short take-off and vertical landing (STOVL) F35B and Carrier Variant (F-35C) aircraft at its own test facility in Fort Worth, Texas. The Brough test facility is a purpose-designed complex with four large test halls, together with associated development laboratories and supporting infrastructure. The facility has been used for structural testing since the 1970s, and prior to the F-35A, it has been used to support Buccaneer, Harrier, Hawk and Typhoon aircraft. Today, work in support of the Hawk and Typhoon, including a Typhoon flight test article, continues alongside the F-35 test campaign.

3
Lifetimes tested during durability testing

20
Miles (32km) of wiring in the durability test rig at BAE Systems Brough

DURABILITY TESTING

Durability – or fatigue – testing is designed to show that the aircraft structure is able to safely handle the spectrum of flight conditions it is expected to experience in service. The purpose of this testing is to highlight any issues resulting from the stresses placed on the airframe before they become an issue on the real flying fleet.

4 // Each phase of testing, lasting a total of 8,000 hours, is equivalent to an entire lifetime of the airframe once it enters service

"It is linked to how we maintain structural integrity," explains Andy Acklam, structures lead for F-35 aft fuselage and empennage at BAE Systems. In his role as structures lead, Acklam liaises with the structural test engineering team to interpret the results.

"You test it to a spectrum, you monitor how they fly with respect to that spectrum, and then you can make sure that you've stayed within those defined life parameters to ensure we have a safe product."

The fatigue test article, known as AJ-1, is being tested in a 350 metric ton structural test rig at Brough and the representative flight loads are being imparted to the airframe via 160 loading actuators, monitored by 2,500 strain gauges and altogether there is more than 20 miles (32km) of wiring.

Testing is carried out in blocks of 1,000 hours and the third 8,000-hour lifetime will provide additional information on the robustness of the airframe. "You have to have a safety margin. So, we over-test because there's always scatter and we have to factor that in," Acklam says.

"There are undercarriage loads, which also cover taxiing loads, and there are various phases where we model a series of flight profiles. So, for example there might be a 3*g* maneuver, followed by a roll, and we build up a series of scenarios. It's all about ensuring structural integrity and making sure the airframe is safe by monitoring it.

"There's a data acquisition system from the rig, so every time each load case is loaded up, you sample the strain gauges you want; you then offload it and all that data is recorded and we can track the response of every gauge for these load cases," he continues. "So then, if there was a problem you would see a trend in that gauge. If a frame started cracking, for example, then a gauge response might go down and the neighboring one might go up. We track that to understand if there is a problem with the test."

Pressurization loads are also an aspect of the fatigue testing and pressurized bays can be pumped up with air, which is then released, to represent a flight cycle. To ensure the safety of the test, the cockpit area is filled with polystyrene, to limit the volume of air inside the pressurized area and a safety net is fixed over the outside of the canopy.

Acklam says there are no plans to conduct further load testing once the third lifetime is completed and AJ-1 will be removed from the rig and returned to the USA. Once back in Fort Worth, it will be subjected to a tear-down inspection to gain an understanding of any damaged areas and these individual components may then be subject to redesign.

"Once the durability testing is completed, the structure will be torn down and any anomalies will be understood and changes embodied into production aircraft, so there will no longer be a requirement for any further structural testing," he says.

BAE Systems has also carried out fatigue testing of the F-35s empennage – vertical and horizontal tails – at Brough for a total of 24,000 hours each. For the vertical tails, a vertical tail maneuver rig and a buffet rig was designed to simulate the dynamic loads that the units will undergo during actual flight.

STATIC TESTING

Prior to the commencement of fatigue testing using AJ-1, a static load test campaign was carried out using a different F-35A airframe, known as AG-1.

BAE SYSTEMS BROUGH

Brough is situated on the north bank of the Humber Estuary in East Yorkshire, UK, and can trace its history back to World War I, when Blackburn Aeroplane and Motor Company established an aircraft manufacturing factory and seaplane testing facility on the site.

During World War II the facility produced a number of different aircraft types for the Royal Navy, including license production of the Fairey Swordfish and Barracuda torpedo bombers. It also developed its own designs during the period, including the Firebrand single-seat strike fighter.

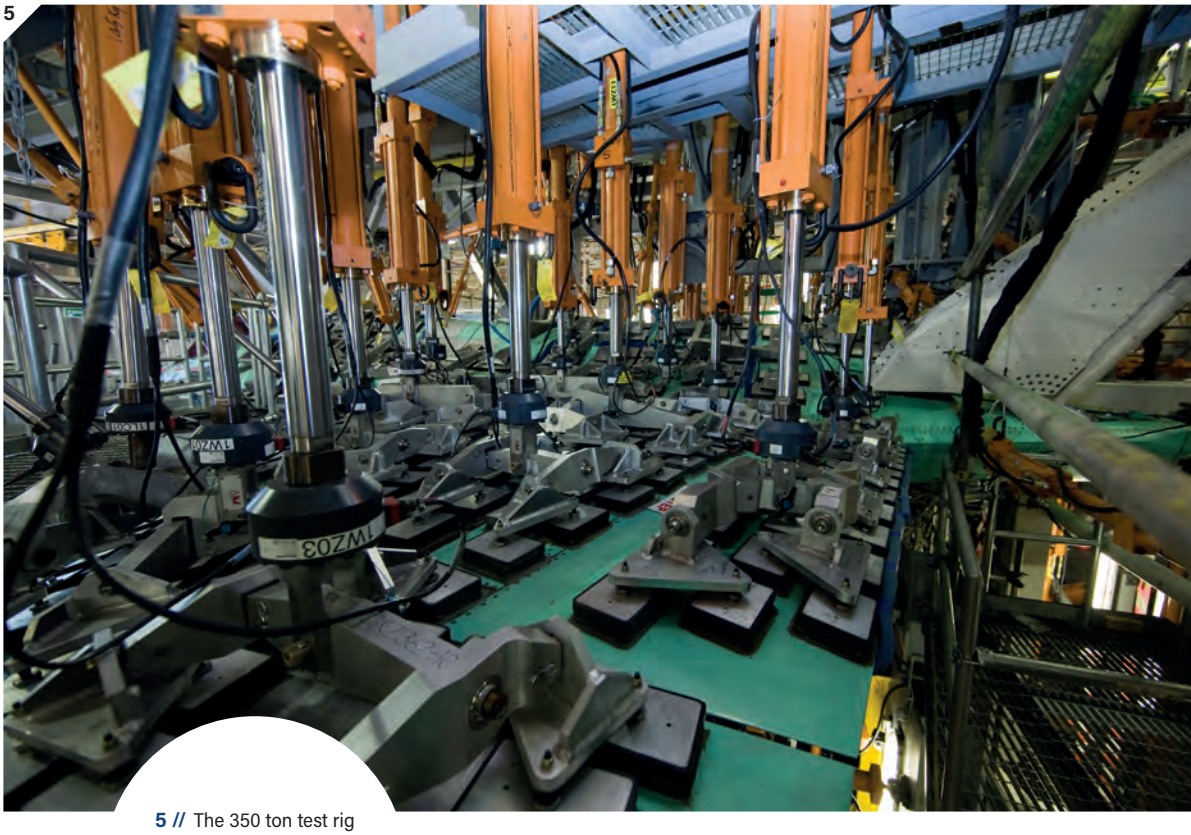
In 1949, Blackburn merged with General Aircraft Limited and for a decade the company was known as Blackburn and General Aircraft Limited, before again being renamed in 1959, as Blackburn Aircraft Limited.

During the post-war period, the company produced aircraft including the Beverley transport and Buccaneer maritime strike aircraft. Blackburn was absorbed into the Hawker Siddeley Group in 1960 and the name had vanished by 1963. In 1977, Hawker Siddeley and the British Aircraft Corporation were merged to form British Aerospace – today BAE Systems.

The Buccaneer was the final aircraft to be manufactured entirely at Brough, but the facility manufactured parts for other aircraft, including the Harrier and Hawk and as a result it can lay claim to being one of the longest continuous aircraft manufacturing sites in history.

Brough has also been used for structural testing since the 1970s and work has been performed in support of Buccaneer, Harrier, Hawk and Typhoon aircraft. Today the Structural and Dynamic Test Department is the structural testing center of excellence within BAE Systems and is currently being used to support the Joint Strike Fighter, Hawk and Typhoon programs.

5



5 // The 350 ton test rig was built to 'fly' the F-35 Lightning II through a series of flight scenarios

AG-1 was transported from the USA by sea in early April 2009, arriving at the port of Hull on the UK's northeast coast. From there, it was transported by barge up the Humber Estuary, before being unloaded by crane at the Brough facility on April 25. The aircraft was one of three static test and three durability test airframes manufactured by Lockheed Martin to support the SDD phase of the F-35 program. A further 13 aircraft have been dedicated to flight testing in the USA.

For the static testing, the airframe was installed in the test rig, 165 actuators replicated the loads that the airframe would see in flight, and the data was captured by 4,000 individual sensors bonded to the airframe, connected by 53 miles (85km) of wiring. At the time testing began in August 2009, BAE Systems said the computing power available to control the load applications was approximately the equivalent of 25 high-end personal computers.

"The purpose of the static test article is to provide flight clearance for the flying aircraft, so we were applying limit and ultimate loads to the airframe, to verify that it behaved as we expected it to behave," Acklam recounts.

"We gathered data from the thousands of strain gauges attached to the airframe and correlated our analysis with those strain gauge results. We picked gauges to verify against our models, to make sure that the model behaved in the same way that the true structure did."

Acklam says that although the F-35 testing – both static and durability programs – followed the traditional qualification certification path, advances in software have meant that testing is more automated than it has been for other aircraft.

Static testing of AG-1 was concluded in July 2010 after 295 days, which was five months earlier than originally planned, and validated that the F-35A airframe can withstand aerodynamic forces 50% beyond its structural design limits.

The strength and stability of the airframe structure was verified to 150% of design limits, or 13.5*g*. BAE Systems said that 174 critical load conditions, or pressures, were applied to the airframe.

Following completion of this phase of testing, AG-1 was removed from the test rig and shipped back to the USA by sea, clearing the way for the aforementioned fatigue trials on AJ-1 to begin.

A range of F-35 testing has been carried out at Brough, in addition to the more recent structural and fatigue campaigns described, including the now-complete thermo-acoustic analysis of the F-35B STOVL and F-35C CV variants. The Thermo-Acoustic Facility (TAF) at Brough was reportedly the only facility in the world designed to measure the footprint of a vertical take-off aircraft, albeit at model scale. In the case of the F-35, a 1/15 scale model was used for the test campaign.

160
Loading actuators in test rig

2,500
Strain gauges used for testing

8,000
Hours in one F-35 lifetime

The F-35B variant had been the subject of some criticism during flight testing with the US Marine Corps, aboard the US Navy's amphibious warfare ships and the thermo-acoustic modeling undertaken by BAE Systems in the UK was critical to the understanding of the jet outwash generated when the aircraft is in the hover.

During the testing, the model was mounted in an anechoic chamber and its underside instrumented with 48 miniature transducers. Hot gases were then piped in to recreate the temperatures and pressures generated by the F-35Bs vectoring engine nozzle and forward lift fan. Following the F-35B trials, the TAF was used to study the effects of jet efflux on the deck of the larger US Navy aircraft carriers from the conventional exhaust nozzle of the F-35C Carrier Variant. \\

EVEN BIGGER THAN EVER!

FROM THE PUBLISHER OF **AEROSPACE TESTING INTERNATIONAL**




DISCOVER BETTER FORECASTING AND MEASUREMENT TECHNOLOGIES HERE!

More than 200 exhibitors will participate in the world's largest fair dedicated to meteorological forecasting and measurement technologies and services

200+ EXHIBITORS EXPECTED

FREE TO ATTEND!

Meteorological TECHNOLOGY WORLD EXPO 2018

9, 10, 11 OCTOBER 2018

AMSTERDAM, NETHERLANDS

Further information:
Please contact Simon Willard at: UKi Media & Events,
Abinger House, Church Street, Dorking, Surrey, RH4 1DF, UK
Tel: +44 1306 743744 • Email: simon.willard@ukimediaevents.com

Register online now!

www.meteorologicaltechnologyworldexpo.com

Stellar cre

Boeing reveals the latest from its testing of the CST-100 Starliner's crew and service modules, as it continues to work with NASA toward the reusable spacecraft's first test flight, due at the end of 2018

1 // Boeing's CST-100 Starliner commercial crew spacecraft will begin flight testing at the end of 2018

2

2 & 3 // Boeing's CST-100 Starliner will launch upon an Atlas V rocket from Space Launch Complex 41 at Cape Canaveral Air Station, Florida

2
Number of CST-100 test flights to be conducted by Boeing

3
Number of CST-100 crew modules under construction

3

Toward the end of next year, Boeing and NASA will perform the first test flight of the CST-100 Starliner, a reusable space vehicle that will be launched from Cape Canaveral and enter low-Earth orbit, before re-entering Earth's atmosphere and recovering on land somewhere in the USA.

The first flight will be unmanned and is one of two planned to occur next year under NASA's Commercial Crew Program (CCP), aimed at developing a safe, reliable and affordable space transportation system for low-Earth orbit missions such as those to the International Space Station (ISS).

As it works toward this important milestone in the program, Boeing is conducting a range of testing on the CST-100 crew and service modules which, together with a launch vehicle, form the Commercial Crew Transportation System (CCTS).

So far, this work has involved extensive testing of avionics systems and subsystems, the spacecraft's rendezvous and docking systems and a series of drop tests of a representative CST-100 crew module structure.

The program will soon progress to testing of the recovery system deployment and culminate in a pad-abort test at White Sands in New Mexico, ahead of the first space launch. With the first launch now on the horizon, it will be a busy year for Boeing engineers as they complete the testing necessary for qualification and certification of the CCTS.

PROGRAM OVERVIEW

Boeing was awarded a US$4.2bn contract by NASA in September 2014 for the development of an integrated CCTS under its CCP. This contract included the development and testing of the system, which would culminate in two test flights, the first unmanned and the second crewed by one Boeing and one NASA astronaut, with a following requirement of up to six post-certification service missions to the ISS.

In May 2015, NASA issued the first of two task orders to include the two initial missions to the ISS, marking the first time that a commercial company had been awarded a NASA contract for a human spaceflight mission.

Under the CCP, Boeing is responsible for the development of a fully integrated CCTS, which comprises the CST-100 crew module, initially capable of carrying four crew members and a service module, launch vehicle, mission operations and ground systems. Most recently, in December 2016, NASA awarded four more crew missions to the ISS.

The CST-100 program philosophy is to use off-the-shelf systems and components wherever possible and it is designed to carry up to seven crew members, or a mixture of cargo and crew, depending upon the mission. The crew module is designed to be reusable up to 10 times, with a six-month refurbishment between missions.

Boeing is building an initial three crew modules. But a new service module will be required at each launch, as the used vehicle splashes down into the Pacific Ocean after re-entry. The initial launch vehicles will be the proven United Launch Alliance Atlas V, but the CST-100 is designed to be compatible with a range of expendable launch systems. In a break with historical US spacecraft

"The CST-100 program philosophy is to use off-the-shelf systems"

recovery methods, the CST-100 is designed to land on land, rather than in the ocean.

Boeing has a number of sites throughout the USA where construction and testing is taking place and there are up to five active test programs ongoing at the present time.

As part of the contract, Boeing is responsible for testing and certification of the vehicle and provides verification to NASA that the requirements have been complied with; however the space body is invited to participate as observers in the process.

"We sign off our verification requirements in the form of test results and briefings and evidence that we have in fact met the performance criteria," explains Boeing's director of crew and mission systems for the CCP, Christopher Ferguson, himself a former NASA astronaut and Space Shuttle commander.

Ferguson adds that because the CST-100 methodology is to use off-the-shelf components wherever possible, the testing methodology is also, for the most part, nothing new. "There's very little new to those who are familiar with avionics or space programs on our vehicle, so those test methodologies are pretty familiar as well," he says.

LANDING LOAD TEST

One key component of early testing is the landing loads test series currently being undertaken at NASA's test facility at Langley, Virginia. The tests are a first for the USA, but have been an integral part of the Russian space program for decades.

The current program follows on from a series of drop tests into water and to date has used the large gantry at the Langley facility, with the intention of determining the stability limits of the vehicle and its response under a number of drop conditions.

Ferguson says that the Russian experience in this regard is understood, but the technology is not directly transportable and so the US testing – while acknowledging the work done in Russia – has started from a clean sheet. "Our landing methods differ in many ways and while we certainly look at the way they operate, we haven't engaged with the Russians first hand," he explains.

PARACHUTE DROP TESTING

One of the unique testing methods employed during the CST-100 program will be the parachute drop test, designed to verify the entire deployment sequence of the module's parachute system. This has previously been undertaken by means of either dropping a test article from a helicopter, or from the back of a transport aircraft, but Boeing will use a helium-filled balloon to lift the module to greater altitudes.

The test article itself will be what Boeing calls a 'boilerplate' vehicle, designed to replicate the weight and aerodynamic shape of the CST-100. "The concept of a helium balloon gives us up to 15,000ft more altitude," Ferguson says. "You can't get a cargo aircraft or

6
Total number of missions to the International Space Station planned

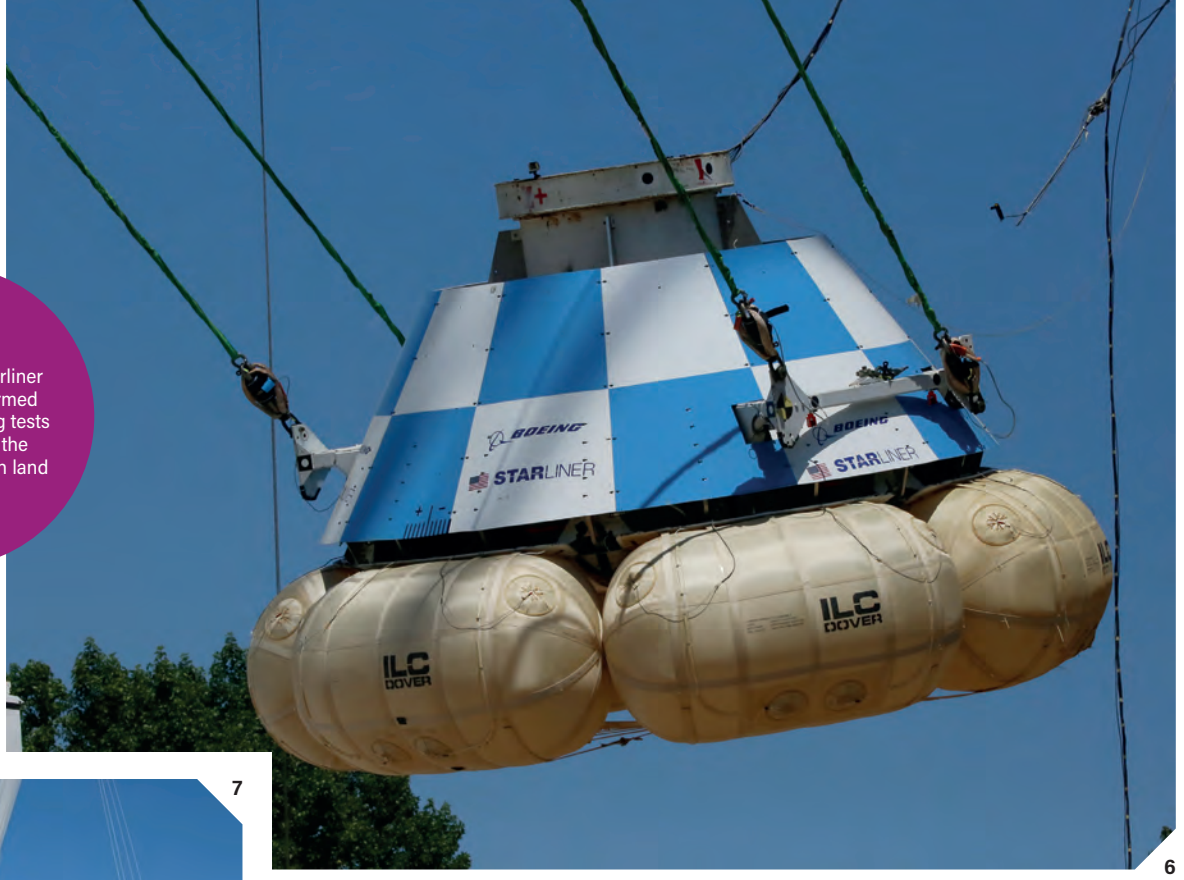
10
Maximum number of times the vehicle can be used

4

5

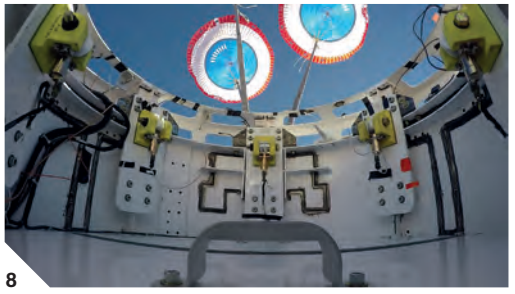
4 // CST-100 Starliner crew seat testing underway at Boeing's facility in Mesa, Arizona, earlier this year

5 // Hot-fire testing of a launch abort engine for Boeing's CST-100 Starliner service module propulsion system



6 // The Boeing Starliner program has performed more than 20 landing tests to determine how the vehicle would fare on land

7



8

7 // A high-altitude balloon lifted Boeing's CST-100 Starliner to 38,000ft during drop testing

8 // Shortly after the Starliner was released from the balloon, the spacecraft deployed two drogue parachutes at 28,000ft to stabilize the spacecraft

a helicopter up to 40,000ft and NASA has stipulated that it wants something a little more comprehensive than the existing parachute testing methodology."

The first in the series of tests was due to begin in late September or early October, as this article was under preparation.

RENDEZVOUS SENSOR TESTING

Until recently, one of the major risks on the program has been the development of the CST-100's rendezvous sensors, an intricate suite of sensors that will allow precise control in three axes for docking with the ISS. The testing is being performed at Boeing's facility in Huntington Beach, California, and much of the risk has now been retired.

"We've done an awful lot of testing at Huntington Beach over the last couple of weeks to retire that risk," says Ferguson. "That's not to say that something new won't crop up tomorrow, but if it does we'll put the resources on it and fix it. I wouldn't say there is one particular issue sticking out in my mind right now as a show-stopper."

PAD ABORT TEST

The pad abort test, currently due to be completed at the end of the second quarter of 2018, will be the last major hurdle before test flight can begin. It will be conducted at White Sands and will be a full demonstration of the CST-100 system to separate from the launch vehicle in the event of a major failure, either on the pad itself or in the ascent stage.

"I describe it as somewhat of an ejection seat for a rocket," Ferguson explains. "It will demonstrate that the vehicle can separate from the launch vehicle, in this case the Atlas V, and bring itself safely back to Earth. It will be a big, integrated test."

TEST FLIGHTS

The current program calls for the first unmanned test flight in the third quarter of 2018, with the second, manned by two crew, to follow in the fourth quarter.

"The first flight will be an uncrewed test flight that we would like to take all the way to a docking with the ISS," Ferguson says. "That would be a big thrill for us to dock on that flight, but if we don't, we'll certainly dock on the second flight."

Despite the schedule, however, Ferguson says the first flight will only occur when Boeing and NASA are confident that the testing has been completed satisfactorily and that the CST-100 vehicle is ready.

"We'll fly when the time is right and we are confident that we can accomplish our mission test objectives," he says. "It will be a big year ahead for us. We've done a lot of subsystem and component-level testing and we're in the thick of that work right now, but next year is where we integrate all the subsystems together and they have to perform as an integrated spacecraft."

All three crew modules and an equal number of service modules are currently in an advanced stage of construction and are in addition to two substantial test vehicles: a 'hot fire' test article at Boeing's facility in White Sands, and a structural test article at Huntington Beach.

"We have a lot of large parts under test right now and there's not a day goes by where we don't get results from these substantial tests," Ferguson concludes. \\

LEARN MORE ABOUT OUR ADVERTISERS **NOW!**

FREE SERVICE!

Visit **www.ukimediaevents.com/info/tea** to request exclusive and rapid information about the latest technologies and services featured in this issue

Aerospace TESTING INTERNATIONAL

www.ukimediaevents.com/info/tea

FROM THE PUBLISHER OF *AEROSPACE TESTING INTERNATIONAL* MAGAZINE

the FUTURE of TRANSPORTATION World Conference

19-20 June, 2018

KÖLN MESSE, COLOGNE, GERMANY

Nine streams, over 250 speakers,
PLUS *meet the companies shaping the future of transportation in our exhibitor zone!*

www.thefutureoftransport.com

2020-2030

AND BEYOND...

CHANGING THE WAY PEOPLE THINK ABOUT TRANSPORTATION & URBAN MOBILITY!

STREAMS & SESSIONS

Getting Transportation Off the Ground

Urban Air Mobility – Technical & Engineering Challenges

MaaS – Mobility as a Service

Changing Landscape For Automotive Manufacturers

Legal & Technical Issues of Autonomous Vehicles

Quantum Shifts

Environmental Sustainability

The Challenge for Rail

Infrastructure & Project Funding

VISIT THE WEBSITE FOR MORE DETAILS AND TO **REGISTER!**

www.thefutureoftransport.com

BEYOND TOMORROW

What role will sound and vibration play in product development in the year 2030?

1

1960 Hand-held sound level meter (Type 2203)

1973 Hydrophone (Type 8101)

1977 Digital filter analyzer (Type 2131)

1981 Sound intensity analyzer (Type 3360)

1983 Modular sound level meter (Type 2231)

1986 Acoustical holography system

On December 4, 1942, Per V Brüel and Viggo Kjær received the official license to trade, establishing Brüel & Kjær, and the company released its first products the following year. They were visionaries in a new market, creating the tools in and for an emerging field, but the products sold then have evolved in myriad unforeseen paths to the products needed today for use in modern environments, complying with modern standards and regulations.

Brüel and Kjær was creating a market for how it saw the world developing then. Could it have dreamed of what it would become? The future is the embodiment of change – evolving technology, shifting customer preferences, more demanding sustainability requirements. As Brüel & Kjær marks its 75th anniversary, is it possible to look at the future of sound and vibration and its role in product development from a broader perspective, with more than the standard three-year product road map in mind? Can the risk that change introduces be harnessed to foster competitiveness and sustainable growth?

No one has seen or visited the future, but all organizations work with a concept of the future in mind on a daily basis. This is sometimes based on conscious assumptions, clear and structured – but often it is not. Change can open up exciting business opportunities, but it can also escalate pressure on supply and value chains.

To develop sustainable business strategies, organizations need to look at extended long-term relationships with resources, technologies and customers.

Product development processes need to take into account the impact of megatrends and the transactional environment.

1 // How sound and vibration equipment has changed over the decades

Megatrends are trends in markets and society that have a long-term, global reach and broad scope that individual organizations have difficulty influencing, and the transactional environment is made up of the trends that individual organizations can influence.

The Beyond Tomorrow project is a vision study by Brüel & Kjær in collaboration with the Copenhagen Institute for Futures Studies. The project focuses on product development and the role that sound and vibration will play as we approach 2030. This study will provide exciting insight, and help to spark a discussion in the sound and vibration community about product development so that all aspects of the testing and product development markets are not only embracing changes that are bound to happen, but also influencing and leading the way into the future.

The concept of this project is based on an iterative progression that consists of a number of stages (trend analysis, subject matter expert/industry leader interviews, a qualitative online survey, desk research that looks at global trends and best practices, scenario development, etc) with a conscious focus on creating insights and perspectives on the future of product development. The perspective of the project is an outside-in approach. By analyzing the contextual environment and the megatrends as well as the transactional environment, the basis is laid for Beyond Tomorrow.

Trend analysis is not enough to create robust ideas and insights. Trend analysis (contextual, megatrend and transactional) on its own tends to create a single perspective,

1991 Danish Primary Laboratory of Acoustics

1996 Windows®-based multi-analysis system (PULSE)

1997 **Hand-held sound intensity system (Type 2260-E)**

2004 Colour touch-screen hand-held analyzer (Type 2250)

2009 Multi-field microphone (Type 4961)

2013 **Tablet-based app for in-vehicle data noise and vibration recording (Sonoscout)**

2013 Wideband holography

2016 New class of air-cooled shaker (LDS V8900)

2017 **Anatomically correct ear canal (Type 5128)**

2030 Beyond Tomorrow

or narrative, of the future. But the future, especially when it comes to product development, will hold surprises and unanticipated events. This is why the Beyond Tomorrow project uses scenarios as a method of developing robust insights. By creating, using and analyzing consequences of four scenarios for the future of product development processes, companies and organizations will achieve a much broader and resilient perspective on the future. This will aid them in their future challenges presented by developing new products and services, rivalry with new competitors, and experiencing new demands from customers as well as other stakeholders.

To develop the scenarios, a group of product-development industry leaders from various regions has been selected to form an expert panel. The panel represents a variety of industries and geographical regions and provides valuable input and insights into the role of sound and vibration in future product.

The primary focus area concerns how businesses are predicting and planning for the future, and what is perceived as vital in order to continue to develop products.

By focusing on product development in broadest possible sense and on understanding the future trends influencing business environments, the Beyond Tomorrow project will help prepare for the future and the role that sound and vibration will play. The final vision report will enable new perspectives for working with product development and innovation, delivering insight and inspiration.

Over the last 75 years, the industry approach to sound and vibration has changed in countless ways, but we know that as the role of sound and vibration has evolved to play an increasingly important part of product development in today's environment, it will continue to evolve in the future.

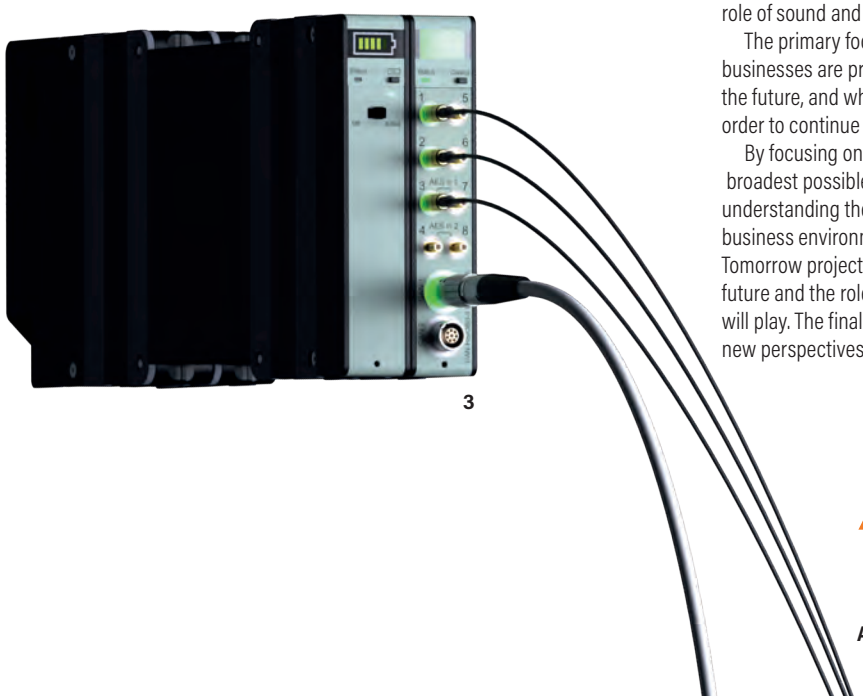
The Beyond Tomorrow project takes the occasion of Brüel & Kjær's 75th anniversary to look forward – beyond tomorrow – and help to set the agenda for that future.

For more information and to receive a copy of the vision study – published December 4, 2017 – visit beyondtomorrow.dk. \\

2

2 // The world's first constant percentage bandwidth acoustic analyzer, designed and developed by Brüel & Kjær

3 // Wireless LAN-XI module with CANbus front end



3


SPACE
TECH EXPO
USA
May 22 – 24, 2018
Pasadena, CA, USA
one show
two continents
"A must-attend event to meet professionals and technical experts from the Aerospace sector in the field of simulation, testing and measurement."
Christophe Loffet, Business Development Manager, V2i
Contact us today for e
www.spacetechexpo.com
info@spacetechexpo.com

SPACE TECH EXPO EUROPE

Nov 19 – 21, 2019
Bremen, Germany

The world's engineering and manufacturing meeting place for space business and technology

Connect with the industry's leading companies showcasing the very latest testing and measurement capabilities, from NDT, modelling & simulation, environmental testing, and materials analysis, to electronic and electrical testing, cable/wire testing, data acquisition, metrology and more.

xhibition opportunities

www.spacetechexpo.eu **info@spacetechexpo.eu**

CONTINUOUS TIME DOMAIN RECORDING

Gap-free time history recording in a single system offers a range of benefits – from cutting costs to reducing the risk of operational errors

Vibration tests (sine, broadband random, shock, and so on) for mechanical environmental testing on a shaker require a large number of analog input channels, especially when testing satellites and their subcomponents. Sometimes hundreds of control, watchdog (notching/limit), and measurement channels are necessary to acquire analog signals such as acceleration, velocity, distance, force and strain.

For these critical tests, time domain data has to be recorded continuously during vibration control; for example, to monitor the function of the specimen or to record the vibrations on the control, watchdog and measurement channels, using accelerometers. Continuously recorded measurement data contains all information on a vibration test and on the load that the specimen has been subjected to.

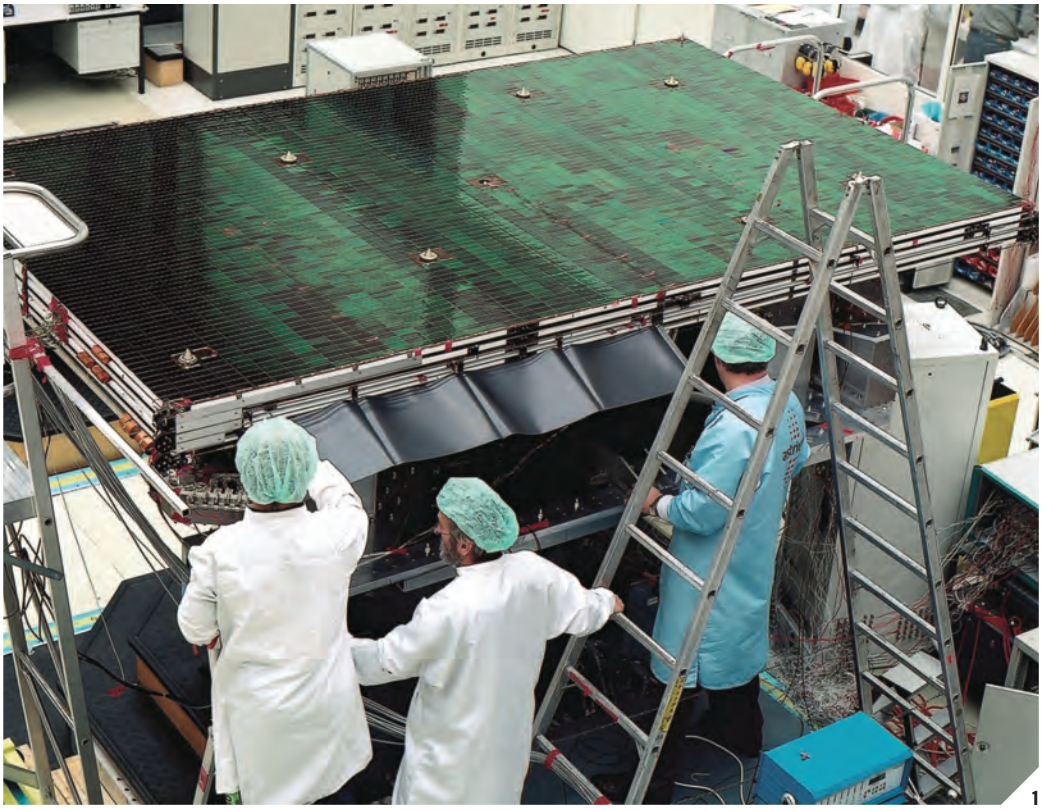
One method that is still widely used in aerospace labs is the time data recording of a vibration test to a second, independent acquisition system in parallel with the usual frequency data recording. This results in additional hardware and maintenance costs, as well as more complex system operation and synchronization.

However, thanks to advanced, powerful measurement and control hardware technology, today manufacturers are able to perform both control processes and continuous time data recording in parallel, in a single system.

m+p international, a leading supplier of vibration testing systems, offers gap-free time history recording with its m+p VibControl shaker controllers. The real-time throughput data capture function allows the system to record all selected channels continuously in the time domain on the embedded data server ('throughput to disc'), irrespective of the channel count and the frequency range utilized. This means that the test engineer can always access all of the original data for analysis purposes.

m+p international's throughput function enables the user to easily post-process the recorded time data after the test run. In addition, recording can be started and stopped independently of the vibration control process.

Vibration control and gap-free time history recording in a single system offers a range of benefits. These include reduced costs, as there is no need for a separate data acquisition system, charge amplifier, additional sensors or cabling, nor are there additional follow-up costs caused by maintenance and calibration. Setup time is reduced and there are fewer errors, as tests only have to be defined once. Furthermore, there are fewer errors during operation, since vibration control and continuous data recording are running in one system, using the same user interface. \\



1

1 // Time history recording in parallel to multichannel vibration control using m+p VibControl *(Photo: Airbus Defence and Space)*

ENABLING SMARTER AIRCRAFT TESTING

A range of data acquisition software solutions is the Swiss Army knife of noise and vibration testing, according to its makers

1

While safety remains the aircraft industry's number-one priority, market demands – such as better fuel economy, increased comfort, lower operating costs, and reduced emissions and noise levels – are forcing a rethink of traditional engineering methods. Successful programs must now deal with new materials and technologies, and greater complexity – all while staying within budget and on schedule.

The smart combination of aircraft system and structural simulation testing and services enables aircraft organizations to virtually analyze all aspects of aircraft performance in a unique, scalable way – from individual components to a fully integrated aircraft, from concept to certification – covering multiple physics, and addressing functional and detailed behavioral levels.

Achieving earlier aircraft maturity is key to an improved development process. Early maturity can only be realized if the starting point of the analysis is right – accurately predicting the noise and vibration behavior of the final integrated aircraft and getting optimal analysis results starts with getting full access to high-quality, reliable data. As part of its Simcenter portfolio, Siemens PLM Software offers a wide range of compact, scalable and modular data acquisition systems for aircraft noise and vibration testing – LMS SCADAS.

This data acquisition hardware provides aviation engineers with reliable results and optimal testing productivity. Seamlessly integrated with LMS Test.Lab, a suite of noise and vibration testing solutions, the hardware family offers accelerated measurement setup and correctly formatted results.

LMS SCADAS systems are all-in-one multitaskers. With a pocket-sized portable system, compact mobile units, autonomous smart recorders and high-channel-count laboratory systems, the range encompasses solutions for nearly any test campaign imaginable, both inflight and lab-based.

2

From day-to-day testing to specialty work, LMS SCADAS can handle all types of applications. It features integrated signal conditioning for a variety of transducers, such as microphones, accelerometers and strain gauges that allow the capture of a broad range of sensors in a single test run.

LMS SCADAS improves testing efficiency by enabling testing teams to skip traditional steps such as auto-ranging. Simplified test setups don't just save time – they eliminate risks as well. The data is delivered in the purest state possible – low noise, no unnecessary conversion and minimal human error.

A commercial, off-the-shelf platform, LMS SCADAS is a safe investment based on years of proven technology. As the Swiss Army knife of noise and vibration testing, it can be used for multiple purposes and in diverse settings. The hardware is designed for sustainability and is fully compatible with current modules and those still in the developmental stage.

1 // The LMS SCADAS range offers compact, scalable and modular data acquisition systems

2 // LMS SCADAS can provide solutions for almost any test campaign, whether inflight or lab-based

With its Simcenter portfolio, Siemens PLM Software provides dedicated simulation, engineering and testing solutions to help integrators and suppliers efficiently achieve earlier aircraft maturity, built on its experience with the aviation supply chain and the needs of engineering stakeholders. Simcenter testing solutions enable engineers to maximize testing productivity and efficiency on all levels. They offer added value throughout the development process, from design verification to acceptance and certification. Simcenter solutions provide in-depth engineering insight and help users increase their testing campaign productivity with traceable, efficient, smart, actionable data. \\

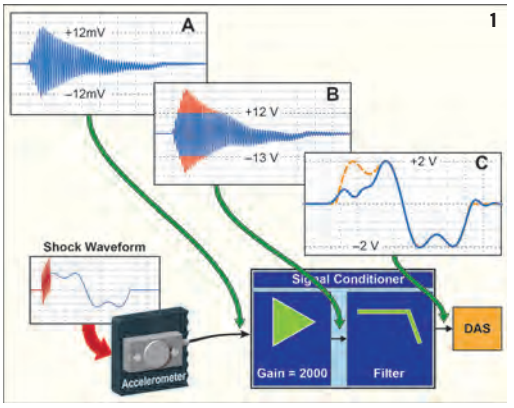
COLLECTING DATA FOR SHOCK MEASUREMENTS

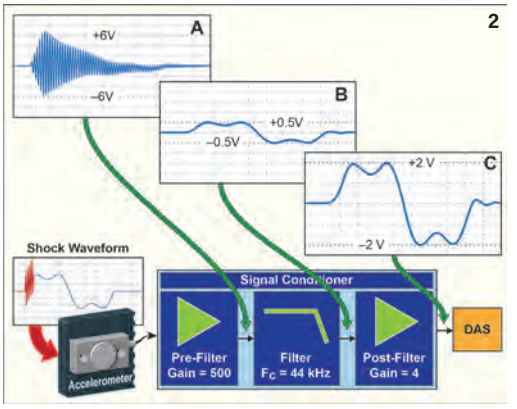
By distributing the gain around the low-pass filter, signal conditioners are helping to tackle the problem of data clipping

Collecting valid acceleration force or pressure data for shock measurements can be a difficult task, as the spectrally rich data can easily be contaminated by the measurement system. The sensor resonant frequency is an important element in the construction of the overall measurement system. Popular piezoelectric transducers used for shock measurements commonly have resonances ranging from 50kHz to more than 100kHz with Qs of 10, while piezoresistive types have resonances of several hundred kilohertz and Qs of 50 or more.

Higher resonances are advantageous, but it is difficult to condition the relatively small in-band signals in the presence of the large out-band ringing of the sensors. To illustrate the problem, we apply a test waveform to an accelerometer model at the same time we stimulate the accelerometer's resonance with the high-frequency burst. Assuming both the in-band test waveform and the out-band energy burst are both 100gpk and the piezoresistive accelerometer has a sensitivity of 10μV/g, we would expect to see waveform A, shown in Figure 1, at the input to the amplifier. If the signal conditioner has a full-scale output of 10V and we desire scaling to allow 500g of full-scale input, then we would require a channel gain of 2,000.

If a general-purpose amplifier was used, rather than an amplifier designed specifically for shock, it is likely that all of the channel gain was placed before the filter. If this signal conditioner was spanned for the expected in-band signal, it would saturate on the large out-band resonance and produce a distorted waveform bounded by the upper and lower signal swing capabilities of the amplifier. The limiting of the ideal waveform, often called 'clipping', results in a distorted signal, as shown in the blue trace in waveform B (Figure 1). It should be noted that the amplitude of the output waveform C is well below the full-scale signal level, leaving no 'warning signs' that the data should be considered suspect.





To solve this problem, Precision Filters' (PFI) signal conditioners distribute the gain around the low-pass filter, apportioning some gain before the filter which, based on a most conservative worst-case analysis, will not cause clipping. The balance of the required gain is placed after the low-pass filter, where, after removal of resonance, it will amplify only the desired in-band portion of the test data. As shown in Figure 2, with pre-filter gain of 500, waveform A is safely within the 10V operating range of the signal conditioner. The low-pass filter removes the out-band resonance, as shown in waveform B; then a post-filter gain of 4 establishes the required overall gain of 2,000, resulting in an undistorted representation of the test waveform (waveform C).

As shown in Figure 1, the low-pass filter will mask a 'clipped' condition, with no indication to the user that the data is invalid. A properly constructed shock signal conditioner must monitor the waveform prior to the low-pass filter and provide an indication that no internal clipping occurred during the transient shock event. PFI's amplifiers employ latching type overload detectors with a two-step 'arm and clear' methodology. Prior to a shock test, the overload detectors are cleared and armed. After the test, the overload registers are examined, to determine whether the amplifier clipped during the test, corrupting the test data. Many low-pass filter types can impart unwanted overshoot and ringing in response to shock inputs. PFI's PULSE mode filters provide outstanding transient response to shock-type waveforms, while maintaining a sharp transition slope from pass-band to stop-band, to attenuate transducer resonance and preserve in-band data. \\

1 // In-band signal distortion caused by clipping on an out-band sensor

2 // Using PFI's distributed gain to avoid clipping on sensor resonance

3 // PFI's 28000 multi-channel signal conditioning system

NEXT-LEVEL LIGHTNING VERIFICATION

How a new impulse generator is ideal for realistic lightning high-current testing of both large wind turbine and aerospace components

Lightning verification testing is becoming mandatory in the wind turbine industry, and several OEMs have experienced how full-scale testing using IEC waveforms provides valuable information on 'inflight' performance. During the past three years, the ELITE research team headed by Global Lightning Protection Services has developed a new set of generators to realize realistic lightning high-current testing to large wind turbine components, namely 80-100m wind turbine blades and complete nacelles.

The test equipment consists of a modular structure, where the different modules – named A, B/C and D banks – are designed to generate the first short stroke, the subsequent short stroke and the long stroke for the highest level of current amplitude and energy, as defined by IEC in the IEC 61400-24, IEC 62305, etc. Furthermore, the equipment enables the full range of direct effects current components for the aviation industry, as described in EUROCAE Ed 105A and SAE ARP 5416A, which every aircraft must comply with.

The main generator is the A-bank, a modular test generator consisting of 12 units, which can be distributed or clustered around the test object depending on the test sample impedance. Here, peak currents and specific energies exceeding 300kA and 30MJ/Ω are available. The avionics D-component can easily be generated by reconfiguring the A-bank with series resistances. The A-bank is mobile, and can be erected around the test setup within one working day.

2

1

The B/C generator is constructed around a powerful battery bank, the current output of which is controlled by power electronics, enabling an output window of 2kA x 1.5 seconds. The system output is defined prior to the test execution, such that the B-component of 2kA and 5ms is transitioned into the C-component of, for example, 400A within 0.5 seconds in one discharge. Once the generator is fired, the power electronics measures the current flow and controls its output until the exact charge of 210C (B+C component) is reached. Arbitrary combinations of B-C current components within the 2kA x 1.5 second window can also be defined.

Finally, the D-bank enables the generation of very fast front waveforms. The subsequent stroke in IEC terms is defined as a 50kA stroke current with 0.25µs rise-time and a decay time of 100µs, where particularly the induced voltages due to the current gradient and magnitude may cause interference with electronic systems. For the aircraft test requirements, the D-component is simply a reduced A-component, so here the ELITE generator is very well equipped.

The test setup is the most critical factor in the execution of the tests due to the large inductance of the full-scale test specimens.

1 // A total of 10 A-bank modules enable steep rise time pulses of full magnitude to be injected into a 70m wind turbine blade

2 // Direct effects testing enabled in a mechanical test facility for wind turbine blades, for realistic full-vehicle, full-threat testing

3 // The A-bank modules placed in two serial branches around a 70m wind turbine blade during direct effects testing

3

To ensure the success of the test, it is necessary to build up a test setup where the location of the generator and the current return path contribute in effectively compensating the inductance of the test specimen. The modular structure of the generator facilitates different arrangements for the test setup, where the individual modules can be distributed around the test specimen. Moreover, numerical simulation is used to identify the impedance of the specimen prior to the test and to design the most efficient layout of the generator modules and the current return path. The concept of modularity also enables the transportation of the generator and the execution of tests at any desired location, and it facilitates the maintenance and replacement of the individual modules.

In conclusion, the new ELITE impulse generator is an innovative tool that complies with the needs and requirements of both the wind turbine and aircraft industry, and contributes in the design of more efficient and robust lightning protection of components and systems, making them more capable to withstand a high exposure to lightning strikes involving large current amplitude, charge and specific energy. \\

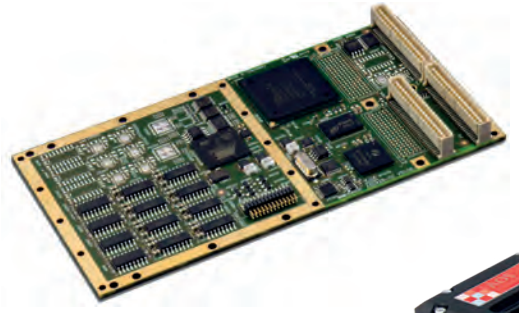
RUGGED AND READY WITH PMC

AIM has launched two variants of its PMC modules – the AMCE1553-x and AMCE429-x – and both are conduction-cooled PMC cards with low power consumption for rugged, embedded applications. The cards are qualified to ANSI/VITA 47 for vibration, shock, humidity, altitude and Class V3 Conduction Cooled/Class V2 for air cooled applications. AMCE cards provide conduction cooling, rear I/O and extended temperature range from -40°C to +85°C. Conformal coating is optional.

Onboard flash memory allows boot-up autonomously after power-up, so they are prepared for fast operational modes such as with the MIL-STD-1760. The DMA engine is optimized for bus transfers and low PCI utilization for real-time applications.

An onboard IRIG-B analog time decoder is included with sinusoidal output and free-wheeling mode for time-tag synchronization.

The AMCE1553-x has up to four dual redundant MIL-STD-1553 channels with eight Open/Ground Avionics Level (+35V) Discrete I/O signals plus Trigger I/O. Single-function variants of the cards are also available.



The AMCE429-x modules handle up to 32 fully programmable (Tx/Rx) ARINC429 channels with a maximum of eight Open/Ground Avionics Level (+35V) Discrete Inputs and eight Open/Ground Avionics Level (+35V) Discrete Output signals in addition to Trigger I/O.

An API programming interface is provided along with 32/64-bit operating system specific drivers for Windows 7/8/10, Linux and VxWorks.

LOW OUTGASSING FOR SPACE TESTS

Low outgassing accelerometers and cables can withstand exposure to the high vacuum level of a space environment, which often causes contaminants to be pulled out of accelerometers and cables. These contaminants from outgassing condense onto nearby components and potentially reduce their performance. PCB manufactures welded, hermetically sealed accelerometers and cables that use materials that conform to NASA guidelines to ensure low gassing. These low outgassing accelerometers and cables can be safely cycled through thermal vacuum chambers during the instrumentation phase of satellite assembly. These accelerometers are ideal for subsequent vibration testing and permanent mounting on the satellite without the risk of releasing contaminants.

PCB's new Model TLD356M131 is a low outgassing, hermetically sealed ICP triaxial accelerometer. It features a low thermal

coefficient from its quartz sensing element. It is ideal for environmental stress screening and HALT/HASS applications. TLD356M131 is rated for continuous cold storage at -190°C (-310°F) so it can remain on the satellite in space. \\

AIRBORNE HIGH-SPEED STREAMING SYSTEM

ASTREC-4 is a rugged, sealed camera controller that supports up to four H-EM high-speed streaming cameras. The unit is equipped with extensive non-volatile memory capacity for recording hours of high-speed events. The controller's cameras can record events during a complete mission in high speed, for later playback in slow motion and in-depth quantitative and qualitative analyses.

Recordings providing full coverage – particularly in rotary wing aircrafts, where it provides data for analysis that has not yet been possible. Once the system returns, the storage bay can be removed for analysis in the lab. This allows for a fast turnaround time of the test vehicle.

Typical users are manufacturers of aircraft, and test ranges for rotary and fixed wing aircrafts. The ASTREC-4 streaming system also fits applications for land-based tests. The four cameras generate a data rate of up to 3,000fps per camera directly into the non-volatile storage of the controller. Through an HD-SDI output, a live view is available to see the image data stream while recording in remote places, or have it connected to a telemetry link for ground station view. For synchronization of the camera, the built-in IRIG-B 122 receiver generates time stamps of every frame. Comprehensive Imaging Studio V4 software enables subsequent data analysis, playing back, and conversion of sequences into common movie formats. ASTREC-4 is tested and certified according to EMI 461 / MIL-810 and DO-160. \\

WORKFLOWS FOR HIGH-SPEED MOTION ANALYSIS

High-speed cameras are a critical tool used in the development of materials and testing in the aerospace industry. As the technology in these cameras continues to evolve, so does the pixel resolution and frame rate – and when it comes to motion analysis, these are the two fundamental attributes where more is better.

More frames-per-second (fps) and a higher pixel resolution equal a large file size. For example, a 1MP 12-bit camera at 1,000fps results in 1.5GB for every second of capture. A 4MP camera at the same frame rate will result in 6GB files per second, and with new 4K cameras such as the Phantom Flex4K-GS and VEO4K at 9MP, the result is over 13GB for every second of capture.

Camera RAM sizes have increased over the years to accommodate the hefty file sizes of extended recording. The main challenge with recording large files like this is the amount of time it takes to transfer the files from the camera. Typically, high-speed cameras use 1GB Ethernet as the main connection and download source, but downloading the full RAM of these cameras can take 20 minutes or more depending on the system.

Phantom cameras include several workflow solutions to solve this problem – from segmented RAM and continuous recording, to the ultra-fast CineMag recording media of UHS and Flex4K cameras, to 10GB Ethernet on VEO cameras, including the new Phantom VEO4K camera that captures up to 1,000fps at 4K resolution.

With 10GB Ethernet a 72GB, six-second recording can download in as little as two minutes.

These workflow solutions are paramount for keeping things moving during tests, and ensuring that high-speed cameras are always ready to do their job – capturing high-quality image data of the subject at hand. \\

ULTRA-HIGH-RESOLUTION DETECTOR FOR RADIOGRAPHIC INSPECTION

The newly developed DR 7 NDT CMOS detector from DÜRR NDT is available for digital radiography purposes. With a pixel pitch of just 19µm, an impressive basic spatial resolution of 25µm can be achieved. This enables the user to perform ultra-high-resolution radiographic examinations, with extremely low noise and brilliant images – making it a very attractive proposition for aerospace applications.

Because of its compact size (8.5 x 50 x 32mm) the detector is ideal for small tubes and other hard-to-reach places – or even inside an object. The advantage of placement inside an object is that this reduces the irradiated wall thickness, which leads to a shortening of the x-ray exposure time and an improvement of the image quality due to reduced scatter radiation.

To provide for efficient performance in a harsh test environment, the detector is equipped with a durable aluminum casing, and its active area of 36 x 26mm is protected by a strong carbon layer. Vibration and shocks are absorbed by the integrated shock absorber, so the CMOS chip remains unaffected by external influences.

The detector is directly connected and powered via the PC USB port. A 5m cable is included, which can be extended if necessary. In combination with the proven and DICONDE-compliant D-Tect software, all functions such as image acquisition, analysis, reporting, export, archiving and database management are supported. A user-friendly software interface allows for seamless integration into automated processes. \\

DENT DAMAGES MADE EASY WITH 3D NDT SOLUTION

Creaform brings an unprecedented powerful, easy, fast and accurate NDT solution for 3D assessments of dent damages located on aircraft surfaces. It includes a HandySCAN 3D scanner and SmartDENT 3D surface inspection software.

This dedicated software is the first on the market to offer 3D visualization. It also provides a guided workflow approach to simplify the measurement extraction of 3D scan data to get exactly the dimensions required for in-service aircraft assessments.

The goal is to greatly reduce operators' impact on measurement results and shorten the time to generate final reports. It saves users both time and money—without compromising diagnosis results and safety.

Creaform's NDT solution offers a number of benefits. It delivers reliable, repeatable, and accurate results regardless of user's level of experience. It also offers speed – results can be obtained 80 times faster than the pit gauge technique. A short learning curve and easy-to-use software ensure minimal training, while real-time 3D visualization and on-site instant reporting come as standard. Finally, as a portable, lightweight, and ergonomic device, it is easy to take from place to place and can easily reach confined areas. \\

Rugged measurement microphone for aerospace testing

Measurement microphone specialist GRAS has introduced the rugged 146AE microphone set, the world's only measurement microphone set with the accuracy of an IEC 61094-4/WS2F measurement microphone. It is shock-resistant, waterproof, dust- and oil mist-resistant, and able to withstand high temperatures – all without compromising measurement quality.

The 146AE microphone set is designed to operate in the harsh environments and conditions testers encounter in aerospace measurements, such as strong vibrations, shock, drop, extreme temperatures, and wet or dusty conditions.

The rugged design of the 146AE makes it possible to perform many different types of measurements in the same test setup, using only a single type of microphone.

Every detail of the 146AE microphone set has been developed to withstand even the most challenging measurement conditions, with materials and mechanical design carefully selected for optimal performance.

The 146AE is exposed to vibrations for 60 hours, kept in temperatures varying from -40°C to 125°C, dropped horizontally from 150cm onto a hard surface, and finally put through a tumbling test, randomly falling 100cm on a floor, more than 500 times.

With this new set, GRAS has bolstered its HALT test to reflect the harsh environments and conditions involved in real life, providing users with valid data, reliable repeatability and minimal downtime or re-tests. \\

FREE READER INQUIRY SERVICE

READER INQUIRY 112

GRAS

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

Index to advertisers

Goodbye to the Queen of the Skies

The world of aviation has begun to bid its final farewells to the Boeing 747 after the grounding of the oldest flying -100 and the final passenger flight in the USA of the -400

When Flight 158 from Seoul Incheon lands in Detroit in December, it will be the last passenger flight for a Boeing 747 in the USA, ending the final chapter of one of the most important aircraft ever produced.

Delta's final 747 flight comes a month after United Airlines retired its last 747-400 in November and follows the grounding of the oldest 747-100 still in service in August.

That aircraft, MSN 19651, was the 25th 747 to come off the production line in 1969, and was used by GE Aviation as a testbed for engine development. GE acquired the aircraft from Pan American Airlines in 1991. MSN 19651 amassed 122,000 of flight hours during 18,775 flights in its lifetime.

The 747-100 was the first of four variants – each with multiple versions. The aircraft was developed in the mid-1960s and took 50,000 employees 29 months to develop from conception to roll-out. Development costs are reported to have been US$1bn, plus the cost of the new plant in Everett, Washington. The plant had to be built so that the 747 could be assembled and today it remains the largest building in the world, by volume. More than 1,500 747s have been manufactured in it over the last 50 years.

Of the 747's many innovations, perhaps the most impressive is the development of its high-bypass turbofan jet engines. The design also included structural redundancy and redundant hydraulics, quadruple landing gear, and dual-control surfaces to address concerns about flyability and safety.

Less obviously, but no less significantly, the 747 was also one of the first aircraft to be designed using fault tree analysis methodology. This enables engineers to study how the failure of a single part will affect the aircraft's other systems.

Flight tests of the 747-100 in 1969 uncovered several problems. Crucially, the JT-9D engines developed by Pratt & Whitney were not powerful enough to deal with the increases in weight and size made since early designs. The problems weren't solved until a year after the aircraft had been in service.

Sales of the 747 took off in the late 1970s and by the 1980s Boeing began developing the 747-300, which had a 23ft (7m) longer flight deck than the 747-100. Design of the 747-400 began in 1985. The larger aircraft, which could accommodate up to 524 passengers, had a larger range, an extended upper deck and 6ft (1.8m) winglets to reduce drag. It entered service in 1989.

Delta Flight 158 isn't quite the final ever passenger flight for a 747. Boeing continues to offer the 747-8, although slower than expected sales of the passenger variant mean that this may soon end. Boeing 747s will still be used by carriers outside of the USA, although those too are being phased out. However, many will continue to be used for cargo.

Many aircraft are labeled iconic, but few deserve it as much as the 747 – the original jumbo jet, which slashed the cost of air travel and changed the nature of it forever. A long, nostalgic goodbye is the least the 747 deserves. \\

FEB. 9, 1969
First flight

747-100
Model number

195FT 8IN
Span

231FT 4IN
Length

710,000 LB
Max. weight

602MPH
Top speed

563MPH
Cruising speed

6,090 MILES
Range at full load

45,100FT
Ceiling

46,500 LBF
Thrust of each of the four Pratt & Whitney JT9D-7 engines

3 CREW
Pilot, co-pilot, flight engineer

URL for first flight film:
WWW.YOUTUBE.COM/WATCH?V=AHBPTAHG7X4

Test and Measurement Technology.
Designed for You.

Gantner instruments

Q.series

Intelligent Solutions for Test Automation and Performance Monitoring

For your data-critical applications:

Validation and Certification of Aircraft Components and Systems, End-of-Line Testing, Structural Health Monitoring.

- Distributed and flexible
- Dynamic signal conditioning up to 100 kHz
- Precise nanosecond time synchronization
- Galvanic isolation of all inputs and outputs
- Repeatable test results due to minimal signal drift
- Open standards support for reliable interoperability

Q.raxx

Q.bloxx

Q.brixx

test.commander

Gantner Instruments Test & Measurement GmbH

www.gantner-instruments.com

Austria: Tel. +43 5556 77463 - 0
office@gantner-instruments.com

Germany: Tel. +49 6151 95136 - 0
testing@gantner-instruments.com


SIEMENS
Ingenuity for life
Today's dreams need tomorrow's engineering.
Simcenter: Predictive engineering analytics for the new era of smart innovation.
Getting a dream off the ground has never been more challenging. Products need to be smarter. Manufacturing processes are more complex. And design cycles are shorter than ever. Simcenter software can help. With its unique combination of multi-disciplinary simulation, advanced testing and data analytics, Simcenter gives you the power to explore alternatives faster, predict performance more accurately... and deliver innovation with greater confidence.
siemens.com/plm/simcenter