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MARCH 2012

AEROSPACE TESTING INTERNATIONAL

F-35 strike force

The F-35 has begun weapon separation tests: head of the JSF program, and arguably the leading man in military aircraft development, talks fighters

Red alert

As the MSL hurtles toward the Red Planet – a look at the critical test of the Mars lander engines

Off-the-shelf

The Italian Aerospace Research Center has a unique approach to testing UAS: a flying laboratory

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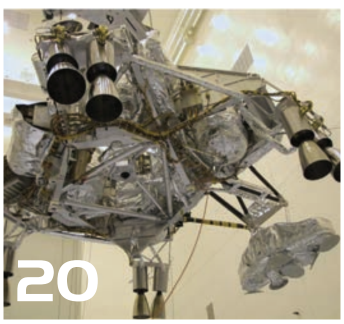

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Rapid Control Prototyping | Autocoding | HIL Testing

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

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

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

During the 1980s, my late father (a senior airline and trial captain for, first, British Caledonian and then British Airways) used to fly primarily the African routes from the UK and down to South America. His return journey from the likes of Brazil and Chile to London, normally at night, were to him the Achilles heel of flying; the pilots' equivalent of the Cape of Good Hope to sailors. He hated it, as it was never easy to fly at the best of times. There is a reason for this.

Either side of the equator weather systems rotate in opposite directions, producing a line of conflict. The Earth's atmosphere is much thicker near the equator, and this area is the birthplace of hurricanes. The warm southern Atlantic picks up moisture against the colder northern Atlantic, at a critical point where the African continent is remarkably close to that of South America. At the same time there is a difference in trade winds, Earth's circulation and differing rainy seasons between continents. To cut a very complicated meteorological story short: this is the most hair-raising stormy region in the world. On June 1, 2009, Air France 447 flew right through it, on a bad night, and plunged into the Atlantic Ocean, killing all 228 people on board.

The Airbus 330's flight-data recorders didn't turn up until two years later. Until then it had been a mystery as to why this ultra-modern aircraft vanished off the radar. Initially, the fly-by-wire technology was thought to have overridden pilot intention. But the answer was simpler than expected.

The transcript from the cockpit shows chaos, confusion, failure and misunderstanding between the pilots. Ultimately, blame has been put on pilot error after technical malfunction – finally exonerating Airbus. The harrowing communication between the pilots during the 15 minutes prior to the catastrophe shows what really happened that stormy night.

While the captain rested in the back, the two much less experienced co-pilots naively ascended and descended through the storm trying to take control of the aircraft after sensors were iced over and the autopilot disengaged. The stall warning had blared 75 times by the time the captain arrived on the flight deck. This conversation took place just three minutes before the crash:
Captain: "What the hell are you doing?!"
Co-pilot: "We've lost control of the plane! We've totally lost control of the plane. We don't understand at all… We've tried everything."
Other co-pilot: "Climb… climb… climb…"
Captain: "No, no, no… Don't climb… no, no."

The aircraft needed to pick up speed, but it was too late, too close to the sea. Just 45 seconds later the aircraft disappeared.

As a youngster I was enthralled by a story my father shared with me after returning from a long stint 'down the line' in South America. While flying through an extraordinarily violent electrical storm stretching to the higher reaches of the atmosphere, his aircraft – I think it was a DC-10 – was struck by lightning. By design, the lightning bolt passed around the skin, but somehow an element of charge followed the avionics to the flight deck, and an apparently very unusual electrical phenomena occurred: a 'ball of lightning' in the cockpit. According to Captain Hounsfield, it was slightly smaller than a football, formed in mid-air, and bounced around the cockpit for several seconds, causing major flares on any surface it hit, then dissipated. It didn't cause any major damage, although they did lose displays – but they were all trained to handle this situation. Where did it happen? Over the mid-Atlantic just south of the Cape Verde Islands.

I discussed the AF447 crash with my father, and his verdict was that this was the one place in the world that, when flying at night, you truly had to have your wits about you, and to know how to fly. He said the cause would have been a lack of pilot training. This was before the black box was recovered.

The pilots flying AF447 could have saved the airplane after it temporarily lost its speed readings, concluded France's air investigation authority, the Bureau d'Enquêtes et d'Analyses (BEA). Instead, they did the opposite of what was required, pulling up the aircraft to a height at which it stalled and fell from the sky at 10,000ft per minute. "The situation was salvageable," Jean Paul Troadec, BEA director, told reporters.

However, from a 'test' angle it does highlight that when an aircraft that is so highly automated fails, and the pilots rely so heavily on this technology, it is a very dangerous situation. Some big questions arise. My father always said that all pilots must be able to cope with *every* eventuality. He was old school.

Christopher Hounsfield, editor

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Quick review for F-35 strike fighter program

A high-powered Pentagon review team has identified a batch of serious technical issues that have the potential to further drive up costs and add to delays on the F-35 program.

The F-35 Joint Strike Fighter Concurrency Quick Look Review was obtained by the Project on Government Oversight non-governmental organization and made public, leading to some uncomfortable media coverage for the Pentagon's JSF program office and the main contractor Lockheed Martin.

While the review team said there were not any "fundamental design risks sufficient to preclude further production", they did find 13 major issues that led them to question the central tenet of the current JSF procurement plan. The tenet, known as concurrency, calls for JSF production to be ramped-up, with more than 500 aircraft being purchased by 2017 ahead of the design of the aircraft being finalized. The team said this would risk incurring billions of dollars in modification costs to bring early production aircraft up to the definitive standard, and that the production ramp-up should be delayed until the F-35 design was more mature. Concurrency is a problem that has plagued military aircraft projects in recent years, leading to US$2 billion in cost overruns to the Lockheed Martin F-22 Raptor fighter, and significantly contributing to the cancellation of the BAE System Nimrod MRA4 by the UK government.

The Quick Look Review found five issues where major consequence issues have been identified, but where root cause and corrective actions are still in development. These included issues with the F-35's helmet-mounted display system, fuel dump subsystem, integrated power package, arresting gear system on the CV variant, and a classified issue believed to be related to the JSF's stealth capability. Three issues – buffet, fatigue life, and test execution – were identified where potentially major consequences are still pending outcomes of further discovery work. Five issues – software, weight management, thermal concerns, autonomic logistics information system, and lightning protection – were identified where consequence or cost is moderate, but where the number of moderate issues poses a cumulative concurrency risk.

Given that the F-35 is at an early stage of flight testing, the QLR team believes it is likely that more problems will come to light.

ONGOING CHANGE REQUESTS

The review called into question the large amount of 'concurrency' built into the F-35 program. "Concurrency is present to some degree in virtually all US Department of Defense programs, though not to the extent that it is on the F-35," the report notes, adding "…the quantity of major change requests from June 2010 to November 2011 is a concern. Currently, there are 725 change requests in the process at the engineering kick-off stage, 696 change requests at the engineering release stage, 538 change requests awaiting manufacturing bill of materials release, and 148 change requests available awaiting implementation."

Undercarriage test bench ready

The A350 XWB's main and nose landing gear test bench is ready for service at Airbus's site in Filton, UK. This latest step in the A350 XWB's progress is achieved more than one year before the aircraft's first flight, and two years before its entry into service.

Extensive testing campaigns are being carried out for all A350 XWBs systems and components well ahead of the first flight. This will ensure the aircraft has a high level of performance, reliability, and maturity built-in from day one.

Wing checks on A380s

European aviation safety authorities have ordered airlines to inspect the wings of 20 Airbus A380 airliners after cracks were found in aircraft operated by Qantas and Singapore International Airlines.

However, the European Aviation Safety Agency did not classify the inspections of the giant 853-seat, double-deck aircraft as an ‘emergency action’ and said the cracks had been found in the ‘non-critical’ wing rib feet that connect the aircraft’s skin with the airframe.

None of the aircraft – all of which were built early in the production run – have been grounded and operators said the inspections would not impact on service schedules. Any operator discovering cracks in the rib feet is required to contact Airbus for instructions. The small cracks have been blamed on small brackets manufactured at the Airbus Filton facility in the UK. The manufacturer has been forced to order a global recall fix for the offending aluminum brackets that hold the wing’s skin to the structure.

PROVISIONAL TYPE CERTIFICATE FOR G280

The Gulfstream G280 has received a provisional type certificate (PTC) from the FAA. It obtained a PTC from the Civil Aviation Authority of Israel (CAAI) on December 29, 2011.

The principal remaining item required before full type certificates are issued by the FAA and CAAI is an update to the software for the aircraft’s state-of-the-art avionics. Gulfstream expects to receive full type certification from both later this year.

“The G280 will be the fastest, largest, most comfortable aircraft in its class, and we are very pleased with its performance throughout the flight-test program,” said Larry Flynn, president, Gulfstream. “With these certificates in hand, we are now able to move forward in preparation for customer deliveries later this year, as scheduled.”

Amphibious assault Merlin helicopter for UK?

UK Royal Navy officers are continuing to push hard to secure future funding for the conversion of the 22 AgustaWestland Merlin HC.3s and six ex-Danish HC.3As into amphibious assault helicopters.

The project, which will enable the service’s Commando Helicopter Force (CHF) to retire its 38 1970s vintage Westland Sea King HC.4s by 2016 and sustain a rotary wing support capability for Royal Marines amphibious landing forces, is still awaiting the go-ahead from UK Ministry of Defence chiefs.

A Royal Navy briefing document says this Merlin conversion is now designated the Merlin Life Sustainment Programme (MLSP), and that it will futureproof the redesignated Merlin HC.4 helicopters and reduce long-term support costs. This will go hand-in-hand with the transfer of the Merlin HC.3 from the Royal Air Force to the Royal Navy’s CHF.

The MLSP project is deemed necessary ‘to address critical obsolescence issues that will start to affect the current Merlin HC.3 fleet in the middle of this decade’. This includes the installation of a new cockpit and avionics of the same standard as those being currently installed in Royal Navy’s Merlin HM.2s as part of the Merlin Capability Sustainment Programme.

According to the briefing, ‘In this way [the ministry] will see improvements in the support and management of the Merlin fleet by having common spares for the Merlin HM.2 and HC.4 fleets. This will also deliver efficiencies in training for both maintainers and aircrew.’

In addition, the Merlin HC.4 will be fitted with a powered folding main rotor head and tail pylon to enable stowage and maintenance of the aircraft in the hanger of the helicopter carrier HMS Ocean or the two new Queen Elizabeth class aircraft carriers. Other ‘maritime enabler’ improvements include a radar identification

Secret US drones exposed

A veil was lifted on US projects to build 'stealth' unmanned aerial vehicles (UAVs) in December 2012, when the Iranian Revolutionary Guards broadcast video imagery of a Lockheed Martin RQ-170 Sentinel drone.

Tehran's elite force claimed to have gained control of the futurist drone by 'hacking' into its compute control system and forcing it to land deep inside Iran.

Not surprisingly, the Pentagon was tight-lipped about the loss of the advanced drone that was operating over Iran without the permission of the Middle Eastern country's hardline Islamic regime. The US authorities claimed they had lost control of the RQ-170 during a mission over Afghanistan. Given heightened tension over the Iranian nuclear program, the official explanation by the US government did not gain much traction.

The United States Air Force revealed the existence of the RQ-170 in 2009. It had been nicknamed the 'Beast of Kandahar' after grainy photographs had been published on aviation enthusiast websites. Since 2007, rumors that the UAV was flying from the Afghan base had been rife. The RQ-170 played a key role in the May 2011 special forces operation to kill al-Qaeda chief Osama bin Laden, using its stealth capabilities to penetrate Pakistani airspace without being detected.

The video imagery released by the Iranians appeared to show that the RQ-170 had been recovered relatively intact. However, close examination of the remains put on show by the Iranians suggests that their claims to have 'taken control' of the UAV may not be the case, and that a violent crash did in fact take place. The Iranians covered up the RQ-170's underside with curtain, implying that it had been badly damaged in a forced landing. Also there appeared to be several new 'welds' on the wings and new painting, suggesting that the Iranians had rebuilt the RQ-170 before they put it on display.

While the Americans will be unhappy that the Iranians have recovered the RQ-170, the US authorities must have factored in the possibility that one might be lost and captured on a high-risk mission over or near Iranian territory. The Iranians have a long tradition of re-engineering aircraft and missiles, so even if Tehran has not gained access to the 'crown jewels' of the RQ-170, which are likely to reside in its ground control system, their aerospace industry will have gained exposure to advanced stealth materials and shapes, modern electro-optical systems, the latest generation of drone flight control systems, and miniaturized power systems.

NOT-SO-SECRET DRONE TEST SITE

Equally as intriguing as the RQ-170 incident was the revelation in December 2011 that the US government was operating a previously undisclosed drone test site at Yucca Lake in Nevada. From commercial satellite imagery available on the Google Earth website, the distinctive shape of General Atomics' MQ-9 Reaper UAV could be seen on an airstrip inside the Tonopah test range. The site, officially controlled by the US Department of Energy, had not previously been associated with US drone operations, leading to speculation that it was the test facility used by the CIA to develop future UAV systems and capabilities.

The RQ-170 event recalled the loss of a CIA Lockheed U-2 spy plane over Russia in 1960, although in this case there was no pilot to capture. There is clearly a new secret 'arms race' underway to build the next generation of spy drones.

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system, flotation gear, Telebrief equipment, and lashing points for deck operations at sea.

The delay in the Merlin HC.4 project is linked to a move by the UK Defence Secretary Philip Hammond to put off a decision on the rotary-wing capability study until later in 2012. The study was billed as providing a new road map for the UK helicopter force's structure, basing, procurement, and logistic support arrangements. At the heart of the strategy was finding a way to match a £1 billion cut in the budget for helicopter programs over the next 10 years with the UK government's commitment to launch an £841 million (approx. US$1,327 million) project to buy 14 new Boeing Chinook heavy-lift helicopters and to sustain a high operational tempo in Afghanistan.

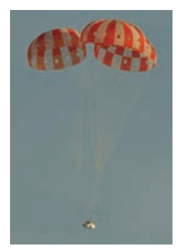
The ministry's highest decision-making body, the Defence Board, under Hammond's chairmanship, considered the study at its meeting on December 16, 2011, after the board's equipment subcommittee looked at a draft in detail the day before. Senior ministry officials say the strategy will now be rolled into decisions over the 2012 spending round (PR12) to be concluded by the end of March 2012.

DECISION TIME

The outcome will also decide the fate of projects to upgrade Westland Puma HC.1 support helicopters, a major upgrade of the Army Air Corps AgustaWestland Apache AH.1 Apache attack helicopters, and an accelerated retirement of 1970s vintage Westland Lynx AH.7 and Gazelle AH.1 utility helicopters.

A ministry spokesman said, "We are currently undertaking a rotary-wing capability study in order to ensure that we have the right structures and forces in place to deliver the plans outlined in the Strategic Defence and Security Review. The study is progressing and we are now conducting more detailed work, which is expected to conclude in 2012."

NASA CONTINUES ORION PARACHUTE TRIALS



A successful drop test of the Orion crew vehicle's entry, descent, and landing parachutes has been completed high above the Arizona desert in preparation for the vehicle's orbital flight test in 2014.

Orion will carry astronauts deeper into space than ever before, will provide emergency abort capability, and will sustain the crew during space travel and ensure a safe re-entry and landing.

An Air Force C-17 plane dropped a test version of Orion from an altitude of 25,000ft above the US Army's Yuma Proving Ground, Arizona. Orion's drogue chutes were deployed between 15,000 and 20,000ft, followed by the pilot parachutes, which then deployed the main landing parachutes, successfully.

Green APU undergoes trials

Civil aircraft could cut their on-ground emissions by a quarter if new technology allows them to be to moved around airports without using their main engines.

Last year, scientists and engineers in Germany carried out trials on electric-powered undercarriages that will significantly help the aviation industry meet future stringent aviation emissions targets.

For short-haul aircraft that often take-off and land seven times a day, this could save between 200 and 400 liters of aviation fuel per day, while reducing noise by around 95%, without the use of towing vehicles.

Lufthansa and the German arm of the US technology company L-3 Communications conducted taxi trials with an Airbus A320 equipped with electrical motors on both main landing gears (MLGs) at Frankfurt airport last December. The trials were part of a feasibility study to gain initial operational experience and data about an MLG-fitted electrical drive system. The motors and control units were temporarily installed on the aircraft and are based on existing industrial components manufactured by L-3's Magnet Motor subsidiary in Starnberg, near Munich, and already in use on other applications such as ground vehicles.

An engineering team comprising staff from Airbus, L-3, and Lufthansa Technik (LHT) replaced the brake assemblies of the inboard MLG wheels with drive units, each one containing a liquid-cooled electrical motor, powered by the aircraft's APU, and a planetary gearbox.

Power supply cables and coolant hoses were installed along the rear of the MLG, across the landing flap trailing edge, upper wing surface, and through opened passenger windows into the aircraft's interior.

The pilots reported that the demonstrator system not only handled well, but was more responsive than the main engines normally used for the task, said Christian Mutz, project manager innovation at LHT.

The aircraft test team trialed a broad range of ground maneuvers, including sustained taxiing up to a maximum speed of 25km/h (13.5kts), a 180° turn on a 40m-wide (130ft) taxiway, runs on sloped surfaces, and various self-powered reverse movements.

Despite strong winds, with gusts up to 70kts, no adverse handling was encountered with the electric taxiing system, said Mutz.

ELECTROLYTE FUEL CELL

Researchers at the German Aerospace Center (DLR), supported by Airbus and Lufthansa, are working on a more revolutionary design that uses a low-temperature polymer electrolyte fuel cell driven by hydrogen, and can provide ground propulsion for an aircraft weighing up to 70 tons.

It allows the pilot to turn off the main engines one minute after landing and not turn them on until between three and five minutes before take-off, in order to heat them up. This means the engines could be used 1,200 hours less per year.

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TAKE IT TO THE MAX

The final phase of wind tunnel testing, a major milestone in airplane development, has begun on the Boeing 737 MAX program.

"Wind tunnel testing is on the critical design path of the program," said Michael Teal, chief project engineer and deputy program manager, 737 MAX program. "Based on previous work in the wind tunnel, we are confident this final phase of testing will substantiate our predictions of the aerodynamic performance of the airplane."

Testing will begin at QinetiQ's test facility in Farnborough, UK, where engineers will substantiate the forecasted low-speed performance of the 737 MAX on take-off and landing. A FTSE 250 company, QinetiQ uses its domain knowledge to provide technical advice to customers in the global aerospace, defense, and security markets.

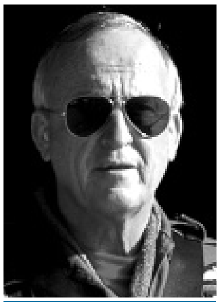
DREAM ENGINE CERTIFICATION

All flight tests expected to be required for type certification of the 787-8 Dreamliner with General Electric GEnx engines have now been completed according to Boeing. This marks the end of all certification flight testing associated with the baseline model of the 787. Testing on engine and airframe improvements will continue as needed, as it does for all airplane programs.

Ground testing to complete certification requirements has also concluded. "The last phase of testing focused on extended operations on board a production airplane," said Mike Sinnett, vice president and chief project engineer, 787 program. "The airplane performed beautifully during this testing, further demonstrating its reliability."

The final flight concluded late last month with the landing of the 35th 787 built.

Flight testing is one of many elements reviewed by the FAA before it certifies a new airplane type. Certification of the 787 Dreamliner with Rolls-Royce engines was completed in August 2011. Each new combination of airframe type and engine requires additional certification.



System safety

WHICH IS SAFER, MILITARY OR CIVIL CERTIFICATION TESTING?

BY DES BARKER

Certification testing challenges exist in those air forces that possess their own flight test organizations, especially those that are mandated to certify military equipment and conduct 'Release to Service' testing. In such cases, the philosophies of certification for military and civil aircraft could be in conflict.

Air force project officers driving system safety in some military flight test organizations are, interestingly enough, divided into two strongly opposing opinion camps on what constitutes the acceptable safety level for the acquisition of new aircraft to an air force inventory. What is worth mentioning, though, is that on the one hand, civil aircraft operate under statutes imposed by civil regulation authorities while military aircraft operate under state prerogative and their certification resides within the remit of the departments of defense.

Adding to the consternation, is the complexity and comprehensiveness of the system safety process in flight test, which has increased substantially over the years and has become manpower- and time-intensive. The regulations and System Safety processes have had to be stringently adapted for compliance with both the basic principles for safety of flight and also the regulations governing occupational health and safety, which has a direct bearing on the responsibility, accountability, authority and liability toward safety management and also technical airworthiness of the air vehicle.

The fundamental objective of the system safety process is to identify, eliminate, and document hazards of the system under test. It is essential that a systems approach to flight safety is taken during experimental and developmental flight test phases. This implies the application of a systematic, formalized approach to safety management that includes regular safety reviews of the system under test.

Importantly, the system safety process is proactive, providing the necessary audit function, risk assessment, risk classification, evaluation of modifications and changes, and monitoring of the effects of such modifications on safety margins. Remedial action is determined and non-compliance is monitored. The system safety process therefore documents the particular system comprehensively, identifies potential hazards, records risk assessments, demonstrates that the risks are controlled, and identifies the requirements for assessing change and the management of deficiencies.

The question can quite rightly be asked, why has the system safety process grown to such as extent? Where does an air force stand in relation to civilian standards regarding the acceptance criteria for aircraft?

Well, very basically, the ethical demands on industry as a result of the advances in technology, the demands from professional societies, public and political advocacy groups, and the law, and corporate concerns for profit and image have all played their parts in driving the worldwide impetus for increased quality-assurance standards.

But there is certainly a fundamental difference between the basic design considerations of military versus civilian aircraft. For example, the flight control system on a modern airliner would typically be provided with quadruplex redundancy and a military fighter would be provided with only triplex redundancy. The typical airliner has several back-up systems to negate the effects of a total electrical failure; these include auxiliary power sources that provide soft failure cases before leading up to a hard failure mode by means of standalone batteries. In the case of a military fighter, however, 10 to 15 minutes of battery power is typically provided. It is therefore clear that in the military world, the redundancy following failure is significantly less sophisticated than for civilian aircraft.

> **"There is certainly a fundamental difference between the basic design considerations of military versus civilian aircraft"**

Not only is there a difference in philosophies between civil and military airworthiness standards, but there is also a difference between countries. Many of the countries with large aerospace industries have, over the years, developed their own standards – such as the MIL-Specs and Federal Aviation Regulations (FAR) in the USA, and the British Civil Airworthiness Regulations (BCAR) and Joint Airworthiness Regulations (JAR) in the UK.

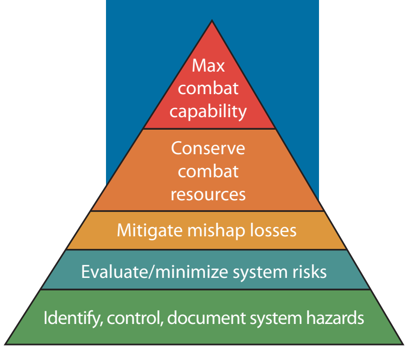
Looking back at certification over the years, it is apparent that safety was mostly implemented by compliance methods – standards such as MIL-STD and specifications such as MIL-Spec. The fallacy was that meeting minimum standards made the system safe. Unfortunately, standards do not often apply to an entire system and also often fail to consider the entire system lifetime. In addition, regulatory requirements often do not keep up with technology advances and quickly become inappropriate for systems under test.

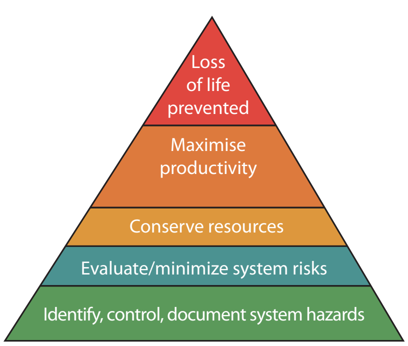
So, what about the philosophical differences between military and civilian acceptance criteria? Well, there are two main differences. For the military, the primary criteria are the prevention of the loss of combat capability, and catastrophic losses in terms of injury, property damage, and the environmental impact from a single mishap.

The civilian or commercial aim, however, is primarily to prevent loss of life, or system life. Although the military and civil certification acceptance criteria are essentially similar, the final drivers and acceptance criteria may differ fundamentally in philosophy. Certification and acceptance authorities would do well to understand the essential differences in philosophy that could exist and adapt accordingly. ∎

Des Barker is the former senior test pilot for the South African Air Force

Objectives of the military system (left). Objectives of the civil system (right)





Freedom from the press

KEEPING A FEW SECRETS FROM THE MEDIA AND THE PUBLIC MAKES MOJAVE ONE OF THE WORLD'S GREATEST TEST GROUNDS

BY MICHAEL BELFIORE

For Stuart Witt, there's nothing sweeter than the sight of construction in progress. He's the general manager and CEO of Mojave Air and Spaceport, 90 miles north of Los Angeles. In January 2012, he drove me out nearly to the end of Runway 3-0's 12,500ft length in the white SUV known as Mojave One, and showed me the fruits of the biggest construction project he has overseen at the airport.

A 20-acre patch of cleared desert opens right out onto the runway. Earthmoving trucks are busy making the spot ready for a fabrication building and a hangar for a new 1.2 million lb turbofan-powered airplane with a 385ft wingspan. Its builder, Scaled Composites, expects it to be the world's largest airplane when ready for flight testing in 2015.

Although it's the biggest, it is only the latest in a series of aerospace test projects that have made Mojave one of the most acclaimed facilities of its kind in the world. Here, the first non-stop around-the-world airplane took flight; the first non-stop, around-the-world jet; and the first civilian-built manned spacecraft.

Mojave's innovative air and spacecraft aren't the products of major government agencies or large defense contractors. In fact, the work underway in its unremarkable-looking collection of hangars in the Mojave Desert is mainly by small private companies. Key to their success, says Witt, is their ability to keep their designs away from prying eyes.

Four Skunkworks-style projects in progress at Mojave

XEUS
Masten Space Systems plans to attach four of its 3,500 lb thrust propulsion modules to a United Launch Alliance Centaur booster rocket to test planetary landings that would be less disruptive to sites of scientific interest than more conventional single-engine touchdowns. Masten acquired the fuel tank in secret and moved it out of sight into an unmarked hangar while it finalized details of the design for the testing.

Lynx
XCOR Aerospace has quietly funded its space flight ambitions by finding individual customers for its rocket engines, fuel pumps, and other technologies. It is now assembling those components into a suborbital rocketplane capable of ferrying a pilot and either a paying passenger or a science package out of the atmosphere. The company plans to begin flight testing by the end of 2012.

SpaceShipTwo
Scaled Composites keeps its flight test schedule and rocket engine development for the world's most publicized private spaceship strictly under wraps, as it has for all of its previous air and spacecraft. Its customer, Virgin Galactic, says rocket-powered test flights should commence this year.

M351
Scaled Composites was revealed as the contractor for the Stratolaunch launch aircraft last December. By then, upgrades needed for it at Mojave Air and Spaceport were well underway, as was design work for the airplane-and-booster-rocket combo. The booster rocket will be built by Space Exploration Technologies.

Masten Space Systems' proposed multi-engine dual thrust axis lander

"What drove Orville and Wilbur to Kitty Hawk," Witt says, "was freedom from encroachment of the press, freedom from industrial espionage, and a steady breeze."

Aleta Jackson, one of the founding engineers of XCOR Aerospace, agrees that privacy and the ability to keep secrets is a major selling point of doing research and development at Mojave. "People play their cards close to their chests," she says. "Generally, the people who are not supposed to know [about a secret project] who find out, don't say anything. There's a general sense in the community that, 'Oh, I saw something I shouldn't have seen, therefore I'm not going to talk about it'."

That is why, says Witt, the announcement of a new company called Stratolaunch, for which the world's largest airplane is being built as a high-altitude launch vehicle, came as a surprise to everyone who wasn't involved in the project – not just to the press. "I've been working on this subject long enough to lengthen runways, widen runways, build taxiways, find a place on the airport where we could build a hangar big enough," says Witt with some satisfaction. "The fact that we were able to keep this under wraps for nearly nine years says that we still enjoy the three elements that took Orville and Wilber to Kitty Hawk." ∎

Michael Belfiore is the author of Rocketeers: How a Visionary Band of Business Leaders, Engineers, and Pilots Is Boldly Privatizing Space. Web: www.michaelbelfiore.com

Law of the land

GIVEN THE STRESSES AND STRAINS PUT ON AN AIRCRAFT'S LANDING GEAR, IT IS IMPERATIVE THAT THESE COMPONENTS ARE SUBJECTED TO VIGOROUS TESTING, BOTH BEFORE AND DURING SERVICE

BY JOHN CHALLEN

When people refer to integration testing in the aerospace industry, the evaluation of an airplane's landing gear must be up there with the most important tasks to be completed. The need for faultless deployment of the landing legs, coupled with the fact that these items are responsible for landing crafts that can weigh upward of one million pounds, means a lot of work is done early in an aircraft's development to get the whole process just right.

One company that knows plenty about what to do and, more importantly, what not to do when it comes to landing-gear evaluation is Goodrich. As one of the industry's major landing system suppliers for commercial and military applications, it lays claim to be the world's largest landing-gear test facility. The site, in Ontario, Canada, opened in 2005 to accommodate the Airbus A380's landing gear, and houses one 'super rig' that stands at more than 24ft high, as well as numerous other rigs for endurance testing.

"We do several tests for a typical landing-gear program for certification, and we have capabilities to complete all the component-level testing for landing-gear equipment," says Paul Lavigne, the company's director of design engineering. "These tests include: strength testing, to demonstrate static margins for the products; fatigue testing, for proving the structural life of the products; retraction endurance testing, to demonstrate functional aspects and wear rates; and drop testing, for performance validation of the shock absorbers themselves." Lavigne adds that, when required, steering tests are carried out for endurance, strength, and fatigue.

Undercarriage facility

An important product offering to come out of the Ontario test facility more recently is the ability to offer HALT (highly accelerated life test) and HASS (highly accelerated stress screen) evaluations. "We also offer interaction testing, for systems equipment, and various forms of environmental testing, at high and low temperatures at gear level, as well as vibration testing," adds Lavigne.

A wide arrange of tests, then – but, says the company, the size of the site is as important as what it actually offers. "The advantage of a facility such as ours is its range of capabilities," says Gerry Kouverianos, vice president of business support at Goodrich. "We have the ability to work on small and large gears that can be integrated into an airplane weighing from 23,000 to 1.2 million pounds."

Every program that Goodrich undertakes may have different requirements, but the approach to testing is largely the same, regardless of the eventual use of the aircraft. "In general, we start with dynamic analysis, taking into consideration the landing conditions and requirements from the airplane's perspective," explains Kouverianos. "If it is landing gear, we make these predictions, and during drop-testing we simulate the situation, and ensure that what we have done represents the analytical case.

"Other scenarios, such as for a helicopter, have different requirements from a typical airplane, and we have to test for a typical crash case," he adds. "The landing gear is designed to perform in a specific way during a crash, so we have valves that blow the hydraulic fluids through them and we absorb the energy, for example. In this scenario, there are components that collapse in a controlled manner to ensure you stay within the specified *g*-force loading."

Despite being less than 10 years old, Goodrich is constantly looking to upgrade and improve the test facility, admits Lavigne. "We've looked at automated testing, data archiving and retrieval, and have made improvements in our greasing philosophies and test processes," he explains. "Over the past couple of years we have introduced the HALT/HASS chamber for reliability testing, and the future is more dependent on making sure we have the right equipment and infrastructure for testing to support our strategy for future programs. We will invest accordingly to support those programs, which are a good mix between military and commercial projects."

The Airbus evaluation

Despite receiving fully tested landing gear, Goodrich client Airbus still undertakes a series of measures at its center in Filton, UK, to ensure that proper integration of the component is guaranteed. "We have two types of facility for landing-gear development work: the FIB (functional integration bench) and 'landing-gear zero' buildings," explains Airbus's Peter Hart, head of landing-gear tests at Filton.

ABOVE: Every effort is made to ensure the landing gear is deployed correctly during landing. This includes proper installation, as well as maintenance during service

RIGHT : Landing gear under test at Airbus' Filton test facility

Mis-carriage landing

One of the most high-profile examples of landing gear malfunction took place in Poland in 2011 when a Boeing 767 belonging to Polish Airlines had to make an emergency landing in Warsaw. At the time of writing the investigation is still ongoing, but Patrick Smith, a 767 pilot, believes that a rare set of circumstances caused the disaster.

"The airplane has both a normal and alternate gear extension system. The normal system uses hydraulics, the alternate relies mostly on gravity, enabling the huge assemblies to more or less free fall into place if need be," he explains. "Neither of these, for reasons we'll learn soon enough, did the trick. Whatever the problem was, it seems to have been something pretty far up the chain of the systems' architectures, meaning that neither of two independent systems was sufficient.

"In all the millions of landings these airplanes have made over the past three decades, nothing like this had happened before," he adds.

"Over the past couple of years, we have introduced the HALT/HASS chamber for reliability testing"

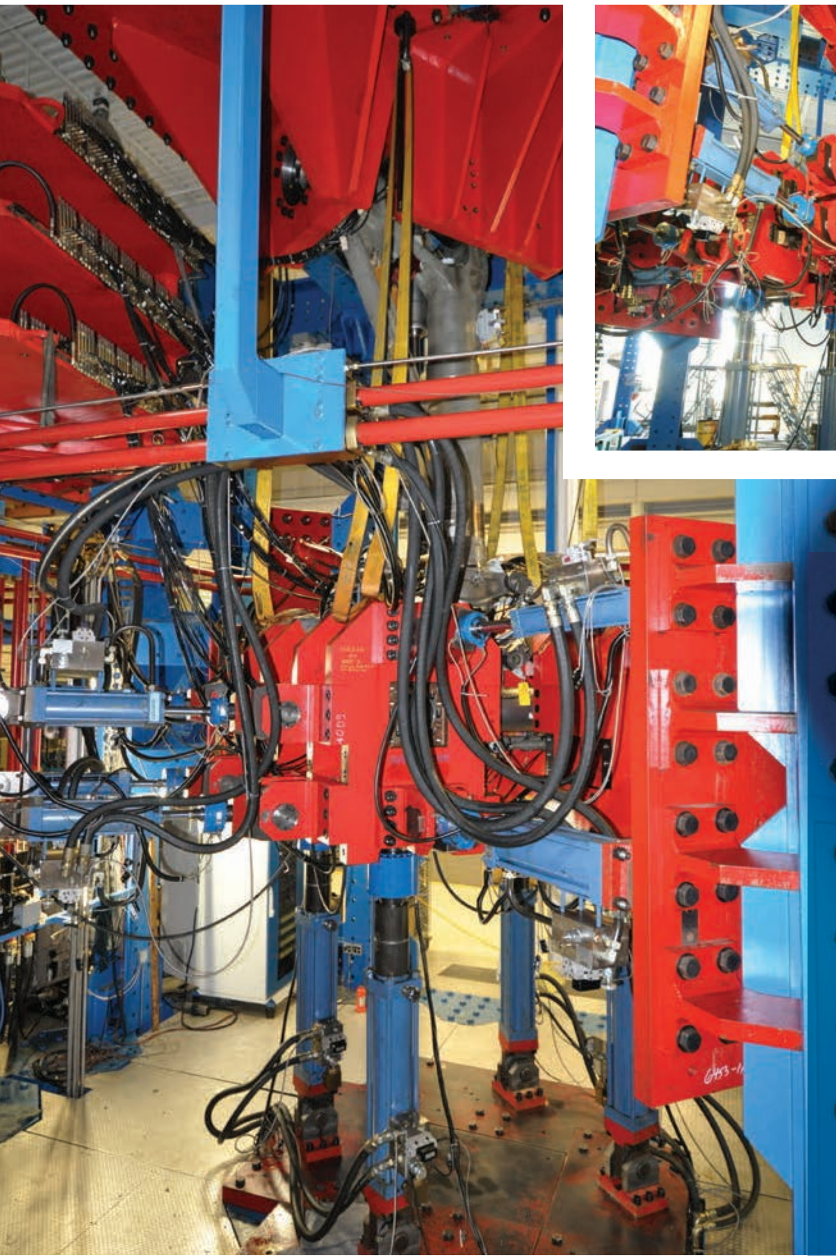
"The FIB is an electronic test rig consisting of aircraft computers and an emulation of the hydromechanical parts of the landing-gear system. This facility allows us to test electronic and inflight software, to make sure it performs the way it is intended."

After evaluation in the FIB, it's off to the landing-gear zeros, which are informally described by Hart as "iron bird rigs for landing gear". Housed in individual buildings, Airbus lays claim to five such facilities – one each for A320, A330, A340-600, and A380; the A350 building is under construction. The large steel structures have the main landing gears positioned relative to each other, spaced across the rig in their correct orientation as they would be on the aircraft. The rigs are similar in size to A380's footprint, with the nose gear positioned close to the main gear for packaging reasons. "The wheels are off the ground, so we run in flight configuration, integrating all the systems responsible for the landing-gear systems: extension/retraction; braking; wheel steering; and back-up," explains Hart.

In order to get the best test results, Hart says that every effort is made to ensure the rigs are as close as the in-service aircraft they are based on. "Because the landing gears are the biggest hydraulic consumer on the aircraft, to test them effectively we use the real aircraft's hydraulic pumps," he explains. "On the aircraft they are attached to the engines, and although we don't have the engines on the landing gears, we have variable-speed electronic motors, so we can drive them at take-off and landing engine speeds." The rigs also have a full hydraulic distribution system, which is representative in terms of its performance. In the landing-gear zero for A380, Hart says there is also an electrical distribution system because that is used as part of the avionics on the real aircraft.

"Each test rig has a dedicated landing gear, which stays in the rig forever, unless at some point in the program we develop a new component. One of the most recent examples of this has been a new brake introduced to A380. The new brake is an improvement for the aircraft because it is lighter, and gives performance improvements," explains the Airbus man. "What we would do on the rig is check the

Minor adjustments being made to wheel torque on A350's landing gear



Goodrich's Ontario facility boasts the largest landing gear test site in the world. Within the facility is the 'super rig', responsible for testing a wide range of components

Military operation

With nearly a year to go until the rollout to customers of the A400M, Messier-Bugatti-Dowty has delivered the first production-standard main landing gear shipset for the Airbus military aircraft.

Under the terms of the contract, the company is responsible for the design, development, production, integration, and support of the A400M landing system. This includes the main and nose landing gear, extension/retraction system, kneeling system and the steering system, including wheels and carbon brakes.

Each of the main landing gears consists of three independent twin-wheel assemblies housed in the aircraft's aerodynamic fuselage sponsons – necessary for the A400M to meet the requirement of soft-field landing capability for unprepared runways.

Another key factor of the landing gear is its kneeling capability, designed to support requirements for loading large military and civilian vehicles. To meet this requirement, Messier-Bugatti-Dowty engineers redesigned the main landing gear shock absorbers to ensure a minimum distance between the ground and aircraft structure regardless of the loading conditions. This design preserves the integrity of the aircraft structure.

brake functions correctly, because it has to have some software modifications to work with the new braking unit, and it is part of a chain of testing. Because the weight of the brake is changing, we have to retest the extension/retraction system to make sure that it is happy with the new weights, and typically that's what the rigs are used for – ongoing modifications throughout the lifetime. If a component is modified, we would install the modified component into the landing-gear zero."

Looking beyond and the A350

Other projects already undertaken on the A380 rig include software upgrades to improve functionality and some actuation work. Hart admits that most work is software-related, rather than hydromechanical. Upgrades have been made to the oldest rig (A320) – mainly the introduction of a new LGCIU (landing-gear control and indication unit), as Airbus tries to ensure they last the life of the aircraft itself. For the forthcoming A350 facility, the specification is being improved.

"Until the A350, converting the rig from its extension/retraction mode to its steering mode required manual intervention and adjustment. This meant it was impossible to do a gate-to-gate scenario, because there were a couple of hours' worth of alterations," explains Hart. "But on A350, we've built in the functionality to do a virtual flight. We've automated the process where the nose landing gear is compressed and attached to the loading system, and can now run through gate-to-gate. This covers push-back braking and steering, take-off roll, nose wheel retraction, cruise, landing, taxi, and approach to the gate."

Hart maintains that the ability to run a test such as this is important to the avionics systems because it follows a fully logical process with specific timings. "When you're looking at software and you've got buffering, for example, if you don't get the timing appropriate you can sometimes miss things that happen. Having this capability will make the facility more realistic." Hart says he expects to be using the A350 landing-gear zero more than others, partly because of the increased functionality, but also because it is being driven to a more in-service-type test scenario. "Rather than a functional test program, it is both that and in-service testing scenario, aimed at accelerating product maturity."

In fact, in March 2012, Airbus announced that the main and nose landing gear test bench for its A350 airliner is now ready for service at Filton. Beyond that, Airbus is planning to make better use of technology links between Filton and France for landing-gear integration work. "We talked about the virtual work on A350, and the other thing we are looking at in the future, bearing in mind we also have an iron bird in Toulouse, is linking the two," reveals Hart. "I think we will see things in that direction where you could create a virtual complete aircraft by virtually linking physical rigs together." ∎

John Challen is a UK-based journalist who specializes in engineering and technology in the aerospace, automotive, and transport industries

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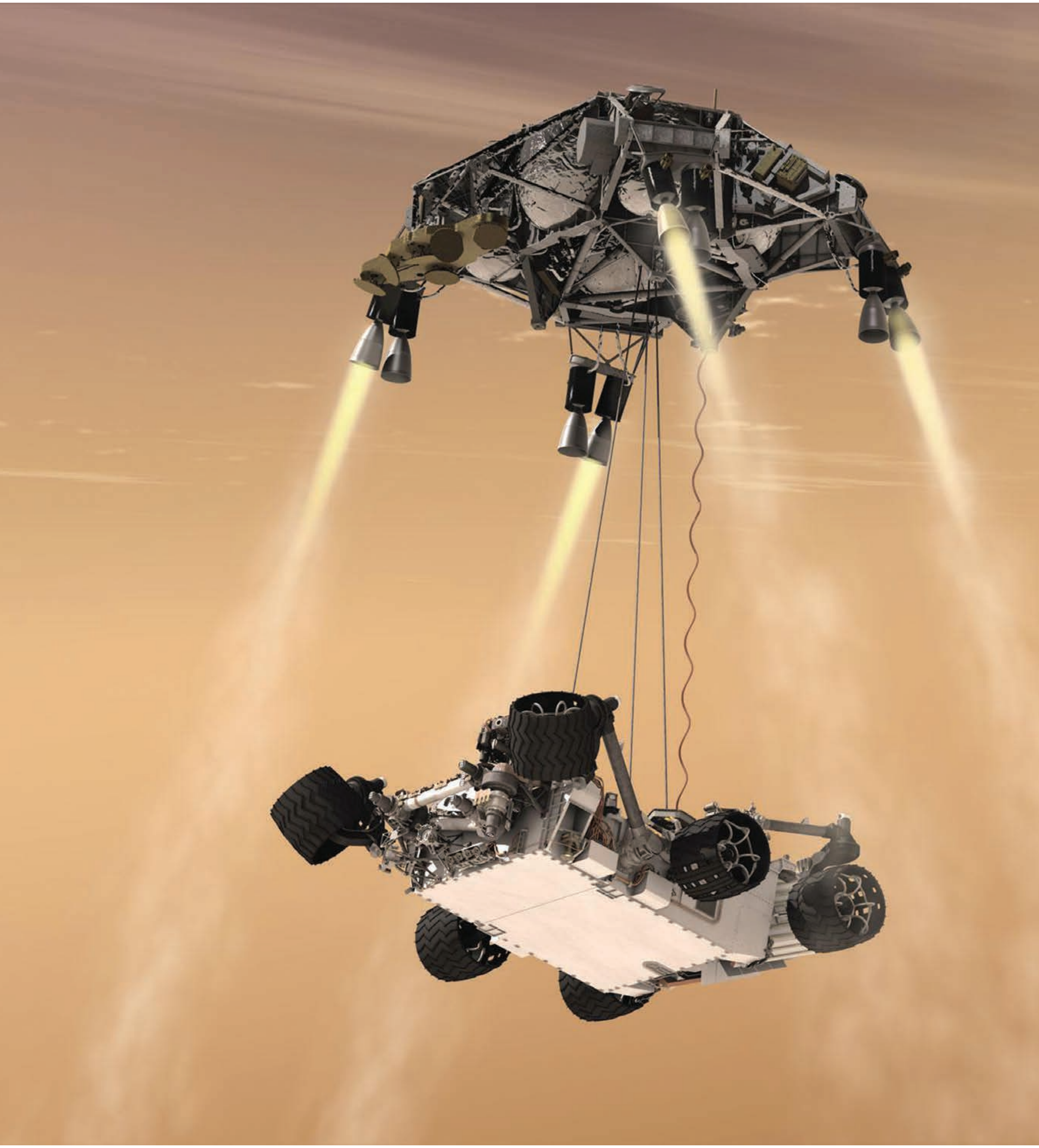


The Skycrane maneuver and the rover Curiosity touching down

Red planet gets green light

THE MARS SCIENCE LABORATORY HAS REACHED A CRITICAL PHASE IN ITS VOYAGE. HOW EASY IS IT TO TEST ROCKET DESCENT ENGINES DESTINED FOR THE ATMOSPHERE OF OUR NEAR NEIGHBOR?

BY SAUL WORDSWORTH

At around 22.00 hours Pacific Daylight Time on August 5, 2012, the Mars Science Laboratory (MSL) mission to land a rover named Curiosity on Mars should be complete. Then will begin phase two of a project that started with a blazing take-off from Cape Canaveral on November 26, 2011. The rover will study the climate and geology of the Red Planet, determine whether life on Mars could ever have existed, and plan for a manned mission. At the time of writing, the spacecraft carrying Curiosity is in cruise configuration.

The entry, descent, and landing (EDL) methodology for the Mars mission has four distinct phases. The guided-entry phase slows the craft down from approximately 6km/sec to Mach 2 until it reaches an altitude of 10km above the planet's surface; the parachute descent deploys a supersonic parachute able to generate drag of up to 289kN (65,000 lb) in the Martian atmosphere; the powered descent begins at an altitude of 1.8km and engages the use of four sets of dual rocket thrusters or Mars Lander Engines (MLEs), slowing the craft down to a mere 3km/h and 20m above the planet's surface; and lastly the Skycrane configuration, whereby the rover is lowered using a tethered landing approach onto the surface of Mars.

Mars Lander Engines

"The MLEs that perform the final descent approaching the surface of Mars are in fact eight Aerojet 700 lb thrust engines," says Ray Baker, cognizant engineer of the MLEs, and a man who has spent much of the past 10 years dedicating himself to this endeavor. "At 20m above the surface, the rover will be lowered on a bridle as it continues to descend. At touch-down, a minimum 6.5m of vertical separation will exist between the engines' nozzles (which are canted to avoid plume interference with the rover) and the ground surface below. The throttling engines will then carry the descent stage away from the rover, leaving the rover on pristine soil."

The MLEs are based on the Viking Lander engines that were originally used in 1975. No one has built such an engine since. It required what Baker calls "a bit of an engineering archaeological effort" before the MSL team found the old drawings and a few spare

RIGHT AND BELOW: Raymond Baker, of NASA's Jet Propulsion Laboratory, is the cognizant engineer for the Mars Science Laboratory spacecraft's landing engines

The engineering test model for the radar system that will be used during the Mars landing is shown mounted onto a helicopter's nose gimbal during a test at NASA's Dryden Flight Research Center

engines from that period in their storage facilities. They then took one of the old Viking engines and placed it straight onto the rocket engine test stand.

"The Jet Propulsion Laboratory (JPL) performed most of the 'hot fire' testing of the MLEs at Aerojet's Rancho Cordova facility just outside Sacramento, California," says Baker. "The JPL has a large steam-ejector system that basically fires small steam rockets in order to fully generate the vacuum necessary to simulate Mars conditions.

"You need a lot of pumping speed to be able to test a rocket in Mars conditions. The thrust stand was configured to measure the MLE peak thrust of over 3,000N at an ambient pressure of less than 0.25psia, or less than 2% of sea-level pressure, equivalent to about 25-30km altitude here on Earth. Thrust was measured using a carefully calibrated strain-gage-type load cell. We also measured temperatures of critical components of the engine using high temperature thermocouples, and gas and liquid pressures within the engine and propellant feed system using standard pressure transducers. The MLE uses a single propellant, unlike many other rocket engines, which use a fuel and oxidizer."

Engine program

The majority of the MLE testing program took place between 2004 and 2007. During that time, MSL tested eight rocket engines. One of those was a Viking Lander spare, one was a rebuilt Viking engine, and the rest were various versions of the Mars Lander engine that is flying today. The data was collected using a high-speed digital data recorder, preprocessed to apply calibrations and to convert to engineering units, and given to the engineers for analysis.

JPL then compiled the data from the various engines tested in the development and qualification program to guide the development of a few different mathematical models used in the design, development, and testing of the MSL Skycrane system.

The first was a thermodynamic model of the throttled engine to understand its performance, efficiency, and behavior; the second was a thermal model used to develop a plan for conditioning the engines in the cold environment of space in preparation for landing on Mars; the third was a dynamic model of how quickly the engine's thrust responds to changes in throttle valve position.

"This dynamic model is currently being used in our end-to-end simulations of EDL, both in our high-fidelity hardware testbeds and in many thousands of computer simulations," says Baker.

Once the data had been collected and an accurate model produced of how the engine would perform, the simulation process with a high-fidelity test vehicle began.

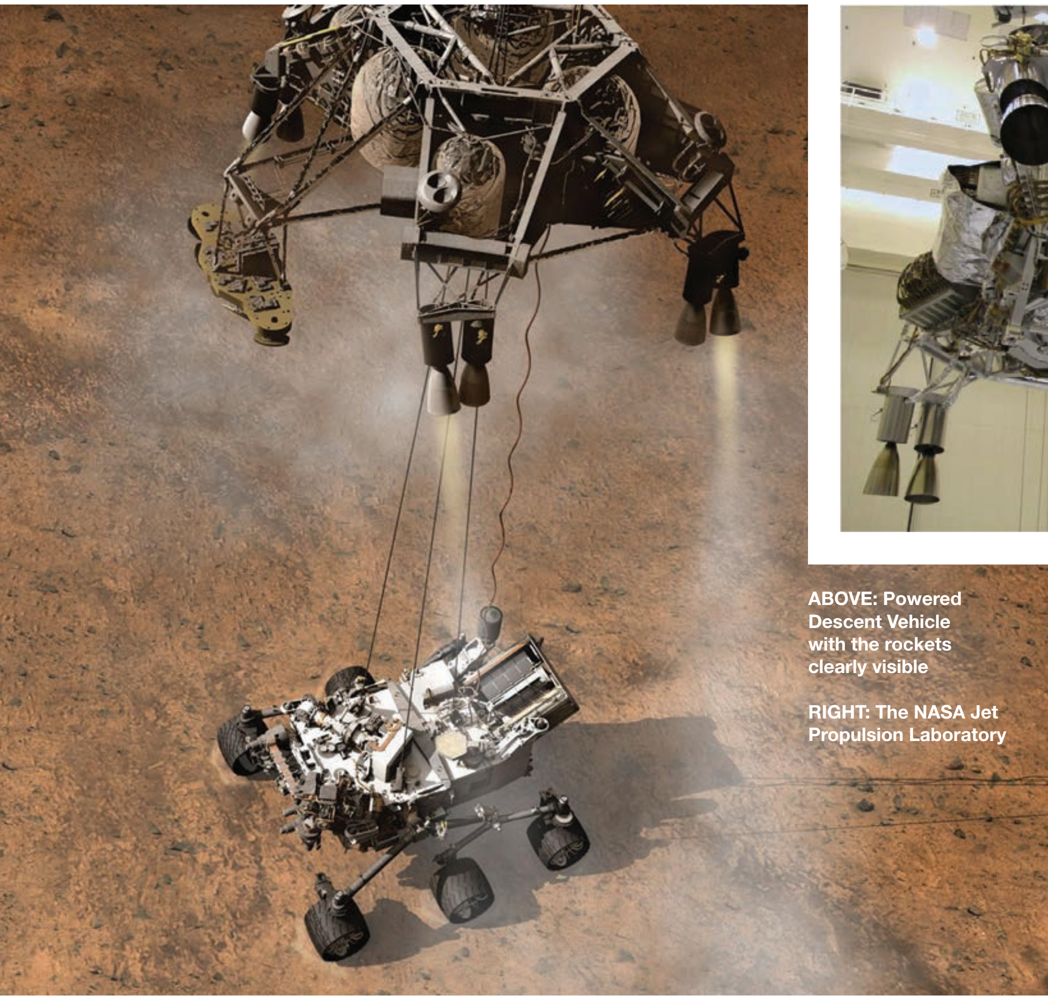
"It doesn't look like the spacecraft, but it has a high-fidelity computer system," says Baker. "Our test vehicle is called the Mission System Testbed (MSTB). It is composed of engineering model and flight spare hardware that is an excellent, if not identical, representation of the components of the spacecraft. We simulate everything from launch to landing on Mars

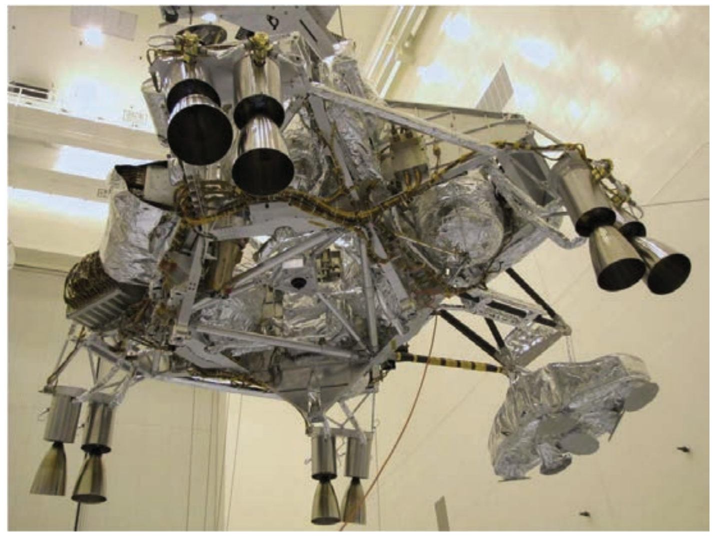
The MSL field test campaign

The MSL will deliver the Curiosity rover to the surface of Mars in August 2012, using a new pulse-Doppler landing radar – the Terminal Descent Sensor (TDS). The TDS employs six narrow-beam antennas to provide unprecedented slant range and velocity performance at Mars to enable soft touchdown of the MSL rover using a unique sky crane EDL technique. Prior to use on MSL, the TDS was put through a rigorous verification and validation process.

A key element of the verification and validation was operating the TDS over a series of field tests using flight-like profiles expected during the descent and landing of MSL over Mars-like terrain on Earth. Limits of TDS performance were characterized with additional testing meant to stress operational modes outside of the expected EDL flight profiles. The flight envelope over which the TDS must operate on Mars encompasses such a large range of altitudes and velocities that a variety of venues was necessary to cover the test space. These venues included an F/A-18 high-performance aircraft, a Eurocopter AS350 AStar helicopter, and 100m tall Echo Towers at the China Lake Naval Air Warfare Center. Testing was carried out over a five-year period from July 2006 to June 2011.

"Overall, the MSL TDS field-test campaign was very successful and the TDS performed extremely well over the required operational envelope," says Jim Montgomery of the JPL and California Institute of Technology. "Early field tests in 2006 and 2007, with a breadboard version of the TDS, uncovered a number of issues, but none that invalidated the TDS design or implementation. Both were shown to be sound. Final tests between 2008 and 2011 with an engineering model of the TDS uncovered minor issues of interest, but nothing of great concern.





ABOVE: Powered Descent Vehicle with the rockets clearly visible

RIGHT: The NASA Jet Propulsion Laboratory

using this system." The flight computer in the MSTB runs the same software that is running on the spacecraft and receives simulated sensory input from supporting ground computers. In this way, the MSTB thinks it is flying and landing on Mars.

The MSTB is equipped with eight engineering model MLE throttling valves. When the EDL is stimulated in the MSTB, the flight computer moves the throttle valves in response to the simulated sensor input from the ground computers, attempting to land the Curiosity rover safely on the surface. The ground computers measure the throttle valve positions and use the model developed using MLE test data to predict the thrust output of the eight MLEs and associated accelerations on the vehicle.

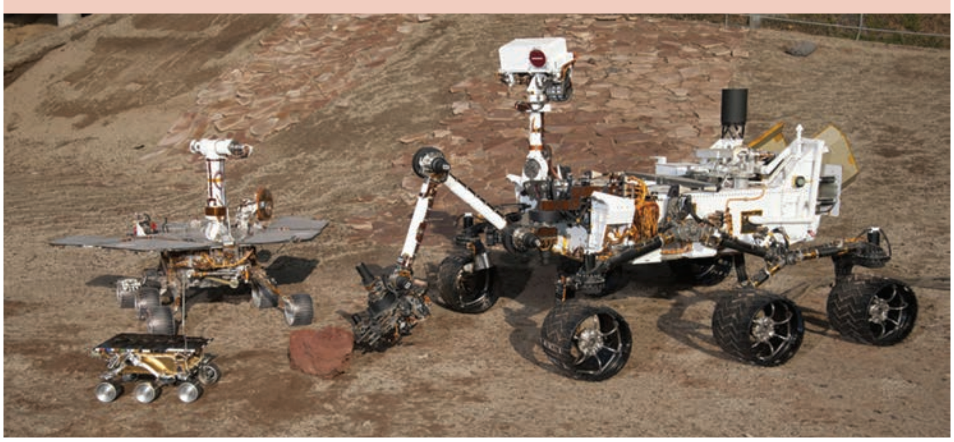
"The MLEs are very large rocket engines with an exceptionally specialized application," says Baker. "Landing on Mars presents some very particular challenges. We're talking about eight rocket engines that are used only in the last 60 seconds of flight before touch down. At that time we are traveling at 100m/sec and are just below 2km from the surface. If we did nothing, it would be 18 seconds before we hit the ground. We then separate from our parachute, and the eight engines, with a maximum system thrust of 24,000N, slows the vehicle all the way down to 0.75m/sec. While these rocket engines are firing and the computer is controlling us and trimming our flight path by throttling the engines, we lower the 900kg rover on a 7m tether. The verification process of the MLE has been a true test of expertise. As with any test program you have a few bumps along the road, but we didn't run into any major mishaps. All we can do now is wait until August." ∎

Saul Wordsworth is a journalist specialising in the aerospace and automotive industries

Like father, like son

The group in the photograph of two test rovers and a flight spare provides a graphic comparison of three generations of Mars rovers developed at NASA's JPL, where the setting is the Mars Yard testing area.

Although not strictly 'aerospace testing', all systems were designed to travel to another planet. The front and center of the image below shows the flight spare for the first Mars rover, Sojourner, which landed on Mars in 1997 as part of the Mars Pathfinder Project. On the left is a Mars Exploration Rover Project test rover that is a working sibling to Spirit and Opportunity, which landed on Mars in 2004. On the right is a Mars Science Laboratory test rover the size of that project's Mars rover, Curiosity, which is on course to land on Mars in August 2012. Sojourner and its flight spare, named Marie Curie, are 2ft long. The Mars Exploration Rover Project's rover, including the Surface System Test Bed rover in this photo, are 5.2ft long. The Mars Science Laboratory Project's Curiosity rover and Vehicle System Test Bed rover, shown below, are




TECNAM
TECNAM
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Photos: G. DiBernardo

Showing FLARE

Developed within the TECVOL program, FLARE has made 63 successful demonstration flights

THE ITALIAN AEROSPACE RESEARCH CENTER HAS DEVELOPED A NOVEL APPROACH TO FLIGHT TEST EXPERIMENTS USING AN OFF-THE-SHELF AIRCRAFT

BY LUDOVICO VECCHIONE

The term 'low cost' is firmly coupled with commercial flight, but it is certainly not associated with test flights and development. On the contrary, flight tests are still very 'high cost', lengthy, and risky, and can easily turn into a nightmare for aerospace program managers. However, without going into real flight conditions, no aerospace technology can truly become 'flight qualified'… which then opens the door to deploying technologies into real products.

Being progressively more involved in projects requiring flight test demonstration, the Italian Aerospace Research Center (CIRA) has developed a new approach to get rid of the cost and the logistic burdens typically associated with flight experiments.

This approach has been developed within the framework of the all-Italian PRORA program, where CIRA has carried out a project called TECVOL (Tecnologie del Volo Autonomo), aimed at the development of autonomous flight technologies for unmanned aircraft systems (UAS), including flight plan execution, obstacle detection and identification, collision avoidance, and approach and landing. The flight validation of these innovative technologies has been carried out using an optionally piloted vehicle (OPV) derived by a commercial, off-the-shelf, ultra-light, high-wing aircraft, a TECNAM P92-Echo S, selected for its low operational cost and reliability.

Ultra-light testbed

The FLARE (Flying Laboratory for Aeronautical Research) flying testbed is operated from a grass airfield near the research center, close to the coastal shoreline. The aircraft is equipped with an integrated avionics suite, designed by

ABOVE: **FLARE on ground idle. It is a single-engine P92 Echo Super light aircraft**

Below: **Onboard flight test instrumentation**

Flying ability

A true optionally piloted vehicle (OPV) can be piloted remotely by a ground pilot interfaced directly with the onboard flight control system, or alternatively, sending just high-level commands to the onboard flight control computer that can autonomously manage the flight mission. Remote operations are possible by means of a wireless radio link between the OPV and the remote flight control station. This can be located either on the ground or on board another aircraft.

The ability to carry a crew aboard, and then to be a manned platform, is a feature that can prompt organizations to choose off-the-shelf certified aircraft as baseline airframes for OPVs. Sometimes, just minor modifications are needed in order to install the necessary subsystems to transform the manned airplane into an OPV, depending to the number of functions that the system needs to accomplish.

Choosing an off-the-shelf certified aircraft for research activities and experimental testing would potentially be a much quicker recertification process than designing and developing a new flying platform to be used as an OPV. The main advantages of such a choice are substantial reductions in the project costs and risks. The Federal Aviation Administration takes care of OPV certification issues by means of the Order 8130.34A (Airworthiness Certification of Unmanned Aircraft Systems and Optionally Piloted Aircraft).

Avoiding the obvious

The Mid-Air Collision Avoidance System (MIDCAS) project will demonstrate the baseline solutions for the unmanned aircraft system (UAS) mid-air collision avoidance function, including separation, acceptable by the manned aviation community, and being compatible with UAS operations in non-segregated airspace by 2015.

The European Defence Agency is the contracting authority for the MIDCAS project on behalf of the contributing members: Sweden (coordinator), Germany, France, Italy, and Spain. The contract was signed at the Paris Air Show in June 2009, and will run for four years with a total investment of US$65 million.

CIRA, which includes navigation sensors (attitude and heading reference system, laser altimeter, standalone GPS, and air data sensor); sensors and processing units for the obstacle detection and identification; electro-optical sensors for enhanced remote piloting; and a flight control computer.

In addition, COTS Detect Sense and Avoid sensors (DSA), which include an electro-optical camera, infrared camera, and a 35GHz Ka-band radar), have been installed on the upper side of the wing. Datalink antennas have also been installed (four on the upper wing and three on the bottom fuselage). In order to accommodate

all experimental avionics on board, the left seat has been removed and the baggage bay has also been used. This experimental setup required the installation of an additional alternator in the engine bay to provide the necessary electrical power for the operation of the avionic suite. Flight computer system algorithms were developed by CIRA researchers, and innovative DSA algorithms based on extended Kalman filter were developed by the Aerospace Engineering Department at the University of Naples.

The whole experimental setup also included a ground segment to monitor the flight experiments and interact with the onboard systems. The main components of the ground segment include a GPS base station, providing the differential correction for the onboard GPS; a datalink system for the communications between the ground control station; and the onboard segment (digital data exchange, onboard video transmission, and vocal communications).

All flights were performed with a test pilot on board who was able to override the systems in the event of system malfunction. The test campaign started in January 2006 with the first experimental setup-verification flight, and ended in March 2011 with the final remote piloted vehicle (RPV) validation flight. In total, 89 flights were executed, including 23 flights devoted to DSA technologies validation and 14 dedicated to the autonomous take-off and landing. Furthermore, CIRA has published 46 scientific papers, spanning all the activities performed within the project, from the aircraft modification to the validation flights.

Flight-test program

The first flights were dedicated to the identification of the aircraft dynamic model necessary for the validation of auto take-off and landing technologies. Using a combination of differential GPS and AHRS systems, the FLARE aircraft landed successfully on a grass airstrip, even with light-to-moderate side winds. The onboard test pilot took control only after touchdown.

Later, DSA flight tests were performed. The experiments demonstrated that the radar measurement, which is augmented by the EO/IR cameras due to an advanced sensor fusion algorithm, enables users to enhance the radar obstacle detection and tracking capabilities, and to obtain a higher data rate. The system was able to guarantee 10Hz real-time, all-weather, all-time operations, with a field of view of 120° azimuth, 18° elevation, and 6Nm range.

Post-processing of the panchromatic data showed a remarkable increase in angular accuracy with respect to radar-only operations. During DSA algorithm validation flights, another P-92 TECNAM aircraft was used as an intruder.

UAS market

In view of its mission to support the competitiveness of the Italian aerospace community, CIRA has recently established closer ties with the national reference industry involved in the UAS market segment. In fact, the final acceptance review of the TECVOL project, a milestone achieved in December 2011, was presented to a review board attended by Alenia Aeronautica.

In conclusion, the use of a commercial ultra-light aircraft as a flying testbed has proved to be the key success factor for this project. Low direct operating cost, ease of installation of sensors and flight instrumentation, and ease of flight and ground operation, were absolutely vital to keep the project on time and on budget. This low-cost project set the path for CIRA's participation in the Mid-Air Collision Avoidance System (MIDCAS) project, funded by the European Defence Agency, together with other Italian industries.

The FLARE project is just one of the many research activities carried out at CIRA in the field of the UAVs. A follow-up of this successful project is already scheduled as TECVOL-II, where new UAS flight functions will be validated, including autonomous guidance algorithms (long-term 4D trajectories taking into account areas to avoid), autonomous taxi, take-off and landing in case of non-instrumented runway, and taxiing obstacle detection and collision avoidance. ∎

Ludovico Vecchione is the division manager of aerospace vehicles at CIRA

Italian investment

In 1984, the Italian government entrusted CIRA with the management of the Italian Aerospace Research Program (PRORA) to support the competitiveness of the Italian aerospace community. The PRORA program is focused on developing strategic research programs, on making strategic testing facilities available, and on the enhancement of the scientific competences and expertise of the national aerospace community.

CIRA ensures PRORA management under the control of Ministry of Research (supported by the Ministries of Economy, Defense, and Economical Development). Today, CIRA employs 326 researchers and hosts about 50 university students each year, and is involved in all the major European projects (JTI CLEAN SKY, SESAR, MIDCAS) as an associated partner. Its 2011 financial figures show US$65 million value in production.

Left: The project has brought the flying lab into the Mid Air Collision Avoidance System (MIDCAS), the international program launched by the European Defence Agency (EDA)

Right: DSA (detect, sense and avoid) sensor suite

"The use of a commercial ultra-light aircraft as a flying test bed has proved to be the key success factor for this project"

Joint strike force

JD MCFARLAN IS THE PROGRAM HEAD FOR THE F-35 JOINT STRIKE FIGHTER PROGRAM. HE IS ARGUABLY THE MOST IMPORTANT PERSON INVOLVED IN MILITARY AIRCRAFT THIS DECADE. *AEROSPACE TESTING INTERNATIONAL* GETS THE LOWDOWN ON THE PROJECT – AND THE MAN

JD McFarlan III oversees the development testing of all variants of the Joint Strike Force F-35 aircraft

BY CHRISTOPHER HOUNSFIELD

It was the highlight moment of the F-35 Joint Strike Fighter Program to date: the amphibious assault ship USS WASP returned to port in October 2011 after a 19-day F-35B test period for the aircraft. During this time the F-35B logged more than 28 hours of flight time and completed 72 short take-offs and 72 vertical landings.

The first carrier landing marked the beginning of ship-suitability testing, known as developmental test 1, for the F-35B short take-off/vertical landing (STOVL) variant. "I think the execution of the first flight test on the first shipboard trials for the STOVL was really the shining moment of the test program," says JD McFarlan III – or 'JD', as he likes to be called.

"We took two STOVL airplanes, BF2 and BF4, to the USS Wasp and conducted what turned out to be 19 days of fairly intense trials on board the ship. During that period of time we conducted 72 short take-offs and 72 vertical landings, and if we compare that to 2010, when the first vertical landing of the program occurred, all that calendar year we achieved 10 vertical landings. I think that seaborne trial is a reflection of the progress that both the aircraft and program have made."

McFarlan is very easy going, considering he serves as vice-president of F-35 test and verification for the Lockheed Martin-based project. In this role he oversees the entire development test program of the Joint Strike Force F-35 aircraft. No mean feat.

About the man

After graduating from Harvard, McFarlan went on to Auburn University, Alabama, graduating in 1984 having obtained a Bachelors degree in mechanical engineering. The same year, he joined the Fort Worth Division of General Dynamics (which subsequently became part of Lockheed Martin) as a propulsion analysis engineer.

"I came to General Dynamics more than 27 years ago because I wanted to work on F-16 fighters. The name changed to Lockheed, and then Lockheed Martin when we merged. So my whole career has been with Lockheed Martin and its legacy companies," he says. "I started out working in the F-16 propulsion group, and as an engineer there I worked as part of a team that integrated both the Greg Lenny F-100 engine and the General Electric F-110 engine into the F-16. From there, I worked a little bit on the F-22 and then I did special projects work that I can't tell you about."

Sure?

"Yes."

Prior to this later, secret, work, McFarlan worked on projects that he says involved "research technology", which was very influential to the way the JSF program developed. This is as much as he will say. This period was followed by work on the F-35: "I worked on the inlet concept of the F-35 – we call it a 'diverterless' supersonic inlet (DSI). You won't find 'diverterless' in the dictionary – it's a made-up aerospace term."

He's right – the word is not in any dictionary, including Oxford, Collins, and Webster's. However, it is on the internet. According to Wikipedia, 'A diverterless supersonic inlet (DSI) is a type of jet engine air intake used by some modern combat aircraft to control airflow into their engines. It consists of a 'bump' and a forward-swept inlet cowl, which work together

"A diverterless supersonic inlet is a type of jet engine air intake used by some modern combat aircraft to control airflow"

100+ EXHIBITORS
3 DAYS
1 VENUE

to divert boundary layer airflow away from the aircraft's engine while compressing the air to slow it down from supersonic speed.'

McFarlan puts it into his own context: "It's the inlet concept on the F-35, it's that bump inlet on the side of the fuselage. I was involved in some of the early research for that. We actually flew that configuration on an F-16 in the mid-1990s and then evolved it onto the X35, flew on the X35, and then we modified it yet again to improve it further for the aerodynamic performance and signature capability on the F-35, and so on. Some of the other work that we did on the STOVL programs led up to JSF; some of the early propulsion concepts obviously got developed under those programs.

The good, the bad, and the not so ugly

McFarlan lives with his wife and two daughters in Fort Worth, Texas, headquarters to Lockheed Martin Aeronautics Company. However, his day-to-day routine entails plenty of travel. "I'm in one of three cities. Fort Worth is where I'm based. Or I might be at Edwards Air Force Base, where the flight test team is currently located for all CTOL jets. The team is responsible for the conventional take-off and landing variant development, as well as the mission systems development. And then there's Patuxent River, Maryland – Pax River as we call it – which is the Navy's flight test center, where we do both STOVL configuration and the carrier variant or CV configuration. I travel between those three locations, with Washington DC being another popular location as that's where the JSF program office is located."

Cost estimates for the F-35 are said to have risen to US$382 billion for 2,443 aircraft, and a senior member of the Pentagon criticized the program for its escalating costs and lack of a proper 'test plan'.

I had been advised to steer away from questions about budgets and rising costs, but there have been problems that are directly linked to the development and test program. So – feeling brave as he was several thousand miles away on the other end of a telephone – I asked why certain things have stalled production? After much quiet deliberation and chatting in the background, McFarlan attempts an explanation saying, "The F-35 program is unique in that it was laid out by government. The program was concurrent – we were doing development at the same time as we were going into production – and so the assumptions when the program was laid out assumed a certain level of maturity in the development phase as it fed into the production program.

Weapons separation

Over the Atlantic Ocean in February 2012, the F-35B test aircraft BF-2 with external weapons pylons flew for the first time. The test measured flying qualities with external pylons, inert AIM-9X Sidewinder air-to-air missiles, and centerline 25mm gun pod. Significant weapons testing for the F-35B and F-35C variants is scheduled throughout 2012, including fit checks, captive carriage, pit drop, and aerial drop tests. McFarlan describes the tests in greater detail: "We have flown on one of our CTOL airplanes out at Edwards with external stores. We've been flying with weapons inside the weapon bays, but you can't tell from a picture whether you've got weapons in there or not. Obviously that's one of the unique capabilities and features of a 'fifth generation' fighter. "Our weapons development activity and actuation is one of our objectives this year in flight testing. So we will be dropping weapons that are located inside the weapons bay later this year. We call those separation tests; it's the first visible thing you do. We conduct testing where we measure the loads on weapons inside the weapon bay with the doors open. We measure the acoustic environment inside the weapons bay on both the structure of the bay and on the weapons. The engineering team predicts the separation characteristics of the weapon and how it will release from the airplane as it's dropped out of the bay. We're going through all that right now, and then in late February we flew external stores.

"We had two external pylons and an AIM-9X on each wing – so for four pylons, two AIM-9Xs; and then we had a GBU-31 and an AIM-120 inside each weapons bay. The AIM-9X tests actually served a good purpose, which was to understand the characteristics of the airplane with that weapon. We also have unique instrumentation in flight test. One of the unique instruments we have is a high-speed digital camera that takes video of the stores as they separate from the airplane when we open the weapons bays. We put that inside an AIM-9X-shaped weapon, but it's not an AIM-9X – it's just the shape of the unit that has the camera inside of it and we'll point that back at the center of the airplane as we drop stores. So part of that testing gets us ready for putting that camera on an airplane so that we can go to that testing to record the characteristics of the weapon as it comes off of the airplane.

A Lockheed Martin F-35 Lightning II undergoes final assembly at the company's manufacturing facility in Fort Worth, Texas

"When we initiated flight testing, the program office reached the conclusion that we really needed to restructure the program in terms of the amount of time it was going to take to finish development. So we had to basically assess the length of time it would take to complete all the software, structural testing, flight testing, etc. Then, in order to make more progress in development before production ramped up, the decision was made to slow down the rate of increase of the production program," explains McFarlan.

It is fair to assume that the program became embroiled in a number of scenarios from various departments, two in particular, with development and production completely overlapping.

But, back to technology. McFarlan is keen to explain that all current technical issues are on schedule and go through a process of resolution: "I guess the purpose of flight testing is to demonstrate how this airplane performs while finding technical issues and resolving them. So we don't consider anything a failure until we can't resolve it and therefore there are no failures. We're really just dealing with typical development issues that one goes through when building advanced aircraft and, in this case, we're developing three aircraft at the same time.

"If you solve the problem on one, you solve it on all three, and the commonality of the airplanes, with all the common ignition and vehicle systems, is a benefit in terms of the challenges we face," he says.

It seems, without doubt, that the greatest technical test hurdle has been with the air inlet system. "There were challenges that probably started in 2010 with our auxiliary air inlet on the STOVL configuration. That is an inlet on top of the airplane that opens up when you have the lift fan running," says McFarlan. "There are multiple inlets on the STOVL configuration. There's what we call an upper lift fan door – that's a one-piece door that opens up the air into the lift fan. Then, behind that, are the auxiliary inlet doors; this is two doors that are split down the center line of the airplane. One opens to the right, one opens to the left, and they are located behind the upper lift fan door. What we learned was that the airflow that comes across the front of the airplane and goes around the lift fan creates vortices that come back and impinge on those auxiliary inlet doors and set up a load on those doors that made them vibrate. So we had to put limits on where we could fly the airplane to avoid high load conditions.

"We were still able to convert coming in from our up and away flight convert, slow down to hover and do a vertical landing. We could still do a short take-off, but there were certain things we couldn't do and so, in early 2011, we collected test data for the structures team to redesign those doors. They redesigned and fabricated new doors and we installed those on BF-1, our very first STOVL airplane and one of our more instrumented airplanes, and in December 2011 we conducted tests to demonstrate that those doors worked. We finished that testing in January 2012. It's a resounding success – they work perfectly," McFarlan says.

International cooperation

Although the USA is the prime contractor through Lockheed Martin, there are nine partner countries providing technology, and potential buyers from approximately 30 countries. I say 'approximately' as the ball-park constantly changes, with firm orders drifting in and out. Japan alone wanted to place orders for the aircraft as late as December 2011, but within two months was threatening to pull out of the deal based on expense.

From a technical point of view, what does McFarlan feel the international cooperation has brought to the table? And in some ways does it compromise the aircraft itself?

"I think it's been good," he replies. "When we started and we teamed with Northrup Grumman and BAE Systems, we picked the best capabilities of both teams and then as we got to the system demonstration, we had both engineers and maintainers from multiple countries. The UK is probably the most represented, but we have support from the Netherlands as well, and most of our UK support is at Pax River by either our BA engineers or other UK Maintainers. We have a UK pilot, who I believe is flying his second flight in a carrier variant as we speak."

So is the aircraft trying to be all things to all people? "It is all things to the customers that have defined their requirements for the airplane and we do have many customers," says McFarlan. "Obviously the biggest influence on those customers drove the three variants, but as I said in the beginning, the fundamental strength of this airplane and what it brings to the users is an unprecedented level of capability, as well as the unprecedented level of cooperation that we have with our partners."

Despite glitches along the way, the F-35 remains the most groundbreaking fighter aircraft to go into production for a generation. I conclude by asking McFarlan to tell me his favorite aircraft in the world; mine is the Harrier. He replies, without a pause, "The F-35." I explain that I meant historically (the P-51 Mustang, Spitfire, B-17, etc), but his reply is the same: "The F-35. I suppose when I was working on the F-16, it was the F-16, but now, obviously, it's the F-35." I suppose it would be, and who could argue. ∎

The first external weapons test mission was flown by an F-35A CTOL aircraft at Edwards Air Force Base, further expanding the program's flight test envelope

Screen test

IN-FLIGHT ENTERTAINMENT AND COMMUNICATIONS SYSTEMS ARE USUALLY THE SECOND MOST EXPENSIVE ELEMENT OF A WIDE-BODY AIRCRAFT, AFTER THE ENGINES, SO IT'S CRUCIAL TO GET THEM RIGHT FIRST TIME

Proof of the pudding: the final cabin systems test for the Airbus A380 was a simulated 15-hour flight with 474 passengers

BY BERNARD FITZSIMONS

In a typical in-flight entertainment and communication (IFEC) installation providing audio and video on demand to all passengers on a wide-bodied aircraft, a head-end audio video controller and on-demand server will interface with the cabin management terminal and data loading ports, as well as the aircraft's flight management system. There will be a distribution network for the content, feeding both overhead and bulkhead monitors, and individual passenger screens. Each passenger seat will also have a seat electronics box, video display, passenger control unit and audio jack, and often a USB port plus a power outlet supported by a seat power box.

A communications network adds further complexity. There may be L-band or Ku-band satellite, or UHF air/ground communications, involving the appropriate external antennas and associated avionics, again with interfaces to the FMS and other aircraft systems. And there will be a distribution network, traditionally wired, but these days more likely using a GSM/GPRS cellular or WiFi network. For a

"We have models to help analyze whether a transmitter with a certain power will deliver enough power to the last seat"

ABOVE: Typical receiver position for the WirelessCabin A319 narrow-band measurements

Thales system on a 380-seater A330-300 that can add 3,500 parts, half of them cables, and most of the rest the seat displays, PCUs, jacks, and ports, plus more than three million lines of software code.

All hardware elements are required to pass the environmental tests specified by RTCA DO-160E or the European equivalent, Eurocae ED-107, which cover everything from temperature, altitude, humidity, and vibration; to fungus resistance, susceptibility to interference, and flammability. Centrifuges are used to identify structural and mechanical strength limits. EMI/RF chambers are used to measure electromagnetic interference and radio frequency emissions, and flame and environmental chambers are also used. But the increasingly common radio installations used to provide passengers with their own WiFi and cell phone connections ultimately need to be tested in a representative aircraft cabin.

Wireless foundation

Germany's TriaGnoSys develops its own satcom, IFE, and cabin communications products, as well as carrying out product development involving both hardware and software for customers. When it comes to wireless communications and IFE, says managing director Axel Jahn, the question is not just how to cover the whole aircraft with the selected radio technology, but also how to ensure that the last seat has enough coverage, and how to dimension the capacity of the network.

"That is where we have done some real testing in aircraft," says Jahn. "We have models to help analyze whether a transmitter with a certain power will deliver enough power to the last seat. And we have measurement results from different aircraft types, where we have measured the power distribution or throughput – the capacity that you can achieve with different technologies."

As part of the European WirelessCabin project, which looked at internet provision via both wide area local network and Bluetooth in the ISM band, plus GSM and UMTS mobile telephony, TriaGnoSys helped the German Aerospace Center (DLR) carry out wide- and narrowband measurement campaigns in an Airbus A319 and an A340-600. The project results triggered ECC decision 06(2007), 'on the harmonized use of airborne GSM systems in the frequency bands 1,710-1,785MHz and 1,805-1,880MHz'. The regulation requires similar measurements for every aircraft type and is the basis for the onboard GSM offering from operators such as OnAir and AeroMobile.

An aircraft cabin is a very severe environment, with the density of obstacles in a confined space causing reflection, diffraction, and scattering of the received power. For collecting GSM and UMTS narrow band data on the A319, a signal generator fed a variety of transmitting antennas – drooping dipole at 800MHz and 1,820MHz, conical at 920MHz, and leaky line at 2,200MHz, with a 6dBm sine signal. Receivers using linear monopole or patch antennas were mounted at passenger ear height on the window side of more than 50 seats. Because the GSM and UMTS bands are regulated, there were also outside receivers at various distances to measure the interference produced on the ground.

The tests established that a single omnidirectional access point transmitting as 6dBm was enough to cover the whole cabin, and was preferable to a directional antenna mounted at one end of the cabin because of the sensitivity of the received power in the passengers' location to the orientation of this antenna. The leaky line provided even power distribution over the 62ft length of the cabin. The external measurements revealed unacceptably high maximum interference levels of around -130dBm, suggesting the need for countermeasures to avoid interference with terrestrial cellular networks.

For the wideband measurements on the A319, researchers used a RUSK channel sounder from MEDAV. This uses a swept-frequency measurement technique to step through discrete frequencies in the desired frequency band centered on the carrier. A 20dB

Sitting comfortably?

Aircraft interior components have their own certification requirements. All elements of the cabin have to demonstrate compliance with flammability, heat release, and toxicity standards to ensure that the occupants would have time to evacuate the aircraft before being overwhelmed by smoke or fumes, but seats have to meet stringent dynamic tests as well.

Essentially, seats have to demonstrate the ability to protect an occupant from injury in a survivable crash. So they must be tested at decelerations of 16*g* forward and 14*g* down, with the seat deformed and tilted 10° to the side. Lumbar loads on the crash test dummies used are measured and must not exceed 1,500 lb, and legs must be protected against axially compressive loads exceeding 2,250 lb in each femur.

Seats must also demonstrate acceptable head injury criteria: an equation is used to derive the number of HIC units from the curve of total acceleration against time, and the result must not exceed 1,000 units. Front-row seats with a bulkhead in front must show either HIC of less than 1,000, or that the dummy's head would not impact the bulkhead.

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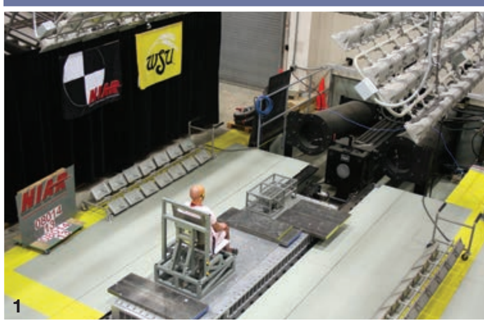
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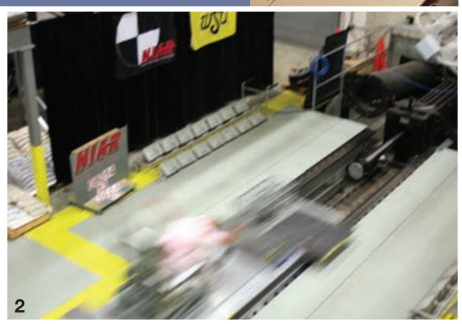
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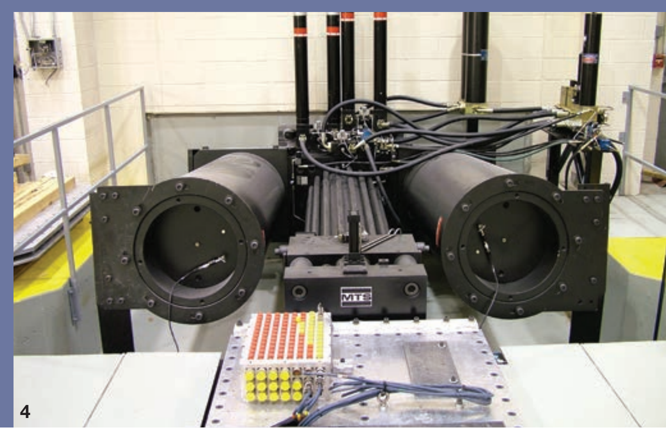

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1. Setup of anthropomorphic test dummy and MTS Systems crash simulator at the US National Institute for Aviation Research's Crash Dynamics Laboratory

2. Test in progress in the MTS Systems crash simulator at Wichita State University

3. Crash test dummy and pre-deformed seat used for seat testing in the crash simulator

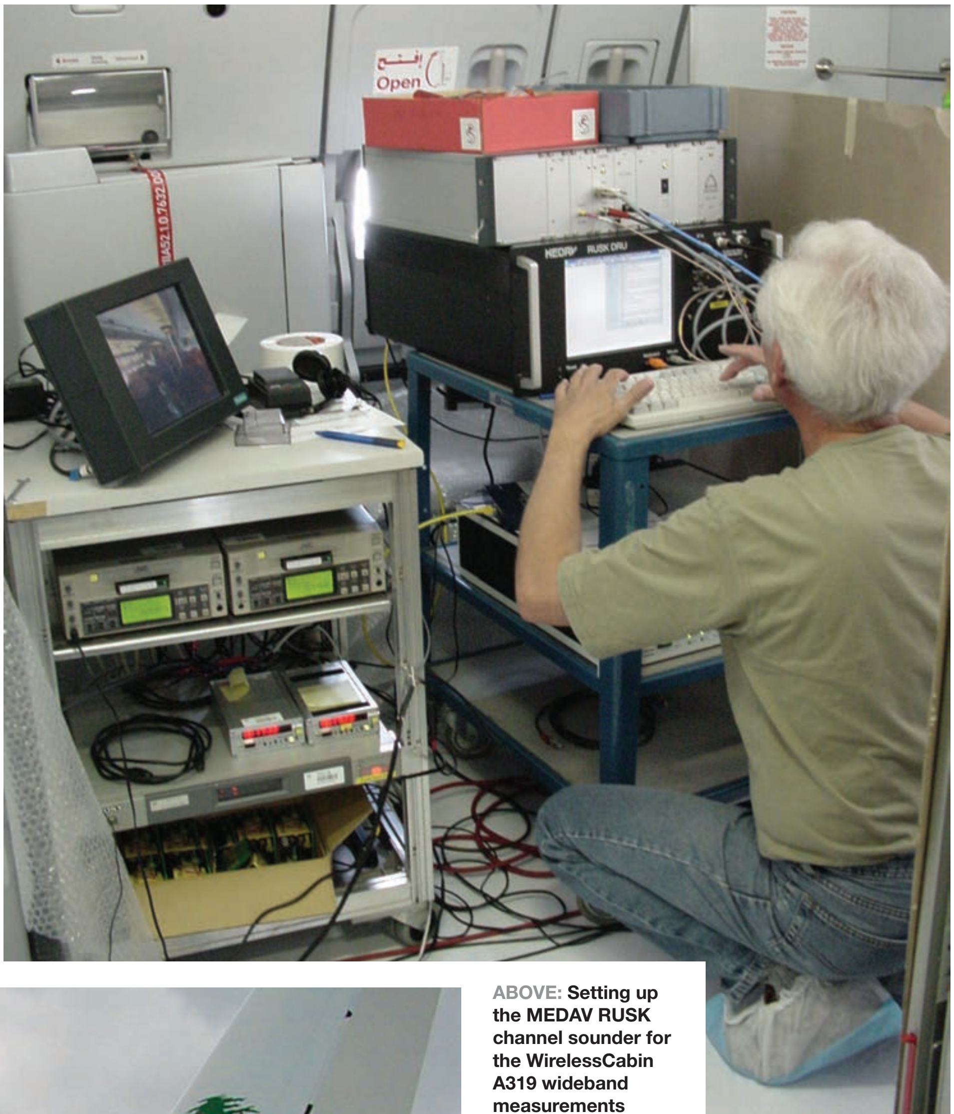
4. The crash simulator at the US National Institute for Aviation Research's Crash Dynamics Laboratory

BELOW: **External measurement of interference during the WirelessCabin program**

attenuator was used to reduce the transmitted power to 13dBm, and rubidium clocks built into the transmit-and-receive devices provided a reliable, absolute time reference.

The drooping dipole (circular polarization) transmit antenna was located above the ceiling on 'row 3' of the cabin for the UMTS downlink measurements. To simulate passengers' use of cell phones, the receivers, using linear-polarization dipole antennas, were placed on the seat, on the tray-table, and at ear level, and 55 seat positions were analyzed. Circular polarization is better where multipath is a concern, but most user terminals have linear polarized antennas because they cost less to manufacture.

Calculating the number of multipath components for each of the 999 impulse responses for each of the 55 seats, a total of 54,945 profiles, identified five zones, each roughly 10ft long, with different characteristics. The number of multipath components increased with the distance from the transmitter, except for the rear four seat rows, where the multipath



ABOVE: **Setting up the MEDAV RUSK channel sounder for the WirelessCabin A319 wideband measurements**

components are more attenuated and more fell below the noise threshold established for the tests.

The WirelessCabin project was the foundation for many subsequent developments, says Jahn, and its results continue to be applied: "In fact, most of today's GSM and WiFi networks in aircraft are based on the measurements and models elaborated in WirelessCabin."

Rack testing

When it comes to developing equipment and installations, Jahn says, TriaGnoSys uses both manual and automatic testing to verify system functions based on a list of requirements agreed with the customer. "For every installation or system we deliver, we have an integration test rack," he says. "Every night, hundreds of test cases are performed automatically." The system is stimulated to represent, for example, a passenger starting to browse the internet, and its reaction and the interaction with the satellite to get up the backhaul link.

"We also have interfaces to the aircraft – the ARINC 429 bus," explains Jahn. "If you are leaving a certain flight level, then maybe some of the external communications have to be blocked. Or there are security scenarios, such as if there is a sky marshal in the aircraft who initiates a certain communication type, then maybe passenger traffic has to be blocked. All these scenarios are tested automatically every night. Usually we use original hardware, and we simulate all these use cases end-to-end."

The test system is supplied with the input and the expected output, he explains: "The system under test needs to provide these outputs, otherwise the test system will register a failure condition, with an unpredicted or wrong outcome of the test case. So in the security scenario, if the passenger can still communicate outside of the aircraft, then the requirement is not fulfilled. That could mean, for instance, that we don't interpret the aircraft signals in the right way or there is a failure, or maybe it doesn't work at all times of the day but only during certain flight phases. So you really have to test it under all circumstances."

Best antenna positions

For new aircraft installations, TriaGnoSys uses the accumulated measurements and the models based on them to calculate the best antenna positions. "Airplane measurements are very expensive," Jahn says. "You have to take the aircraft maybe for a day. It's time-consuming and you want to already have a scenario where you think this installation would be the final scenario.

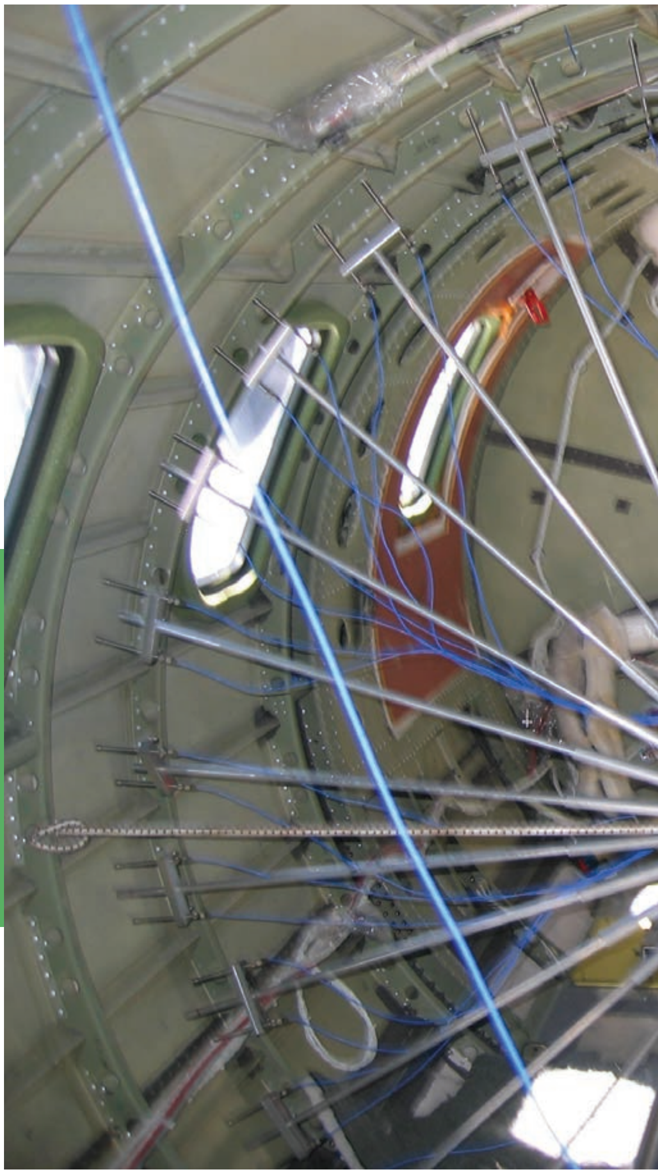
"The positioning of the installation is crucial, and if you were to repeat the measurement with 10 antenna positions, that would require such enormous effort and time that you could not do it in a day. So we usually want to have one or two antenna positions that the installation company has already agreed would be suitable, then we can do some simulations and see if it's feasible, and then we do the measurement for the final verification."

The Boeing 747 is a particularly difficult aircraft, he says: "The upper deck has very difficult propagation. If you have two antennas, in the front part the signals can propagate onto the upper deck, or maybe you have an antenna that is guided from the lower deck to the upper deck and back down to the lower deck."

There is a large statistical impact from multipath propagation, he adds, with reflections from the cabin walls, and propagation in the honeycomb structure of the floor and ceilings: "All these weights are then summing up, and if they have the wrong phases, then they can disrupt each other. If they are constructive in phase, they can even increase the signal level. And it's not steady either over time or over the area, and you need to have sufficient margins on all positions." In fact, the quality of WiFi or GSM signals is affected in the same way as shortwave radio reception varies with the location of the antenna.

"You have to select the installation locations and then you need to do the aircraft certification with them," Jahn sums up. "If you have to change the installation position, then maybe you have to reassess the certification, so it's really a very crucial decision and you can't change it easily at the end." ∎

Bernard Fitzsimons writes extensively on avionics, in-flight entertainment, aircraft communications, and other aerospace topics



The inner ear

CABIN NOISE CAN AFFECT THE COMMERCIAL EFFECTIVENESS OF AN AIRLINE SO ITS REDUCTION IS A PARAMOUNT DIRECTIVE

BY MARK VALENTINO

Directives to assess and minimize cabin noise have become a top priority for the aerospace industry. From large commercial jets to helicopters to propeller-driven general aviation, the aim is the same – reduction of cabin noise. High-amplitude acoustic signals, whether in the audible ranges of the human ear (20Hz to 20kHz), or beyond human hearing capability (infrasound and ultrasound), can range from being noisy and causing mild discomfort, to resonating human body components and inducing headaches or nausea.

Noise testing is critical to the commercial success and competitiveness of the aerospace manufacturing industry and is desired for passenger comfort.

The noise source

Noise source location and source strength must be determined first, before acoustic engineers can improve the condition. Preliminary data can be obtained in wind tunnel testing, but for the most realistic noise and the best characterization, an in-flight study is preferred. Noise can be derived from many sources.

Some of the most common noises are from fuselage structural vibration, exterior wind noise leaking through windows and door seals, gearbox noise, propeller noise, engine noise, and general squeak and rattle. Knowledge of the acoustic field inside the fuselage can direct the noise abatement procedures for lighter and more efficient damping/insulation solutions. Noise generated from passenger activities also needs to be accounted for in order to predict and control interior cabin abatement.

Detecting the noise can be difficult when measuring sound power entering the cabin at different locations and from multiple external sources. They tend to become polluted due to hard wall surfaces and reverberant components within the cabin. Early noise source identification methods included accelerometer measurements and sound intensity measurements using two 'phase matched' microphones spaced closely apart. Although easy to use, they were time consuming, lacking in resolution, and provided limited information.

Modern methods using a large array of strategically placed microphones, along with complementary software for data reduction, enable test engineers to obtain a greater amount of information, in a fraction of the time. The spherical beamforming HELS (Helmholtz Equation Least Square) method and other acoustic holography methods have been implemented for improved sound pressure mapping, acoustic pressure, surface velocity, acoustic power, and intensity measurements.

The HELS method

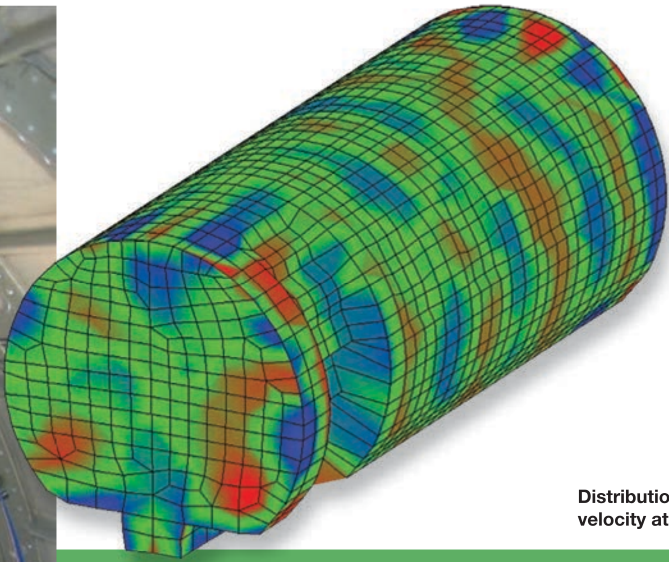
HELS is based on nearfield acoustical holography (NAH) and allows the visualization of acoustic pressure, normal intensity, and normal surface velocity mappings. It differs from the Fourier transform NAH method by analyzing the acoustic field through an expansion of spherical wave functions, which greatly simplifies reconstruction, and enabling complex problem solving on an arbitrarily shaped surface with fewer measurement points; saving both setup time and material costs.

According to Manmohan S. Moondra of SenSound LLC, with HELS, "The acoustic pressure is expressed as an expansion of the particular solutions to the Helmholtz equation. Under spherical coordinates, these particular solutions lead to the spherical wave functions. The coefficients that are associated with the expansion functions are determined by solving an over-determined linear system of equations obtained by matching the assumed form solution to the measured acoustic pressures, and the errors incurred in this process are minimized by the least squares and can be expressed as the following equation:

$$\hat{p}(\vec{x};\omega) = \sum_{j=1}^{J} C_j(\omega)\Psi_j(\vec{x};\omega)$$

This lends itself well to low- to mid-frequency measurement requirements as required by propeller or engine noise, which is typically in the 50-300Hz range, or normal surface velocity between 1Hz to 1kHz.

Circular microphone array, PCB Microphone model T130D21



Distribution of surface velocity at 155Hz

> "There are active and passive methods to combat the noise sources and each method has its advantages"

Trial and setup

A mid-sized business jet was used in the test. All interior panels in the passenger cabin were removed and flight testing was conducted at 30,000ft and Mach 0.73. The closed surface included the forward cabin skin and floor, aft cabin skin and floor, and two closing surfaces (between the cockpit and the forward cabin and at the aft divider location).

A conformal circular microphone array of 60 microphones was built (see Figure 1) to cover the circumferential measurements and a planar microphone array of 50 microphones (for example, PCB model 130E22) was built for the closing surface measurements. The circumferential measurements were taken every 2cm in the longitudinal direction, located 2cm from the skin.

Placement areas of highest interest and likely location of passengers should be assessed. The reconstructed location of the fuselage skin and the closing surfaces are then derived. The interior acoustic pressure field was reconstructed in seven interior planes, including setup of custom microphone arrays and fixtures for circumferential and longitudinal measurements of acoustic pressures along the fuselage body. Identification of 'hot spots' in the cabin skin, where noise is more likely to be transmitted into the cabin, can then be determined.

Control strategies

Once the noise is identified, engineers can take appropriate steps to minimize it. There are active and passive methods to combat the noise sources and each method has its advantages. An example of an active method would be to place speakers in strategic areas and broadcast counteractive noise signals to cause destructive interference. When performing passive methods, consideration should be made to weight reduction, which also reduces fuel cost and travel time.

Some examples of passive methods include special panels, coupling between exterior and interior transmission of sound so it is impaired before it enters the cabin, and other dampening materials.

HELS and other NAH-based methods can provide noise source locations in order to improve the sound inside today's aircraft and helicopters, enabling manufacturers to reduce noise for their passengers. Microphones have been proven to provide the appropriate acoustic pressure response required for HELS and NAH measurements. With the advent of lower cost, prepolarized array microphones, flight test engineers are now able to characterize many of the likely passenger locations during a single test flight, saving time and money for the program. ∎

Mark Valentino is the acoustic product manager for PCB Piezotronics Inc based in Depew, New York, USA

Land of the giants

BEFORE LUFTHANSA COULD TAKE DELIVERY OF THE LATEST 747-8 SUPERGIANT, MAJOR PREPARATIONS HAD TO BE MADE TO ENSURE THE CORRECT MAINTENANCE FACILITIES WERE AVAILABLE

The B747-8 International can transport a payload weighing 22 tonnes more than that of the B747-400 over a range of more than 14,000km

“Around 80 mechanics and engineers of Lufthansa Technik will be trained on the new type”

BY WOLFGANG REINERT

In only a few weeks, Lufthansa will take delivery of the first of 20 new Boeing 747-8 Intercontinental aircraft. The airline, the first customer for the passenger version of this aircraft, also holds an option for 20 more. To ensure that regular service with the world’s longest passenger aircraft is perfect, right from the start, one aircraft from Boeing’s flight test and certification program was brought to Frankfurt for extensive fit-check tests during early December 2011. Following termination of Boeing’s own test program, the aircraft cabin is to be prepared for its future service with Lufthansa, and the airliner will be delivered to the carrier in 2012.

The practical test at Frankfurt Airport was the successful conclusion of a long-term preparation program by Boeing, Lufthansa, and Lufthansa Technik.

In the preceding months, the manufacturer and the airline had planned the availability of the aircraft in a process of close consultation. The content of the pre-delivery evaluation was precisely defined and coordinated so as to enable the greatest possible use to be made of the fit-test visit. A precise plan of action was prepared by a special project team consisting of experts from Boeing, Lufthansa, and Lufthansa Technik. As a consequence, 85% of this aircraft’s time on the ground could be used for extensive and varied service and handling tests, such as positioning, docking of passenger jetways, towing, loading and unloading, cleaning, catering, fueling, and de-icing.

Lufthansa Technik, responsible for technical support of Lufthansa’s fleet, also used this one-time opportunity to test the world’s longest passenger aircraft in its maintenance hangars.

“The provision of this prototype enabled us to check our equipment and docking system preparations in advance, and thus ensure a smooth maintenance process in Frankfurt right from the inauguration of this aircraft,” says Dean Raineri, the director of New Aircraft Readiness Aircraft Maintenance. “Our concrete aim is to achieve a deployment reliability of at least 98.5% from day one, which roughly corresponds to the current level of our 747-400 TDR – technical dispatch reliability.”

Line maintenance

Once the 747-8 is in service, Lufthansa Technik will perform all line-maintenance activities in the Frankfurt maintenance facilities. A-checks for this aircraft type must be performed after a maximum of 1,000 flight hours and C-checks are due after two years of operation.

Even though the introduction of the 747-8 does not entail as many new features for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The aircraft is 5.6m longer than its predecessor, the Boeing 747-400, making it the longest passenger aircraft in the world

FAA freight certification

It was in August 2011 that the FAA granted Boeing an Amended Type Certificate (ATC) and an Amended Production Certificate for the 747-8 Freighter, while the European Aviation Safety Agency (EASA) also granted the company an ATC for the airplane.

With the cargo version, the stretch provides customers with 16%t more revenue cargo volume compared to its predecessor.

Lufthansa Technik as was the case with the A380, the company's maintenance experts studied and analyzed this prototype just as intensively. By the time Lufthansa puts the 747-8 into service in spring 2012, a core team of around 60 Lufthansa Technik employees will have invested some three years of preparation in order to attain maintenance readiness for this aircraft type.

In this preparatory phase, three sectors were key elements for Lufthansa Technik. The first was the review and modification of existing infrastructure and the required tools and equipment. Among other things, new special tools for maintaining the 747-8, such as large lifts for heavy components, had to be obtained.

The procurement and provision of spare parts was a further challenge. Following an iterative analytical process, Lufthansa Technik ultimately ordered around 60,000 spare parts, which it will keep on hand for maintenance services. One special focus here was on the possible transport of a spare GENX-2B engine for the 747-8, on account of its massive dimensions – more than 5m (16ft 5in) long and over 3m (9ft 10in) high and wide. With a weight of 12 metric tons, rapid global logistics of an engine in the event of an aircraft-on-ground (AOG) situation is possible only with certain large aircraft types, such as the Boeing 747 freighter. Due to the virtually identical dimensions of the Trent 900 engines of Lufthansa's Airbus A380 fleet, the planning largely adhered to the AOG concept developed for that engine.

The third key aspect in the preparatory phase was the training and licensing of the corresponding technical personnel. Around 80 mechanics and engineers of Lufthansa Technik will be trained on the new type by the time Lufthansa puts it into service, and 25 of them have already attended four weeks of practical training at Boeing, which is the prerequisite for obtaining the license.

Two of the three key sectors were checked during the test. Particular attention was paid to the handling of the 747-8 in the hangar. Lufthansa Technik Hangar 5 in Frankfurt, the 'jumbo hangar', was originally designed for the Boeing 747-100. The Boeing 747-8 is considerably larger than its predecessors; for example, it is 5.6m (18ft 4.5in) longer than the 747-400.

"We already had an extremely positive experience with a similar test when the Airbus A380 went into service," says Raineri. "Even the best planning is not proof against surprises once the real aircraft is actually in the hangar, and we wanted to avoid having any coming up during real maintenance. As no major surprises occurred during the pre-delivery evaluation, we can say that our planning here was right on target."

Hangar dock

In the previous months, the hangar's wing dock had been extensively modified, as it was previously fitted to the dimensions of the Boeing 747-400. Among other things, the dock was equipped with wheels to enable the working platform to be matched to the different fuselage lengths. The fit-check showed that only a few minor modifications were necessary in order ensure that the various working levels of the dock have optimum access to the different aircraft types. These modifications have now been completed, so the dock is perfectly prepared for working on both Jumbo versions.

The scale of this new aircraft also makes for challenges in other areas. "The new dimensions of the 747-8 mean that Lufthansa can only accommodate up to four 747-8s in the hangar at once, instead of six 747-400s as before. This, of course, impacts our scheduling and maintenance planning, particularly in combination with our short-range fleet," says Raineri.

Lufthansa Technik is planning to expand its facilities in Frankfurt, as Lufthansa's fleet growth for the coming years already shows the need. Currently, Hangar 7, the company's A380 hangar in Frankfurt, can be used if necessary. If the need should increase further, capacity could be extended by expanding Hangar 7 with its stage two.

In addition to the infrastructure check in the narrow sense, another major priority in the test phase in Frankfurt was to give Lufthansa Technik's new 747-8 maintenance experts the opportunity to put their theoretical knowledge into practice before the start of service by familiarizing themselves with the new work processes and modified design on the actual aircraft. Compared with its predecessors, the 747-8 has more extensive electrical and electronic systems, modified wing profiles, redesigned flaps, fly-by-wire outboard ailerons, and more economical engines, to name just a few features.

"Working in close cooperation with Boeing and our subsidiary Lufthansa Technical Training, we were able to license our personnel well in advance so that we obtained the EASA 145 approval for line maintenance operation for the 747-8 and its new GEnx engines in autumn 2011," explains Raineri. "The German Federal Office of Civil Aviation requires proof not only that the personnel have been appropriately trained, but that all technical and organizational prerequisites have been met. As of January 1, 2012, we also hold the EASA 145 approval for base maintenance work on this aircraft. This was possible only due to the excellent long-term planning of our colleagues in the core project team."

Manufacturer collaboration

In addition to all internal preparations, a close collaboration with Boeing during the flight test phase was made possible. This enabled Lufthansa Technik to follow all technical insights from the flight test program right from the start. A virtual maintenance conference with Boeing representatives is still held every month to share insights on the technical highlights of the new Jumbo during real operation of the cargo aircraft. Several teams observed the Boeing maintenance crew between the individual test flights. This enabled them to find out whether 'teething problems' existed, and estimate, "whether we needed to make special preparations at our end", according to Raineri.

The individual findings are compiled, documented and provided to all involved Lufthansa Technik departments in a specially developed web-based knowledge pool. Additionally, a group of Lufthansa Technik specialists is overseeing the production of the Lufthansa 747-8 at the manufacturer's site.

Lufthansa Technik is already performing line maintenance work in Frankfurt. Some freight carriers have already put the cargo version into service. For example, the British company Global Supply Systems has commissioned Lufthansa Technik to perform line station maintenance in Frankfurt as well as Air Bridge Cargo. "Our experience with the cargo aircraft already in service is invaluable for our preparations for the Lufthansa fleet – as is the regular sharing of information with the other 747-8 operators, which enables us to respond to any irregularities or problems that occur in regular flight service in good time," he says.

Because of all this preparation, Raineri is certain that Lufthansa Technik is optimally positioned for the entry into service of the Boeing 747-8 Intercontinental at Lufthansa: "There are, of course, always a few uncertainties that crop up only in regular service, but we're not too concerned, as our technicians and engineers have decades of experience in aircraft maintenance. We have done everything possible in the way of preparation. Now we're looking forward to the arrival of this fantastic aircraft."

Wolfgang Reinert is a manager with corporate communications for Lufthansa Technik AG

Bio record-breaker

At the Paris AIr Show in 2011, the 747-8 broke new records after completing the first transatlantic flight of a large commercial airplane powered on all engines by a sustainable aviation jet fuel.

All four of its General Electric GEnx-2B engines were powered through the entire flight by a blend of 15% camelina-based biofuel mixed with 85% traditional kerosene Jet A fuel.

Bar testing, no modifications were made to the airplane, its engines or operating procedures prior to departure.

Newly designed: the aircraft's GEnx-2B67 powerplants. The B747-8I engines are not only quieter in operation than earlier generations, they burn less fuel and generate fewer emissions

Wired workhorse

AFTER A DECADE OF FLY-BY-WIRE TESTING, THE JUH-60A ROTORCRAFT AIRCREW SYSTEMS CAPABILITY AVIONICS LABORATORY REMAINS THE ONLY FULL-AUTHORITY FBW ROTARY WING RESEARCH PLATFORM IN THE USA. FRANK COLUCCI LOOKS AT RECENT ACCOMPLISHMENTS AND UPCOMING PROJECTS

Active inceptors give the RASCAL evaluation pilot real-time force feedback based on aircraft state (US Army)

BY FRANK COLUCCI

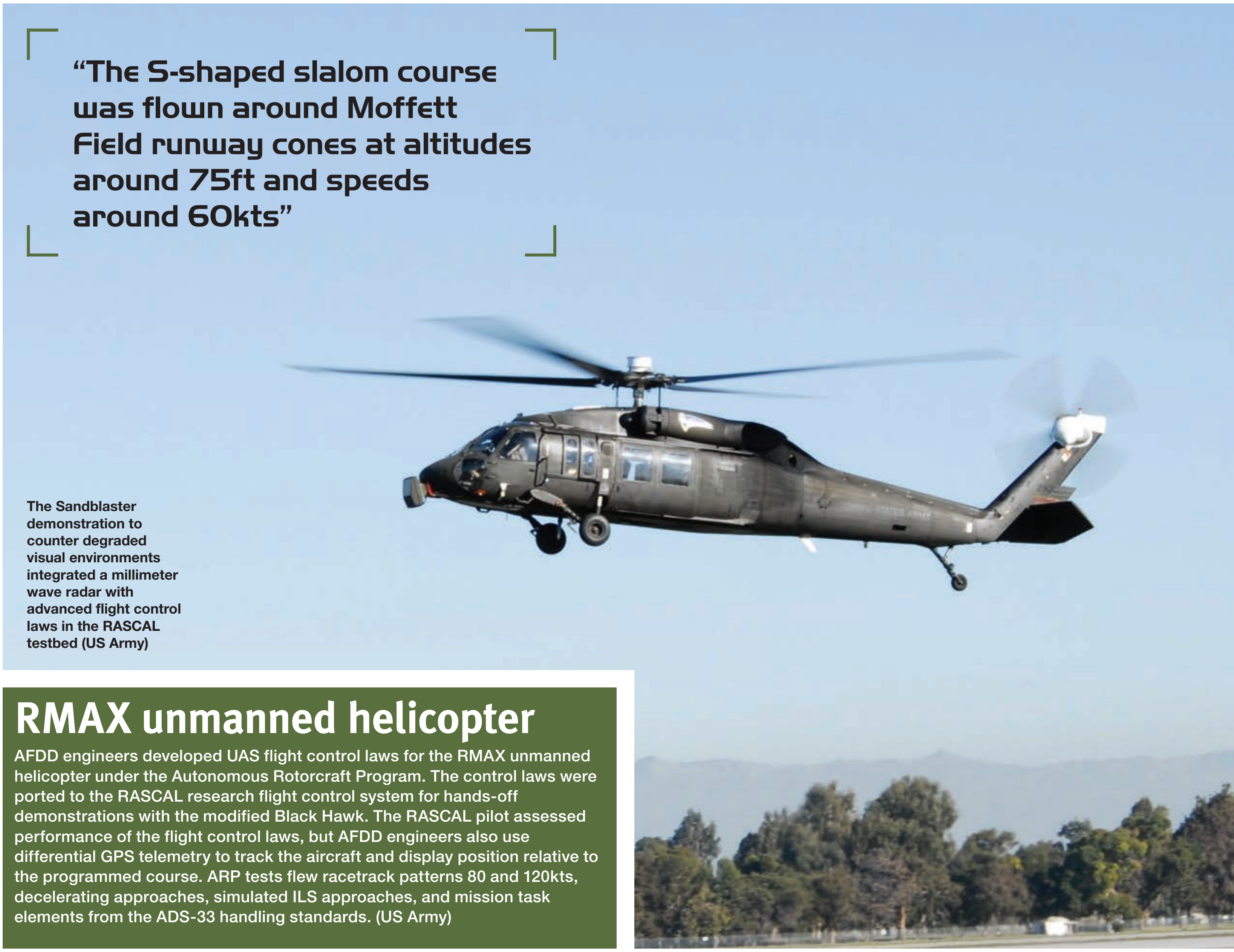
The US Army Aeroflightdynamics Directorate (AFDD) at NASA Ames Research Center in California is home to a one-of-a-kind Black Hawk helicopter with two parallel flight control systems. The instrumented JUH-60A Rotorcraft Aircrew Systems Concepts Airborne Laboratory (RASCAL) flies with a research pilot working fly-by-wire controls in the right seat, a safety pilot with conventional mechanical control links on the left, and a test engineer monitoring databused measurements in the cabin.

"It's a rapid prototyping facility that allows us to evaluate new candidate systems before they're actually built," explains RASCAL project manager Jay Fletcher. "The real value is being able to test new hardware and software in a real flight environment before it has to be built into a real production system." RASCAL reduced fly-by-wire (FBW) hardware and software risk on the production-ready UH-60M upgrade for the US army. It demonstrated Sandblaster brownout approach technology for the Defense Advanced Research Projects Agency (DARPA) and trailed another Black Hawk hands-off in autonomous flight following tests for Sikorsky Aircraft. (See *Aerospace Testing International*, March 2011.) RASCAL and associated computer design tools supported development of control laws and tactile cueing algorithms for the new Navy/Marine Corps CH-53K heavy-lift replacement helicopter. The manned research helicopter also flew a slalom-style course hands-off to simulate an autonomous unmanned aircraft system for AFDD. In more than 10 years of FBW experimentation, RASCAL has engaged its failsafe research flight control system (RFCS) more than 11,000 times.

Sandblaster demonstration

The clear-air Sandblaster demonstration integrated RASCAL flight controls with autonomous point-in-space flight control software from Sikorsky Aircraft, millimeter wave radar from Sierra Nevada Corp, and a terrain database from Honeywell terrain database. The system took the FBW RASCAL to a 25ft safety hover hands-off in simulated brownout and showed evaluation pilots landing zone obstacles on a cockpit display. Fletcher notes, "It is a testament to the flexibility of the original RASCAL design that we are able to seamlessly integrate a wide [range of] new hardware and software with RASCAL." Follow-on tests will integrate RASCAL with alternative sensors.

RASCAL works in conjunction with a desktop-to-flight development environment – software tools that enable flight control engineers to take control laws from concept to flight test. Closed-loop models of new vehicles 'fly' in piloted, real-time simulations. Control laws are subsequently checked and pilots trained in a hardware-in-the-loop simulator with an actual RASCAL flight control computer and pilot interface driving simulated RFCS actuators and helicopter dynamics. Flight control software tested in the development facility goes into the RASCAL helicopter, and flight



"The S-shaped slalom course was flown around Moffett Field runway cones at altitudes around 75ft and speeds around 60kts"

The Sandblaster demonstration to counter degraded visual environments integrated a millimeter wave radar with advanced flight control laws in the RASCAL testbed (US Army)

RMAX unmanned helicopter

AFDD engineers developed UAS flight control laws for the RMAX unmanned helicopter under the Autonomous Rotorcraft Program. The control laws were ported to the RASCAL research flight control system for hands-off demonstrations with the modified Black Hawk. The RASCAL pilot assessed performance of the flight control laws, but AFDD engineers also use differential GPS telemetry to track the aircraft and display position relative to the programmed course. ARP tests flew racetrack patterns 80 and 120kts, decelerating approaches, simulated ILS approaches, and mission task elements from the ADS-33 handling standards. (US Army)

test results are compared to simulation models. The structured process and hardware-in-the-loop facility transplanted trajectory-following control laws from a 200 lb unmanned R-MAX helicopter to the 20,000 lb manned JUH-60A for the NASA/US Army autonomous rotorcraft project (ARP). Since September 2011, RASCAL has flown about 15 test hours for the ARP and verified the autonomous flight system at speeds from hover to 130kts forward flight. "There are some challenges that are unique in a full-scale aircraft," explains Fletcher. "We're flying at a lot higher speed than the RMAX. It's also important to demonstrate it on a platform that's a little more relevant to what the US Army is looking for in its requirements."

The ARP science and technology effort aims at controls for notional unmanned air vehicles (UAVs) that can fly intelligence, surveillance, and reconnaissance, or other missions, without operator intervention. Flight tests include hover and low-speed mission task elements taken from the ADS-33E-PRF handling qualities specification. "It just gives people a reference point that we are familiar with," Fletcher observes. "One of the problems is that there isn't, as far as we're aware, a standard test course for autonomous operations, or a standard autonomous mission that you could use to evaluate one system against another."

Test course

The S-shaped slalom course was flown around Moffett Field runway cones at altitudes around 75ft and speeds around 60kts. The speed dictated large lateral control inputs and bank angles around 40°. While conventional helicopter autopilots with just 5 to 10% control authority provide a deliberately sedate response, RASCAL full-authority FBW controls allow large, rapid maneuvering inputs. "The main functional feature that fly-by-wire offers you is full-authority control over the actuators. It's that the computer is able to move the actuators throughout their whole range of motion," notes Fletcher. "That makes a variety of things possible, including generically greater levels of augmentation – velocity hold, rate hold. It also allows these higher levels of autonomy."

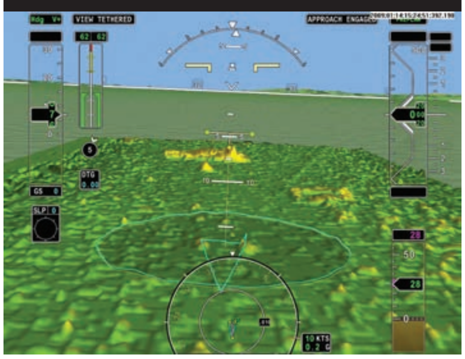
RASCAL will continue to explore autonomous flight control technology this year, including obstacle field navigation (OFN) previously demonstrated on the RMAX. The little UAV used passive stereo cameras and a scanning laser to distinguish obstacles. RASCAL engineers will integrate the JUH-60A with a Burns Engineering laser radar (LADAR) previously flown on an AFDD EH-60L for the Air Force 3DLZ brownout countermeasures demonstration. The LADAR goes on RASCAL this spring for OFN flight tests this summer. According to Jay Fletcher, "We'll be able to sense objects in the field of view, and the flight control system will be able to avoid them."

Research renovations

Delivered to the US Army in 1978, the JUH-60A RASCAL was only the twelfth Sikorsky Black Hawk built, but today has just 2,000 flight hours in its logbook. "It's an old aircraft flying the latest technology software," notes Fletcher. RASCAL started its research life with analog cockpit instruments, a six-channel Lear Astronics (today BAE Electronic Systems) research flight control computer, and a Boeing RFCS with parallel hydraulic actuators to switch control from safety to research

Control computers

RASCAL and associated computer design tools supported development of control laws and tactile cueing algorithms for the US Marine Corps CH-53K heavy lift replacement helicopter now in development. The CH-53K triplex flight control system uses Hamilton Sundstrand flight control computers and BAE active inceptors (sidearm cyclics and limited-travel collectives) that give pilot and co-pilot tactile feedback based on control, power, and structural limits. FBW controls promise to enhance the stability and responsiveness of the 84,000 lb CH-53K and provide multiple operating modes to reduce crew workload, particularly with heavy loads. (Sikorsky)



pilot. Safety rules state RASCAL RFCS servos and right-seat, fly-by-wire controls are engaged at altitudes only above 25ft. With the RFCS working, the safety pilot is back-fed mechanical control cues from the rotor system. Either pilot can override the RFCS, and monitoring software disengages the FBW controls automatically if it detects a fault.

The programmable, high-bandwidth, full-authority RFCS with advanced multimode flight control laws enables the research Black Hawk to simulate nearly any aircraft. (The US Navy has two partial-authority Seahawks used to train test pilots at Patuxent River, Maryland.) Initially, the right-seat RASCAL pilot had a three-axis, side-arm controller and electrically back-driven collective in place of the standard cyclic, collective, and pedals. The UH-60M Upgrade (60MU) program gave RASCAL active inceptors from BAE Systems.

Pilot cues

Unlike springs, stick shakers, and other traditional force-feedback mechanisms, active inceptor sticks vary feedback forces to give the RFCS pilot tactile cues that change with aircraft condition. A soft stop or vibration in the inceptor can warn pilots of over-torque or approaching obstacles.

The force-feedback sticks in the RASCAL are pre-prototypes of the pilot cyclic and collective in the UH-60MU. "They were ruggedized to give us years-worth of use," says Fletcher. "It's a valuable tool for us to use in our handling qualities and flight control research."

RASCAL validated control laws written by Sikorsky for the FBW UH-60M Upgrade. "We worked with Sikorsky to develop, test, and evaluate the flight control software through five major and 17 minor software upgrades," notes Jay Fletcher. The instrumented test helicopter with narrow-chord main rotor blades, first-generation T700-GE-700 engines, and research flight control actuators was a reasonable facsimile of the broad-blade UH-60MU at speeds up to 80kts. US Army and Sikorsky pilots flew about 100 hours back-to-back on the FBW RASCAL and conventional EH-60L to compare handling qualities and mature the MU flight control system.

Upgrade flight control software went through another 495 flight hours on two UH-60MU test aircraft before budget concerns put the upgrade production on hold. Fletcher nevertheless observes, "The development conducted at AFDD and with RASCAL significantly reduced technical and programmatic risk by exposing important development issues early in the program when they were relatively easy and inexpensive to fix, and on a platform with a failsafe flight control system."

Cockpit research

The research cockpit has recently been updated with two 10in sunlight-readable liquid crystal displays compatible with night-vision goggles. "They're fairly generic and we can reprogram them for whatever experiment we're doing," says Fletcher.

RASCAL has also received a laser-based rotor-blade state measurement system that tracks blade flapping, pitch, and lead-lag motion. "There aren't that many helicopters that have instrumentation to measure the blade motions. RASCAL is one of only two I know of," notes Fletcher. RASCAL engineers plan to implement rotor-state feedback in the flight control computer in the next year or two. "It would improve the disturbance or gust rejection characteristics. It would increase the stability of the flight control system. It would potentially allow us to reduce things like shaft moment loads."

Previous RASCAL load-alleviation tests for joint heavy lift capabilities achieved 10 to 15% load reductions that could extend main rotor shaft-life four times and trim fuselage structural weight. Last October, RASCAL also tested cable angle feedback control laws to improve flight characteristics and performance with external loads. AFDD built a modular load for sling tests. The instrumented package includes an embedded GPS/INS, which allows engineers to measure precise load position and velocity. The RASCAL aircraft uses identical instrumentation to provide aircraft state feedback for the flight control system.

Strain gauges and other instruments feed the CDAU via a MilStd 1553 databus. Jay Fletcher notes, "We also have a variety of analog sensors that go to our flight control computer, things like engine torque, fuel flow, and radar altimeters. Those get digitized and the flight control computer puts them on the 1553 bus so they can be recorded." Two remote multiplexing units interface the recorder with other analog sensors such as the blade motion measurement system through the aircraft. The CDAU can also record GPS position data. Fletcher adds, "Everything that we record, we also telemeter to the ground." ∎

Frank Colucci has written about the helicopter industry for 30 years. He routinely covers rotorcraft design, civil and military operations, test programs, advanced materials, and avionics integration.

The RASCAL has parallel fly-by-wire and conventional control systems to safely evaluate new flight control laws and integrated flight control concepts (US Army)

DARPA integration

AFDD performs basic and applied research for the US Army, DARPA, and other paying customers. The DARPA-funded Sandblaster demonstration integrated advanced flight control laws with the RASCAL research flight control system. Sandblaster validated the tools needed for a safer approach to a point in space, but DARPA will sponsor future demonstrations with smaller, lighter sensors. (DARPA)

ALMOST 18 MONTHS AFTER THE UPGRADED LYNX AH MK 9A WAS FIRST DEPLOYED TO AFGHANISTAN, NEW EQUIPMENT IS BEING INTEGRATED TO ENHANCE ITS CONVOY OVERWATCH AND ESCORT ROLES

BY DAVID OLIVER

In December 2008, AgustaWestland was awarded a £50 million (then approx. US$74.2 million) Urgent Operational Requirement (UOR) contract to upgrade 12 Army Lynx AH Mk 9 aircraft that first entered service in 1991. Developed within an Anglo-French helicopter agreement dating back to 1968, the twin-engined general purpose and utility Lynx AH Mk 1 was built by Westland Helicopters, with more than 100 being delivered to the UK's Army Air Corps, many of which were later modified for the anti-tank role as the AH Mk 7. Designed for the tactical transport role, the AH Mk 9 featured tricycle wheel landing gear, advanced composite main rotor blades, and an increased maximum take-off weight.

When the Lynx AH Mk 7 was first deployed to Afghanistan, its performance was seriously compromised when operating from Kandahar Airfield, which is 6,000ft above sea level in ISA 40°C temperatures, and it was virtually grounded during the summer months. It was clear that a major upgrade program was

Cool for cats

> **"When the Lynx AH. Mk 7 was first deployed to Afghanistan, its performance was seriously compromised when operating from Kandahar"**

required if the Lynx was to be made 'fit for purpose', and the answer was the Mark Nine 'Alpha'.

The Mark 9 Alpha upgrade used technologies being developed for the AW159 Lynx Wildcat program, including the installation of LHTEC CTS800-4N engines, which replaced the AH Mk 9's original Roll-Royce Gem 42 turboshafts. The new engines produce 37% more power, allowing the Mark 9 Alpha to operate in extreme hot and high conditions with an additional 2,200 lb payload. The basic upgrade required modifications to be carried out to the main gearbox, top deck structure, exhausts, and rear fuselage to accommodate the CTS800-4N engines. Additionally, changes were carried out in the cockpit for the new environmental control system, cockpit lighting, and control and digital displays, plus the electrical system and DC generation. Internal modifications include four-man armored troop seats and a fast roping frame.

Demonstrator aircraft

A written-off airframe supplied by the MoD was used to trial the installation and changes required to the structure of the aircraft, as a risk reduction exercise. Similarly, AgustaWestland's Super Lynx 300 demonstrator aircraft, which is powered by the CTS800, was used to perform a range of trials in support of the program to speed up the qualification process prior to re-entry into service.

The first flight of the Lynx AH Mk 9A took place just 10 months after contract award on September 16, 2009 at AgustaWestland's Yeovil, UK, facility. In December 2010, the first four upgraded helicopters were delivered to the Army Air Corps' 9 Regiment. Three of these four aircraft were used for conversion-to-type and conversion-to-role training at its Dishforth base in Yorkshire, and in early 2011 for pre-deployment training with the Joint Helicopter Force (Kenya) at Laikapia Air Base on the foothills of Mount Kenya.

In March 2010, AgustaWestland was awarded a £42 million Batch 2 contract extension to upgrade an additional 10 helicopters. This contract meant all of the existing fleet of 22 Lynx AH Mk 9 helicopters were to be upgraded to Mark 9 Alpha standard, the last of which was delivered on December 15, 2011. Incorporated in these Batch 2 helicopters was a night enhancement package that included a digital night-vision goggle system and the Raytheon ARC-231 secure airborne communications system with additional antennas.

Several of the Mark 9 Alphas were delivered with the L3 Wescam MX-15 multisensor turret during the upgrade program. AAC Lynx AH Mk 7 helicopters had been used as surveillance platforms in Northern Ireland equipped with OXBOX and RAHU cameras, and first carried the L3 Wescam MX-15 multisensor turret more than five years ago. Early last year, 661 Sqn, 1 Regiment AAC converted from the AH Mk 7 to Mark 9

RIGHT: A Joint Helicopter Force Lynx AH Mk 9A at Camp Bastion fitted with the lightweight MX-10 EO/IR sensor turret under the nose (Pictures: David Oliver)

BELOW RIGHT: The rear crew's tactical display console in the rear cabin of the AH Mk 9A for trials of the MX-10 system

BELOW: The Lynx AH Mk 9A's L3 Wescam MX-10 sensor turret mounted on its integrated vibration mount

> **"The AH Mk 9A is more than capable of carrying the additional weight of the MX-15"**

Alpha. They first tested the MX-15Di electro-optical/infrared system as an interim measure during pre-deployment training at El Centro, California, before the squadron deployed to theater to support 'Operation Herrick' as part of Joint Helicopter Force (Afghanistan) in July 2011.

With the additional power of the LHTEC CTS800-4N, the AH Mk 9A is more than capable of carrying the additional weight of the MX-15, plus the door-mounted FN Herstal M3M (GAU-21) machine gun system, throughout the hot summer months in Afghanistan. However, the original mounting of the MX-15 on a bracket above the port shock strut of the main wheel unit created a blind spot that reduced its effectiveness.

For Herrick 15, which commenced in November 2011, the Joint Helicopter Force (Afghanistan) Lynx Mark 9 Alphas began to be fitted with the L3 Wescam MX-10 electro optical/infrared sensor. At less than half the weight of the MX-15, the MX-10 has a compact integrated vibration mount that allows it to be fitted under-nose slightly offset to port, thus giving an almost 360° sweep. The sensor also has enhanced IR capabilities and is being tested in theater with a large tactical display console in the rear cabin, which is being used for trials of a live downlink of camera footage to the operations room. In addition to the rear crewman, the co-pilot, often a qualified airborne forward air controller, can operate the system using a foldaway touchscreen in the cockpit. The MX-10 fit will be a considerable capability enhancement to the AH Mk 9A's force protection role in support of Task Force Helmand.

The original 12 Batch 1 aircraft will be returned to AgustaWestland to be modified to Batch 2 standard over the next 12 months, and the first was delivered in January 2012. ∎

David Oliver is a freelance aviation writer, author, and an IHS Jane's consultant editor

RIGHT: The AH Mk 9A co-pilot's fold-away touchscreen tactical display in the cockpit (David Oliver)

BELOW: The 1,840 shp LHTEC CTS800-4N turboshaft engine installed in the Lynx Mark 9 Alpha

French language

Dr Paul French is a senior lecturer, with the Research Institute, Liverpool John Moores University and a leader in the field of carbon fiber research. He says "We had to work out some way of processing composites, because it is such an important material in the aerospace industry. So we looked at laser sources we could possibly use. There is a growing interest in using so-called Ultrafast lasers, delivering extremely short pulses of laser light, measured in femtoseconds, and also UV lasers. While both these types of lasers have their merits, they are relatively expensive and sometimes complex laser sources.

"The fiber laser offers a viable alternative. These lasers can couple significant laser power into small focal-spot sizes that generate a very intense beam, and it is this latter factor that creates a viable process. Coupled with lower costs and greater robustness, these laser sources offer a practical industrial tool for processing composites. The results using these lasers were very encouraging, and we have invested in a fiber laser for our own laboratory at John Moores University to further this process."

Laser quest

The composition of carbon fiber reinforced plastics has made the Boeing 787 stand out as a revolution in aircraft design. The use of laser technology during the test phase was imperative

BY DR PAUL FRENCH & DR MOHAMMED NAEEM

Hopes of more affordable flights soared when the new Boeing 787 Dreamliner took to the skies in late 2011. Featuring a carbon composite design, the latest passenger jet is lighter than rivals, resulting in substantial fuel savings.

Carbon fiber reinforced plastic (CFRP) offers aerospace manufacturers superior mechanical properties compared with metal alternatives. Its low density, high strength and high stiffness-to-weight ratio means it's well-suited to many aerospace applications. For example, CFRP is used in the manufacture of nacelles, the leading edge of which is drilled to make the liner acoustically absorbent.

The diameter of the holes, combined with the top sheet thickness, depth of the honeycomb structure, and the percentage of the area covered with holes, all determine the frequency response of the acoustic liner.

But the composition of CFRP, in particular the high heat conductivity of the carbon fibers, makes processing difficult using the traditional techniques. Mechanical milling and drilling has been known to cause costly heat damage, chipping, delamination, and tool wear.

Although using water jets give a high-quality cut, it can cause delamination and requires a pilot hole to be drilled mechanically if the cutting process starts anywhere other than at the edge of the sheet. Another potential issue with water jet cutting is the effective disposal of waste cutting products.

The good news is that much of this damage can be avoided through correct application of laser processing. An ongoing UK study by UK-based company JK Lasers, in conjunction with Liverpool John Moores University, has revealed that lasers can effectively cut, mill, and drill CFRP without compromising the material's integrity.

Cut and drill

During trials, a 200W fiber laser (JK200FL) and scanning head were used for trepanning and milling. It was also used in cutting and drilling tests using more conventional process heads.

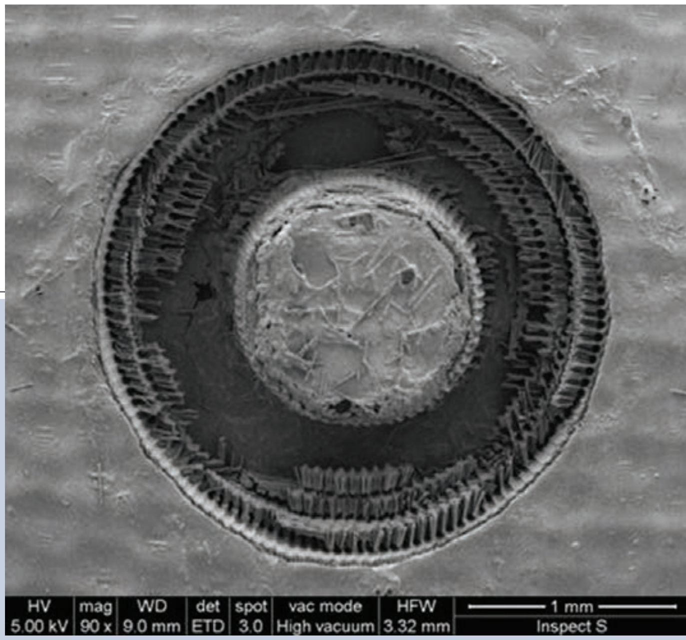
Past experience of cutting CFRP revealed that trying to cut the material as if it were a metal failed to produce a satisfactory cut for composites with a thickness of more than 1mm. To overcome this, researchers used a larger kerf width that would allow material to escape without matrix adhering to the freshly cut face and stop slug of material falling out. The cutting strategy devised by the team is illustrated in the diagram on the last page of the article.

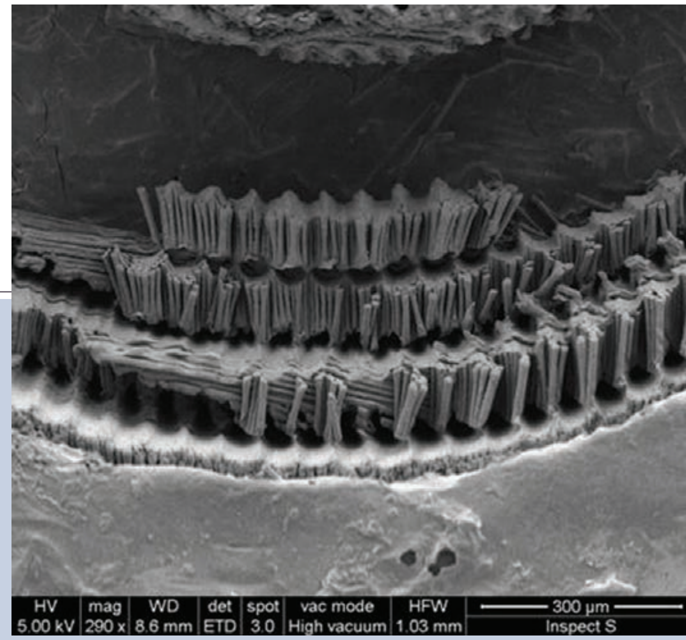
Each ring is an individual scan path for the laser beam. The central dark area shown in the figures is the central slug of material that will fall out as soon as the hole has been cut. In these particular experiments, the diameter of the central slug was 1mm, with the final diameter of the outer ring measuring 2mm. The distance between the individual rings was either 200μm or 300μm with a partially drilled slug using this type of drilling mechanism.

The last three outer cutting paths of the laser are visible, as well as the individual witness marks of the pulses. The slug still sits in the center of the hole. The laser parameters used to machine this hole were the JK200FL in modulation mode, 50μsec, pulse energy 10 mJ,

> "The use of lasers for cutting CFRP composites has yet to be exploited by the aerospace industry"

The first South Carolina-built 787 moves to 'Final Assembly' Position 3 early on the morning of December 18, 2011, shortly after achieving weight on wheels for the first time (picture: Boeing)





ABOVE LEFT: **A partially drilled slug using the described drilling mechanism**

ABOVE RIGHT: **A magnified view of the lower portion of the hole in the figure above left**

peak power 100%, 10% duty cycle, frequency 2kHz, and 18W average power.

The image above right is a magnified view of the lower portion of the hole in the figure above left. It shows that the fibers are cut into short-length bundles. Isolating the fibers in this way means heat builds up in the bundles, removing the polymer matrix material through the mechanism of conduction along the short fiber lengths. In this particular example, the fiber bundle lengths was 200µm. The short bundles of fibers were then ejected with the vaporized polymer material.

Compared with mechanical cutting and milling, the JK200FL's small spot size produced a much cleaner edge and caused minimal thermal damage. In composites of 1mm thickness or more, it was used to spiral drill holes, which produced a high-quality cut with very slight burnback that was limited to the top layer of fibers.

Researchers believe this burnback is caused by the plasma plume created during the drilling process. It is important not to process the CFRP too close to the back-reflecting plate. This can reflect laser energy onto the back surface, causing surface damage. By increasing either the cutting speed or the flow rate of the assist gas, this surface damage can be reduced.

Fine layers of composite

For the given feed-rate of 0.5m/min, the improvement of increasing the flow rate of carbon dioxide from 2 l/min to 12 l/min results in a 60% reduction in damage, with a reduction of just over 50% for 2m/min. Increasing the cutting speed also gives similar reductions in damage. Increasing the cutting speed from 0.5m/min to 2m/min reduces the damage by nearly 70% at a flow rate 2 l/min, and 60% at 12 l/min.

By altering the processing parameter, it is possible to machine fine layers of composite

Research institute

The General Engineering Research Institute at Liverpool John Moores University is a dedicated manufacturing and metrology research institute that is rated in the top quarter of all UK university-based research institutes in the general engineering discipline. It has four main research groups covering lasers in manufacturing: optical metrology; advanced grinding and machining; electronic assembly inspection; and ultrasonic microscopy.

> **"Researchers believe this burnback is caused by the plasma plume created during the drilling process"**

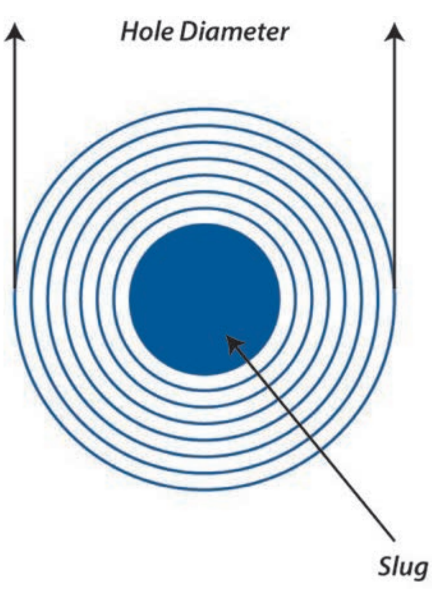
material producing pockets in a composite structure that are required when machining out damage areas for repair. The figure below right shows an image of composite material that has been machined in this way and demonstrates the fine control the fiber laser can produce when operated as a laser milling tool.

A further benefit of using a laser is the fact that it's a non-contact material removal process. This means the risk of tool wear is significantly reduced.

The use of lasers for cutting CFRP composites has yet to be exploited by the aerospace industry. Commercial research has highlighted how the power of fiber lasers can be harnessed for CFRP processing. Thermal management is the key to processing CFRP, and the use of an assist-gas such as CO_2 can reduce damage. The results suggest that laser-spiral drilling and milling may play an important role in CFRP processing application for the aerospace and automotive sectors.

CFRP can be used in a wide range of industries to create new products such as the lighter, more fuel-efficient Boeing 787 and other future aircraft. But to fully realize these benefits, the costs and complexity of processing CFRP must be addressed.

The preliminary results of the JK Lasers' research in partnership with Liverpool John Moores University, suggest that lasers are more than capable of rising to the challenge.



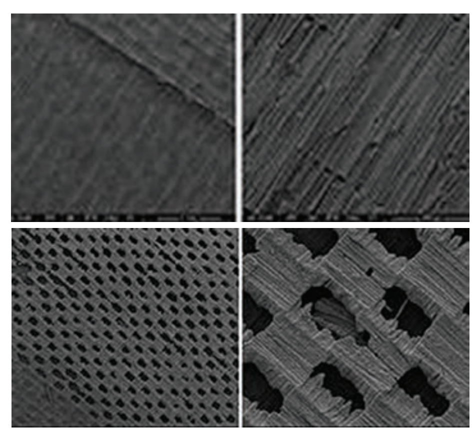
By revolutionizing the quality of CFRP processing without compromising the material's strength and stability, lasers will help drive down the costs associated with carbon composite manufacture in the years to come. ∎

Dr Paul French is a senior lecturer, with the General Engineering Research Institute, Liverpool John Moores University. Dr Mohammed Naeem is worldwide technical key account manager with JK Lasers based in the UK

ABOVE: **A 200W fiber laser and scanning head were used for trepanning and milling**

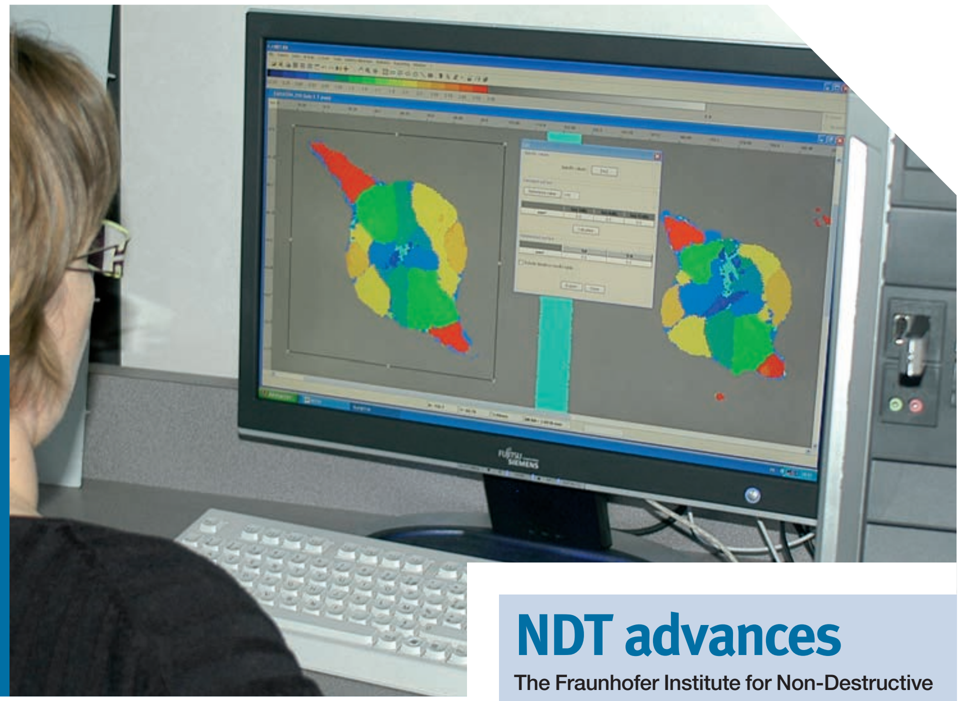
LEFT: **The cutting plan and diagram devised by the team**

BELOW: **A composite material that has been machined**



On the pulse

NEW DATA ANALYSIS SOFTWARE FOR ULTRASONIC NON-DESTRUCTIVE TESTING IS 100% COMPOSITE-ORIENTATED, SIMPLIFYING AND SPEEDING UP THE DIAGNOSIS PROCESS



BY GUILLAUME ITHURRALDE

The ultrasonic non-destructive testing (NDT) of aeronautic composite structures requires, in addition to the inspection itself, a lengthy analysis of the results. Detection of defects in carbon fiber reinforced plastics (CFRP) by ultrasonic pulse echo inspection is usually based on the analysis of both attenuation and time-of-flight C-scans. Differences in amplitude, as well as differences in time-of-flight, can be the result of porosity, inclusions, or delamination defects. This complex analysis becomes the critical path in the testing process and can be very costly.

Now, innovative and user-friendly software tools have been developed to simplify and speed up this diagnosis. They are dedicated to composites, and for the purposes of equipment harmonization and cost reduction they can be applied on files acquired with most ultrasound instruments supplied by the major manufacturers.

The aim of these tools is to concentrate on all the data that affects the acceptance criteria for the three steps of the analysis: detection of foreign bodies and delamination; porosity content estimation; and thickness measurements. Many repetitive actions can be automated, but the final decision is made by the operators. These tools help to focus attention on any suspicious areas, and advise operators if a concession needs to be requested, or if the component needs to be repaired or rejected.

These tools can even be applied on huge C-scans obtained when very large components have to be scanned, or after merging several smaller files acquired separately. At the end of the analysis process, all the results are automatically reported to editable files.

Software systems

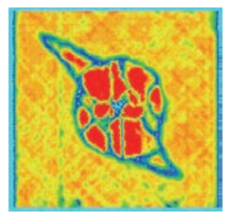
All of these tools are included in a software package called Ultis, and they are currently used on a daily basis to inspect many EADS products and platforms. Their deployment in Airbus is complete, and time savings of 70% were noted in the analysis process of the A380 center wing box, compared with the previous software used, demonstrating an immediate return on investment. Also, all CFRP components manufactured for A350 in France, Germany, Spain, and the UK will be analyzed using these tools. Full qualification was completed at the end of 2011, and the acceptance criteria defined in AITM6 (Airbus test method for NDT) standards are included as presets.

Several subcontractors and laboratories have been convinced by the benefits of the tools included in Ultis. As the analysis parameters are customizable, it should not be difficult to adapt the process to other standards from other aircraft manufacturers, or from other composite structures such as wind turbine blades. For the same reason, it is easy to use all these tools on data generated after inspections with other testing methods including visual, X-ray, and infrared thermography. ▮

Guillaume Ithurralde is the chief technical officer with NDT Expert, based in Toulouse, France

ABOVE: **Analysis after impacting composite laminates**

RIGHT: **Impact indication on a cartography (C-scan)**



NDT advances

The Fraunhofer Institute for Non-Destructive Testing (IZFP) in Germany, is currently working on developing new analytical methods that will make it possible to determine the mechanical stresses in nanostructures. Four-dimensional microscopy is the technology of the future, and combines imaging and analysis in space and time. The use of micro and nano-manipulators to move particles provides an additional way of examining nanostructures. In addition, the Dresden Fraunhofer Cluster Nanoanalysis is researching nanoanalysis in the field of high-resolution transmission electron microscopy, as well as X-ray and electron tomography.

Portable digital radiography

In the aerospace industry, strict NDT specifications have been set to detect very small discontinuities in engine parts and airframe structures, both in production and ongoing maintenance. These strict standards were set because a crash involving a civil or military airliner could result in huge loss of life.

Portable digital radiography (DR) opens a window of opportunity for the aerospace NDT industry due to several key advantages, including wide latitude, high quality, high POD, immediate imaging, environmental friendliness, and more. Some steps have been taken by OEMs (Boeing, Rolls-Royce, Pratt & Whitney) to promote DR – in fact, some have developed their own standards for NDT inspection using DR. The use of DR in NDT for the aerospace industry will develop in the forthcoming years and will be used for both maintenance and production.

Sagit Rogenstein is head of communications at Vidisco Ltd based in Israel

Back in business

AEROSPACE TESTING INTERNATIONAL TAKES AN EXCLUSIVE LOOK AT THE FLIGHT TEST PROGRAM OF N262AZ, AN INCREDIBLE REPLICA OF THE FIRST COMBAT FIGHTER JET, THE ME-262

BY JOHN C. PENNEY

The Me-262 was the first jet fighter to be employed in combat in Europe during the latter stages of World War II. N262AZ was the first of what was intended to be five flying replicas originally contracted by the Messerschmitt Foundation to be built by Texas Airplane Factory. The project changed hands and ended up at Paine Field in Everett, Washington, where its construction was completed and an FAA Phase One flight test program was signed off as complete. The owner of the aircraft, Judge Lou Werner, decided to have it ferried to Sanders Aeronautics to be checked prior to beginning operational flying. He subsequently donated the aircraft to the Collings Foundation. The saga begins there…

Upon arrival at Eagles Nest, the right landing gear leg collapsed when clearing the runway! This event offered a small clue as to what would follow as they began to dig into the airframe and the aircraft's systems. The in-depth list of items that Sanders chose to address looked at the major projects completed prior to the test pilot's involvement, which included: re-engining the aircraft with certified engines; total rewiring of the electrical system; redesign and upgrade of the hydraulic and fuel systems; rebuilding the leading edge slats; removing twist from the left wing, horizontal stabilizer, elevators and rudder; redesign of the horizontal stabilizer trim system; and a complete redesign of the cockpit controls and instrument panel. This took about four and a half years, but was no less than absolutely necessary.

"Upon arrival at Eagles Nest, the right landing gear leg collapsed when clearing the runway"

Flight one

Back to flight one. After the target test points for the first flight, it had been decided that the first five test sorties would be conducted out of Mather near Sacramento, as its runway was 11,301 x 150ft versus 4,000 x 100ft. We would return to Eagles nest after verifying landing performance at Mather.

The first landing approach, contrary to the pilot's desires, was made from a 'tight' left base turn to RW-22L due to FAA-imposed limitations. The very short final approach was stabilized and trimmed at 125 KIAS and the flare and touchdown were very controlled. During high-speed taxi tests and on this landing, N262AZ humbled the pilot with a directional PIO during deceleration braking. Even with high-gain, low-amplitude response, the pilot had to wrestle with this characteristic of the boosted brake system. The system requires a breakout pedal force that, once reached, inputs a threshold brake pressure slightly above zero.

After shutdown on the Mather ramp, N262AZ was thoroughly inspected and serviced for a second flight. An inop boost pump shut the aircraft down and flight two was delayed for a week awaiting replacement.

The next series of four flights from Mather were used to continue system functional tests; make initial gear and flap cycles, and trim force changes; and to take an initial look at stall speeds, initial static and dynamic longitudinal stability, short period damping, dihedral effect and steady heading sideslips, and landing field performance, prior to redeploying to Eagles Nest.

FAR LEFT: The J-85 power plant had been informally assigned with the approval of the Messerschmitt Foundation in Germany

LEFT: John Penney took the Me 262 up for it's first test flight after a five year restoration at Sanders Aeronautics on June 2, 2011 to begin a 25 hour test flight profile

Test flight initiation

The original test pilot, CJ Stevens, a talented and combat-experienced F-4 fighter pilot, race pilot, and lead test pilot for the CAFE foundation, was suddenly faced with a medical challenge that resulted in myself assuming the primary flight test duties.

We needed to come up with a flight test plan that drew upon the information we could glean from the storybook accounts found in the pages of the aircraft's logbook (there is no official data), and from the ground functionals accomplished by lead Me-262 project manager Korey Wells and Brian Sanders. Prior to starting the test program, it was imperative to complete a flutter ground vibration test (GVT) to identify any critical flutter modes. The results identified several items to be addressed in the flight control system and revealed that all the flight control surfaces were considerably below critical mass balance. It also resulted in massive anti-flutter ballasting in the forward section of the engine compartments to counter a possible wing torsional flutter mode. There had been no flutter analysis/testing, ground or flight, prior to this time. We were getting closer.

The first flight occurred on June 6, 2011. Goals for that flight (which was performed gear down, flaps in) were to assess basic controllability, verify basic systems integrity, reconfigure flaps to landing, and assess final approach trim and controllability and go-around controllability and performance. Several pace call-outs verified that the airspeed indications were reasonably accurate up to the planned maximum of 150 KIAS.

Functioning of the aircraft systems was satisfactory, but this pilot was quite interested in a few characteristics that were not anticipated. The fact that the Me-262 may be the only production fighter aircraft with underslung, wing mounted engines, really didn't sink in with the test pilot until making power changes; symmetrical power changes resulted in an expected pitching moment.

However, what was not anticipated was the degree of noticeable rolling moment due to thrust asymmetry. We all know that dihedral effect is more pronounced in aircraft with wing sweep, but one can usually identify a slight yaw as the lead-in to the roll. With the 262, a thrust asymmetry of as little as 2% rpm seemed to result in an immediate, pronounced rolling moment. I am still sorting in my mind whether the differential pitching moment caused by differential thrust with the lateral displacement of the engines may be a factor here. And, to make this more of a nuisance, the cabling to the engine fuel controls had as much as a 0.5in hysteresis band perceived at the throttle knobs. The throttle cables have subsequently been replaced. ∎

John C. Penney is president of MiG Masters LLC, based in Colorado, USA

First-ever flight

On April 18, 1941, the prototype Me-262 V1 flew for the first time. Delays in supplying the BMW 003 turbojet meant the aircraft was powered by a nose-mounted Junkers Jumo 210 propeller engine. The prop engine was retained on the prototype as a safety feature following the arrival of the BMW 003s. This proved lucky as both turbojets failed during their initial flight, forcing the pilot to land using the piston engine. Testing in this manner continued for over a year and it was not until July 18, 1942 that the Me-262 flew just as a jet.

Messerschmitt test pilot Fritz Wendel's Me-262 beat the first Allied jet into the skies by about nine months. As the aircraft was refined, the BMW 003 engines were abandoned due to poor performance and replaced by the Junkers Jumo 004.

Eye of the engineer

TEST ENGINEERING NEEDS TO BECOME SMARTER, AND WILL REQUIRE A FUNDAMENTAL, INNOVATIVE, NEW APPROACH AS PART OF THE REDESIGN OF THE END-TO-END DEVELOPMENT PROCESS

BY DR IR. JAN LEURIDAN

To meet consumers' and society's expectations, next-generation aircraft will have to be far more economical and ecological. The aviation industry is facing major design, development, and assembly challenges; successful programs must deal with new materials, new technologies, and more complexity, while staying within budget and meeting shortened time-to-market demands.

Given this new 'normal', the traditional aviation industries' engineering process is under scrutiny. Earlier aircraft maturity has become a priority, so controlling the element of time-to-market has become critical for every aircraft manufacturer. Rework needs to be kept to an absolute minimum; it is best avoided. Because of the increasing use of new technology to meet the shift toward new performance and ecological standards, traditional system and subsystem design needs to be re-evaluated. The increased use of advanced composite materials in airframes and electrically powered systems, replacing heavier counterparts and therefore making the aircraft more economical to operate, gives rise to new and unexplored test issues.

Traditional test processes will have to undergo a major structural overhaul. Test time needs to be shortened, tests need to be performed as early as possible, and test methodology and systems must embrace amplified system complexity. Test engineering will have to become smarter; it will require a fundamental, innovative, new approach as part of the redesign of the end-to-end development process.

This approach will have to deliver an adequate answer to a number of highly interconnected challenges, as described in the following.

Battling the productivity issue

First of all, new test engineering procedures must be used to help solve the productivity issue. Time constraints will become more dominant, and extreme time constraints make it necessary that all tests can be performed quickly, efficiently, and accurately. The same constraints call for a boost in the engineering team's efficiency, and this requires more intelligent testing systems, more consistency and ease-of use, and more results in a shorter timeframe.

Growing complexity also necessitates computing power being able to match the task. This enables us to collect more data through more channels, for networked systems and software that shares data seamlessly between different applications, with built-in scalability and customization possibilities, so that data can be more easily interpreted. And last but not least, test data should be considered as a knowledge base that processes can benefit from.

Controlled systems

Secondly, controls have become of major importance in modern aerospace systems, and this increased use of controllers stretches the testing environment. Given this new context, classical test strategies will need to be adapted as those controllers become a major contributor in reaching increased performance targets. Ignoring their presence when planning the validation testing of subassemblies is asking for integration problems later on in the program.

That is why today's development programs use MIL-SIL-HIL technologies intensively, allowing more realistic test configurations. The test planning needs to fully support this updated development process. Component and subsystem validation testing becomes more complex, as the interaction with controllers and other systems becomes an integral part of the testing environment.

Validation testing is very expensive, and the trick is to be smart in how you combine testing and simulation. As matters become more complex, engineers need a deeper physical insight into how systems behave in order to secure the system function and performance. Models should be used to carefully plan the validation test campaign. Those models, even prior to calibration by test, are a vital source of information about sensitivity of parameters.

At the same time, model-based test strategy development will provide a baseline data set, which can be used during the test campaign by the design team for real-time correlation. This will help test and design engineers to collaborate efficiently and be more agile during the campaign, possibly adapting planning based on preliminary correlation and

UVS program - courtesy of CIRA

ultimately maximizing the physical insight gained during the testing. All of this results in better test feedback for the development process.

A good example of this is the LMS solution for aircraft structural dynamics qualification. The LMS ground vibration testing solution and its corresponding engineering services cover the process from pre-test structural dynamics simulation, to ground vibration testing, to the use of GVT results for calibrating structural dynamics models for flight-flutter testing.

Validating the process

Traditional development testing serves prototype validation, and today's test campaigns should provide information to calibrate the parameters of the models that were developed to support the design. But even after calibration, those models sometimes don't deliver the expected fidelity required to predict the performance characteristics of the end-product. Often, the root cause of this flaw is the incompleteness of the model, rather than inaccuracy of the parameter values.

This is sometimes a consequence of not having taken into account some relevant physical phenomena in the model. But with

> **"Test serves simulation and simulation serves test"**

up-front, as early as possible in the development program – ideally, even before any hardware has been built. Engineers also need to increase simulation realism and productivity for component and subsystem verification.

The answer: smart test engineering

The industry needs an answer to cover all existing challenges, and 'smart test engineering' can deliver that answer. The productivity issue – about model-based test strategies, about updating development strategies through feedback from test data, about the testing of subsystems in a modeled environment mirroring a real-life situation – has been discussed.

All of this means that test data should also be used to build better simulation models. Simulation should be used to build more focused and accurate test set-ups. Test serves simulation and simulation serves test. To make this 'smart test engineering' happen, the frontiers between simulation and real-life test should fade out. Test and simulation divisions will have to exchange results, and adapt and learn from each other. Test and simulation should be integrated. ∎

Dr ir. Jan Leuridan, executive vice-president and chief technical officer, LMS International

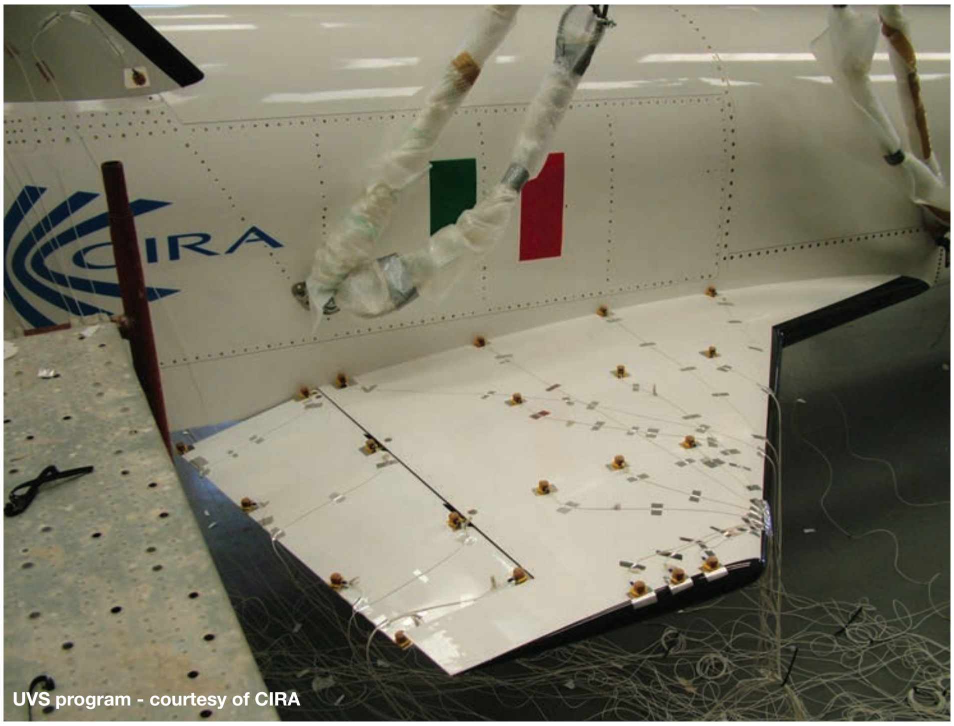
ABOVE: The author, Dr ir. Jan Leuridan, executive vice-president and chief technical officer, LMS International

LEFT AND BELOW: The LMS ground vibration test solution covers the process from pre-test structural dynamics simulation; to ground vibration testing, to the use of GVT results for calibrating structural dynamics models for flight flutter testing

today's complex designs, the most probable cause of inaccuracy lies in the dynamic interaction between the systems – the connections between the various models used in the design. These are new tasks for the test engineers: spotting the flaws in the models and capturing the phenomena that are not included in the models. In a sense, testing will serve as a validation of the design process.

The need to test up-front

Finally, aircraft programs are increasingly engineered on a global basis, involving a geographically extended system of suppliers. Furthermore, a modern aircraft is increasingly a 'system of systems', and within this context the risk of high-profile program failures needs to be avoided. Therefore engineers must be able to analyze conflicting requirements and various interaction scenarios to anticipate any system level challenges from the start. Recent program delays and cost overruns illustrate the importance of dynamic interaction on a system level, as early and efficiently as possible. To meet this challenge, testing and simulation have to be combined, and tests have to be performed



UVS program - courtesy of CIRA

Tough cameras in harsh MIL environments

Controllers for digital streaming cameras from AOS Technologies allow customer-specific configuration of input and output signals, as well as functionality

Conventional high-speed cameras can record fast events that last several seconds. However, inflight component testing requires the entire duration of a flight to be recorded. Standard speed cameras that record at 30fps are not fast enough to record all fast incidents. This necessitates use of a camera system that can record at high framing rates for minutes, or even hours.

The camera of such a streaming system will often be mounted in a remote location with limited space. This means that the camera must be compact in size to fit into the existing space. Furthermore, an ultra-solid design and structure is required to withstand the harsh environmental flight conditions, such as shock, vibration, and changes of temperature and moisture.

The AOS H-EM HS is representative of this category of camera. This compact camera (65 x 55 x 75mm/2.6 x 2.2 x 3in) can record at 100fps with a resolution of 1,280 x 1,024 pixels, or even at 200fps in HD resolution (1,280 x 720 pixels). Higher frame rates are possible by further reducing the resolution. Images with these specifications can be directly streamed to a controller through a single, small-diameter cable, which can be as long as 70m (200ft).

The AOS H-EM HS camera is not just a high-speed streaming camera that has been adapted for rugged use; the entire design process was focused on the system functioning under extended environmental conditions. The camera is designed to meet MIL-STD-810, and the manufacturing and quality procedures ensure that these standards are maintained.

Demanding applications

Controllers for digital streaming cameras from AOS Technologies offer fully customizable control software that allows customer-specific configuration of the input and output signals, and the functionality. This keeps the necessary modifications to the airplane and test routine to a minimum. The controller is also designed to meet MIL-STD-810.

In demanding environments, such as the airborne test and measurement world, it is sometimes necessary to adapt the digital camera to the specific needs of the test setup. This has led to an emerging range of applications for which digital streaming systems can be used.

AOS Technologies takes on turnkey responsibility in such projects: from close interaction with customers at the start of the concept, to developing special mechanics and, where necessary, add-on electronics – and, of course, providing the necessary software. In the final project phase, AOS Technologies works closely with customers when installing the system and preparing for the mission. AOS Technologies has a proven track-record in installing camera systems and successfully implementing projects with major aircraft manufacturers.

Finally, experience in airborne applications is essential to guarantee not only the best fit of camera and accessories to meet the customer's requirements, but also to match their budget. In many cases, specific requests can be answered by a particular software configuration in the controller, eliminating the need for additional hardware.

After-sales service

Since airborne camera systems have to perform reliably over a long period of time, after-sales service and long-term availability of spare parts must not be overlooked during the evaluation process. Specially trained partners and subsidiaries around the world and on all continents offer ongoing technical service and support, not only during installation and integration, but also for user support, repairs, system extensions, and upgrades.

The AOS H-EM HS camera is designed to meet MIL-STD-810

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Go to online reader enquiry number 101

Imaging sensors for UAVs

Unmanned aerial vehicles (UAVs) are the first choice whenever risky reconnaissance missions or tedious inspection flights have to be made.

To operate autonomously even in unknown terrain, UAVs need 'sensory organs' to perceive their environment, plus intelligent mission control software. The Institute of Flight Systems at the German Aerospace Center (DLR) is researching innovative flight control systems and algorithms for autonomous flight, and testing the systems with virtual test flights in the laboratory, and also on several research UAVs.

Artificial sensory organs

Today's UAVs can fly along preplanned waypoints, and some of them can also take off and land automatically. However, not one of them is able – or even permitted – to operate in general airspace, because they currently have no way of 'seeing' the world around them. To do so, UAVs need imaging sensors that capture their environment.

These could be optic cameras, radar systems, laser scanners, and so on. To be used in flight control, the measurement data from the sensors has to be processed with optimum speed, ideally in real time. The 'onboard intelligence', a computer inside the aircraft, then bases its decisions on this data as it plans the flight path, or even decides to abort the mission in an emergency.

Different UAVs for different tasks

The DLR is currently using several UAVs in its development work. Three ARTIS (Autonomous Rotorcraft Testbed for Intelligent Systems) helicopters (midiARTIS, meARTIS, and maxiARTIS) implement different drive concepts: two-stroke engine, electric drive, and turbine. The rotors are 2-3m in diameter, and the maximum take-off weight is 25kg. Prometheus, in contrast, is a pusher propeller airplane with a twin-tail unit. This fleet of aircraft can fly missions that require highly precise navigation in an extremely tight space, or that need to cover a large range at high flying speed.

Virtual test flights in the laboratory

To check that the UAV flight control computer functions correctly, the DLR Institute of Flight Systems uses a dSPACE system for real-time simulation of each UAV's sensors (acceleration and rotational speed sensors, sonar, magnetometer, and so on), environmental conditions, flight mechanics, and actuator dynamics. Additional conditions such as wind, sensor noise, and sensor failure can easily be configured in the dSPACE ControlDesk experiment software.

The flight control computer uses this simulation to generate flight commands that it sends to the dSPACE system, which in turn uses the commands to compute the corresponding sensor data. This procedure enables the flight control computer to fly the mission in the laboratory as if it were on a real test flight.

In this simulation environment, the experimental aircraft learned to fly in several steps: first (for the helicopters) careful hovering; then waypoint flight and automatic take-off and landing; and finally fast, aggressive flight along three-dimensional spline paths. After that, trials were run with the methods for automatic world modeling and processing, and for three-dimensional map creation.

Flight over unknown terrain

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CONTACT

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Go to online reader enquiry number 102

Fourth-generation NVH solutions

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VTI's new SentinelEX Series of smart DSA's incorporate the latest technological innovations and analog design methodology to deliver unmatched measurement performance. The company's fourth generation of DSA instrumentation includes functionality such as FPGA-based synthetic instrument customization, corporate wide cloud data management, comprehensive runtime health monitoring, and precision distributed measurement synchronization.

Measurement performance

Measurement performance is elevated to new levels with 625 kSa/sec data rates; true differential inputs with superior common mode performance (CMRR of -120dB) reducing unwanted noise; an industry-leading spurious free dynamic range (SFDR of -125dB) offering exceptional measurement fidelity; and uncompromised excitation flexibility, fully programmable from 2mA to 20mA, to maximize transducer performance and response.

Hardware enhancements also include comprehensive runtime health monitoring and self-calibration, without the need to disconnect external transducer cabling, for uninterrupted system level confidence. Exceptional precision distributed measurement synchronization is accomplished using IEEE 1588, ensuring test data time-correlation.

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Flexibility and freedom

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VTI's fourth generation SentinelEX Series smart DSA

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Go to online reader enquiry number 103

Induct-a-ring shaker

The Unholtz-Dickie Model T2000 Shaker, available with either 2in (51mm) or 3in (76mm) pk-pk stroke, is now available with power amplifiers rated up to 720KVA output. This combination produces staggeringly high acceleration (220g-pk) and velocity (>280in/sec) output. Specific breakthrough performance examples include 180g rms random on a 10 lb (4.5kg) load; 96g peak sine on a 160 lb (73kg) load; and 100g peak/11ms half-sine shock pulse on a 650 lb (312kg) load.

Why haven't numbers like these been available before now? What improved technical design component has made this radical increase in vibration and shock ratings possible? The answer can be found by looking closely at the T2000 Shaker armature. It's called the 'Induct-A-Ring'.

Induct-A-Ring design

The T2000 Shaker's armature is air-cooled and solid metal throughout, with power transferred to its solid aluminum driver coil by induction. The Induct-A-Ring design thereby eliminates the three soft spots in conventional 'wound coil' armature designs by incorporating an epoxied multiturn (water-cooled) driver coil, a flexing AC current lead that has to carry 1,000A or more, and flexing water hoses that deliver critical coolant to the driver coil. All three can operate reliably in a high displacement, high-acceleration vibration environment.

Putting induction to work

Stationary AC coils rigidly mounted within the massive iron structure of the T2000 Shaker body are directly coupled to the power amplifier output. Amplifier output power is transferred to the actual moving armature through highly efficient inductive coupling between the fixed AC stator coils and the single-turn driver coil on the armature frame.

Electrically, the internal coil configuration of the T2000 behaves essentially like a transformer with a single-turn secondary. The advantage of being able to deliver hundreds of KVA of power amplifier output to the moving armature's driver coil without the need for a flexing current lead is enormous. Taking this lead out of the picture creates a step-change in armature reliability.

Air-cooling the armature

Another inherent benefit of the Induct-A-Ring design is its ability to air-cool the driver coil, therefore eliminating the flexing water hoses required by conventional, high-force armature designs. AC currents that flow in the Induct-A-Ring single-turn coil travel primarily along its outer surface due to the well-known 'skin effect' that applies to AC current conductors.

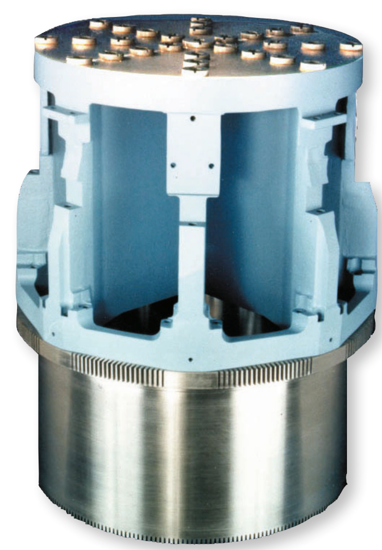
Because the resulting heat resides on the surface of the solid driver coil, forced air-cooling using a remote blower is practical. Elimination of the closed-loop, water-cooling hardware (especially the flexing water hoses) used in conventional armature designs again scores a major breakthrough in reliable operation under extreme vibration conditions.

The 'slinky effect'

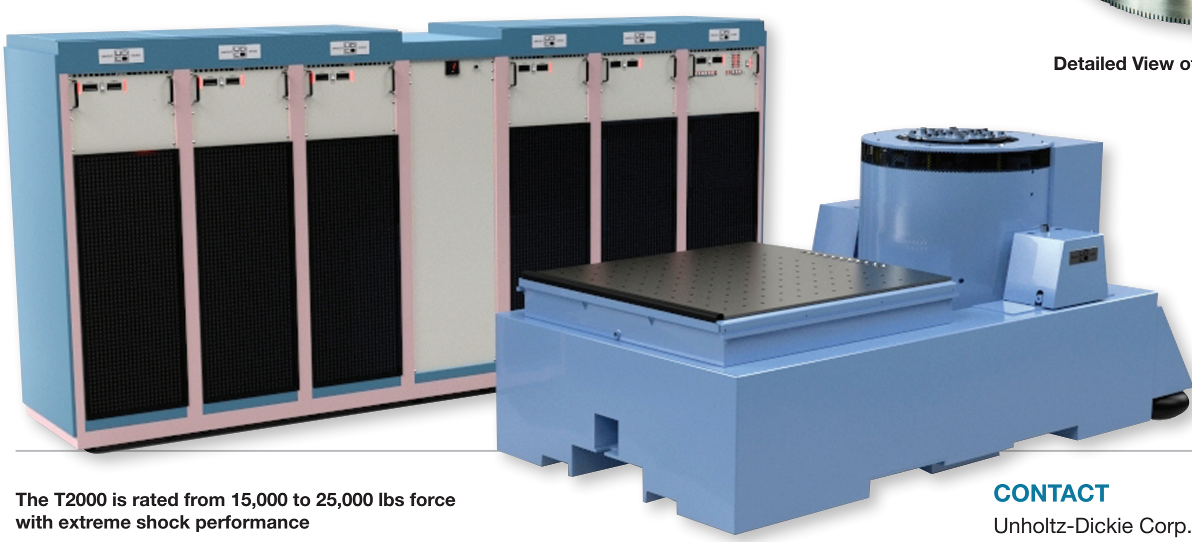
One of the best-known bits of folklore in the vibration testing industry is a failure mode of wound coil armatures – known as the 'slinky effect'. When the generated force acting on the wound driver coil of a conventional armature exceeds a critical point, the coil separates from the armature frame; the fractured epoxy joints fail further until the coil may then break free from the armature frame completely, resulting in a catastrophic shaker failure.

When the operator later attempts to remove the armature by pulling the frame vertically out of the shaker, the no-longer-attached driver coil often reveals itself as an elongating helix dangling from the armature frame – the dreaded 'slinky effect'.

The T2000 Induct-A-Ring armature is immune to this condition because of its solid metal construction, which has no windings or epoxy joints employed in the force-generating driver coil.



Detailed View of Induct-A-Ring armature



The T2000 is rated from 15,000 to 25,000 lbs force with extreme shock performance

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Go to online reader enquiry number 104

Imaging sensors for UAVs

Unmanned aerial vehicles (UAVs) are the first choice whenever risky reconnaissance missions or tedious inspection flights have to be made.

To operate autonomously even in unknown terrain, UAVs need 'sensory organs' to perceive their environment, plus intelligent mission control software. The Institute of Flight Systems at the German Aerospace Center (DLR) is researching innovative flight control systems and algorithms for autonomous flight, and testing the systems with virtual test flights in the laboratory, and also on several research UAVs.

Artificial sensory organs

Today's UAVs can fly along preplanned waypoints, and some of them can also take off and land automatically. However, not one of them is able – or even permitted – to operate in general airspace, because they currently have no way of 'seeing' the world around them. To do so, UAVs need imaging sensors that capture their environment.

These could be optic cameras, radar systems, laser scanners, and so on. To be used in flight control, the measurement data from the sensors has to be processed with optimum speed, ideally in real time. The 'onboard intelligence', a computer inside the aircraft, then bases its decisions on this data as it plans the flight path, or even decides to abort the mission in an emergency.

Different UAVs for different tasks

The DLR is currently using several UAVs in its development work. Three ARTIS (Autonomous Rotorcraft Testbed for Intelligent Systems) helicopters (midiARTIS, meARTIS, and maxiARTIS) implement different drive concepts: two-stroke engine, electric drive, and turbine. The rotors are 2-3m in diameter, and the maximum take-off weight is 25kg. Prometheus, in contrast, is a pusher propeller airplane with a twin-tail unit. This fleet of aircraft can fly missions that require highly precise navigation in an extremely tight space, or that need to cover a large range at high flying speed.

Virtual test flights in the laboratory

To check that the UAV flight control computer functions correctly, the DLR Institute of Flight Systems uses a dSPACE system for real-time simulation of each UAV's sensors (acceleration and rotational speed sensors, sonar, magnetometer, and so on), environmental conditions, flight mechanics, and actuator dynamics. Additional conditions such as wind, sensor noise, and sensor failure can easily be configured in the dSPACE ControlDesk experiment software.

The flight control computer uses this simulation to generate flight commands that it sends to the dSPACE system, which in turn uses the commands to compute the corresponding sensor data. This procedure enables the flight control computer to fly the mission in the laboratory as if it were on a real test flight.

In this simulation environment, the experimental aircraft learned to fly in several steps: first (for the helicopters) careful hovering; then waypoint flight and automatic take-off and landing; and finally fast, aggressive flight along three-dimensional spline paths. After that, trials were run with the methods for automatic world modeling and processing, and for three-dimensional map creation.

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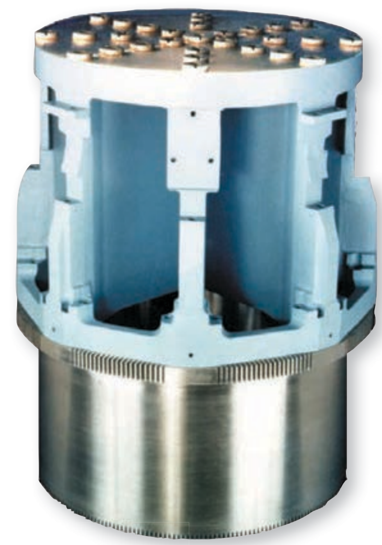

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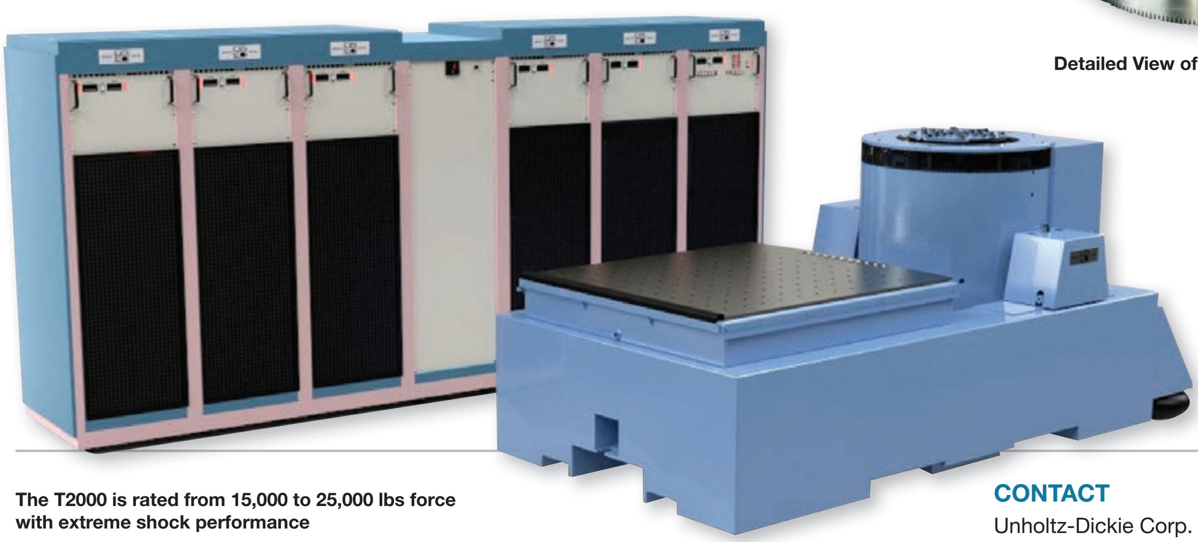

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Project improves internal and external processes

Business process improvements are frequently the key projects within any organization, regardless of size. The impact of change is significant. As organizations grow, they need to continuously analyze and refine their processes to ensure they are doing business as effectively and efficiently as possible. Fine-tuning of internal and external processes provides a competitive advantage in a global marketplace. The development of these organizational processes was important to enable Test-Fuchs to provide benchmark performance to global aerospace companies.

In 2011, a major Europe-based aircraft manufacturer entrusted Test-Fuchs with a challenging project that established hydraulic, air, nitrogen, and water test capabilities at several locations, plus 30 new test facilities and test devices with the necessary infrastructure. The equipment was spread at locations across Europe and the project required significant additional production volume, and working with a customer with a different culture and philosophy.

Working in partnership with its customers is one the reasons for the success of Test-Fuchs, which works hard to meet the demands of its clients. Customers constantly require change, due to economic factors, new product introductions, mergers and acquisitions, expansion or contraction, and the company is continuously reviewing its processes in order to adapt effectively as its customers' requirements change.

Test-Fuchs has developed several ideas to harmonize the different requirements from different sites and to offer an attractive cost solution to the customer. The concept involves major investment in test equipment, followed by lifecycle management, including calibration, maintenance, and spare-parts management. Additionally Test-Fuchs takes into consideration site-specific requirements, as well as the technical and cultural differences of each location.

This project lifted the internal organization of Test-Fuchs to a new, higher level. Processes were developed that provided complete solutions, from the beginning of the tender phase, through to design and production, in a complex and multicultural environment.

Further information

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www.test-fuchs.com
or go to online enquiry card 105

Acoustic measurement brochure

PCB Piezotronics Inc has released a new Acoustic Measurement brochure. PCB is the founder of ICP technology, which all modern prepolarized microphone and preamplifier designs are based on. In the brochure, readers will find a variety of prepolarized (0V) and externally polarized (200V) models in the Free-Field, Pressure and Random Incidence designs, ranging in size from 6mm to 25mm (¼in to 1in). With 1,000 employees, and years of test and measurement manufacturing experience, PCB has the expertise to provide optimal sensors for specific applications. PCB sensors are used in various applications, from engine resonance to cabin noise. The company's microphones and preamplifiers are designed to compliment each other. The PCB industry exclusive 378B02 free-field system was nominated internationally for a top sensor design. It is the only prepolarized condenser microphone and preamplifier combination to accurately measure to 120°C, making it an excellent choice for aircraft engines measurements, exhaust measurements and other high-temperature applications. The in-house robotic manufacturing capability, laser capability, and the clean assembly rooms all ensure quality, on-time delivery, and stable microphones. PCB acoustic microphone calibrations come with test documentation showing the actuator pressure response and corrected responses. PCB is 9001 certified and all calibrations are NIST traceable and compliant with ISO 10012-1, ANSI/NCSL Z540-1-1994, and ISO 17025.

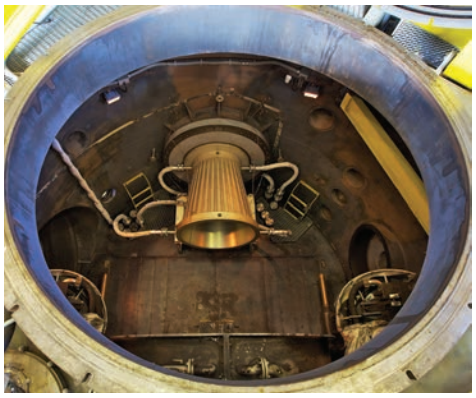
Further information

Acoustic Measurement brochure available.
Tel: +1 716 684 0001
Web: www.pcb.com
or go to online enquiry card 106

Ice effect wind tunnel simulation

CIRA, the Italian Aerospace Research Center, has traditionally played a key role in both fostering and pursuing active research on aviation safety issues, supporting aircraft manufacturers involved in type certification or qualification processes worldwide, or developing technologies to increase the standard safety levels.

Since 2002, CIRA has operated the world's largest and most advanced experimental facility for ice effects simulation. Its Icing Wind Tunnel (IWT) is the largest refrigerated wind tunnel in service, featuring the highest testing speed (Mach 0.7), and combining temperature simulation, altitude simulation (approx. 23,000ft), and humidity control. It is outfitted with a dedicated 'spray bar system' for the generation of icing clouds in all the conditions prescribed in the current FAR/JAR regulations. Looking ahead, CIRA will also be able to comply with the new aircraft icing certification environment from February 2012 (FAR part 25 and 33 Appendix O and Appendix D), detailing the size, water content, and other characteristics



of the SLD (supercooled large droplets), a special meteorological condition occurring in various parts of the world.

CIRA is also fully involved in developing technologies aimed at improving onboard autonomous guidance systems. The Italian Ministry for the Economic Development supported a research project aimed at the development and demonstration of innovative avionic SW applications for highly autonomous management of UAS-MALE (unmanned aircraft system – medium altitude, long endurance).

The innovative aspects of the project concern the exploitation of the most advanced flight and payload automation technologies toward the optimization of the unmanned aerial system (UAS) performances, and the increasing of the whole system safety level. The final goal of the research project is to make available, for National UAS Industry stakeholders, advanced avionic SW that could be integrated in a whole certified UAS platform.

Further information

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Space race to Los Angeles

May 2012 marks the launch of a new show dedicated to bringing together global decision makers, engineers, and the supply chain involved in spacecraft, satellite, launch vehicle, and space-related technologies.

Held at Los Angeles Convention Center between May 8-10, 2012, Spacecraft Technology Expo is the first and only show of its kind and is free to attend. Focused on the design, build, and testing of spacecraft, the expo will feature more than 100 companies promoting software services and components manufacturing, through to complete spacecraft. Exhibitors include Boeing, United Launch Alliance, ATK, Siemens, Honeywell, and Cobham Life Support.

Aside from the booth offerings, Spacecraft Technology Expo boasts a Human Spaceflight Park – a dynamic area designed to promote companies and technologies involved in all areas of manned spaceflight. Visitors to the show can expect to see a SpaceX Dragon capsule, as well as a full-scale model of XCOR Aerospace's LYNX, displayed in the USA for the first time.

Accompanying the show will be a three-day, two-track conference aimed at evaluating the latest technologies and engineering innovations. The program will bring together leading industry experts and minds, including eminent speakers such as Dr Howard Ross, chief technologist at NASA Glenn Research Center.

Further information
www.spacetechexpo.com
or go to online enquiry card 108

Informed decisions from measured data

For 30 years, the nCode brand, based in Sheffield, UK, has earned a reputation for providing cutting-edge durability and data-analysis solutions. Major OEMs and component suppliers have selected nCode solutions to understand product performance, accelerate product development, and improve design. For example, Turbomeca has recently selected nCode Automation to ensure storage, management, analysis, and traceability of thousands of measurement channels of test data.

Turbomeca, a specialist in the design, production, sale, and support of low- to medium-power gas turbines for helicopters, found nCode Automation particularly appealing due to the combination of security, data management, and analysis on a central server. Especially suited for applications where large amounts of data are generated, nCode Automation provides direct access to data, analysis, and reports to all departments, sites, and project partners through a web browser. Productivity benefits allowing measured data to be closely monitored have been extended with the recent release of nCode Automation 8. Key information is delivered through interactive reports and email notifications now triggered based on pre-defined performance indicators extracted from the data. Further applications include managing data from long-term structural tests, and operational loads monitoring programs on airframes.

Further information
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or go to online enquiry card 109

Handheld vibration analyzer – a complete toolbox

Brüel & Kjær now offers a dedicated handheld vibration analyzer that is perfect for aerospace applications. Compact, and based on the award-winning design of the company's sound level meters, Vibration Analyzer Type 2250-H-001 is ideal for analysis, troubleshooting, and quality checking tasks.

An intuitive interface displays powerful real-time analysis on a clear touchscreen, which features simple drag-and-drop operation. To zoom-in on an FFT spectrum, you simply drag the stylus across the desired frequency span, tap zoom, and then measure using the correct range. The interface can be programmed with a beginner-proof display, and yet with a single click shows fine details for in-depth, expert analysis – using the multi-user facility.

Thanks to close customer consultation, the analyzer features templates for commonly-used quality checks, to assist with getting quick and clear results. Tolerance limit checking uses simple 'tolerance windows' that are laid over the onscreen spectrum to give quick and unequivocal pass/fail results. In addition, the voice comments can be recorded and attached to each measurement project in the system.

Automated signal recording can allow later analysis, recording to SDHC cards for a memory capacity of up to 32GB. Meanwhile, the standard-format .WAV files are easily transferred into other analysis tools, utilizing user-specified metadata for efficient data sorting and retrieval.

The vibration analyzer comes with dedicated PC software for analysis, reporting, and archiving, and comes with a specially made shoulder bag featuring space for the analyzer and the many accessories, making it easy to take anywhere.

Further information
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Tel: +45 77 41 21 48
Web: www.bksv.com
or go to online enquiry card 110

Higher resolution for signal conditioners

Dewetron signal conditioners enable customers to set user-defined input ranges, all the time providing the full ±5 V output. This feature guarantees using the full resolution of the data acquisition system's A/D converters, and consequently increases the quality of your measurement data.

Here we can use an example: your sensor scaling is 2.14mV/V for its full scale of 200kg (this is what you find on the sensors datasheet). You are using a bridge amplifier that has a slightly too small ±2mV/V range and the next range is ±5mV/V. You have to set the signal conditioner to ±5mV/V. This means that you only use ~21% of the selected range and the ±5V output of the signal conditioner will always stay between 0 and +2.14V. Considering a 16bit A/D digitizer (which is set to ±5V all the time), the maximum resolution is 14g. If you use a DAQP-STG signal conditioning module and set a user-defined input range of 0 – 2.14mV/V, this results in a resolution of 3g, which is almost five times better.

Further information

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Pole position

G-SEATS PROVIDE AN ENHANCED PILOT TRAINING AND TEST EXPERIENCE WITH HIGH-FIDELITY MOTION CUEING

BY MARIE LAURE GELIN

G-Seats are fighter and helicopter pilot training systems that are able to simulate the positive and negative accelerations on a pilot's body (as induced by aircraft movement in surge, sway, and roll) by means of the seat itself, without the need for a 6DOF motion system. G-Seats simulate the effects of positive and negative *g*-forces by changing the shape of the seat pan, altering the tension of the seat harness straps, and raising or lowering the height of the seat bucket. The seat is positioned via its own command system, which responds to real-time software via Ethernet.

High-fidelity cues

The challenge of developing a good G-Seat is to provide the fighter pilot with a high-fidelity training experience, as if they were flying a real aircraft. An important aspect in the development of G-Seats is the tuning and calibration of motion cues. These need to match the feelings a pilot experiences when accelerating and decelerating, when maneuvering into roll, and when pulling vertical *g*-forces.

Usually this is achieved with the help of an experienced pilot, who instructs the engineer to adjust motion settings to match his experiences. There is a level of subjectivity to this, because the quality of the calibration depends on both the aircraft with which the pilot has experience, and the way he remembers the exact motions and feeling.

Ideally, when a pilot tunes and calibrates a simulator it should be for the same aircraft with which he has experience, so as to avoid differences in motion cues caused by characteristics of the aircraft.

The Moog G-Seat features the same high-fidelity controllers and user-friendly interfaces as Moog motion and control loading systems. Each is designed in close collaboration with customers to ensure compliance with the demanding performance specifications of high-end training simulation. At the heart of the G-Seat solution is an all-digital design that interfaces with the host via Ethernet and features several innovative control algorithms to increase cueing fidelity. The G-Seat can have up to nine moving elements in its seat bucket, seat pan, back-pad, shoulder harness, and seatbelt. All these elements are driven by high-response brushless DC electric motors. The cueing system is designed to provide motion cues in all three translational axes. Seat pan rotation and differentiated harness tensioning are also available.

G-Seat demonstration model

At I/ITSEC 2011 in Orlando, Moog showcased the G-Seat demonstration model that was one of the first outcomes of a partnering agreement between Moog and Reiser. The partners agreed to jointly develop and manufacture new G-Seat products to match specific customer requirements.

The teaming agreement covers both companies' extensive and complementary expertise in this application. Development company Moog brings its know-how to the motion cueing and control loading systems – including the G-Seats. Reiser Systemtechnik, based in Berg, Germany, also brings its experience and capabilities in the design, development, and manufacture of replica cockpits, crashworthy ejection seats, and mechanical and electronic components and systems for aerospace and automotive simulation.

During I/ITSEC 2011, pilots were invited to experience a G-Seat demo in a replica cockpit of the Eurofighter Typhoon fighter aircraft. The pilots pulled *g*-forces and were able to experience the motion cueing elements in the seat. After a five-minute flight, pilots were asked to fill in a questionnaire to share their experiences, and a total of 21 pilots with experience in a high-g environment completed it. The results show that 95% of the pilots believe that having a G-Seat fitted in a simulator is very important. These findings clearly demonstrate that G-Seat provides important added value in simulators, making the training experience much more realistic. ∎

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