

Technology update

Quiet please!

While major technology efforts are being made to reduce external noise created by commercial aircraft, improving cabin acoustics is also an industry aim. As previously reported, the UK research company, **QinetiQ**, has developed a predictive acoustic modeling capability based on its studies of the attenuation of sound and vibration through complex structures such as an aircraft fuselage. Now, the company has revealed that it is providing predictive acoustic modeling for the **Boeing 7E7** Dreamliner. QinetiQ is also in "ongoing dialogue" with Boeing on a number of other technology areas in support of the 7E7's requirements. The two companies announced a Memorandum of Understanding in February 2004 that covered areas including aviation security, air traffic management, fuel cells, and acoustics.

QinetiQ's acoustic engineers take measurements to understand the behavior of existing structures and then use the data acquired to investigate and optimize the characteristics of future designs before building them. The overall goal is to deliver a quieter cabin environment achieved at acceptable weight and cost. According to QinetiQ, its acoustic modeling capabilities are complemented by its work on sound generated by turbulent airstreams. Research facilities include anechoic chambers, reverberant rooms, and a "transmission suite."

Other European supplier links with the 7E7 companies have been announced recently. **Messier-Bugatti** of the **Snecma Group** is providing electric brakes (as is **Goodrich Aircraft Wheels**, so airlines can choose either supplier). **Latecoere** of Toulouse will provide passenger doors, marking the first time that Boeing has selected a French provider for major airframe structure. Two



Predictive acoustic modeling technology via QinetiQ is being used to reduce the 7E7's cabin noise level.



The 7E7 will be fitted with electrically activated brakes that use electro-mechanical actuators as opposed to hydraulic pistons. The electric brakes will be supplied by either Messier-Bugatti or Goodrich.

subsidiaries of France's **Zodiac Groupe** are also involved, including California-based **Monogram Systems**, which will provide the 7E7's water and waste systems, and New Jersey-based **Air Cruisers**, which will provide the escape slides.

According to Boeing, the 7E7 will be the first large commercial airplane with electrically actuated brakes. The

braking forces are generated with electro-mechanical actuators as opposed to traditional hydraulic pistons, which the company claims provides a high rate of reliability and lower weight compared to traditional systems. Electric brakes also offer self monitoring through the 7E7's computers, which is a maintenance advantage for airlines.

Stuart Birch

Lightweight spoiler

A new spoiler, designed to cut mass by some 50 kg compared to conventional types, has been developed by **Airbus** for the A330/340 aircraft—with no manufacturing cost penalty. Work on the lightweight spoiler started in 2001.

Airbus became involved in an R&D program conducted by an Austrian company, **Fischer Advanced Composite Components** (FACC), in cooperation with **Kaiserslautern University** in Germany. In the USA, **Vought** was also involved. Focus of the work was on the development of a spoiler main hinge fitting using a particular version of resin thermal molding (RTM) technology that involves resin being injected into carbon fiber dry fabric pre-forms.

According to Airbus, this method is unlike conventional ones, which use pre-impregnated fabrics and tapes. The new method was particularly attractive as it allowed fittings to be integrated into the bonding process of spoiler production, eliminating the time-consuming assembly of metal fittings and also the weight of the attachment elements.



The design of Airbus' weight-saving spoiler involves resin being injected into carbon fiber dry fabric pre-forms. The technology could be used for other, larger structures.

Achieving the novel solution required for the lightweight spoiler brought several technical challenges, notably how the interface loads to the wing structure and actuation system could be kept the same or within specified limits so that it and conventional heavier versions could be interchangeable. According to Airbus, the solution involved the ques-

tion of matching pre-curvedness and stiffness.

Another challenge was how the system's steel roller bearings could be installed in the CFRP (carbon fiber reinforced plastic) main hinge lugs. With thermal expansion conditions beyond the level experienced in the past by the team involved with the development program, ensuring safe anti-rotation locking at low temperatures with no friction jams at high temperatures was identified as a real challenge. But not only were these difficulties solved, new ideas for further improvements were also achieved.

With the spoiler a success, Airbus is considering the possibility of developing a considerably larger RTM structure, integrating the main fitting into the front spar and so make the spoiler bonding assembly a "one-autoclave-shot" structure. The spoiler has been tested on an A340-600.

Stuart Birch

Nimrod's brakes

The new **BAE Systems** Nimrod MRA4 maritime reconnaissance and attack aircraft, which has now commenced a flight test program, is equipped with **Dunlop Aerospace** (a **Meggitt** company) modular brake control and anti-skid systems that provide automatic dual processing capability. In the event of a main system failure, anti-skid protection is automatically switched to the alternative brake control system.

To carry the new aircraft's increased weight compared to the previous Nimrod, it also has a new landing gear system with eight wheels. It marks the first time that Dunlop has supplied carbon brakes and a dual-digit control system for an eight-wheeled configuration. The aircraft, which has a range of 6000 mi, carries a crew of 10, and is powered by four **Rolls-Royce** BR7 engines.

Stuart Birch



Carbon brakes with a dual-digit control system by Dunlop Aerospace are fitted to the Nimrod MRA4, which has started flight trials.

Supersonic trainer

The first production T-50 Golden Eagle supersonic trainer began final assembly in December at **Korea Aerospace Industries'** (KAI) manufacturing facilities at Sacheon, South Korea. The Fuselage Automated Splice System (FASS), a computer-controlled laser alignment apparatus, was used to mate the forward, center, and aft sections of the fuselage.

The FASS system is accurate to within 0.001 in for "precise and quick mating" of the fuselage sections and offers a 70% reduction in labor hours, claims KAI. Components installed after fuselage mate include line-replaceable units such as avionics, pumps, and engine, and external components such as landing gear, wings, vertical, and horizontal tails.

N.S. Park, General Manager of the Sacheon plant, said the company has finished ground structural testing, and is over 60% complete with its flight test program.

"The development program is validating an excellent design, and this has allowed us to proceed with production with no major changes," said Park.

After assembly is complete, the aircraft will be painted, fueled, and leak checked. Following that, it will go into field operations, where the final system ground checkouts, acceptance test flights, and a comprehensive configuration audit and acceptance inspection will be performed.



KAI has reached final assembly of the first T-50 supersonic trainer, which was developed by KAI for the Republic of Korea Air Force, with help from Lockheed Martin for the avionics system, flight-control system, and wings.

KAI has built 128 F-16s under license from **Lockheed Martin**, with the last delivered in August 2004. The manufacturing processes learned from that program helped KAI determine an efficient manufacturing plan for the T-50. The company is averaging "only 3.1 quality corrections per 1000 man hours," said Park.

The T-50 is the only supersonic trainer in development or production, according to KAI, and is also the company's first attempt at designing and building a high-performance aircraft. The aircraft is being developed by KAI for the **Republic of Korea Air Force** (ROKAF).

Lockheed Martin is responsible for developing the T-50 avionics system, flight-control system, and wings. KAI and Lockheed Martin have an agreement for joint international marketing of the T-50. The program entered the transition-to-production phase with initial contract from the ROKAF awarded to KAI in December 2003. The first production aircraft is expected to be delivered in late 2005. The second aircraft was scheduled to enter final assembly in January.

KAI dates from 1999 through the consolidation of **Samsung Aerospace, Daewoo Heavy Industries, and Hyundai Space and Aircraft.**

Jean L. Broge

L-3 adapts

The Integrated Systems (IS) subsidiary of **L-3 Communications** will be developing a flying test bed for risk-reduction flight testing of the Trent 1000 engine, which **Rolls-Royce** is designing for the new **Boeing 7E7**.

This program requires the modification of a Boeing 747-200 aircraft to include a pylon strut adaptor to interface with the Trent 1000 engine. L-3 IS will be responsible for the aircraft modification, maintenance, logistics support,

and flight crews for the duration of the engine test program.

The engineering phase of the program will begin immediately, with the aircraft arriving at the L-3 IS Waco, TX, facility. The program will draw heavily on engineering, production, and flight test experience from other major 747 aircraft modification programs being accomplished at the Waco facility.

The Trent 1000 is the lead engine on the Boeing 7E7 program, having

been selected by launch customer **All Nippon Airways** (ANA) to power its fleet of 50 Dreamliners. The engine has also been chosen by **Air New Zealand**, the only other Boeing 7E7 customer to make a selection at press time. Development testing of the Trent 1000 will start in Spring 2006, leading to certification in 2007. It will enter service with ANA in 2008.

Jean L. Broge

Composite solution

Engineering design consultancy **GRM Consulting** has developed what it describes as a "fast and simple" method to identify the optimum lay-up of fibers for aerospace composite materials using the minimum amount of material.

"Having proved the new system in a recent project for the motorsport industry, we plan to extrapolate the technology for use by the aerospace industry to reduce development times and get the best out of composite materials," said GRM Consulting Managing Director, Martin Gambling. "We are looking to future aerospace projects for possible applications, for example, the **Airbus A400M**."

The system used by the company combines **Vanderplaats'** GENESIS software with GRM's own OptiAssist pre-processing tool.

The aim of the initial project to which the system was applied involved the development of a racecar safety cell via changes to the lay-up of laminate fibers. The cell needed to be "as light as possible" but still meet official requirements.



Martin Gambling believes his company's technology—demonstrated initially as a racecar application—could save weight and reduce development times in the aerospace industry for both civilian and military applications.

To determine the correct lay-up pattern, a topology optimization was carried out using GENESIS, allowing the thickness of the individual laminate plies to be optimized under the prescribed load cases.

The software can be used to optimize for buckling, vibration, stiffness, and strength.

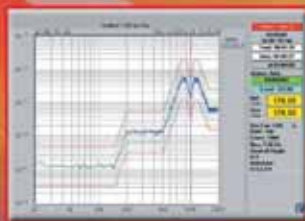
"The output of the analysis indicated the correct location of lay-up patches in areas where engineers expected the lay-up of the structure to differ," said Gambling. "These patches were then allocated a number of different plies to optimize. It was important that the patches were compatible and had continuous fiber orientations, for which OptiAssist was used."

GRM sees applications of the system being apposite for both military and civil aerospace projects. The system is designed specifically to define laminated composite optimization parameters including lay-up sequences, ply symmetry, linked plies, and discrete ply increments.

"The new design achieved for the racecar safety cell provided an 18% weight saving with equivalent stiffness compared to the existing version," said Gambling. "It is a manufacturable, workable solution developed in a study that took four days, including model creation time."

Stuart Birch

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Extremes for the Osprey

The tilt-rotor V-22 Osprey is one of the world's more unusual aircraft and has brought many design challenges. **Flight Refuelling** has designed and built the telescopic re-fueling probe for the aircraft, which is now being tested by **Boeing**. Flight Refuelling is also conducting structural and environmental tests of the equipment. To do so under real-world conditions, a range of climates from arctic cold to desert heat are being re-created in an environmental test chamber. A crucial element of this test is the ability to deliver military-grade oil at high pressure over a temperature range of -55 to $+145^{\circ}\text{C}$ to ensure that the probe actuates in the most extreme flight conditions. **WYKO Fluid Power Engineering Services** has designed and built an hydraulic power pack to meet the requirement.

The refueling probe is over 9 ft long when extended and must be retractable to meet the aircraft's shipboard stowage requirements. Retracted, it is completely flush with the aircraft's nose section. The rigorous test program requirements were particularly challenging, according to Mark White, Senior Project Engineer at WYKO.

"To meet the requirements posed by such extreme working environments meant the specifications for the hydraulic power pack were equally extreme," said White. "It had to deliver oil at a flow rate of between 1 to 6 L/min at a pressure of 396 bar and at a very broad adjustable temperature range. It also had to be capable of pumping two different military specification hydraulic oils."

The system is designed around three separate hydraulic circuits that are connected to a common reservoir. Two auxiliary circuits are used to condition the oil in the reservoir prior to the main circuit delivering it to the test facility. These circuits have hot and cold capabilities—heating or cooling the oil—depending on the system's requirement. A temperature probe coupled to a **Eurotherm** controller continually monitors oil in the reservoir and sends a "cool" or "heat" signal to a controller that oversees the system. The controller decides which auxiliary circuit to run depending on



The V-22 Osprey's retractable flight refueling probe is undergoing structural and environmental tests under a range of real-world conditions, with climates from arctic cold to desert heat being re-created in an environmental test chamber.



WYKO's hydraulic power pack for the test program of the V-22 Osprey's retractable flight refueling probe was used to determine the system's ability to deliver military-grade oil at high pressure over a temperature range of -55 to $+145^{\circ}\text{C}$.

the ambient temperature and the required setpoint temperature for the current test.

"In basic terms, the cool circuit is designed to control temperature below around 25°C to 'superchill' whilst the hot circuit controls above that temperature and heats," said White. As the temperature passes through a predetermined set temperature (ambient) the controller shuts down one circuit and starts the other.

"The fundamental issue is with the characteristics of the hydraulic fluids being used," he said. "The viscosity of military spec fluid can be around $2\text{ mm}^2/\text{s}$ at 130°C and $4500\text{ mm}^2/\text{s}$ at -45°C . At the higher figure it behaves

much like water at room temperature and at the lower, takes on the consistency of sticky toffee and is extremely difficult to pump."

This fact meant that every hydraulic component and pipefitting had to be checked for compatibility with the extremes of temperature and pressure, according to WYKO. The same was true for the materials, both electrical and mechanical, used in the construction. It was not possible to find a gear pump that could operate over the entire temperature and viscosity range of the fluids used, hence the use of two auxiliary circuits, which switch in and out as necessary. A check ball piston pump close-coupled to an inverter-controlled motor carries out the final delivery of the conditioned hydraulic fluid to the thermal chamber.

The piston pump is in turn fed by a boost pump that is enabled whenever the temperature falls below about 10°C . The boost pump is only necessary to provide sufficient suction pressure to the main pump at low temperatures. The fluid passes from the main pump across a pressure filter and out to the temperature-controlled chamber where the test rig is housed. The fluid is continually monitored for pressure, temperature, and flow.

An idea of the difficulties facing WYKO can be gauged from the fact when one fluid reached -39°C , its viscosity doubled in a span of 5°C .

Cooling the oil to extremely low temperatures required considerable research and development time. White said that the original concept involved the use of liquid nitrogen as the coolant in the heat exchanger. However, the -195°C input temperature and the nature of the medium was found to be too aggressive when passing through the heat exchanger, causing localized freezing of the oil and a laminar flow effect that resulted in a reduced chilling ability of the system. A refrigerated cooling system, which provided superior controllability, was then adopted.

A further difficulty to overcome was to maintain the required setpoint tem-

perature, both via closed-loop control and use of adequate insulation materials. Thermal breaks had to be designed into brackets that minimized conduction of heat and suitable insulation that could cope with extremes of temperature variation.

"The complexities of achieving the end results are mainly hidden by a simple operator control setup, access to pre-determined functions at set temperatures being provided via a standard HMI display," said White.

Stuart Birch

Teleflex gets grinding

Viper Grinding of aircraft engine turbine blades and nozzle guide vanes is a technique developed by **Rolls-Royce** to allow stock removal rates up to eight times those achievable via conventional grinding of nickel alloys using a plated CBN wheel. **Teleflex Aerospace Manufacturing UK**, believed to be the first aerospace subcontractor in Europe to use Viper Grinding, has reduced multiple operations on up to 10 different machines to one or two set-ups on a **Makino A55** horizontal machining center supplied by **NCMT**. Teleflex claims that its savings have carried over to customers via price reductions and allowed capital investment to be recouped in 18 months.

Viper Grinding includes coolant at very high pressure (about 100 bar) be-

ing directed at the point of grinding, which necessitates operator protection. Teleflex found that the Makino with double skin construction and specially guarded slideways met its criteria. The first engine set of 16 nozzle guide vanes was completed within six weeks of the machine going on stream. Using traditional grinding techniques, a cell containing 10 machines would have been used, employing five operators to clamp every part once on each machine, according to Teleflex. It would have taken two weeks to set up and the longest operation would have been about 30 min. On the Makino, the vane was machined complete in two clampings, taking 26 min to machine one side and 20 min the other, with an hour to change over with one operator involved.

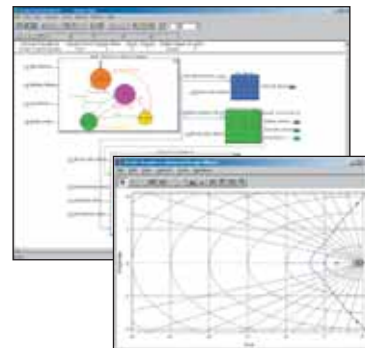
The second new component produced on the machine was a shroudless turbine blade, made from a nickel-based, high-temperature alloy casting. The fir tree root form is ground in a single hit on the Makino, including everything under the planform, *i.e.*, the leading and trailing edge rhomboids, lock plate grooves, root end face, and key peg plus the under-neck area. Set-up time for the part was two days including off-line programming using **UGS CAD-CAM** software, but the next time the job is put on the machine for a repeat batch, it takes only an hour to set. The single machining operation took



Advanced grinding techniques of aerospace engine turbine blades and nozzle guide vanes is claimed to be saving time and money up and down the aerospace supply chain.

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less than 15 min. Again, a conventional approach would have been lengthy, involving up to seven machines taking three to four days to set and involving three operators.

In other aerospace manufacturing developments, **Saint Gobain** has completed a three-year R&D program that

has resulted in Vortex. The new Vortex technology is for the manufacture of highly porous, permeable grinding wheels, which may have either a vitrified or organic bond structure. The company describes Vortex as being applicable for creep feed grinding on a machining center of components such as

turbine blades. The new wheel absorbs "copious" quantities of coolant and diffuses it readily in the cutting zone, taking heat out of the chips and discouraging clogging of the cutting edge.

Stuart Birch

On time Trent

Less than 20 months after its first run, the **Rolls-Royce** Trent 900 engine under development for the **Airbus** A380 has been given its airworthiness certificate. The A380 is scheduled to make its maiden flight early this year. The on-schedule Trent 900 is the first large engine program to complete certification through the new European Aviation Safety Agency (**EASA**) and is reported to have met or exceeded all performance targets including fuel burn.

The engine will be used by Airbus to support the A380's flight test program, and 18 will be sent to Toulouse. Initially, the Trent 900 will operate in commercial service on the A380 with launch customer **Singapore Airlines** (SIA), producing 70,000 lb of thrust, although it is certificated at 80,000 lb with growth potential.

Rolls-Royce has announced that the engine had reached 93,000 lb during test bed running. In the time since the Trent 900 first ran, seven development

engines have been used for safety and reliability testing. Tests have included bird strikes and severe weather simulation including hail and ice ingestion. A statutory full-power blade-off test was completed satisfactorily. The Trent 900 has completed a 60-h flight test program installed on an A340-600 flying test bed. **Qantas**, **Virgin Atlantic**, and **Lufthansa** have specified the Trent 900 to power their A380s.

Following tests, Airbus has said that A380 engine jet blast would have no impact on elevated runway edge lights "wherever they are located" on the extremities of a 45-m-wide runway. The **French Civil Aviation Authority** (DGAC) conducted the tests in collaboration with Airbus. Six types of lights were tested representing designs found in the U.S., Australia, and Europe. Dynamic tests using an A340-600 were complemented by static tests using wind blast facilities to see if the jet blast at lift-off from an A380's outer engines would cause



The Rolls-Royce Trent 900 engine, shown being installed on the Airbus A380, has reached a thrust of 93,000 lb during test bed running, but will be certified at 80,000 lb with growth potential.

damage to the lights. According to Airbus, after several take-offs at maximum thrust and with the engine above the lights when taking off, none of the 54 lights of six types placed along the runway was damaged.

Stuart Birch



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