Don't flap

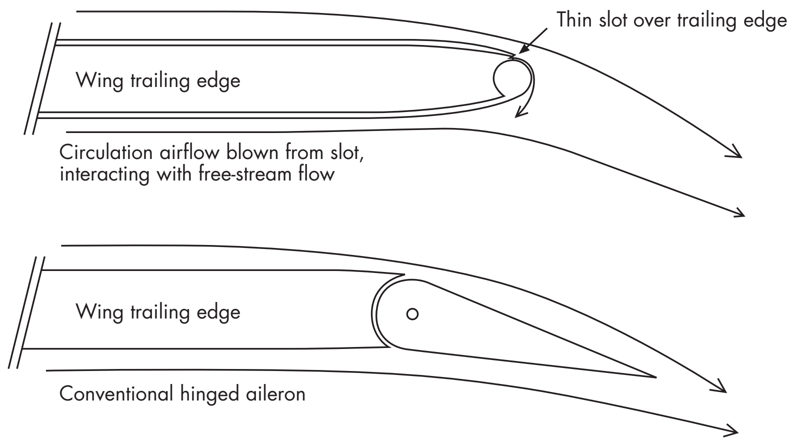
Systems developed for UAVs may be upscaled not only to larger, manned military aircraft but also for civil applications, bringing weight and cost savings. One example of such systems involves flapless technology.

BAE Systems' partnership with leading UK universities into flapless flight research has recently advanced, with scale air vehicles successfully test flown to demonstrate new concepts of flapless airflow control. Flapless in this context means no ailerons or elevators, with only blown air to control roll and pitch. Two air vehicles were flown late last year, which form the first of a set of planned demonstrators as part of the FLAVIIR (Flapless Air Vehicle Integrated Industrial Research) program for future UAVs. A third, integrating the technology of the first two, is due to fly shortly.

Wind-tunnel test of the Santos flapless research vehicle, which is the result of a five-year project that will cover key aspects and technologies of the next-generation UAV.

Funded by BAE and the UK's **EPSRC** (Engineering and Physical Sciences Research Council), the project involves 10 universities and is managed by **Cranfield University**, north of London. The work is particularly significant for both military UAVs and manned military aircraft in terms of the enhancement of stealth characteristics by greatly reducing gaps and edges, both of which increase radar cross section.

But an added bonus, according to BAE, is that a reduction in moving and electrical parts brings cost, reliability, weight, efficiency, and maintenance benefits to both military and civil types. According to BAE, the first vehicle flown achieves roll control by blowing air from the trailing edge of one wing, which in turn entrains the upper surface flow and so increases lift, thus producing roll. That aircraft features a two-stroke engine and a wingspan of 1.59 m, a mass of about 2.5 kg, and a cruise speed of 25 to 30 m/s. The second aircraft is based on the **Vector**-II delta-wing electric fan model aircraft, with a 1.2-m span, 2.3-kg mass, and cruise speed of 30 m/s. Both aircraft also feature a secondary air supply via a turbocharger-based compressor.



BAE Systems has a partnership with the Engineering and Physical Sciences Research Council and several universities to explore flapless technology, part of which entails air-circulation control.

BAE describes the vehicle achieving pitch control by the deflection of the main propulsive jet. This deflection is achieved by using secondary jets that exhaust from small slots at the upper and lower surface of the main jet and follow a curved surface, which in turn entrains the main jet and results in full-thrust vectoring.

The third test vehicle, designated Santos, will see the integration of the technology from both earlier aircraft into a single electric platform driven by two electric ducted fans, one for main thrust and the other for secondary air supplies. Further developments may involve extrapolation of the Santos concept by examining aspects of jet engine design with secondary supply requirements.

Also scheduled is a 40-kg autonomous vehicle (Demon). A likely jet engine to be used for this vehicle is the single radial compressor **AMT** Olympus with secondary supplies probably via a form of engine bleed. The program schedule is for this flying demonstrator to be completed in early 2009. BAE added that as the other technologies in the program are researched, further flapless vehicles would be developed.

The five-year project covers all key aspects and technologies of the next-generation UAVs, including aerodynamics, control systems, electromagnetics, manufacturing, materials/structures, numerical simulation, and integration. The 2009 aircraft would represent a "maintenance-free," low-cost UAV without conventional control surfaces and without a performance penalty against a comparable conventional design.

"Future UAVs will be necessarily cheaper, more modular, and will rely on designs that consider many cross-discipline interactions and trade-offs," said Project Manager Philip Woods, who is based at BAE Systems' Advanced Technology Center.

Together with Cranfield, other universities taking part in the program include **Leicester**, **Liverpool**, **Manchester**, **Nottingham**, **Southampton**, **Wales** (Swansea), **Warwick** (Warwick Manufacturing Group), **York**, and **Imperial College**, London.

Stuart Birch

Testing the 787's power

The first testbed run of **Rolls-Royce**'s Trent 1000 engine for the **Boeing** 787 Dreamliner (due to enter service with **ANA** in 2008), was scheduled to take place as this article went to press. Assembly of the initial test engine started in November last year, with the arrival at Rolls-Royce's Derby aerospace facility in the UK of the first intermediate pressure compressor drum from program risk and revenue sharing partner (RRSP) **Kawasaki Heavy Industries**. There are six RRSPs in the Trent 1000 program, with a total investment share of 35%.

Rolls-Royce's test program of the Trent 1000 is starting. The engine will power the Boeing 787 Dreamliner.

The other five partners include **Carlton Forge Works**, **Goodrich**, **Hamilton Sundstrand**, **Industria de Turbo Propulsores**, and **Mitsubishi Heavy Industries** (MHI).

Early rig testing of components—including fan rig and combustor tests—validated computer modeling results, according to Rolls-Royce. MHI is responsible for the combustor. The fan-rig tests were held at the **AneCom** facility at Wildau, Germany, where a fan assembly scaled down to 34 in—from the production engine's 112 in—was installed. The Trent 1000 has 20 swept (curved leading edge) blades of hollow, titanium construction to provide what the company claims as "industry best" levels of lightness, aerodynamic efficiency, and resistance to foreign-object damage.

Rolls-Royce has scheduled seven Trent 1000 development engines for ground testing with nine to support flight test work. The engine—with a designed thrust range of 53,000 to 75,000 lb—will initially be flown early next year on a 747 testbed. Certification is due in the summer of 2007, after which the B787 is slated to make its flight.

By late last year, the Trent family of engines, the first of which entered service 11 years ago, had amassed 15-million flight hours on airline operations. Rolls-Royce expects this to have risen to 35 million by the time the Trent 1000 enters service.

Stuart Birch

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Circle 8

Boeing gets specific on 747-8 propulsion

After considering competitive bids, **Boeing** officially announced in January the team of suppliers that will provide propulsion systems for its 747-8 airplane launched last November. The external team consists of **GE-Aviation** for engines, **Middle River Aircraft Systems** (MRAS) for the thrust-reverser system, and **Spirit AeroSystems** for the nacelle and strut. The internal team includes Boeing Winnipeg for the aft pylon fairing, Boeing Portland for the engine mounts, and Boeing Propulsion Systems Division for the engine build-up and strut build-up.

GE-Aviation, Middle River Aircraft Systems, and Spirit AeroSystems (the latter a former division of Boeing) will make up the external team that will provide the propulsion systems for the 747-8 airplane family. The internal team will include Boeing Winnipeg, Boeing Portland, and Boeing Propulsion Systems Division.

The 747-8 family will include the 747-8 Intercontinental passenger model and the 747-8 Freighter. GE will supply the GEnx-2B67 engine for the airplane, which is scheduled to enter service in September 2009 for freighter operator **Cargolux** of Luxembourg. Based on the GEnx engine to be launched on the Boeing 787 Dreamliner, the engine designed for the 747-8 will be rated at 66,500 lb of thrust.

The GEnx is claimed to be the only jet engine being developed with both the front fan case and fan blades made of composite materials, resulting in improved engine durability and weight reduction. The engine also features a new-generation combustor for efficient fuel mixing before ignition, which significantly lowers NOx levels. The first full GEnx-2B67 engine will go to test in 2007, with engine certification scheduled for 2008.

According to Tom Brisken, General Manager of the GEnx program at GE-Aviation, MRAS will become a new direct supplier to Boeing, developing, certifying, and supplying the all-composite thrust-reverser system directly to Boeing rather than through GE. MRAS, which touts its expertise in composites, acoustics, and weight reduction, expects to deliver first production hardware in 2008.

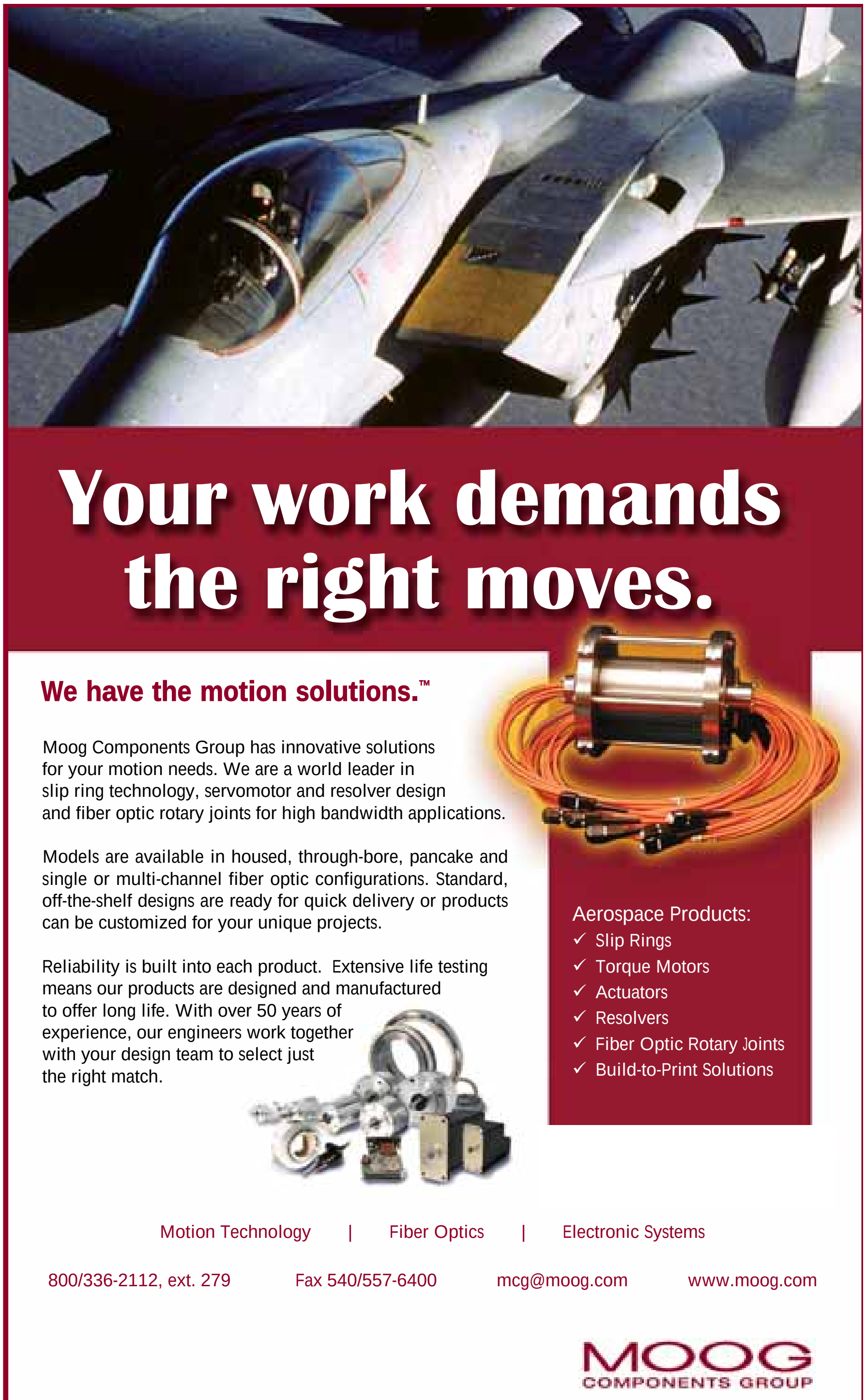
Spirit's contribution to the engine system will include the upper fairing, fan cowl support beam, and strut box for the inboard and outboard struts. Spirit's work package for the nacelles includes the inlet assembly, which will incorporate a seamless, one-piece composite acoustic barrel for a 105-in.

Circle 9

diameter fan, composite fan cowl doors, the primary exhaust with sound-dampening chevrons, and plug (or cone).

The 747-8 passenger variant will seat 450 passengers in a typical three-class configuration. Boeing says it will provide an 8000-nmi range, 21% greater cargo volume, and 8% lower seat-mile costs compared to the 747-400. The 747-8 Freighter will fly 4475 nmi with a maximum structural payload capacity of 154 ton, with a 16% increase in revenue cargo volume than the 747-400F with slightly greater range.

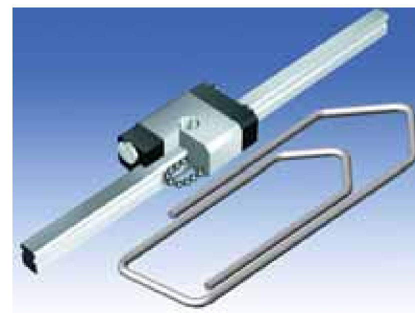
Jean L. Broge



Circle 10

THK adjusts its weight

Ever weight conscious, the aerospace industry is a constant challenge to component makers to come up with new solutions. According to **THK**, its latest systems have been specially designed to reduce weight, size, and complexity of mechanisms used for adjusting passenger seats, footrests and food trays, and for positioning galley lifts.



THK's ultra-small RSR linear motion guide uses a block running on precision-ground stainless steel balls.

Although traditionally used slide packs fitted to aircraft seat runners are relatively simple and low-cost, they often require ancillary mechanisms to be fitted before they can be installed. They can also be noisy, inaccurate, and prone either to complete failure or to partial dismounting of the slide rails, causing seats or other sliding mechanisms to become misaligned, says THK.

THK's solution is the use of guides that it claims offer systems designers and manufacturers a choice of fully integrated units that are simple and quick to install. Its SRS LM guide has dual-raceway construction and has been designed specifically for use in space-limited applications with high loads and where the direction of the load may vary.

The company's RSR guides are claimed as among the smallest in the world. They use a block running on precision-ground stainless steel balls set into what THK describes as virtually frictionless raceways. The balls circulate within the body of the LM block itself, facilitating a wider range of stroke lengths to be accommodated.

Stuart Birch

Searching for new light alloys

A new technology link between the aerospace and automotive industry has emerged with a project at the **University of Manchester** to develop a new class of light-alloy solutions aimed at transforming the way aircraft and automobiles are built. The project, called Light Alloys for Environmentally Sustainable Transport, will be carried out in conjunction with **Airbus**, **Alcan**, **BAE Systems**, **MEL**, **Jaguar**, and **Novelis**.

In recent years, there has been a gradual strengthening of links between the aerospace and automotive industries. The use by some car makers (notably **Audi**, **BMW**, Jaguar, and **Aston Martin**) of light alloys has increased this, with shared knowledge of materials science and manufacturing processes helping the transition.

"The materials concerned [aluminum, titanium, and magnesium] are exceptionally difficult to form into complex shapes or weld, which dramatically limits their use in the design and manufacture of air and land vehicles," said George Thompson, a professor at Manchester University's School of Materials.

Manchester announced in a statement that the project, for which the UK's **EPSRC** (Engineering and Physical Sciences Research Council) has awarded it a $10-million grant, "will focus on developing new methods for the processing, forming, joining, and surface engineering of aluminum, titanium, and magnesium. The aim is to develop new engineering processes that will enable aircraft and car manufacturers to design and build lighter, more environmentally friendly vehicles using these materials."

The project will be led by George Thompson, Head of the Corrosion and Protection Center in Manchester's School of Materials. It presents major challenges. "The materials concerned are exceptionally difficult to form into complex shapes or weld, which dramatically limits their use in the design and manufacture of air and land vehicles," he said. "This [limitation] is a major issue for the aerospace and automotive industries, which are under increasing pressure to save fuel and reduce pollution. If we can improve processes such as the welding of aluminum panels, then they will be able to build much lighter aircraft and cars, saving on fuel and emissions." Railway and sea transport could also benefit from the work.

About a third of the project's funding has been earmarked for technologically advanced equipment to aid the research, which will include characterization facilities, advanced welding systems, and laser surface-treatment equipment. Research is to concentrate particularly on joining, forming, microstructure, and surface modification and will address crucial issues including the use of anti-corrosive chromate coatings in the aerospace industry with regard to their potential impact on

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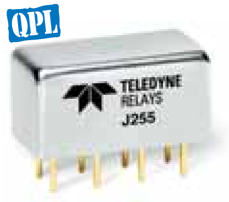

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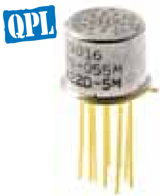

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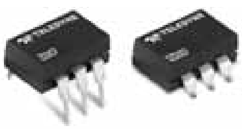

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Circle 11

the environment. The work is scheduled for completion in five years and will involve some 50 research specialists.

The processing methods developed should enable components to be manufactured at less cost and with considerably less waste material than is currently possible, explained Philip Prangnell, Professor of Materials Engineering in Physical Metallurgy at Manchester's School of Materials. "Ultimately, we hope that our research will see stronger, lighter, more environmentally compliant materials incorporated into the next generation of aircraft and cars," said Prangnell.

Stuart Birch

Aerolux's oven-ready solution

Fabricating insert equipment for aircraft galleys can be expensive in terms of time, but **Aerolux** has been making increasing use of CNC-machining techniques for a more cost-efficient solution. Half of all the prismatic parts it manufactures are machined from solid aluminum via two **Hurco** VMX 42 vertical machining centers.

Ken Metcalfe (right) and Aerolux Engineering Manager Glen McQuire check an aluminum frame for an aircraft galley refrigerator that has machined components.

Although safety-critical parts in aircraft are always machined to prevent the risk of crack generation, food-related equipment is usually fabricated. But Aerolux has found that some parts other than those relating to safety are quicker and less costly to make by milling instead of welding. Managing Director Ken Metcalfe said that a refrigerator door and frame typically needs between 10 to 12 h to fabricate, but machining more than halves that time. Because repeatability is improved—parts can be assembled more accurately from batch to batch and with no welds to trim—there is significant time to be saved during the finishing phase.

"Second-operation work such as drilling and tapping, which was previously by hand on fabrications, is now completed in-cycle on the machining center, saving further time," said Metcalfe. "The cosmetic appearance of products has been improved because it is possible to radius corners when CNC machining a refinement, a feature that is not feasible when fabricating products."

The introduction by Aerolux of a Hurco system was first tried in 2004. Aerolux had been successfully fabricating galley equipment for 18 years, so the move was a radical departure from proven techniques. An immediate benefit (particularly for an airline operator) was reduction in weight because it was possible to mill sections down to only 2 mm, much thinner than can practically be fabricated. It has also been possible to machine the groove that accepts the oven door seal rather than using two frames, one inside the other, to achieve a similar—and heavier—result.

As a result of its experience, Aerolux has installed a second Hurco and plans to redesign other components to benefit from machining. Metcalfe estimates that within a year, most of the components used for Aerolux's galley products will be CNC machined. Turned parts are also produced by CNC lathes.

When Metcalfe initially decided that a switch to machined components was needed, he tried subcontractors, but this was not cost-effective due to small batch numbers and the need to monitor quality. Aerolux also produces galley components for the rail industry.

Stuart Birch

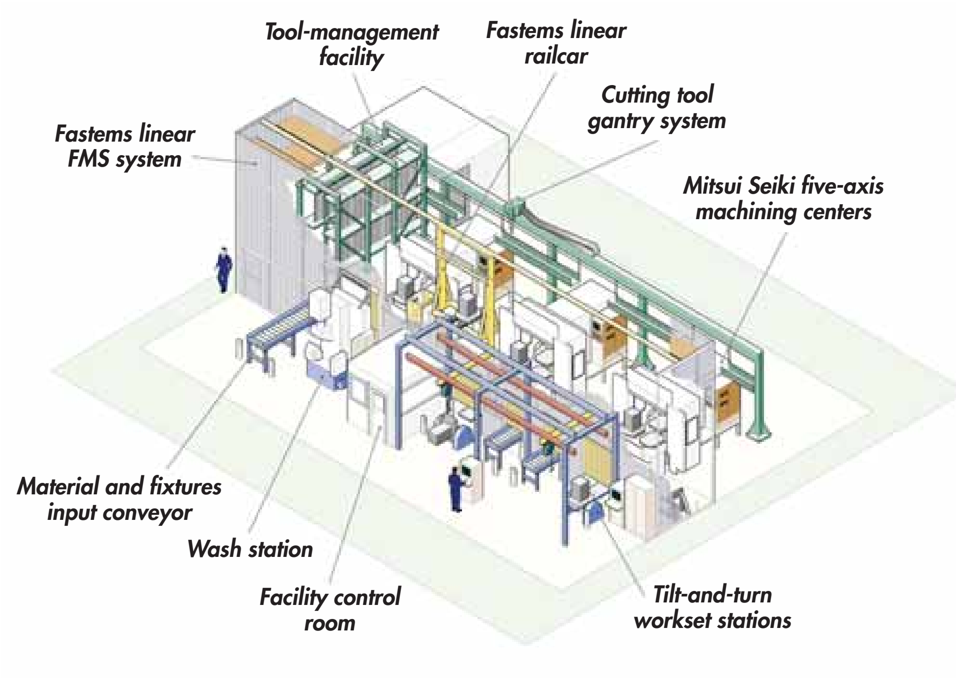
Machining flexibly for fighters

Flexible machining systems (FMS) have become an integral part of the aerospace industry's drive for efficiency. At **BAE Systems**' Samlesbury facility, a **Fastems** FMS is used exclusively for the production of parts for the **Lockheed Martin** F-35 Joint Strike Fighter and for the **Eurofighter** Typhoon. It runs 24 hours a day for six days a week and has produced many thousands of components in small batches for more than 90% of available hours.

Originally installed in 1997 to manufacture Typhoon parts, early production volumes provided spare capacity and the facility was also used to produce commercial aircraft components for companies including **Airbus**. But as the Typhoon program gathered pace, requiring production of some 600 parts on the FMS, and with an increasing volume of parts also needed for the F-35, the facility is now being focused wholly on machining parts for military aircraft, with the simpler Airbus components transferred to other machines at Samlesbury.

The Fastems FMS includes three **Mitsui Seiki** five-axis, high-speed horizontal machining centers and two tilt-and-turn stations for loading and unloading parts, both with conveyors to feed material from a store. It also has one conveyor adjacent to the load stations for input and output of raw-material pallets, an integrated washing system, and a central tool store. The 22.5-m long system comprises 136 positions, 96 of which are for raw materials on 800- x 1200-mm Europallets and 40 for fixtured parts on 630-mm^2 machine pallets. To maximize storage space within a limited floor area, racking stands at 7.1 m.

For maximum flexibility of operation, any machine pallet can be routed to any of the Mitsui Seiki machining centers to achieve a recorded 98% system



The Fastems/Matsui Seiki flexible machining facility at BAE Systems has achieved 98% system efficiency producing military aircraft components.

efficiency, 3% above BAE's original objective, according to Fastems. The company regards the 620-station central store for BT40 tools with an overhead gantry running the length of the FMS to replenish the 120 tool magazines serving each machine tool, as the most significant element of the facility. Every machine tool has a standard set of 40 tools as a core supply for all machining operations, the gantry delivering job-specific tools, specials, and sister tooling at the same time as part programs are downloaded to machines, with software control facilitating optimum tool movements to provide maximum spindle utilization.

Fastems has just developed a new version of the central tool store using an overhead six-axis **Fanuc** robot to provide added integration flexibility.

Stuart Birch

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