

Tech focus

This month's focus is on advances in materials and manufacturing.

Sticking point for Synthetic Gecko

Extrapolating solutions within nature to achieve engineering applications invariably sounds unlikely, but one of the new technologies unveiled by **BAE Systems** at July's Farnborough International Airshow in England does just that. It is a new type of adhesive system inspired by the small gecko lizard, which is able to climb walls by using minuscule suckers on its feet.

BAE Systems' variation on the theme is called Synthetic Gecko. The real gecko's mural capability centers on the soles of its feet, which are patterned with millions of tiny hairs with split ends. At the tip of

each split is a mushroom-shaped cap less than 0.001 mm in diameter. "These ensure that a gecko's toes are always in very close contact with the surface beneath—so close that molecular forces of attraction create the grip, which is released by a peeling action as the foot is lifted and the bond broken," said Jeff Sargent, research physicist based at BAE Systems' Advanced Technology Center. "We wanted to mimic the gecko's ability, recognizing that a synthetic material could have tremendous engineering potential."

Using the micro-engineering clean-room facilities at the center, Sargent and colleague Sajad Haq created layers comprising thousands of microscopic polyimide stalks with splayed tips that resemble the real gecko's mushroom-headed hairs. BAE Systems stated at Farnborough that a sheet of little more than 1 m² could be used to suspend the weight of an average family car. The company is now carrying out further research into the influence of surface roughness and water on the adhesive properties of the material to

test its effectiveness.

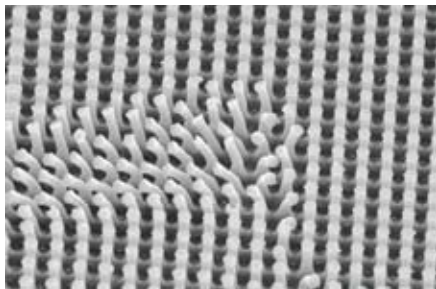
BAE Systems talked about another manufacturing technology at the airshow, namely the Sentinel corrosion-monitoring system that has been down-selected by the **Lockheed Martin** F-35 Joint Strike Fighter team. Developed by BAE's Advanced Technology Center and the company's Australian business, Sentinel is sufficiently mature to be developed within the F-35's Systems Development and Demonstration (SDD) phase.

According to Steven Harris, Materials Group Leader at the Center, it is estimated that the U.S. **Department of Defense** spends \$40 billion a year on corrosion-related issues, the **U.S. Air Force** more than \$1.5 billion.

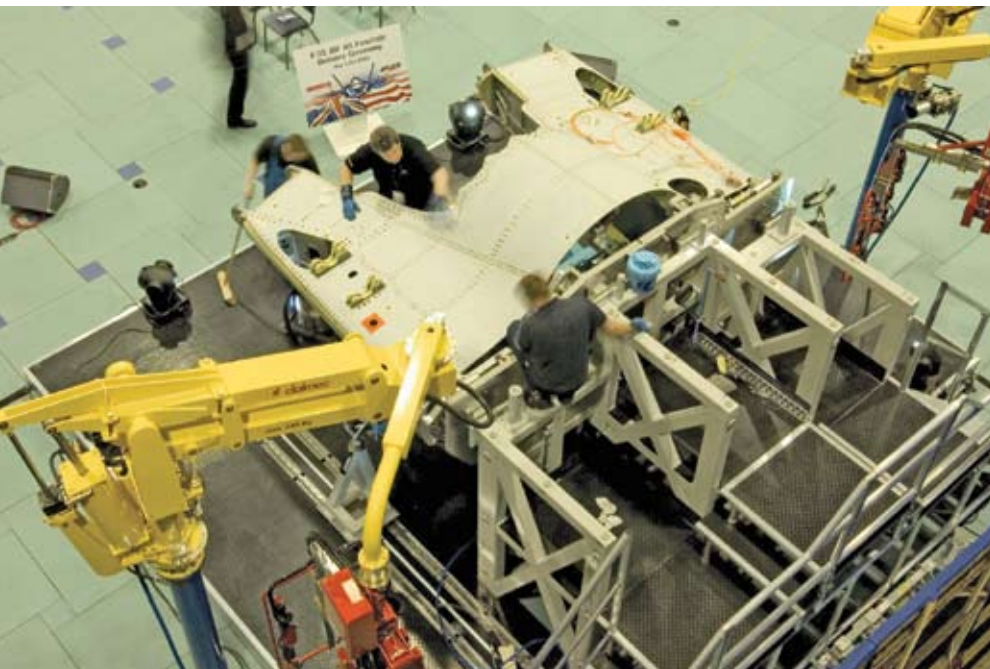
"In an aircraft, it is vital to get to any possible corrosion damage before it happens," said Harris. "If you do, you can repaint and add protection rather than go to the very expensive stage of repairing the airframe." For some military aircraft, corrosion maintenance hours may exceed flight hours, he noted.

The Sentinel system monitors the loss of corrosion inhibitor in paint and indicates when paint replacement is necessary. The sensors involved have been designed to be low in cost and can be placed in various areas of an aircraft. A problem facing BAE during the development of Sentinel was ensuring that the sensors are sufficiently robust to provide accurate and consistent data in changing atmospheric conditions.

Additional research by BAE involves the development of comprehensive anti-corrosion sensors to measure temperature, humidity, salinity, pH levels, and heat conductivity. And further ahead is the possibility of an environmental degradation model, which could calculate a microclimate and predict the failure of protective systems leading to the onset and growth of pitting corrosion. This output would be presented as a life prediction for several sections of the airframe, and the data could be used for asset management, inspection planning, and materials selection and design.



Synthetic gecko feet created a potential new adhesive.



Although corrosion prevention is a design and manufacturing priority, the new Sentinel monitoring system from BAE Systems will enable a continuous check to be made on the structure of the F-35 Joint Strike Fighter.

Stuart Birch

Canadian composite tech transfer pays off

With help from Canada's national aerospace laboratory, **Delastek** is finding more business for its composite parts.

The technology behind the parts was developed by the **National Research Council of Canada Institute for Aerospace Research** (NRC Aerospace), and later transferred to Delastek. The technology involves making composite rib chords using resin transfer molding along with an adhesive process to bond the rib chords to helicopter wing skins. NRC Aerospace used the technology for what it says is the most complex composite aerospace structure ever built in Canada: an all-composite wing box for a next-generation tilt rotor from **Bell Helicopter Textron Canada**.

NRC Aerospace began work in April 2004 in response to Bell's desire to obtain composite parts for its products from Canadian suppliers. Two teams at NRC Aerospace worked together to develop the technology.

One team, at the Institute's Montreal-based Aerospace Manufacturing Technology Centre, manufactured composite rib chords for the wing box using resin transfer molding (RTM). In that process, a resin is injected into a mold containing a woven fabric. The mold is then heated to cure the resin. The process used a modular mold concept to fabricate two different ribs using removable inserts within the same pressure cavity, reducing overall costs. Another cost-saving innovation was using a higher temperature inside the mold, obviating the need for an autoclave.



Thermocouples are installed on the bonding fixture for temperature control.

The RTM technology was transferred to Delastek after delivery of the first completed wing skins. The company, which initially had no experience with the technology, took part in the project by doing some machining, making the rib mould, and participating in the production process.

NRC Aerospace will help Delastek develop the process for a new RTM part to be supplied to Bell.

Patrick Ponticel



A modular mold was used by NRC Aerospace to fabricate composite rib chords.

The NRC Aerospace Structures and Materials Performance Laboratory in Ottawa constructed a bonding fixture and developed a new process to bond the ribs to the wing skins. Unique was the use of cure monitoring and process control to ensure even heating along the entire rib. It also permitted the process to be halted and revised at any time during the 20-minute processing window.

The rib chords are the first known primary composite aircraft structure (PCAS) produced in Canada using RTM, while the rib-wing joints are believed to be Canada's first instance of PCAS bonding.

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EDO has composite solution for inlet duct

With the goal of dramatically reducing the cost of composite technologies in airframe structures, **EDO** has manufactured a prototype engine-inlet duct using a low-cost Vacuum-assisted Resin Transfer Molding (VaRTM) and braiding process under the auspices of the **U.S. Air Force Composite Affordability Initiative (CAI)**.

The duct has a foreshortened, compact geometry with low inlet loss, but the shape is problematic in terms of manufacturing, and the objective of the process demonstration was to achieve required performance and quality with the most

affordable manufacturing process.

EDO made the duct for **Lockheed Martin Aeronautics**, prime contractor of the F-35 Joint Strike Fighter. VaRTM is a flight-qualified, low-cost, high-quality infusion and molding process already used by EDO to produce airframe structures for the JASSM missile fuselage.

Braiding took place over a large mandrel, which is segmented into 35 pieces that are removable for part curing. The mandrel was braided with five layers of continuous graphite fiber, with local buildups up to eight plies thick. Braiding is an automated circular weaving process that applies tensioned fibers to the part surface. EDO used its 288-carrier braiding machine (the largest of its type in the United States, the company says), allowing the duct to be produced with no gaps between yarns.

The duct design includes honeycomb core inserts to produce a stiffened duct wall. The honeycomb core is filled with closed-cell foam to assure that resin will not fill the cell walls. Reinforcing keel straps were also selectively laid up into the duct structure.



The braided duct preform awaits the VaRTM resin infusion process.

A high-performance epoxy resin was then infused into the braided part using the VaRTM process. After the epoxy cured, the internal mandrel was removed from the molded part, one segment at a time. Stiffeners were then bonded to the duct exterior to reinforce the structure at key locations.

The finished duct assembly is currently being pressure-tested and exposed to hammer-shock tests that simulate the pressure spike associated with an engine shock wave.

Patrick Ponticel



Shown here in the carrier braider, EDO's composite inlet duct is undergoing tests.

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