Technology update

Write stuff from BAE

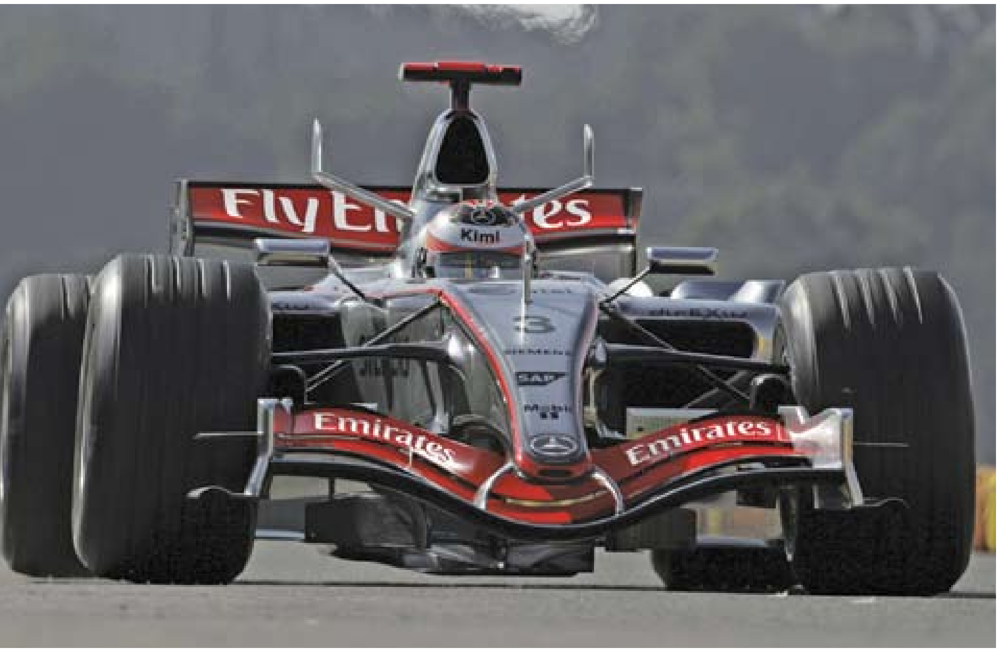
Technology capable of "writing" electrical circuits directly onto surfaces has been developed by **BAE Systems**' Advanced Technology Center (ATC) in the UK. Already tested by the Formula One Team **McLaren Mercedes**, with whom BAE has had a 10-year technology partnership, it could have extensive aerospace and defence applications, including the UAV sector. Announcing its work, BAE stated that the technology—Direct Write—would increase the functionality and flexibility of existing structures and designs.

Direct Write deposits electrical wires, resistors, capacitors, and other electrical components in 3-D on conformable surfaces. There are many potential applications for Direct Write, but the aerospace and automotive industries, with their continuing need to better manage weight and improve packaging, are particularly apposite.

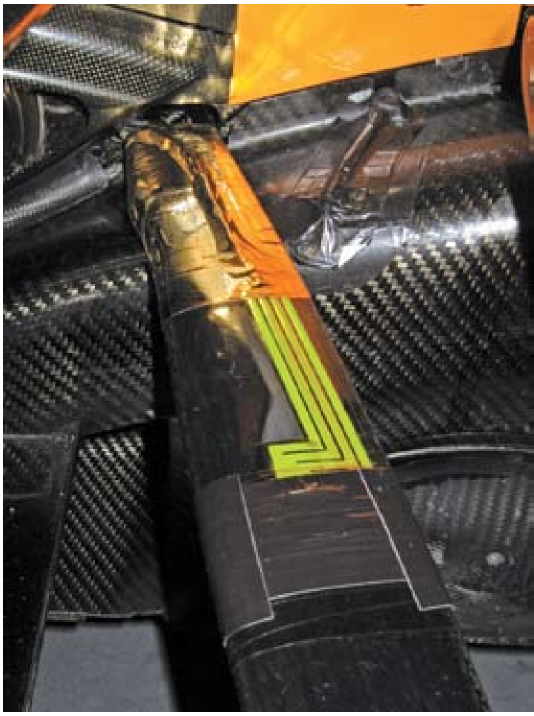
"The technology will keep weight down on aircraft by printing the electronics—and eventually, the sensors themselves—directly onto aircraft components," said Jagjit Sidhu, Principal Scientist at ATC. "What we are doing is simplifying processes and getting rid of unnecessary wiring. We are working on the basic elements at present, looking at getting functionality into the sensors. Direct Write will increase the functionality and flexibility of existing structures and designs."

BAE Systems' scientists estimate that it could be only four to five years before the technology is integrated into aircraft development, both via original design and mid-life updates. A particularly important potential area concerns implementation of the technology into aircrew helmets.

"Putting avionics into the helmet is becoming more and more feasible," said Sidhu. "It could certainly help reduce the weight of some of the equipment currently in use." Pilot health could also be monitored.



Direct Write is an example of technology crossover between aerospace and automotive engineering, with BAE Systems seeing great potential for it in aerospace.



Direct Write was extensively tested during a 5000-km program by the Formula One company, Team McLaren Mercedes, with which BAE has a technology partnership.

The research and development work involving Direct Write on racecars to enhance track performance has included some 5000 km of wet and dry testing with no degradation in the performance of interconnects, demonstrating the durability of the process in a very harsh environment, BAE Systems announced in a statement.

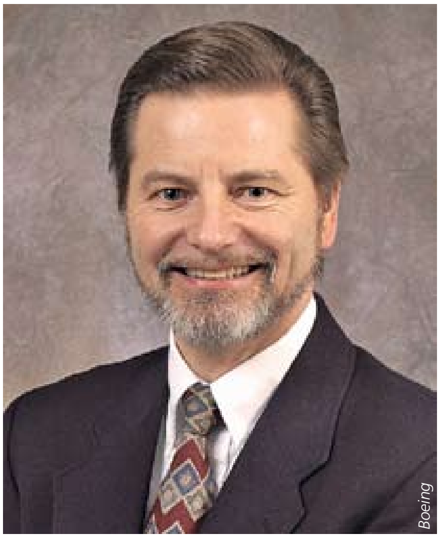
The technology allows McLaren Mercedes to write electrical connections directly onto components, to facilitate a lower aerodynamic profile than conventional systems would allow. The result might only be fractions saved per lap, but in F1 that can represent a major advantage. Load cells interconnected via Direct Write technology have also been evaluated over the 5000 km of testing.

Stuart Birch

SAE standard provides guidance for human-machine interface

Technology is the force that drives innovation in today's sophisticated aircraft. But while technological innovation offers many benefits, attention still needs to be paid to the most basic and crucial type of system: the interface between flight crew and aircraft.

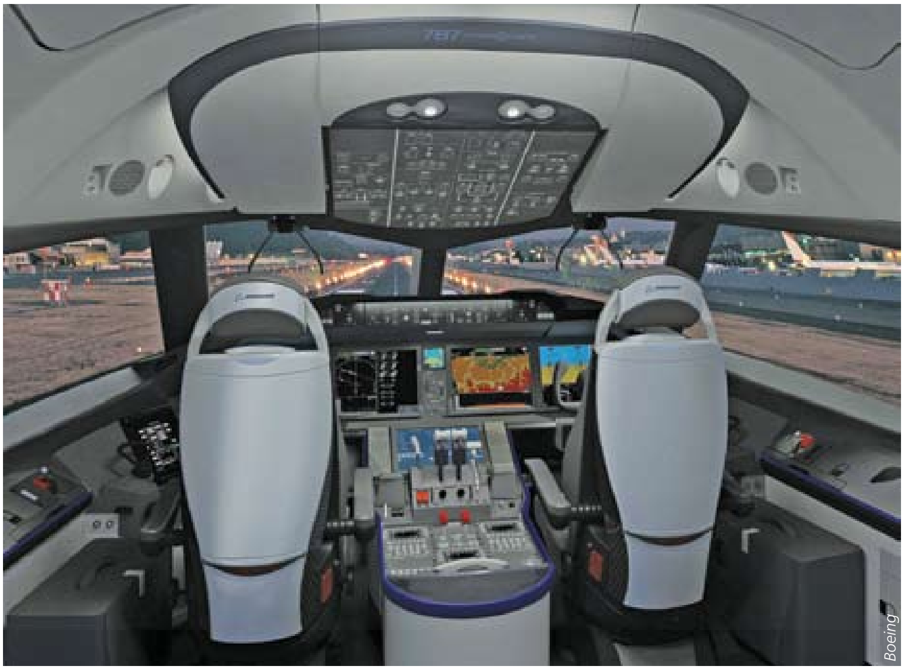
That is the position of **SAE International**, and one of its many aerospace committees has developed a standard to address the issues involved in that interface. The goal is the safest and most cost-effective crew interface system possible.



Human factors must be considered early in the design process, not "designed in" later, said ARP 5056 co-sponsor and Boeing Technical Fellow Alan Jacobsen.

SAE Aerospace Recommended Practice (ARP) 5056, Flight Crew Interface Considerations in the Flight Deck Design Process, defines recommended flight crew interface design processes and methods for new flight deck designs as well as for modification of existing ones. The standard applies to commercial transport, regional, and business aircraft."

"The increased utilization of automated systems, coupled with the increased operating sophistication of aircraft in the modern international airspace system and the increased data and information demands on today's flight crews, has made the proper application of sound human factors design principles more important than ever," said Alan Jacobsen, co-sponsor of ARP 5056 and a Technical Fellow at **Boeing** who serves as the leader of the company's Human Factors Team for the 787 Dreamliner. Other co-sponors and key players in development of the standard were Bill Connor, retired **Delta Air Lines** Captain and Co-Chair of the SAE G-10 Committee, and Etienne Tarnowski of **Airbus**. Some of the other entities involved in development of the standard were **Raytheon**, **Eclipse Aviation**, **Honeywell**, **Rockwell-Collins**, **Thales**, **Garmin**, **NASA**, the **FAA**, and several airlines.



Boeing's involvement in the development of the SAE Aerospace Recommended Practice 5056, Flight Crew Interface Considerations in the Flight Deck Design Process, ensures that controls in the 787 Dreamliner cockpit (shown) will be intuitive and easy to use.

Jacobsen noted that the industry has become more sensitive recently of how failing to take a human-centered design approach "can lead to bad interfaces—*i.e.*, interfaces that are error-prone or difficult to train. This sensitivity has led to newer flight crew interfaces that are more intuitive and error-tolerant than earlier designs."

The standard guides companies away from "reviewing in" human-machine design considerations after the design is near completion. A better idea, and one the standard supports, is "designing in" those considerations. The "designed-in" approach not only avoids the high costs of late modifications entailed under the "reviewed-in" approach, but also results in a better design, Jacobsen said.

An interface's effectiveness can be judged based on its physical, perceptual, and cognitive attributes, according to Jacobsen. Physical characteristics include the size of controls, knobs, and switches, along with the distance between them, and their tactile feel. Perception relates to how well pilots can read and identify information in all lighting environments. Cognitive merit relates to such things as possible hidden modes that can lead to errors. And, Jacobsen added, "Given that people will continue to make errors, how easy does the interface allow the pilot to recover from an error? How much training is required to operate the device or function? Does the interface lead to significant confusion? Is there positive or negative transfer of knowledge across functions?"

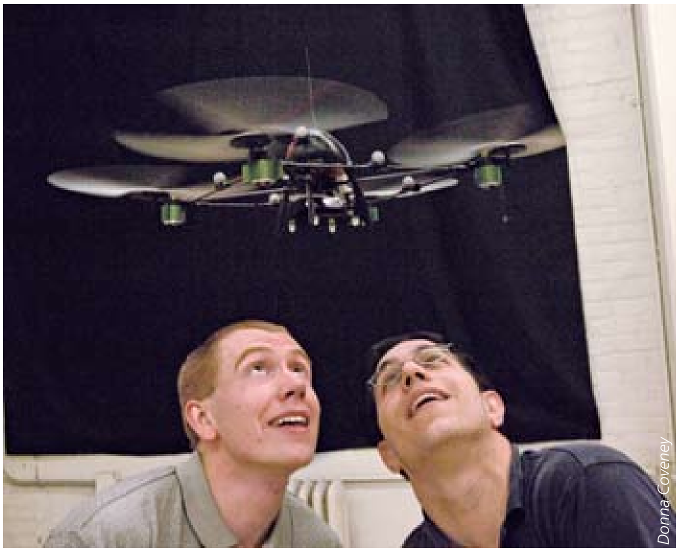
Jacobsen preferred not to identify examples of good and bad aircraft interfaces, but said bad interface design is found in all industries. "Digital time pieces and automobile CD players are notorious for having poor interfaces, as there are often hidden modes and buttons that have different meanings dependent on poorly annunciated modes, and owners often have to take out the instruction manual to reset the time or even change the pre-select buttons," he said.

Patrick Ponticel

UAVs show team spirit by going autonomous

While some UAVs can be easily carried in a backpack and launched by hand, they still typically require a team of trained operators on the ground, and they perform only short-term tasks individually rather than sustained missions in coordinated groups.

However, **MIT** researchers, in collaboration with **Boeing**'s Phantom Works, have developed a multiple-UAV test platform that could lay the groundwork for an intelligent airborne fleet that requires little human supervision, covers a wide area, and automatically maintains the "health" of its vehicles (for example, vehicles anticipate when they need refueling, and new vehicles launch to replace lost, damaged, or grounded ones).



MIT graduate students watch one UAV in a fleet of four that they helped develop to execute surveillance and tracking tasks.

Jonathan How (left), a professor in aeronautics and astronautics, joins graduate students Brett Bethke (center) and Mario Valenti in demonstrating their "hands-off" technique of simultaneously controlling several fully autonomous UAVs using a PC.

At the Boeing Tech Expo at Hanscom Air Force Base last year, students on the team conducted more than 60 flights on demand with two UAVs. In the MIT Aerospace Controls Laboratory, the research team regularly conducts flights using three to five UAVs, which have achieved complex tasks such as persistent surveillance of a defined area.

Said John Vian, a Technical Fellow at Phantom Works who collaborates with the MIT team: "They have demonstrated quite successfully that UAV swarms can achieve high functional reliability by incorporating advanced health monitoring and adaptive control technology." Adaptive control addresses the fact that the parameters of the system being controlled are uncertain or vary slowly over time.

A fleet of UAVs could one day help the U.S. military and security agencies in difficult, often dangerous missions such as round-the-clock surveillance, search-and-rescue operations, sniper detection, convoy protection, and border patrol. The UAVs could also function as a mobile communication or sensor network, with each vehicle acting as a node in the network.

Such missions depend on "keeping vehicles in the air. The focus of this project is on persistence," said Jonathan How, an aeronautics and astronautics professor at MIT who leads the research team. Persistence requires self-sufficiency. "You don't want 40 people on the ground operating 10 vehicles. The ultimate goal is to avoid a flight operator altogether."

The test platform consists of five miniature "quadrotor" aircraft—helicopters with four blades instead of one—each a little smaller than a seagull. It also includes an indoor positioning system, as well as several miniature autonomous ground vehicles that the UAVs can track from the air.

Each UAV is networked with a PC, allowing a single operator to command the entire system and fly multiple UAVs simultaneously. No piloting skills are required, with software flying the vehicles from takeoff to landing.

The vehicles in MIT's test platform are inexpensive, off-the-shelf gadgets; they can be easily repaired or replaced with a new vehicle, just as might happen in a real-world scenario involving numerous small UAVs on a long-term mission. The researchers can thus experiment constantly without concern for mishaps with expensive equipment.

"In this project, the larger system is what does the useful thing; the vehicle becomes just a cog in the wheel," said Mario Valenti, a Ph.D. candidate in electrical engineering and computer science (EECS) who works on the project with Brett Bethke, a Ph.D. candidate in aeronautics and astronautics, and Daniel Dale, a candidate for a master's degree in EECS.

Valenti, Bethke, Dale, and colleagues operate the platform as often as possible, trying out different tasks, testing the system's response to sudden changes in mission (such as the appearance of new targets or the loss of a UAV) and coordinating with the autonomous ground vehicles. The laboratory provides a dynamic, real-time environment—a room with walls, furniture, equipment, and other obstacles. The researchers analyze the performance of the test platform over time, using the resulting information to maximize the control system's ability to anticipate and recover from system failures.

The team has also designed an automatic docking station that allows the UAVs to recharge their batteries when they are running low. When the aircraft finish "refueling," they can then return to assist in ongoing flight operations.

In addition, the team recently achieved a milestone in autonomous flight: landing on a moving surface. Using "monocular vision," one of the quadrotors successfully landed on a remote-controlled lab cart. A video camera fastened to the UAV uses a visual "target" to determine in real time the vehicle's distance relative to the landing platform. The ground station then uses this information to compute commands that allow the UAV to land on the moving platform. This technology could enable UAVs to land on ships at sea or on Humvees moving across terrain.

Georgia Institute of Technology is also part of the research team, with the work sponsored by Phantom Works in Seattle.

Jean L. Broge