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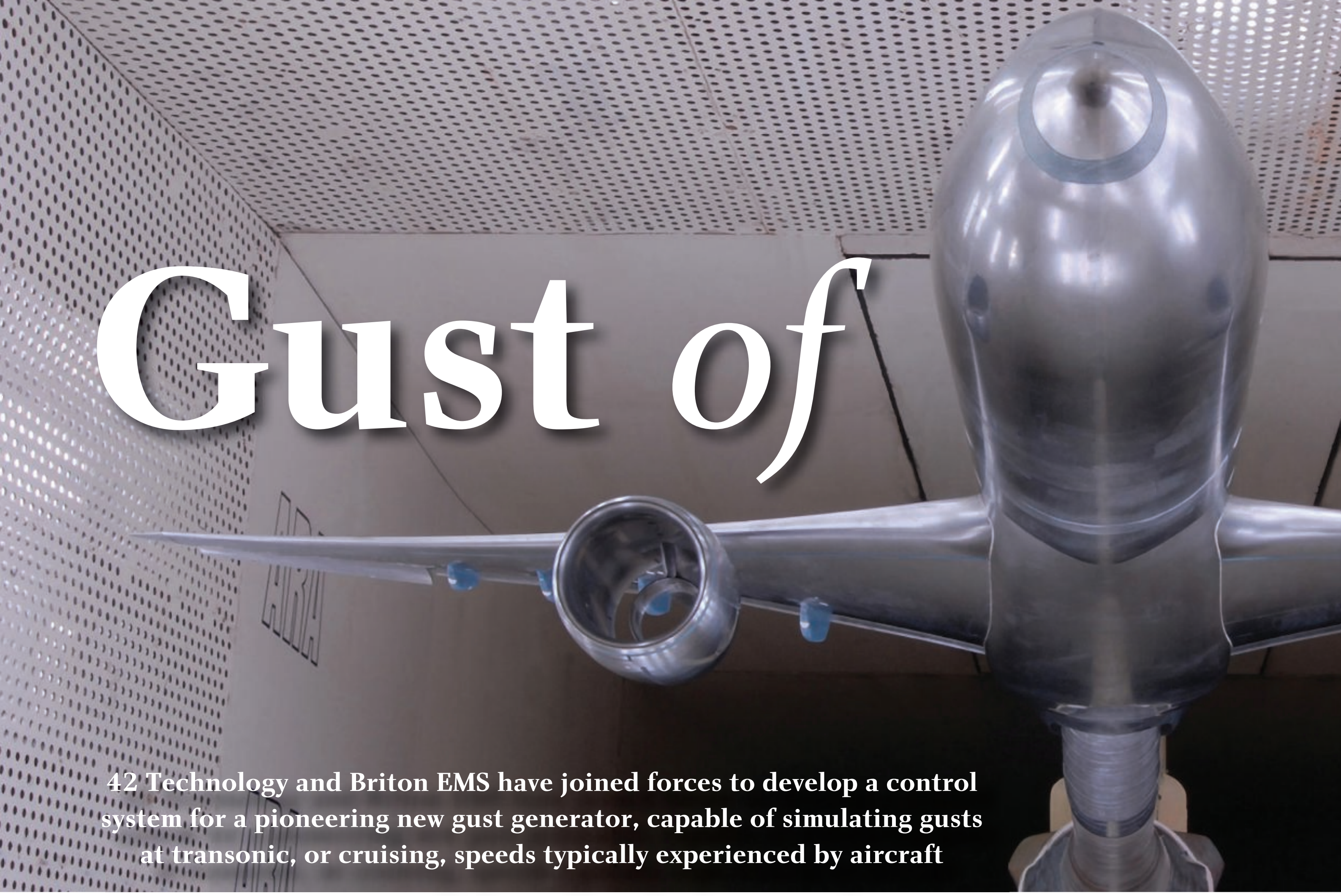


Gust *of*

42 Technology and Briton EMS have joined forces to develop a control system for a pioneering new gust generator, capable of simulating gusts at transonic, or cruising, speeds typically experienced by aircraft

High-speed wind tunnel testing presents several significant challenges in the simulation of an aircraft flying close to the speed of sound, and the accurate measurement of the forces, moments and pressures associated with that. For example, the resolution of small differences in drag of a few Newtons, vital for the reduction of fuel burn in the cruise, needs to be done while the model simultaneously experiences thousands of Newtons of lift force. Normally, the wind tunnel aims to have the most uniform, lowest turbulence flow possible, in order to make these measurements. However, as most passengers know, real flying is not always super smooth like the tunnel.

Now, though, 42 Technology and electronics manufacturer Briton EMS, along with other UK companies, have joined forces to help the Aircraft Research Association (ARA) develop and launch an innovative new research tool for use within its high-speed wind tunnel in Bedford. The two companies have developed a sophisticated control system for ARA's new gust generator, the first of its kind in the world capable of simulating gusts at transonic, or cruising, speeds that are typically experienced by aircraft.

A scale model of a wing coated in pressure-sensitive paint was used to test the operation of ARA's new gust generator during its installation

AIRCRAFT PERFORMANCE

The new generator will help drive new research into improving understanding of how turbulence affects aircraft performance and is part of an investment at ARA in new systems and services, funded to the order of £9 million by the Aerospace Technology Institute. The tool could help manufacturers to optimise their aircraft designs or to develop systems to compensate for gusts, leading to smoother flights and lower operating costs.

42 Technology and Briton EMS – who have frequently worked together for industrial and consumer electronics clients – teamed up with ARA's in-house engineering team to design, manufacture and install the control system for the new generator. 42 Technology designed the system to link the generator's control desk with a network of 1,800 solenoid valves, each of which needs to be opened and closed within 20 milliseconds to deliver the required gust profiles. The control system is housed in four two-metre high electronics cabinets and was completed from initial design to installation in less than two months.

change

A 1/30th scale model of an Airbus A350 fabricated in high grade steel and ready for a series of wind tunnel tests

Tolga Aydemir, 42 Technology

KEY OBJECTIVES

Tolga Aydemir, the electronics engineer at 42 Technology who was responsible for designing and developing the control electronics from idea creation through to design for manufacturing, describes the design process involved. "ARA had already defined the mechanical construction and proposed use of monostable solenoids to create the required gust profiles when they appointed 42 Technology and Briton EMS to help design and develop the control system," he explains. "The use of monostable valves is unusual for this application, because they offer fast turn-on times, but slower spring-returned closures. The project's three key objectives were: to develop a control system that could drive the solenoids as fast as possible, to provide the same shape of turn-on and turn-off signals, and to have the system manufactured and installed within two months."

ARA had already successfully developed a prototype control unit to switch 10 valves during proof-of-principle studies, but recognised the need for a more efficient approach. "Assuming each solenoid draws 200 mA at 24 V, then driving 1,800 of them could potentially cause significant thermal issues and a peak current demand of 350 A from a 24 V rail," points out Aydemir. "In addition, ARA planned to install the new control system within the basement of its transonic wind tunnel building, which could limit turn-on/turn-off times with cable lengths of around 25 metres between the solenoids and their driver electronics."

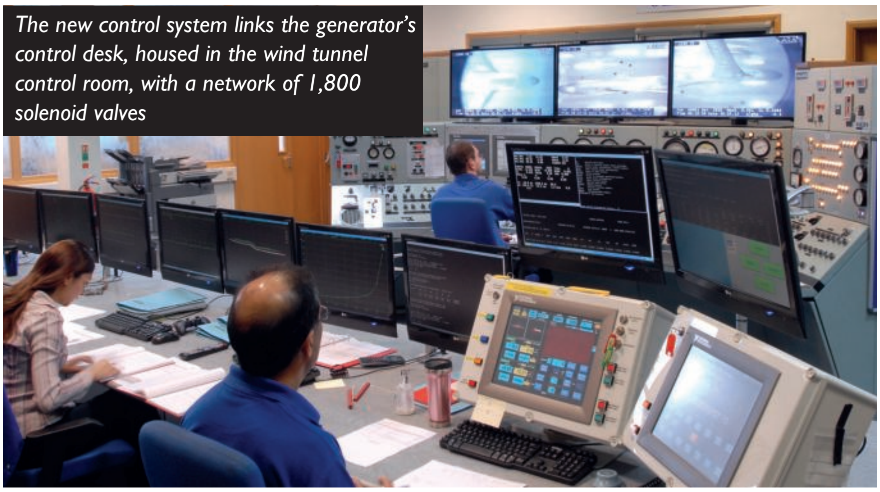
One of the principal challenges for 42 Technology was to find a faster and more controlled way to switch the solenoids. "The design team identified several options before recommending a pulsed switching topology, and then carried out detailed simulations to determine ideal pulse widths and voltages," he says. "As a result, the team was able to demonstrate optimised turn-on/turn-off times of one to two milliseconds, compared with ARA's previous levels of 10-15 ms. Reservoir capacitors were proposed as a practical way to deliver up to 72 kW of pulse power during a turn-on pulse and to avoid the need for expensive and large-scale power supplies, plus associated cabling."

DETAILED DESIGN GO-AHEAD

Within a month of being appointed, 42 Technology had produced a proof-of-principle demonstrator unit from off-the-shelf parts and components that allowed ARA to carry out further testing before giving the go-ahead for detailed design. At the same time, 42 Technology and Briton EMS started work on the PCB designs and layouts, and were looking for opportunities within the system design to speed up manufacturing, in order to meet ARA's challenging installation deadline.

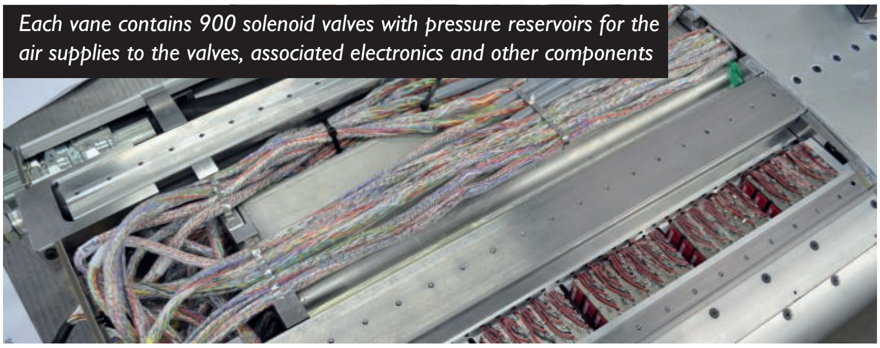
Kevin Williams, chief engineer at ARA, adds: "Briton EMS and 42 Technology were instrumental in helping to develop ARA's new gust generator and to meet the demanding delivery deadlines for this large-scale project. Their engineers worked well alongside our in-house team to recommend the ideal switching topology, to develop and integrate the control system, and to help us launch a world first for aerospace research."

As Peter Curtis, chief technical officer, ARA, points out, the company's new gust generator was principally developed to help organisations validate



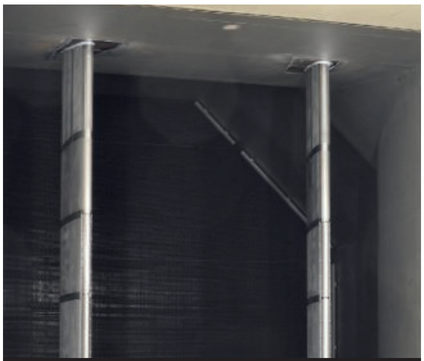
The new control system links the generator's control desk, housed in the wind tunnel control room, with a network of 1,800 solenoid valves

Kevin Williams, chief engineer, ARA



Each vane contains 900 solenoid valves with pressure reservoirs for the air supplies to the valves, associated electronics and other components

Peter Curtis, chief technical officer, ARA



The gust generator's two vanes each weigh around one tonne and are installed in the transonic/high speed wind tunnel

their computational models, although aircraft manufacturers and ARA's other clients are now showing considerable interest in using it to help with aircraft certification. "Aircraft need to be designed to withstand a vertical gust loading in transonic cruise, but designers typically need to make conservative assumptions: there is limited understanding on the size of gusts, how they affect an aeroplane and almost no tools available to validate through physical testing. Taking a conservative approach means, for example, that the wings are potentially stronger and heavier than they need to be, which impacts fuel efficiency."

So, what makes ARA's new gust generator special? Curtis points to three key elements: two removable vanes, located in the high speed/transonic wind tunnel (TWT), which use the physical amplification of trailing edge blowing to make fast changes to the tunnel flow direction; the large numbers of control valves that enable fine tuning of the gust shape; and the complex control system for all these valves.

"The shape of the gust is defined within the certification requirements, although the control system for the new gust generator provides the capability to alter the duration, magnitude and shape of the gust as required," he explains. "Each vane comprises a steel spar with an aluminium skin, weighs around 1 tonne, and contains 900 solenoid valves, pressure reservoirs for air supply to the valves, associated electronics and other components."

SINGLE MAJOR EVENTS

Moreover, the use of solenoid valves in this application is unusual. "Most rigs tend to work in low speed tunnels where oscillating vanes can be used to study the effects of turbulence," he adds. "The ARA gust generator is designed to work in a high-speed environment where the valves and associated control system are used to generate much shorter, high magnitude gusts; in other words, single major events typically lasting from 4 to 100 ms. The magnitude of gust is such that the angle of attack of the aircraft changes in the order of a couple of degrees. This might not sound much, but at high speed it can effectively double the lift generated by the wing for an up-gust, or reduce it to virtually zero for a down-gust, both of which are possible with this new rig."

To verify the gust rig's capability, ARA is using dynamic pressure sensitive paint (PSP) for the first time, alongside more traditional wind tunnel data acquisition systems. "Dynamic PSP, from US company Innovative Scientific Solutions, has a response time that is significantly faster than the expected pressure change and is 'visualised' using high-power illumination and sensitive cameras with high frame rates and fast exposures. The system can be used to acquire up to 10,000 samples per second," states Curtis.

ARA's in-house team of specialists, with help from selected external partners, took around 18 months to develop the gust rig from first concepts through to initial tests in the TWT. "Following the initial tests some detailed re-design has proved necessary to reduce air leakage in the system and make some other refinements. Further work is also needed to fully characterise the performance of the rig," he adds. ARA is on track to complete both the re-work and the performance assessment within the next six months.