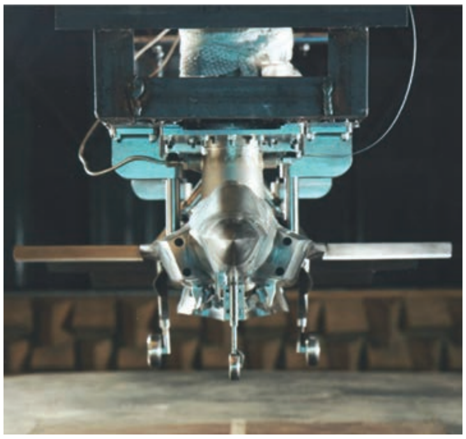
BELOW: In its VTOL mode, the F-35B generates a particularly harsh noise environment. BAE Systems' acoustic test work has examined the effects of this noise on the aircraft's structure, as well as its impact on the ground and ground crew operations



these goals. We can't add a heavy thermal acoustic package, so the ATF plays a vital role in helping us design an extraordinarily quiet and vibration-free interior without excessive weight."

...and lift

BAE Systems operates to a radically different set of test parameters aimed at proving customer-specified test points. Colin Lattimore, capability lead at the structural test facility, notes that the AFF is capable of operating at noise levels up to 175dB. Of course, the F-35 can generate very high levels of noise. "The vertical take-off and landing variant produces high acoustic fields, particularly at take-off and landing, and when the bays are open in flight. It is in this acoustically harsh configuration that the aircraft components are tested, to ensure their structural integrity during service," he says. Nevertheless, he adds, "The AFF is designed to replicate the acoustic loading on aircraft structures and does not provide any representative indication of the broader environmental impact of the noise generated by these air vehicles."

Lattimore explains that the last of the F-35 thermo-acoustic tests – including work on the nozzle bay door, wing bay, and horizontal tail – were completed more than four years ago. "The thermal acoustic testing is now complete, with the Brough facility being decommissioned. F-35 testing was undertaken on 1/15th scale models, simulating jet effluxes at full-scale temperatures and pressures in order to representatively simulate the near-field environment and facilitate predictions of the operational limitations of the aircraft with respect to ground crew operations and vessel superstructure.

"The principle purpose of subjecting aircraft structures to extreme acoustic loading is twofold," he says. "Firstly, testing provides the structures team with empirical data to validate the finite element models, enabling them to be enhanced, improved, or corrected, and to highlight mechanisms and/or locations of structure failure. The test facilities are also used to provide evidence of structural integrity, or functionality of structures or avionics."

Although the dedicated thermo-acoustic testing capability has been decommissioned, the progressive wave tube and reverberation chamber has been used on other programs. Over the past two years, this has included work in support of GE Aviation – Electrical Distribution Unit and Power Panel 3 acoustic tests – and Ultra Electronics – High Pressure Pure Air Generator 2200 Mk1 acoustic tests.

Form and function

Gulfstream's ATF falls under its acoustics and vibrations department, within which a dedicated

DNW case study

FAIST ANLAGENBAU GMBH HAS RECENTLY HELPED MODERNISE THE ACOUSTIC WIND TUNNEL FACILITIES OF DNW (THE FOUNDATION OF GERMAN WIND TUNNELS)

German sound proofing specialist Faist Anlagenbau recently received an order from the Foundation of German Dutch Wind Tunnels (DNW) to update its wind tunnel facility, currently being used to test scale models of aircraft and components such as landing gear and turbines for their aero-acoustic properties.

Based in Braunschweig, Germany, DNW recently converted its aerodynamic wind tunnel into an aero-acoustic wind tunnel, with the goal of reducing wind noises of components or complete aircraft. Per Schneider, sales engineer at Faist Anlagenbau, picks up the story: "One of our tasks was the fabrication and assembly of the more than 7m-high turning vanes at the four corners of the tunnel. They guide the airflow, which has a speed of up to 90m/s, in such a way that no turbulence and only low pressure losses arise and the noise level is effectively reduced."

The result of this design work, which was done in cooperation with experts for aerodynamics and acoustics at DNW and DLR, are individually designed aerodynamic and acoustically optimized profiles that precisely guide the airflow while absorbing the sound. This task is undertaken by turning vane silencers consisting of an external cladding made of perforated sheet metal and an internal absorber. The complete construction is held by an inner steel skeleton comparable to the inner construction of an airplane wing.

Accuracy and flexibility

The manufacturing of these elements was a challenge. Vlado Lazic, head of project management for acoustic measurement rooms and test cells at Faist, explains: "Angle of attack, height and cross-sections of a total of 27 turning vanes were individually defined. The turning vane contour had to be shaped in an aerodynamic way." Values calculated by a CFD program by DLR were applied to determine the perfect contour. These data sets were the basis for implementing the design planning. Complex details of the design were made by CAD and then imported into the CAM production system.

Faist produced various prototypes that were checked by the customer and then released for series production. The installation of the modules was at least as demanding as the manufacturing. Vlado Lazic notes, "The challenge was the fact that the floor only had a limited load capacity and the turning vanes could neither be fixed at the top nor to each other. So the force had to be equally distributed into the floor and the turning vanes had to guarantee a very high stability because wind loads of 13kN act on the individual turning vanes under operation."

Fan discharge silencer

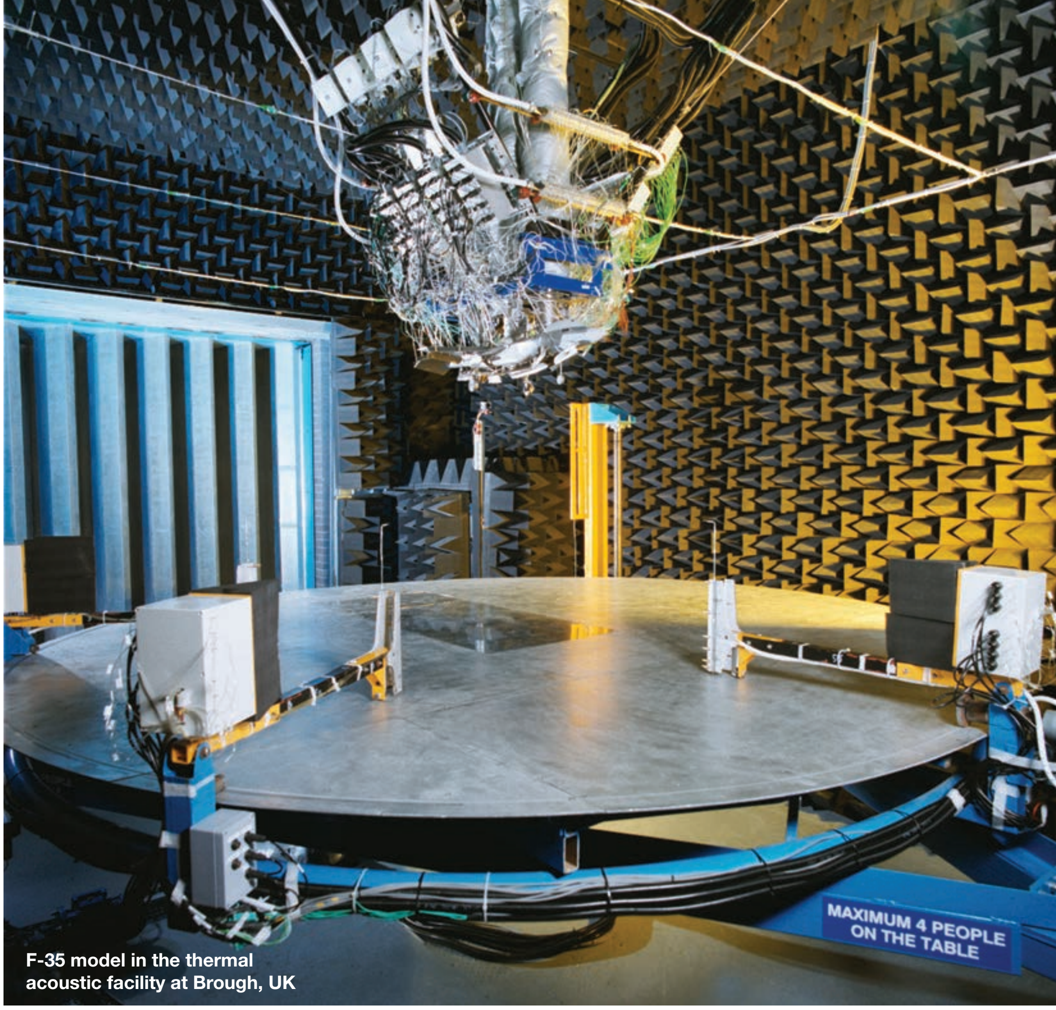
Together with the company TLT, Faist also manufactured a fan tailcone designed as a silencer downstream of the fan, the tailcone has a diameter of almost 5m. Per Schneider says, "Its task is to absorb the noise emission of the fan already at its source. This especially applies to low frequency ranges, which set specific demands on noise reduction. At the same time it is the task of the tailcone to act aerodynamically and to ensure the high efficiency of the fan. The flow-optimized contours create a significantly reduced pressure loss enabling a reduced energy consumption at the fan drive, and so positively influences the operating costs of the facility."

Dr Andreas Bergmann, head of DNW-NWB in Braunschweig, ATF lead test engineer is assisted by other engineers in the group depending on the size and scope of the testing underway. The facility has all the regular capabilities of a typical engineering grade installation, but testing for external noise is not significant. Maxon says, "Our facility can test absorbent materials that can be used to help reduce exterior noise, but we primarily focus our efforts on interior noise reduction.

"The ATF can also perform sound transmission loss, sound absorption, sound power level, and noise emission testing. In addition to this standard testing, we also use the facility as an engineering research and development laboratory. Mock-ups and prototypes can be quickly redesigned and tested to determine acoustic improvements prior to flight test," he says.

The ATF's work is all about ensuring and optimizing the customer experience, and very rarely has any impact on certification testing. Nevertheless, it is vitally important to Gulfstream's overall test effort and surprisingly varied in its focus, as Maxon is keen to point out: "We try to test every material and isolate every potential noise source that can make its way onto our aircraft and be transmitted into the cabin, from interior decorative coverings to exterior wing-to-body air vents," he says.

"If a component has the potential to make noise, we test it. We've tested operating air



F-35 model in the thermal acoustic facility at Brough, UK

comments, "In order to meet the noise requirements on future airplanes, it is necessary to be able also to detect noise sources of the lowest intensity which make up the total noise emission in their sum. At the moment this is only possible in the ultra-quiet wind tunnel DNW-NWB."

Sound absorption

The first wind tunnel has an acoustic performance with a sound pressure level of 55dB(A) at a maximum air flow of 717m³/s generated by a 2MW fan. At this wind tunnel, and also at others, especially in the plenum and the tunnel, the technology of the broadband compact absorbers (BCA) is applied. This technology reaches a sound absorption of as=0.99 acc.

This acoustic cladding consists of modules in a sandwich structure with a smooth surface that does not reveal its sound-absorbing function when you look at it. Its intelligence is hidden in the sandwich structure of the modules. Layers of open-cell absorption material are built in an acoustically transparent perforated sheet-metal basket. The layer next to the wall consists of a sheet-metal resonator fixed on an additional acoustic layer. These two components in combination build the compound panel absorber (CPA), a mass–spring system. The unique combination of the CPA for low frequencies and the open-cell absorber for medium and high frequencies is called the broadband compact absorber (BCA). The BCA provides sound absorption efficiency over a wide frequency range.

Depending on the calculated mode field of the unclad test room, which mainly depends on position and frequency of the noise source, the free field conditions, especially in the range of low excitation frequencies, are ensured by variable resonators and their selective positioning in the test room. These assessments guarantee free field conditions down to the required cut-off frequency.

BELOW: The fan tailcone (NWB Braunschweig)