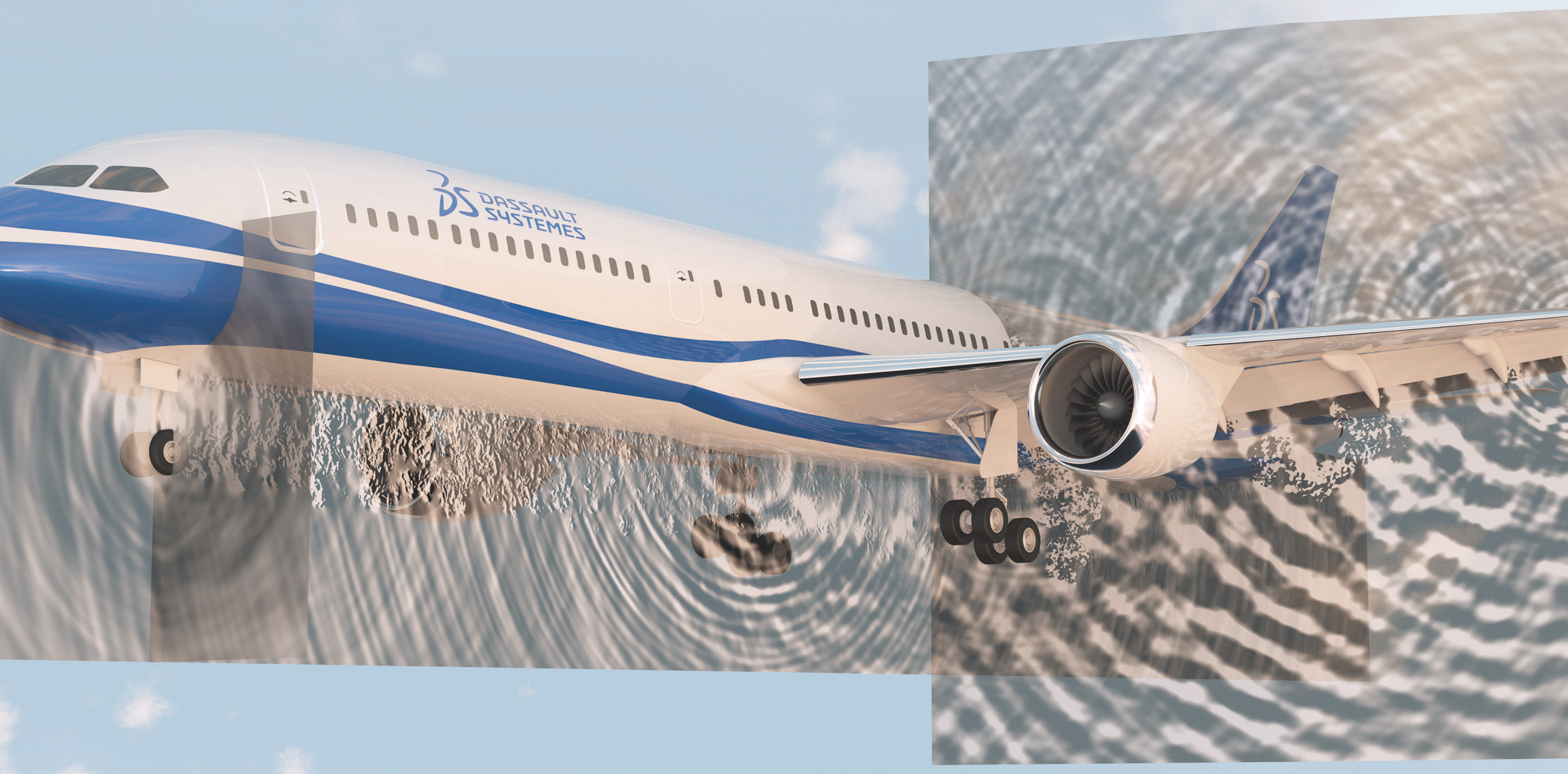
SIMULIA

3DEXPERIENCE

# QUIETER AIRCRAFT, LESS AIRPORT NOISE, BETTER COMMUNITY RELATIONS

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DASSAULT SYSTEMES

The roar of aircraft has become an unwanted part of daily life for the millions of people worldwide who live around airports. Protests against aircraft noise have seen flights restricted at many major airports, limiting the number of flights allowed, the hours of operation and the types of aircraft allowed. Quieter aircraft would therefore have a competitive edge at these airports, with operators potentially getting more slots or lower landing fees.

To win deals with airlines flying these kinds of restricted routes, aircraft designers need to focus on the experience of people on the ground as well as in the air. Simulation allows engineers to calculate noise levels around the aircraft without committing to mechanical prototypes and test flights. It can also exactly determine where the noise is coming from and compare different options for noise mitigation. Taking noise reduction into account earlier in the design process allows acoustic performance to be a key part of design rather than an afterthought.

## SOURCES OF NOISE

There are many noise sources on an aircraft. The fans and jets of the engines may be the most obvious, but turbulent air flow around structures such as the landing gear and the high lift devices can also contribute significantly to the acoustic profile of the aircraft. Components cannot be considered in isolation—the interaction of multiple components can affect the airflow and significantly change the noise spectrum at system level, and there may be trade-offs between aerodynamic and aeroacoustic performance.

There are two types of noise: tonal and broadband. Tonal noise is centered at a particular frequency and can often be connected to a resonance on the aircraft such as a whistling cavity, while broadband noise covers a wider portion of the spectrum. Both types need to be reduced, but bringing down broadband noise tends to be more challenging.

## VIRTUAL AIRCRAFT NOISE SOURCES ASSESSMENT

In physical tests, beamforming is used to measure the noise produced by the aircraft and to map it to different parts of the structure. Simulation can accurately replicate these beamforming maps on a virtual aircraft long before a physical prototype is available for flight tests, but in addition, it can also isolate different noise sources that would not be visible in measurements. At some frequencies, engine noise dominates the flight test data, swamping other noise sources. Simulation can remove the engine noise, revealing the contribution from the other components such as the sides of the flaps in Figure 1.

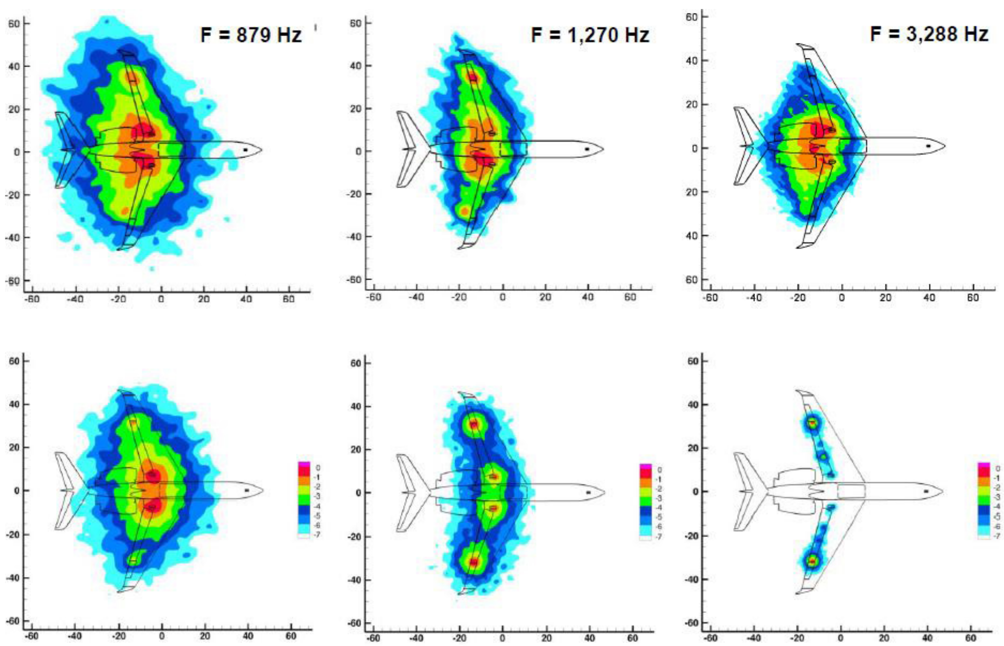


Figure 1: Beamforming maps. Top: Measured noise from a flight test. Bottom: Simulated noise, without the engine contribution. [1]

## DESIGN FOR REDUCED NOISE

Once noise sources have been identified, engineers can then set to work reducing them. This is a multi-disciplinary design optimization, with trade-offs between aeroacoustics and other KPIs such as aerodynamics, weight and structural strength. Simulation is key to allowing these trade-offs to be made earlier in the design process, which both reduces costs and allows more avenues of inquiry to be explored for better final performance.

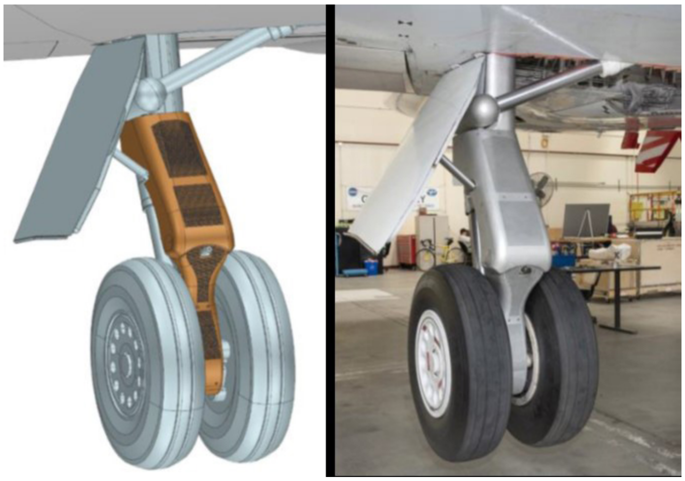

Figure 2: Simulation model and physical prototype of a noise mitigation concept main landing gear for a business jet. With this design the engineers were able to achieve the targeted 3 dB reduction [1]

## MEET CERTIFICATION AND AIRPORT TARGETS

Both certification requirements (ICAO Chapter 14) as well as aircraft noise restrictions for airports in densely populated areas such as the Quota Count system are becoming more and more stringent. Incorporating noise targets into the early design can help to reduce risk and safety margins, and thereby reduce development cost and avoid delays during flight testing and certification. Guaranteed noise levels for new aircraft will be required for airlines to maintain routes into many busy airports.

## IMPROVE PRODUCT QUALITY

The environmental impact of aircraft is an increasingly important differentiator in the aviation market. Aircraft noise is linked to community annoyance and sleep disruption, with adverse impacts on health and learning.[2] Designed for low community noise, new aircraft increase acceptance by local communities and offer more flexibility for the customer.

## THE SIMULIA SOLUTION

SIMULIA offers a holistic solution to aircraft noise reduction, with all aspects of the engineering data – from the certification requirements to the CAD models—managed on the **3D**EXPERIENCE® platform.

The first step is to prepare the geometry, assembling the components and setting moveable parts such as landing gear and control surfaces for operating conditions. Because very small geometry details can affect an aircraft's noise profile, the highest geometrical fidelity is required in combination with high simulation accuracy in order to capture all of the noise sources. SIMULIA PowerCASE includes templates that can set up the simulation to mimic certification methodology based on targets.

Following high-lift and airframe acoustics simulation strategies, SIMULIA PowerFLOW then calculates the airflow and resulting noise around the aircraft model. PowerFLOW is a computational fluid dynamics (CFD) tool using the Lattice Boltzmann Method to perform simulations that accurately predict real world conditions. As part of SIMULIA fluids solutions, the PowerFLOW suite offers validated application solutions and best practice methodologies for aerodynamics, aeroacoustics and thermal management, allowing groups working on these different but related fields to collaborate.

Postprocessing allows far-field noise analysis and Effective Perceived Noise Level (EPNL) calculation, and produces beamforming maps that help users quickly identify and localize noise sources. After checking the KPIs and noise targets, engineers then have the choice to develop mitigation concepts if needed and modify the geometry. Thanks to the **3D**EXPERIENCE platform collaborative tools, other groups in the design team also receive the updated model, breaking the silos around the different groups and accelerating design loops to weeks instead of months or years.

If the virtual aircraft passes the certification requirements and other noise targets, physical testing can then begin. The simulation results support measurements and can reduce the number of flight tests required. In addition, the simulation results will inform and optimize operational procedures in realistic scenarios. The end result of this process is a quieter aircraft design that meets certification requirements.

## CUSTOMER CASE: NASA

The NASA Integrated Aviation Systems Program (IASP) conducts flight-oriented, system-level research and technology development to effectively mature and transition advanced aeronautic technologies into future air vehicles and operational systems. The program used SIMULIA PowerFLOW to analyze aircraft noise on a business jet and to develop mitigation techniques.

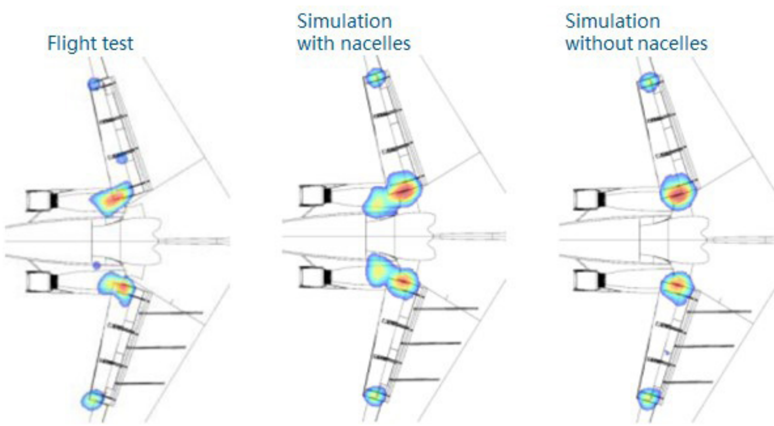


Figure 3: Beamforming maps, measured and simulated, showing the effect of the nacelles on noise [1]

By comparing the results of simulations with and without different components such as nacelles, the engineers were able to isolate the contributions of each part of the system at significantly lower cost than physical testing. The results of these simulations were then used to inform the design of aircraft subsystems such as the landing gear and the flaps (Figure 3).

Both for the baseline and the landing gear with noise reduction concept showed good correlation of simulation results to flight test data (Figure 4). The redesigned landing gear successfully achieved a targeted 3 dB reduction in noise over a wide frequency band.

With the SIMULIA aircraft community noise solution, NASA IASP was able to successfully validate simulation against measurements, assess the performance of noise reduction concepts, and meet noise reduction targets.[1]

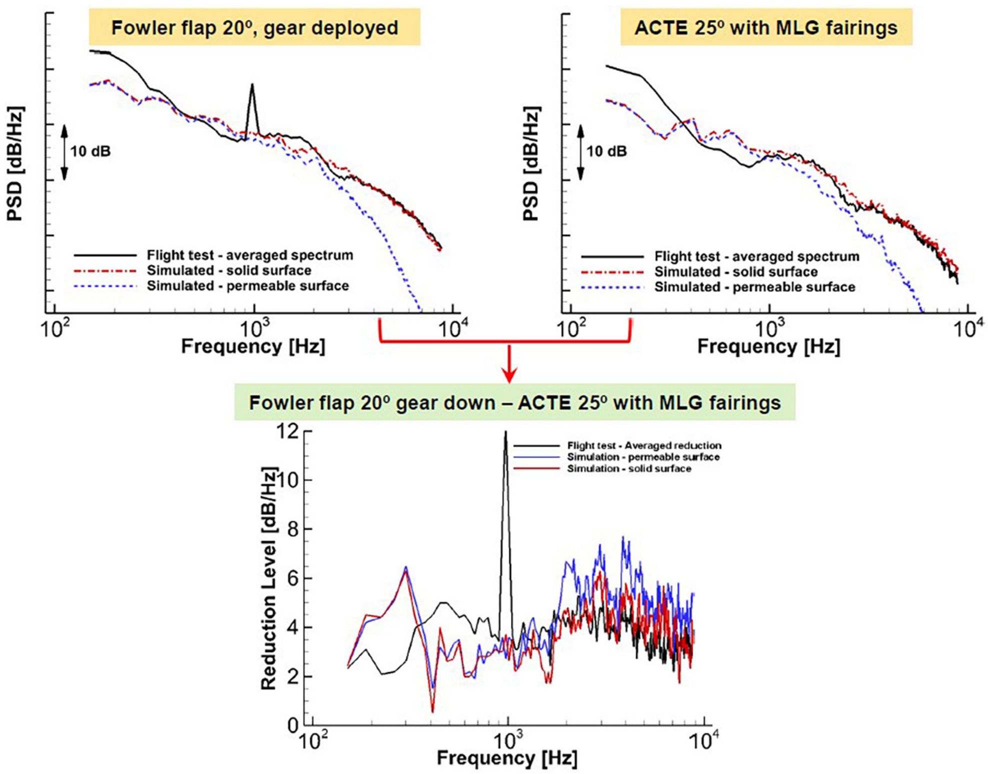


Figure 4: Far field noise spectra for the baseline and the landing gear, comparing measured data to two different simulation scenarios (solid and permeable surface) [1]

## SUMMARY

Aviation industry growth is resulting in increased aircraft noise near airports, and these communities are reacting by imposing increasingly strict noise level constraints. Quieter aircrafts will be preferred at many airports, with more slots and smaller landing fees. As a result, aircraft noise needs to be taken into account from the earliest stages of aircraft design, and engineers must assess its impact on real communities.

Working with a virtual aircraft allows digital design and analysis loops within weeks for fraction of the labour and hardware cost instead of months or even years of lead time for wind tunnel and flight tests. Thanks to the **3D**EXPERIENCE platform and SIMULIA fluids solutions, noise targets and performance can be calculated on digital level, years before physical prototypes become available, so certification requirements can be met early in design phase to reduce risk during flight-testing.

Simulation users also gain deeper insights into noise generation mechanisms and develop noise reduction concepts. Informed by the virtual model, customers have managed to reduce community noise (EPNL) by 3 dB (equivalent to halving the rating on the Quota Count scale) through noise reduction concepts and integrated system design. SIMULIA's aircraft community noise solution helps aircraft designers meet certification requirements and airport community noise targets, giving them a competitive edge in the always competitive aviation market.

## REFERENCES

[1] M. Khorrami, P. Ravetta, D. Lockard, B. Duda, R. Ferris, "Comparison of Measured and Simulated Acoustic Signatures for a Full-Scale Aircraft with and without Airframe Noise Abatement", AIAA 2018-2975

[2] M. Basner, C. Clark, A. Hansell, J. I. Hileman, S. Janssen, K. Shepherd, V. Sparrow, "Aviation Noise Impacts: State of the Science", Noise Health. 2017 Mar-Apr; 19(87): 41–50.

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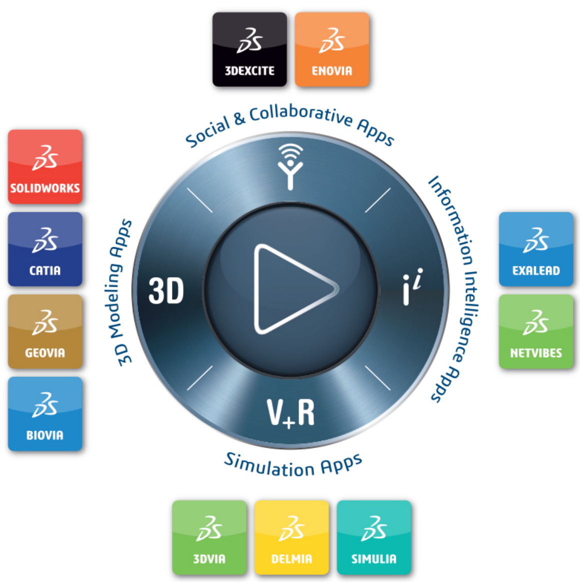


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