DIGITAL INDUSTRIES SOFTWARE

Acoustic qualification testing for space hardware

Solution brief

The noise levels generated at launch can reach 146 decibels (dB) or higher inside the fairing and cause structural damage and jeopardize the functionality of instruments and subsystems. For example, large surfaces, lightweight components and their supporting structures are especially sensitive to the acoustic pressure waves directly impinging on them. The sources of these acoustic waves that appear under the payload fairing are rocket engine combustion noise at liftoff and unsteady aerodynamic phenomena during atmospheric flight.

The spacecraft should be capable of withstanding the maximum expected launch vehicle ground and flight environments, and this is verified by running physical tests. Simcenter™ Testlab™ software, which is part of the Xcelerator portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software, provides a full suite of dynamic environmental tools for testing space hardware, consolidating years of expertise and end-user feedback from leading companies in the space industry. Vibration control modes such as sine, random and shock are offered together with acoustic control modes in an advantageous tokens licensing package, which enables of the user to sequentially execute the physical tests with a cost-efficient investment.

Challenges

- Accurately reproduce acoustic launch environments
- Ensure space hardware integrity during qualification tests
- Avoid missing strict launch window deadline
- Reduce spacecraft testing risks

Solutions

- Use Simcenter Testlab Acoustic Control for RFAN
- Use Simcenter Testlab Multiple-Input Multiple-Output Random Control for DFAN
- Leverage wide range of built-in safety checks
- Provide advanced processing capabilities

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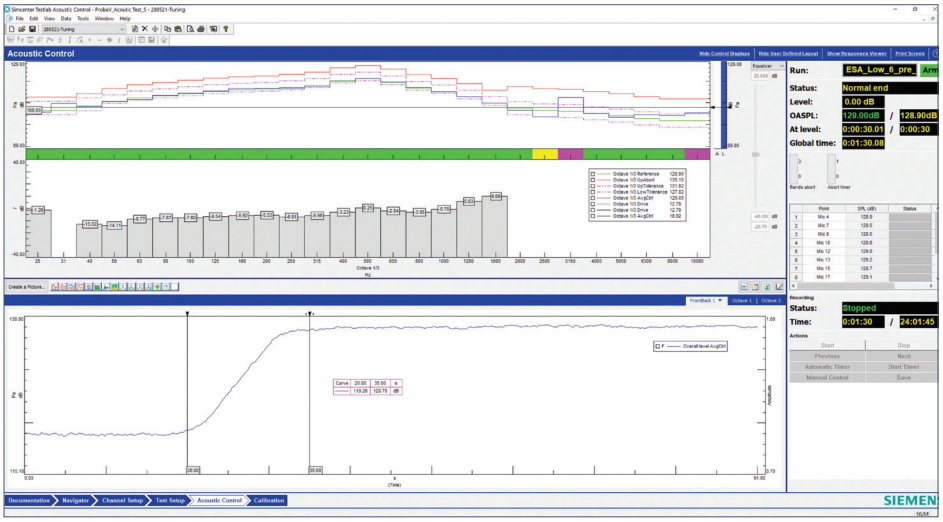
Solution focus

Results

- Achieve high level of spacecraft protection
- Increase testing efficiency
- Rapidly deliver the right answers to the engineering team



Environmental acoustic testing

At the system level of assembly, most spacecraft are required to be acoustically tested. Acoustic testing at lower levels is typically reserved for large, low-surface-density components and subsystems, such as solar arrays, antennas and reflectors. Acoustic loads can cause paint flaking, debonding and cracking of built-up structures, and electronic failures in equipment mounted on honeycomb panels. Using Simcenter Testlab software solutions provide state-of-the-art test methods to replicate such loads, either using a reverberant acoustic field or loudspeakers in ordinary (acoustic) rooms to mimic the loads – a technique known as direct field acoustic noise (DFAN).

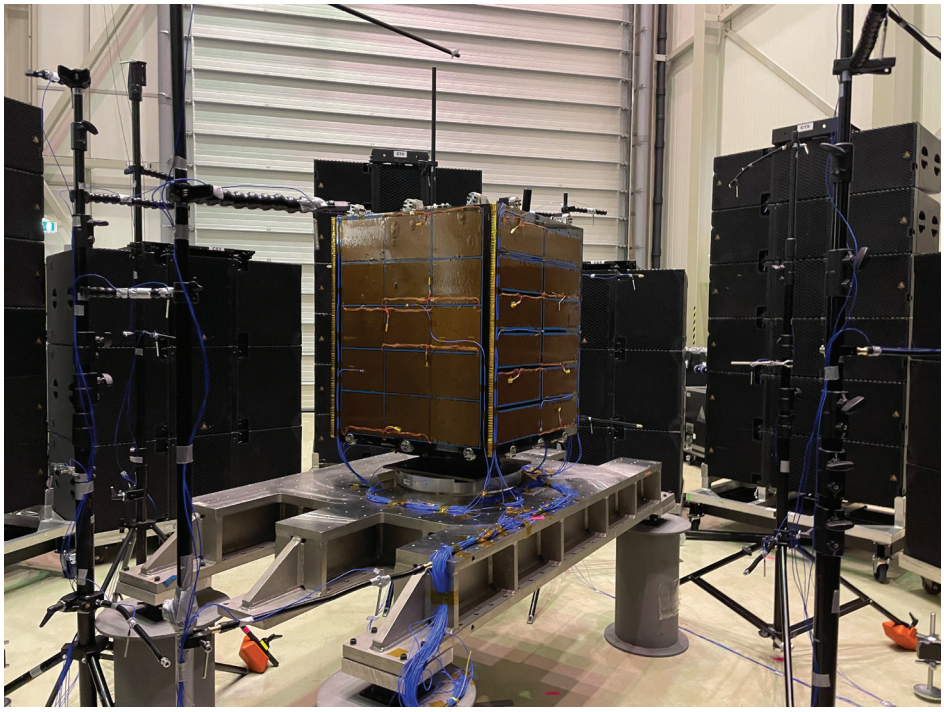
Reverberant field acoustic noise testing

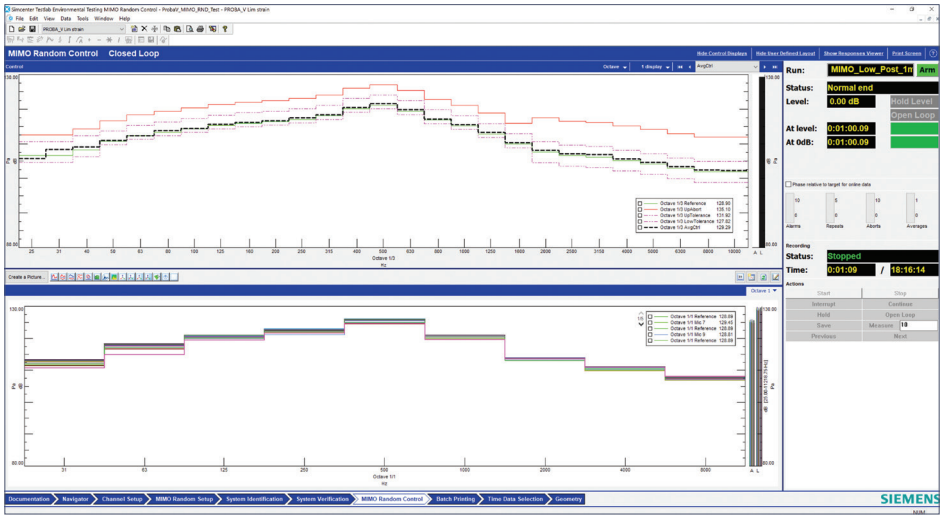
Simcenter Testlab Acoustic Control is a closed-loop control solution for operating reverberant rooms. It implements a robust proportional integral control algorithm based on parameters that can be measured with standard microphones during setup (and are adapted to the room's acoustic properties). The automatic control provides spatial uniformity of sound pressure level in one-third or full octave bands within tight tolerances and an extra check on overall sound-pressure-level responses.

Simcenter Testlab Acoustic Control enables you to integrate three layers of safety checks to avoid over testing: at individual microphones, overall sound pressure levels and structural responses of the test specimen since the user can define power spectral density abort profiles for the vibration acquisition channels. This solution has been designed to provide lab engineers and technicians with a comfortable system to carry out the delicate job of qualifying the satellite for acoustic loading. Dedicated features, such defining the reference profile in an Excel spreadsheet

software editable table format, a check-box to select which microphone should be included in the loop for measurement or setting any abort parameters on both acoustic or vibration channels, enable smoother workflows for the users.

The control system can work using multiple signals to feed the different types of power amplifiers of the acoustic sources. Simply setting the bandwidth of each signal and the desired crest factor value enables the user to safely develop the environmental test. In a standard application of Simcenter Testlab Acoustic Control, the user leaves the task of defining and updating the amplitude of the drive signal to the closed-loop controller. This is the Simcenter Testlab Automatic Control mode. However, several reasons may motivate the test engineer to take manual control before stepping into the next level of a test schedule. For example, the test engineer could be interested in manually slowly raising the level. In addition, he/she may want to reduce the excitation at a certain band; for instance, if unexpected structural responses are being monitored. Such manual control can be done with the mouse directly on the sliders, or with the keyboard arrow keys to have even finer control of the voltage level sent to the power amplifiers of the acoustic sources.





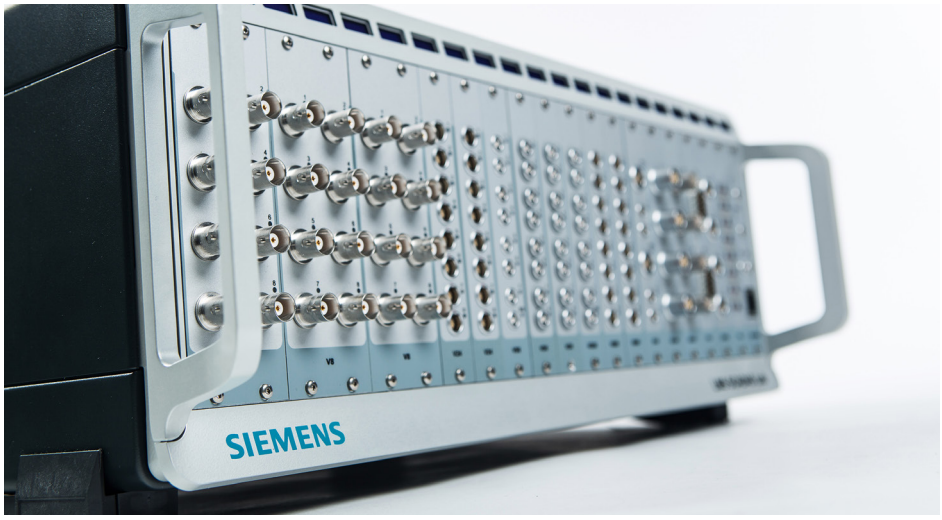
Direct field acoustic noise testing

Simcenter Testlab Multiple-Input Multiple-Output (MIMO) Random Control for direct field acoustic tests is a narrow-band, closed-loop control solution. Since this technology does not require a dedicated facility, tests can be conducted at the spacecraft or component designer's integration facility. This reduces the handling risk during transportation, as well as the potential risk of program cost and schedule overruns. A dedicated graphic user interface (GUI) enables a smooth definition of the acoustical test specifications and tolerances in one-third or full octave bands. Furthermore, innovative pretest analysis assists the user in defining the optimal narrow-band control parameters so optimal online MIMO control delivers a safe, time- and energy-efficient workflow for the environmental acoustic test. The narrow-band operation enables line-by-line abort checking for each control or measurement channel. Background noise measurements serve as a basis for an open-loop threshold check. Responses and notching predictions for control and measurement acoustic and vibration channels are also supported, as well as overload predictions for the multiple signals driving the loudspeakers and singular values analysis for system conditioning checks.

Simcenter pretest analysis

Pretest analysis has been implemented to overcome the technical challenges in multi-channel acoustic control. The novelty of Simcenter analysis lies in applying algorithms that enable automatic data-driven design of key control

parameters. The intent is to keep the sound pressure level inputs within tolerance, thus preserving a safe testing procedure. Furthermore, it aims to reduce the time spent between design and execution of the test, avoiding trial-and-error approaches in defining the control strategy. Simcenter Testlab MIMO Random Control features include a dedicated acoustic mode to input the specified sound pressure level profile, acceleration- and strain-based limiting, advanced test schedule settings, time history recording and reporting capabilities in two clicks.



DFAN as a service

The Simcenter Engineering and Consulting services team at Siemens Digital Industries Software has developed a DFAN as a service capability. Incorporating both test and simulation, the Simcenter Engineering and Consulting services team can provide and manage DFAN testing as a service capability. Space agencies and key industrial partners are engaging to create the necessary guidelines for the safe and correct execution of DFAN tests. The European Space Agency (ESA) and other technology companies, such as Siemens AG, are working together on an ESA DFAN handbook on the topic. Siemens' state-of-the-art technologies for environmental acoustic testing, which focuses on DFAN testing, has proven to be reliable.

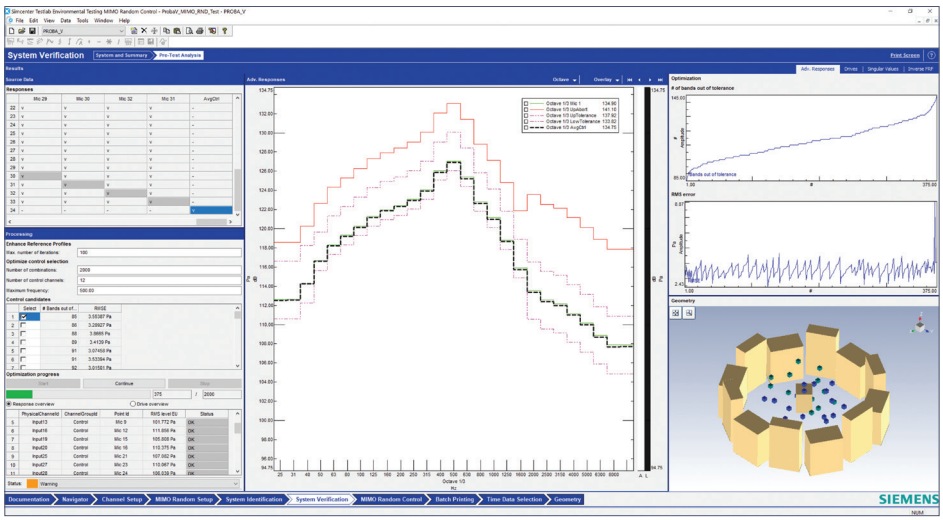
Integrating with the Simcenter data acquisition product family

All Simcenter Testlab solutions for dynamic environmental testing fully support NASA, ESA and international spacecraft testing standards and are compliant with American National Standards Institute (ANSI) standards for the octave-filtering acquisition process.

For traceability and reporting purposes, Simcenter Testlab offers throughput recording for all controlled/measured channels and extensive data documentation capabilities.

Simcenter Testlab solutions for dynamic environmental testing can be easily and seamlessly integrated with Simcenter SCADAS™ hardware, providing the most flexible and robust lab layout configurations for measuring, recording, processing and storing signals from hundreds of sensors (accelerometers, strain gauges, force sensors, etc.) attached to the satellite.

Whether you are looking for a qualification testing solution using the trusted traditional methods, or are moving forward with a more versatile and innovative technique such as DFAN, our leading position in mechanical qualification testing and drive for innovation means we can offer you efficient and reliable solutions and services that far exceed expectations.



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