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Siemens Digital Industries Software

Simcenter testing solutions for aviation engineering

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Delivering solutions
that add value

While safety remains the key priority, market demands – such as better fuel economy, increased comfort, reduced emissions and noise levels and lower operating costs – are forcing the aircraft industry to rethink traditional engineering methods. Successful programs must deal with new materials, technologies and more complexity while staying within budget and on schedule.

Siemens Digital Industries Software provides dedicated simulation, engineering and testing solutions to help integrators and suppliers efficiently achieve earlier aircraft maturity. These solutions are built on a solid understanding of, and experience with the aviation supply chain and the requirements of all engineering stakeholders.

Siemens Digital Industries Software allows you to maximize testing productivity and efficiency on all levels.

Simcenter™ testing solutions for noise and vibration engineering offer added value throughout the development process, from design verification to acceptance and certification. They provide in-depth engineering insight and help you increase the productivity of your testing campaigns with traceable, efficient, smart and actionable data.

Simcenter testing solutions transform test data into engineering conclusions. Sharing those conclusions is easy thanks to the integration with system simulation.

Simcenter Testlab

Powering testing productivity

Simcenter™ Testlab™ software offers you an integrated, scalable single platform suite for structural dynamics, noise and vibration testing that combines high-speed, multi-channel data acquisition with a full suite of integrated testing, analysis and report-generation tools. Designed to improve testing efficiency and convenience, Simcenter Testlab sets new standards for ease-of-use, productivity and data consistency.

Going straight to the source of noise and vibration issues

With its unique workflow-based interface, Simcenter Testlab naturally follows the test campaign process, guiding the user through the steps and suggesting optimal settings for measurement and analysis parameters. That means no more trial-and-error troubleshooting; the platform leads you directly to the source of the problem using comprehensive, integrated analysis capabilities and the

Simcenter source-transmitter-receiver methodology. Simcenter Testlab enables you to trace a problem's fundamental cause and solve it effectively, cost-efficiently and quickly.

Simcenter Testlab is the perfect solution to obtain deep engineering insight. It transforms test data into solid engineering conclusions. Sharing those conclusions with your engineering team is easy thanks to seamless

integration with Siemens Digital Industries Software's simulation software solutions and other system simulation packages. Simcenter Testlab further provides physical testing support to calibrate models to fidelity levels that make model-based systems engineering a reality.

Built-in productivity

Simcenter Testlab is tightly integrated with Simcenter™ SCADAS™ hardware for data acquisition. With a single hardware and software platform, you can cover all laboratory and in-field tests as well as recorder-based testing jobs. Embedded analysis during data acquisition speeds up the testing process and compiles the right data from the start.

Simcenter Testlab permits on-the-spot test result validation and traces the root cause of a problem, ensuring that testing time is used in the most productive manner possible.

In addition, a Windows automation interface and direct support for a wide range of industry-standard data formats enable the effortless integration and implementation of proprietary legacy test and analysis methods, as well as the International Standards Organization's (ISO) certified and self-developed methodologies.

Simcenter Testlab at a glance

- Integrated suite of testing, analysis, reporting and data management software for structural dynamics, acoustics, rotating machinery and dynamic environmental testing
- Maximum scalability and optimal investment protection with future-ready technology and techniques
- Supports proprietary legacy methods
- Traceable and transparent data
- Provides standard qualification testing, advanced troubleshooting and deep engineering insights in a single solution

Simcenter SCADAS

Taking efficiency to a higher level

Simcenter SCADAS data acquisition hardware is your key to reliable results and optimal testing productivity. Seamlessly integrated with the Simcenter Testlab suite, this hardware family provides accelerated measurement setup and correctly formatted results. In short, Simcenter SCADAS allows you to take your mind off the deadline and focus on the test.

Compact, scalable and modular

Our Simcenter SCADAS systems are all-in-one multitaskers. Powerful, versatile and flexible, these hardware solutions ensure reliable results and optimal testing productivity. With a pocket-sized portable system, compact mobile units, autonomous smart recorders and high-channel count laboratory systems, the range encompasses solutions for nearly any test campaign imaginable, both in-flight and lab-based. From day-to-day testing to specialty work, just hook up the systems that best suit your needs and get started.

Versatile and powerful

Simcenter SCADAS can handle all types of applications. It features integrated signal conditioning for a variety of transducers, such as microphones, accelerometers and strain gauges that allow you to capture a broad range of sensors in a single test run. The systems cover a broad frequency range – from lowfrequency structural dynamic tests up to 96 kilohertz (kHz). High-precision data is guarateed, thanks to best-in-class noise floor, harmonic distortion and interchannel specifications.

An Simcenter SCADAS system offers much more than supreme data quality. It offers built-in process understanding.

Simcenter SCADAS increases your testing efficiency by enabling you to skip traditional steps such as auto-ranging. Simplified test setups don't just save time; they eliminate risks as well. The data is delivered in the purest state possible: low noise, no unnecessary conversion and, best of all, minimal human error.

Safe investment
As a commercial, off-the-shelf platform, Simcenter SCADAS is a safe investment featuring years of proven technology. As the Swiss Army knife of noise and vibration testing, it can be used for multiple purposes and in diverse settings. The hardware is designed for sustainability and is fully compatible with present and future modules.

Simcenter SCADAS at a glance
- Scalable solutions: a pocket-sized portable system, compact mobile units, autonomous smart recorders and high-channel count laboratory systems
- Integrated signal conditioning and support of a variety of transducers
- Mix-and-match all types of Simcenter SCADAS products, and connect Simcenter SCADAS Mobile hardware directly to your Simcenter SCADAS Lab
- Built-in process insight
- Optimal support

Structural dynamics

Providing profound insight into structural dynamics behavior

Understanding the structural dynamics behavior of all systems and subsystems is key in aircraft design validation and certification. With modal testing and analysis, the dynamic properties of a structure consisting of resonant frequencies, damping and mode shapes are identified. Besides providing a better understanding and handling of vibration problems, modal testing and analysis permit you to monitor system evolution and validate or update dynamic models used in further analysis. It is a key enabler in getting new aircraft models to market faster.

Siemens Digital Industries Software has a 30-year track record in structural dynamics testing. Its Simcenter solutions offer an integrated approach to test preparation, modal testing, modal analysis, numerical model correlation, model updating and model use. Our broad experience, from impact testing on small structures to large-scale campaigns using hundreds of measurement channels, puts a tradition of cutting-edge expertise at your fingertips as you maximize testing efficiency.

Modal analysis made easy

Structural dynamics testing used to be a lengthy, complex process involving extensive trial-and-error and time-consuming test setups. With Simcenter Testlab Structures software and Simcenter SCADAS, you can perform large-scale modal surveys in hours rather than days.

Your testing department can fully protect its system investment as Simcenter Testlab can easily be expanded and tailored to your changing needs. Simcenter Testlab Structures offers a unique range of testing and analysis techniques. Starting with impact testing, you can extend the solution with modal analysis, multiple input and multiple output (MIMO) testing or operational modal analysis capabilities. You can focus on identifying root causes of vibration problems and apply powerful analysis tools to explore the best solution for practically every structural weakness.

Advanced analysis tools incorporate time- and frequency domain-based modal analysis and curve fitting techniques, including the Simcenter Testlab Polymax modal parameter identification software. You can run operational deflection shapes or modal analysis in parallel with data acquisition. Preliminary modal results help you validate data quality and gain valuable insight on the spot. Mode animation immediately reveals missing measurements or incorrect calibration values, while preliminary mode shapes can show you where additional measurement points or different excitation sites are required.
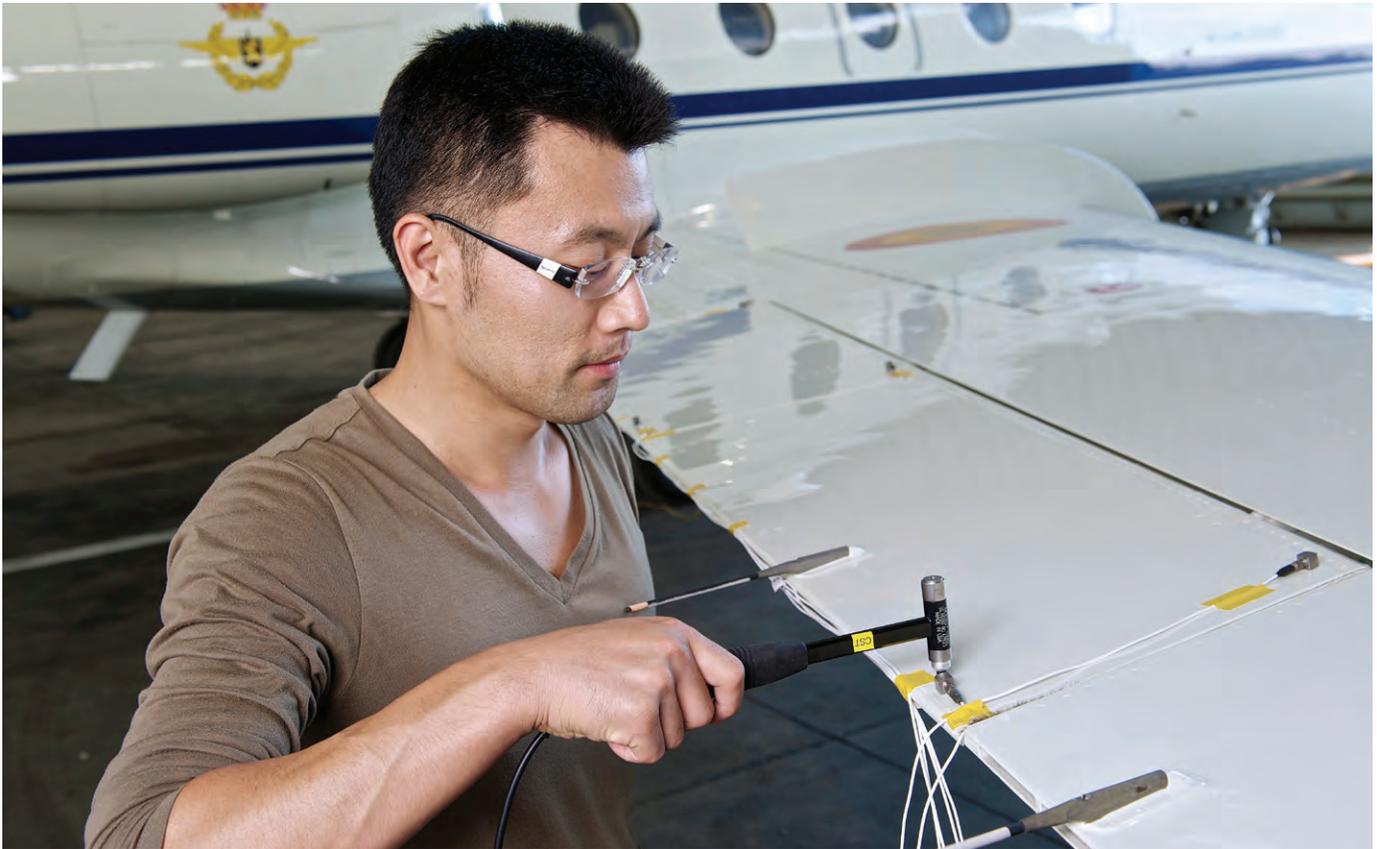
No compromises for the expert

Process efficiency and maintainability are at the heart of Simcenter solutions. In addition to standard tools combining advanced technology with an easy-to-operate environment, the system can incorporate your own tools and methods.

Fast assessment of control surface structural dynamics using Simcenter Testlab Polymax parameter identification software.
Image courtesy of Belgian Defense.

Validating structural dynamics and aero elastic stability

Siemens Digital Industries Software provides a full set of solutions for ground vibration, wind tunnel and flight tests that enable you to study the risk of flutter, validate the aircraft's flight envelope and prove compliance with aero elastic stability requirements.

Accelerating ground vibration testing
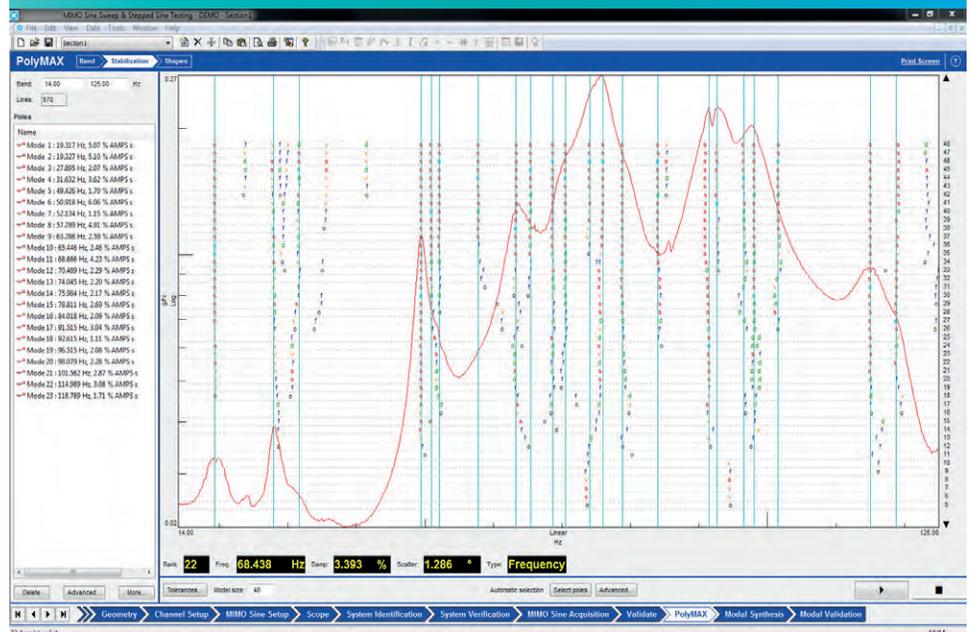
The Simcenter Ground Vibration Testing solution and its corresponding engineering services cover the process from pretest structural dynamics simulation, to ground vibration testing, to the use of GVT results for calculating structural dynamics models for flight flutter testing. Our unique approach of combining testing and simulation helps you accelerate and optimize the complete ground vibration testing (GVT) cycle.

Simcenter Ground Vibration Testing includes test instrumentation management, modal analysis technology, integrated data management, online validation and efficient reporting tools. Using embedded and proven GVT technologies enables you to quantify the level of confidence you can have in data that has been obtained through modal validation and nonlinear behavior assessment of the structure. You can also increase the test

observation by using multiple excitation techniques. The tight integration between Simcenter SCADAS and Simcenter Testlab helps you minimize the time required for test setup and execute testing faster.

With a pretest virtual GVT, you can optimize the instrumentation plan and the aircraft suspension. Consequently, you can reduce the risk of missing critical modes during the physical test. Simulation results can be used for online correlation during the physical test resulting in shorter test cycles.

### Mitigating the risk of flutter

Siemens Digital Industries Software provides a dedicated flutter solution with fully automated, cyclic modal parameter extraction and mode tracking for successive test conditions. Analyzing modal parameters in near real time enables you to speed up your process, while raw time data is stored for posttest reanalysis. By monitoring the evolution of frequency and damping values for critical modes, you can make sure there is no risk of flutter.

The Simcenter Testlab Polymax method introduces clear stabilization diagrams for an unambiguous and fully automatic interpretation of modal parameters. Automatically generated reports provide you with representative flutter plots and modal parameters plotted against preset test conditions.

To validate data efficiently and effectively offline, Simcenter Testlab Modal Analysis offers you a package with all the required functionality, such as data preprocessing, modal parameter estimation, mode shape animation and result validation.
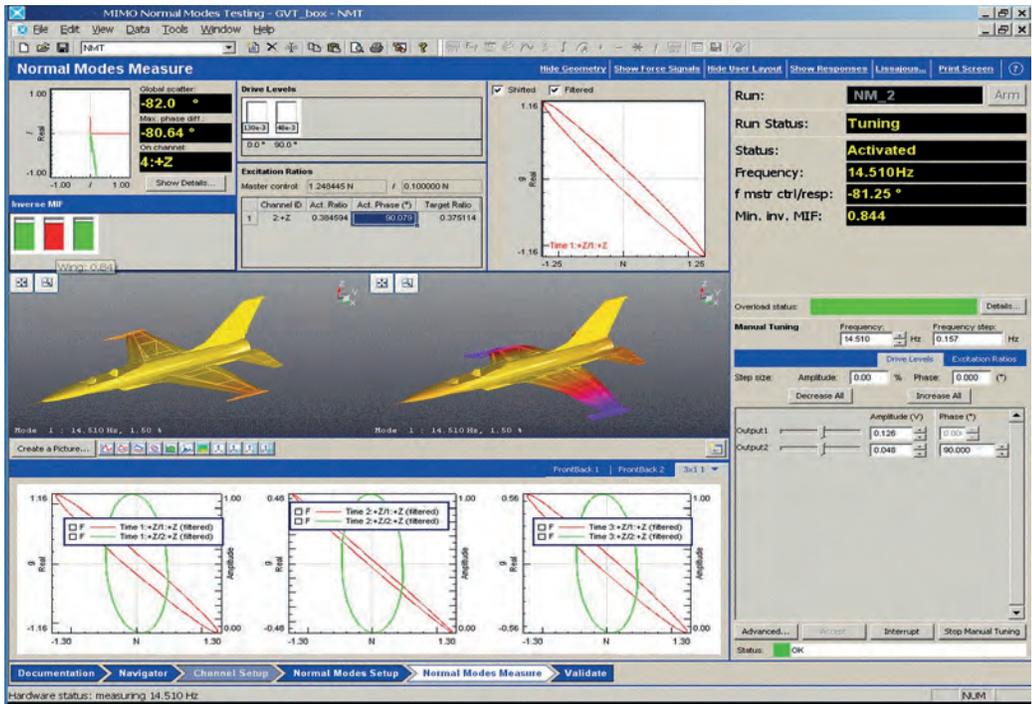

Tuning flutter critical modes during ground vibration testing.
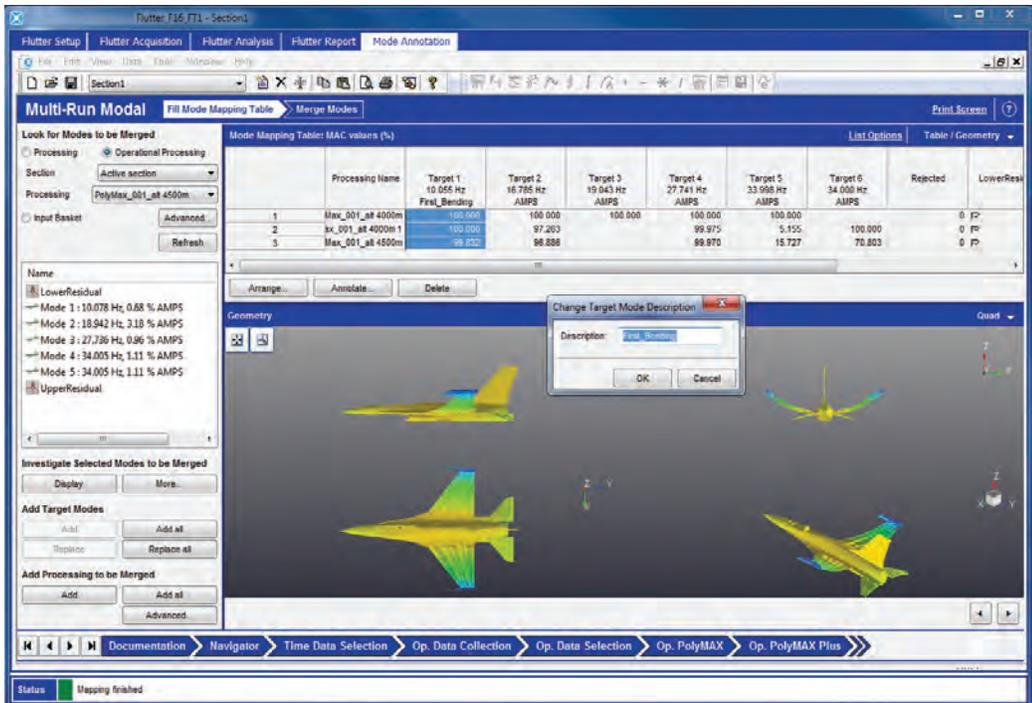
Tracking flutter critical modes during flight testing.

Experimental modal analysis can help to further enhance virtual models of landing gear, supporting both stability studies and structural investigations. Image courtesy of Goodrich.
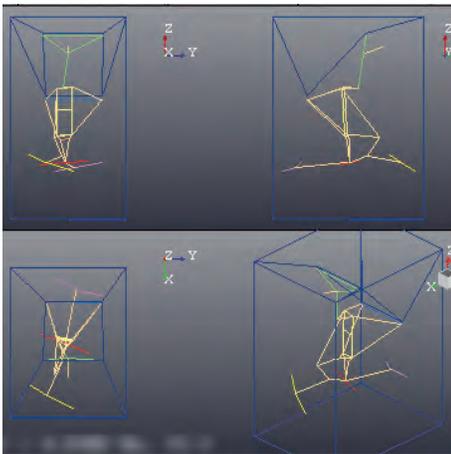
Ensuring a smooth landing

Landing gears need to meet required modal stability and structural performance so it will safely react to all loads and circumstances to ensure safe, comfortable takeoff, landing and taxiing. Siemens Digital Industries Software offers hands-on solutions that help you meet this intricate challenge.

The Simcenter Ground Vibration Testing solution provides you with full insights into landing gear modal behavior, from component to ready-to-integrate gear.

Operational modal analysis enables you to thoroughly explore how environmental and loading conditions affect structural behavior, while modal parameter estimations enable structural identification based on operational data. The technique also takes into account difficult parameters, such as input forces, variable geometry, temperature or mass changes.

Our Simcenter testing solutions provide powerful tools for drop test data acquisition and postprocessing, including force, movement, speed, acceleration and pressure and stress data, giving you rapid insight into the inherently nonlinear behavior of the landing gear. The exact same tools can be used for landing gear integration testing and taxi testing.

Tracing the root cause of shimmy

Landing gear shimmy is a complex phenomenon that impacts aircraft performance and safety. Its root cause may be traced to a multitude of variables and can eventually result in structural damage or even collapse.

Siemens Digital Industries Software has over 30 years of experience with vibration-related solutions, including design issues associated with mitigating shimmy-related problems. A structured approach and state-of-the-art testing technology help you gain deeper engineering insights into critical landing gear properties and identify, predict and resolve shimmy issues. Test data is integrated into the CAE model for accurate phenomena reproduction, including shimmy instability during landing. Highly accurate simulation tools help you understand the variables and make test-validated design choices.

Efficient engine integration testing
Guaranteeing safe operation during engine failure requires you to thoroughly analyze windmillling or sustained engine imbalance loads. Engine integration requires reliable damping estimates and validation by test-and-analysis correlation of specific load transfer characteristics for the engine-to-airframe interface via the pylon.

Our Simcenter solutions offer you a full range of modal excitation techniques for in-depth understanding of these connections, including their often inherent nonlinearities. Specific instrumentation required for integration testing, such as strain gauges or linear variable differential transformers (LVDT), can be directly connected to Simcenter SCADAS. The expert data exchange features in Simcenter Testlab foster co-engineering throughout the supply chain, a crucial factor in efficient integration testing.

Simcenter engineering can help you mitigate problems related to shimmy. We help you trace its root cause and determine design alternatives. Image courtesy of Belgian Defense.

Understanding engine pylon non-linearities to prove compliance with sustained engine imbalance certification requirements. Image courtesy of Airbus Defense and Space.

Dynamic environmental testing

Enabling users to grasp the bigger picture

Vibration testing is a critical phase in the structural qualification test campaign of any aircraft or aircraft subsystem. Verifying functional performance and structural integrity in vibration-rich environments poses a unique set of challenges. What's more, tests involving extreme vibration loads are often run on valuable prototypes, requiring them to be extremely safe. Siemens Digital Industries Software tackles these challenges with a complete and versatile solution for safe, productive and smart dynamic environmental testing.

Implementing the test-in-full-confidence principle, Simcenter environmental testing solutions are safe by design, from both the software and hardware points of view. The Simcenter system is the de facto standard for spacecraft testing, in which nothing is left to coincidence.

From standards-based to tailored testing

Aviation authorities impose strict rules on test validation, and aircraft-mounted systems are becoming increasingly complex. As a result, traditional standards-based design and testing leads to very expensive overdesign, thus mitigating the value of using new lightweight materials. In addition, innovations on the airframe level complicate not only systems integration, but also the verification process.

Flight and ground loads must be more accurately estimated, and specific methods for developing customized qualification tests are required. Siemens Digital Industries Software designed the Simcenter Testlab Dynamic Environmental testing solution to comply with this new need for tailored, nonstandard test specifications. The result is a versatile testing solution, ready to run any type of test and use complex, tailored vibration specifications.

Increase testing productivity

To complete tests faster when test time is imposed by the procedure itself, the pre- and posttest phases play a crucial role. With its template-based test setup definition, efficient setup validation, productive test supervision and batch reporting, Simcenter Testlab can be used to provide in-depth engineering insight in the blink of an eye. The raw time histories of an entire sine test run are but a mouse click away. A time-frequency analysis, revealing the test object's nonlinear responses, takes just one extra click.
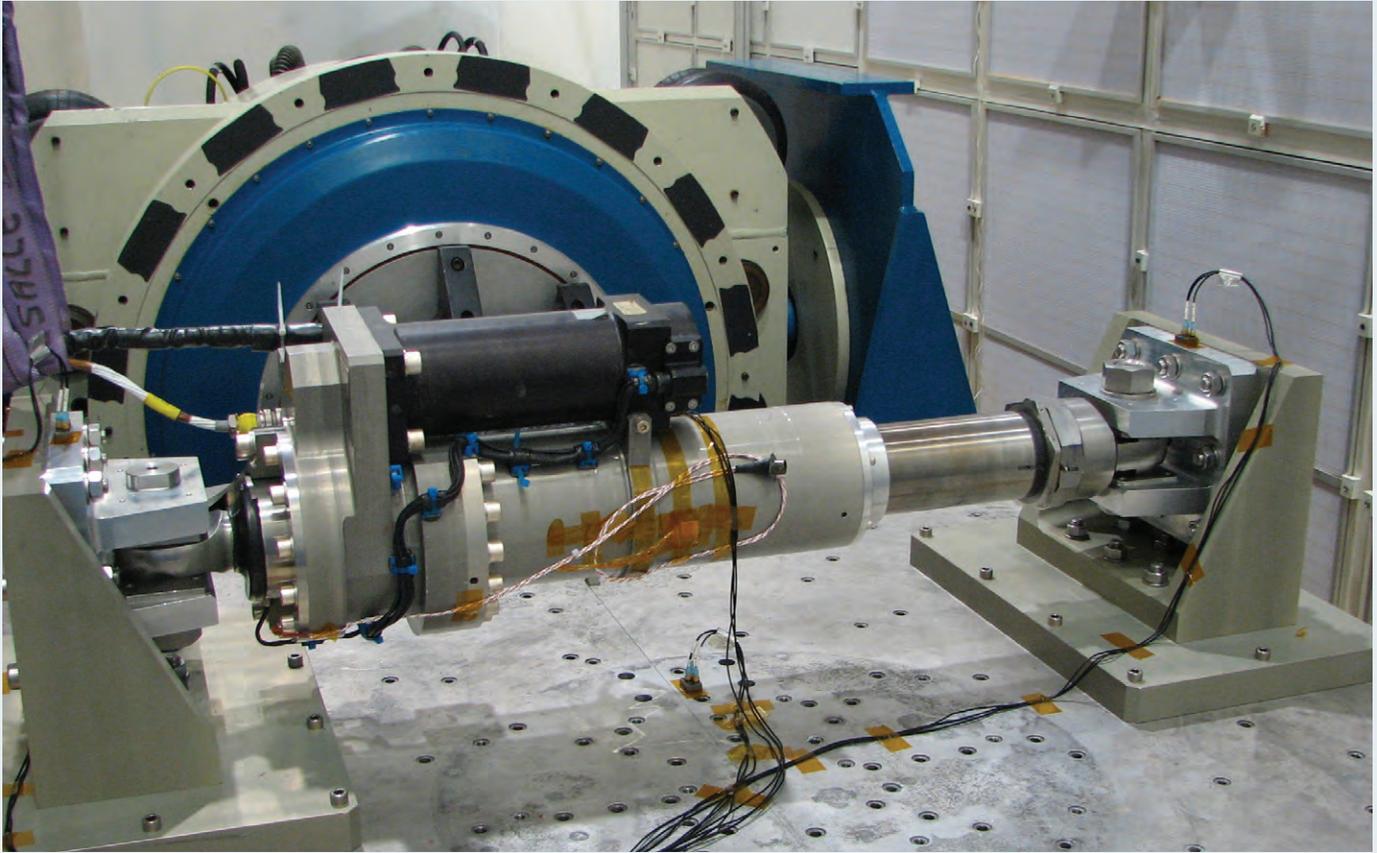
When testing prototypes, insight into the physics of failure is crucial. Additionally, a proper understanding of the shaker system and the test fixture is vital to correctly interpret test results. The Simcenter Testlab Dynamic Environmental Testing solution is designed with all this in mind, supporting an unlimited number of response measurement channels. Its vast data management and reporting features enable you to effortlessly handle even massive test-result sets.
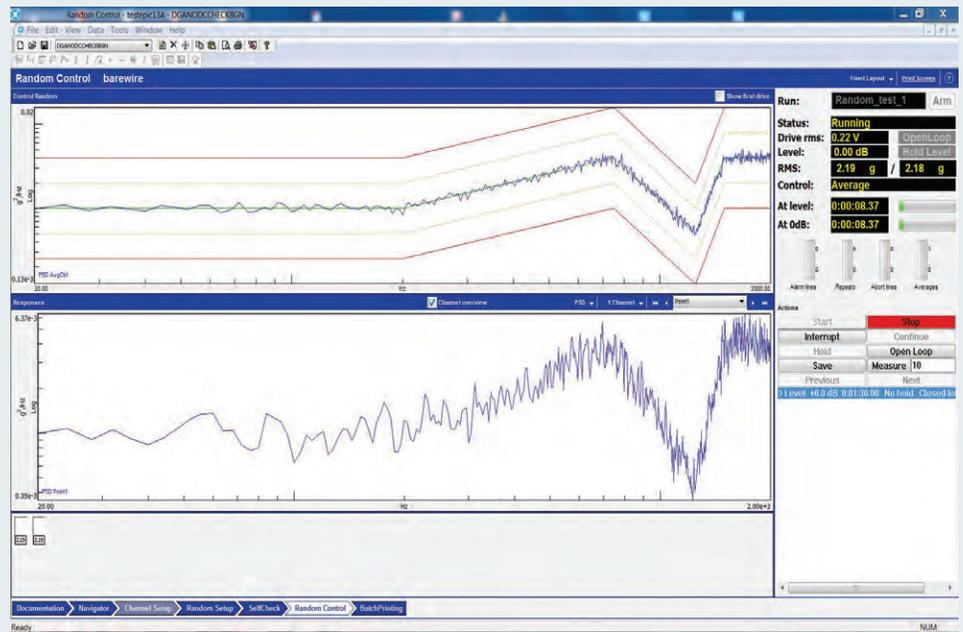
Simcenter Testlab Dynamic Environmental Testing helps to qualify aerospace components reproducing vibration loads in a safe and accurate manner. Image courtesy of SABCA.

Acoustic testing

Silencing noise and perfecting sounds

Noise reduction and sound engineering are a continuous challenge in the aircraft design process for both exterior and interior acoustics. Strict regulations and today's standards for passenger comfort require a more quiet aircraft.

Stringent regulations on takeoff, flyover and landing noise are forcing manufacturers to limit noise emission from the engine (fan inlet noise, bypass outlet noise, jet mixing noise and shock cell noise) and the airframe (turbulent layer noise, landing gear noise, winglet noise and antenna noise). In addition, today's expectations for passenger comfort have raised the bar for interior noise levels and improved sound quality.

However, acoustic requirements are more than often in conflict with the ever more stringent environmental requirements for lighter, greener and more ecofriendly aircraft. The development of new materials and composite structures brings an undoubtedly significant weight reduction. On the other hand, this weight reduction typically has a negative impact on the acoustic performance of the aircraft. Finding the balance between those conflicting requirements is day-to-day challenge for acoustic engineers. In addition, the need to stay within budget and on schedule adds to the challenge. There is a need for deeper engineering insight in order to achieve this.

For example, optimizing acoustic cabin comfort can be a complex engineering task. Controlling interior noise levels requires a system-level treatment technique that addresses both airborne acoustic energy and structure-borne vibration energy. Successful engineering relies on choosing the right materials or acoustic treatments and having a deep understanding of how they work, how to test them for feeding models, how and where to install them and how to test final performance improvement.

Scalable solutions for accurate acoustic testing and sound engineering

Simcenter testing solutions offer a complete and unique suite of software and hardware for acoustics testing and analysis, including straightforward acoustic analysis, material and component testing, sound power and fly-by noise testing, sound source localization, vibro-acoustic engineering, sound quality analysis and validation of simulation models.

Scalable to your project requirements, each solution offers task-specific advantages in terms of return on investment (ROI). Simcenter solutions can be customized and integrated into your own project requirements for projects such as jet-engine or wind-tunnel testing.

Where is the sound coming from?

Siemens Digital Industries Software has designed a number of cutting edge sound source localization solutions to increase overall testing productivity.

For exterior and interior noise, identifying the location of a sound source is a challenge and can be quite time consuming. To map how noise radiates to the exterior, flyover or wind tunnel measurements can provide valuable information.

Siemens Digital Industries Software has designed a number of cutting-edge sound source localization (SSL) solutions to increase overall testing productivity for both in-flight and on the ground sound source localization. Those solutions have been developed in collaboration with MicroDB and Airbus and allow for a significant saving of time and resources.

They include:

- **General purpose solutions** for acoustic troubleshooting and SSL: classical sound intensity measurements using one or more dedicated sound intensity probes measured at several consecutive points close to the radiating surface. This well-accepted method is easy to set up, spans a large frequency band and provides an intensity map

- **Dedicated solutions** for flyover noise quantification, sound power and source ranking, with customized multi-channel, array-based measurement and processing systems for localization of the noise sources. The beamforming technique is enhanced with deconvolution techniques providing a better spatial resolution and includes de-Dopplerization, a method in which the relative speed of the aircraft with regard to the antenna is taken into account
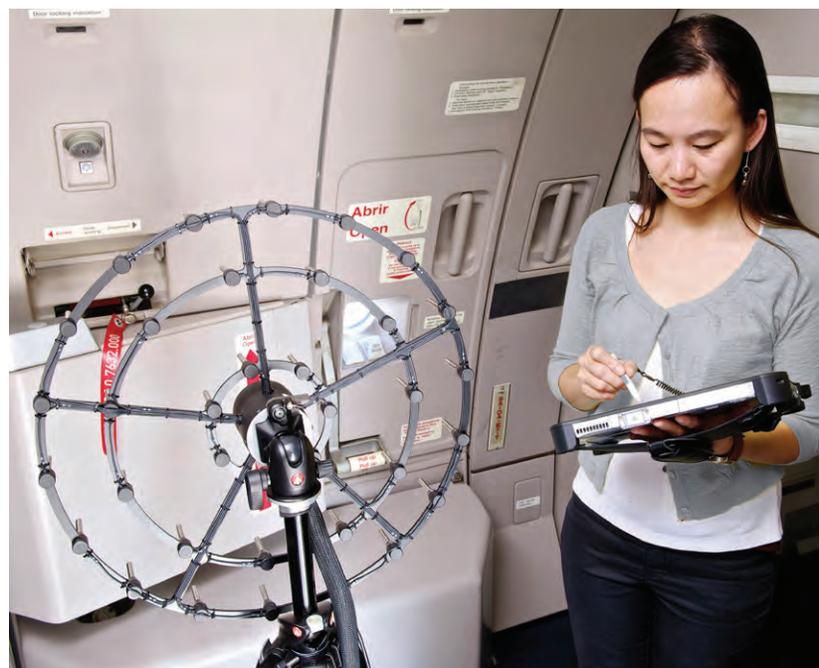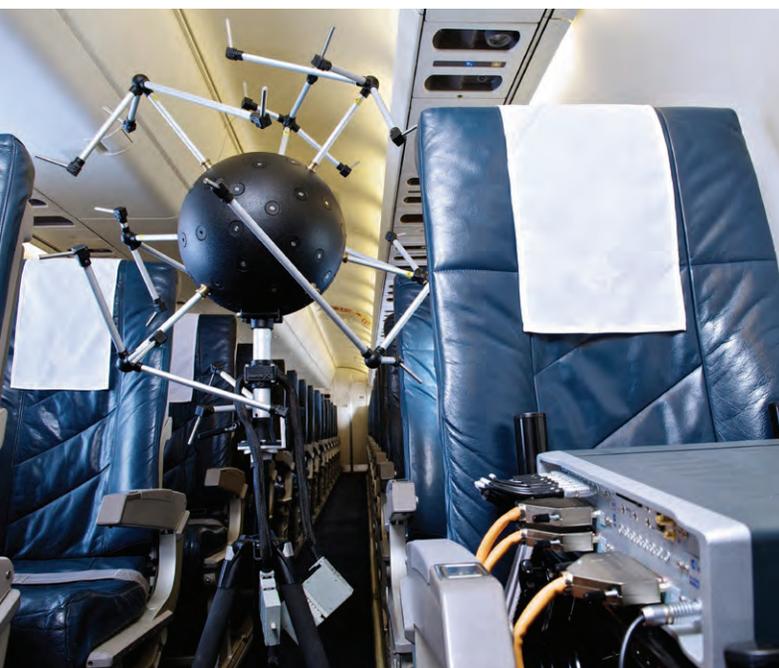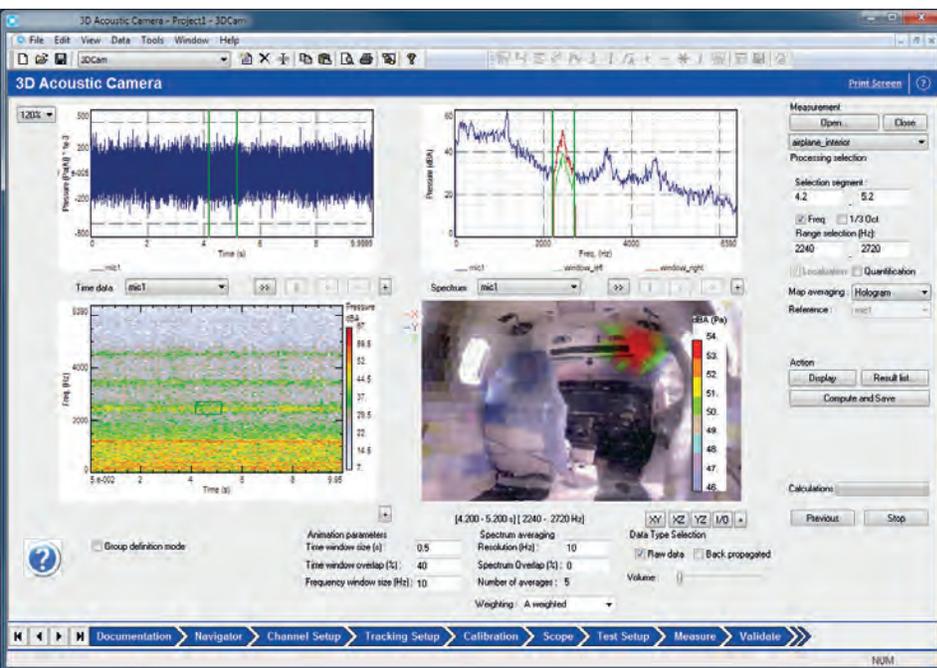
- **Interior sound source localization** for cockpit noise or cabin noise and acoustic leak detection can be performed using the Simcenter Testlab 3D Acoustic Camera. The solid spherical 3D acoustic camera allows for one-shot SSL and speeds up aircraft acoustic testing and engineering processes, enabling you to perform measurements in a few seconds that provide acoustic maps, back calculated and projected on a 3D view of the cabin or equipment. This yields on-the-spot accurate and comparable results. It can be employed not only for source localization, but also for quantification and ranking. It allows you to have a full acoustic view on the radiation of the sound in a very short time, even from transient sounds (for example, from the sound of electronics or landing gear retracting). The combination of a solid surface array with additional microphones on extension arms also allows you to cover a broad frequency range for interior measurements. It quickly reveals the full sound profile of the aircraft interior in various ground and flight conditions, and offers excellent spatial resolution to clearly separate sound sources.

- **The Simcenter™ Soundbrush™ syste**m was developed for quick troubleshooting of noise sources. It is an all-in-one pressure or intensity scanning tool with integrated automatic position detection. This device allows you to show in real time a 3D map of the sound intensity around the surface or object that is scanned.

Shaping the right sound quality

Passenger comfort is a key differentiator for any aircraft manufacturer. Cabins are continuously being improved to provide the quietest, most comfortable and enjoyable flights for both passengers and crews. Analyzing the quality of the interior sound can contribute to avoiding bad passenger experiences. Even safety can be at stake, especially on noisier aircrafts such as propeller or military aircrafts, when understanding the crew's instructions is crucial. Siemens Digital Industries Software provides ideal tools for sound quality analysis:

- Measurement and analysis tools: easy recording with interactive replay and filtering for a subjective evaluation of original and modified sound
- Tools for sound design: for objective evaluation, a wide range of sound quality metrics are available, such as speech interference level(SIL), preferred speech interference level (PSIL), articulation index, loudness, fluctuation strength, tonality, etc.

Finding the root cause of noise through transfer path analysis helps you identify the main sound sources and transfer paths, both airborne and structure-borne. Image courtesy of Belgian Defense.

Pinpointing the root cause of sound

How does the operational vibration in the main gearbox of a helicopter propagate by its connections to the frame, and what is its relative contribution to the sound inside the cabin compared to the acoustic-borne noise of the rotor? Understanding which part, component or panel radiates the most is not always sufficient, but the source-transfer-receiver model provides a very useful approach. Efficient design modification in complex mechanisms can only be obtained with an in-depth understanding of the system. Simcenter testing solutions reflect our vibro-acoustic engineering expertise. Finding the root cause of noise through transfer path analysis helps engineers make important design decisions, save time and costs and improve the entire development cycle. The Simcenter product suite will help you gain engineering insight into the different phenomena and provides tools for the various aspects of this approach, including:

- Analysis and test methods to build and validate a complete optimization process
- Modal and vibro-acoustic model identification
- Operational data measurement at source and receiver, including operational deflection shape visualization
- Transfer path analysis
- Calibrated vibration and noise source for accurate vibro-acoustic transfer function measurements

Simcenter Testlab Sound Quality Testing helps you objectively and subjectively assess product sound quality and optimize your sound design. Image courtesy of Belgian Defense.

The extra-small Simcenter SCADAS XS allows you to perform a wide variety of in-flight noise and vibration diagnostic tests. The 12+ channel system with onboard signal conditioning processes all standard noise and vibration signals. Image courtesy of Belgian Defense.

Streamlining operational measurements

Simcenter SCADAS data acquisition systems efficiently replace tape and other cumbersome data-recording solutions that are used to acquire operational noise or vibration data. The range includes handheld systems for quick headset measurements or general purpose in-flight measurements as well as high channel-count configurations for acoustic measurements in flight and on the ground, including microphones and large array configurations.

These solutions allow you to

- Synchronize easily with other events thanks to the standard Inter-range instrumentation group (IRIG-B) interface or a Global Positioning System (GPS) time synchronization
- Measure data during online processing and viewing on a connected personal computer (PC) or record in complete standalone mode to a solid state CompactFlash (CF) card. A handheld remote control makes operation of the device extremely simple
- Built-in signal conditioning eliminates the need for additional equipment and ensures the highest possible data quality.

Selecting the right materials and components

The way in which acoustic material absorbs and reflects sound can have as much impact on the design as the material itself. Simcenter Testlab Acoustics software offers a full spectrum of tools to study and examine the sound behavior of materials and components and can help determine how they would affect the overall sound. For optimal passenger comfort, fuselage panels, ceiling and floor panels or separation panels can help to absorb acoustic energy. Simcenter acoustic testing solutions provide:

- Traditional methods and standardized solutions, including absorption and sound transmission loss measurement of complete panels according to the two-room method
- Transmission loss measurements using the four-microphone transfer matrix method, such as for the characterization of muffler design of the environmental control system (ECS)
- Sound absorption characterization of small samples using the two microphone transfer function matrix or larger components using the reverberant room method. Array-based techniques for sound source localization can complement these traditional methods to obtain more advanced engineering insights.

Are target noise objectives being met?

Noise certification requires detailed noise measurement procedures. One of the critical elements of the procedure is the measurement system and processing software. Simcenter testing software and hardware enables you to be compliant with international standards, and provides the capability for time synchronization, customization and integration, making it ideal for:

- Aircraft flyover, approach and takeoff noise certification measurements
- Static noise tests for aircraft engines
- Noise certification of installed auxiliary power units and associated aircraft systems during ground operations.

Interactive analysis of fly-over data according to international standards.
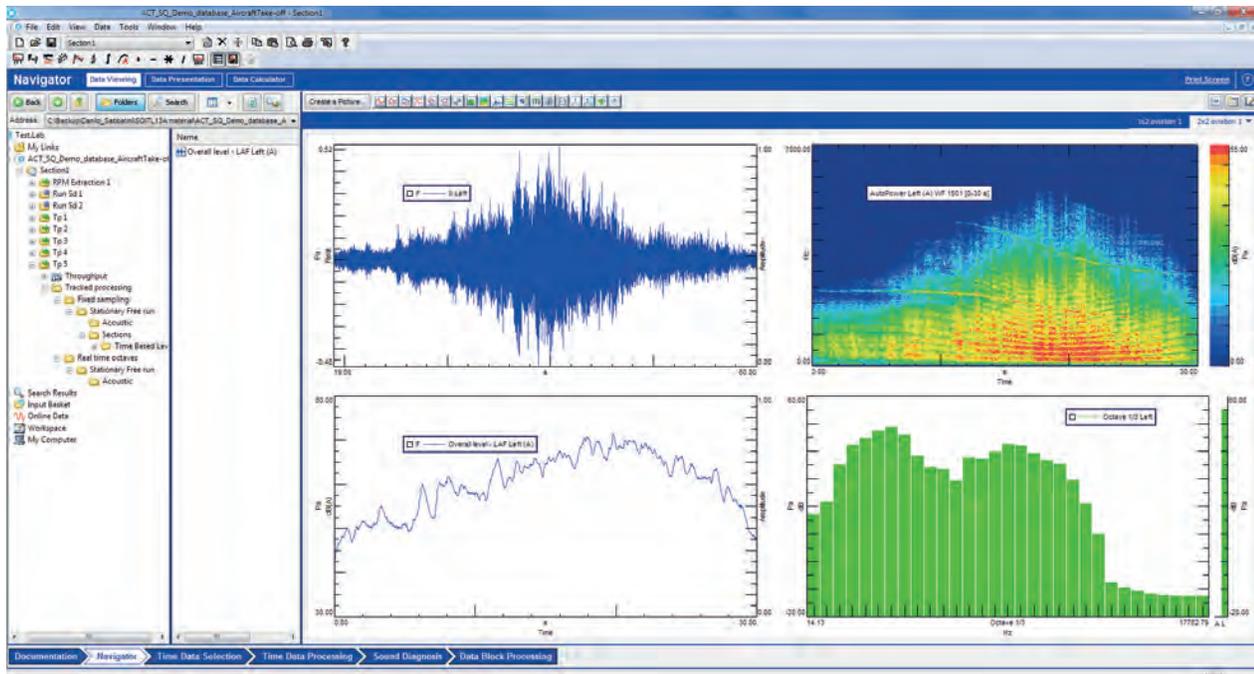
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