SIEMENS DIGITAL INDUSTRIES SOFTWARE

Simcenter 3D for aerostructures

Streamlining the structural sizing and assessment process from end-to-end

Solution benefits

Perform end-to-end aerostructure assessment in a fully integrated environment

Integrated aeroelasticity environment linked with CAD and Simcenter Nastran to perform flutter, divergence, and trim analyses

Eliminate mistakes and ramp up productivity with ready-to-use failure prediction methods from reference handbooks

Accelerate mission loads generation

Efficiently extract the most critical load cases that impact structural integrity

Customize the solution by integrating your knowhow and tools intuitively and taking advantage of your aerostructure experience

Evaluate results with dedicated criticality-focused postprocessing

Streamline report generation

The Simcenter 3D software for aerostructures solution can help you meet shorter timelines and reduce structural analysis costs with the ability to perform end-to-end aerostructure assessment in a fully integrated environment. Eliminate mistakes and ramp up productivity with ready-to-use failure prediction methods and customize your solution by integrating your internal tools and IP to streamline your aerostructures analysis processes.

Due to the growing number of new and emerging airframe manufacturers, there is more pressure to deliver with shorter lead times and at competitive costs. However, meeting shorter project timelines is challenged by the fact that aircraft engineering teams today use disconnected systems for load generation and management, design, simulation, margin of safety, and flutter analysis. Additionally, 60 percent of the nonrecurring cost of a commercial aircraft is spent on the structure, which means that any improvement in the structural analysis process will have a key impact on reducing the delays and the cost overruns.

The powerful geometry editing and meshing capabilities of Simcenter 3D Engineering Desktop are ideal for pre- and postprocessing structural and aerodynamic models. Using Siemens Digital Industries Software's Simcenter 3D, which is part of the Simcenter portfolio, simplifies the modeling process by integrating highend finite element method (FEM) tools with geometry capabilities that assist the user in developing analysis models faster than with traditional computer-aided engineering

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Simcenter 3D
for aerostructures

(CAE) preprocessors. The same environment provides all means to create and manage an aero-dynamic model, link it with the structural model, quickly filter critical load cases, and define aero-elasticity analyses. Simcenter 3D Margin of Safety enables structural assessment with standard analytical methods and/or company methods.

One-stop Structural and Aeroelastic analyses

Flying vessels require more than typical structural analysis. Aeroelasticity allows to combine elastic, inertial, and aerodynamic forces at the same time. The seamless integration in Simcenter 3D Engineering Desktop of the dedicated features for pre- and postprocessing provide a unique, parametrical, and consistent environment to perform such analysis, bringing all advantages of this fully-integrated solution, such as:

- CAD-Analysis associativity
- A managed environment through close integration with Teamcenter

Seamless integration for Aeroelastic models and analyses

Based on Simcenter Nastran Aeroelastic analyses, available from the Simcenter Nastran Advanced Structural Dynamics bundle, Simcenter 3D provides all means to:

- Create aerodynamic models, based lifting surfaces and slender bodies
- Connect structural and aerodynamic meshes thanks to dedicated “splines” to transfer loads between both models
- Define analyses parameters consistently with the structural analysis definition, possibly relying on the International Standard Atmosphere (ISA) model to ease conversions between velocities, mach numbers, altitudes, and density ratios.

The following analyses (based on Simcenter Nastran SOL144, SOL145, and SOL146) can all be modeled from within Simcenter 3D:

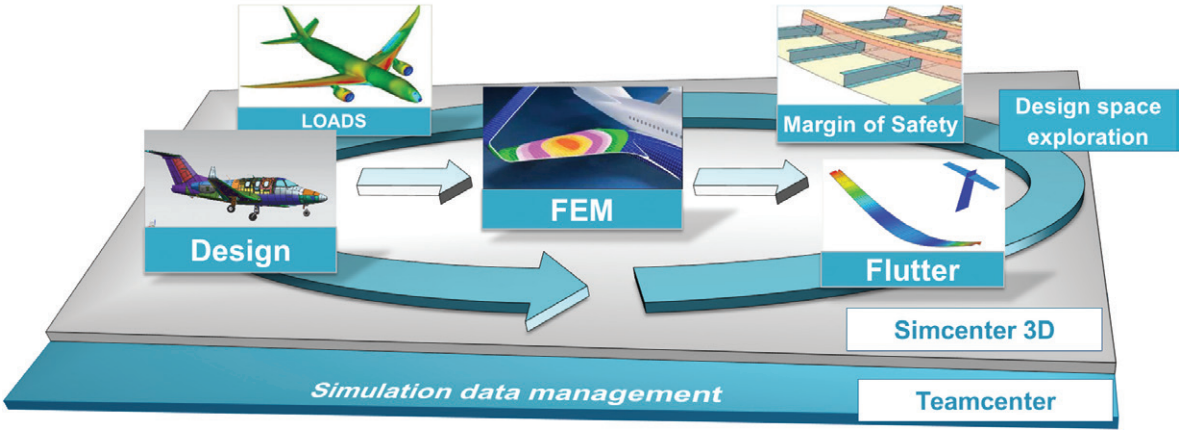
- Flutter (including K, KE, PK, and PKNL methods)
- Static divergence
- Trim analysis
- Control effectiveness
- Static loads evaluation
- Atmospheric Gust
- Wake
- Dynamic maneuver

Integrated aeroelastic postprocessing

Simcenter 3D not only provides means to display results on the aerodynamic model (such as modal shapes for flutter or forces for static analysis), but it can also display global results within the same environment. Frequency vs. velocity and damping vs. velocity diagrams are directly displayable to speed up the analysis of flutter-critical speeds throughout the flight envelope. Trim analysis post-processing also comes with fully integrated global results to assess the effectiveness of control surfaces.

Quickly filter critical load cases

Aircraft structural design can involve hundreds of thousands of load cases, but only a subset of these are critical to structural design. How do you determine which ones are important for analysis?



Simcenter 3D provides out-of-the-box load case enveloping capabilities that can help you quickly find the most critical loads for a component or an entire assembly.

Efficiently analyze margin of safety

In addition to the detailed finite element models approach, engineers can size aerostructure components using a library of analytical engineering methods. With the capability to generate stress reports using data and simulation results, engineers benefit from a consistent and integrated global process, resulting in time savings over the full design cycle.

With an increasing amount of data and results to be handled and shared between teams, models, simulation results and tools can be managed and traced in Teamcenter® software.

Integrated solution to predict margin of safety

The integrated environment also helps you perform an end-to-end process to predict margin of safety for aerostructures through dedicated pre- and post- capabilities such as:

- Preprocessing to prepare margin-of-safety calculations for numerous load cases
- Postprocessing that focuses on the criticality of results expressed as Margins of Safety or Reserve Factors
- 3D display of margin values combined with the typical finite element (FE) postprocessing display to graphically locate the areas that need design updates

Simcenter 3D Margin of Safety software comes with standard engineering formulas from aerostructure reference handbooks, such as E.F. Bruhn's, "Analysis and Design of Flight Vehicle Structures," M.C.Y. Niu's, "Airframe Stress Analysis and Sizing," National Advisory Committee for Aeronautics (NACA) technical notes, NASA technical memorandums, etc. Each method comes with detailed engineering documentation.

Flexibility to embed user-defined methods

Simcenter 3D Margin of Safety and load case filtering allow you to integrate in-house libraries of methods. The availability of analysis building blocks (for example, ready-to-use engineering formulas, such as buckling and plasticity curves and out-of-the-box standard methods) enables users to save a large amount of time on integrating methods.

Customized reporting

A detailed stress report can be generated in Microsoft Word format from the Simcenter 3D Margin of Safety result and the associated finite element analysis (FEA).

The template is composed of key words, and thus can be tailored to fit company best practices. The template can include user textual feedback, snapshots, summary tables, etc.

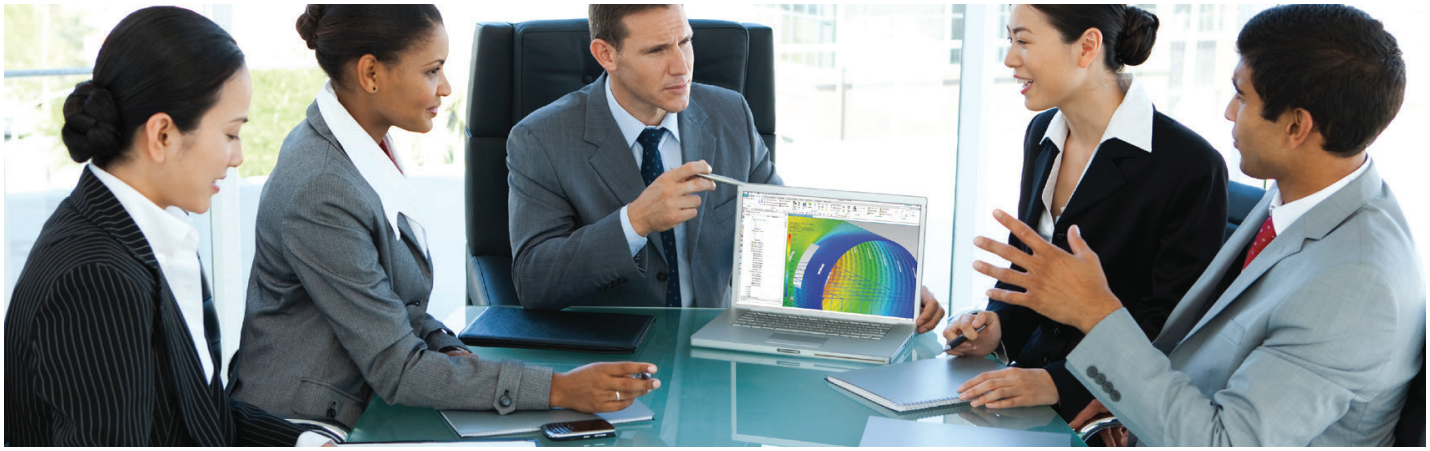
Industry applications

Simcenter 3D Aerostructure facilitates full traceability for certification of an end-to-end integrated solution for sizing. It streamlines the structural process from computer-aided design (CAD), FE simulation and margin-of-safety calculations to reporting. Simcenter 3D Aerostructure offers a scalable solution for embedding in-house margin-of-safety methods as libraries.

CAD/CAE associativity helps you efficiently manage design changes. And a seamless connection with Teamcenter® software helps you manage the increasing amount of data and results you need to share between teams, models, simulation results and other simulation tools.

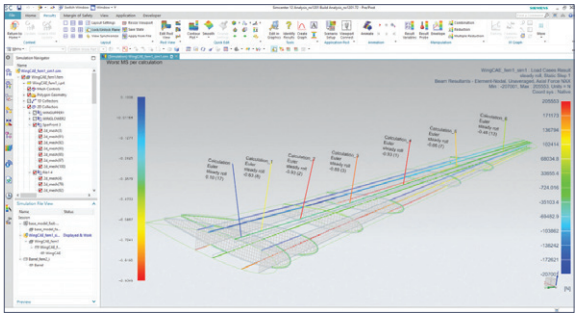
Aerospace and defense

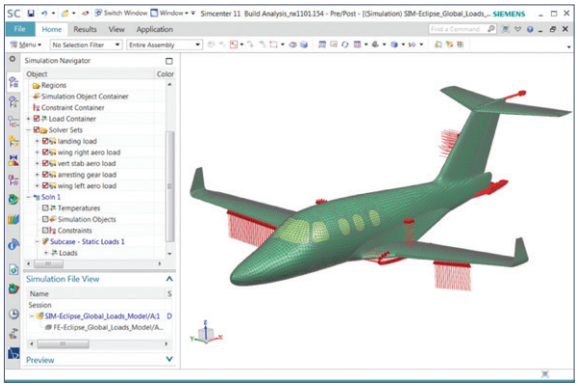
Specific vertical application dedicated to the sizing of frames, wings and the global view of airplanes.



Simcenter 3D
Margin of Safety

Simcenter 3D Margin of Safety brings a streamlined, traceable and enterprise-wide approach to aero-structure sizing so you can calculate everything from static loads to margins of safety.





Module benefits

- Traceability for certifying an end-to-end integrated solution for aerostructure sizing
- Streamline the structure process from CAD, FE simulation and margin-of-safety calculations to reporting
- Scalable solution for embedding in-house margin-ofsafety methods and libraries
- Manage design changes efficiently with CAD/CAE associativity

Key features

- Dedicated preprocessing enables you to prepare margin-of-safety calculations for numerous load cases simultaneously, which is available in Simcenter 3D, a powerful finite element pre-/postprocessing open environment
- Dedicated postprocessing focuses on criticality of results (expressed as Margins of Safety or Reserve Factors) either from a global, failure mode or load case point of view
- Results can be browsed to assess structural integrity thanks to sortable and filterable tables
- Each method provides a log for detailed explanations of assumptions
- Dedicated 3D display of margin values combined with the typical FE postprocessing display enables you to graphically locate the areas that need design updates

Simcenter Nastran
Advanced Dynamics bundle

Simcenter Nastran Advanced Dynamics is a cost-effective bundle that provides a set of commonly used and advanced dynamics functionality.

Simcenter 3D uses the Simcenter Nastran Advanced Dynamics solver bundle for aeroelasticity simulation. The entire aeroelastic simulation process makes use of Simcenter 3D Engineering Desktop for pre- and postprocessing of the aerodynamic model. The Simcenter Nastran Advanced Dynamics solution is then used for solving the model.

The following Simcenter Nastran aeroelastic solutions are available in this module and are based on the doublet-lattice method:

- Simcenter Nastran SOL145 (Aeroelastic Flutter Analysis)
- Simcenter Nastran SOL144 (Aeroelastic Static Analysis)
- Simcenter Nastran SOL146 (Aeroelastic Dynamic Analysis)

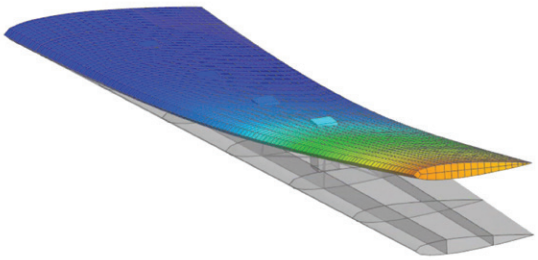
In addition to aeroelastic analysis solutions, the Simcenter Nastran Advanced Dynamics bundle also includes solutions for Simcenter Nastran Dynamic Response, Simcenter Nastran FRF representations, Simcenter Nastran super-element analysis, Simcenter Nastran recursive domain (RD) modes, Simcenter Nastran DMP (distributed mem-ory processing), and Simcenter Nastran direct matrix abstraction program (DMAP).

Module benefits for aeroelastic simulation

- A cost-effective bundle to perform comprehensive aeroelastic analysis and accelerate product time-to-market
- Integrates with Simcenter 3D Engineering Desktop, for a complete environment for all aeroelastic simulation
- Decreases the learning curve for a simplified usage of aeroelasticity throughout the engineering community
- Build system assembly models using a hybrid assembly of components based on finite elements

Key features for aeroelastic simulation

- Includes all capabilities of Simcenter Nastran Aeroelasticity, based on doublet-lattice method, including aerodynamic model definition, and connection between structural & aerodynamic models
- Analyze structural models in the presence of an airstream using aeroelastic analysis
- Assess flutter for the whole flight envelope
- Analyze quasi-static trim variables taking into account any control surfaces configuration
- Perform transient or frequential dynamic analysis (e.g. gusts)
- Modify and adapt out-of-the-box (OOTB) solution sequences using DMAP



Capabilities chart

General capabilities	Specific capabilities	Simcenter 3D Engineering Desktop	Simcenter 3D Margin of Safety	Simcenter Nastran Advanced Dynamics bundle
	Engineering Desktop dedicated aerostructure features			
Load Case Filtering	CAD/FE/Stress associativity for geometry update or load update	•		
	Fully intergated solution	•		
	Load extraction from static linear FEM analysis (Nastran SOL101 and SOL144)	•		
	Analytical loads-space filtering methods (standard methods or end-user methods)	•		
	Out-of-the-box Loads-space 2D and 1D filtering methods (Bounding Box, Convex hull)	•		
	Dedicated post-processing for Load Case Filtering			
Other features	Shear Moment Torque Diagram	•		
	Linear combination of load cases	•		
	Margin of Safety			
Workflow and integration	CAD/FE/Stress associativity for geometry update or load update		•	
	Fully intergated Stress analysis		•	
	Data management compatibility	•	•	
	Analytical methods from reference standard methods or end-user methods		•	
	Dedicated post-processing for Margin of safety		•	
	Stress report automated generation		•	
	Metallic static material support (isotropic, othotropic, anisotropic)	•	•	
	Composite material support (unidirectional long fiber)	•	•	
	Massive geometry data populating through journaling		•	
Loads	Load extraction from static linear FEM analysis (Nastran SOL101 and SOL144)		•	
	Load extraction via freebody		•	
	Load data from the user input		•	
	Load data from external load files		•	

General capabilities	Specific capabilities	Simcenter 3D Engineering Desktop	Simcenter 3D Margin of Safety	Simcenter Nastran Advanced Dynamics bundle
Loads *(continued)*	Group load case (load case set)		•	
	Loads case envelop (filtering/ selection of LC by result values)		•	
	Strength requirement of Load case (ex: Ultimate/Limit)		•	
	Pre-defined load idealization		•	
	Configurable load idealization		•	
Postprocessing and reporting	**Postprocessing**			
	3D post-processing of critical MS, Load Case , failure mode		•	
	Table of critical MS, Load Case , failure mode		•	
	Detail log of the analysis run		•	
	Reporting			
	Structured templated document	•	•	
	Critical margin of safety table		•	
	3D snapshots (CAD, FE results...)	•	•	
	Material summary	•	•	
Integrated and user-defined methods	**Integrated metallic methods**			
	Tension/compression/Shear		•	
	Tresca (plane stress)		•	
	Tsai-Hill		•	
	Plate (Flate/curved) buckling analysis under different loads (compressive/shear/bending/ mixed interaction)		•	
	Column buckling analysis (Euler/Euler-Johnson, Euler-Engesser)		•	
	Torsionnal buckling		•	
	Profile Cripling analysis		•	
	Inter-rivet buckling		•	
	Shear, bending, tension, interaction of a bolt		•	
	Bolt/load redistribution		•	
	Integrated metallic methods			
	Plasticity (plastic reduction factor charts, StressFromStrainIn Plastic Domain)		•	
	Material law (Fsy estimation, Secant/tangent modulus, Stress F07)		•	

General capabilities	Specific capabilities	Simcenter 3D Engineering Desktop	Simcenter 3D Margin of Safety	Simcenter Nastran Advanced Dynamics bundle
Margin of Safety *(continued)*				
Integrated and user-defined methods *(continued)*	**Integrated composite methods** *(continued)*			
	Plate buckling analysis under different loads (compressive/ shear/mixed interaction)		•	
	Documentation			
	End-user documentation		•	
	Methods formulation documentation		•	
	User-defined methods			
	Integration of customer methods : legacy analysis codes or launch of executable		•	
	On the fly mathematical formulation definition		•	
	Automation of high-level process (i.e. automate series of clicks) through journaling	•	•	
	Add user defined material	•	•	
	Add user defined material properties (ex: allowables)	•	•	
	Add user defined profile cross-section	•	•	
	Integration of specific post-processing of MS (including results files in external viewer)		•	
	Method integration documentation management		•	
	Abiliity to redistribute non-native methods		•	
Structural dynamics and aeroelasticity				
Structural and aeroelastic analysis	Aeroelastic Flutter			•
	Aeroelastic Static - Trim			•
	Aeroelastic Static - Divergence			•
	Aeroelastic Dynamic - transient response			•
Structural and aeroelastic analysis *(continued)*	Aeroelastic Dynamic - frequency response			•
	Superelements			•
	Direct matrix abstraction programming (DMAP)			•
	Structural linear dynmics			•
Parallel processing	Shared memory parallel (SMP)			•
	Distributed memory parallel (DMP)			•
Aeroelasticity	Lifting surfaces and slender bodies definiton	•		
	Load tranfer between structural and aerodynamic model definition	•		
	Control surfaces definition	•		
	Aerodynamic model associativity with CAD	•		
	International Standard Atmosphere integration	•		
	Correction factors definition	•		
	Flutter analysis definition using K, KE, PK, or PKNL method	•		
	Static divergence definition	•		
	Trim analysis definition	•		
	Dynamic aeroelastic analysis definition (gust, wake, dynamic maneuvers...)	•		
	Dedicated flutter postprocessing (including v-g and v-f diagrams)	•		
	Dedicated trim postprocessing	•		
	Dedicated postprocessing of dynamic transient response	•		
	Dedicated postprocessing of dynamic frequency response	•		

Legend:

• = included in module

Note: Simcenter 3D Engineering Desktop is a minimum prerequisite for all Simcenter 3D products. Other dependency or prerequisites may apply for individual products.

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Americas 1 800 498 5351

Europe 00 800 70002222

Asia-Pacific 001 800 03061910

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