

DIGITAL INDUSTRIES SOFTWARE

Simcenter 3D for strength and durability simulation

Enabling in-depth fatigue and lifing analysis

Solution benefits

Explore multiple design options and optimize your design for strength and fatigue performance

Perform fatigue life prediction analyses quickly

Get insightful and rapid feedback on critical durability areas

Simulate new materials and manufacturing processes, complex connections and welds

Predict loads on a system and component level

See immediately what your finite element results mean with respect to strength and durability

Simcenter™ 3D software offers a distinctive suite of tools to support strength and fatigue design in all stages of development. This includes easy-to-use wizards for strength and fatigue in the design phase; fatigue information on the current simulated part; detailed analysis of complex load scenarios, including weldments and connections; as well as new materials and manufacturing processes.

The best way to predict a product's strength and durability

Shorter development cycles and ever-increasing quality requirements have stretched the test-based durability approach to its limit. Evaluating and refining the durability performance by

simulation methods is the only valid alternative. The durability modules of Simcenter 3D give you access to state-of-the-art analysis methods, enabling engineers to interactively assign loads to a model. The solution permits efficient analysis of seam and spot welds as well as new methodologies for composite materials.



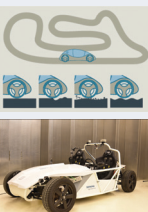
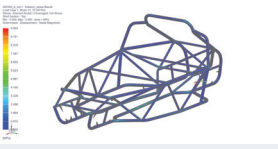
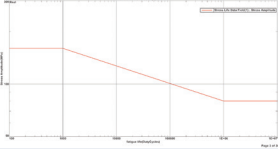
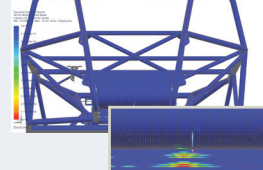
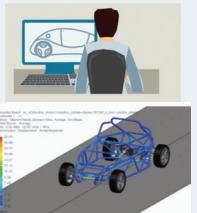

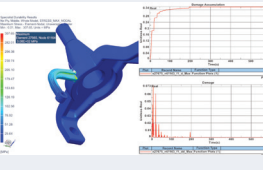
Durability

SIEMENS

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Simcenter 3D

for strength and durability simulation

Loads	Create digital twin of test	Simulate test	In depth analysis																														
<p>Measure</p> 	<p>Stress calculation</p> 	<p>Apply material</p> 	<p>If and where fatigue occur</p> 																														
<p>Simulate</p> 	<p>Load events Duty cycles</p> <table border="1" data-bbox="511 850 755 913"> <thead> <tr> <th>Load #</th> <th>Load Name</th> <th>Date Source</th> <th>Series #</th> <th>Series Name</th> <th>Search</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>SHOCK-1</td> <td>MRI Source</td> <td>1</td> <td>SHOCK-1 (MOTION CONTROL) (MOTION)</td> <td>Search</td> </tr> <tr> <td>2</td> <td>SHOCK-2</td> <td>MRI Source</td> <td>2</td> <td>SHOCK-2 (MOTION CONTROL) (MOTION)</td> <td>Search</td> </tr> <tr> <td>3</td> <td>SHOCK-3</td> <td>MRI Source</td> <td>3</td> <td>SHOCK-3 (MOTION CONTROL) (MOTION)</td> <td>Search</td> </tr> <tr> <td>4</td> <td>SHOCK-4</td> <td>MRI Source</td> <td>4</td> <td>SHOCK-4 (MOTION CONTROL) (MOTION)</td> <td>Search</td> </tr> </tbody> </table> 	Load #	Load Name	Date Source	Series #	Series Name	Search	1	SHOCK-1	MRI Source	1	SHOCK-1 (MOTION CONTROL) (MOTION)	Search	2	SHOCK-2	MRI Source	2	SHOCK-2 (MOTION CONTROL) (MOTION)	Search	3	SHOCK-3	MRI Source	3	SHOCK-3 (MOTION CONTROL) (MOTION)	Search	4	SHOCK-4	MRI Source	4	SHOCK-4 (MOTION CONTROL) (MOTION)	Search	<p>Apply methods and parameters with one click</p> <ul data-bbox="917 850 1047 1018" style="list-style-type: none"> Stress Life Predefined Stress Life Preconfigured Stress Life Strain Life Interlaminar Van Paepegem Short Fiber Master S-N Curve Nominal Stress Seam Weld Notch Stress Seam Weld Force Based Spot Weld Stress Based Spot Weld My Stress Life 	<p>Why and when they occur</p> 
Load #	Load Name	Date Source	Series #	Series Name	Search																												
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Eliminate over- or under-designed components

Analyze loads acting on the critical regions and improve the load flow from the application points that have the greatest influence on the critical areas. This leads to much better designs than reinforcing around the critical areas saving on weight and materials.

Enabling a more efficient and safe physical validation

Virtual test rig experiments facilitate the analysis of the impact of individual load events on component damage. Such analysis also permits the flexibility to define your specific load scenarios for each of the components, thereby saving testing time.

Include manufacturing and assembly aspects in durability analysis

New materials and manufacturing processes often have an important influence on fatigue behavior. With Simcenter 3D, one can take into account such manufacturing influences while performing durability analysis.

Design it right the first time

To perform fatigue analysis in an efficient way, durability modules provide access to:

- Test data such as loads used, test schedule definitions, etc.
- Simulation data, such as multibody results and finite element simulations of the digital twin
- State-of-the-art strength and fatigue simulation methods
- Fatigue-specific postprocessing

Providing a platform for multidiscipline simulation

The Simcenter 3D durability solution is part of a larger integrated multidiscipline simulation environment with the Simcenter 3D Engineering Desktop at its core. This centralized desktop environment provides all the pre/post-processing tools for all of the Simcenter 3D solutions. This integrated environment helps you to achieve faster CAE processes and streamline multidisciplined simulations. It integrates durability with disciplines such as stress and strain, and structural solutions. It can also perform load prediction using motion solutions of short or endless fiber composites that exhibit nonlinear behaviour, all while maintaining a tight integration with damage tolerant design.

Industry applications

Aerospace and defense

Simcenter 3D is used to predict lifing for mechanical systems like turbines, landing gears, control mechanisms, slat tracks and other critical assemblies. Local stress concentrations are identified based on all possible combinations of local load conditions to address durability problems long before prototypes are built. A wide range of methods can localize weak spots and assess fatigue life.

Automotive and transportation

Simcenter 3D is used to execute fatigue-life assessments on body frames, panels, cross-members, and door systems, as well as sunroofs, latches, and locking systems. The Simcenter 3D Durability module also enables a high degree of accuracy for specific seam and spot weld analyses. Advanced numerical durability predictions can be applied to engines, powertrain parts, engine brackets, gear box chain heels and exhaust lines.

Industrial machinery

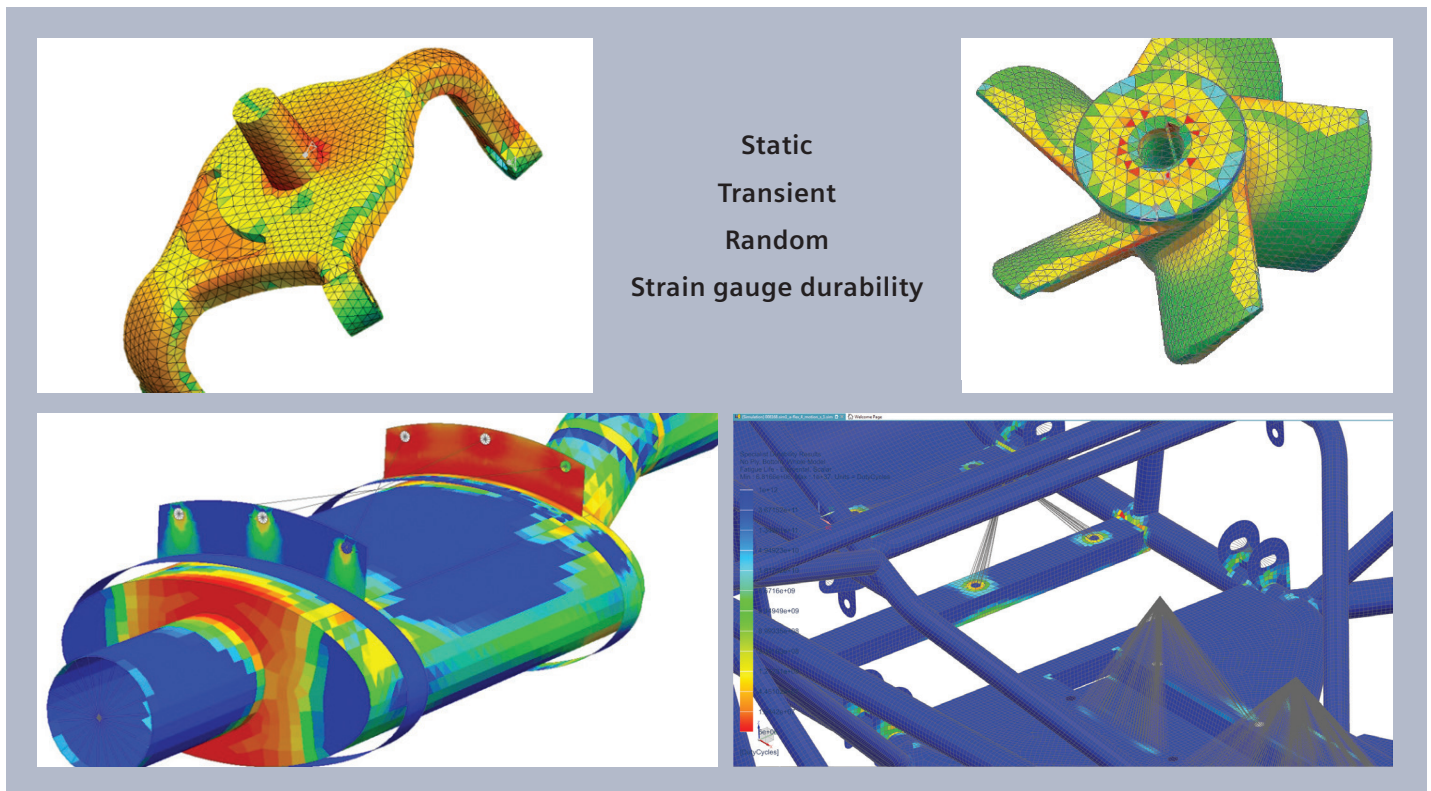
In industrial applications, achieving cost efficiencies depends on critical parts that are typically subjected to large dynamic multiaxial load cases. Any metal component subjected to dynamic loading cycles can be efficiently optimized. Simcenter 3D Durability can be used to determine rotor base fatigue life in large rotating machines.

Medicine

Durability and full function is especially important for medical devices. Simcenter 3D Specialist Durability is used to avoid failures of critical systems.

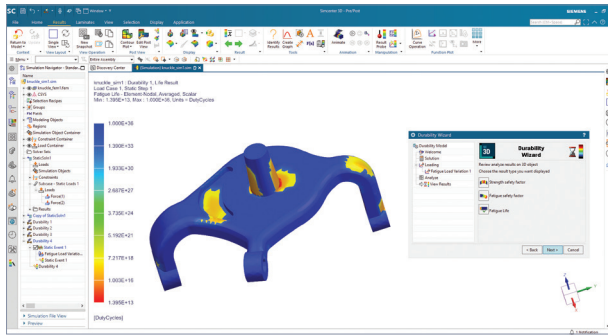
Marine

Simcenter 3D Specialist Durability connection modeling allows you to have a digital twin for the kilometers of welds performed in ship structures. For high-end yachts with lots of composite materials, the Simcenter 3D Specialist Durability Composite Fatigue module facilitates state-of-the-art analysis.



Simcenter 3D Durability wizard

Simcenter 3D Durability wizard is a simulation wizard for calculating the fatigue life of mechanical components subjected to cycles of loading. This solution is performed after users have calculated a stress state from static loading using a finite element (FE) solver. The durability algorithms in the wizard are based on the crack initiation method for fatigue analysis.



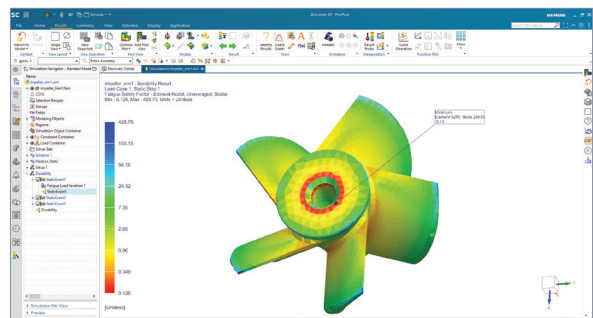
Durability Report			
Durability 5			
Fatigue Load Variations			
Load Variation	Number of Cycles	Scaling Factor	Scaling Function
Fatigue Load Variation 1		1	1.00000 Half Unit Cycle
Fatigue Analysis Options			
Evaluation Type			
Options			
Stress Safety Factors			
Ultimate			
Von_Mises			
Number of Fatigue Duty Cycles: 1e+20			
Fatigue Safety Factors			
Fatigue Strength Factor: 1			
Fatigue Life			
Stress_Life			
Results			
Coordinate System			
Absolute Rectangular			
Number of Load Cases:			
Load Case 1: Number of Iterations = 1			
Iteration 1			
	Strength Safety Factor(Unitless)	Fatigue Safety Factor(Unitless)	Fatigue Life(DutyCycles)
Max	7.67E+01	4.65E+03	1.00E+36
Min	1.74E+01	4.11E-01	2.39E+16

Module benefits

- Improves robustness by predicting the life of product designs and determining which design features are over- or under designed
- Reduces physical testing costs by allowing you to analyze product life in a virtual environment
- Accelerates product design by allowing designers to quickly perform what-if reanalysis of new designs
- Understand the impact of changes to product durability

Key features

- Use linear stress or strain results in static solutions with NX™ software stress wizard, Simcenter Nastran® software, MSC Nastran, Abaqus and ANSYS
- Define the cyclic loadings that define the duty cycle of the part over its lifetime
- Compute static safety factors, fatigue safety factors and fatigue life
- Available fatigue criterion: Smith-Watson-Topper, strain or stress life
- Display contour plots for strength safety factor, fatigue safety factor or fatigue life
- Prepare a technical durability report



Simcenter 3D Specialist Durability Modeling

Simcenter 3D Specialist Durability Modeling provides a rich and intuitive tool set to prepare solutions, send them to the solver and postprocess durability results. It starts with the new strength and durability wizard and enables the setup of complex durability scenarios with many finite element and load history cases. Durability solutions may be configured using the provided parameters or configured to follow the standard procedures of the user.

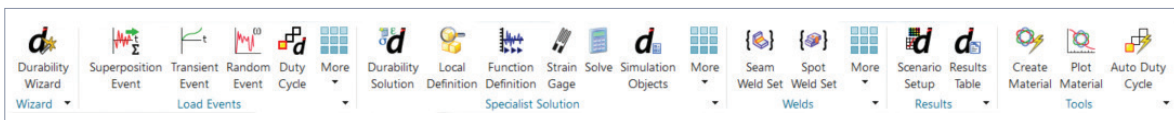
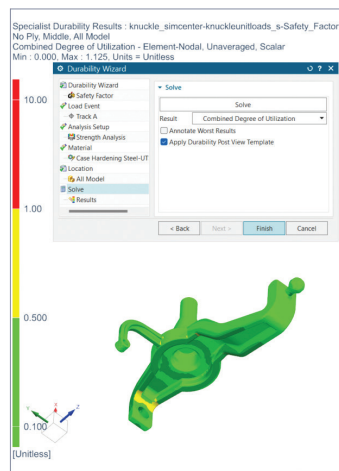
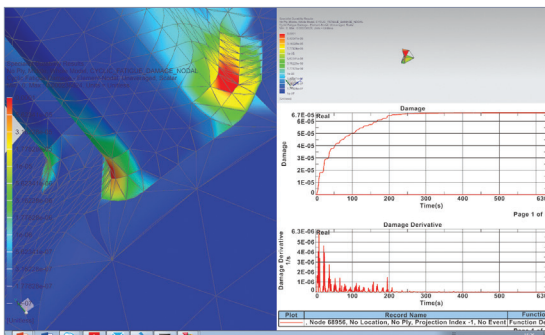
Simcenter Specialist Durability starts with a standardized setup using a wizard then with just a few mouse clicks enhances the tests with all the state of the art lifeing and fatigue tools. A wide range of results are also included, from automated results plots in the wizard to detailed analysis of events, damage, remaining useable lifetime and more.

Module benefits

- Intuitive and flexible parameter-based setup
- Full range of analysis in one tool
- Quickly isolate fatigue-critical events, locations and load cases under complex duty cycles
- Understand the cause of fatigue problems

Key features

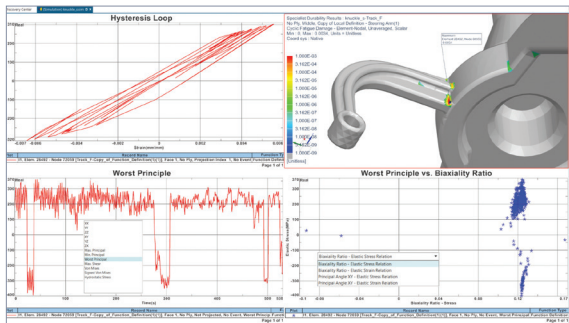
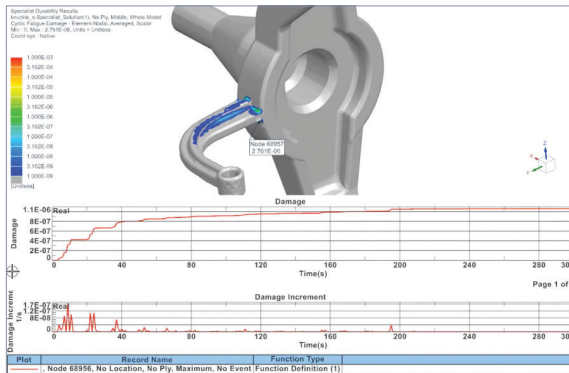
- Automated use of finite element, loads prediction, and motion results
- Parameter-driven analysis templates, solver profiles and durability simulation objects
- Direct component-load importing from prototype measurements smart virtual sensors or Simcenter 3D multibody simulation and third-party, time-data formats
- Direct access to Simcenter 3D materials databases, dedicated tools to create and access durability data, and fatigue material databases
- Integration with Simcenter Testlab™ software load-data processing tools for durability load-case selection
- Assign complex duty cycles to assemblies and their connections, including seam and spot welds
- Dedicated 2D and 3D postprocessing scenarios for application specific plots



Simcenter 3D

Specialist Durability solver

The Simcenter 3D Specialist Durability solver is the modern open release of the well known FALANCS solver, used for strength, fatigue, and lifing analysis. It automatically extracts the load and temperature cycles from any load event. It may be run on the same computer or independently in batch mode including parallel process. It provides all standard durability methodologies but may easily be extended with any fatigue methodology due to unique openness via user-defined fatigue methods.



Module benefits

- Reduce fatigue analysis time
- Quick and accurate fatigue-life predictions based on realistic loading conditions
- Explore multiple design options and optimize the design for fatigue performance

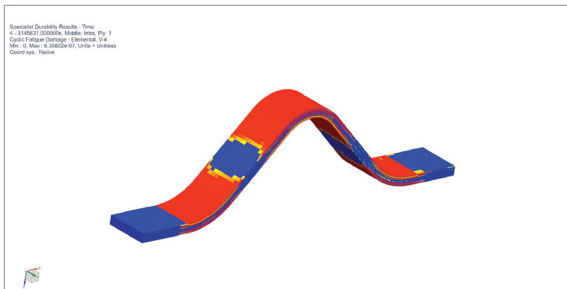
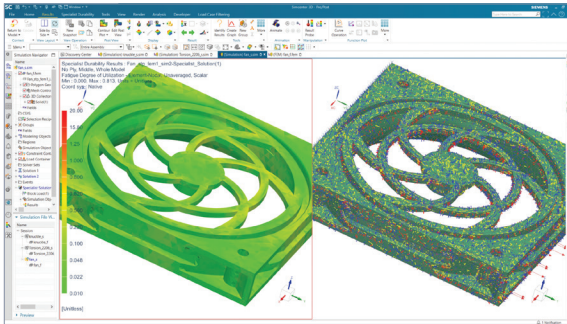
Key features

- Industry standard fatigue-life solver with proven accuracy and speed
- Parallel processing enabled with the standard license
- All industry standard methods
- New and unique user defined methods interface
- Batch processing
- Easily extensible by user defined methods

Simcenter 3D

Specialist Durability Composite Fatigue

Simcenter 3D Specialist Durability Composite Fatigue provides a unique methodology for analyzing short and continuous-fiber composites. It can incorporate stiffness reduction and stress redistribution during the fatigue life of composites under complex load situations. New technologies reduce the effort it takes to test for parametrization of the methods.



Module benefits

- Know the real progressive damage behavior of your composite material
- Allows damage-tolerant design
- Ability to predict fatigue damage to composite material
- Defined parameter identification processes available

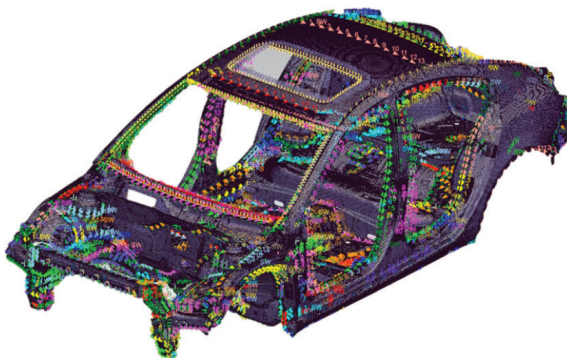
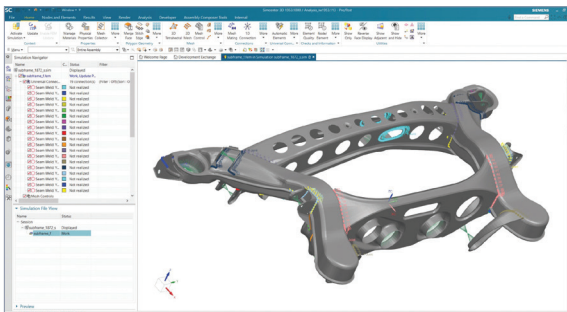
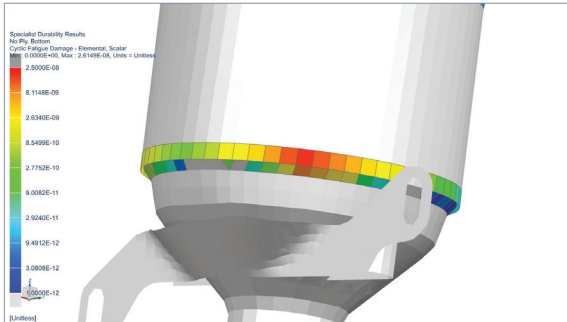
Key features

- Unique workflow that enables stiffness reduction and stress redistribution
- Variable amplitude and multiaxial loads
- Ply-based fatigue behavior modeled without the need for full stacking tests
- Master SN-curve approach for arbitrary short-fiber orientations
- Intra- and Interlaminar methods for continuous-fiber composites
- User-defined methods, including stiffness reduction and stress redistribution

Simcenter 3D

Specialist Durability for Connections

Simcenter 3D Specialist Durability for connections allows you to set up and conduct special spot weld and seam weld analysis runs. Welds are taken from connections modeled in Simcenter 3D, defined in the xMCF format, or detected in existing meshes. The load setup and analysis are conducted with the same tools from Simcenter 3D Specialist Durability Modeling and may even be mixed in the same analysis case.



Module benefits

- Comprehensive software to predict fatigue of seam and spot welds under arbitrary loading conditions
- Provides accurate predictions of seam weld fatigue life without remodelling
- Increases engineers' throughput by enabling automatic detection of weld topologies
- Powerful software to handle welded assemblies irrespective of size and number of welds
- Efficiently handles both traditional approaches and most accurate approaches on the same model
- Validate more weld variants and their fatigue life within shorter development cycles
- Understand and improve fatigue testing for seamwelded assemblies

Key features

- Innovatively designed algorithms: Automatic detection of welds and weld geometry from FE models and groups based on joint types, penetration grade and sheet thickness
- Support industry typical FE connection modeling for seam and spot welds
- Handles all load cases: transient, random, harmonic, proportional and non-proportional and schedules
- Special tools for seam welds: Mesh independent notch stress method (R1MS, R03MS, R005MS), including notch effects (effective notch stress method) using the microstructural length p^*
- User-defined methodologies can access all weld data

Capabilities chart

General capabilities	Specific capabilities	Simcenter 3D Durability Wizard	Simcenter 3D Specialist Durability Modeling	Simcenter 3D Specialist Durability solver	Simcenter 3D Specialist Durability Composite Fatigue	Simcenter 3D Specialist Durability for Connections
Loads and stresses	Loads from Simcenter Testlab		•	•	•	•
	Loads from industry test formats (IST, MSC, EDAS,...)		•	•	•	•
	Loads from Simcenter 3D Motion		•	•	•	•
	Loads from Simcenter 3D Smart Virtual Sensing		•	•	•	•
	Finite element results (Simcenter Nastran, Simcenter Samcef, ABAQUS, ANSYS, universal format)	•	•	•	•	•
	Non-Linear stresses and/or strains		•	•	•	
	Block load events	•	•	•	•	•
	Superposition events (unlimited number of loadcases, automatic matching)		•	•	•	•
	Transient events (editor to select increments, change order, invert ordering)		•	•	•	•
	Pre-stress and static load cases		•	•	•	•
	Flexible event (directly analyse Simcenter3D Motion Flexible Body)		•	•	•	•
	Smart virtual sensing specialist durability event		•	•	•	•
	Duty cycle events		•	•	•	•
	Duty cycles from spreadsheets		•			
	Materials	Simcenter 3D material database	•	•	•	•
Generation of material set based on existing material data (UML, universal slope, ...)			•			
Material individually assigned to selection and groups		•	•			
Weld standard data (IIW, Eurocode, BS, ...)			•			
Durability databases			•			
Setup	Directly from finite element calculation	•	•			
	Inherit or overwrite materials	•	•			
	Temperature-dependent fatigue material data		•			
	Parameter databases		•			
	User defined analysis templates - define methods and parameters in one selection		•			
Fatigue methods and solver	High cycle fatigue – stress-life	•	•	•		
	Low cycle fatigue – strain-life	•	•	•		
	Infinite life – safety factor / margin of safety / degree of utilization	•	•	•		
	User defined fatigue methods		•	•		
	Structural stress seam weld analysis					•
	Notch stress seam weld analysis (incl notch severity)					•
	Stress based spot weld analysis					•
	Force based spot weld analysis					•
	User defined weld methods					•
	Multiple mean stress influence methods		•	•	•	•
	Multiaxial fatigue		•	•	•	•
	Notch/size effects – stress gradient correction		•	•	•	•
	Localized parameters (material/parameter map)		•	•		
	Fatigue below surface method		•	•		
	Use material data for user defined probability of survival		•	•		•
Multiple damage accumulation rules (linear)		•	•	•		
Short-fiber reinforced composites (reference SN-curve approach)				•		

General capabilities	Specific capabilities	Simcenter 3D Durability Wizard	Simcenter 3D Specialist Durability Modeling	Simcenter 3D Specialist Durability solver	Simcenter 3D Specialist Durability Composite Fatigue	Simcenter 3D Specialist Durability for Connections
Fatigue methods and solver <i>(continued)</i>	Intra-ply fatigue of endless-fiber composites (unidirectional/woven. etc)				•	
	Inter-ply fatigue of endless-fiber composites (unidirectional/woven. etc)				•	
	Automatic iteration of FE runs to account for global stiffness changes				•	
	Arbitrary damage accumulation				•	
	User defined damage rules for composites				•	
	Parallel processing (local and on external machines)		•	•	•	•
	Different methods (e.g. stress-life and weld) on different locations(groups) in one analysis		•	•	•	•
	Different methods (e.g.different parameters) on one group in one analysis		•	•	•	•
Postprocessing	Damage/lifetime	•	•	•	•	•
	Detailed analysis of stress and strain (max/min/max amplitude, mean)		•	•	•	•
	Mileage/Real lifetime		•	•	•	•
	Remaining usable lifetime		•	•	•	•
	Design life factors		•	•	•	•
	Safety factors / Degree of utilization	•	•	•	•	•
	Temperature overview (min/max), Modeller and solver		•	•	•	•
	Individual for groups		•			
	Individual for events of duty cycles		•			
	For intermediate time steps		•		•	
	Hot spot detection		•			
	Detailed function analysis on strain gauge and individual nodes/elements		•			
	Function analysis on all critical planes		•			
	Biaxiality plots		•			
	Hysteresis plots		•			
	Parametric plots of stress/strain/temperatures (peanut plots)		•			
	Damage accumulation time histories		•			
	Load contribution analysis		•			
Event contribution analysis		•				

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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