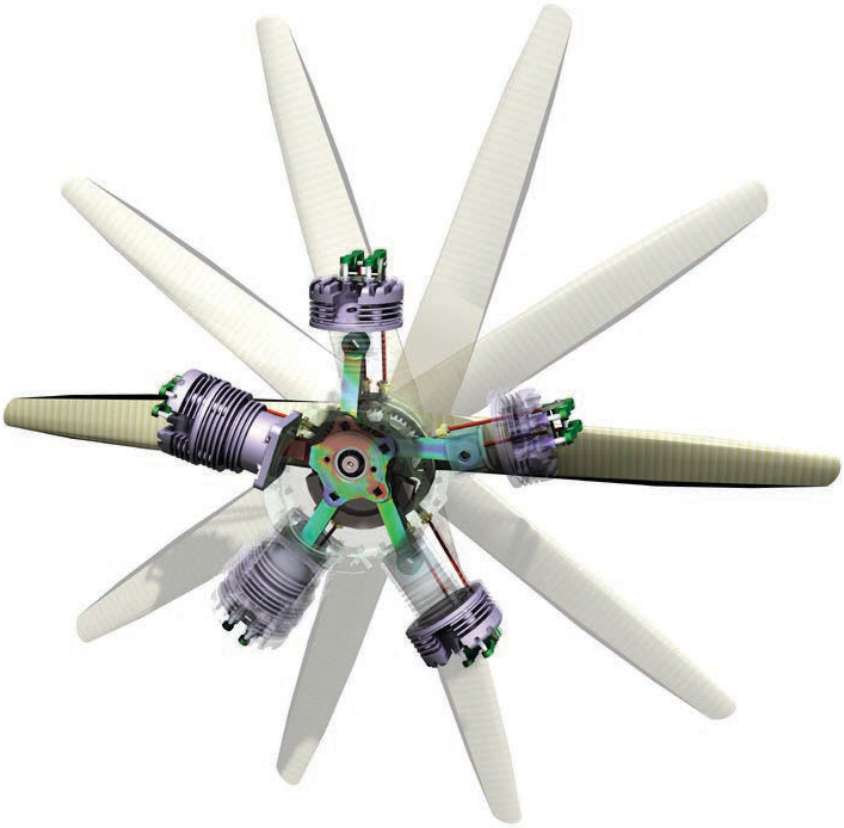
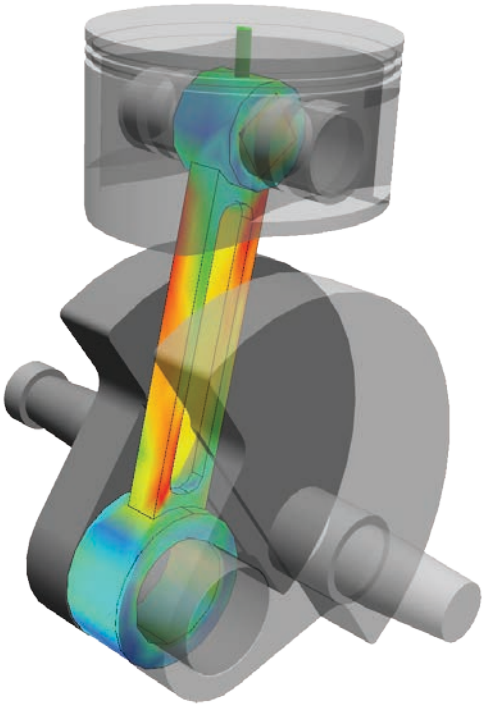
SimWise 4D

Integrated Motion, Stress Analysis and Optimization





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SimWise 4D

Integrated Motion Simulation Stress Analysis and Optimization

SimWise 4D is a software tool that allows the functional performance of mechanical parts and assemblies to be simulated and validated. It combines 3D multi-body dynamic motion simulation with 3D finite element analysis and optimization in a Windows based, CAD neutral product, priced affordably for every engineer. Each of the major components of SimWise 4D, the motion module, and the FEA module, is available as a separate product and are powerful in their own right but the real benefits arise when the two are combined together in the 4D product.

Designs that are made up of moving mechanical parts present challenges when it comes time to answer fundamental questions like “Does it work?”, “Will it break?”, “How can it be designed better?”, and “How long will it last?”.

Dynamic forces are hard to calculate and the part stresses induced by motion are even more difficult to quantify. Many of these designs are validated in the test lab or in the field using prototypes of pre-production designs. If problems are found the designs must be revised and the process repeated, resulting in a costly and time-consuming approach to product validation

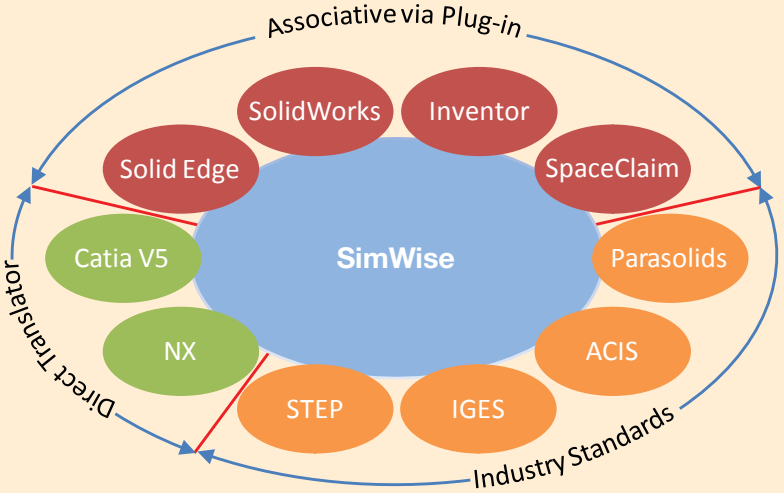
SimWise 4D gives you the ability to explore the functional performance of your design before prototypes are built. Options can be explored in a timely and cost effective manner because hardware does not need to be built until you have confidence that your design works as intended. The capabilities of SimWise 4D make “getting it right the first time” more than just a slogan; it makes it an integral part of your design process.

CAD Independence

All of the SimWise products are independent of any CAD system. Simple geometry, suitable for creating basic design layouts, can be created within SimWise. The detailed geometry required for accurate simulation can be imported from most major CAD systems. SimWise can directly read files created by Catia V5, Creo Elements/Pro, SOLIDWORKS, Solid Edge, Autodesk Inventor, and Siemens NX.

Additionally IGES, STEP, ACIS, and Parasolids files can be read.

SimWise provides add-ins for SOLIDWORKS, Solid Edge, Autodesk Inventor, SpaceClaim Engineer, and Geomagic Design that transfer parts and assemblies from these CAD systems together with any assembly constraints directly into the SimWise database. If the parts or assemblies are updated in these CAD systems, the updates can be sent to SimWise and only the effected parts of the simulation model will be updated.



SimWise can access data from a wide variety of CAD systems

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SimWise Motion
3D Motion Simulation

SimWise Motion is rigid body kinematics and dynamics simulation software that lets your build and test functional virtual prototypes of your designs on the computer and simulate the full-motion behavior of those designs. It imports geometry, mass properties, and constraints from your CAD system and allows you to add motion specific entities to the model resulting in a functional operating prototype of your design. It simulates that prototype using advanced physics and mathematical techniques and presents the results of the simulation in various graphic and numeric formats. You can quickly determine how your design operates and determine if it meets your design objectives or if modifications are necessary. All on the computer, all without costly and time-consuming physical prototypes.

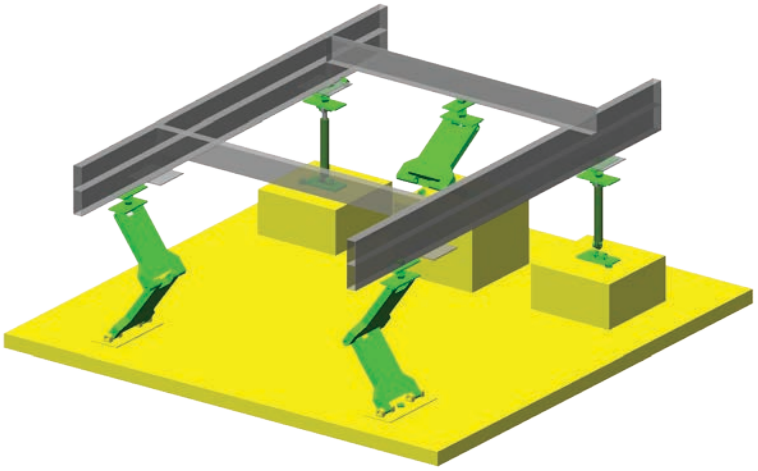
SimWise Motion has a rich set of functional objects that are added to your CAD model to build a functional operating prototype. These objects include:

- Rigid, revolute, spherical, curved slot, planar constraints
- Rods, ropes, springs, gears, belts, pulleys, conveyors
- Bushings (flexible connections)
- Motor and actuators
- Point forces, torques, distributed forces, pressure, friction forces

Collisions between parts are handled easily allowing the simulation of mechanisms like ratchets, clamps, grips, and others that rely on contact between two or more parts to operate. Contact forces and friction forces that occur at the time of contact are calculated and available for plotting, query or use by SimWise FEA.

Motors, actuators and forces can be driven by the SimWise formula language, tabular data, values in an Excel spreadsheet, or by a Simulink™ model co-simulating with SimWise Motion. This allows phenomena like motor start up and spin-down characteristics, variable speed actuators, and electro-mechanical controllers to be incorporated in the simulation model.

Assembly constraints from CAD systems are automatically and associatively converted to SimWise Motion constraints. Many times CAD assembly models are over constrained so a “constraint navigator” is available to walk through each motion constraint and modify as necessary to remove redundancies. Limits can be set for constraints to model rotational or translational “stops”. Friction forces can be activated on an individual constraint basis by specifying the



Powerful Formula Language and Function Builder

SimWise contains a powerful formula language that allows simulation entity properties, instantaneous simulation values, and mathematical expressions to be combined into an expression that is evaluated during the simulation and which can be used to define physical values in the simulation. Formulas can also be used to generate values for display on meters. For example the formula:

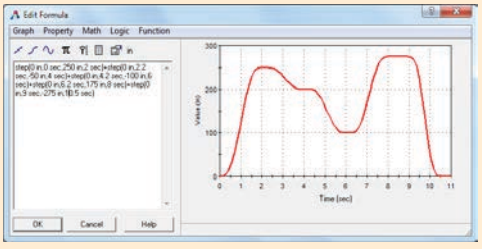
```
0.5*Body[49].mass*mag(Body[49].v)*mag(Body[49].v)
```

When added to a meter will display a graph of the kinetic energy of Body[49].

The formula language can also be accessed using a function builder that allows equations to be assembled interactively. The function builder contain an integrated graphing capability so as a function is defined, its graph is displayed and updated.

Programmability

SimWise contains a very rich automation interface which allows it to be both interfaced with and controlled by other applications. Programming languages such as C++, C#, Visual Basic, Java, and even vbScript can be used to customize SimWise. You can automate the integration of SimWise into your proprietary processes and your proprietary calculations can be used from within the SimWise environment.



The function builder allows complex functions to be defined graphically

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SimWise Motion
3D Motion Simulation

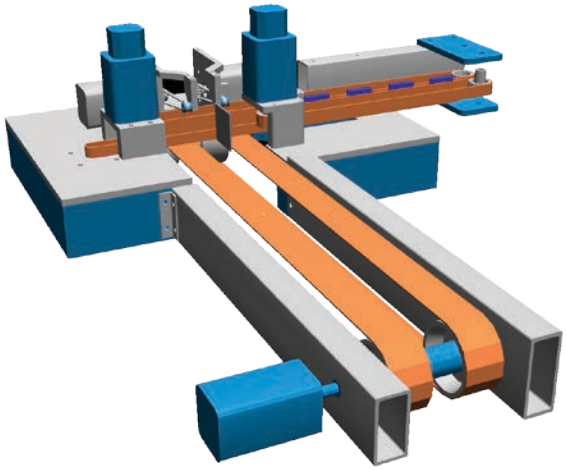
friction coefficient and a physical dimension based on the constraint type.

All SimWise Motion objects can be selectively made active or inactive based on some criteria defined by the SimWise formula language. For example, a rotational constraint can be active as long as its reaction force is below a specified value. Once the reaction force exceeds the value, the constraint will deactivate and no longer constrain its attached parts. This would model the effect of the constraint "breaking" due to the internal forces being too high.

The SimWise Motion simulation engine calculates the displacement, velocity, and acceleration of each body in the motion model and reactions forces that act on each body as a result of its dynamic motion. This includes the motion and forces that result from any collisions between parts.

Each of these quantities can be displayed on meters either in graph or digital format. The values can be accessed with the formula language or tabulated on an HTML report. Graphical vectors can be created that visually show the quantities calculated during the simulation. The vectors can change size and direction as the quantities they display change. Motors and actuators can report their force or power requirements to help you determine the proper sizing of these elements, and parasitic losses due to friction can be determined.

SimWise Motion help you to answer the question "Does it Work?" and provides the data necessary for SimWise FEA to help you answer the question "Will it Break?".



SimWise Motion supports a conveyor constraint for modeling materials handling

Photorealistic rendering and animation

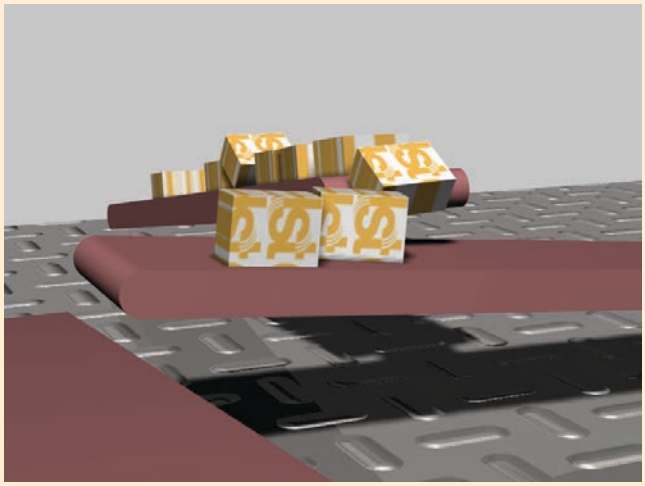
SimWise uses high quality, high performance rendering technology from Lightworks. Multiple light types and sources, texture mapping, shadowing and other effects are available. Combined with the SimWise animation capabilities it can produce very realistic "movies" of a design as it operates. Stress contour results can also be incorporated in the animations. You can watch your design operate and see how the stresses induced by the operation effect individual parts. The rendered animations and images can be exported to formats that allow placement on web sites, in documents, and presentations.

Cameras that move in space or which can be attached to parts are supported. This allows you to produce "fly-through" type animations or view the design operating from a "birds-eye" view as if you were sitting on one of the parts.

SimWise also provides an animation technique known as keyframing. With keyframing you can specify motions in ways that are not based on physics. For example, you can script a corporate logo flying through the air, or a parts-exploding automobile engine to show how it is assembled. Even cameras can be keyframed to create "movie-like" scenes that pan, zoom, and highlight product features. You can also combine physics-based, simulated movement with keyframed animation to create complex motion sequences.

Annotation and Mark-up

Annotations in the form of text, call-outs, and distance and radial dimensions can be added to the simulation model. The distance dimensions are active in that they update if the model is moved or animated. SimWise also provides a distance dimension that shows the points of closest approach and the minimum distance between two bodies. This dimension also updates as the bodies move.



Texture mapping, reflections, and shadows can all be used in animations

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SimWise FEA

Mechanical Stress and Thermal Analysis

SimWise FEA is a Finite Element Analysis tool that performs stress, normal modes, buckling, and heat transfer analysis on mechanical parts. It is highly automated and handles much of the complexity associated with FEA while offering powerful features for users who are steeped in the intricacies of the Finite Element Method.

It imports geometry from your CAD system and allows you to add structural and thermal specific entities to the model resulting in a functional structural prototype of your design. It simulates that prototype using advanced physics and mathematical techniques and presents the results of the simulationin various graphic and numeric formats. You can quickly determine whether your design is robust enough to operate as intended or if modifications are necessary. All on the computer, all without costly and time-consuming physical prototypes and before warranty issues arise.

SimWise FEA has a rich set of functional objects that are added to your CAD model to build a functional structural prototype. These objects include:

- Concentrated loads, distributed loads, torques, and pressures
- Restraints and enforced displacements
- Prescribed temperatures, conductive and convective heat flux, and radiation

All of these values can be driven by the SimWise formula language. All of these objects are applied to the underlying geometry, not to nodes and elements as in a traditional FEA product.

SimWise uses a fast iterative Finite Element Analysis solver that takes advantage of multi-core processors and which is based on a Preconditioned Conjugate Gradient method. SimWise FEA exclusively uses ten-node tetrahedral elements and the solver is optimized for this type of problem.

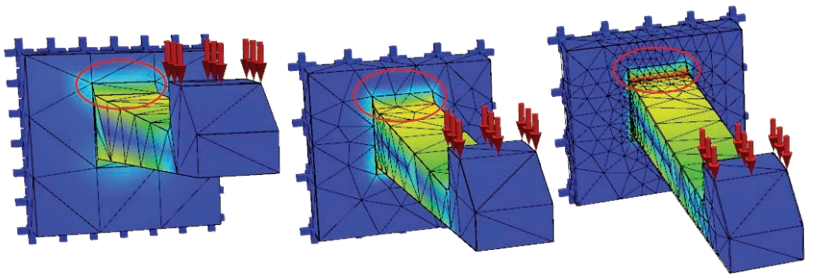
SimWise FEA performs the following types of analyses:

- Linear Static Stress
- Steady State Thermal
- Trasient Thermal
- Normal Modes
- Buckling
- Combined Thermal/ Structural

SimWise FEA can display FEA results as shaded contours, deformed shapes, or animations. In addition to these engineering values, SimWise FEA also calculates factors of safety and errors in the stress results and both of these can be displayed as shaded contours.

The error results can be used to drive an iterative solution process called h-adaptivity where the error results are used to refine the Finite Element mesh in areas with large error values and use that new mesh to run another solution. The errors in the new solution are compared to a goal and if error values in the model still exceed the goal, the process is repeated with successive mesh refinements and analyses until the error goal is achieved. Confidence in the results are increased and no special knowledge about appropriate meshing techniques is required.

If more control over the mesh is required, SimWise FEA provides mesh controls that can be attached to geometric faces or edges. The control allows the mesh size to be specified on that particular feature and the resulting 3D mesh will be the specified size along or across the geometric feature.



Initial Mesh - Error 13% *Refinement 1 - Error 8%* *Refinement 2 - Error < 5%*

h-Adaptivity refines the mesh until an error threshold is achieved

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SimWise 4D
Optimization

Optimization allows you to answer the **"How can it be made better?"** question about your design.

Once you know a design will work and is strong enough to operate safely, you can start to consider making trade-offs between product attributes in the areas of weight, cost, manufacturability, and performance. SimWise 4D includes the HEEDS® optimization engine from Red Cedar Technology which, using its unique SHERPA algorithm, rapidly iterates through many design alternatives looking for design parameters that meet all targets and criterias.

Three things are needed for optimization:

- **Parameters** – The values that will be changed to achieve an optimized objective. These can be any type of SimWise value, such as the stiffness of a spring, or the location of a joint.
- **Objective** – The value(s) to be optimized. Any SimWise quantity that can be displayed on a meter along with most SimWise object attributes can be an objective.
- **Constraints** – Place bounds on the optimization. Any SimWise quantity that can be displayed on a meter along with most SimWise object attributes can be used as a bound.

As the optimization runs, the engine will choose different values for the parameters and run multiple Motion, FEA, or Motion+FEA simulations. The high performance SHERPA search algorithm in the HEEDS® engine guide the choice of parameter values. The data from each run are preserved and can be reviewed. Each run is ranked in terms of how it meets the optimization criteria and the rankings can be used to arrive at the final values used for your design.

If your SimWise model was transferred from a CAD system via one of the CAD Plug-Ins, then you can also choose to transfer Design Variables and Dimensions from the CAD system to SimWise. These Variables and Dimensions can also be used as a Parameter, Objective, or Constraint in the optimzation process. Each time the optimzation engine determines that a CAD Variable or Dimension needs to be changed, the CAD system will be passed the new value, the model will be updated, and transferred back to SimWise for the next optimization step. The complex process of updating the CAD model, and running mutliple Motion and/or FEA analyses is completly managed by SimWise.

Some of the benefits of using SimWise Optimization include:

- **Reduced development costs and improved product performance** - With the optimization methods available in SimWise coupled with its integrated Motion and FEA solvers and associative links to CAD, you can uncover new design concepts that improve products and significantly reduce development, manufacturing, warranty and distribution costs
- **Sensitivity studies** - Use SimWise Optimization to identify the variables that affect your design the most. You can then ignore variables that are not important or set them to values that are most convenient or least costly. This allows you to control quality more effectively while lowering cost.
- **Lets you focus on innovative design** - There's no need to experiment with different optimization algorithms and confusing tuning parameters for each new problem. The HEEDS SHERPA algorithm adapts itself to your problem automatically, finding better solutions faster, the first time.

Best of all there is nothing extra to purchase. All of the capabilities needed to peform sophisticated, analysis driven optimization are part of SimWise 4D.

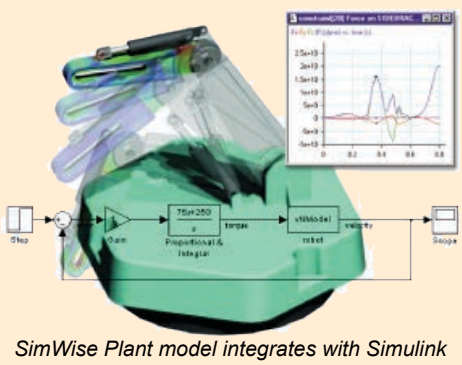
Simulink Interface

MATLAB® /Simulink is widely used to design and simulate control systems in a variety of domains. As products grow more sophisticated, many mechanical assemblies are run by controllers and the ability to simulate the controller together with the mechanical system is necessary.

SimWise can functon as a "plant" model in Simulink which allows a SimWise model to be placed in a Simulink model as a block representing the mechanical model.

Any SimWise value displayed on a meter can be defined as an "ouput" signal from the Plant Model and be connected to another Simulink block's input.

A Simulink block's output may be connected to an input control in SimWise and the input control can be mapped to almost any numeric attribute of a SimWise object. For example the amount of force generated by a linear actuator or the speed of a rotary motor.



SimWise Plant model integrates with Simulink

Benefits:

- Control engineers can test their control algorithms with dynamic mechanical models including phenomena like 3D contact and friction.
- The mechanical engineer and the controls engineer can combine their independant models.
- Development time and cost can be saved by evaluating the controller and mechanical system early in the design process without having to build physical prototypes.

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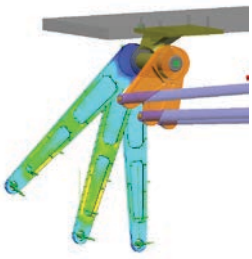
SimWise Durability
Fatigue Life Analysis

SimWise Durability is an add-on module to SimWise 4D that allows you to answer the "**How long will it last?**" question about your design before you ever build a prototype.



Fatigue damage is one the most common causes of structural failure, and can lead to disastrous outcomes. Therefore, prediction of structural fatigue life is essential in modern product design.

SimWise 4D already calculates the dynamics loads that result from the motion of a mechanism, and the stresses and strains that result from those dynamic loads.

SimWise Durability applies widely accepted FEA fatigue calculations to the stress/strain history to determine the part fatigue life. It presents this data as a shaded contour plot just like FEA stress or temperature results. From this you can quickly determine if the part life is within the design objectives, and if not, where changes need to made to improve fatigue life.

SimWise Durability provides about 150 different materials containing fatigue properties per SAE J1022.

Fatigue life can be calculated using uni-axial or biaxial methods and SimWise Durability supports both.

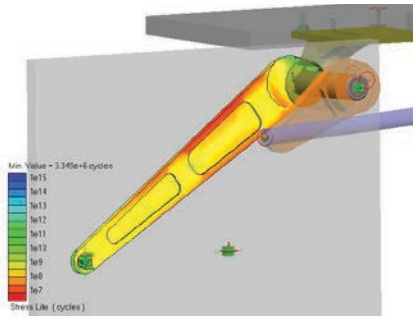
The following calculation methods are supported:

- Manson Coffin
- Morrow
- Basquin
- ASME
- BWI Weld
- Smith-Watson-Toper
- Max Shear Strain
- Goodman
- Gerber
- Dang Van

Benefits:

- Reduce reliance on physical tests and avoid costly design and tooling changes.
- Reduce costs and weight by assessing more design options.
- Perform better physical tests by simulating first.
- Reduce warranty costs by reducing failures.

SimWise 4D is a prerequisite for SimWise Durability.



Fatigue life plot of a door arm

An unprecedented Value Proposition

There are many options when choosing a set of CAE tools; FEA applications, 3D Dynamic Motion applications, CAE tools that are part of CAD systems. SimWise sets itself apart in this crowded field because it offers unsurpassed value.

Consider that for a fraction of the price of some single-purpose CAE tools, SimWise delivers:

- 3D Dynamic Motion Simulation including contact, friction, formulas, and more.
- Linear static, normal modes, buckling, steady state and trasient thermal and combined thermal and structural analysis.
- Adaptive FEA meshing providing local mesh refinement in areas of hgh stress gradients, producing accurate results with minimal input.
- Combined Dynamic Motion and FEA analysis allowing the stresses that result from the dynamic operation of an assembly to be calculated.
- Optimization using FEA, Motion or combined results.
- Integration with MATLAB/ Simulink for co-simulation of mechanical assemblies and control systems.
- The ability to open and update CAD files directly from SOLIDWORKS, Solid Edge, Autodesk Inventor, NX. Pro/ Engineer, and CATIA.
- Plug-ins for SOLIDWORKS, Solid Edge, Autodesk Inventor, SpaceClaim, and Geomagic Design that allow associated model transfers along with assembly constraints, parameters and dimensions to be used for optimization.
- Key-framed animation coupled with photo-realistic rendering allowing production of high definition videos and fly-throughs of a design in operation.
- Optional Durability module providing fatigue calculations in order to predict product life.

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SimWise 4D Integrated Motion and Stress Analysis

Measurable Parameters
Velocities, accelerations and displacements

Force and torque

Friction force, collisions

Interference detection and closest distance between bodies

Motion Drivers
Motor and actuators

Point forces, torques, distributed forces, pressure

Table input, sliders, Simulink controls

FEA
Stress, strain, deflection, vibration, buckling

Heat transfer, h-adaptivity

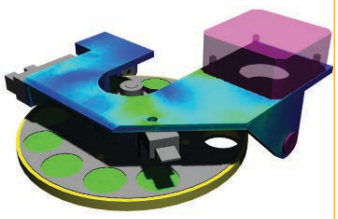
FEA results meter and factor of safety plots

Advanced mesh control

Input Geometry Formats
ACIS, Parasolids[1]

CATIA V5, NX

STEP, IGES



Constraints
Rigid, revolute, spherical, curved slot, planar

Rods, ropes, springs, gears, belts

Bushings

Generic (user-defined)

Fixed constants on body faces for FEA

Integrated Motion and Stress Analysis
Converts joint forces to distributed loads

Transfers inertial information for stress analysis of parts

Calculates stress and strain at every time step

Utilizes finite element technology to solve redundantly constrained assemblies

Optimization
Parameters, objectives and constraints from Motion and FEA objects

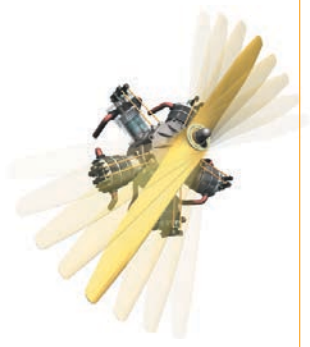
Optimize using Motion, FEA or combined results

CAD dimensions and variables can be used as parameters

Industry leading HEEDS optimization engine

Annotation and Dimensioning
Text and pointer annotations, vectors

Distance and radii dimensions



Animation Capabilities
Flexible key framing and animations of exploded assemblies

Shadows, surface rendering, and texture mapping

Clipping planes to "cut away" sections

AVI video creation

Output
Meter data from simulations in MS Excel format

Snapshot tool automatically creates JPG, TIF, and BMP image files

DAT files

VRML and HTML files for web distribution

Simulation reports

Ease-of-Use Features
Getting Started

Online Tutorial Guide

CAD Environment Emulation

Transient Zoom

CAD and Other Integration
Autodesk Inventor

SpaceClaim

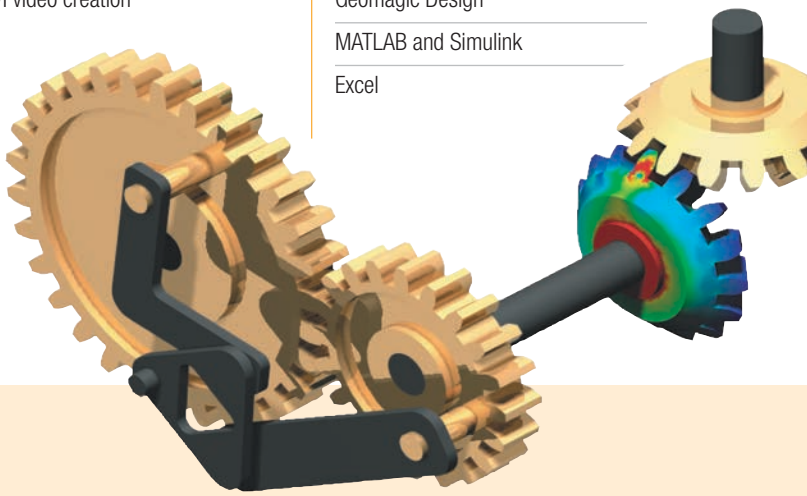
SOLIDWORKS

Solid Edge

Geomagic Design

MATLAB and Simulink

Excel



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Try it free!
Download your SimWise 4D evaluation software at:
www.design-simulation.com/SimWise4D

Questions?
To learn more about SimWise 4D, please call us at:
1.800.766.6615 or 1.734.446.6935

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