Simulate Everything

Altair® HyperWorks® is the most comprehensive, open architecture CAE simulation platform in the industry, offering the best technologies to design and optimize high performance, weight efficient and innovative products.

HyperWorks includes best-in-class modeling, linear and nonlinear analysis, structural optimization, fluid and multi-body dynamics simulation, electromagnetic compatibility and antenna placement, visualization and data management solutions.

Drive Innovation

Over the last two decades, Altair has pioneered simulation-driven design to generate innovative design solutions for its clients, developing and implementing intelligent simulation technologies that allows users to significantly reduce products weight, saving cost, fuel and CO₂ emissions.

Save Money

Altair has made its products available to customers using a patented license management system, which allows metered usage of the entire suite of products.

This value-based licensing model has been extended to partner products, providing a dynamic and on-demand platform that now also includes cloud-based solutions.
“HyperWorks offers our engineers the full potential of CAE in all of its bandwidth at a very competitive price; and, with the third-party products offered within the Altair Partner Alliance, the multidisciplinary portfolio offered by Altair is further increased.” – EADS Innovation Works
**Deliver Exceptional Value – Direct Software Savings**

Traditional software offerings operate usage ‘token’ systems which stack applications. The HyperWorks software products are accessed via a patented licensing system which allows multiple applications to be opened on the desktop and the ‘tokens’ levelled to the maximum token value product.

The HyperWorks licensing system delivers significant cost savings compared against the industry standard stacking systems. In addition, by leveling the tokens to the maximum product value, the company only pays for incremental usage.

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*For multiple users a plateau in licensing costs occurs. This is a function of the leveling and the fact the company is effectively paying only for incremental usage.*

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“*If we didn’t have HyperWorks, our jobs would be much harder, and there would be a lot more guesswork involved without substance to back it up and solve so many of the potential issues we analyze.*” – **Unilever**
For over ten years, Altair has made its products available to customers using its patented license management system. Altair customers purchase a pool of license tokens known as HyperWorks Units (HWUs), which allows metered usage of the entire suite of Altair products. This model has been extended to include third-party products from Independent Software Vendor (ISV) partners, and is known as the Altair Partner Alliance (APA).

Customers can now use their existing pools of HWUs to access a continuously expanding list of partner solutions, across a broad range of disciplines, at little or no incremental cost. It is a revolutionary new paradigm, bringing together our partners and our customers to provide a dynamic, on-demand delivery platform for enterprise analytics applications.

Our Current Solution Library Includes:

- Additive Manufacturing
- Collaboration and Automation
- Composites
- Computational Fluid Dynamics (CFD)
- Crash and Safety
- Design
- Durability
- Electromagnetics
- Manufacturing
- Material Management
- Noise, Vibration & Harshness (NVH)
- Optimization
- Structural Analysis
- System Level Design
- Vehicle Dynamics

For more details, visit altairhyperworks.com/APA

“We see Altair not only as a software supplier but as our reliable partner who proposes a complete software offering and who brings the expertise, as well as the associated technical support we need. Since we use our HyperWorks Units also for the Altair Partner Alliance tools we are more efficient and more flexible on the licenses we own.” – SEGULA Technologies
Altair OptiStruct is an industry proven, modern structural analysis solver for linear and nonlinear simulation under static and dynamic loadings. It is the most widely used solution for structural design and optimization in all industries. OptiStruct helps designers and engineers analyze and optimize structures for performance characteristics such as strength, durability, and NVH, to rapidly develop innovative, lightweight, and structurally efficient designs.

Benefits

- **Fast and Accurate Solver Technology**
  - Most advanced solver for NVH analysis: OptiStruct supports the most advanced features and results output necessary for efficient and insightful noise, vibration and harshness (NVH) analyses and diagnostics.
  - Robust solver for nonlinear analysis and powertrain durability: OptiStruct has grown to support a comprehensive range of physics for powertrain analysis. This includes solutions for heat transfer, bolt and gasket modeling, hyperelastic materials, and efficient contact algorithms.
  - Highly parallelized solver: Through methods such as domain decomposition, OptiStruct can be executed on hundreds of cores providing a high degree of scalability.
- **Seamless integration into existing processes**: Integrated in HyperWorks, OptiStruct can help significantly reduce corporate spending on competitive solver technology, while providing superior analysis workflows.
- **Award-Winning Optimization**
  - Innovative optimization technology: For over 20 years, OptiStruct has lead the development of innovative optimization technology with many first-to-market technologies such as stress and fatigue based topology optimization, topology-driven design for 3D printed lattice structures, and technologies to design and optimize advanced materials such as composites.
  - Optimization-enabled solutions: OptiStruct provides the most comprehensive library of performance criteria and manufacturing constraints allowing the needed flexibility to formulate the widest range of optimization problems.

Product Highlights

- The most advanced solver for NVH analysis
- Full featured solver for nonlinear analysis
- Highly parallelized solver
- 20-year legacy of award-winning structural optimization technology
- Advanced Laminated Composite Optimization Capability

Learn more: altairhyperworks.com/optistruct

Capabilities

- **Integrated Fast and Large Scale Eigenvalue Solver**: A built-in, standard feature of OptiStruct in an Automated Multi-level Sub-structuring Eigen Solver (AMSES) that can rapidly calculate thousands of modes with millions of degrees of freedom.
Creating Design Concepts
- **Topology optimization**: OptiStruct uses topology optimization to generate innovative design proposals. OptiStruct generates an optimal design proposal based on a user-defined design space, performance targets, and manufacturing constraints. Topology optimization can be applied to 1D, 2D and 3D design spaces.
- **Shape optimization**: Shape optimization is performed to refine an existing design through user-defined shape variables. The shape variables are generated using the morphing technology – HyperMorph® – available in HyperMesh®.

Advanced NVH Analysis: OptiStruct provides unique and advanced functionality for NVH analysis including one-step TPA (Transfer Path Analysis), Powerflow analysis, model reduction techniques (CMS and CDS super elements), design sensitivities, and an ERP (Equivalent Radiated Power) design criterion to optimize structures for NVH.

Design and Optimization of Additively Manufactured Lattice Structures:
- **Lattice structures offer many desirable characteristics such as lightweight and good thermal properties. They are also highly desirable in biomedical implants due to their porous nature and the ability to facilitate the integration of tissue with the trabecular structure. OptiStruct has a unique solution to design such lattice structures based on topology optimization. Subsequently, large scale sizing optimization studies can be run on the lattice beam while incorporating detailed performance targets such as stress, buckling, displacement and frequency.**

**Analyses and Feature Highlights**

<table>
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<tr>
<th><strong>Stiffness, Strength and Stability</strong></th>
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<td>• Linear and nonlinear static analysis with contact and plasticity</td>
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<td>• Large displacement analysis with hyperelastic materials</td>
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<td>• Fast contact analysis</td>
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<td>• Buckling analysis</td>
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Noise and Vibrations
- • Normal modes analysis for real and complex eigenvalue analysis
- • Direct and modal frequency response analysis
- • Random response analysis
- • Response spectrum analysis
- • Direct and modal transient response analysis
- • Preloading using nonlinear results for buckling, frequency response, and transient analysis
- • Rotor dynamics
- • Coupled fluid-structure (NVH) analysis
- • AMSES large scale eigenvalue solver
- • Fast large scale modal solver (FASTFR)
- • Result output at peak response frequencies (PEAKOUT)
- • One-step transfer path analysis (PFPATH)
- • Radiated sound analysis
- • Frequency-dependent and poro-elastic material properties

**Powertrain Durability**
- • 1D and 3D bolt pretension
- • Gasket modeling
- • Contact modeling and contact-friendly elements
- • Plasticity with hardening
- • Temperature dependent material properties
- • Domain decomposition

**Heat Transfer Analysis**
- • Linear and nonlinear steady-state analysis
- • Linear transient analysis
- • Coupled thermo-mechanical analysis
- • One-step transient thermal stress analysis
- • Contact-based thermal analysis

**Kinematics and Dynamics**
- • Static, quasi-static, and dynamic analysis
- • Loads extraction and effort estimation
- • Optimization of system and flexible bodies

**Structural Optimization**
- • Topology, topography, and free-shape optimization
- • Size, shape, and free-shape optimization
- • Design and optimization of laminate composites
- • Design and optimization of additively manufactured lattice structures
- • Equivalent static load method
- • Multi-model optimization
Altair RADIOSS is a leading structural analysis solver for non-linear problems under dynamic loadings. It is highly differentiated for scalability, quality, robustness, and consists of features for multi-physics simulation and advanced materials such as composites. RADIOSS is used across many industries worldwide to improve the crashworthiness, safety, and manufacturability of structural designs.

**Product Highlights**

- Best scalability for large, highly non-linear structural simulations
- Most complete material and rupture libraries
- Unique feature for accurate airbag simulations
- Rich multiphysics capabilities
- Wide offer of FE Safety models, dummies, barriers, and impactors

**Benefits**

**Scalability, Quality and Robustness**

RADIOSS’ advanced multi-processor solution (Hybrid Massively Parallel Processing) has enabled the best scalability in the industry for large, highly non-linear structural simulation. Special provisions in the implementation guarantee full repeatability of results regardless of the number of computer cores, nodes, or threads used in parallel computation. Numerical scattering of results is highly minimized.

The use of Advanced Mass Scaling (AMS) and intelligent single precision calculation option increases simulation speed by orders of magnitudes while retaining the same accurate results. AMS provides an advanced and competitive solution for quasi-static problems, model with smaller mesh size locally. AMS is also an alternative to implicit non-linear simulation which has convergence problems due to high non-linearity in the contacts, complex material behaviors, or rupture modeling.

With RADIOSS’ multi-domain approach, detailed and accurate analysis can be achieved with a significant elapse time decrease. The model is split into different domains which are computed with their own and adequate time step. Applications such as detailed meshed parts in a global structure, and ditching (fluid and structure in different domains) have big advantages with the RADIOSS multi-domain approach.

**Industry Standard for Crash, Occupant Safety and Impact Analysis**

For over 30 years, RADIOSS has established itself as a leader and an industry standard for crash, safety and impact analysis. The number of customers continues to increase at an impressive rate to include over 1000 companies worldwide, with 40% of these customers in the automotive industry.

RADIOSS is ranked with a 5-star worthy crash code. Automotive and aerospace companies value the contribution RADIOSS makes in understanding and predicting...
design behavior in complex environments such as automotive and aerospace crash and impact simulations.

RADIOSS has direct access to a large library of finite element dummy, barrier, and impactor models to perform vehicle occupant safety simulation. It provides the most comprehensive and high quality toolset in the industry through partnerships with leading crash and safety testing facilities and model providers.

In addition, Altair’s HyperCrash® modeling environment provides outstanding support for automotive crash and safety simulation with RADIOSS.

**Most Comprehensive Material and Rupture Libraries**

RADIOSS has the most comprehensive material and rupture libraries with more than 300 combinations. A comprehensive collection of linear and non-linear material, failure and rupture models is provided for modeling complex events. Correlated material laws and failure criteria include definitions for concrete, foam, rubber, steel, composites, biomaterials, and more. Multiple failure criteria may be applied to any material. Crack propagation can be followed using an Extended Finite Element Method (XFEM) for multi-layer structures.

**Advanced Multiphysics Simulation**

Besides Lagrangian Finite Element technology, RADIOSS also uses other technologies such as Euler, Arbitrary Lagrangian Eulerian (ALE), Smoothed-Particle Hydrodynamics (SPH), and the Finite Volume Method (FVM).

With Euler, ALE and SPH formulations, RADIOSS enables Fluid-Structure Interaction (FSI) simulation taking into account multiple fluids.

The innovative Finite Volume Method enables full FSI simulation of airbags in full car models with accuracy and speed.

**Optimization Ready**

Integration with HyperWorks makes RADIOSS a powerful design tool. Aside from modeling and visualization, RADIOSS models are ready for optimization. Advanced design optimization and robustness studies can be performed easily through Altair’s OptiStruct® and HyperStudy® products to improve design performance. RADIOSS’ high scalability, quality and robustness are essential for successful numerical optimization.

**High Performance Computing**

With a sophisticated customer base that values performance, reliability, safety, and innovation, the RADIOSS team is committed to supporting the most up-to-date, advanced computing architectures and integrating new technologies to improve performance, scalability, and usability. RADIOSS is leading the industry in understanding many of the state-of-art computing hardware’s potential for powering complex simulation software applications and environments.

**Main features**

- 3D shell and solid elements
- Rigid bodies, bar and beam, and advanced springs elements
- Contact interfaces for structural, fluid and fluid structure interaction analysis
- Large material library with different failure models (XFEM), equation of State and thermal behavior
- All kinds of boundary conditions (imposed motion, imposed force and pressure, initial state, ...)
- Specific boundary conditions for fluids (inlet, outlet, silent, ...)
- Finite Volume (FVM) based airbag simulation with reversible flow vent hole
- Sensors, element activation or de-activation

**Safety models**

- Adult and child models for frontal, side, and rear impact (developed with Humanetics partnership)
- Pedestrian impactors
- Human dummy model
- Frontal, side, and rear barriers (developed with CELLBOND partnership)
- IIHS-RCAR Bumper Barrier

**Features and Capabilities**

**Analysis Types**

- Non-linear explicit dynamic or implicit structural analysis
- Lagrangian, Eulerian, and Arbitrary Euler-Lagrangian (ALE) formulation
- Finite Volume (FVM) based airbag simulation

RADIOSS’ application areas include simulations of crash safety, drop and impact, blast and hydrodynamic impact, fluid structural interaction, terminal ballistics, hyper-velocity impact, forming, and composite mapping.
AcuSolve®

AcuSolve was designed with a philosophy that you shouldn’t have to sacrifice robustness and convenience to achieve accurate results. With AcuSolve, you aren’t forced to spend days or weeks iterating on mesh quality to obtain a stable and accurate solution. Build your mesh, run the solver, and interrogate the solution.

Advanced physics? No problem!
Have applications that challenge your current solver’s capabilities? Eddy resolving turbulent simulations, moving mesh simulations, and fluid-structure interaction are a few such examples that come to mind. AcuSolve’s single solver technology simplifies these simulations for you. There's no need to struggle with differencing schemes, time integration settings, CFL based stability limits, or any other solver setting when investigating complex physics with AcuSolve.

All supported flow regimes are handled by a single solver that doesn't require any tuning for specific applications.

High Speed, Parallel Performance
What really allows you to leverage CFD to its fullest extent is the ability to interrogate multiple design candidates early on in the design process. This requires a fast solution process, which AcuSolve provides via:
• Solution of the fully-coupled pressure/velocity equation system, yielding rapid nonlinear convergence.
• Efficient parallel architecture that provides distributed, shared, and hybrid parallel operation.
• Proven parallel scalability on thousands of compute cores.

Simulation Features
Flow Modeling
AcuSolve’s flow simulation capability focuses on incompressible and subsonic compressible flows. Within this class of

Product Highlights
• Efficient and flexible workflow
• Full set of physical models for flow, turbulence, and heat transfer simulations
• Accurate and stable even on highly skewed meshes
• Fast and efficient solutions for both transient and steady-state simulations
• Parallel scalability demonstrated on thousands of computing cores
• Advanced multi-physics capabilities including rigid body and flexible body coupling

Learn more: altairhyperworks.com/acusolve

AcuSolve is Altair’s most powerful Computational Fluid Dynamics (CFD) tool, providing users with a full range of physical models. Simulations involving flow, heat transfer, turbulence, and non-Newtonian materials are handled with ease by AcuSolve’s robust and scalable solver technology. These well validated physical models are delivered with unmatched accuracy on fully unstructured meshes. This means less time spent building meshes and more time spent exploring your designs.
problems, a full set of material models for investigating Newtonian and non-Newtonian flow fields is available. Specialized flow models, such as Stokes flow, are also available for applications in which the full Navier-Stokes equations are not needed.

### Heat Transfer and Radiation Modeling

AcuSolve supports a full set of features for analyzing heat transfer in both solid and fluid mediums. Supported features include:
- Conjugate heat transfer
- Natural convection
- Enclosure radiation
- Solar radiation
- Thermal shells for modeling thin solids
- Simplified heat exchanger models

### Turbulence Modeling

Altair AcuSolve provides a complete selection of turbulence modeling capabilities to fulfill your simulation needs. Available RANS models include:
- Spalart-Allmaras
- SST
- k-omega

For higher resolution transient simulations, AcuSolve supports the following models:
- Spalart-Allmaras based Detached Eddy Simulation (DES and DDES)
- SST based Detached Eddy Simulation
- Fixed coefficient and dynamic Large Eddy Simulation models

### Moving Mesh Capabilities

AcuSolve supports two approaches for handling deforming meshes. An Arbitrary Lagrange Eulerian (ALE) mesh motion algorithm provides the most general solution for complex motions. Simpler motions are accommodated by AcuSolve’s boundary condition tools that let you define how the motion of a boundary surface should propagate through the model.

### User-Defined Functions (UDF)

AcuSolve permits customization of material models, boundary conditions, source terms, and many other features within the solver by writing your own functions. In addition to the standard set of data access functions within the UDF, AcuSolve also provides client-server programming capabilities. This allows you to couple your CFD simulation with external applications such as control system codes.

### Multiphysics Capabilities

AcuSolve’s advantages for multi-physics computations result from its strength in simulating transient flows and deforming meshes. AcuSolve supports the following multi-physics applications without coupling to external codes:
- Rigid body dynamics of non-interacting bodies
- Linear structural deformations

Coupling to other products in the HyperWorks suite provides the following additional capabilities:
- Finite mass particle tracing (coupling with AcuTrace)
- Multi-body dynamics (coupling with MotionSolve)
- Non-linear structural deformations (coupling with RADIOSS)

### Pre-processing Features

AcuSolve’s dedicated Graphical User Interface, AcuConsole®, contains a full set of options to help you build your CFD models quickly and efficiently. It provides full support for AcuSolve’s features and can be used as an interactive tool or as an automation platform for a batch process.

### Post-processing Features

Post-processing of AcuSolve results is handled by AcuFieldView™, an OEM version of Intelligent Light’s FieldView CFD post-processor. AcuFieldView allows you to post-process your AcuSolve simulations using client-server based parallel operation and comes equipped with a full set of tools to automate the interrogation of your solution.
FEKO® is a leading electromagnetic simulation software that uses multiple frequency and time domain techniques. True hybridization of these methods enables the efficient analysis of a broad spectrum of electromagnetic problems mainly related to antenna design and placement, scattering, radar cross section (RCS) and electromagnetic compatibility (EMC), including electromagnetic pulses (EMP), lightning effects, high intensity radiated fields (HIRF) and radiation hazard.

Product Highlights

• State-of-the-art simulation tool for antenna design and placement, and RCS
• EMC analysis, including emissions, immunity, and shielding effectiveness
• Wide set of hybridized methods to solve large and complex problems
• Specialized tools, including windscreen antennas, arrays, cable modeling, and CMA
• HPC-enabled efficient, reliable, and accurate solvers

Benefits

One Product, Multiple Solvers
By offering a selection of different solvers, FEKO users can choose the method that is most suitable to the problem that they are trying to solve, or use more than one solver for cross validation purposes. All FEKO solvers are sold in a single bundle and are also part of the Altair HyperWorks licensing system.

True Hybridization
FEKO offers industry leading hybridization of different solvers to combine the beneficial characteristics and allow more efficient and accurate analysis of multi-scale problems that are both complex and electrically large.

Specialized Solutions
FEKO was the first to commercially offer a characteristic mode analysis (CMA) solver, which is still today the most proven and reliable. FEKO includes specialized solutions for bidirectional cable coupling, windscreen antennas and large finite arrays. Model decomposition workflows for classical antenna placement and EMC problems enable equivalent representation of the transmitting/receiving antennas and other devices.

Capabilities

Solver Overview
• Frequency and time domain full wave solvers: MoM, FDTD, FEM and MLFMM
• Asymptotic methods: PO, LE-PO, RL-GO, UTD
• True hybridization of methods to solve complex and large multi-scale problems
• Unique CMA solver calculates modal currents, eigenvalues, modal significance and characteristic angles

Learn more: altairhyperworks.com/feko
**Solver Performance Features**
- The FEKO solver is fully parallelized and optimized to exploit multi-CPU distributed memory resources
- GPU-based solver acceleration
- Optimized out-of-core solver to deliver solutions when RAM limits are reached

**User Interface**
- State-of-the-art 3D Parasolid CAD modeling interface, including import/export of CAD and mesh formats
- Integrated mesh engine for generating triangle, tetrahedron and voxel simulation meshes
- Interface to Altair HyperMesh
- Comprehensive post-processing including 1D, 2D, and 3D plots, export of measurement results, report generation, etc.
- Full Lua script automation for modeling, configuration and post-processing, with macro recording support

**Optimization**
- Automated optimization of multi-variable and multi-goal problems with several algorithms, including GA and particle swarm
- Real-time monitoring of the optimization process
- Interface to Altair HyperStudy

**Specialized Solutions**
- Bi-direction coupling with complex cable bundles and along arbitrary cable paths
- Special solver for efficient analysis of antennas integrated into layered windscreens
- Efficient methods for finite and infinite arrays and periodic structures
- Metamaterials and composites

**Model and Domain Decomposition**
- Decomposition of electromagnetic problems to reduce computational cost
- Numerically efficient equivalent sources for complex sources and receivers

**Non-Radiating Networks**
- Lumpked, linear circuit models can be included in a simulation, often used for matching networks
- S-, Z- or Y-parameter files or SPICE circuit file Network definitions

**CADFEKO Features**
Set up the entire problem within the CADFEKO GUI, covering all aspects from geometry modelling to mesh generation.
- CAD and mesh import/export of most major formats including Parasolid, AutoCAD, IGES, STEP, Pro/ENGINEER®, Unigraphics, CATIA V4 & V5, ACIS Exchange (SAT)
- Gerber, ODB++ and 3Di for printed circuit boards
- CAD healing functions for fixing inconsistencies, gashes, slivers, spikes, and filling holes

**POSTFEKO Features**
Visualize and compare simulation and measurement results in the comprehensive POSTFEKO GUI.
- 2D/3D plots and animations of near and far fields (radiation patterns), currents, SAR
- Impedance, S-parameters
- Contours, iso-surfaces, ortho-slices
- Cartesian graphs, polar graphs, Smith charts
- Multiple models, multiple views
- Mathematical operations
- Imported data and measurements
- Export of various data formats, images, and animations

**Report Generation**
Active POSTFEKO sessions can be exported to a PowerPoint, Word, or PDF report. A quick reporting option requires minimal input from the user, while a template-based report may be generated where the user has full control over the content of the document.
Multiscale Designer™

Multiscale Designer is an efficient tool for development and simulation of multiscale material models of continuous, woven, and/or chopped fiber composites, honeycomb cores, reinforced concrete, soil, bones, and various other heterogeneous materials. Applications include multiscale material modeling for design, ultimate failure, statistical-based material allowables, fatigue, fracture, impact, crash, environmental degradation, and multiphysics simulations and provides plugins to commercial FEA solvers; Optistruct, RADIOSS, LS-DYNA, and Abaqus.

Product Highlights

- Develop multiscale material models using forward homogenization and inverse optimization technologies
- Built-in parametric unit cells for unidirectional, woven, chopped, and particulate fiber composites
- Simulate nonlinear material behavior including ultimate failure at the micro-scale
- Obtain virtual material allowables supported by test and perform fatigue analysis
- Efficient plugins to commercial FEA codes Optistruct®, RADIOSS®, LS-DYNA, and Abaqus

Benefits

While a number of multiscale modeling frameworks exist, Multiscale Designer provides unmatched combination of practicality, mathematical rigor, validation, and versatility.

Practicality

Multiscale Designer is equipped with a systematic model reduction technology that simplifies complex unit cells, having hundreds of thousands of finite elements, to a manageable number of deformation modes and state variables. The optimal kinematics (modes and state variables) are automatically selected to provide the desired level of accuracy for quantities of interest. Multiscale Designer is equipped with a built-in parametric library of unit cell models that permit optimization and stochastic simulations. The current parametric library of unit cell models includes; continuous fiber, woven fabrics, short and long chopped fiber, ordered particles, and random particle microstructures. This eliminates the overhead of generating complex unit cell models and their linkage to macro-scale FEA solvers. In addition to the parametric library of unit cells, user defined unit cell models (CAD and/or FEA mesh) can be imported and/or generated entirely within Multiscale Designer.

Mathematical Rigor

Multiscale Designer is free of scale separation and provides mesh insensitive results inherent to competing multiscale products. The characteristic material length scale is automatically identified by Multiscale Designer based on user-specified experimental data at the coupon-level. In addition, Multiscale Designer is equipped with stochastic multiscale capabilities that translate geometrical and material uncertainties into macro-scale component uncertainties.

Learn more:
altairhyperworks.com/multiscale
Validation
Multiscale Designer is integrated with an experimental material database and a multi-step optimization engine that identifies model parameters having a high degree of uncertainty (such as void content, micro-cracks, interface/interphase properties).

Versatility
Advanced Multiscale Designer features include; generation of A- and B-basis material allowables with minimum testing and high accuracy, microstructural optimization, multiscale fatigue, and multiscale multiphysics simulation capabilities.

Capabilities
Mechanical
Multiscale Designer - Mechanical computes linear and nonlinear material models which are subsequently used in a nonlinear analysis to resolve micro-scale fields (stresses and strains at the micro-scale) at a computational cost comparable to that of macro-scale modeling. Both the forward homogenization approach, where micro-scale properties are known prior, and the inverse optimization approach, where micro-scale properties are determined from known macro-scale homogenized properties, are available. Multiscale Designer - Mechanical is based on a micromechanical approach that possesses a minimal number of internal variables representing inelastic deformation of the micro-phases and has been validated against more than 50 benchmark problems of various composite product forms at the coupon and component levels.

Stochastics
Multiscale Designer - Stochastics also provides forward homogenization and inverse optimization stochastic simulation capabilities. The forward homogenization stochastic simulation process computes a probability distribution function for the homogenized macro-scale properties given the variability of the micro-scale geometry and constitutive properties. The inverse optimization stochastic simulation process reverse engineers the probability distribution function of the micro-scale constitutive properties based on the variability of the experimental data at a macro-scale (coupon) level. Multiscale Designer – Stochastics provides the data necessary for the calculation of A- and B-basis material allowables via a virtual allowables supported by test methodology.

Fatigue
Multiscale Designer - Fatigue is based on the two-scale asymptotic homogenization approach in time, and reduced order homogenization in space, that can be effectively applied to any material architecture and any constitutive equations of micro-phases. Multiscale Designer - Fatigue has been validated for chemical vapor Infiltrated (CVI), melt Infiltrated (MI) ceramic composites, and PMR-15 and MVK-14 reinforced carbon fiber composites.

Multiphysics
Multiscale Designer - Multiphysics is based on the unified coupled multiscale mechano-diffusion-reaction model of environmental degradation of polymer and ceramic matrix composites. Multiscale Designer - Multiphysics couples multiple physical processes at multiple scales, including oxygen and/or moisture diffusion, reaction, and deformation. The salient feature of Multiscale Designer - Multiphysics is its computational efficiency accomplished through model reduction for multiple physical processes.
HyperStudy®

HyperStudy provides engineers and designers a user-friendly environment with state-of-the-art design exploration methods and data mining tools to:

• Efficiently understand the relationships between design parameters and design requirements
• Easily sort, analyze, and explore large design data sets
• Perform quick trade-offs between conflicting design requirements
• Quickly calibrate simulation models to correlate with test data
• Increase product life and robustness
• Reduce design development cycles
• Increase the return on their CAE solver investments

Capabilities

Design of Experiments (DOE)
DOE helps engineers to clearly understand the relationships between design variables and overall system performance. DOE methods in HyperStudy include:

• Full factorial
• Fractional factorial
• Box-Behnken
• Plackett-Burman
• Central composite design
• Latin HyperCube
• Hammersley
• User defined
• Direct input of external run-matrix.

Fit Approach
Fit approach is used to create meta-models to replace computationally intensive simulations. They are also used to smooth

Learn more: altairhyperworks.com/hyperstudy

HyperStudy is a multi-disciplinary design exploration, study, and optimization software for engineers and designers. Using design-of-experiments, metamodeling, and optimization methods, HyperStudy creates intelligent design variants, manages runs, and collects data. Users are guided to understand data trends, perform trade-off studies, and optimize design performance and reliability. HyperStudy’s intuitive user interface combined with its seamless integration to HyperWorks makes design exploration technology accessible to non-experts.
noisy functions to enable optimization algorithms to work more effectively. Fit models can be used DOE, optimization, and stochastic studies. HyperStudy’s fit module allows use of different methods for different responses. Available fit methods are:

- Least squares regression
- Moving least squares
- Radial basis function
- HyperKriging

**Optimization**

HyperStudy offers multidisciplinary optimization as well as reliability and robustness optimization. Through multidisciplinary design optimization, engineers can improve the overall design performance. If variations in design and operating environments are critical to design quality, reliability and robustness optimization can be used to reduce the sensitivity of designs to these variations.

HyperStudy contains a comprehensive suite of optimization algorithms that include:

- Altair’s proprietary optimization algorithm adaptive response surface method and global response surface method (ARSM and GRSM)
- Sequential quadratic programming (SQP)
- Method of feasible directions (MFD)
- Genetic algorithm (GA)
- Multi-objective GA (MOGA)
- Sequential optimization and reliability analyses (SORA).
- Single loop approach (SLA)
- User-defined optimization algorithms (through included API)

**Stochastic**

The stochastic approach in HyperStudy allows engineers to assess reliability and robustness of designs and provide qualitative guidance to improve and optimize the design based on these assessments. Stochastic studies can be performed using either the exact simulation or fit model.

HyperStudy sampling methods include:

- Simple Random
- Latin Hypercube
- Hammersley
- Statistical distribution functions (Normal, Uniform, Triangular, Weibull and Exponential)

**Post-Processing and Data Mining**

HyperStudy helps engineers to gain a deeper understanding of a design through extensive post-processing and data-mining capabilities. This significantly simplifies the task of sorting, analyzing and exploring large design data sets. Some of the available tools are:

- Correlation matrices
- Scatter plots
- Effects and Interactions tables and plots
- Histograms
- Parallel coordinate plots
- Box plots

**Parameterization of Analysis Models**

HyperStudy has a number of models among which are HyperMesh®, MotionView®, Spreadsheet, Workbench, SimLab® and FEKO®. HyperMesh, MotionView and SimLab models are HyperStudy’s direct integration with Altair pre-processors HyperMesh, MotionView and SimLab. They provide the capability to directly parameterize finite-element, multi-body, and fluid-dynamics-solver input data for CAE solvers, thus making the study parameterization process easy and efficient. FEKO, Spreadsheet, and Workbench models simplify the use of these tools with HyperStudy by direct parameter and response import. For other solvers, included with HyperStudy is a powerful parameterization tool with a built-in text and numeric processor.

**Shape Parameter Definition Using Morphing Technology**

Shape changes can be easily created on complex finite-element models using the powerful morphing technology in HyperMesh. These morphed shapes can be saved as HyperStudy shape parameters.

**Direct Interfaces to Popular Solvers**

To facilitate streamlining the study process without additional data filtering and translation steps, HyperStudy directly reads the plot and animation data of many solvers, including:

- ABAQUS
- Adams
- ANSYS
- DADS
- Excel
- Fluent
- LS-DYNA
- MADYMO
- MARC
- Matlab/Simulink
- MotionSolve®
- NASTRAN
- OptiStruct®
- PAMCRASH
- RADIOSS®
- StarCD
Benefits
Reduce Product Development Time
Build simple models early in the design phase and add complexity as the design evolves. MotionSolve supports a large set of modeling elements and a variety of analysis methods to facilitate this. Through virtual testing, you avoid time consuming physical testing and get to the right answer earlier.

Improve Product Quality
Build multi-body models that have the fidelity to capture phenomena of interest to you and accurately solve the underlying equations to characterize product behavior. Examine the product behavior to determine if the design meets your need.

Accelerate Product Innovation
Evaluate the behavior of complex systems in realistic settings. In conjunction with Altair HyperStudy®, perform design of experiments (DOE) and stochastic simulation to characterize and optimize product performance. In conjunction with Altair OptiStruct®, use the computed loads for accurate component optimization.

Reduce Design and Manufacturing Risk
Through virtual testing evaluate a wide variety of alternative concepts and designs very quickly and choose the best design. Moreover, as the design evolves, validate updated designs with models that have already been built.

Capabilities
Modeling
MotionSolve supports a rich set of modeling elements that allows you to build multi-body systems with the desired degree of complexity. MotionSolve offers built-in integration with the CAD, FE, Controls, Hydraulics, CFD, and Optimization.
The modeling capabilities include:

- Common system-modeling entities
  - Mass- and inertia-bearing rigid elements
  - A library of constraint connectors
  - A library of force connectors
  - General 3D contact
  - Generic nonlinear algebraic and differential equations
  - Motion input

- Advanced modeling elements
  - Flexible bodies
  - Joint friction
  - Higher-pair joints between surfaces and curves
  - Contact between deformable curves / surfaces
  - Distributed loads
  - Transfer functions & State Matrices
  - Splines for inputting test data
  - Frequency & Amplitude
  - Dependent Bushings
  - Event sensors
  - User-defined elements to model non-standard entities

Analysis

With MotionSolve, you can evaluate the dynamic behavior of systems, study vibration characteristics, assess the performance of control systems in realistic situations, perform packaging studies, generate realistic loads to predict component life and damage, and improve your system’s performance. These are done through the built-in analysis methods. If these analyses are not adequate, you can create your own analyses methods and use these in MotionSolve.

MotionSolve provides many options for studying system behavior.

- Six integrators to solve a large variety of dynamics problems. This includes implicit/explicit, stiff/non-stiff, and DAE/ODE based methods of numerical integration.
- Four static/quasi-static solvers to compute static equilibrium configurations and loads. The algorithms together cover force imbalance and energy minimization methods.
- Automatic redundant constraint detection and removal
- Kinematic analysis for motion driven systems
- Linear analysis with state matrix export, eigenvalue computation, and modal energy distribution tables
- Co-simulation to solve multi-physics problems
- Your own custom analyses specified in user-subroutines

Vehicle Dynamics, Durability & NVH Simulation

MotionSolve contains special purpose tools for the automotive market. It provides a wizard-driven, vehicle library that enables you to assemble realistic vehicles easily. Subsequently, you can perform half vehicle events and full vehicle driving maneuvers. You can also script your own events.

With support for TNO, FTire, and CD Tire, MotionSolve provides tires and roads of varying fidelity for your applications. With automated reporting, MotionSolve makes it easy for you to understand the dynamic behavior of vehicles. With these core capabilities you can study vehicle dynamics, perform rough road simulations for component durability, and study the NVH characteristics of your vehicle.

General Machinery & Mechanism Simulation

MotionSolve provides a comprehensive 3D-Contact capability that enables you to easily build and analyze complex systems that may contain thousands of contacts. Parallel processing is used to obtain fast solutions.

An automated report generation capability helps you easily review and understand system behavior and share it with others.

Easy Customization

MotionSolve is easily customized with Fortran, C, C++, and Python user subroutines. Custom solver functions and subroutines may be developed to capture the physics underlying unique components; solver messages can be customized to meet your special requirements; custom analyses can be created and used with models defined in MotionSolve. Results from the solver can be tailored to fit any CAE output format.

HyperWorks Integration

With MotionSolve, HyperWorks delivers a complete mechanical system simulation environment. You can:

- Easily build multi-body models in MotionView® as well as in HyperMesh®
- Solve these in MotionSolve
- Understand system behavior visually with the HyperView® and HyperGraph® post-processors
- Improve system fidelity by generating reduced flex-bodies with the OptiStruct® FE Solver
- Perform system level DOE, optimization and stochastic studies with HyperStudy®
- Perform component optimization with OptiStruct
- Couple with AcuSolve®, to solve problems involving rigid body motion with fluid force effects

Computational fluid dynamics coupled with multi-body dynamics

Excavator flexbody simulation

Unmanned Aerial Vehicle dynamics analysis
Altair HyperMesh is a high-performance finite-element pre-processor that provides a highly interactive and visual environment to analyze product design performance. With the broadest set of direct interfaces to commercial CAD and CAE systems and a rich suite of easy-to-use tools to build and edit CAE models, HyperMesh provides a proven, consistent analysis platform for the entire enterprise.

### Benefits

**Open-Architecture Design**
Combining the broadest set of direct CAD and CAE interfaces with user-defined integrations, HyperMesh fits seamlessly within any simulation environment.

**High-Speed, High-Quality Meshing**
Streamlines the modeling process and provides a suite of tools to model even the most complex geometries.

**Model Build and Assembly**
HyperMesh provides a part based workflow enabling modular model build. Representation management of different topological variations for the same part speeds up the process to assemble models for different disciplines. Work package distribution for concurrent model generation is available. HyperMesh provides bi-directional communication to PDM for data exchange.

**Increases End-User Modeling Efficiency**
Using sophisticated batch meshing technology, HyperMesh eliminates the need to perform manual geometry clean-up and meshing, thus accelerating the model development process.

### Advanced 3D Model Visualization
3D visualization of all element types (1D, 2D and 3D elements) within an FEA model eases model checking and visual verification.

### Model Setup
A variety of sophisticated tools help with efficient model setup. The ID Manager ensures that all entities of a model even across or per include files adhere to a specified numbering scheme of a workgroup or a company to ensure modularity. HyperMesh provides connector technology, a highly automated way for assembly of hundreds of parts with spot- and seam welds, adhesives or bolts. Automated contact management tools are a huge time saver when defining contacts between individual parts.

### Composites Modeling
Ply and laminate entities facilitate composites modeling in terms of individual layer shapes and their stacking sequence. CATIA CPD and Fibersim readers extract composite data and map it onto FE meshes automatically. Plies and ply angles can be visualized in 3D for easier model verification.

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**Learn more:**
altairhyperworks.com/hypermesh
Meshing Capabilities
HyperMesh presents an advanced suite of easy-to-use tools to build and edit CAE models. For 2D and 3D model creation, users have access to a variety of mesh generation capabilities, as well as HyperMesh’s powerful automeshing module.

High Fidelity Meshing
• Surface meshing
• Solid map hexa meshing
• Tetra meshing
• CFD meshing
• Acoustic cavity meshing
• Shrink wrap meshing
• SPH meshing

Surface Meshing
The surface meshing module in HyperMesh contains a robust engine for mesh generation that provides unparalleled flexibility and functionality. This includes the ability to interactively adjust a variety of mesh parameters, optimize a mesh based on a set of user-defined quality criteria, and create a mesh using a wide range of advanced techniques.

Solid Meshing
Using solid geometry, HyperMesh can utilize both standard and advanced procedures to connect, separate, or split solid models for tetra-meshing or hexa-meshing. Partitioning these models is fast and easy when combined with HyperMesh’s powerful visualization features for solids. This allows less time spent preparing geometries for solid meshing. The solid meshing module quickly generates high quality meshes for multiple volumes.

Mesh Controls
Mesh controls promote meshing automation for surface, batch meshing, adaptive and volume mesh generation. Detailed local and global control of mesh parameters for either the entire model or for individual features and regions of the geometry are possible. Mesh controls can be saved in the database or exported and reused in other models, promoting standardized mesh quality and repeatability.

Batch Meshing
The BatchMesher™ in HyperMesh is the fastest way to automatically generate high-quality finite element meshes for large assemblies. It is available as a standalone application or directly within HyperMesh.

By minimizing manual meshing tasks, this automeshing technology provides more time for value-added engineering simulation activities. BatchMesher provides user-specified control over meshing criteria and geometry clean-up parameters as well as the ability to output to customized model file formats.

Industry Specific Meshing
HyperMesh provides a variety of meshing algorithms for different industries and verticals, such as acoustic cavity meshing and mesh coarsening for NVH applications, and shrink wrap meshing or SPH meshing. HyperMesh also offers a highly-competitive suite of tools for CFD meshing.

CAD Interoperability
HyperMesh includes direct readers to popular native CAD file formats. Moreover, HyperMesh has robust tools to clean-up imported CAD geometry that contain surfaces with gaps, overlaps and misalignments which hinder high-quality mesh generation.

By eliminating misalignments and holes, and suppressing the boundaries between adjacent surfaces, users can mesh across larger, more logical regions of the model. This significantly increases meshing speed and quality. Boundary conditions can also be applied to these surfaces for future mapping to underlying element data.

Customize HyperMesh to Fit Your Environment
Customize your modeling experience through an easy-to-use interface containing drag-and-drop toolbars, configurable pull-down menus and keyboard-controlled shortcuts.

Custom Utilities: Create custom applications that are fully integrated within the HyperMesh interface.

Solver Input Translators: Users can extend HyperMesh’s interface support by adding input translators to read different analysis data decks.

Solver Export Templates: Export templates allow the HyperMesh database to be exported to user-defined formats for proprietary and specialized solvers.

CAE Solver Interfacing
HyperMesh provides direct import and export support to the industry’s most popular solvers. Additionally, HyperMesh provides a completely tailored environment for each supported solver.

- Abaqus
- Actran
- AcuSolve®
- Adams
- ANSYS
- CFD++
- EXODUS
- Femfem
- Fluent
- HyperMath®
- LS-DYNA
- Madymo
- Marc
- Moldex3D
- Moldflow
- MotionSolve®
- Nastran MSC
- Nastran NX
- nCode
- OptiStruct
- PAM-CRASH
- PERMAS
- RADIOSS®
- Samcef
- Simpack
- Simpack
- StarCD
Altair HyperView is a complete post-processing and visualization environment for finite-element analysis (FEA), multi-body system simulation, digital video and engineering data. Amazingly fast 3D graphics, open architecture design and unparalleled functionality set a new standard for speed and integration of CAE results post-processing. Coupling these features with HyperView’s advanced process automation tools dramatically improves visualization, correlation, and reporting results.

**Product Highlights**

- Complete visualization environment for FEA, CFD, and MBD simulation data
- Multi-page and multi-window post-processing
- Report templates for efficient evaluation of results across different simulations
- Comprehensive post-processing of composites results
- Supports most CAE solver formats
- Industry specific toolkits for NVH, Aero, Safety, CFD, and Manufacturing
- Results comparison and correlation with test data

**Benefits**

**Improve Productivity**
- Industry-leading 3D graphics manipulation and animation speed.
- Direct readers for popular CAE solvers and the ability to create user-defined results translators.
- Powerful XY-plotting and 3D-plotting.
- Customize the interface and create specialized tools to fit individual engineering environments and needs.
- Direct link to Altair HyperView Player for web communication and collaboration.

**Gain Design Insight**
- Synchronize and visualize FEA results, multi-body systems results, XY plotting, and video data.
- Overlay of multiple CAE models in one window.
- Overlay of video data on CAE models using advanced methods.
- Perform result mathematics to build user-defined results types such as failure indexes.
- Query model in-depth based on user-defined criteria.

**Automation and Report Creation**
- Automated session building: Automate the generation and presentation of standard plots and tables, as well as quickly compare results and correlation studies using the “Report: Overlay” option.
- One step report generation: Export HyperView session reports to HTML or Publish to PowerPoint, including text, images, AVIs, and H3Ds.

**Extendable User Interface**
- Templex programming: Create custom-curve math functions, perform data analysis and curve statistics within annotations and labels, and parameterize any text file.
- Custom pull-down menus: Develop user-defined menus to provide easy access to reports, plot macros, and custom wizards.
- Tcl programming layer: Automate procedures through a programmable Tcl/Tk command layer.
- Custom import and export templates: Define custom import and export templates for reading and writing XY plotting data.

Learn more: altairhyperworks.com/hyperview
CAE Animation & Data Plotting

HyperView delivers a complete suite of interactive animation, data plotting and digital video functionality. Users can easily synchronize, compare and visualize FEA results, multi-body systems results, XY plotting (simulation or test data) and digital video data simultaneously in the same environment.

Animations
- Contours (Scalar & Tensor)
- Vector plots
- Tensor plots
- Deformation plots
- CFD streamline plots
- Deformed animations
- Linear animations
- Modal animations
- Transient animations
- Multi-body dynamics animations including flex-bodies

To aid in results comparison and correlation HyperView provides user oriented image and video planes for combining test data with simulation results.

HyperView also supports:
- Exploded views
- Iso-surfaces
- Part and component tracing
- Interactive cut planes
- Graphic annotations
- User oriented image and video planes

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Report Generation
Generating a standard report is made easy with HyperGraph by using the Publish PowerPoint capability along with the Report Templates functionality. The contents are synchronized between both applications, so that even individual changes in HyperView can be updated automatically in the presentation. Users have detailed control of the formatting and the content that is exported. The utility supports all common file formats for graphics and video.

HyperView Player
HyperView Player, is a stand-alone 3-D viewer that provides a collaborative solution for enterprise-wide product data visualization. Users can export 3-D animation results in Altair’s compact H3D format, which can be visualized and manipulated in HyperView Player. The player can be inserted as an object into a PowerPoint presentation or into a web page, thus making it the ideal solution for communicating analytical results effectively to the audience: analysts, testing engineers, tool and die makers, product design engineers, and product managers.

Solver Interfacing
HyperView supports many popular CAE solver formats through direct readers, providing a flexible and consistent high-performance post-processing environment for animating and plotting CAE simulation results. Additional solver formats can be supported through user-defined results translators that convert results into the Altair H3D compressed binary format.

HyperWorks also offers two translators, HvTrans and HgTrans, for working with any type of engineering data. HvTrans allows you to extract, translate, and compress CAE results while HgTrans enables you to convert, compress, and process data files using custom math expressions that can be built from the embedded math function library.

Solvers supported include:
- RADIOSS®
- OptiStruct®
- MotionSolve®
- Abaqus
- Adams
- ANSYS
- DADS
- LLNL DYNA
- LS-DYNA
- MADYMO
- MARC
- MOLDFLOW
- Nastran
- NIKE3D
- PAM-CRASH
- SIMPACK

Rich composites specific functionalities
Video overlay with new multiple-point alignment method
Visualization of CFD results
Altair HyperGraph is a powerful data analysis and plotting tool with interfaces to many popular file formats. Its intuitive interface and sophisticated math engine make it easy to process even the most complex mathematical expressions. HyperGraph combines these features with high-quality presentation output and customization capabilities to create a complete data analysis system for any organization.

**Product Highlights**
- Plots huge amounts of data in a customized layout from single or multiple result files
- Fast repetitive plot generation through report templates
- Efficient data comparison between model iterations or simulation and test data
- Fully automated PowerPoint report generation
- Over 200 built-in mathematical functions and operators
- Interfaces with more than 130 data formats

**Benefits**
HyperGraph provides design, test and engineering professionals with an intuitive plotting and data analysis package:
- 2D & 3D plotting environment: Explore your data in xy-, complex- or polar plots and bar charts; use HyperGraph3D for three-dimensional line and surface plotting.
- Plotting huge amounts of data: Retrieve fully labeled plots from data files based on metadata and channel information with HyperGraph’s advanced plotting options.
- Summary Tables: Conditionally formatted summary tables provide an effective way to identify critical key performance indicators for sessions with multiple plots and pages.
- Accelerate repetitive plot generation: Store reports over several windows and pages and reuse them for model variations and iterations.
- Marker tracking: Track markers from a video and derive displacement over time curves.
- Math function library: Add user-defined math functions to Altair’s large math library.
- Comparison of test and simulation results: Compare sets of test and simulation data in a highly automated way.
- Unit Scaling: HyperGraph supports automated unit scaling based on result file meta data
- Customize the interface: Modify interface and tools to fit any engineering environment.

**Improve Productivity**
- Reports: Automate the generation and presentation of standard plots and tables, compare results and perform correlation studies using the “Report: Overlay” option.
- Plot macros: Use plot macros to capture and replay often-used mathematical curves.
- Tcl/Tk programming layer: Automate procedures through a programmable command layer.
- Custom import and export templates: Read and write XY plot data.
• User written math functions: Build custom math functions within the interface, register existing C and Fortran routines or use HyperGraph’s interface with HyperMath to access its math functions.
• Custom pull-down and context sensitive menus: Provide easy access to reports, plot macros, Tcl/Tk utilities and 3rd party executables.
• Vertical specific user profiles for NVH, crash, forming or multi-body dynamics.

**Plot Builder And Plot Details**
HyperGraph’s customizable automatic plot builder generates a series of fully annotated XY plots, polar plots, bar charts and complex plots directly from engineering and test data files according to customers requirements. A wide array of formatting options allow users to specify how plotted data appears and is arranged on pages within the session. An intuitive and highly efficient interface provides browser-driven direct access to edit or modify all plot areas including axes, header, footer, legend and curve properties simultaneously for multiple plots.

**Analyzing Your Data**
Create new math curves from existing data curves by writing mathematical expressions or by selecting from a library of over 200 built-in mathematical functions and operators. HyperGraph also contains a sophisticated math engine for performing complex mathematical operations or building custom math expressions including:
• Crash injury
• Signal processing
• Curve fitting
• Filtering
• Eigensystem analysis
• Integration and differentiation
• Statistical analysis
• User-defined math functions
• User-defined expressions

**Supported Data Formats**
HyperGraph supports more than 130 data formats. The most common include:
• Altair® Formats (.H3D, .abf)
• Abaqus (.odb and .dat)
• Adams
• ANSYS
• DADS
• DIAdem
• Excel (.csv)
• HDF 5.0
• ISO/ ISO-MME 13499
• ISO 6487
• LS-DYNA
• Madymo
• MotionSolve®
• Multi-column ASCII
• Nastran (.op2, .pch, .f06)
• nCode
• OptiStruct®
• PAM-CRASH (.dsy and .thp)
• RADIOSS®
• Ride data files
• RPC-3
• Universal Block 58 and XRF
• xy-data files

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![HyperGraph is part of the HyperWorks framework](Image)

![Campbell Diagram in plotting client and table view](Image)

![Mouse over highlighting of notes for better visibility](Image)

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![Animation of X-Y data as gauge](Image)

![Colormap plot for Modal Participation](Image)

![Bottle plot with HyperGraph 3D](Image)
Altair HyperCrash is a highly tuned pre-processing technology specifically designed to automate the creation of high-fidelity models for crash analysis and safety evaluation. Through a comprehensive and procedure-oriented toolset, HyperCrash improves and simplifies the complex problems of creating a quality crash model.

Benefits

- Reduce model assembly and loadcase set-up time from days to hours with advanced model management procedures
- HyperCrash has built-in solver rules to avoid modeling mistakes during creation of most entities
- Easily manage penetrations, intersections, model assembly contact management, and dummy positioning
- The HyperCrash database enables organizations to seamlessly support standard and proprietary corporate engineering procedures and data structures
- HyperCrash enables part replacement at all modeling levels – component, subsystem and complete assembly
- A generic data model simplifies and optimizes model creation and modifications

Capabilities

GUI
HyperCrash employs a modern graphical user interface (GUI) to provide streamlined processes for building complex crash simulation models. Users can visualize, organize, and manage all levels of modeling data and information with a point-and-click access to the tree-style model browser. In addition, HyperCrash provides a fast intuitive toolset for preparation and set-up of analysis input decks.

Multiple Solver Support
HyperCrash is a multi-solver pre-processor with comprehensive interfaces to RADIOSS® and LS-DYNA. A huge library of dummies is supported. The model checker prevents user errors before the export of a model and numerous tailored panels help to set up models for both solvers. HyperCrash also has an interface to read and edit PAM-CRASH models.
• Comprehensive support for over a thousand keywords
• Complete dummy positioning module
• Conversion between all supported solvers
• Belt systems
• Joints
• Connections

Mesh Editing And Model Connections
Users can modify and edit crash meshes from within HyperCrash or take advantage of the seamless integration with HyperMesh®. Dependencies like contacts, loads and boundary conditions will be updated automatically. HyperCrash also offers many methods and options for editing and tuning a mesh for a crash analysis:
• Adding, duplicating and moving nodes
• Finite element creation (1D, 2D, and 3D)
• Split parts or move elements from part to part
• Renumber selected entities, parts or the complete model
• Clean the model by removing unused entities
• Create, modify and check rigid bodies
  - Full support for connection types (Spotweld, Mastic, Adhesive, and more)
  - User defined connection representations

Safety Tools Module
This module provides a streamlined, user-friendly interface to set up, edit and define all safety-related characteristics for crash simulation and analysis. In addition to the standard set of safety tools, HyperCrash contains a unique seat-deformer utility that allows the seat foam - on both the lower and back of the seat - to be deformed based on the intersection between the dummy and the seat.

Safety features include:
• Dummy positioning
  - Interactively position dummy (torso, head, limbs)
  - Load and save dummy positions
  - Merge dummy in the model
  - Works with LS-DYNA & FTSS dummies
• Seat belt creation and routing
• Airbag toolset for creation and folding
• Seat deformer: Deform the seat automatically to remove the initial intersections with the dummy.

Mass Balance
The Mass Balance module completely manages the mass and inertia properties of each part as well as the entire crash model. After the masses are set for all parts and components, HyperCrash automatically balances the total mass of the model according to the mass on the front and rear tires. HyperCrash can display, check and report the center-of-mass locations for each part, rigid body and the complete model.

The mass of each part can automatically be fitted to the mass of the CAD part.

Quality
The Quality module is a configurable and customizable set of utilities for evaluating the quality of a model by performing hundreds of different checks on the part, component and model level. A variety of checks are executed, ranging from simple element checks to part connectivity and modeling errors in the input deck. Users visually review the state of each check represented by status color (red, orange and green).

• Model Cleaner
  - Remove unused options
  - Check connectivity for failed welds, unconnected parts and topology of connected parts
  - Automatically remove initial penetrations

• Model Checker
  - Exercises hundreds of unique checks
  - Model robustness for crash-worthiness criteria
  - User-defined criteria checks and filters
SimLab is a process oriented, feature based finite element modeling software that allows you to quickly and accurately simulate engineering behavior of complex assemblies. SimLab automates simulation-modeling tasks to reduce human errors and time spent manually creating finite element models and interpreting results. SimLab is not a traditional off-the-shelf pre- and post-processing software, but a vertical application development platform for capturing and automating simulation processes.

**Product Highlights**

- Process oriented, feature based finite element modeling software
- Automated mesh generation without CAD geometry cleanup
- Reusable mesh specifications at feature level; for example fillets, cylinders, holes
- Templates for contact detection, bolt, and crankshaft modeling
- Solver interfaces include OptiStruct®, Abaqus, Nastran, and PERMAS

**Benefits**

Highly efficient, feature based modeling approach:
- Improves modeling repeatability and quality
- Directly identifies geometry features inside of the CAD environment such as fillets, cylinders, or chamfers

Automates modeling tasks for complex assemblies:
- Meshing
- Assembly of parts and components
- Mesh generation for mating surfaces of an assembly
- Part connections

Accelerates CAE model development for complex assemblies:
- Employs an advanced template based meshing process
- Removes manual mesh clean-up
- Simplifies load and boundary condition definition and generation

**Capabilities**

**Meshing**

SimLab takes a different approach to generating a high quality mesh. It transfers the features from the CAD model, such as fillets and cylinders, to the finite element model. These features can be used in a later step in the process without the need to access the original CAD geometry again.

There are many unique and useful tools for generating various types of meshes within SimLab. A template system pulls all of these tools together into streamlined...
and automated processes geared towards generating the highest quality mesh that adheres to requirements of any analysis type: NVH, durability, fatigue, CFD, and more.

Automated mesh generation
- Tetra and hexa meshing of solids
- Quad and tria meshing of surfaces
- 1D mesh creation for joining parts and contact surfaces

Feature based meshing
- Automatically identifies CAD features
- Applies template criteria to mesh creation of features, such as cylinders, fillets, holes
- Automatic recognition of contact surfaces
- Analysis and criteria based meshing uses templates and captured knowledge to generate appropriate meshes for each analysis type, for example stress, NVH, acoustic, fatigue, and others

Geometry
SimLab uses a unique methodology in working with CAD geometry to generate an accurate mesh quickly. The processes used by SimLab make it possible to eliminate all geometry clean-up which enables users to focus on the mesh generation procedures instead of healing poor geometry.

SimLab contains routines to directly access the native geometry of the following CAD systems:
- CATIA V5
- Pro/Engineer
- UG
- Any Parasolid based CAD systems such as SolidsWorks, SolidEdge, etc.

Managing Assemblies
- Robust and comprehensive toolset for handling a full system of components.
- Recognition of mating components and contact surfaces
- Quick assignment of boundary conditions to many groups within an assembly
- Library of common connecting elements

Loads and boundary conditions
When working with complex models and assemblies the average model size can easily reach millions of elements and nodes. At this point it is no longer practical to apply boundary conditions on an individual node or element basis. SimLab provides a host of advanced tools and utilities that guide users through automated processes to manage this task easily.

Process oriented features
- Mapping of results from a fine to a coarse mesh and from a coarse to a fine mesh
- Menu driven modeling of bearings and applying bearing pressure
- Positioning of spatially displaced result fields onto the model. (Example, thermal analysis results onto a structural model)
- Automated templates for
  - Bolt modeling
  - Gasket, bearing loads and joint modeling
  - Mass property idealization
  - External material and property based connections
  - Contact detection (between parts) and modeling of the contacts
  - Condensation model preparation for AVL Excite

Post-processing
SimLab includes an integrated post-processor. In addition, customized processing tools such as bore distortion and frequency response are available.
Altair MotionView is a user-friendly and intuitive multi-body systems modeling environment. Its built-in parametric modeling capability and open architecture allows users to quickly build, analyze, and improve mechanical system designs even before physical prototypes are available. Coupled with a next generation solver in MotionSolve, MotionView provides a perfect solution for your multi-body dynamics simulation needs.

**Product Highlights**
- Intuitive and solver neutral environment for multi-body systems modeling
- Hierarchical modeling
- Built-in parametric modeling for efficient studies on model variations
- Extensible GUI and data model to support local customization
- Free data management with HyperWorks Collaboration Tools

**Benefits**

**Accelerate Product Innovation**
With MotionView you can build parametric models, assess alternative designs, and optimize designs to meet the product objectives.

**Reduce Product Design Time and Cost**
You can evaluate products early in the development cycle with MotionView’s physics-based simulation capabilities. Furthermore, you can build a model once, validate it and reuse it in different contexts.

**Improve Product Quality**
MotionView allows you to easily conduct what-if analyses and stochastic simulations to characterize and optimize product behavior and mitigate the effects of manufacturing variations on product performance.

**Enforce Corporate Quality Standards**
MotionView can capture your company’s know-how as repeatable processes to ensure usage consistency. You can customize the user interface to meet your needs, use automation capabilities to reduce repetitive procedural tasks and standardize and share subsystems, system models, and data files with other users.

**Capabilities**

**Powerful Modeling Environment**
MotionView contains many capabilities designed to simplify the creation of complex mechanical models.
- A hierarchical modeling structure to understand model composition
- Parametrics to facilitate downstream DOE and optimization studies
- Built-in support for symmetry planes to minimize input
- Conditional logic to enable multiple topology configurations within a single system model
- A macro language that, based on user input, generates parametric sub-system models

Learn more: [altairhyperworks.com/motionview](http://altairhyperworks.com/motionview)
• Automated system assembly via a wizard that reduces model assembly to just a few mouse clicks
• Easy import of test data into the multi-body system model
• Easy import of CAD geometry to create the system model; all popular formats are supported

Intuitive User Interface
MotionView’s intuitive user interface allows experienced and novice engineers to build and analyze multi-body systems rapidly.
• Built-in workflows to simplify and standardize mechanical systems modeling
• A modern user interface with context menus in the graphics window
• A project browser with context sensitive menus, find and filtering options ensuring easy model navigation
• A wide variety of graphically accessible tools to create, modify, and manipulate models easily

Automation and Customization
MotionView is completely customizable. You can modify MotionView to meet your needs.
• Build custom objects with MotionView’s unique Model Definition Language
• Create custom panels and menus to graphically create custom objects
• Send models to solvers and retrieve results
• Use scripting to automate repetitive modeling tasks and minimize mouse actions
• Export component loads in FE & fatigue formats for downstream component design, strength, fatigue, and optimization calculations
• Generate reports to communicate system performance with others in your team

Easy Flex-body Generation and Usage
MotionView provides a simple yet powerful set of tools to create flexible bodies in your model.
• Easily import reduced finite element models to represent flexible bodies
• Perform error checking to identify and diagnose modeling errors
• Connect flexible bodies to a multi-body system model
• Convert a rigid component to flexible and vice-versa
• Mirror flexible bodies about a plane of symmetry to facilitate data reuse

A Comprehensive End-to-end Solution
MotionView supports the MODEL—ANALYZE—REVIEW—OPTIMIZE paradigm of use for multi-body systems. In a single environment you can perform all of your tasks - no need to switch between products.
• MODEL: Create or assemble complex multi-body models graphically
• ANALYZE: Send a validated model to a multi-body solver to run a simulation. MotionSolve and ADAMS are natively supported
• REVIEW: Analyze and correlate simulation results to test data, compute performance metrics, plot results, view animations, create and publish reports summarizing model behavior
• OPTIMIZE: Execute DOE, optimization, and stochastic studies through HyperStudy® to understand system behavior; optimize components with OptiStruct®

Industry Specific Capabilities
In addition to the standard set of model management options, MotionView provides specialized tools for various industries.

Automotive
MotionView supports a comprehensive library of higher-level, automotive-specific modeling entities such as tires, roads, drivers, springs, bushings, bump-stops, dampers, that are required for building vehicle models. You may add your own components to the built-in set. In addition, MotionView supports model and task assembly wizards. With just a few mouse clicks you can assemble a fully parametric vehicle with your selection of front and rear suspension topologies, a full IC engine powertrain, choice of tires, smooth and rough roads and simulate any of the standard suspension and driving events. Component loads can be sent for downstream strength or durability analysis. Simulation reports are automatically generated.

General Machinery
With MotionView you can import CAD and FE geometry to quickly build your system. All popular formats are supported. Component mass and inertia properties are automatically computed. 3D contact is easily specified between complex geometry shapes. You can also import data from CSV files to create “hard points” in any coordinate system of your choice. These core capabilities may be used to quickly assemble a system and perform your analysis of choice.
Altair HyperForm is an industry proven comprehensive finite-element-based sheet metal forming simulation framework. Its unique process-oriented environment captures the forming process with a suite of highly tailored and configurable analysis and simulation tools to optimize all aspects of stamped products development. HyperForm delivers a cost-effective solution to meet the demands of customers varying from individual analysts, and tool shops, and to large OEMS.

**Product Highlights**

- Efficient setup for complex multi-stage forming processes of metals and composites
- Intuitive browser-driven setup for product and process optimization
- Fast, robust, and best-in-class incremental and one-step solver
- Customized post-processing tools with one-click report generation
- Optimal blank nesting in transfer die or progressive die layout for maximum material utilization

**Benefits**

**Immediate Cost Savings**
Remarkable cost savings are possible because of competitive pricing (based on Altair’s patented HyperWorks Units licensing) and dramatic reduction of product development lead time.

**Accurate and Reliable Solver**
The most accurate incremental sheet metal forming solver on the market (Altair RADIOSS®) is seamlessly integrated into HyperForm’s process-driven user interface. This solver accurately predicts wrinkles and splits prior to cutting steel, avoiding the unnecessary costs associated with die machining and press downtime.

**Efficiently Captures the Stamping Process**
HyperForm’s open framework combined with an extensive built-in knowledge of the manufacturing domain efficiently captures the stamping process. User productivity is further increased through a comprehensive collection of tailored, process-oriented automations for virtually every stamping scenario.

**Complete Solution for Stamping**
HyperForm offers a complete solution for managing the entire stamping simulation process. It includes robust modules for feasibility and cost analysis, parametric draw die design, final process validation, process and die structure optimization, and results visualization are included for end-to-end stamping simulation.

**Metal Forming Solutions for Every Need**

**Product and Cost Engineers** can study manufacturing feasibility and the impact of manufacturing on product performance under structural loading.

**Die Designers** can create conceptual draw dies with a parametric die module to run feasibility analysis or to iterate on the optimal die shape.

Learn more: altairhyperworks.com/hyperform
Process Engineers can validate a complex multi-stage stamping process for metals or composites by performing an accurate contact analysis to predict areas of wrinkling, high thinning, loose metal, springback and related manufacturing issues.

**Capabilities**

**Fast and Accurate Feasibility Analysis**
The fastest and most accurate inverse solver in the marketplace for quick one-step analysis addresses forming feasibility early in the product development cycle, minimizing downstream formability challenges and associated costs. It also enables rapid initialization of structural CAE models with thinning and work hardening resulting from stamping in order to incorporate the effect of manufacturing on structural performance.

**Efficient Cost Analysis**
The accurate blank shape prediction and intuitive nesting interface proposes proper blank-sizing and layout to minimize material scrap at the early stages of the product development process.

**Concept Draw Die Design**
The intuitive, parametric, and NURBS based die face development module delivers a powerful tool for process engineers to quickly develop and verify multiple tooling options.

**Fast and Robust Process Validation**
Through its best-in-class incremental solver (Altair RADI OSS®), HyperForm provides product and die engineers with powerful capabilities to:
- Analyze and validate the robustness of the manufacturing process
- Determine wrinkles and splits prior to cutting steel
- Avoid unnecessary costs associated with die tryouts

**Results Visualization**
Customized post-processing tools in HyperView® can be used to visualize blank draw-in, thinning, strains and stresses, and Forming Limit Diagram (FLD). One click report generation enables efficient communication and faster resolution of stamping problems.

**Optimize the Process**
Through a seamless integration with HyperWorks optimization tools (Altair HyperStudy® and OptiStruct®), HyperForm offers unique capabilities to analyze and optimize not only the sheet metal but also the tool structure, allowing die designers to conceive lightweight and stiffer structures.

**Tube Bending and Hydroforming**
In addition to the complete sheet metal forming capabilities, HyperForm includes powerful utilities for tube bending and hydroforming, delivering a nearly hands-off model auto-setup process.

**Results Mapping**
For precise mapping of stamping results from an adaptive or finer stamping mesh to a relatively coarser mesh, a general purpose results mapper is available under HyperCrash®.
Altair® HyperXtrude® is a simulation environment designed to help extrusion companies meet the ever increasing demands to produce complex profiles with tight tolerances, quality surface finishes, and high strength properties at reduced cost. HyperXtrude is a virtual press where users can visualize material flow and temperature inside a die during extrusion and make necessary changes to ensure balanced flow, while identifying and eliminating product defects.

**Benefits**

- **Validate and correct die design**: Use HyperXtrude simulations to understand and improve the performance of a die from multiple perspectives (nose cone, product quality, weld strength, process efficiency).
- **Extrude new alloys**: Flow stress and material behavior of new alloys requires an accurate simulation. HyperXtrude can handle a wide range of alloys.
- **Determine die stresses and failure**: HyperXtrude together with OptiStruct® is used to determine tool deflection, mandrel shift, stress concentrations, and potential early die failure.
- **Increase productivity**: HyperXtrude and HX-Process™ are used to optimize ram speed, billet preheat, and billet taper heating to improve productivity and reduce cost.
- **Increase recovery and reduce scrap**: To minimize front and back scrap, the weld length can be computed and the skin material of the billet entering the product can be tracked. HX-Process can optimize the billet length to reduce the scrap considering all aspects of extrusion and fabrication.
- **Determine product quality**: Product quality can be improved by eliminating extrusion defects and the effects of die deflection on the product shape. By determination of seam weld location and strength, grain size and yield strength the product quality is further assessed.
- **Quenching Analysis**: Quenching the extruded profile is crucial for controlling grain size and mechanical properties of the profile. Quenching analysis is used to predict the cooling rate, temperature, and uniformity of cooling during the process.

**A Complete Solution**

**Die design engineers:**

- Test and validate new die designs
- Determine correct bearing lengths
- Adjust porthole and pocket dimensions
- Predict die deflection, stresses, and failure

**Learn more:**
altairhyperworks.com/hyperxtrude
Simulation Engineers:
- Troubleshoot problem dies
- Improve productivity
- Predict product quality

Production Engineers:
- Optimize process conditions
- Manage extrusion inventory
- Reduce scrap and maximize recovery
- Prepare cost estimates and quotations
- Determine the performance of quench system

Quality Engineers:
- Determine product quality
- Predict grain size and recrystallization
- Calculate yield strength

Capabilities
HyperXtrude comes with powerful and complete features that enable an extrusion engineer to optimize the die and improve product quality in the design stage before going into the first die trial.

Extrusion-specific user interface:
- Extrusion Wizard for efficient setup of the entire extrusion process
- Tube Extrusion Wizard for super alloy extrusion dies
- Seamless job submission to local or remote computers

Support for all die types:
- Solid, semi-hollow, and hollow profiles
- Multi-hole dies
- Feeder plates and spreader dies
- Direct, indirect, conform, and co-extrusion processes

Product quality and defects:
- Predict profile shape and nose cone
- Predict surface defects
- Predict the location and quality of seam welds
- Determine transverse weld length
- Track surface impurities and determine when they enter the profile
- Predict grain size and yield strength of the profile

Thermal management:
- Simulate coupled flow and thermal solution
- Determine optimum billet preheat and taper
- Determine temperature changes in tool between different extrusion cycles

Virtual die trials:
- Visualize material flowing through the die passages
- Determine causes for flow imbalance and overheating
- Study responses to design changes

Tool deflection analysis:
- Simulate coupled flow, thermal, and stress analysis
- Calculate die deflection and mandrel shift during extrusion using OptiStruct®
- Minimize tool deflection to meet product tolerances
- Identify causes for tool breakage
- Optimize the shape and size of dummy block, backers, and bolsters using Altair® OptiStruct®

Super alloy extrusion:
- Simulate glass lubrication
- Predict glass pad erosion
- Compute lubrication effectiveness

Quench Analysis:
- Supports for press and solution quenching
- Analyze different quenching types
- Quench factor analysis
- Compute temperature history and cooling rate during quenching

Comprehensive material database:
- Database of commonly used alloys
- Fit flow stress model
  - Based on extrudability number
  - From flow stress table data
- Material models using user defined subroutines

Contact friction:
- Viscoplastic friction model
- Coulomb friction model
- Slip velocity model

Optimize die design:
- Accurate and easy to use bearing length correction module
- Modify pocket and porthole dimensions with Altair HyperStudy®

Extrusion system management with HX-Process™:
- Calculate optimum process conditions
- Determine best press to increase productivity
- Optimize billet length to reduce scrap
- Estimate costs
- Prepare quotations

Results:
- Profile deformation and nose cone
- Extrusion load
- Seam weld locations and strength
- Transverse weld length
- Billet skin tracking
- Particle traces and velocity vectors
- Temperature distribution
- Strain and strain rate
- Flow stress
- Stress tensor
- Tool deflection and stresses
- Product quality:
  - Grain size
  - Yield strength
  - Surface quality
- User defined results
- Glass lubrication effectiveness
- Quench Analysis:
  - Cooling Rate
  - Quench Factor
Click2Cast is a casting process simulation software that allows the user to enhance and optimize their manufactured components.

**Benefits**
Click2Cast® helps users avoid typical casting defects such as air entrapment, porosity, cold shots, and more. Thanks to the simple and quick mold filling and solidification simulation. Click2Cast offers an innovative user experience allowing the complete simulation to be done in 5 simple steps and through a completely user-friendly interface designed for beginners and experts alike.

- Predict common casting defects upfront
- Optimize running and feeding systems
- Avoid expensive trial and error

**Minimal Training with Maximum Benefit**
Casting simulation usually requires hours of training coupled with extensive expertise, adding cost both in training and hiring experts. Click2Cast eliminates such expensive investments by focusing on the ease of use and keeping all complexities in the background.

**Features**

**Ease of Use with 5 Simple Steps**
- Import Geometry
- Define Ingate
- Define Process Parameters
- Run Analysis, Optimize, and Cast Final Part

**Ease Templates to Simulate**
- High Pressure Die Casting
- Low Pressure Die Casting
- Gravity Sand Casting
- Permanent Mold Casting

**Design better products**
- Quickly evaluate ‘Castability’
- Visualize solidification to optimize ingate location
- Simulate casting with auto-generation of risers
- Guide manufacturing engineers to refine process

**Increase Manufacturing Quality and Profitability**
- Quickly evaluate casting complexity for quoting

**Product Highlights**
- Guided casting process simulation software with innovative user experience
- Identify casting defects such as air entrapment, cold shuts, turbulence, and shrinkage porosity in just a few clicks
- Visualize flow front, solid fraction, solidification modulus, temperature/velocity profiles and more
- Simulate high/low pressure, gravity, sand, and permanent mold castings
- Optimize “ingate” design and location

Learn more: altairhyperworks.com/click2cast
Optimize Ingate Design and Position
Click2Cast allows quick and simple ingate simulation - simply select the size and position and Click2Cast will auto-generate the ingate.

Validate Full Casting Designs
Click2Cast allows users to validate full casting designs including cavities, runners and overflows.

Finite Element Based Formulation
Click2Cast is Finite Element based formulation. Typical challenges of meshing the domain are overcome by integrating with the Altair suite of meshing applications, bringing the accuracy of FEM to the world of casting flow and solidification computations. This provides an extremely accurate and fast solution for both fluid flow and solidification calculations.

C2C solver uses parallel processing, which enables a significant reduction in calculation time. Since Click2Cast uses a biphasic air-metal model for computation, the effect of air when filling the mold is better captured to predict the air entrapment.

Results Analysis
- Flow Front
- Temperature
- Velocities
- Cold Shuts
- Air Entrapment
- Mold Erosion
- Filling Time
- Solid Fraction
- Solidification Time
- Shrinkage Porosity

“Click2Cast is extremely easy to learn, as it guides you through the set-up process. With minimal knowledge of castings, you can generate meaningful data your first day. We use it to quickly evaluate castings for porosity and other defects as part of our quoting process. As we proceed with the projects into production we use Click2Cast to help optimize the design and location of gates and runners.” - Steve Fetsko
Altair’s HyperWorks Virtual Wind Tunnel is a vertical application tailored for external aerodynamic studies. Designed with the users’ needs in mind, the graphical user interface provides easy access to problem definition and solution strategies. The automated and customizable report generation after each simulation run provides a consistent method for design evaluation. HyperWorks Virtual Wind Tunnel integrates smoothly with other Altair products.

**Product Highlights**

- Application to perform external aerodynamic studies
- Accurate, robust, and scalable computational fluid dynamics (CFD) solver
- Streamlined workflow for problem definition and solution strategy
- Automated & customizable report generation

**About HyperWorks Virtual Wind Tunnel**

Altair’s HyperWorks Virtual Wind Tunnel (HyperWorks VWT) is a vertical solution providing an efficient environment for external aerodynamic studies. With its automated and streamlined workflow based on Altair’s Computational Fluid Dynamics (CFD) solver AcuSolve®, HyperWorks VWT performs simulations of flow around objects, delivering transient or steady state solutions. With a focus on the automotive use case of drag and lift prediction of vehicles, other use cases include aerodynamics of buildings, bicycles, or motor bikes.

VWT combines several HyperWorks technologies, from advanced volume meshing to high-fidelity CFD simulations, rich and powerful post-processing, and an intuitive user interface.

**Accurate, Robust and Scalable CFD Solver**

HyperWorks VWT is powered by Altair’s computational fluid dynamics solver, AcuSolve, providing fast turnaround times, accuracy, and robustness.

Architected for parallel execution on shared and distributed-memory computer systems, using a hybrid parallelization technique, AcuSolve provides fast and efficient transient and steady-state solutions for unstructured grids. It is capable of scaling over a large number of computing cores.

HyperWorks VWT utilizes Reynolds-Averaged Navier-Stokes (RANS) and Detached-Eddy Simulation (DES) technology to model turbulent flows and to predict the flow field. DES technology combines fine-tuned, statistical RANS technology for modeling near walls and attached boundary layers.
with the ability of large-eddy simulation (LES) to model the separated regions in the wake behind the vehicle. Accurate external aerodynamics results are achieved for both steady-state simulation using the RANS approach when physics allows and transient simulation using the DES approach. AcuSolve’s fluid structure interaction (FSI) capabilities are included in VWT to support studies of flexible components in an external flow field, e.g. aerodynamic spoilers.

Rotating parts, e.g. wheels, are modeled by prescribing a tangential wall velocity to include rotational effects into the simulation. For automotive use cases, heat-exchangers or condensers are modeled with a porous material model to consider the pressure drop through the components. The fluid material used during the simulation is defined via density and viscosity, and can be adapted to model for example water or air at a specific temperature.

**Advanced Meshing**

HyperWorks VWT comes with a fast and efficient unstructured volume mesher including boundary layer generation.

User defined volume mesh refinement zones are used to create a locally refined volume mesh to capture important flow phenomena, e.g. the wake of a vehicle or a building. Parameters for boundary layer meshing can be defined globally or on a part basis to have maximum control of the total element count and use refined layers only in regions where it is necessary. Volume meshing for an external automotive aerodynamics analysis (including underbody, underhood compartment and, boundary layers) is typically done in a few hours.

**Analysis Report**

After each simulation, a report is automatically generated summarizing the results like drag and lift history, providing mesh statistics, and containing the problem definition and solution strategies. User defined probe points can be included into the simulation domain to monitor the evolution of the flow field in a particular location, e.g. pressure fluctuation over time. Furthermore, VWT supports user defined planar section cuts for result contour plotting, e.g. velocity contours on the symmetry plane of the vehicle.

Both report entities, the time history plots of the user defined probe points as well as the planar section cuts for contour results plotting, are included in the automatically generated report.

**Streamlined Workflow**

HyperWorks VWT comes with a light graphical user interface (GUI) containing various automations to reduce the user input and increase efficiency during case setup. The user imports the surface mesh of the aerodynamic study object, e.g. vehicle or building, into VWT, defines the physics and volume meshing parameters, submits the simulation, and obtains a simulation report. Analysis templates can be used to ensure consistent simulation conditions and reporting mechanisms during design evaluation.
solidThinking Inspire® enables design engineers, product designers, and architects to create and investigate structurally efficient concepts quickly and easily. Inspire uses the industry leading Altair OptiStruct® technology to generate and analyze design concepts. The software is easy to learn and works with existing CAD tools to help design structural parts right the first time, reducing costs, development time, material consumption, and product weight.

**Product Highlights**

- Structurally efficient concept generation and analysis
- Support for optimization and analysis of parts and assemblies
- Quickly and easily cleanup and defeature problem areas in the geometry
- Investigate linear static and normal modes analysis
- User friendly interface with extremely short learning curve

**Benefits**

**Design Faster**
Generate concepts which meet structural performance requirements at the beginning of the design cycle. This results in significant time savings over the traditional approach of design, validate, redesign to meet structural requirements.

**Design Smarter**
Inspire makes it easy to perform “what-if” scenarios where package space, connections, load conditions, and shape controls can be modified. Reviewing the resulting concepts often reveals valuable insights.

**Design Lighter**
Inspire makes efficient use of material, only placing it where required to satisfy structural performance requirements. Reduced design weight leads to material cost savings, performance improvements, and reduced shipping costs.

**Capabilities**

**Geometry Creation and Simplification**
Create, modify, and de-feature solid models using Inspire’s modeling tools:
- Sketch Tools – Build or modify parts by sketching lines, rectangles, circles, and arcs.
- Geometric constraints such as mirroring, scaling, revolving, push/pull, tangency and perpendicularity can also be applied.
- Trim/Break – Cut and remove sketch curves at the point of intersection.
- Boolean Operations – Add, subtract, or intersect solid parts to create more complex geometry.
- Defeature - Remove imprints, rounds, fillets, holes, and pockets, or plug holes and pockets, or create patches and bridges.
- Midsurfacing – Midsurfacing tools allow users to find and extract 2D sheets from single thickness thin solid geometry

Learn more: altairhyperworks.com/inspire
**Optimization Options**
Inspire offers users a number of topology options:
- **Optimization Objectives** - When running an optimization, designers can choose to either maximize stiffness or minimize mass.
- **Stress Constraints** - A global stress constraint can be applied to limit the maximum stress in the model during optimization.
- **Displacement Constraints** - Displacement constraints can be applied to a model to limit deflections in desired locations and directions.
- **Acceleration loads** – Angular velocity and acceleration tools allow users to define the speed of rotation of the entire model and the axis about which it rotates.
- **g-Loads** – g-Loads tool allow users to simulate a model undergoing acceleration, which imparts a force on all parts of the model.
- **Displacement Constraints** - Displacement constraints can be applied to a model to limit deflections in desired locations and directions.
- **Temperature Loads** - Temperature tool allows users to simulate the effects of temperature changes in a model.
- **Export to OptiStruct** - designers can export OptiStruct input files for advanced simulations.

**Contacts and Assemblies**
Optimize and analyze full parts and assemblies inside of Inspire.
- The Contacts tool allows users to find neighboring parts and designate whether they should be bonded, contacting, or have no contact.
- Users can connect multiple parts in a model using the Fastener and Joints tools to add bolts, screws, pins, or sliding pins.

**Manufacturing and Shape Controls**
Generate design concepts that are not only structurally efficient but also manufacturable using Inspire’s shape controls:
- **Symmetry Planes** – Force asymmetric design spaces to generate symmetric optimized shapes.
- **Cyclic Repetition** – Create cyclically repeating shapes like propellers or wheels.
- **Draw Directions** – Generate shapes that can be easily molded or stamped by applying single or split draw directions.
- **Extrusion Shape Control** - Generates constant cross-section topologies in a specified direction.

**Analysis**
Investigate linear static and normal modes analysis on a model and visualize displacement, factor of safety, percent of yield, tension and compression, von Mises stress, and major principal stress.

**Customizable Materials Database**
Inspire is packaged with a material library including various aluminum, steel, magnesium, and titanium alloys. Custom materials can also be added.

**PDM**
Inspire allows users to open models from Teamcenter or Windchill PDM systems. It is also possible to save Inspire models back to the PDM system.

**Part Instances**
- **Parent-Child Instances** – Individual parts can be copied and pasted as an instance. Whenever one is updated, the other is automatically updated as well. Instancing information can also be imported from CAD files.

**Pattern Repetition** – When a design space is repeated multiple times in a model using part instances, Inspire will automatically apply pattern repetition to the design spaces so they generate identical shapes.

**Interactive Results Visualization**
Explore optimized shapes using a simple slider to add or remove material. Users can decide which features are important and then pick the concept design best suited to their needs.

**Assembly Configuration**
Multiple assembly configurations can be created. These configurations can then be used to evaluate various design scenarios and the resulting concepts.

**Multiple Language Formats**
Chinese, English, French, German, Italian, Japanese, Korean, Portuguese, Spanish

**Shape Controls & Design Constraints**
- **Min/Max Size**
- **Draw Direction**
- **Symmetry**
- **Pattern Repetition**
- **Cyclic Repetition**
- **Stress Constraints**
- **Frequency Constraints**
- **Displacement Constraints**

**Geometry Import**
- ACIS
- Catia (V4 & V5)
- Creo
- IGES
- Inventor
- JT
- Parasolid
- Pro/E
- SolidWorks
- STEP
- STL
- UG NX (Unigraphics)

**Geometry Export**
- IGES
- Parasolid
- STEP
- STL
solidThinking Evolve® allows designers to develop forms faster, using either Windows or OS X. It enables the capture of an initial sketch, exploration of styling alternatives, and visualization of products with realistic renderings generated in real time. Evolve provides organic surface modeling, parametric solid controls, and polygonal modeling with NURBS-based surfaces and solids and a unique ConstructionTree™ history feature. It frees designers from the constraints of traditional CAD tools, while allowing the export of digital models required by others in the product development process.

**Product Highlights**

- Hybrid modeler with organic surface modeling, solid surfacing, and polygonal modeling
- Unlimited construction history provides real-time updates when modifications are made to parameters or surfaces
- Real-time photo realistic rendering
- Available on both Windows and Mac

**Benefits**

**Model Freely**

Created by designers for designers, Evolve provides free form surfacing, solid modeling, and polygonal modeling in a single package. This allows the best approach to be applied to each aspect of a design. Evolve allows users to mix and match modeling techniques on the fly without any additional plugins.

**Make Changes Effortlessly**

The ConstructionTree history allows users to edit a point or a parameter and then let Evolve automatically update the entire model. Typically surface modelers require the recreation of an entire model to accommodate a dimensional change.

**Render Beautifully**

Quickly test and evaluate designs, materials, or environments in real-time while developing your model. Evolve offers users the ability to create photorealistic images and animation with a built-in renderer.

**Capabilities**

**Best-in-class Construction History**

- Unlimited construction history provides real-time updates when modifications are made to parameters or surfaces.
- Browse the graphic representation of the construction history to identify and select source objects within the history tree with immediate reconstruction.
- Manipulate both the parameters and points of all objects freely. Never forget the steps involved in construction - the entire tree is saved inside the file and is accessible at any time.
- Thanks to the possibility to freely manipulate your models, you can easily experiment with new shapes and improve your creativity.

**Advanced NURBS Modeling**

Evolve uses NURBS (Non Uniform Rational B-Splines) as its geometry type. This curve and surface definition method offers the...
greatest flexibility and precision. NURBS are capable of representing any desired shape, both analytic and free form, and their algorithms are extremely fast and stable. Full NURBS-based modeling, construction history, and the most advanced modeling tools make Evolve a matchless tool for designers.

**Polygonal Modeling and Subdivision Surfaces**

Evolve also features an advanced polygonal modeler with support of n-side polygons. It is possible to create and extrude polygons, split faces and edges, refine, decimate, and perform many other operations. The unique implementation of interactive subdivision surfaces with construction history gives the user maximum power for refinement and smoothing of polygonal meshes.

**Reverse Engineering**

- **Fit points** - Create a surface from a point cloud data set.
- **PointCloud from object** - Create a PointCloud given a surface.
- **Planar Clouds from PointCloud** - Creates a specified number of points clouds lying on parallel planes from a given points cloud. This command can be useful to simplify a points cloud derived from 3D scanning.

Beside a section planes direction, the user can specify either the number of planes, or the distance between planes.

- **Curve from PointCloud** - Creates a curve from a point cloud. This tool creates a curve starting from a selected point and approximating the points ordered by minimal distance.

**Real-Time Photo Realistic Rendering**

Take advantage of a truly comprehensive rendering system integrating all industry-leading rendering techniques. The most efficient memory management functions, unlimited output resolution, as well as multi-threaded and multi-processor renderings makes Evolve the perfect tool for generating photo realistic images. Real-time rendering further improves interactivity during the review and visualization phases of design.

**Animation**

Take your design presentations to the next level by creating photo realistic animations. Create videos or Quicktime VR movies to communicate complex ideas, or import H3D files to produce stunning simulations.

**Direct Import**

- 3ds
- ACIS
- Adobe Illustrator
- CATIA (V4 & V5 & V6)
- DWG
- DXF
- H3D
- I-DEAS
- IGES
- Inventor
- NX
- OBJ
- Parasolid
- Point cloud
- Pro/E
- Rhinoceros
- SolidWorks
- STEP
- STL
- VDAFS
- VRML
Altair’s Simulation Manager allows users to manage the life cycle of simulation projects through an intuitive web based portal. Guidance for different aspects of a simulation project life cycle are provided to the user, starting from project creation, setting up of Key Performance Targets (KPT), modeling, job submission, analysis, extraction of Key Performance Indicators (KPI), subsequent validation and powerful dashboards.

**Product Highlights**

- Data Management of projects and simulations
- Seamless access to Compute Manager™, Results Visualization Service, Display Manager™, and Process Manager
- Key performance indicator dashboards for goals and simulations
- Goals and Metrics Management
- Seamless integration of desktop and remote/HPC applications

**Benefits**

**Traceability**
- Rapid traceability and knowledge query into simulation data
- Standardization of CAE processes and data storage
- Unified interface for entire simulation life cycle management through a single portal
- Elevation of simulation project data through the entire enterprise using comprehensive dashboards
- Seamless access to compute and remote visualization infrastructure

**Minimize Effort Duplication**
- Reduce efforts for reworking of models and obtain traceability of CAE models and reports to CAD/PDM
- Manage projects, simulations, and targets/goals within the context of product classification such as programs, categories or simulation disciplines
- Define and compare actual observations against set product performance targets

**Ease of Use:**
- Easy to use web based application
- Seamless connection to local and remote data repositories
- Product validation according to standard enterprise workflows
- Search of simulations based on metadata or full text

**Automation**
- Automatic metadata extraction from CAD/CAE models, inputs and results, such as materials, thickness, versions, and more
- Access to desktop and remote applications via web browser
- Extraction of plots and animation results from huge result files without download
- Automatic status updates from PDM systems

**Capabilities**

The Simulation Manager offers a complete set of capabilities for users to manage their simulation life cycle.

**Data Management**
- CAE project and simulation data can be organized and categorized via classification and project templates
- For better organization, existing datatypes can be modified or new ones added
Goals and Metrics Management
- Faster qualitative conclusions for simulations and cross discipline collaborations are enabled via dashboards
- Multiple ways to visualize and analyze goals
- Manage standard goals from a catalogue and reuse them across projects

Process Management
- Define and capture CAE workflows
- Capture input and output for each task
- Send notifications for task assignments
- Execute human and automated tasks

Indexing and Query
- Simple and advanced searches and classification-based searches allow users to find their CAE data easily
- Automated data capture and indexing framework allow quick access to simulation data
- Register custom parsers to extract customer specific meta data
- Powerful search filters

Integrated with Compute Manager and Display Manager
- Interactive job submission and monitoring
- Remote access of result files directly on HPC infrastructure without downloading
- Seamlessly access desktop and remote applications

Traceability and Dashboards
- Comprehensive view of simulation history
- Traceability from CAD/PDM to the final CAE report and vice versa
- Summary dashboards of simulation projects

Security
- Optional Lightweight Directory Access Protocol (LDAP) integration
- Role- or user based access controls

Growing Demand for Simulation Manager
Easy access to HPC and cloud computing resources, coupled with lower costs of hardware infrastructure and the general trend for increasing simulation model size, complexity and model variations is leading to an explosion in the amount of simulation data. Typical PLM systems are not designed to handle the vast amount of data that is generated during the simulation life cycle.

A top down approach to implement simulation data traceability with PDM systems can be disruptive, counterintuitive, and expensive with long implementation cycles. Altair’s Simulation Manager is designed to work within the CAE environment without disrupting the CAE workflow and is compatible with existing CAD, PDM and simulation tools. Without any installations at the client site, users are able to organize and manage their simulation data through a simple web browser. With comprehensive dashboards and role-based access controls, CAE analysts, managers, and executives are able to obtain easy access to the state of their simulation projects through a simple and powerful web portal.

Installation & Deployment
Altair recognizes the importance of making data management systems easy to deploy, configure, and use. Simulation Manager can be used out-of-the-box with minimal configuration, such as meta data changes and addition of new content types. Additionally, Altair offers professional services to configure and customize Simulation Manager based on customer requirements.

Supported Platforms
- Operating Systems (Server)
  - Windows Server 2008/2012 R2 64-bit
  - Linux 64-bit
  - SLES 12
  - RHEL 6
  - CENTOS 6
- Supported Browsers (Clients)
  - Windows: Firefox, Chrome and Internet Explorer
HyperWorks Unlimited®

Today engineering teams need to deliver more robust and innovative products with processes and solutions at an ever increasing pace. This requires the exploration of multiple scenarios and is limited by the ability to mobilize resources quickly. Firms need on-demand access to HPC and data management that can be supported with minimal IT burden.

Powered by Altair’s enterprise software, PBS Works, Altair’s cloud-based HyperWorks Unlimited appliances provide users with a secure cloud-based platform (either on-premise or off-premise) to run, monitor and manage their simulations and meet their computing needs.

HyperWorks Unlimited Physical Appliance: A private cloud solution that is optimized for CAE with properly configured hardware and software, offering unlimited use of all Altair software within the appliance. Altair is the only company to offer best-in-class application software and HPC workload management tools, within an industry leading licensing and business model to fit growing simulation needs.

HyperWorks Unlimited Virtual Appliance: A CAE cloud solution, bringing software, platform, and infrastructure as a service to Altair customers within a single and intuitive portal. It leverages Altair’s patented licensing system, providing access to a selection of the HyperWorks products and a modern, scalable HPC infrastructure through a secure and efficient web-based platform.

Benefits
Both HyperWorks Unlimited Virtual Appliance and HyperWorks Unlimited Physical Appliance allows companies to expand CAE computing capacity and quickly utilize HPC so that they can intelligently manage resources efficiently.

HyperWorks Unlimited delivers a unique value to organizations by providing the hardware, off-the-shelf software and support needed to integrate engineering processes.

Product Highlights
• Pre-configured and ready to use on day one
• Simplified IT administration
• Unlimited use of all HyperWorks solver applications
• PBS Works suite to create the ideal user experience
• Full global support from Altair

HyperWorks Unlimited

HyperWorks Unlimited is a state-of-the-art cloud appliance available in both physical and virtual formats, offering unlimited use of all Altair software. Altair’s CAE cloud appliances address the unique needs of enterprises by simplifying access to an HPC infrastructure at an affordable cost. This allows engineers and scientists access to hardware, software, and HPC support that enables robust product designs.

Learn more: altairhyperworks.com/hwul
Essentially, Altair is productizing HPC for any company to leverage so that this type of capability is no longer only possible for large organizations.

- Robust Design Capabilities: Includes unlimited HyperWorks Units for usage within the appliance for massive virtual exploration.
- Productized HPC: Delivered as a turnkey system, loaded with Altair’s HyperWorks applications plus PBS Works™ for workload management for simplified deployment. Installation takes hours vs. days or weeks. Only Altair delivers both HPC workload management and simulation applications — nobody understands the needs of HPC users better.
- Powerful HPC Solutions: Integration of the HyperStudy® design exploration engine with the PBS Works suite lets engineers vary designs to perform Design of Experiments (DOE) and stochastic and numerical optimization studies then submit the runs directly to the HPC system. The PBS Works suite provides modern and intuitive framework for:
  - Resource provisioning
  - Workload management and scheduling
  - Security and licensing framework
  - Enabled remote visualization, notification, and collaboration
- Innovative Licensing Model: Leverage Altair’s licensing system to access HyperWorks products on a secure HPC infrastructure. Apply the following Altair products in your design processes:
  - RADIOSS®: Complete finite element solver for structural analysis
  - FEKO®: Comprehensive suite for Electromagnetic Analysis
  - AcuSolve®: Leading general-purpose CFD solver
  - OptiStruct®: Award-winning design synthesis and structural optimization solver
  - MotionSolve®: Comprehensive suite for analysis of Multibody System performance
  - BatchMesh®: High-fidelity FE-mesher for large assemblies in one click
- Third Party Solver Support: Open architecture allows for third party solvers to be fully integrated for a monthly fee on a “bring your own license” model.

Who Needs HyperWorks Unlimited?
Both HyperWorks Unlimited Physical Appliance and HyperWorks Unlimited Virtual Appliance are ideal solutions for companies of all sizes and provide a competitive advantage to users in a broad range of industries.

- Small firms can now perform engineering and simulation once only available to OEMs without the need for extensive capital and IT. HPC capabilities are democratized so that everyone can engage in DOE and become more competitive in a matter of minutes.
- Medium businesses can now afford to expand their HPC resources because they are no longer constrained by solver licenses.
- Larger organizations with dispersed regional engineering centers can quickly add new and additional capacity with local support at the department level which otherwise would have no local HPC compute resources or support.

What Users Are Saying
75% of users that employed HyperWorks Unlimited computing resources in a trial found it useful to their project.
100% were able to complete a equal or greater amount of work when compared to their previous computing environment.

“This is the way HPC should be for all CAE engineers – this simple, this powerful, this reliable.” – Stanley Black & Decker

100% of users that operated HyperWorks Unlimited in a trial found the computing performance to be the same or faster than their previous computing environment.

“It’s an incredible product that gives our engineers access to all the software they need, fully configured and ready to use.” – Mubea

88% of participants in the HyperWorks Unlimited trial rated their experience positive or extremely positive.

“Altair’s cloud solutions, namely HyperWorks Unlimited Virtual Appliance, allow us to seamlessly scale our CAE needs through a simple application aware, web browser gateway. We use HyperWorks on the cloud exactly the same way we would use it on our desktops, with the added ability of setting up large runs directly on the HPC infrastructure and post-processing all the runs on the server side, eliminating the need for downloading large result files.” – LeanNova

100% of HyperWorks Unlimited trial participants would recommend HyperWorks Unlimited to a colleague or friend.

“For companies like ours looking to do large-scale exploration, the ease of instantaneously accessing CAE and HPC without the massive integration expense and large deployment time is extremely beneficial. Altair is uniquely eliminating the barriers to HPC with its technologies and business model on the cloud.” – LeanNova
PBS Works™

Benefits
Architected for exascale computing and providing the backbone for Altair’s CAE appliances and cloud offerings, the PBS Works suite is focused on speed, scale and resilience. Proven for over 20 years at thousands of global sites, PBS Works is applicable to a vast array of industries including automotive, aerospace, academia, energy, electronic design automation, defense, weather and more.

Companies who have invested in HPC resources to optimize their solver usage need to be sure their HPC assets will operate reliably around the clock. Just as importantly, the systems need to be easy to use, manage, and scale while still being cost-effective.

PBS Works addresses these challenges with the most comprehensive suite of integrated HPC workload management products available from a single vendor.

PBS Works simplifies and streamlines the management of HPC resources with powerful policy-based job scheduling, user-friendly web portals for job submission and remote visualization, and deep analytics and reporting. With PBS Works, users can optimize system utilization and improve application performance.

HPC Solutions
Altair delivers market-leading software for both IT managers and design engineers. The industry-leading feature set includes Green Provisioning™ for power-aware scheduling, market-leading security, GPU and coprocessor scheduling, scalability to millions of jobs a day, and the ability to work efficiently with massive datasets. Engineered to make HPC easy, fast, and reliable, Altair’s HPC solutions include:

Cloud Computing
Altair’s cloud solutions, HyperWorks Unlimited, are a state-of-the-art cloud appliances available in both physical and virtual formats, offering

PBS Works, named the #1 solution by HPCwire readers, is Altair’s comprehensive secure workload management suite for high-performance computing (HPC) environments. This integrated suite simplifies the use of HPC while improving resource utilization and ROI. Altair is the only company to offer best-in-class application software, HPC workload management tools, and an industry leading licensing and business model to fit growing simulation needs.

Suite Highlights
• PBS Professional®: Industry-leading workload manager and job scheduler for HPC environments
• Compute Manager™: Web-based portal for simplified job submission and management
• Display Manager™: Web-based portal for remote visualization and collaboration
• PBS Analytics™: Easy to use job accounting, reporting, and analytics product
• Altair SAO: Software Asset Optimization to right-size software investments

Learn more: altairhyperworks.com/pbsworks
unlimited use of all Altair software. Altair’s CAE cloud appliances address the unique needs of enterprises by simplifying access to an HPC infrastructure at an affordable cost. This allows engineers and scientists access to hardware, software, and HPC support that enables robust product designs.

Web-Based Access
PBS Works’ Compute Manager and Display Manager provide web accessible interfaces to visualize and work with data and applications remotely, even across networks with challenging latencies. The two together offer end users an efficient way to leverage HPC facilities, minimizing the time spent learning how to run applications and on non-core activities such as transferring data back and forth.

• Compute Manager is a job submission, management, and monitoring portal, that hides the complexities of HPC facilities for end-users to focus only on their data and applications.
• Display Manager is a platform for collaboration and remote visualization of applications and data.

Analytics
PBS Works’ PBS Analytics and Altair SAO offers the solutions organizations need to measure and analyze utilization of all IT assets including software license utilization, hardware, and user-based utilization trends.

• PBS Analytics is an easy to use job accounting and reporting solution that delivers advanced analytics to support data-driven planning and decision making by providing a global view of HPC usage for chargeback, capacity planning, troubleshooting and project management.
• Altair SAO is a tool for measuring and analyzing application use for right-sizing global investments. SAO works seamlessly with popular license managers to provide a single, aggregated view of enterprise software assets to improve capacity planning.

Workload Management
PBS Professional® is Altair’s industry-leading workload manager and job scheduler for HPC environments. PBS Professional® is a fast, powerful workload manager designed to improve productivity, optimize utilization and efficiency, and simplify administration for HPC clusters, clouds and supercomputers.

PBS Professional automates job scheduling, management, and monitoring and reporting. It is the trusted solution for complex systems as well as smaller clusters.

Supported Platforms
PBS Works products support a multitude of platforms and has been integrated with hundreds of end user applications across all industries – including leading commercial applications, open source software, and proprietary/home-grown codes.

Visit www.pbsworks.com/platforms to see the entire list.
Altair HyperWorks offers the broadest range of solutions to simulate and optimize products’ performance in areas including structural linear and nonlinear analyses, system-level optimization, fluid and multi-body dynamics simulation, electromagnetic phenomena, and multiphysics analysis. Additional optimization and analysis capabilities are available to all the HyperWorks customers through the Altair Partner Alliance (APA).

### Capabilities Chart

<table>
<thead>
<tr>
<th>Capabilities</th>
<th>OptiStruct</th>
<th>RADIOSS</th>
<th>MotionSolve</th>
<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
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<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>+</td>
</tr>
<tr>
<td>Optimization</td>
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<td>★</td>
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#### Structural Simulation

<table>
<thead>
<tr>
<th>Linear Solutions</th>
<th>OptiStruct</th>
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<tr>
<td>Statics</td>
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<td>★</td>
<td>★</td>
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<td>+</td>
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<td>Normal Modes</td>
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<td>★</td>
<td>★</td>
<td>★</td>
<td>+</td>
</tr>
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<td>Complex Modes</td>
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<tr>
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<td>★</td>
<td>★</td>
<td>★</td>
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<td>Direct Frequency Response</td>
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<td></td>
<td></td>
<td>+</td>
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<tr>
<td>Modal Frequency Response</td>
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<td></td>
<td></td>
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<tr>
<td>Direct Transient Response</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Modal Transient Response</td>
<td>★</td>
<td></td>
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<table>
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<th>Implicit Nonlinear Solutions</th>
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<th>FEKO</th>
<th>APA</th>
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<tbody>
<tr>
<td>Quasi-Static</td>
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<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>+</td>
</tr>
<tr>
<td>Transient</td>
<td>★</td>
<td>★</td>
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<td>★</td>
<td>★</td>
<td>+</td>
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<tr>
<th>Explicit Nonlinear Solutions</th>
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<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
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<tbody>
<tr>
<td>Structural Impact, Crash</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>+</td>
</tr>
<tr>
<td>Arbitrary Lagrangian Eulerian Method (ALE)</td>
<td>★</td>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Explicit Advanced</th>
<th>OptiStruct</th>
<th>RADIOSS</th>
<th>MotionSolve</th>
<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
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<tr>
<td>Advanced Mass Scaling</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>+</td>
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<table>
<thead>
<tr>
<th>Materials</th>
<th>OptiStruct</th>
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<tr>
<td>Linear</td>
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<tr>
<td>Plasticity (Rate Independent)</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>+</td>
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<tr>
<td>Plasticity (Rate Dependent)</td>
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<td>★</td>
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<td>+</td>
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<tr>
<td>Hyperelasticity</td>
<td>★</td>
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<td>★</td>
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<td>★</td>
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<table>
<thead>
<tr>
<th>Connectors</th>
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<th>APA</th>
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<tr>
<td>Pretension</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>+</td>
</tr>
<tr>
<td>Joints</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>+</td>
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<table>
<thead>
<tr>
<th>Contact</th>
<th>OptiStruct</th>
<th>RADIOSS</th>
<th>MotionSolve</th>
<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
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<tbody>
<tr>
<td>Friction</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
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<tr>
<td>Small Sliding</td>
<td>★</td>
<td>★</td>
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## Advanced Modeling

<table>
<thead>
<tr>
<th>Component Mode Synthesis</th>
<th>Sub structuring</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Parts and Instances</th>
<th>Direct Matrix Input</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Sub Modeling</th>
<th>Ply-based Composite Laminates</th>
</tr>
</thead>
<tbody>
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## Thermal Simulation

### Solutions

<table>
<thead>
<tr>
<th>Linear Steady-state</th>
<th>Linear Transient</th>
</tr>
</thead>
<tbody>
<tr>
<td>■■■</td>
<td>■■■</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-linear Steady-state</th>
<th>Non-linear Transient</th>
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<tbody>
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<td>■■■</td>
<td>■■</td>
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### Thermal Modeling

<table>
<thead>
<tr>
<th>Conduction</th>
<th>Radiation</th>
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<tr>
<td>■■■</td>
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<table>
<thead>
<tr>
<th>Convection</th>
<th>Thermal contact</th>
</tr>
</thead>
<tbody>
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## Multi-Body Simulation

### Solutions

<table>
<thead>
<tr>
<th>Kinematic</th>
<th>Quasi-Static</th>
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<td>■■■■</td>
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<table>
<thead>
<tr>
<th>Dynamic</th>
<th>Linearization</th>
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### Advanced Modeling

<table>
<thead>
<tr>
<th>Linear Flexible Bodies</th>
<th>Rigid-body Contact</th>
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<tbody>
<tr>
<td>■■■</td>
<td>■■■</td>
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</table>

<table>
<thead>
<tr>
<th>Non-linear Flexible Bodies</th>
<th>Universal Bushing</th>
</tr>
</thead>
<tbody>
<tr>
<td>■■■</td>
<td>■■</td>
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</table>

| Higher-pair Joints | |
|--------------------||
| ■■■                | |

## Fluid Dynamics Simulation

### Solutions

<table>
<thead>
<tr>
<th>Incompressible and weakly compressible Stokes and Navier-Stokes equations</th>
<th>Computational Aero Acoustics (CAA)</th>
</tr>
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<tbody>
<tr>
<td>★+</td>
<td>★+</td>
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<table>
<thead>
<tr>
<th>Multi-Species transport equations</th>
<th>Fully coupled temperature/flow</th>
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</thead>
<tbody>
<tr>
<td>★+</td>
<td>★+</td>
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</table>

| Newtonian and Non-Newtonian Flow | |
|----------------------------------||
| ★+                               | |

### Turbulence Models

<table>
<thead>
<tr>
<th>Direct Numerical Simulation (DNS)</th>
<th>k-omega 2-equation model</th>
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<tbody>
<tr>
<td>★+</td>
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<table>
<thead>
<tr>
<th>Large Eddy Simulation (LES)</th>
<th>Hybrid RANS/LES</th>
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<table>
<thead>
<tr>
<th>Spalart-Allmaras based Delayed Detached Eddy Simulation (DDES)</th>
<th>Spalart-Allmaras based Detached Eddy Simulation (DES)</th>
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</thead>
<tbody>
<tr>
<td>★+</td>
<td>★+</td>
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<table>
<thead>
<tr>
<th>Dynamic sub-grid scale</th>
<th>Constant coefficient Smagorinsky</th>
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<td>★+</td>
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<table>
<thead>
<tr>
<th>Reynolds Averaged Navier-Stokes (RANS)</th>
<th>Improved Delayed Detached Eddy Simulation (IDDES)</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Spalart-Allmaras 1-equation model</th>
<th>SST DES</th>
</tr>
</thead>
<tbody>
<tr>
<td>★+</td>
<td>★+</td>
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</table>

| SST 2-equation model | |
|---------------------||
| ★+                  | |
## Moving Mesh Technology

<table>
<thead>
<tr>
<th>Method</th>
<th>OptiStruct</th>
<th>RADIOSS</th>
<th>MotionSolve</th>
<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
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<tbody>
<tr>
<td>Arbitrary Lagrangian Eulerian (ALE)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
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<td>Free surface simulation</td>
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<td>✫</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
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<tr>
<td>Non-conformal Mesh Interfaces</td>
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<td>✫</td>
<td>✭</td>
<td>✫</td>
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## Particle Tracer

<table>
<thead>
<tr>
<th>Tracer</th>
<th>OptiStruct</th>
<th>RADIOSS</th>
<th>MotionSolve</th>
<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
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<tbody>
<tr>
<td>Finite mass and massless particle tracing</td>
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<td>✫</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
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<tr>
<td>Bi-directionally coupled</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✫</td>
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</table>

## Electromagnetics Simulation

### Frequency-domain Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>OptiStruct</th>
<th>RADIOSS</th>
<th>MotionSolve</th>
<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method of Moments (MoM)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Multi-level Fast Multipole Method (MLFMM)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Finite Element Method (FEM)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Physical Objects (PO)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Ray-launching Geometrical Optics (RLGO)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Uniform Theory of Diffraction (UTD)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
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</table>

### Time-domain Method

<table>
<thead>
<tr>
<th>Method</th>
<th>OptiStruct</th>
<th>RADIOSS</th>
<th>MotionSolve</th>
<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finite Difference Time Domain (FDTD)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
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</table>

### Special Formulations

<table>
<thead>
<tr>
<th>Formulation</th>
<th>OptiStruct</th>
<th>RADIOSS</th>
<th>MotionSolve</th>
<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic Mode Analysis (CMA)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
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<tr>
<td>Low Frequency Stabilization</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
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<tr>
<td>Cable Harness Analysis</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Windscreen Antenna Analysis</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
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<tr>
<td>Adaptive Frequency Sampling (AFS)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
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</table>

### Advanced Modeling

<table>
<thead>
<tr>
<th>Modeling</th>
<th>OptiStruct</th>
<th>RADIOSS</th>
<th>MotionSolve</th>
<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Order Curvilinear Elements</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
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<tr>
<td>Integrated SPICE circuit simulation</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
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</table>

### Excitations

<table>
<thead>
<tr>
<th>Excitation</th>
<th>OptiStruct</th>
<th>RADIOSS</th>
<th>MotionSolve</th>
<th>AcuSolve</th>
<th>FEKO</th>
<th>APA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single or multiple plane waves</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Waveguide ports (both analytical and numerical)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Voltage and current ports on wires and edges</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Elementary electric/magnetic dipoles</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Aperture sources (also measurements)</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Spherical modes</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
</tr>
<tr>
<td>Far-field patterns</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
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<tr>
<td>Impressed line currents</td>
<td>✭</td>
<td>✫</td>
<td>✭</td>
<td>✭</td>
<td>✫</td>
<td>✫</td>
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</tbody>
</table>
### Solution Requests

<table>
<thead>
<tr>
<th>Near fields</th>
<th>S-parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Far fields (gain, directivity, radar cross section etc.)</td>
<td>Transmission &amp; Reflection Coefficients</td>
</tr>
<tr>
<td>Specific Absorption Rate (SAR)</td>
<td>Network port currents / voltages</td>
</tr>
<tr>
<td>Input impedances</td>
<td>Error estimation (with adaptive mesh refinement)</td>
</tr>
<tr>
<td>Currents &amp; Charges</td>
<td>Spherical Modes</td>
</tr>
</tbody>
</table>

### Coupled Physics

<table>
<thead>
<tr>
<th>Thermal-Structure Coupling</th>
<th>Modal (Practical) Fluid-Structure Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Fluid-Structure Coupling</td>
<td>Fluid-Multi-body Coupling</td>
</tr>
</tbody>
</table>

### User-defined Functions (UDF)

<table>
<thead>
<tr>
<th>Materials</th>
<th>Loads, boundary conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elements</td>
<td>Responses</td>
</tr>
</tbody>
</table>

### Parallel Computation

#### CPU Parallelization

<table>
<thead>
<tr>
<th>Single Memory Processing (SMP)</th>
<th>Hybrid SPMD/SMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Program, Multiple Data (SPMD)</td>
<td></td>
</tr>
</tbody>
</table>

#### GPU Parallelization

<table>
<thead>
<tr>
<th>GPU Acceleration</th>
<th>GPU-based</th>
</tr>
</thead>
</table>

### Material Database

<table>
<thead>
<tr>
<th>Non-linear Materials</th>
</tr>
</thead>
</table>
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