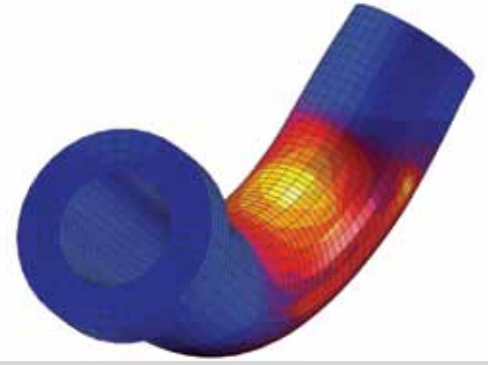# Marc
## Nonlinear Analysis for Engineering Applications & Manufacturing Processes

## Overview

Marc is a powerful, general-purpose, implicit nonlinear finite element analysis (FEA) software program that accurately simulates static, dynamic and coupled physics problems for a wide range of design and manufacturing applications. Unlike linear FEA methods that rely upon making simplifying assumptions, Marc enables you to emulate the complex nature of real-world behavior and mechanical processes to ensure highest design confidence and product performance under realistic environments and operating conditions. Recognized as the world's first commercial nonlinear FEA software, Marc has, since 1971, delivered innovative, easy-to-use and robust solutions that are well-suited for analyzing the structural integrity and performance of parts experiencing geometric, material, and/or boundary nonlinearities.

## Advanced Modeling to Simulate Real-World Behavior

- Capturing the correct part characteristics and behavior is crucial in predicting the complex nature of today's real-world analysis challenges. Marc uses the latest, proven, linear and nonlinear numerical analysis and modeling techniques to perform static, transient, buckling, post-buckling, creep, and time- and frequency-based dynamic simulations for a variety of engineering and materials research applications.

- Marc includes a comprehensive finite element library with no practical limit to the number of elements or element types allowed in your analysis. Marc also provides an extensive set of material models to represent the nonlinear behavior of metals, composites, elastomers, and other non-metallic materials, including capabilities to model plasticity, viscoelasticity, hypoelasticity and other nonlinear properties. The material models can be temperature dependent and also allow for isotropic, orthotropic, and anisotropic behavior. Temperature, flux, convection, radiation, and other time-dependent boundary conditions can be prescribed, as well as unique capabilities for handling gaps, cooling passages, and coupled electrostatics heat transfer (Joule effect) structural analysis.

- The wide range of nonlinear modeling capabilities in Marc helps engineers innovate with manufacturability in mind and enables the successful development of cost effective products. Typical example applications include:
  - Metallic assemblies and Components
  - Non-Metallic load bearing components
  - Heat Transfer and Thermal Stress
  - Coupled Multiphysics Analyses

## Powerful Auto-remeshing and Adaptive Finite Element Meshing Capabilities

In applications involving materials experiencing extreme deformations, the finite element mesh may become highly distorted, usually leading to a loss in accuracy or analysis failure. However, Marc overcomes this problem by automatically generating a new global mesh ("remeshing") and transferring the solution from the old mesh to the new mesh ("rezoning"). Marc's robust global adaptive remeshing and rezoning capability creates high-quality meshes on individual bodies during the deformation process and automatically reapplies the contact boundary conditions to achieve accurate and fast solutions to highly non linear problems. Selective enrichment of the mesh in areas where material nonlinearity occurs helps to minimize computational costs and achieve high precision where it is needed.

## Unmatched Automatic Multibody Contact Analysis

Marc features the industry's most advanced 2-D and 3-D capabilities to model contact between bodies. Contact between deformable bodies (collection of elements) and rigid bodies (geometric entities), contact between multiple deformable bodies, self-contacting bodies, and interference fit analyses are automatically solved with no limit to the number of contacting bodies. Unlike other programs that require you to manually sort and pair-up individual contact surfaces, Marc

## Capabilities

- Advanced nonlinear materials
- Industry proven contact to accurately simulate product performance and manufacturing
- Coupled solutions of nonlinear structural, thermal, electromagnetics.
- Advanced heat transfer analysis capabilities
- Special purpose material models including Shape Memory Alloy and Solder models
- Comprehensive connector and fastener models to simulate commonly found connections
- State-of-the-art iterative solvers and parallel processing on shared and distributed memory machines
- Automated remeshing and adaptive meshing to increase solution robustness and accuracy
- Motion and suspension analysis powered by Adams
- Advanced damage and fatigue analysis of metals and composite structures
- Predict crack initiation and propagation under realistic load conditions

## Benefits

- Shorten the design optimization process, while improving design and product performance through integrated simulation
- Reliable analysis capabilities to reduce product design, development, manufacturing & warranty costs
- Robust solver technology that greatly enhance the value of nonlinear solutions encountered in many industries

MSC ✕ Software®

allows you to simply select an entire body and it will automatically track the contacting surfaces and tying constraints of contact.

## Superior High-performance Parallel Simulation

The domain decomposition method (DDM) provided by Marc is a high-performance parallel processing algorithm that runs on shared and distributed memory computing platforms. With DDM, the solver will automatically split a large-scale model into as many individual domains as there are CPUs to minimize inter-domain message-passing interface (MPI) communication and simulate the entire FEA process in parallel.

## Pre- and Post-processing Flexibility And Ease-of-use

A full range of capabilities for the visualization and interpretation of analysis results is provided by Marc Mentat®, the dedicated, interactive graphical user interface (GUI) specially built for Marc. Construction of high-quality finite element meshes can be created directly or automatically derived from non-uniform rational B-spline (NURBS) geometry. CAD geometry and finite element data can be imported from leading modeling systems and easily edited in any coordinate system. Marc Mentat also helps you build a complete load case description and automatically associates material properties and boundary conditions to the finite element mesh when applied to the geometry. Multiple analysis jobs can be initiated, controlled, and monitored, and post-processing graphical controls and plotting capabilities enable you to visualize the results.

Marc is also integrated with Patran® (via the Patran Marc Preference), which has similar facilities for generating, editing, and verifying finite element meshes. With either GUI, you have the pre- and post-processing flexibility to construct and analyze comprehensive models for nonlinear FEA.
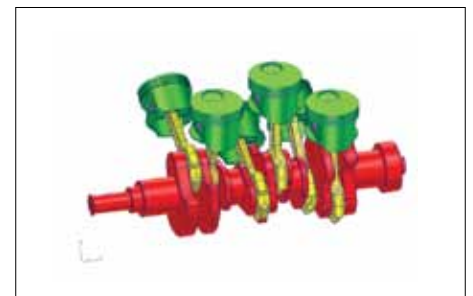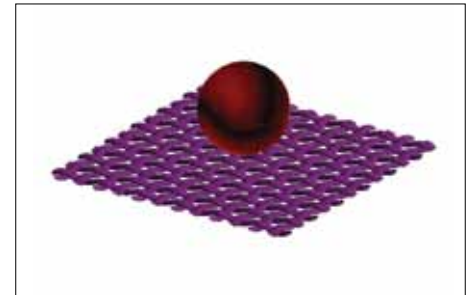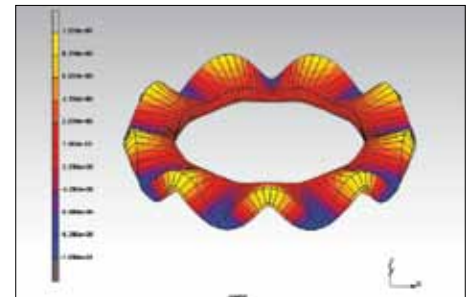
## Open Approach To Problem Solving For Enhanced Productivity

Marc allows you to customize loads, boundary conditions, and material properties through versatile user subroutines. Written in FORTRAN, user subroutines can accommodate special analysis needs, such as spatial or temporal distribution of loads, complex material properties, and friction coefficients, for example. Marc offers a rich library of pre-defined user subroutines to help you solve various problems.

A multivariable table input capability provides a flexible and easy alternative for specifying loads and boundary conditions and applying material properties and load history models. Continuous functions and parametric input can be specified to improve accuracy and reduce the size of the input file. This capability enhances the connectivity of Marc with CAD programs and other MSC.Software products, such as MSC Nastran™ and Patran.

Marc Mentat supports the use of the Python scripting language to give you access to the database and tailor the program flow. Patran also provides an open CAD environment that allows users to tailor its GUI for enhancing productivity.

The Marc product family is supported on all major UNIX, Linux, and Windows platforms, and can run on shared memory architectures and distributed and networked computing systems.

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