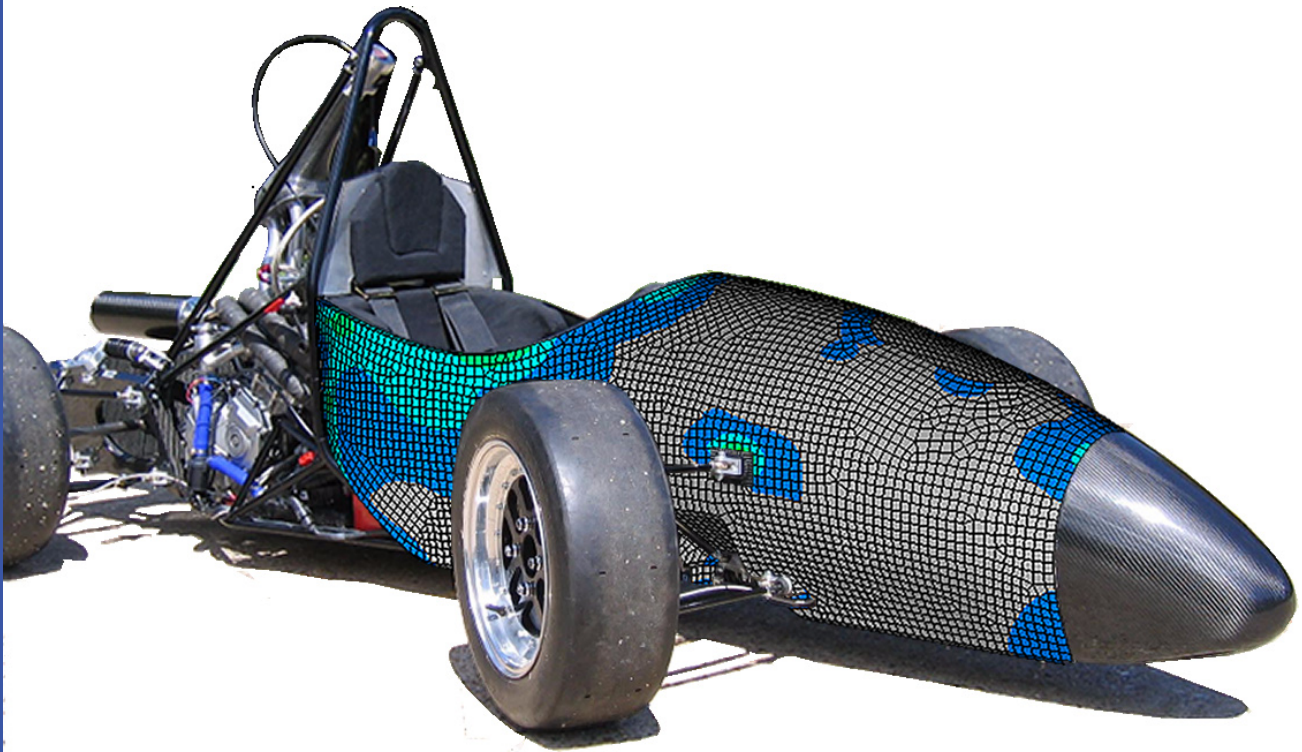# GENESIS

Structural Design Optimization Software

GENESIS® is a fully integrated structural finite element analysis and design optimization software package. Analysis capabilities include: static, normal modes, direct and modal frequency analysis, random response analysis, heat transfer, and system buckling calculations.

Design optimization is based on the advanced approximation concepts approach to find an optimum design efficiently and reliably. Actual optimization is performed by the well established DOT and BIGDOT optimizers, also from VR&D. Design capabilities include: topology, shape, sizing, topography, topometry and freeform optimization.

- Fast, reliable and accurate finite element analysis.

- GENESIS provides improved designs at reduced cycle times.

- Topology optimization at early stage of design.

- Shape, sizing, topometry, topography, and free form optimization for detailed design.

- SMS Eigensolver runs eigensolutions 2 to 10 times faster than the conventional Lanczos method. SMS can solve problems with over 20 million degrees of freedom.

- BIGDOT optimizer solves problems in excess of 3 million design variables. For example, topology optimization problems are currently being solved in excess of 3 million design variables and are getting bigger everyday.

**VR&D**

MODELING OPTIONS

Analysis

- Linear static
- Nonlinear Contact (Gap elements)
- Inertial relief
- Dynamic normal modes
- Buckling
- Frequency response
- Random response
- Heat transfer
- Sensitivity

Design optimization

- Multi-objective and hybrid optimization capabilities
- Topology, shape, sizing, topometry, topography, and freeform optimization

Payload Interface Composite Strut Frequency Tuning
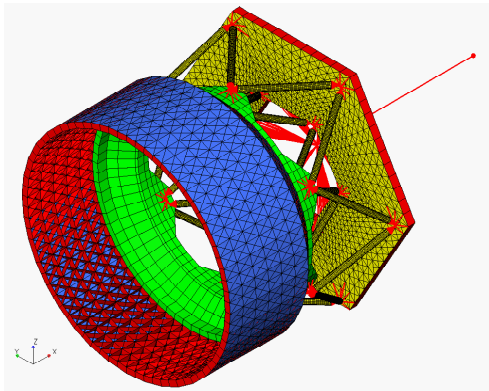
SUPER FAST EIGENSOLVER

GENESIS uses our SMS eigenvalue solution algorithm for lightning fast normal modes analysis. SMS allows eigensolutions to run from 2 to 10 times faster than the conventional Lanczos method.

MODELING FEATURES

- No fixed problem size limit.
- Blocked profile and sparse matrix equation solvers with automatic bandwidth optimizer.
- SMS, Lanczos, and subspace iteration eigenvalue solution algorithms.
- Design sensitivities calculated analytically in most cases.
- Optimization is performed using the latest approximation methods for maximum efficiency.
- Topology optimization finds the optimum shape with the specified mass.
- Structural design variables control the shape, as well as member dimensions.

FINITE ELEMENT ANALYSIS

Reliable element library

Multiple material properties

- Isotropic
- Orthotropic
- General anisotropic

Multiple loading conditions

- Point, pressure, thermal, gravity and centrifugal static loads
- Thermal loads from solution of heat transfer analysis
- Enforced displacements and deformations
- Enforced temperatures
- Heat flux and convection
- Point, pressure, and gravity dynamic loads
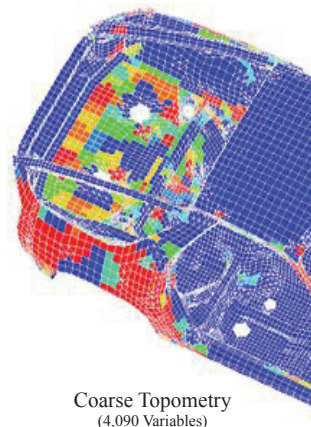- Super elements

Multiple boundary conditions

- Single and multipoint constraints
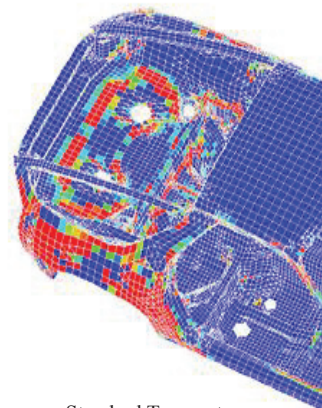
TOPOMETRY DESIGN

Element by element optimization

Coarse topometry optimization

- Allows group-by-group sizing optimization
- Fabrication constraints:
  - *Mirror*
  - *Cyclic*
  - *Extrusion constraints*

Coarse Topometry
(4,090 Variables)

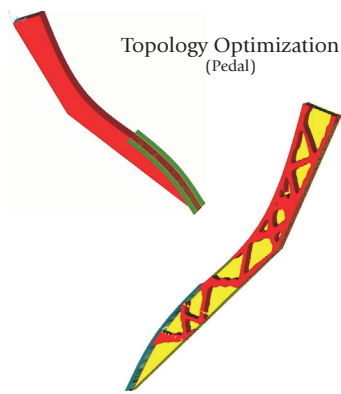Standard Topometry
(34,560 Variables)

TOPOLOGY DESIGN

Automatic generation of design variables

Enforced symmetry available

Built-in responses
- Mass Fraction
- Strain Energy
- Displacement
- Velocity
- Acceleration
- Frequency
- Random response
- Buckling load factor
- Moment of Inertia
- Center of Gravity

Topology Optimization
(Pedal)

Objective function
- Any built-in response
- Combination of responses
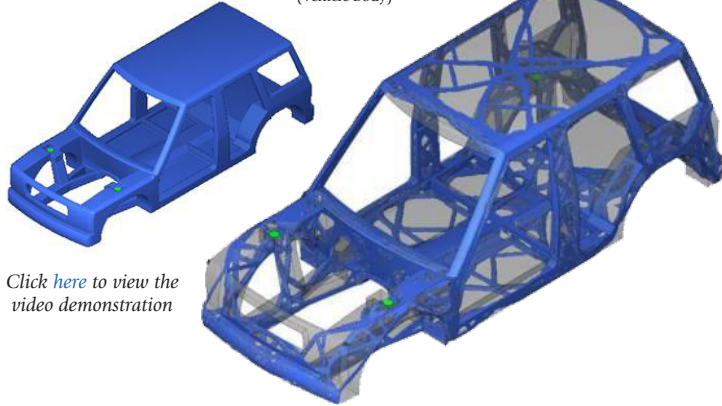- User responses

Constraints
- Any built-in response
- Manufacturing constraint
- User responses

Isodensity surfaces
- Helps visualize the topology results
- Used to create a new FEA mesh for analysis and/or shape and sizing optimization

Full Body Topology Optimization
(Vehicle Body)

Click here to view the video demonstration

SHAPE, SIZING, TOPOGRAPHY & FREEFORM

Simultaneous design
- member dimensions
- grid location

Design variable linking
- Linear and nonlinear

Semiautomatic basis shapes and grid perturbations
- Simplifies input required for shape optimization
- DOMAIN elements define how perturbations vary throughout the model
- Natural basis vectors

Automatic generation of topography perturbations

Automatic generation of rib patterns

Library of beam and plate elements
- Relates design variables directly to member dimensions, not just section properties
- Built-in beam cross-sections: *Square, Rail, I-beam, Circle, Tee, Angle, Spar, Tube, Box, & Rectangle*
- Built-in plate element models: *Solid, Sandwich, and Two thickness sandwich*

Custom cross-sections
- Allows nonlinear equations to relate design variables to section properties
- Allows the use of external user routines

Wide range of user selectable responses
- Built-in responses: *stress, strain, strain energy, force, buckling load factor, natural frequency, eigenvector, displacement, velocity, acceleration, random responses, temperature, distance, length, area, volume, angle, mass, and inertia.*
- Custom responses: *user defined equations, or external routines.*
- External routines linked with GENESIS

Flexible objective selection:
- Minimize or maximize any response(s)
- Match selected response(s) to target value(s)

Lower and/or upper bound constraints on any response

Auto-generation of stress constraints

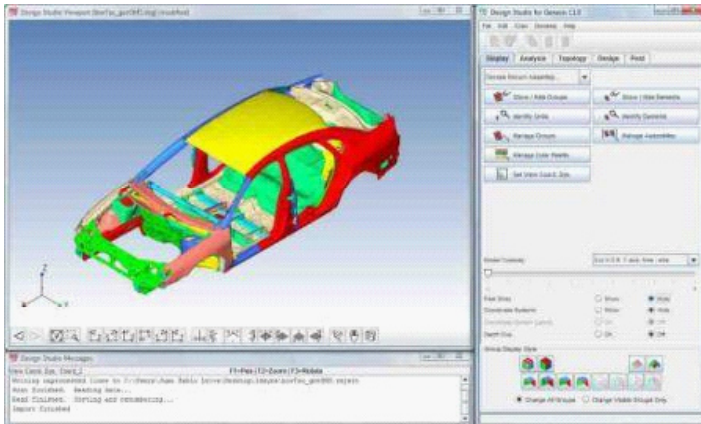## Auto-mode-tracking for frequency and/or eigenvector constraints

Automatic mesh smoothing

Stress ratio option

PRE AND POST PROCESSING

Design Studio for GENESIS

Design Studio for GENESIS is a design oriented pre- and post-processor graphical user interface for the GENESIS program.

Design Studio for GENESIS

Design Studio for GENESIS Features:

- Built-in and easy to use trails make it easy to create design objectives and constraints
- Built-in trails makes it easy to parameterize the model
- Contour plots and animations for stress, displacement, and thickness etc.
- Deformed shape plots and animations
- On the fly isodensity topology plots
- Option to export CAD (STL, IGES), or bulk data representation of topology results
- Frequency response plots
- Helps to create reports and presentations
- Allows users to make picture files (png format)
- Allows users to create movies (gif format)
- Catalogs of views to create pictures with same orientations
- Back and forward buttons to return to previous view
- Color control for printings
- Lua scripting plugin
- Many well documented tutorials and examples used in VR&D workshops, or a self taught learning track

OTHER VR&D PRODUCTS

SMS eigensolver

The SMS eigensolver may be added to existing NASTRAN installations to offer significant performance advantages over the default method when a large number of eigenvectors is required for a system with many degrees of freedom. Benchmark tests and user experiences have seen solution times anywhere between 2-10 times faster when using SMS. SMS may also be embedded into your product/software. Contact us for details.

VisualDOC

VisualDOC is a Multidiscipline Design Optimization software system that simplifies adding optimization to almost any design task. It uses powerful, intuitive graphical interface, both gradient based and non-gradient based optimization, response surface (RS) approximate optimization, and design of experiments (DOE) methods. VisualDOC interfaces easily to your own code or third-party analysis programs.

DOT - Design Optimization Tools

DOT is a general purpose numerical optimization software library which can be used to solve a wide variety of nonlinear optimization problems. If you require only an optimization engine to incorporate into your design software, DOT will serve that purpose.

BIGDOT

BIGDOT is intended to solve very large, nonlinear constrained problems where gradient information is available, and function and gradient evaluation is efficient. BIGDOT is capable of solving continuous, discrete/integer or mixed variable problems. Problems in excess of three million design variables have been solved by BIGDOT.

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