



GENESIS

Structural Analysis and Optimization

New Features and Enhancements

Version 9.0

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1 Introduction

This document describes the new and enhanced features added to Genesis in version 9.0.

Most of the new improvements in this version were added to solve larger and more complex optimization problems. In particular, performance of frequency response optimization has been greatly improved. The rest of the improvements have been added to satisfy user requests and overall enhancement.

Genesis has been improved to take full advantage of 64-bit computers. When used with 64-bit operating systems, Genesis can now access larger amounts of memory. In previous versions, Genesis has been restricted to use up to 8GB, 2GB or even less memory. Now it is possible to use larger amounts, such as 48GB, 64GB or more on 64-bit systems. An additional benefit of using 64-bit machines is a gain in speed; up to 25% gain has been observed on a Windows XP x64 PC running in either the 32- or 64-bit executables.

The adjoint sensitivity method has been added to improve the speed of calculation of frequency response responses. Now, Genesis can solve larger dynamic topography and topometry problems. To further improve dynamic optimization, new alternative approximations have been added for modal displacements, velocities and accelerations.

Coarse topometry has been added to Genesis. This capability allows group-by-group sizing optimization rather than the standard element-by-element of the original topometry. Groups are collections of neighbor elements. These groups of elements are automatically created by the program based on a user specified maximum number of elements per group. This capability reduces the number of design variables to speed up the optimization process.

Fabrication constraints are now available for topometry optimization. Now the user can use mirror, cyclic and/or extrusion constraints to obtain more manufacturable designs.

Existing fabrication constraints in topology have been improved to allow for more combinations. In version 9.0, extrusion and castings can be combined with mirror and cyclic symmetries. These new combinations are mesh independent. In other words, the mesh does not need to be symmetric to obtain a symmetric design.

New analysis types can be used in topology optimization. Now responses from buckling, modal and direct frequency response loadcases can be used the the optimization problem. For stability loadcases, the buckling load factor (LAMA) response can now be selected with TRESP1. For direct and modal frequency response loadcases, now displacements (DDISP & MDISP), velocities (DVELO & MVELO) and accelerations (DACCE & MACCE) can be selected with TRESP1.

Mode tracking has been enhanced to allow tracking buckling modes. This new capability can be used with all types of optimization.

New Features

A multi-objective optimization index function has been added for parametric optimization. This new function greatly simplifies setting up multi-objective optimization problems. This new data (DINDEX) is similar to the topology optimization entry TINDEX .

Superelement capabilities have been improved. With this new version, using the new K4AA solution control command, the reduced elemental structural damping matrix can be generated and exported (in DMIG format). When needed, the exported damping matrix can be read into GENESIS using the existing K2PP data statement.

The GNUUSER executive control command can now optionally call an executable that can provide user-calculated derivatives. In addition, the new GNMSS executive control command can locate a shared library that provides the user mass matrices. With these changes, all user-supplied subroutine functionalities can now be accessed through shared libraries and/or external executables. Therefore, the Genesis library (libgenesis.a) will no longer be provided.

2 Analysis Enhancements

1. Internal memory access has been upgraded to use 64-bit integers. With 64-bit operating systems, GENESIS can now access a larger amount of memory.
2. The LENVEC executive control command has been modified to allow its input data number to have the G suffix to indicate a billion words (1 word = 4 bytes). For example, to specify the use of 48 billion bytes (approximately 48Gbytes) use LENVEC=12G.
Executive Control Statement - LENVEC
3. The PBEAML data entry has been added. It has two libraries of sections for beam elements containing a combined total of 32 cross-sections. PBEAML also enhances GENESIS compatibility with Nastran programs.
Bulk Data Statement - PBEAML
4. A reduced elemental structural damping matrix for superelement analysis can now be generated and exported in DMIG format using the new statment K4AA. K4AA is used in GENESIS "REDUCE" runs.
Solution Control Statement - K4AA=DMIG
5. Genesis created damping matrices can now be read into GENESIS using the K2PP solution control statement. In the previous version, Genesis could only read externally created damping matrices.
Solution Control Statement - K2PP
Bulk Data Statement - DMIG
6. Stress recover of CTRIA3 elements has been improved. Now the calculated stresses represent the center stress. Before, the stresses were calculated at the origin of the element coordinate system. By default, the new method will be used. The new parameter T3SRM can be used to switch back to the old method.
7. Shear deformation is now accounted for in composites (PCOMP) that are built up using only isotropic materials (MAT1). In previous versions, shear deformation was accounted for only in the case where all orthotropic layers in the composite have G1,Z and G2,Z (MAT8).
Bulk Data Statement - PCOMP
8. User functions of dynamic displacements, velocities and accelerations can now be calculated and printed in the output file or in the punch post processing file.
Executive Control Statement - UFDATA
Solution Control Statement - UFDISP, UFVELO and UFACCE
Note: In version 9.0, this capability will require a special license and will not be available in all installations.
9. The latest version of SMS is available with this version.
Bulk Data Statement - EIGR, SMS option

New Features

10. The method to supply a user reduced mass for Guyan Reduccion has been changed. Beginning with version 9.0, to provide a reduced mass for Guyan reduction, the user will need to provide the GNMASS functionality through a shared library. A static Genesis library will no longer be provided, therefore linking a GNMASS user-supplied subroutine into a custom executable will no longer be possible.

Solution Control Statement - MAAUSER

3 Shape, Sizing, Topometry and Topography Optimization Enhancements

1. Coarse topometry has been added to Genesis. This capability allows group-by-group sizing optimization rather than the standard element-by-element of the original topometry. Groups are collections of neighbor elements. These groups of elements are automatically created by the program based on a user specified maximum number of elements per group. This capability reduces the number of design variables to speed up the optimization process.

Bulk Data Statement - DSPLIT (COARSE Option)

2. Fabrication constraints are now available for topometry optimization. Now the user can use mirror, cyclic and extrusion constraints to obtain more manufacturable design proposals.

Bulk Data Statement - DSPLIT (SYM Option)

3. A multi-objective optimization index function has been added for parametric optimization. This new function greatly simplifies setting up multi-objective optimization problems. The new DINDEX bulk data entry allows the creation of an objective function which is a combination of multiple responses. The DINDEX entry is similar to the topology entry TINDEX. A new DOPT parameter, DINDEXM, controls whether the responses are combined directly or inversely and whether the responses are normalized or not.

Bulk Data Statement - DINDEX

Bulk Data Statement - DOPT, DINDEXM

4. Hybrid objective functions can now be used. With this capability some responses can be minimized/maximized with the new entry DINDEX, while others can be matched to targets using the existing DMATCH or DMATCH2 entries.

Bulk Data Statement - DINDEX & DMATCH/DMATCH2

5. New responses have been added for parametric optimization. The real, imaginary, magnitude or phase of user functions of modal or direct frequency response displacements, velocities and/or accelerations can now be referenced in DRESP1.

Bulk Data Statement - DRESP1

Note: In version 9.0, this capability will require a special license and will not be available in all installations.

6. A new approximation is now available for modal displacements, velocities and accelerations. With this new approximation, the sensitivity module requires much less in-core memory and the approximate optimization module is now extremely fast.

Bulk Data Statement - DOPT,MODAPP

7. Stress ratio method has been improved. Move-limits have been added to improve the convergence rate and solve problems more effectively.

Bulk Data Statement - DOPT,ISRMET

New Features

8. A new way to interpret ATTi lists on DRESP1 for the MASS and VOLUME RTYPE and PROP PTYPE has been added. From version 9.0 on, the default is for all the masses or volumes associated to the PIDs in the ATTi list in DRESP1 to be summed together to form a single response. Previously, Genesis created a vector response. A new DOPT parameter, DR1MV, has been added to switch to the old interpretation.

Bulk Data Statement - DOPT,DR1MV

9. The user-supplied program for DRESPU has been enhanced. Now, the external user executable can optionally provide sensitivity calculations to avoid using the finite difference method.

Executive Control Command -GNUSER

Bulk Data Statement - DRESPU

Bulk Data Statement - DOPT,IUGRAD

4 Topology Optimization Enhancements

1. A new buckling load factor (LAMA) response has been added to topology optimization. In previous versions, LAMA could only be used with parametric optimization.
Bulk Data Statement - TRESP1
New TRESP1 RTYPE - LAMA
2. New dynamic responses have been added to topology optimization. New responses for direct and/or modal frequency responses are magnitude, phase, real or imaginary components of displacements, velocities or accelerations. In previous versions these responses could only be used with parametric responses.
Bulk Data Statement - TRESP1
New TRESP1 RTYPE - DDISP, DVELO, DACCE, MDISP, MVELO and MACCE.
3. New combinations of fabrication constraints are now allowed. Now geometry based fabrication constraints (such as the ones used for extrusion and or castings) can be mixed with mirror and cyclic symmetries. Symmetric constraints, when used with geometry based fabrication constraints, now allow the enforcement of symmetries in structures even when the finite element mesh is not symmetric.
Bulk Data Statement - TSYM1, TSYM2, TSYM3
4. The subroutines in the topology preprocessor have been enhanced to speed up the process of finding symmetric elements. In previous version, this process took a significant amount of time, whereas with version 9.0 this process is extremely fast.

5 Overall Optimization Enhancements

1. Mode tracking has been enhanced to allow users to track buckling load factor responses. In previous version only natural frequencies could be tracked. This change affects LAMA in DRESP1, as well as the new LAMA in TRESP1.
Solution Control Statement - MODTRK or
Bulk Data Statement - PARAM, MODTRK
2. The adjoint method has been implemented in dynamics optimization. This method can be used in all types of optimizations. In previous versions, the adjoint method was only available for statics and buckling load cases.

6 Output Enhancements

1. New user functions of displacements, velocities or accelerations can now be printed in either the output file or in the post-processing file (punch).
Solution Control Statement - UFDISP, UFVELO and UFACCE
File name - *.out and *.pch
Note: In version 9.0, this capability will require a special license and will not be available in all installations.
2. Updated files are now printed at an earlier stage in the Genesis run. Now, the updated input file is printed before the analysis, so that even when Genesis is run in CHECK mode, users can obtain the first updated file. In the previous version, the first updated file was not printed until after the first analysis.
Solution Control Statement - UPRINT
File name - pnameUPDATExx.dat
3. DPRINT now controls in which design cycles the density and thickness results files are printed. In previous versions, APRINT was used to control this. APRINT no longer control these prints.
Solution Control Statement - DPRINT, THICKNESS, DENSITY

7 New Input Data

7.1 Executive Control

UFDATA Selects a user supplied file for user functions of dynamic displacements, velocities and accelerations

7.2 Solution Control

K4AA Requests the export of the reduced elemental structural damping matrix

UFDISP Requests that user function of dynamic displacements be printed in the output file or in the post processing file

UFVELO Requests that user function of dynamic velocities be printed in the output or in the post processing file

UFACCE Requests that user function of dynamic accelerations be printed in the output or in the post processing file

7.3 Bulk Data

PBEAML Property definition for CBEAM elements using physical dimensions for a cross-section type contained in a library of cross-sections.

DINDEX Identifies one or more DRESP1, DRESP2, DRESP3, DRESPG or DRESPU entries for defining a multi-objective problem

7.4 New Analysis Parameters

T3SRM Control the method for stress recovery use in CTRIA3 elements

7.5 New Design Parameters

DINDEXM Design multi-objective function formulation. Defines if individual responses are added directly or inversely and if the responses are normalized or not

DR1MV Switch for selecting if MASS and VOLUME DRESP1 entries create a single response or a vector response for the PROP ptype.

MODAPP Modal response approximation method switch.

8 Enhanced Data in GENESIS Version 9.0

8.1 Executive Control

LENVEC	Now LENVEC can use larger values on 64-bit systems. The G option added; e.g. LENVEC=12G or 12000M to access 48GB of memory
GNUSER	For DRESPU data, the user can now provide both responses and sensitivities. GNUSER will still reference one user executable

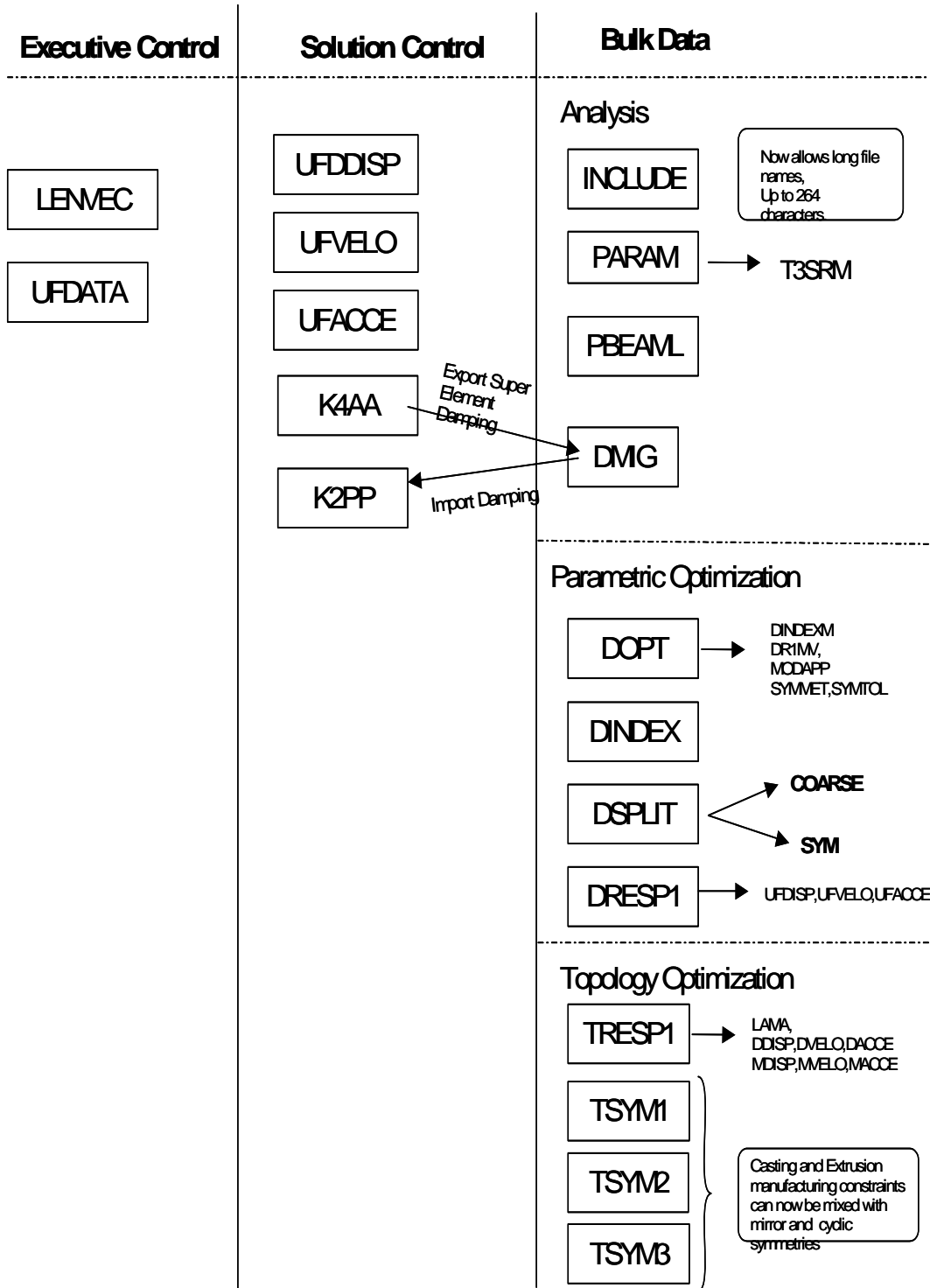
8.2 Solution Control

DPRINT	Now controls the printing of the OPOST (thickness) and the DENS (density) post-processing files
INCLUDE	Include filenames now can have up to 256 characters
MODTRK	Now controls tracking of buckling as well as natural vibration modes
UPRINT	Updated files are now printed earlier. Running in CHECK mode (instead of ANALYSIS) will be enough to print the updated file corresponding to design cycle 0

8.3 Bulk Data

INCLUDE	Include filenames now can have up to 256 characters
PARAM	Now accepts T3SRM
DOPT	Now accepts the following new parameters. DINDEXM, DR1MV, MODAPP. Existing ADJOIN parameter now also controls if dynamic responses are to be calculated directly or with the adjoin sensitivity method
DSPLIT	Now accepts following data types: COARSE and SYM. With the SYM option, Topometry optimization can now accept mirror, cyclic and extrusion fabrication constraints
DRESP1	Now accepts the following RTYPEs: UFDISP, UFVELO and UFACCE
TRESP1	Now accepts the following RTYPEs: LAMA, DDISP, DVELO, DACCE, MDISP, MVELO and MACCE
TSYM1	Now accept new fabrication constraints combinations. For example, filling constraint that can be used to create castable designs can now be used simultaneously with mirror or cyclic symmetries
TSYM2	Now accept new fabrication constraints combinations
TSYM3	Now accept new fabrication constraints combinations

9 New and Enhanced Data Relationships



10 GENESIS Manual Updates

All GENESIS manuals have been updated to reflect the new features, as well as the new and modified data entries.

Manual Title	File NAME	Status
GENESIS: Analysis Manual	volume1.pdf	Updated to reflect all new updates and new features
GENESIS: Design Manual	volume2.pdf	Updated to reflect all new updates and new features
GENESIS: Analysis Examples	volume3.pdf	Updated
GENESIS: Design Examples	volume4.pdf	Updated. Nine new examples were added
GENESIS: Quick Reference Manual	quickref.pdf	Updated to reflect all changes and new data entries
GENESIS: New Features and Enhancements	newfeat.pdf	This document

11 New Example Problems

The following table describes new examples and their corresponding input file names. The listed files are provided with the installation CD

NAME	PROBLEM SOLVED	SPECIAL FEATURES
D066.dat	Multi-Objective Coarse Topometry Optimization	Use of DINDEX
D067.dat	Two-Objectives Coarse Topometry Optimization; Case 1	Use of DINDEX and COARSE option in DSPLIT
D068.dat	Two-Objectives Coarse Topometry Optimization; Case 2	Use of DINDEX and COARSE option in DSPLIT
D069.dat	Two Objectives Coarse Topometry Optimization; Case 3	Use of DINDEX and COARSE option in DSPLIT
D070.dat	Topometry Optimization Using Double Mirror Symmetry Conditions	MXZ and MYZ mirror symmetric options in DSPLIT
D071.dat	Topometry Optimization Using one set of Extrusion and Mirror Symmetry Conditions	EZ (Extrusion), MYZ (mirror) symmetric options in DSPLIT
D072.dat	Topometry Optimization Using Multiple sets of Extrusion and Mirror Symmetry Conditions	EX, EZ, MYZ symmetric options in DSPLIT
T016.dat	Topology Optimization with Buckling Load Factors constraints and with Fabrication Constraints	Use of buckling load factor response in topology optimization. LAMA type in TRESP1
T017dat	Topology Optimization of a Simple Supported Plate, Direct Displacement Minimization to Increase Overall Stiffness	Use of direct (Frequency Response) displacement response in topology optimization. DDISP type in TRESP1

12 Changes in Version 9.0 with Respect to Version 8.0

GENESIS version 9.0 should run any input that was successfully running in version 8.0 with no changes.

Optimization problems using lists of PIDs on MASS or VOLUME DRESP1 entries will need to set DOPT parameter DR1MV to 0 to obtain the same behavior as previous versions.

Optimization results using modal frequency response optimization might change as a new approximation method is incorporated and different local optimum might be reached. Old answers can still be obtained by setting DOPT parameter MODAPP to 1.

Results using isotropic materials in PCOMP now are expected to be more flexible (and accurate) as shear deformation was added to this special case.

Stresses in CTRIA3 elements might change (becoming more accurate) as a new method for stress recovery has been added. Old answers can be obtained using the new (PARAM) parameter T3SRM.

The creation of custom Genesis executables is no longer supported. Users with a custom GNMASS subroutine will need to compile the subroutine into a shared library, and load that library with the new GNMASS executive control command. Users with a custom GNUSER subroutine will need to compile it into a stand-alone executable, and run that executable with the GNUSER executive control command. Users with custom DRESP3 responses will need to compile the routines into a shared library and load that library with the DRESP3 executive control command. Users with custom DVPROP3 sections will need to compile the routines into a shared library and load that library with the DLIB executive control command.