Overview of MSC/NASTRAN Version 67

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Version 67 is the next version of MSC/NASTRAN that will be released. This paper presents an overview of the new Version 67 capabilities in the areas of mesh error analysis, matrix solvers, nonlinear analysis, design sensitivity, acoustic analysis, heat transfer, and the executive system, among others.

MSC/NASTRAN Version 67 Capabilities

The following represent major capabilities added to MSC/NASTRAN Version 67 (V67):

Error Corrections: The goal was to correct 90% of the existing errors and to remove some of the General Limitations. As of January 30, 1991, we had not quite met this goal–we were at 87%. (Out of 377 errors, 329 had been corrected.)

Mesh Error Estimation: This will calculate and print the element stress error in the analysis. It functions in the same manner–and has the same limitations–as Grid Point Stress. In addition to the Grid Point Stress Case Control commands, GPSDCON=SetID is required for printing grid point errors and ELSDCON=SetID is required for printing element errors. The mesh error estimate provides an indication of where the user should create a finer mesh in order to reduce errors.

Adaptive Load Increment: The arc-length method was implemented in V66. This capability is enhanced in V67 with an adaptive scheme. Adaptability includes automatic arc-length adjustment, implementation of other options for the arc-length method, and a bisection algorithm for the conventional Newton's method and for the arc-length method. The BFGS update option is also added for arc-length methods.

Adaptive GAP Element: The adaptive GAP element is developed to converge stably by using adaptive penalty values, stiffness updates, bisection, and subincrements within an increment. Also, the friction capability of the adaptive GAP element is enhanced to distinguish between static and dynamic friction.

Nonlinear Materials with Elastic Anisotropy: The capability to perform nonlinear analyses of materials exhibiting elastic anisotropy is added. Types of behavior are: (1) elastic-plastic (MAT2 or MAT9 coupled with MATS1(TYPE=PLASTIC)); (2) thermo-elastic (MAT2 coupled with MATT2 or MAT9 coupled with MATT9); and (3) creep (MAT2 or MAT9 with CREEP).

Solid Element Enhancements for Nonlinear Analysis: Internal iterations have been modified for computational efficiency. In addition, IN of 1 and 2 on the PSOLID entry are now recognized for nonlinear analysis.

Linear Analysis Using SOL 99: The adaptive time-stepping algorithm is made available for linear transient response analysis by allowing SOL 99 to process a linear model.

Gimbal Angle Enhancement and Rotation Vector Approach: The gimbal angle computations were erroneous in certain instances; they are now made stable with the addition of bisection logic. In addition, the locking at 90 degrees has been removed. Also, a rotation vector approach is implemented, which is selected by PARAM, LANGLE.

SOLs 106, 129: These are the Structured Solution Sequence (SSS) equivalents of SOLs 66 and 99, respectively. Restarts involving only upstream superelements are fully automatic; restarts involving the residual structure are manual (and are done in the same manner as in SOLs 66 and 99).

TRIAR Element: The TRIAR is a triangular element that contains Theta-Z stiffness. This is a companion to the QUADR, which was introduced in V66. The TRIAR has the same limitations as does the QUADR: it is for flat surfaces only; it is for linear analysis only; it is not to be connected to beams; it does not have membrane-bending coupling, and it is not to be loaded with Z-moments.

Dynamic Sensitivity: The sensitivity capability is expanded to include sensitivity coefficients for direct and modal frequency response and for modal transient response. Responses are displacements, velocities, accelerations, SPC forces, stresses, and element forces. Design variables include sizing variables, shape variables, or both. This capability is in SOLs 108, 111, 112, and 200. Extending this to dynamic optimization will occur in V68 for SOL 200.

Shape Sensitivity: This computes the change in response quantities as a function of grid perturbation, and is available in SOLs 108, 111, 112, and 200. Extending this to shape optimization will occur in V68 for SOL 200.

Superelement Sensitivity: This enables design parameters to be defined outside of the residual structure, in upstream superelements.

Handbook for Structural Optimization: The handbook is brought up to the level of V67 capabilities, along with error corrections and additional examples.

Acoustic Analysis: Acoustic analysis capabilities are added to analyze internal cavities such as those found in automobiles, trucks, airplanes, and submarines. This enhancement is available for eigenvalue, transient, and frequency response SSSs (Sols 101 and above). Fluid points are modeled with GRIDs by placing a -1 in Field 7 (CD Field). The fluid itself is modeled with HEXAs, PENTAs, or TETRAs by specifying PFLUID in Field 7 (new field) on the PSOLID entry. Two new acoustic elements have also been added: an acoustic absorber and an acoustic barrier.

Acoustic Sensitivity: Sensitivity analysis is extended to cover acoustic elements.

Sparse Solver: A new solver is added, which significantly reduces the amount of time required in DECOMP and FBS for sparse matrices. CPU savings of 20-80% have been observed for sparse (density less than 10%) matrices. In addition, this method can handle indefinite (non-positive definite) matrices. This solver is selected by SYSTEM(126) or with the NASTRAN keyword SPARSE. The table below shows savings in CPU time and database size for four models; bold type represents V67 values and regular type represents V66 values.

Model	DOF	Band-width	CPU secs.	Factor K words	Computer
Car Body	47071	1083	506 **277**	48810 **7668**	Cray Y-MP
Car Door	34769	677	230 **140**	21387 **5869**	Cray Y-MP
Helicopter	5487	135	215 **192**	1049 **338**	IBM 3090
Shocktower	21926	456	344 **149**	9897 **3882**	IBM 3090

Sparse MPYAD: Matrix operations $[A]^T[B]\,[A]$ and $[A]^T[B] + [C]$ are solved more efficiently (faster and with less I/O) for sparse matrices.

Parallel Normal Modes Methods: The Householder method for eigenanalysis now takes advantage of parallel processing. Also, some parts of Lanczos (DECOMP, FBS) are now parallel.

Thermal Force Effects in GPFDR: The effects of thermal loads are now included in the grid point force balance output from the GPFDR module.

Aeroelastic Enhancements: These include multiple subcases in flutter, removal of the limit on the number of aero groups, and other new features.

Supersonic Aerodynamics: A new option (Aeroelasticity II) is provided, which incorporates the ZONA51 code for computing unsteady supersonic aerodynamics. This can be thought of as a complement to the existing subsonic doublet lattice capability in that it shares the same user interface and provides for multiple interfering lifting surface analysis. The new capability can be used with SOLs 21, 75, 76, 144, 145, and 146. The ability to analyze aerodynamic bodies is not included in this new capability. The current Aeroelastic option is also required.

DBC, TRANS, and ACCESS Enhancements: These utilities are enhanced to cover new V67 capabilities, as well as to support existing capabilities (design optimization, buckling, dihedral cyclic symmetry, and complex eigenvalues).

Reduced Computer Resources: Several capabilities are designed to reduce scratch and permanent space requirements relative to V66. These include:

> LTU: More extensive last time used (LTU) deletion logic is implemented.
>
> EQUIV: Better bookkeeping is provided for equivalenced datablocks, which prevents multiple copies of the same datablock.
>
> SCR300: This physically deletes scratch space (300-series files) used by modules.

Database Utilities: Capabilities are provided to upload and download the MSC/NASTRAN database for transfer across dissimilar computers (much as MSC/TRANS does for the graphics database). In addition, the capability of migrating from previous versions to Version 67 is provided.

VIEW Module Enhancements: An automated VIEW module has been written, which takes advantage of finite element methodology in the calculation of gray diffuse view factors in three dimensions. Utilizing adaptive integration techniques, the code determines if a given view factor requires improvement based on error indicators, self-shadowing information, and third-body information. No user-supplied subdivision information is required. Improvements in overall accuracy and efficiency over the previous method are substantial.

Dynamic File Allocation for IBM: This capability processes INIT and ASSIGN statements in the FMS Section to dynamically create and allocate datasets. This capability can be turned on or off by the user (the default is off, to make runs consistent with V66). This capability is implemented for the MVS/XA operating system.

External Setting of System Cells and Keywords: This capability allows users to set system cells and NASTRAN keywords at a global system and user level, rather than strictly in the MSC/NASTRAN file.

Concurrent Development: This represents a project, and not really a V67 capability. In the past, we did all development and testing on a DEC VAX computer, and released that system first. Only then did we port to other platforms. For V67 we have changed to a mode of concurrent development, whereby we simultaneously develop and test on four systems: Convex, Cray X-MP UNICOS EMA, DEC VAX, and IBM MVS/XA. This makes our code better, because we have caught machine-dependent errors up front instead of catching them after formal testing has started. Concurrent development will lead to less of a time lag between releasing the first and fourth systems. (Note that, while we use the term "concurrent *development*," in all likelihood we will have, at best, *near* concurrent *releases*.)

Additional Ports of V67: As with all previous versions, V67 will be ported to a number of platforms, the exact order and dates of which have not been entirely determined. One change from previous versions is that we will create a native Cray Y-MP version of V67 at some time.

Quality Assurance: This, too, is not a V67 capability in its own right but, rather, a way of doing business. MSC is implementing QA procedures that comply with applicable portions of Title 10, Code of Federal Regulations Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Title 10, Code of Federal Regulations, Part 21, Reporting of Safety Related Defects and Non-Compliances. By implementing these practices and procedures, we intend to design and verify quality *up front* in the software design and implementation cycle, as well as to expand the scope of testing. In all, our aim is to further strengthen the meaning of our Mission Statement, which reads: "MSC provides quality engineering software and related support services for the long term."