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NASA TECH BRIEF

Goddard Space Flight Center

NASTRAN Computer System Level 12.1

The problem:

To devise a general purpose, structural analysis digital computer program for solving the linear response of large, three-dimensional structures subjected to static, dynamic, thermal, and random loadings. The program must be commensurable over these types of loads, convenient to use, efficient for large problems, and usable for small problems. Provisions for condensing problems to smaller size and for plotting structural deformations must be included. Matrix operations should be organized according to various structural cases and should be explicitly addressable. The program must be adaptable to computers of different manufacture; modular in design to permit up-dating and extension; standardized to permit the interchange of input and output information between various users; and extensively documented.

The solution:

The finite element structural analysis system, NASTRAN, a general purpose program applicable to very large three-dimensional structures without paying a severe overhead penalty for small problems. The program uses the finite element displacement method. Problems must be essentially linear, but nonlinearities can be treated in a piecewise linear fashion. Static, thermal, dynamic, and random algorithms are commensurable so that large problems formulated for one type of loading can be continued with any of the other types of loading without the structure being remodeled.

A structural model can be condensed so that the solution for its behavior can be expressed in terms of a fraction of its original problem size. However, a certain minimum amount of core space must still be provided. Twelve individual structural solution cases have been tailored to particular problem needs. A special language, DMAP, allows the NASTRAN matrix operations to be addressed explicitly. NASTRAN currently operates on the large computers of three different manufacturers (IBM 360/models 50 to 95, UNIVAC 1106 through 1108, and CDC 6400 through 6700), but is adaptable to large computers of other manufacturers (such as Honeywell, SDS, Burroughs, and RCA). Plots can be generated on table, microfilm, and incremental plotters.

The system construction is modular, with the executive or management modules separated from the solution modules. Interfaces between modules are so defined that when the routines within a module are updated, corrected, or modified, no other part of the system is disturbed because the interface requirements are preserved.

The system is open-ended so that the content can be extended. Engineering input data and problem control data have been standardized so that information can be interchanged between analysts. Documentation contained in four manuals covers theoretical aspects, data input preparation, programming details, and demonstration problems.

How it's done:

The problems solvable by NASTRAN fall into four general categories: (1) static structural problems, (2) elastic stability problems, (3) dynamic structural problems, and (4) general matrix problems. Problems with as many as 65,535 degrees of freedom can be handled in both real and complex arithmetic. Static loads can be point forces or distributed pressures, steady centrifugal or gravity body forces,

(continued overleaf)

thermally and mechanically enforced deformations, and inertial forces from steady accelerations.

Three eigenvalue extraction methods available for vibration characteristics and static buckling problems are: the determinant method, the method of inverse power with shifts, and the GIVENS tridiagonalization method coupled with the Q-R method for vectors. Two integration methods available for solving dynamic transient problems are: a modal method, and a finite difference method using central differences. Random problems are solved only in frequency space, by first determining the dynamic transfer functions through a frequency response module, and then applying the random forcing spectrum to get the response auto-spectrum. A special section of the user input, called Case Control, brings different combinations of engineering data, boundary conditions, and loads together into subcases of the basic problem. The Case Control also regulates the output. The central solution algorithm is a decomposition routine which factors the coefficient matrix into upper and lower triangular factors. Decomposition is further subdivided according to whether the matrix is real, complex, symmetric, or general.

Material property specifications can be very general. Elastic and thermal moduli can include the complete anisotropic set of 21, and can be stress and temperature dependent. Mass can be scalar at a point, given in terms of distribution properties at a point or coupled properties amongst points. Damping can be viscous or structural and can be frequency dependent.

The displacement method finite elastic elements include beams, membranes, shears, bending plates, axisymmetric shells, axisymmetric solids, general influence coefficients, and pure scalars.

NASTRAN is currently adapted to the following plotters, SC 4020, EAI 3500, BL LTE, Calcomp 763, and DD80, but can generally be adapted to plotters of other manufacture.

Notes:

1. NASTRAN input requirements include only that information pertinent to the specific problem under consideration, making the program more convenient and efficient to use than those programs requiring additional information for suppressing unrelated options. In addition, NASTRAN automatically assumes the processing of the problem, eliminating the necessity for the analyst to have specialized knowledge of the computer.
2. Problem size is limited only by practical considerations of running time, and by the ultimate capacity of the computer storage devices.
3. The program is written principally in a subset of FORTRAN IV version 13, which is common to IBM, UNIVAC, and CDC machines; a few routines are written in assembly language for each specific machine.
4. The NASTRAN documentation carries the following official NASA publication numbers and titles: SP 221 NASTRAN Theoretical Manual, SP 222 NASTRAN User's Manual, SP 223 NASTRAN Programmer's Manual, SP 224 NASTRAN Demonstration Problem Manual, SP 260 NASTRAN: A Summary of the Functions and Capabilities of the NASA Structural Analysis Computer System. SP's 221–224 are encyclopedic in content, while SP 260 is a general descriptive document.
5. The current level of NASTRAN being released is LEVEL 12.0. Patches are also being released to upgrade the system to LEVEL 12.2. The operating systems needed to manage NASTRAN on the various computers are:

IBM 360 series	0S360PCP or MFT or MVT
UNIVAC 1100 series	EXEC VIII
CDC 6000 series	SCOPE 3.2

   LEVEL 8.0 is available for the IBM direct coupled 7090(4)/7040(4) operating under IBSYS DCS. Later levels have not been updated for this computer, due to lack of demand.
6. NASA is providing continuing management of NASTRAN through an office at the Langley Research Center. The address is:

   Dr. J. Philip Raney, Head
   NASTRAN System Maintenance Office
   Mail Stop 188-C
   NASA Langley Research Center
   Hampton, Virginia 23365
7. Inquiries concerning either the tapes or the manuals for this system should specify the level desired, and may be directed to:

   COSMIC
   Barrow Hall
   University of Georgia
   Athens, Georgia 30601
   Reference: B71-10285

Patent status:

No patent action is contemplated by NASA.

Source: T. G. Butler
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