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NEW ENHANCEMENTS IN APRIL 85 NASTRAN RELEASE

by Gordon C. Chan
Sperry Systems Management Group
Huntsville, Alabama

INTRODUCTION

Several new features have been added to COSMIC NASTRAN, along with some enhancements to improve or update existing capabilities. Most of the new features and enhancements were not developed by COSMIC; they have been provided by industry users to be incorporated into NASTRAN for wider use. The major new features and enhancements are discussed here.

NEW FEATURES

1. DIAG 48

DIAG 48 has been added to provide a synopsis of the significant developments in the past NASTRAN releases (April 83, April 84, and April 85) and to provide an index listing of all Diagnostic Output Messages and Operation Requests (DOMOR). The synopsis provides a timely communication between COSMIC NASTRAN and its users, and keeps the latter better informed. The synopsis also indicates references where additional materials can be found. The diagnostic index listing gives users complete, accurate, and up-to-date information about all Diagnostic Requests currently available. The DOMOR is also listed in the Users' Manual, but the manual is infrequently updated. Therefore, if there is any discrepancy between the two sources, the listing from DIAG 48 should be used.

DIAG 48 will be updated in each future NASTRAN release.

2. VOLUME AND SURFACE COMPUTATION OF THE 2-D AND 3-D ELEMENTS

The volumes and the surface areas of the 2-dimensional and 3-dimensional elements can be requested for output by the PARAM card, as follows:

```
PARAM  VOLUME   m
PARAM  SURFACE  n
```

where m and n are scale factors, greater than zero. The calculations are actually done in the Element Matrix Generation (EMG) module, with the results tabulated and printed before the termination of the module.

In the April 85 NASTRAN release, the EMG module has been expanded to include one more output data block such that the element ID's volumes, surface areas and associated grid points and their coordinates can be saved. This new output data block can be a GINO written file, to be used internally within the NASTRAN system, or a FORTRAN binary file, intended for external use. The contents of this output data block, the choice of GINO or FORTRAN file, and the definitions of the surface areas are presented in Appendix A, pages 2.4-222 and 2.4.222b.

3. NOLIN5 INPUT CARD

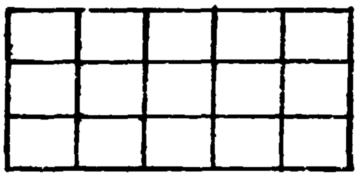
A new non-linear load, NOLIN5, has been added to the family of NOLINi bulkdata cards. The first four (NOLIN1 through NOLIN4) are applications of the non-linear loads as functions of the displacement, and they are described in the User's manual. The new NOLIN5 card offers non-linear load as a function of both displacement and velocity; thus allowing wider application of the non-linear load including damping. See Appendix A, pages 2.4- 205a and 2.4- 205b, for the formulation and specification of this new load.

4. NASTRAN PLOTOPT=N (where N=2,3,4 or 5)

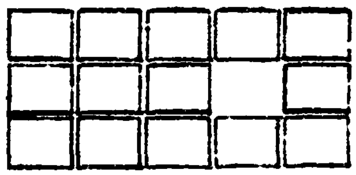
The undeformed plot of a NASTRAN model is particulary useful in pre-analysis structure checking. However, in all previous NASTRAN releases, such a plot can be obtained only if there is no error in the input deck. A missing material card, for example, which is practically not needed in plotting, would terminate a NASTRAN run. A new Plot Option has been added to the NASTRAN card in the April 85 release. The new NASTRAN PLOTOPT has a default value of zero (N=0) if there is no plot tape assigned in a NASTRAN job, or one (N=1), if a plot tape has been assigned. The other options (N=2 through 5) can be used for various error conditions in the Bulk Data and in plot commands as indicated in the Appendix A, page 2.1-5.

5. SHRINK-ELEMENT PLOTS

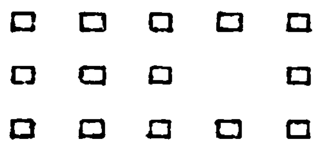
A new Shrink-Element option has been added to the plotting capability. The user can specify that all elements in a plot are to "shrink in place" by a given percentage. This option should be very useful in pre-analysis structure checking, or in graphic presentation of the structure model. The following diagrams illustrate the use of Shrink-Element plotting. The model is a simple panel, supposedly made up of 15 CQUAD1 elements. The plot on the left side is a NASTRAN regular plot. The plot on the right side clearly shows a missing element. The middle plot can be used in model presentation; it gives a better definition of the connecting elements. The command for Shrink-Element plots is included in Appendix A, pages 4.2-25, 4.2-29 through 4.2-31.



NASTRAN Regular Plot



Shrink-Element plot (SHRINK=.90)



Shrink-Element Plot (Shrink=.35)

6. OUTPUT SCAN

A new output SCAN feature has been added to NASTRAN. This is a major contribution to the April 85 release, and can significantly reduce the amount of ouput that an analyst must review. Using this SCAN feature, the user can indicate only the top "n" (and bottom "n") values, or values above "x" (or below "y") of stresses and/or forces which are to be printed. The user can also request SCAN on any element SET, in any SUBCASE, SUBCOM, or in the master set (i.e. above all subcases). Both SORT1 and SORT2 types of data blocks can be scanned. Any number of the SCAN cards can be used in a NASTRAN job, and are placed in the Case Control section of the Bulk Data. A SCAN request in the Master Set is common to all Subcases. However, unlike the ELSTRESS or ELFORCE cards, a SCAN request in a Subcase level will not override a SCAN request in the Master Set. The final results are sorted and printed in a descending order. The description of the SCAN input card is presented in Appendix A, pages 2.3-41a through 2.3-41f.

The Output Scan operation is driven by a new SCAN module which has the following DMAP specification:

```
SCAN   CASECC,OESi,OEFi/OESFi/C,N,ELEMENT/C,N,COMPONENT/C,N,TOPN/
       C,N,MAX/C,N,MIN/C,N,LCS1/C,N,LCS2/C,N,COMPONENTX $
```

where:

i	= 1 (for SORT1 output data blocks), or 2 (SORT2 data),
ELEMENT	is an element BCD name,
COMPONENT	is a coded word whose bit(s) is set to correspond to the field number(s) (1 through 31) of the output page whose values are to be scanned,
TOPN	is the number of "top" and "bottom" values to be printed,
MAX,MIN	define a range of values; values outside this range only are printed,
LCS1,LCS2	are the beginning and ending element ID's to be scanned (SORT1); or SUBCASE ID's (SORT2),
COMPONENTX	is same as COMPONENT, except for field number(s) 32 through 62.

The SCAN module has been incorporated in all NASTRAN rigid formats. Since the SCAN input card in the Case Control section has been decoded by the Input File processor (IFP), and all useful information stored in the CASECC data block, the DMAP for SCAN in the rigid format takes on a simpler form, with most of the parameters not needed:

```
SCAN   CASECC,OESi,OEFi/OESFi/C,N,*RF*  $
```

On the other hand, if the SCAN module is called by the user via DMAP-alter, and no SCAN input card is used in the Bulk Data (therefore no SCAN data saved in CASECC), the following form should be used for a "stress-Scan":

```
SCAN,     ,OESi,/OESX/C,N,ELEMENT/C,N,COMPONENT/C,N,TOPN/
           C,N,MAX/C,N,MIN/C,N,LSC1/C,N,LSC2/C,N,COMPONENTX $
```

and for a "force-SCAN":

```
SCAN,     ,,OEFi/OEFX/C,N,ELEMENT/C,N,COMPONENT/C,N,TOPN/
           C,N,MAX/C,N,MIN/C,N,LSC1/C,N,LSC2/C,N,COMPONENTX $
```

Normally, the Output File Processor (OFP) should be called immediately to print the scanned data in OESX, or OEFX.

The SCAN module actually re-processes the data blocks originally generated for the OFP - e.g. the stress data block OESi, and force data block OEFi. It is obvious then that SCAN cannot operate on data which has not been generated. For example, if the stresses for elements 1 through 100 were requested to be output from an ELSTRESS card, a SCAN request for elements 101 through 200 would produce zero values (not a fatal error condition). It is also obvious that there is a need for a NOPRINT option in the STRESS and FORCE request cards to eliminate massive output printing and make SCAN much more useful. See the NOPRINT option described below for more details.

In a special case where the user requests SCAN on the element stresses, and there is no ELSTRESS (or STRESS) card in the Case Control deck, the IFP module would automatically generate internally a STRESS input card with the following arguments:

```
ELSTRESS  (SORT1,NOPRINT,REAL) = ALL
```

Similary, an ELFORCE card would be generated.

Currently SCAN handles only the stress and force output data blocks. It is possible in the near future that other output data blocks, such as displacement, velocity, PSD, etc., might be included in the Scan Operation.

IMPROVEMENTS

1. NOPRINT OPTION ON STRESS AND FORCE OUTPUT REQUEST CARDS

A new NOPRINT option has been added to the output request PRINT or PUNCH of the STRESS (or ELSTRESS) and FORCE (or ELFORCE) cards. This new option allows NASTRAN to compute, save data in the output data block, and not to print (by OFP). This is not the same option as NONE, which instructs NASTRAN to skip over stress or force computation and not to write an output data block. The new NOPRINT option is particularly useful in the SCAN and PLOT operations, where the user can compute without massive printout all of the element stresses or forces and have the results scanned, and/or plotted. See the update pages in Appendix A, pages 2.3-17 and 2.3-18.

2. AUTOMATED FIND AND NOFIND OPTIONS ON THE PLOT CARD

The April 85 NASTRAN release will provide an automatic FIND for plot SCALE, ORIGIN, and VANTAGE POINT. Thus, for each PLOT SET n command, the scale will be determined such that the elements in SET n will fill the image area of a plot. This automatic option can be disenabled by the NOFIND keyword on the PLOT command. The PLOT NOFIND will produce an image using the immediately preceding SCALE, ORIGIN, and VANTAGE POINT. See the update pages in Appendix A, pages 4.2-25, 4.2-29 through 4.2-31.

3. IMPROVED FULLY-STRESSED DESIGN

TRIM6, QDMEM1, QDMEM2, and IS2D8 have been added to the element list that can be included in the fully-stressed design computation and iteration process.

Previously, the fully stressed design process altered the element properties by use of a linear ratio of calculated stress to the allowable stress. That is, in the case of a BAR or ROD element, the cross sectional area was changed to force the applied stress to equal the allowable stress. This process could yield non-convergent results for a case of pure bending of the QUAD2 element, where the altered property is the thickness. In the April 85 release, the program has been changed to provide more rapid convergence that includes the situation of equal stresses of opposite sign, on upper and lower extreme fibers of the plate elements. This improved process is only active if the user does not specify a value for the iteration factor gama on the POPT card.

4. HIGH-LEVEL PLATE ELEMENTS

The thickness calculations of the triangle for the high-level elements (TRIM6, TRPLT1, and TRSHL) are presented in the Theoretical Manual, page 5.8-45, equations 16 and 17 and in the Programmer's Manual, page 8.24-6, equations 35 and 37. These simple equations were evaluated incorrectly in the manuals, and the results were repeatedly used in these high-level element formulations. Equation 28 of the Theoretical Manual, page 8.24-8 is also incorrect, where (-b) should be (b). This may partially explain why these elements never produced good answers in the past. In addition, the Grid Point Weight-and-Balance tables verified the fact that the consistent mass matrices of these high-level elements gave extremely bad results. These errors have been corrected in the April 85 release for the calculations in stiffness matrices, thermal loads, and stress recoveries, and the consistent mass matrices have been replaced by the lumped mass formulation; these high-level plate elements begin to yield reasonable results. It is hoped that the consistent mass matrices will be corrected in the near future.

5. EIGENVALUE MESSAGES

The real eigenvalue extraction procedures have been enhanced by including an automatic matrix topology analysis, and by the addition of user information messages. During the matirx decomposition of the dynamic matrix, the leading principal minors in the Sturm's sequence are counted each time the sign changes. This, in turn, indicates the number of roots below the eigenvalue shift-point, a property of the Sturm's sequence. The importance of this information is then translated into useful messages and provides for a more complete evaluation of the eigenvalue results. The messages (#3307, #3308, and #3309) indicate whether or not the lowest eigenvalue has been found, or if there is a missing mode in the frequency range the user specified. However, occationally no conclusive message can be issued due to lack of basic information during the decomposition process.

The printout of these messages can be suppressed by the use of DIAG 43.

6. ANSI 77 FORTRAN CODE

All FORTRAN source code of COSMIC NASTRAN has been upgraded to the ANSI 77 standard. This began with the UNIVAC ASCII version of NASTRAN in the April 84 release. (The UNIVAC FORTRAN V version is no longer supported.) In this new April 85 release, the CDC version of NASTRAN is upgraded from FORTRAN 4 to the FORTRAN 5, a subset of ANSI 77 FORTRAN. Previously, the VAX version required many custom changes; especially in the source code that handles character-word (byte) manipulation. A set of character-word functions is standardized in the ANSI 77 source code, such that all four machines (CDC, IBM, UNIVAC, and VAX) will operate identically. In addition, the labeled commons that carry the open-core working space in all ANSI 77 FORTRAN source code have been standardized, so that the NASTRAN 15 links are similary structured in all four machines. At present, only a very few routines remain machine-dependent.

CONCLUSION

The input card descriptions for the new features SCAN, NOLIN5, Shrink-Element Plot, FIND, and NOFIND, VOLUME, SURFACE are presented in Appendix A. The pages in this appendix are written in NASTRAN Users' Manual format, so that they can be copied and moved directly into the users' own manual for future reference. The page numbers at the bottoms of these pages indicate where they should be inserted in the NASTRAN Users' Manual as published in September 1983.

APPENDIX A

A Collection of NASTRAN User's Manual Update Pages

2 (default)	Print two copies of the full title page.
3	Print a one-line comment (which can be modified by the user by updating subroutine TTLPGE) followed by the short title items on the same page.
4	Read __another__ card __immediately following__ the NASTRAN card, print its contents on one line and follow it by the short title items on the same page.
>4	Do not print any title page (same as TITLEØPT = 0).
-2	(UNIVAC only) Print a short title page and suppress the alternate logfile assignment which is not allowed in real-time environment.

As can be seen, when TITLEØPT = 4 is specified on the NASTRAN card, the user must supply __another__ card __immediately following__ the NASTRAN card to be read by the program. The user can therefore utilize this feature to print one-line individual comments (along with the short title) for individual runs.

22. PLØTØPT - defines the action to be taken by NASTRAN in the case where plottings are requested and error(s) exists in Bulkdata. The default is zero (PLØTØPT = 0) only if there is no plot tape assigned in a NASTRAN job, or one (PLØTØPT = 1) if plot tape has been assigned. The plot option (0 through 5) are listed below:

__PLØTØPT__	__BULKDATA__	__PLØT CØMMANDS__	__NASTRAN ACTION__
N=0	no error	no error	executes all links, no plots
	no error	error	stops after link1 data check
	error	err or no err	stops after link1 data check
N=1	no error	no error	executes all links, and plots
	no error	error	stops after link1 data check
	error	err or no err	stops after link1 data check
N=2	err or no err	no error	stops after undef. plots in link2
	err or no err	error	stops after link1 data check
N=3	err or no err	err or no err	attempts to plot; stops in link2
N=4	no error	no error	executes all links, and plots
	no error	error	attempts to plot; stops in link2
	error	no error	stops after undef. plots in link2
	error	error	stops after link1 data check

N=5	no error	no error	executes all links, and plots
	no error	error	executes all links, but no plots
	error	no error	stops after undef. plots in link2
	error	error	stops after link1 data check

Examples

Following are some examples of the use of the NASTRAN card.

Example 1

NASTRAN BUFFSIZE = 900, SYSTEM(2) = 3, CØNFIG = 3

The above card changes the 1st, 2nd and 28th words of /SYSTEM/. SYSTEM(2) = 3 changes the system output unit from 6 (default) to 3.

Example 2

NASTRAN SYSTEM(4) = 4, NLINES = 40

The above card changes the 4th and and 9th words of /SYSTEM/. SYSTEM(4) = 4 changes the system input unit from 5 (default) to 4. This means that all subsequent input data must be present on unit 4.

Example 3

NASTRAN TITLEØPT = -1, FILES = (UMF,NPTP)

The above card requests a short title page and establishes the UMF and NPTP files as executive files.

Example 4

NASTRAN SYSTEM(14) = 30000, SYSTEM(79) = 16384

The above card changes the 14th and 79th words in /SYSTEM/. SYSTEM(14) = 30000 changes the maximum number of output lines from 20000 (default) to 30000. (See the description of the MAXLINES card in Section 2.3) SYTEM(79) = 16384 turns on DIAG 15 thereby requesting the tracing of GINØ ØPEN/CLØSE operations. (See the description of the DIAG card in Section 2.2.)

Example 5

NASTRAN BANDTPCH = 1, BANDTRUN = 1

The above card requests the punching of the new SEQGP cards unconditionally generated by the BANDIT procedure and the subsequent termination of the NASTRAN job.

Example 6

NASTRAN BANDIT = -1

The above card requests the unconditional skipping of the BANDIT operations.

NASTRAN DATA DECK

REFERENCE

1. Everstine, G.C., BANDIT User's Guide, COSMIC Program No. DOD-00033, May 1978.

Case Control Data Card ELFØRCE - Element Force Output Request

Description: Requests form and type of element force output.

Format and Example(s):

```
          ┌⎛ SØRT1     PRINT     REAL  ⎞┐     ⎧ ALL  ⎫
ELFØRCE   │⎜ SØRT2  ,  PUNCH  ,  IMAG  ⎟│  =  ⎨ n    ⎬
          └⎝          NØPRINT    PHASE ⎠┘     ⎩ NØNE ⎭
```

ELFØRCE = ALL

ELFØRCE(REAL, PUNCH, PRINT) = 17

ELFØRCE = 25

ELFØRCE(SØRT2, NØPRINT) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
NØPRINT	FØRCE output will not be printed nor punched.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° ≤ phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Forces for all elements will be output.
NØNE	Forces for no elements will be output.
n	Set identification of a previously appearing SET card. Only forces of elements whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. FØRCE is an alternate form and is entirely equivalent to ELFØRCE.
5. ELFØRCE = NØNE allows overriding an overall request.
6. In heat transfer analysis, ELFØRCE output consists of heat flow through and out of the elements.

Case Control Data Card ELSTRESS - Element Stress Output Request

Description: Requests form and type of element stress output.

Format and Example(s):

```
            ┌ ( SØRT1      PRINT      REAL  ) ┐     ┌ ALL  ┐
ELSTRESS    │ ( SØRT2  ,   PUNCH   ,  IMAG  ) │  =  │  n   │
            └ (           NØPRINT     PHASE ) ┘     └ NØNE ┘
```

ELSTRESS = 5

ELSTRESS = ALL

ELSTRESS(SØRT1, PRINT, PUNCH, PHASE) = 15

ELSTRESS(SØRT2, NØPRINT, REAL) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
NØPRINT	STRESS output will not be printed nor punched.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \le$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET card (Integer > 0). Only stresses for elements whose identification numbers appear on this SET card will be output.
NØNE	Stresses for no elements will be output.

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. STRESS is an alternate form and is entirely equivalent to ELSTRESS.
5. ELSTRESS = NØNE allows overriding an overall request.

(Continued)

ELSTRESS (Cont.)

6. If element stresses in material coordinate system are desired (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements and only in Rigid Format 1), the parameter STRESS (see the description of the PARAM bulk data card in Section 2.4.2) should be set to be a positive integer. If, in addition to element stresses in material coordinate system, stresses at the connected grid points are also desired, the parameter STRESS should be set to 0.

Case Control Data Card SCAN - Output Scan Request.

Description: Scan output data and eliminate values that do not meet the specification set by this SCAN card.

Format and Example(s):

```
              STRESS
SCAN  (  {    FØRCE    } , element, component )  =  { topn    } [, SET  i ]
              HELP                                   { max,min }
              ØN-LINE
```

```
SCAN  (STRESS, CBAR, AXIAL)  =  10
SCAN  (STRESS, BAR, AXIAL, SA-MAX)  =  15, SET 102
SCAN  (FØRCE, RØD, 2,  3)  =  17
SCAN  (FØRCE, 3, CRØD, 2)  =  +2000., -1500., SET 102
SCAN  (RØD,   SHEAR,  FØRCE,  TØRQUE)  =  5000., 400.
SCAN  (HELP)
```

Option	Meaning
STRESS	Request scan on Stress file, of SØRT1 or SØRT2 format. (BCD).
FØRCE	Request scan on Force file, of SØRT1 or SØRT2 format. (BCD).
element	Any NASTRAN element name, with or without the leading letter "C".
component	One or more components specified by keywords, or by numeric codes. The numeric codes are the field numbers on the heading of the output page, whose values are to be scanned. (Each element has its own page heading.) See Remark 11 for the keywords and their corresponding field numbers. (BCD(s) or integer(s) > 0).
topn	The highest n values, and the lowest n values, found by SCAN in the field(s) specified by component are printed out; e.g., top n tension and top n compression stresses. (Integer > 0).
max,min	Values exceeding max, and below min, in the field(s) specified by component are printed out. (Real).
SET i	Element set identification of a previously appearing SET card. Only forces or stresses of elements whose identification numbers appear on this SET card will be scanned for output (Integer > 0).

(Continued)

SCAN (Cont.)

HELP A table of the component keywords and their corresponding field numbers will be printed immediately before the Bulk Data echo, and job continues.

ØN-LINE Request SCAN operation to be run on-line under real-time environment.

Remarks: 1. Multiple SCAN cards can be requested in a NASTRAN run. They do not override one another.

2. A SCAN card specifies only one element type; an element type can have more than one SCAN card.

3. More than one component field can be requested in a SCAN card. However, these fields will be scanned together as a group.

4. SCAN sorts and prints the scanned values in descending order. All fields of the same output line are printed.

5. If the component keyword is misspelled, a list of the valid names and their corresponding fields will be printed automatically. Job will be flagged for fatal error termination.

6. Some component keywords imply multi-field scan; e.g., "AXIAL" may imply axial forces for grid points 1, 2, 3, etc.

7. Component numeric code specifies field numbers 1 through 62 only.

8. Normally SCAN will scan only data already generated for the Output File Processor (ØFP). That is, SCAN cannot scan data that have not been created. However, if no ELSTRESS (or STRESS) card is specified before a stress SCAN card, a STRESS card is generated internally in the following form:

STRESS (SØRT1, NØPRINT, REAL) = ALL

Forces are handled similarly.

9. The Label line (after TITLE and SUBTITLE) is limited to 36 characters. The rest of the line is replaced by SCAN header.

10. When the ØN-LINE option is requested, all other input parameters are not needed on the SCAN card. These parameters will be prompted on the CRT screen by the computer system when the SCAN module is executed.

(Continued)

11. The component keywords for stress and force, and their corresponding output field numbers, are listed below:

FORCE/STRESS	KEYWORD	COMPONENT (OUTPUT FIELD NO.)
ROD, TUBE, CONROD		
STRESS	AXIAL	2
STRESS	TORSIONAL	4
STRESS	MARGIN	3, 5
FORCE	AXIAL	2
FORCE	TORQUE	3
SHEAR, TWIST		
STRESS	MAX-SHR	2
STRESS	MARGIN	4
STRESS	AVG	3
STRESS	MAX	2
FORCE	FORCE-1	2
FORCE	FORCE-2	3
FORCE	MOMENT-1	2
FORCE	MOMENT-2	3
TRIA1, TRIA2, QUAD1, QUAD2, TRBSC, TRPLT, QDPLT		
STRESS	NORM-X	3, 11
STRESS	NORM-Y	4, 12
STRESS	SHEAR-XY	5, 13
STRESS	MAJOR	7, 15
STRESS	MINOR	8, 16
STRESS	MAX-SHR	9, 17
FORCE	MOMENT-X	2
FORCE	MOMENT-Y	3
FORCE	SHEAR-X	5
FORCE	SHEAR-Y	6
TRMEM, QDMEM, QDMEM1, QDMEM2		
STRESS	NORM-X	2
STRESS	NORM-Y	3
STRESS	SHEAR-XY	4
STRESS	MAJOR	6
STRESS	MINOR	7
STRESS	MAX-SHR	8

(Continued)

FORCE/STRESS	KEYWORD	COMPONENT (OUTPUT FIELD NO.)
ELAS1, ELAS2, ELAS3, IS2D8		
STRESS	OCT-SHR	2
FORCE	CIRCUM	2
FORCE	FORCE-1	4, 9
FORCE	FORCE-2	3, 6
FORCE	FORCE-3	5, 8
FORCE	FORCE-4	2, 7
BAR, ELBOW		
STRESS	SA-MAX	7, 8
STRESS	SB-MAX	14, 15
STRESS	MARGIN	9, 16
STRESS	AXIAL	6
FORCE	AXIAL	8
FORCE	TORQUE	9
FORCE	SHEAR	5, 6
FORCE	MOMENT-A	2, 3
FORCE	MOMENT-B	4, 5
CONEAX		
STRESS	NORM-U	4, 22
STRESS	NORM-V	5, 23
STRESS	SHEAR-UV	6, 24
STRESS	MAJOR	8, 26
STRESS	MINOR	9, 27
STRESS	MAX-SHR	10, 28
FORCE	MOMENT-U	3
FORCE	MOMENT-V	4
FORCE	SHEAR-XY	6
FORCE	SHEAR-YZ	7
TRIARG		
STRESS	RADIAL	2
STRESS	CIRCUM	3
STRESS	AXIAL	4
STRESS	SHEAR	5
FORCE	RADIAL	2, 5, 8
FORCE	CIRCUM	3, 6, 9
FORCE	AXIAL	4, 7, 10

(Continued)

SCAN (Cont.)

FORCE/STRESS	KEYWORD	COMPONENT (OUTPUT FIELD NO.)
TRAPRG		
STRESS	RADIAL	2, 6, 10, 14 ... 22
STRESS	CIRCUM	3, 7, 11, 15 ... 23
STRESS	AXIAL	4, 8, 12, 16 ... 24
STRESS	SHEAR	5, 9, 13, 17 ... 25
STRESS	SHR-FORC	6, 10, 14, 18 ... 26
FORCE	RADIAL	2, 5, 8, 11
FORCE	CIRCUM	3, 6, 9, 12
FORCE	AXIAL	4, 7, 10, 13
TORDRG		
STRESS	MEM-T	2, 7, 12
STRESS	MEM-C	3, 8, 13
STRESS	FLEX-T	4, 9, 14
STRESS	FLEX-C	5, 10, 15
STRESS	SHR-FORC	6, 11, 16
FORCE	RADIAL	2, 8
FORCE	CIRCUM	3, 9
FORCE	AXIAL	4, 10
FORCE	MOMENT	5, 11
FORCE	CURV	7, 13
IHEX1, IHEX2		
STRESS	NORM-X	3, 22, 41, 60 ... ETC.
STRESS	SHEAR-XY	4, 23, 42, 61 ... ETC.
STRESS	PRINC-1	5, 24, 43, 62 ... ETC.
STRESS	MEAN	9, 28, 47, 66 ... ETC.
STRESS	NORM-Y	11, 30, 49 68 ... ETC.
STRESS	SHEAR-YZ	12, 31, 50, 69 ... ETC.
STRESS	PRINC-2	13, 31, 49, 67 ... ETC.
STRESS	NORM-Z	17, 36, 55, 74 ... ETC.
STRESS	SHEAR-ZX	18, 37, 56, 75 ... ETC.
STRESS	ESTRESS	19, 38, 57, 76 ... ETC.

(Continued)

SCAN (Cont.)

FORCE/STRESS	KEYWORD	COMPONENT (OUTPUT FIELD NO.)
IHEX3		
STRESS	NORM-X	3, 23, 43, 63 ... 643
STRESS	SHEAR-XY	4, 24, 44, 64 ... 644
STRESS	PRINC-1	5, 25, 45, 65 ... 645
STRESS	MEAN	9, 29, 49, 69 ... 649
STRESS	NORM-Y	12, 32, 52, 72 ... 652
STRESS	SHEAR-YZ	13, 33, 53, 73 ... 653
STRESS	PRINC-2	14, 34, 54, 74 ... 654
STRESS	NORM-Z	18, 38, 58, 78 ... 658
STRESS	SHEAR-ZX	19, 39, 59, 79 ... 659
STRESS	ESTRESS	20, 40, 60, 80 ... 660
TRIAAX, TRAPAX		
STRESS	RADIAL	3, 11, 19
STRESS	AXIAL	4, 12, 20
STRESS	CIRCUM	5, 13, 21
STRESS	MEM-C	6, 14, 22
STRESS	FLEX-T	7, 15, 23
STRESS	FLEX-C	8, 16, 24
FORCE	RADIAL	3, 7, 11
FORCE	CIRCUM	4, 8, 12
FORCE	AXIAL	5, 9, 13

Use output field numbers(s) to specify component(s) for elements or keywords not listed above. See sections 2.3.51 and 2.3.52 of the NASTRAN Programmer's Manual for additional element stress and force component definitions.

Input Data Card <u>NØLIN5</u> - Nonlinear Transient Response Dynamic Load

<u>Description</u>: Defines nonlinear transient forcing functions of the form.

$$P_i(t) = S\ T(x_j(t)) \left| \dot{x}_j(t) \right| \dot{x}_j(t), \qquad \text{if CJ} \le 6$$

$$P_i(t) = S\ T(x_j(t)) \left| x_j(t) \right| x_j(t), \qquad \text{if CJ} \ge 10$$

<u>Format and Example</u>:

1	2	3	4	5	6	7	8	9	10
NØLIN5	SID	GI	CI	S	GJ	CJ	T		
NØLIN5	21	3	4	2.1	3	1	6		

<u>Field</u>	<u>Contents</u>
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number if GI is a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number if GJ is a grid point (0 < Integer ≤ 6; 11 ≤ Integer ≤ 16); blank or zero or 10 if GJ is a scalar or extra point (See Remark 4 below)
T	Identification number of a TABLEDi card (Integer > 0)

<u>Remarks</u>:

1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may <u>not</u> be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN5 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.
4. The permissible values for the component number CJ are given in the following table:

CJ / $\dot{x}_j$ or x_j	Grid point	Scalar or extra point
Displacement (x_j)	1 ≤ Integer ≤ 6	0 or blank
Velocity ($\dot{x}_j$)	11 ≤ Integer ≤ 16	10

(Continued)

NOLIN5 (Cont.)

Note that velocity components are represented by integers ten greater than the corresponding displacement components.

5. Velocity ($\dot{x}_j$) is determined from the relation

$$\dot{x}_{j,t} = \frac{x_{j,t} - x_{j,t-1}}{\Delta t} ,$$

where Δt is the time increment and $x_{j,t}$ and $x_{j,t-1}$ are the displacements at time t and at the previous time step respectively.

6. Since the forcing functions $P_i(t)$ is a product of TABLEDi, displacement, velocity and the scale factor S, any zero value of these quantities will make $P_i(t)$ equal to zero. This condition may occur when initial displacement or velocity are zeros, and no other load applied to the structure

am. STRESS - optional in static analysis (rigid format 1). This parameter controls the transformation of element stresses to the material coordinate system (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements). If it is a positive integer, the stresses for these elements are transformed to the material coordinate system. If it is zero, stresses at the connected grid points are also computed in addition to the element stresses in the material coordinate system. A negative integer value results in no transformation of the stresses. The default value is -1.

an. STRAIN - optional in static analysis (rigid format 1). This parameter controls the transformation of element strains/curvatures to the material coordinate system (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements). If it is a positive integer, the strains/curvatures for these elements are transformed to the material coordinate system. If it is zero, strains/curvatures at the connected grid points are also computed in addition to the element strains/curvatures in the material coordinate system. A negative integer value results in no transformation of the strains/curvatures. The default value is -1.

ao. NINPTS - optional in static analysis (rigid format 1). A positive integer value of this parameter specifies the number of closest independent points to be used in the interpolation for computing stresses or strains/curvatures at grid points (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements). A negative integer value or 0 specifies that all independent points are to be used in the interpolation. The default value is 0.

ap. VOLUME - optional in all rigid formats. The volume computations for the 2-D and 3-D elements are activated by this parameter when they are generated in EMG. The results are multiplied by the real value of this parameter. If the 7th output data block of the EMG module were specified (via DMAP-alter), the element ID's, volumes, surface areas (see (aq) below), SIL, and grid point coordinates would be saved in the data block, a GINO written file. If the 7th output data block were one of the INPi (i=1,2,3,...,9,T) files, the same element data would be saved, in a FORTRAN binary written file. The following table summarizes the data being saved.

RECORD	WORDS	CONTENTS
0	1,2	Header record, begins with GINO BCD name
	3-34	Title, BCD
	35-66	Sub-title, BCD
	67-98	Label, BCD
	99-101	Date, BCD

(Continued)

PARAM (Cont.)

Record	Word	Contents
1	1,2	Element name of the first element, BCD
	2	Element ID, integer
	3	Volume (multiplied by scale factor n), or zero, real
	4	(No. of surfaces)*100 + (No. of grid points), integer
	5	Surface area of first surface real
	:	:
	4+N	Surface area of N-th surface, real
	4+N+1	SIL of the first grid point, integer
	4+N+2,3,4	x,y,z coordinates of the first grid point, real
	:	Repeat last 4 words for other grid points
2		A record similar to record 1 for the second element.
:		:
LAST		Last record for the last element.

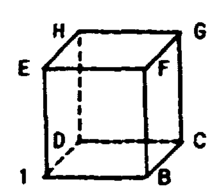
The trailer of the output data block has the following information:

Word 1 = LAST (No. of records written, header excluded),

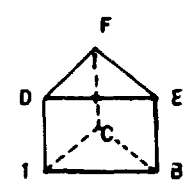
Words 2 thru 6 contain no useful information.

aq. SURFACE - optional in all rigid formats. The computations of the external surface areas for the 2-D and 3-D elements are activated by this parameter when they are generated in EMG. The results are multiplied by the real value of this parameter. See (ap) for the case where the surface areas are to be saved in an output file. The surface areas of the 3-D elements are defined below:

SURFACE AREA NO.	CORNER GRID POINTS USED
Brick (8 or more grid points):	
1	1,B,C,D
2	1,B,F,E
3	B,C,G,F
4	C,D,H,G
5	D,1,E,H
6	E,F,G,H



SURFACE AREA NO.	CORNER GRID POINTS USED
Wedge (6 grid points):	
1	1,B,C
2	1,B,E,D
3	B,C,F,E
4	C,1,D,F
5	D,E,F



(Continued)

Tetrahedron (4 grid points):

1	1,2,3	
2	1,2,4	
3	2,3,4	
4	3,1,4	

Structure Plot Data Card PLØT - Plot Generation

Description: Specifies all plot parameters so as to cause plots to be generated for the selected plotter.

Format:

```
      [ STATIC    ] [ DEFØRMATIØN  ]                                        [ RANGE f1, f2 ] [ PHASE LAG φ ]
      [ MØDAL     ] [ VELØCITY     ]                                        [ RANGE λ1, λ2 ] [ MAGNITUDE   ]
PLØT  [ CMØDAL    ] [ ACCELERATIØN ] [CØNTØUR] [i1, i2 THRU i3, etc.]       [ TIME  t1, t2 ]                 ,
      [ FREQUENCY ]
      [ TRANSIENT ]
[MAXIMUM DEFØRMATIØN d],

                                                                                  [        GRID PØINTS ]
[SET j1][ØRIGIN k1] [ SYMMETRY     ] w [ PEN     ] p  [SYMBØLS m[, n]]  [ LABEL  ELEMENTS    ]  ,
                    [ ANTISYMMETRY ]   [ DENSITY ]                              [        BØTH        ]
                                                                                  [        EPID        ]
[ SHAPE              ]
[ VECTØR v           ]
[ SHAPE, VECTØR v    ]  ,  [NØFIND] .
[ ØUTLINE            ]
[ HIDDEN             ]
[ SHRINK s           ]

[SET j2][ØRIGIN k2] .... etc.
```

Option	Meaning
1. STATIC	Plot static deformations in Rigid Formats 1, 2, 4, 5, 6 and 14; Heat Rigid Formats 1 and 3; Aero Rigid Format 11.
MØDAL	Plot mode shapes in Rigid Formats 3, 5, 13 and 15.
CMØDAL	Plot mode shapes in Aero Rigid Format 10.
FREQUENCY	Plot frequency deformations in Rigid Formats 8 and 11 and Aero Rigid Format 11.
TRANSIENT	Plot transient deformations in Rigid Formats 9 and 12; Heat Rigid Format 9; Aero Rigid Format 11.
2. DEFØRMATION	Nonzero integers(i) following refer to subcases that are to be plotted. Default is all subcases. See SHAPE and VECTOR for use of "0" command.
VELØCITY	Nonzero integers(i) following refer to subcases that are to be plotted. Default is all subcases.
ACCELERATIØN	Nonzero integers(i) following refer to subcases that are to be plotted. Default is all subcases.
3. CØNTØUR	Refers to stress or displacement contour lines and values. If deformed plots are requested, then the contours will be drawn on the deformed shape. If an underlay is requested (via "0" in the subcase string), the contours will be drawn on the undeformed shape.

(Continued)

<u>PLØT</u> (Cont.)

RXY or RXZ or RYZ - requesting vector sum of two components

R - requesting total vector deformation

N - used with any of the above combinations to request no underlay shape be drawn.

All plots requesting the VECTØR option shall have an underlay generated of the undeformed shape using the same sets, PEN 1 or DENSITY 1, and symbol 2 (if SYMBØLS is specified). If SHAPE and VECTØR are specified, the underlay will depend on whether "O" is used with DEFØRMATIØN. It will be the deformed shape when <u>not</u> used and will be both deformed and undeformed shapes when it <u>is</u> used. The part of the vector at the grid point will be the tail when the underlay is undeformed and the head when it is deformed. If the "N" parameter is used with VECTØR, no shape will be drawn but other options such as SYMBØLS will still be valid.

16. ØUTLINE — Connecting lines between grid points that lie on the boundary of the structural model will be plotted. The outline will reflect the deformed shape unless "O" is included in the subcase string. The ØUTLINE option will be ignored if the CØNTØUR option is not also requested.

17. HIDDEN — Provides a hidden image plot of the elements in the plot set. The HIDDEN option will be ignored if the CØNTØUR option is also requested. The LABEL option should not be used with the HIDDEN option.

18. SHRINK s — The real value (s) is the factor used to shrink or reduce elements within connecting grid points. The value s is limited to 0.1 to 1.0 with a default value of 0.75.

19. NØFIND — Disenables the automatic FIND for this plot. That is, the SET defined for the present plot will be drawn using the SCALE, VANTAGE PØINT and ØRIGIN from the previous PLØT command.

<u>Remarks</u>:

1. The plot card is <u>required</u> to generate plots. Each logical card will cause one picture to be generated for each subcase, mode or time step requested, using the <u>current parameter values</u>.

2. If only the word PLØT appears on the card, a picture of the undeformed structure will be prepared using the first defined set and the first defined origin.

3. If no FIND card is given after the previous PLØT card, the specified set on the PLØT card is used to perform an Automatic Find operation.

<u>Examples</u>:

Following are some examples illustrating the use of the PLØT card:

1. PLØT

   Undeformed SHAPE using first defined SET, first defined ØRIGIN and PEN 1 (or DENSITY 1).

2. PLØT SET 3 ØRIGIN 4 PEN 2 SHAPE SYMBØLS 3 LABEL

   Undeformed SHAPE using SET 3, ØRIGIN 4, PEN 2 (or DENSITY 2) with each grid point of the set having a + placed at its location, and its identification number printed adjacent to it.

(Continued)

PLØT (Cont.)

3. PLØT MØDAL DEFØRMATIØN 5 SHAPE

Modal deformations as defined in subcase 5 using first defined SET, first defined ØRIGIN, and PEN 1 (or DENSITY 1). Subcases must have previously been defined in the Case Control Deck via the use of MØDES cards, otherwise all modes will be in an assumed subcase 1.

4. PLØT STATIC DEFØRMATIØN 0, 3 THRU 5, 8 PEN 4, SHAPE

Static deformations as defined in subcases 3, 4, 5 and 8, deformed SHAPE; drawn with PEN 4, using first defined SET and ØRIGIN, underlayed with undeformed SHAPE drawn with PEN 1. This command will cause four plots to be generated.

5. PLØT STATIC DEFØRMATIØN 0 THRU 5,

SET 2 ØRIGIN 3 PEN 3 SHAPE,

SET 2 ØRIGIN 4 PEN 4 VECTØRS XYZ SYMBØLS 6,

SET 35 SHAPE

Deformations as defined in subcases 1, 2, 3, 4 and 5, undeformed underlay with PEN 1, consisting of SET 2 at ØRIGIN 3, SET 2 at ØRIGIN 4 (with an * placed at each grid point location), and SET 35 at ØRIGIN 4. Deflected data as follows: SHAPE using SET 2 at ØRIGIN 3 (PEN 3) and SET 35 at ØRIGIN 4 (PEN 4); 3 VECTØRS (X, Y and Z) drawn at each grid point of SET 2 at ØRIGIN 4 (PEN 4) (less any excluded grid points), with ○ placed at the end of each vector.

6. PLØT STATIC DEFØRMATIØNS 0, 3, 4,

SET 1 ØRIGIN 2 DENSITY 3 SHAPE,

SET 1 SYMMETRY Z SHAPE,

SET 2 ØRIGIN 3 SHAPE,

SET 2 SYMMETRY Z SHAPE

Static deformations as defined in subcases 3 and 4, both halves of a problem solved by symmetry using the X-Y principal plane as the plane of symmetry. SET 1 at ØRIGIN 2 and SET 2 at ØRIGIN 3, with the deformed shape plotted using DENSITY 3 and the undeformed structure plotted using DENSITY 1. The deformations of the "opposite" half will be plotted to correspond to symmetric loading. This command will cause two plots to be generated.

7. PLØT TRANSIENT DEFØRMATIØN 1, TIME 0.1, 0.2, MAXIMUM DEFØRMATIØN 2.0, SET 1, ØRIGIN 1, PEN 2,

SYMBØLS 2, VECTØR R

Transient deformations as defined in subcase 1 for time = 0.1 to time = 0.2, using SET 1 at ØRIGIN 1. The undeformed shape using PEN or DENSITY 1 with an * at each grid point location will be drawn as an underlay for the resultant deformation vectors using PEN or DENSITY 2 with an * typed at the end of each vector drawn. In addition, a plotted value of $d_{max}/2.0$ (where d_{max} is the value specified on the MAXIMUM DEFØRMATIØN card) will be used for the single maximum deformation occurring on any of the plots produced. All other deformations on all other plots will be scaled relative to this single maximum deformation. This command will cause a plot to be generated for each output time step which lies between 0.1 and 0.2.

(Continued)

PLØT (Cont.)

8. PLØT CMØDAL DEFØRMATIØN PHASE LAG 90., SET 1 VECTØR R

The imaginary part of the complex mode shape will be plotted for SET 1.

9. PLØT CØNTØUR 2

PLØT CØNTØUR 2 ØUTLINE

CØNTØUR MINPRIN

PLØT STATIC DEFØRMATIØN CØNTØUR 1 ØUTLINE

The first PLØT card will cause Major Principal Stress contours to be plotted on the undeformed shape of the complete model and the second PLØT card will cause the outline of the model to be plotted due to the defaults associated with the CØNTØUR card. Contour stress plots of the Minor Principal Stress will be plotted on the outline of the deformed shape by the third PLØT card.

10. PLØT SET 10 SHRINK .85

The undeformed shape of the elements defined by SET 10 will be drawn, with element sizes reduced to 85 percent of the scaled size. Grid locations will be automatically scaled to fill the image area.

11. SET 10 = ALL
SET 20 = 100 THRU 200
FIND SCALE ORIGIN 1 SET 10
PLØT SET 10
PLØT SET 20 NØFIND
PLØT SET 20

There will be 3 frames of the undeformed structure plotted. The first will display the entire structure, scaled to fill the image area. The second frame will display elements 100 thru 200, using the scale for the previous plot. The third frame will display elements 100 thru 200, scaled to fill the image area.