

THE STAGING SYSTEM:

DISPLAY AND EDIT MODULE

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SUMMARY

The Display and Edit (D&E) Module, described in this paper, is one of six major modules being developed for the STAGING (Structural Analysis through Generalized Interactive Graphics) System. Several remarks are included concerning the computer environment and the architecture of the data base. But the thrust of the paper is, clearly, to provide an understanding of the utility of this module. This is accomplished by defining, to a reasonable level of detail, the more prominent features of D&E.

INTRODUCTION

To assure an adequate appreciation for the D&E capabilities, it is important to have a good conceptual understanding of STAGING and of the need for STAGING. Over recent years, the finite element technology has literally "burst" onto the scene, becoming one of the most powerful and popular analytical methods available today. One result of this popularity has been a proliferation of computer programs, all claiming to be unique or better than other similar programs. In some cases, the claim is simply untrue. In more cases, capabilities do overlap, but the programs are still unique enough to justify their existence. In all cases, the programs cannot communicate easily with one another and are cumbersome to use. The net result is that we have less capability than we need, but more than we can use effectively. To cope with this problem, efforts are underway to develop STAGING.

STAGING is a highly interactive capability intended to: (a) synthesize the finite element methodology into a cohesive, user-oriented capability, and (b) radically reduce the time required to conduct a finite element analysis. The system will allow potential users to rapidly generate finite element models and interpret analysis results independent of the analysis program chosen to conduct the analysis. Although STAGING is specifically being aimed at the finite element methodology, early consideration is being given for its eventual extension to other technical disciplines.

STAGING (fig. 1) consists of six major modules; (a) Executive Monitor, (b) Preprocessor, (c) Display and Edit, (d) Postprocessor, (e) Analysis

Programs, and (f) Generalized Data Base. The Executive Monitor will serve as a "traffic cop" to help a user find and use a particular capability, and to ensure the proper flow of information between modules. The Preprocessor will be used to generate bulk information for the analysis codes. D&E will provide a host of interactive graphic utilities to assist in "fine tuning" previously generated data, and effectively display the analysis results. The Postprocessor will allow easy generation of additional engineering information from the basic output files of the analysis codes. The Analysis Module will simply be a file of available design and analysis computer programs. And, finally, the Generalized Data Base will provide efficient storage for all geometric and non-geometric information associated with a particular analysis.

A number of general purpose subroutines are provided to facilitate the transfer of information to and from the data base. Conversion programs are written, using these subroutines, to allow each of the major system modules to communicate with the data base through the Executive Monitor.

COMPUTER ENVIRONMENT

Hardware

The major hardware components include: a CDC 6000 series computer, the CDC CYBER Graphics terminal (ref. 1), and the CDC System 17 mini-computer. The System 17 mini-computer is being used to perform a limited amount of local processing (e.g. continuous 3-D rotation), while the CYBER Graphics terminal is being used as the primary interface between the host computer and the user. Within the year, D&E will also be accessible from a Tektronix 4014 scope.

In the more distant future, networking techniques will be used to make D&E available to the user community. A part, or all, of D&E will be downloaded from a central host computer to a mini-computer and used in a local mode. The current feeling is that networking can provide an effective answer to maintaining large software systems, reduce the time required to streamline these same systems, and consequently, provide more time for implementing new features.

Software

The code for most routines is FORTRAN, with the exception of a few specialized routines for character manipulation and permanent file management which are written in 6000 assembly language. These routines are isolated in the code and clearly identified. The program uses the CDC segmentation loader (ref. 2) and operates in less than 60K octal words of core memory on the CDC 6600. Also, a strong emphasis is placed on isolating the graphics code to reduce the amount of frustration for future implementations of D&E on other graphics devices. And finally, the DTNSRDC data handler routines (ref. 3) are being used to manage the data base.

DATA BASE

The data base provides a convenient mechanism for storing the geometric model and all related information, including the analysis results. Functionally, the data base is composed of the following four levels: structures, substructures, elements and nodes (fig. 2). This hierarchical concept is important and is used extensively by D&E. Associated with the individual items within a level is an attribute list that contains specific information about each particular entity. The data base handler routines are used to allow a user to interrogate and modify the data base efficiently and effectively. An understanding of these basic concepts is all that is required to use D&E effectively.

DISPLAY AND EDIT FEATURES

The power and flexibility of D&E can best be characterized by simply defining the discrete capabilities of the module. To put some order into the litany of features that is about to follow, they will be grouped into these broader categories: (a) Substructure Definition, (b) Displaying the Input Model, (c) Picture Manipulation, (d) Displaying the Results, (e) Editing, and (f) Global Commands. The actual mechanics of the interactive process are contained in a command tree (ref. 4). The command tree structures the user's options, and allows the user to systematically progress through the D&E capabilities. Examples of these capabilities are illustrated in figure 3.

Substructure Definition

A substructure is defined as any arbitrary collection of nodes and elements that are present in the data base. The actual definition of a particular substructure is left completely to the user, and is used by him to improve his visual interpretation, and interaction, with that portion of the model in which he is most interested. A substructure can be defined using one, or more, of the following features:

- a. Specifying a range of element/node numbers.
- b. Specifying individual elements/nodes.
- c. Specifying a range of values for any attribute.
- d. Merging two or more substructures to form a new substructure.
- e. Identifying geometric bounds.

Geometric specified bounds are defined using keyboard entries to specify an area or volume in either rectangular, cylindrical, or spherical coordinates. In a more limited sense, the lightpen can also be used to define the desired area or volume.

Displaying the Input Model

The input model can be viewed in one of three ways: in two-space (2D), in three-space rotatable (3DR), or in three-space non-rotatable (3DNR). The distinction between 2D and 3D is obvious. However, a 3D model can be displayed as a 2D model and vice versa. If the third coordinate is present in 2D, it will be ignored, and if absent in 3D, it will be given a default value of zero. 3DR and 3DNR present a more subtle distinction. The basic difference lies in where the 3D to 2D projection is carried out. The CYBER Graphics terminal features software (ref. 5) that will project a model using its mini-computer controller to describe the picture. The small core memory of the controller severely limits the size of the display. In the 3DNR mode the same projection is carried out on the host computer. Consequently, it is possible to display approximately twice the information in 3DNR as it is in 3DR. The tradeoff is that it takes longer to generate the picture in the 3DNR mode. Therefore, the 3DNR mode is used only when the 3DR mode would generate too much information.

In addition to displaying the actual geometry, all of the attributes associated with each entity can be displayed as alphameric or vector quantities superimposed on the geometric model. Examples of alphameric quantities include geometric and material properties. Examples of vector quantities include forces, moments and constraints.

Picture Manipulation

Picture manipulation varies from 2D to 3D. The base capabilities of 2D do, however, apply in exactly the same way for both 3D and 3DNR modes. These capabilities include:

a. picture zooming and recentering. These functions are performed through software in the controller and are considered LOCAL to the CYBER Graphics terminal.

b. generating a split screen view (fig. 3a). Up to four views can be generated simultaneously using the split screen option. Either a "free" (in which rotation can still occur) or "freeze" left side can be generated. In either case, only the main picture can be zoomed or used for lightpen selection.

c. shrinking elements (fig. 3b). Each element on the screen can be reduced about its center to 80% of its original size.

d. rescaling the picture. A new scale can be applied to the picture, or the picture can be scaled to fill the entire screen.

e. restoring the original picture. This option removes the effects of split screening and shrunk members, and restores the original picture re-centered.

It should be noted that 3DNR and 3DR have provisions for two more capabilities:

f. displaying of an X-Y-Z axis system. The axis system is centered in the middle of the picture and points along the X, Y, Z axes of the model.

g. generating a perspective view.

Finally, 3DR adds a feature its name implies: a capability to rotate around any of the three screen coordinate axes in a continuous or discrete mode. Continuous mode provides for automatic updating of the rotation. The discrete mode allows the user to rotate the model quickly, but in fixed steps.

Displaying the Results

After conducting the analysis, the answers are stored in the data base in the correct attribute arrays. Four basic capabilities are available to help the user review his results. They include X-Y plots, contour plots, deformed plots, and dynamic plots. Of course, the entire complement of picture manipulation capabilities is still available to help the user improve his visual interpretation of the results. As with the input model display section, the user need not pre-select the results displays he may wish to use.

The X-Y plotting capability (fig. 3c) is very flexible. The user may interactively activate the following options:

- | | |
|-----------------------|----------------------|
| a. line style | c. graph style |
| 1. points | 1. linear X/linear Y |
| 2. connected points | 2. log X/linear Y |
| 3. solid lines | 3. linear X/log Y |
| 4. short dashed lines | 4. log X/log Y |
| 5. long dashed lines | d. titling |
| b. grid | 1. X-axis |
| 1. full grid | 2. Y-axis |
| 2. tic marks | 3. graph title |

As many as ten curves can be generated on each plot. The user may also plot any attribute in the data base against any other attribute. And, finally, provisions have been made for automatic rescaling to ensure a reasonable picture every time.

Contour plots are available for 2-D displays only. As with the X-Y plotting capability, the user has control over the data to be plotted and the labelling of the graph. Scaling is performed automatically. The user can select the distance between contours, or use a value supplied by the system, to generate the contour intervals.

Deformed plots (fig. 3d) can be displayed alone, or superimposed on an undeformed plot. Dashed lines are used to easily distinguish the deformed plot from the undeformed plot. A magnification factor can be applied to the displacements to improve their visual appearance.

The dynamic plot capability is provided to facilitate film strip generation. In operation, the user need only specify the number of analysis time steps he wishes to process and the time-length of the film strip. The remaining process is automatic. The user has the option of previewing the information on the graphics scope or disposing it directly to an off-line plotting device.

Editing

Provisions are available to allow a user to easily alter the contents of the data base. Specifically, it is possible to add, delete, or modify any value of any attribute list in the data using keyboard entries and lightpen interaction. In a similar fashion, it is also possible to add or delete substructures, elements and nodes from the same data base.

Certain convenience features have been added to accelerate the editing process. For example, a user wishing to make the same changes to several different elements can activate the attribute lists of these elements by "picking" them from the graphics scope using the lightpen. Then, using the keyboard, the user can enter the new value for the particular attribute he wishes to change. The system will process this information and ensure that the change is reflected in each of the activated attribute lists.

Another useful feature is that the user can search a part, or all, of the data base for a particular value, or range of values, and replace them with a new one. A final example is that node points can be easily moved about in 2-D space. This feature is particularly helpful for moving the interior points of a model. An application of this feature could be to improve the aspect ratio of certain elements in a 2-D model.

GLOBAL Commands

GLOBAL commands initialize features that are accessible to the user any time during his session. Because these features will be made available to the user in other STAGING modules, they will eventually be included as features of the Executive Monitor. GLOBAL features that are currently available include:

- a. STOP - the stop option ends execution of the user session. The option must be "picked" twice to actually stop. The first "pick" reminds the user that the new data base has not been automatically catalogued.
- b. SAVE DATA BASE - the current data base can be saved in one of two ways. First, it is possible to overwrite the original copy of the data base. In this case, the contents of the old file will be purged automatically and the new data base will be catalogued with the same file name. The second option is

to enter a new copy of the file name by entering a new permanent file name, or cycle number. This new name will then become the current permanent file name.

c. CLOCK - this feature allows the user to check on how much time he has left in his current session.

d. STATISTICS - this feature provides information to the user to help him track the size of his model. The information includes such things as the number of nodes, elements, and substructures, and the limit values of the display.

e. HELP - this feature can be used to provide further definition of the "pickable" options available to the user. It can also be used to display the options at the next level up and the next level down in the command tree. And finally, the HELP feature can be used to display the history of "picks" a user has made to get from the top of the command tree down to his current level.

f. HARDCOPY - the CYBER Graphics terminal has no inherent hardcopy capability because it is a refresh terminal. Consequently, software is provided to process the current display to a suitable hardcopy device.

g. SKIP - this command is intended for experienced users who know their way around the command tree. It allows the user to skip up as many levels as the user has traveled through. The user is cautioned that subroutines normally called, as he progresses through the normal RETURN mechanism, are not called in the SKIP mode. Consequently, this feature can cause problems for the inexperienced user later in the session.

h. COMMENT - the comment log is provided to improve communication between the program developers and the program users. Users are encouraged to use the log to ask questions, criticize, or make general comments. The comment log is periodically reviewed by the program developer and has proved to be an effective mechanism for debugging, and streamlining, the D&E capability.

i. RETURN - this option re-activates the menu for the module the user was working in before activating the GLOBAL command feature. The only exception is when input is required for type-ins. In this case, RETURN must be "picked" and the segment re-entered.

j. Error Recovery - occasionally an error will occur that causes the program to abort on the host computer. The host will recover the error and ask the user if he wishes to continue. If the user says yes, the screen will erase and control will be transferred to that menu from which the abort was initiated.

CONCLUDING REMARKS

The D&E module represents an important first step toward a much more ambitious goal, that goal being to integrate the entire spectrum of design and analysis computer programs, while maximizing the utility and efficiency of these same programs. Efforts will continue to be made to streamline the D&E

module and to add new features to it. But even in this unpolished state, user reaction has been surprisingly good. This reaction tends to lend further credence to the old adage that a picture, in the right place and at the right time, is still worth a thousand words.

The remaining five major STAGING modules are being developed concurrent with D&E. It is estimated that, within this calendar year, the six major system modules will be integrated to form the first tangible version of STAGING.

REFERENCES

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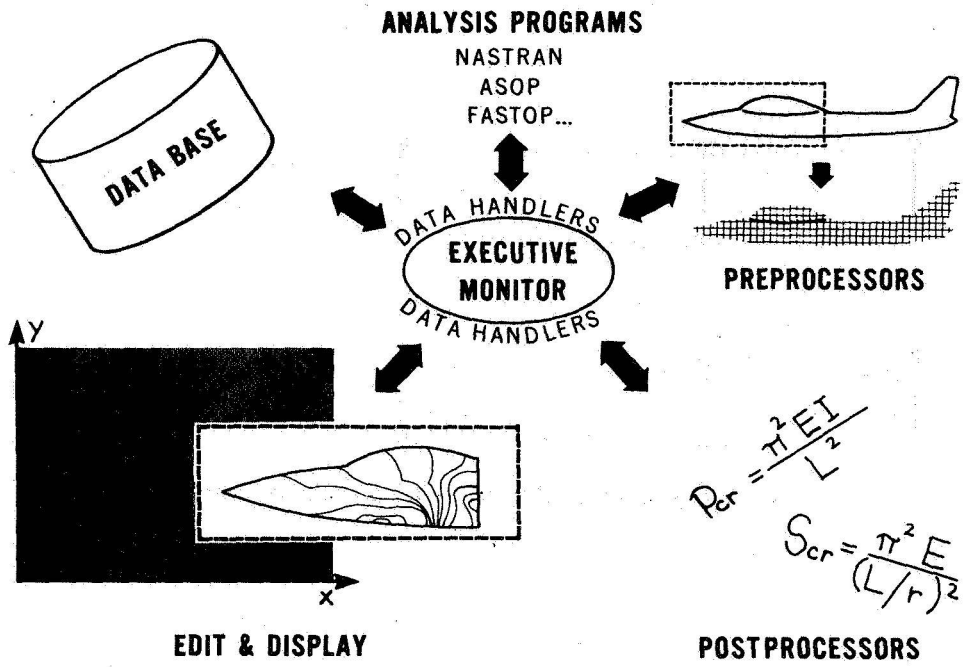


Figure 1.- STAGING modules.

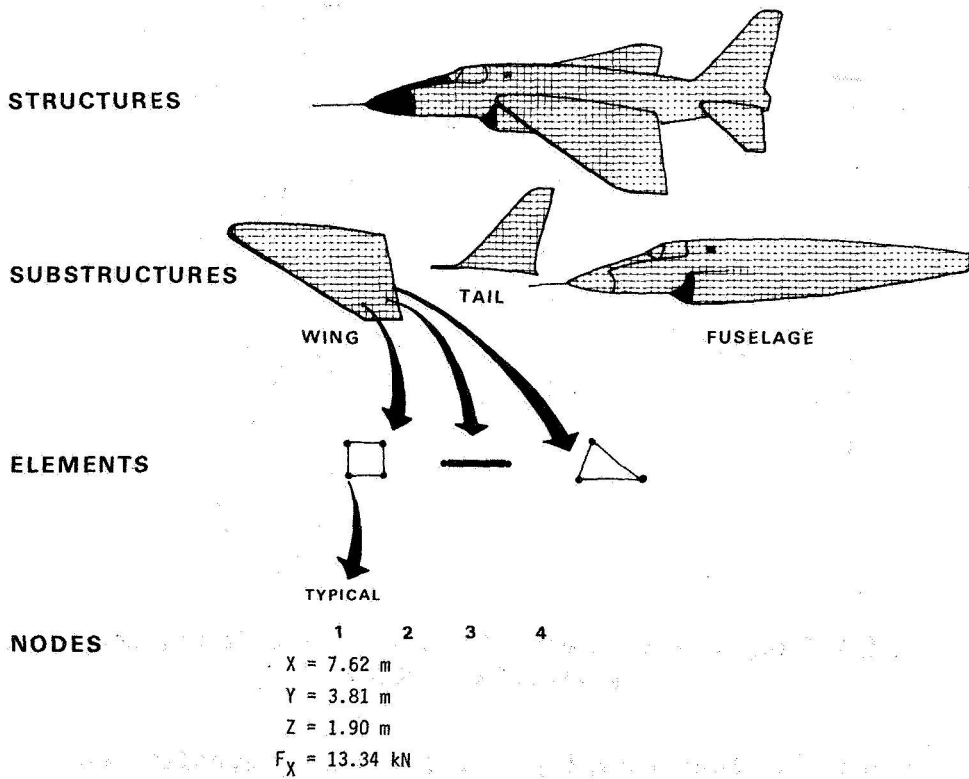
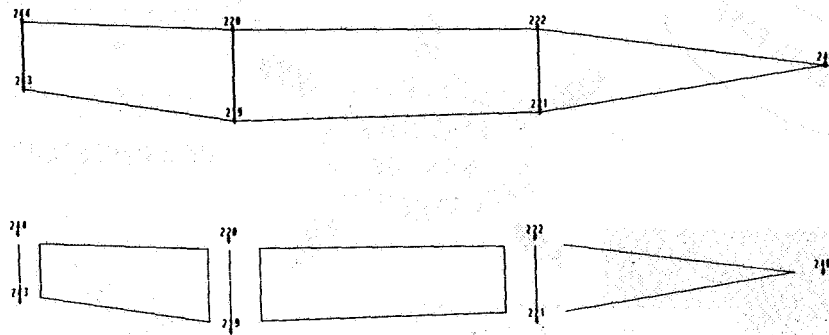
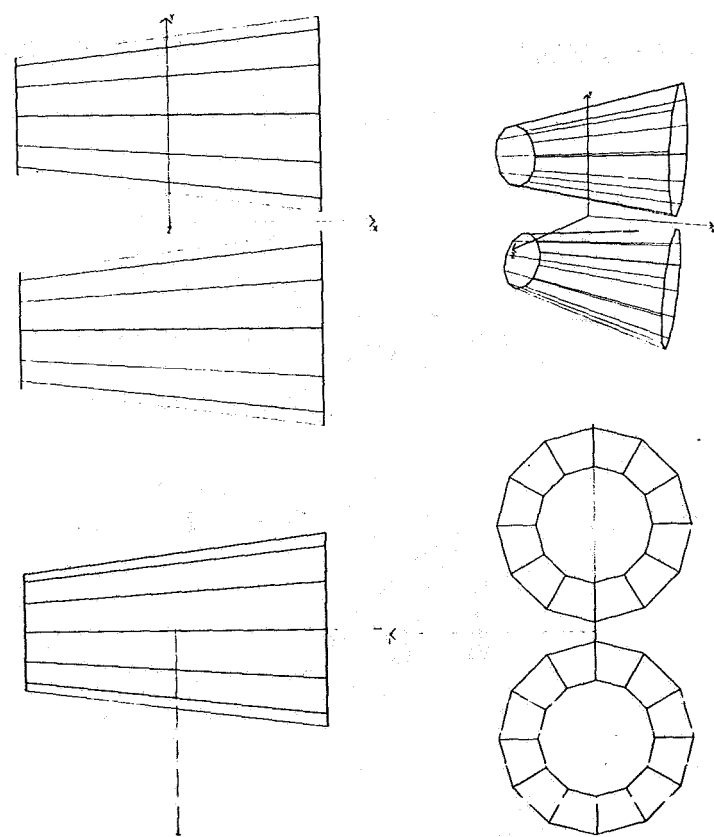


Figure 2.- Conceptual view of the data base.

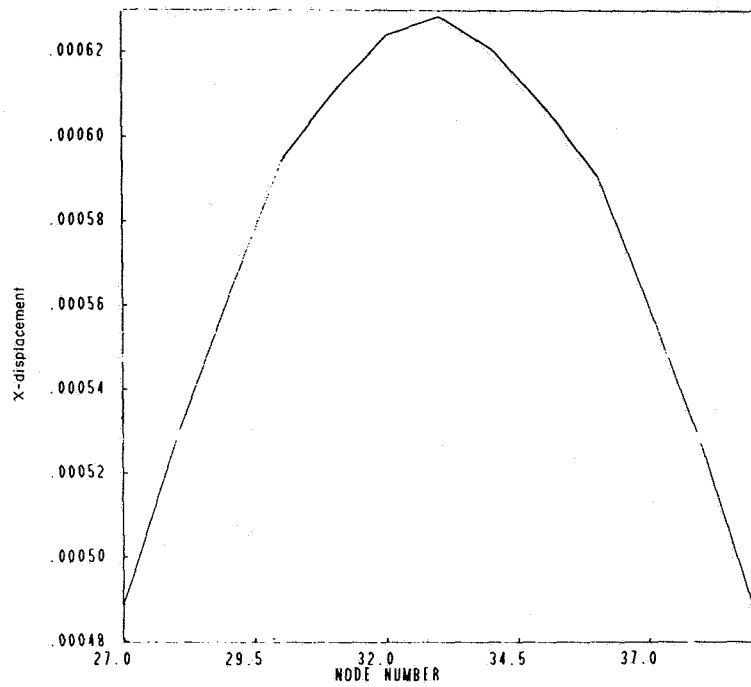


(a) An 80-percent shrink shows rod elements.

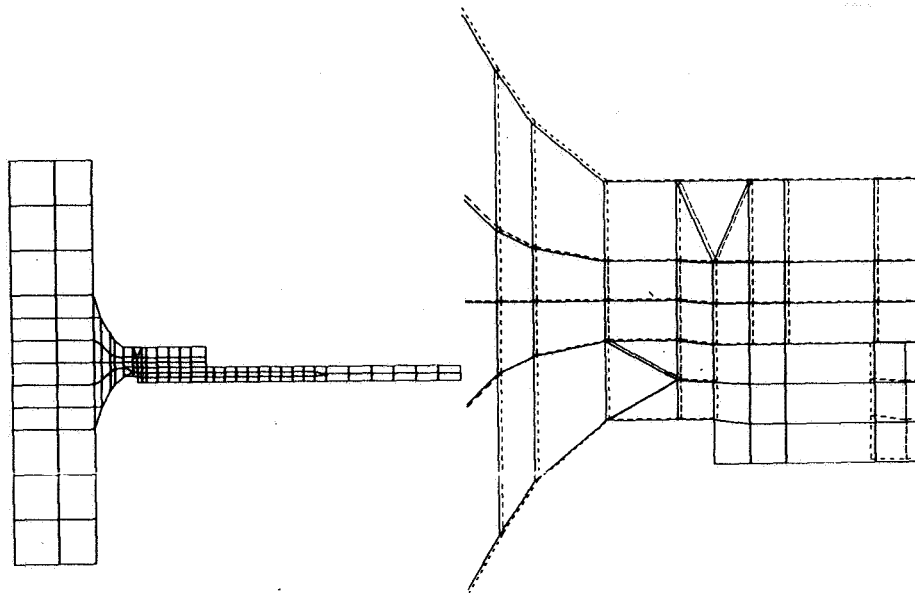


(b) 4-way split screen with top, side, front, and perspective views.

Figure 3.- Four examples of D&E display capabilities.



(c) X-Y plot of node number versus X-displacement.



(d) 2-way split screen with zoomed deformed plot.

Figure 3.- Concluded.