UTILITY PROGRAMS AT MARTIN MARIETTA WHICH SUPPLEMENT MSC/NASTRAN AND SDRC-SUPERTAB

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ABSTRACT

Martin Marietta has many man-years of experience with MSC/NASTRAN and SDRC-SUPERTAB (I-DEAS). Through constant use of this software, certain utilities, programs, and libraries have evolved that enhance the entire analysis process. It has been found that, collectively, these "utilitities" provide a large productivity enhancement to the engineer by providing functions that were overlooked or not provided by SDRC and MSC. This paper documents the concept and function of many of these utilities with the hope that others may benefit by developing similar routines.

INTRODUCTION

Martin Marietta Missiles and Electronics Group (formerly Martin Marietta Orlando Aerospace) has successfully been using SUPERTAB since 1981, and played an important role in the original development of NASTRAN. In more recent years, our licenses have expanded to include MSC/NASTRAN and I-DEAS on several VAX-clusters and on an IBM 3090VF. Through the years, many utilities have naturally evolved that aid in efficient, productive modeling with the I-DEAS software, particularly when used in concert with MSC/NASTRAN. Taken alone, these utilities are not necessarily very dramatic; however, taken together, they form a unified system that streamlines the entire analysis process and makes a dramatic difference in an engineer's productivity.

In the sections that follow, a description of the utilities is made and placed under the general heading of either a pure SUPERTAB utility or those pertaining to both MSC/NASTRAN and SUPERTAB. Table 1 provides a brief description of each utility addressed.

PROGRAM	DESCRIPTION	INPUT	OUTPUT
Normals	Orients shell element normals in a specified direction.	Universal file	Universal file
Rasterize	Converts I–DEAS picture files and plots to a rasterizer.	SDRC picture files	Hard Copies
Prop–plots	Plots elements by property IDs in batch mode.	I–DEAS model file	Hard Copies
Unicolor	Colors a monochrome Universal file based on PID or MID.	Universal file	Universal file
Surfaces	Depicts each continuous plate surface with color.	Universal file	Universal file
Picture	Interactive graphical picture file editor.	SDRC picture files	Hard Copies
SE_Combine	Combies separate superelement universl file.	Universal file	Universal file
FEM/SINDA	General purpose thermal analysis program.	Universal file*	Universal file*
Supernas	Automates NASTRAN execution and I–DEAS post–processing.	NASTRAN input deck	Hard Copies
Unisyn	Component mode synthesis code for test or analytic data.	Universal file	NASTRAN input deck*
Relabel	Adds an integer to every label in model.	NASTRAN punch deck	NASTRAN punch deck
Dynaplot	Dynamics post–processing utility for MSC/NASTRAN.	NASTRAN punch deck	Hard Copies*

*Other forms of input/output are available.

Table 1 - Summary of I-DEAS, MSC/NASTRAN Utilities

SUPERTAB UTILITIES

• *NORMALS*

Beginning users of SUPERTAB, or people not using a pre-processor at all, often create plate/shell elements without regard to element outward normals. Indeed, even experienced users often do not like to concern themselves with this detail. The result of this, of course, is an inconsistent definition of element top surface that can result in meaningless element stress and strain contours.

NORMALS is a program that operates off a Universal file and changes plate/shell connectivity so that the element outward normals point as closely as possible to some target point. The program can function on all the elements of the model, or some subset, defined by a group, color, or label range. Figure 1 shows a plot of a model with *feature lines turned off* before and after the program NORMALS is run.

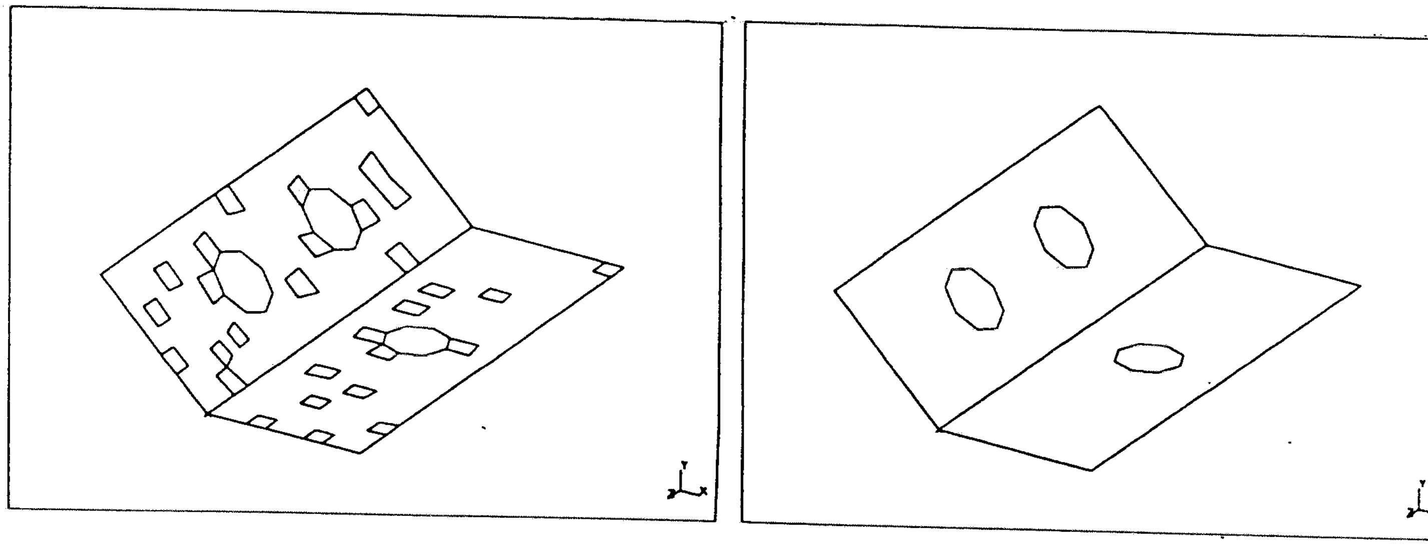

Figure 1 - Model Before and After Correction with Program *NORMALS*

• *RASTERIZE*

Most I-DEAS users are very familiar with the process of making color hardcopies. Typically it involves an analyst sitting at a terminal which downloads screen images to a multiplexed hardcopy unit. This process can be slow, requires an analyst to be located at a terminal that is physically attached to the hardcopy unit, and produces hardcopy that is often limited by the resolution of the user's screen.

RASTERIZE gives the analyst another method for producing color hard copy that eliminates the problems addressed above. RASTERIZE takes advantage of an on-line rasterizer that is connected as an output queue to one of the host's ports. Plot files coming from the host are converted by the rasterizer to raster data that is then sent to an attached hardcopy unit (at maximum resolution for that particular hardcopy).

RASTERIZE works in batch mode by converting I-DEAS binary or formatted picture files to Tektronix IGL plot format and subsequently routs the resulting plot file to the on-line rasterizer. The end-product to the analyst is the graphical equivalent of a "print" command, effectively sending I-DEAS picture files to a queued color hardcopy unit. One interesting option that RASTERIZE allows is the conversion of a color continuous tone image to a still-readable gray scale. This allows stress contour plots, for instance, to be produced that retain their meaning in a monochrome report.

• *PROP_PLOTS*

Many engineers build models and add new property IDs not only when properties/materials *actually* change, but also when some significant change in *geometry* is encountered. This gives the engineer convenient "hooks" back to important sub-sections of his model that otherwise would be lost in a MSC/NASTRAN-to-SUPERTAB translation. The result of this is that many more properties are defined in the model than are actually needed, creating a bit of a bookkeeping problem for the analyst.

PROP_PLOTS was created to provide a convenient method to document all the property IDs that an engineer has made when creating his model. PROP_PLOTS is a command procedure that prompts the user for responses to a few simple questions (like desired views, property ranges, display options), writes a program file to generate picture files for each property ID, runs I-DEAS in batch-mode to create the picture files, converts the picture files to Tektronix IGL format, and finally submits the resulting plot files to an on-line rasterizer (via the RASTERIZE program, mentioned above). Thus the engineer, with almost no work, can pick up a collection of plots, complete with labeling, that documents each property ID used in his model.

- *UNICOLOR*

UNICOLOR is a simple FORTRAN program that operates off a SUPERTAB Universal file and automatically "color-codes" the model according to property and/or material ID. This program is quite helpful when dealing with large models "inherited" from another engineer, or perhaps even another company. The code immediately gives some coherence to an otherwise difficult-to-interpret collection of elements shown on the screen.

- *SURFACES*

Like UNICOLOR, SURFACES attempts to bring some organization to an unfamiliar model via strategic color-coding. SURFACES calculates plate/shell element normal vectors and assembles an element connectivity list from a SUPERTAB Universal file. Elements are then colored to be the same provided that they are contiguously connected and have a normal within a specified angle of all adjacent elements. Consequently, each color would represent a specific collection of elements defining a completely contiguous surface. For example, Figure 2 shows a cylindrical model of a missile with internal bulkheads and longitudinal stiffeners with the outer cylinder displayed in a single color, and with each internal bulkhead and longitudinal stiffener shown in its own unique color representation.

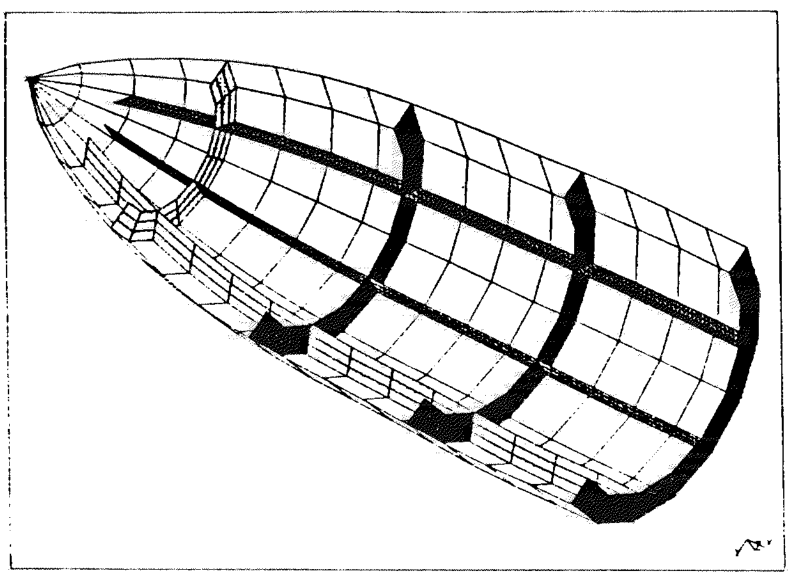

Figure 2 - Model After Color Coding with Program *SURFACES*

- *PICTURE*

For presentation purposes, it is often necessary to modify or "edit" an I-DEAS display to add notes, arrows, or remove unnecessary portions of the display. This is accomplished through the program PICTURE which reads a binary or formatted picture file and displays the resulting image on a Tektronix color terminal. The program is a menu-driven graphical editor that allows the user to manipulate screen segments, and add or delete any information that he desires, including the Martin Marietta company logo. The program then drives an attached color hard-copy device or rasterizer to produce the desired output. An example plot is given in Figure 3.

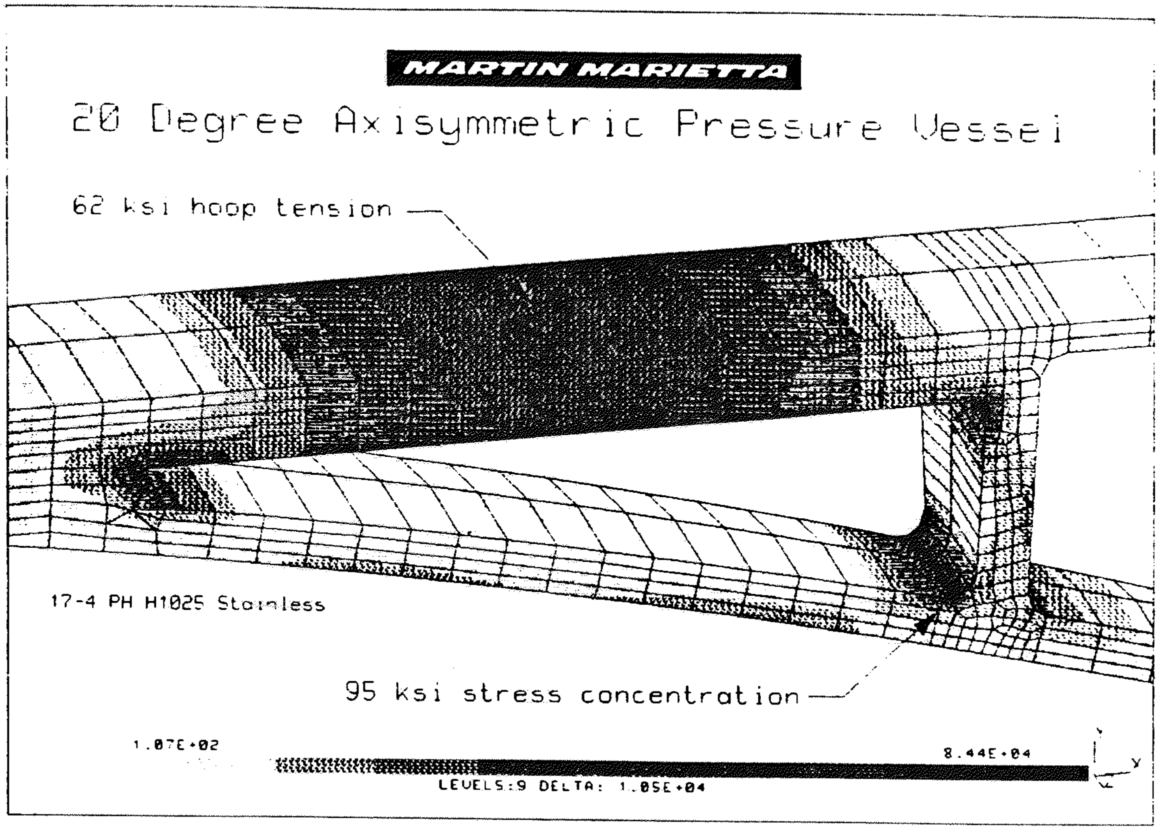

Figure 3 - I-DEAS Customized Output from Program *PICTURE*

- *SE_COMBINE*

MSC/NASTRAN Superelement analysis is performed routinely at Martin Marietta Missiles and Electronics Group for a wide variety of defense systems. One difficulty of superelement analysis is the display of analysis results in SUPERTAB post-processing. Separate universal files result for each superelement, with nodal boundary data (between adjacent superelements) being represented redundantly. Thus the analyst cannot simply read all universal files separately and then perform a dataset combine in I-DEAS, or boundary data will be erroneous. SE_COMBINE is used to process these separate universal files prior to entering I-DEAS. SE_COMBINE seeks out the redundant information and eliminates it, and then produces a single contiguous universal file for subsequent processing. The I-DEAS analyst then observes analysis results for the entire system. These results appear identical to those determined by a non-superelement solution sequence.

- *FEM/SINDA*

Efficient solution to nonlinear time-dependent thermal analysis equations mandates the use of finite difference methods (unlike F.E. techniques used in MSC/NASTRAN). Past attempts to create finite-difference networks from SUPERTAB, however, have resulted in simulations with compromised geometrical integrity, largely because network resistors run from element centroid to element centroid (instead of node-to-node). FEM/SINDA avoids this difficulty by creating networks based strictly upon the original node locations using a thermal analog of the finite-element method. The result is a thermal analysis network rigorously based on the finite-element method, maintaining complete compatibility with SUPERTAB, and consequently with any structural model that is solved with MSC/NASTRAN.

For more detailed information concerning FEM/SINDA, see *FEM/SINDA: Combining the Strengths of MSC/NASTRAN, SINDA, SUPERTAB, and PATRAN for Thermal and Structural Analysis*, P. Richard Zarda, *et. al.*, The MSC 1989 World Users Conference Proceedings.

COMBINED SUPERTAB-MSC/NASTRAN UTILITIES

- *SUPER-NAS*

It does not take long for an experienced finite-element analyst to realize that he spends too much time post-processing the results of his simulation. For large models, it can take significant time just to display, for instance, a continuous tone image of top surface von-Mises stress for a single load case. Furthermore, many of the operations performed in post-processing are purely mechanical. Clearly, much of the process could be automated. Ideally, this automation would occur in a batch-mode process (thus permitting low-cost, low priority queues to be used) executed at night, allowing an engineer to retrieve his results in the morning. This is essentially what SUPER-NAS does.

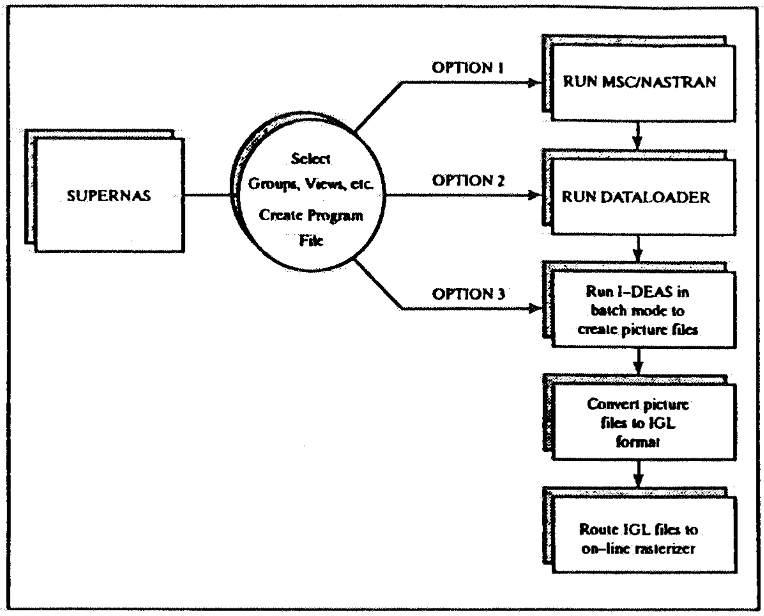

Figure 4 - *SUPER-NAS* Functional Flow-Chart

As Figure 4 shows, SUPER-NAS is a command procedure that prompts the user for the desired post-processing (element groups, views, display options, datasets, etc.) and develops an appropriate program file that, once the MSC/NASTRAN job is completed, is run in a batch-mode I-DEAS session. This I-DEAS session creates binary picture files that are then converted to Tektronix IGL format and submitted to an on-line rasterizer. The result is full-color plots of stress, displacements, modes, etc., of the desired element groups in the desired views waiting for the engineer in his bin in the morning. SUPER-NAS, of course, can also be run in the daytime hours; experience has shown that this procedure will easily beat an engineer trying to create the same plots in interactive fashion, while, at the same time, freeing the engineer to pursue more creative activities.

- *SOLUTION LIBRARY*

The Martin Marietta Solution Library is very simple in concept: it is a collection of generic MSC/NASTRAN input decks, complete with I-DEAS output Alters, for virtually every possible solution sequence. These decks serve as company standards, complete with comments and warnings, on how to perform a given analysis. These solutions decks result in significant time savings, particularly when the analyst is executing an unfamiliar solution sequence. Additionally, the library serves as an efficient mechanism for disseminating updates, including I-DEAS Alters, for new releases of the software.

• *UNISYN*

In response to a need for additional component mode synthesis capabilities, a program was developed which incorporates inputs from dynamic and static test or analysis, develops the governing equations of motion, and synthesizes an MSC/NASTRAN deck which may be used to analyze future modifications to the structure. The program, called UNISYN, uses SDRC Universal files as a database for physical and modal definition of the structure.

UNISYN generates models by deducing a specimen's generalized properties through specification of its mode shapes, modal mass, and natural frequencies (via a Universal file) and, optionally, through specification of the specimen's mass distribution (interactively or via MSC/NASTRAN matrix inputs) and static behavior under a known load (via a Universal file). Once the generalized properties are determined, a transformation to physical coordinates is performed allowing the user to make changes to the model in physical terms, as well as providing him with graphical displays. Output from the program consists of a Universal file for display of the modal basis set, a synthesized MSC/NASTRAN bulk data deck, and a file containing the results of an orthogonality and effective mass check performed using the modal basis set and the physical mass matrix (if any). The generated MSC/NASTRAN deck permits synthesis to be performed on the structure, such as determining the effect changes in mass or boundary conditions will have in determining response. Additionally, the synthesized MSC/NASTRAN deck may be interfaced with other decks (either traditional or UNISYN-derived), permitting simulations of entire systems. Since MSC/NASTRAN is being used as the analysis mechanism, the entire range of rigid- format solution sequences is available, including superelement formulations.

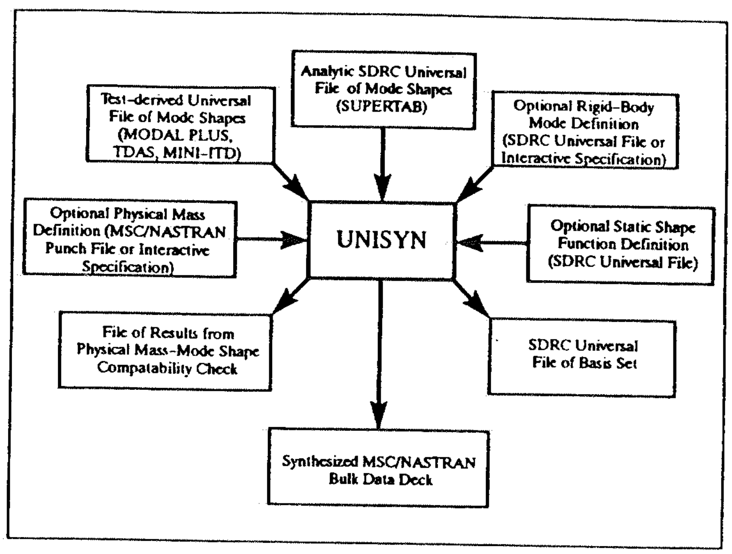

Figure 5 - Input/Output Structure of Program *UNISYN*

Figure 5 details the input/output structure of UNISYN. For more information see *Interfacing MSC/NASTRAN with SRDC-IDEAS to Perform Component Mode Synthesis Combining Test, Analytical, and F.E. Data*, R. W. Graves, The MSC 1988 World Users Conference Proceedings.

• *RELABEL*

RELABEL is a simple program that adds fixed increments to all node, element, property, restraint, etc., labels present in a MSC/NASTRAN data deck. This facilitates the assembly of many disjoint substructures (with overlapping IDs) into a complete system model, suitable for processing in I-DEAS. This program is actually preferred to the alternative of relabeling separate models inside of SUPERTAB, since RELABEL preserves *all* MSC/NASTRAN entities and avoids unnecessary SUPERTAB-MSC/NASTRAN translations.

• *DYNAPLOT*

Standard MSC/NASTRAN dynamic analysis plotting routines are not ideal with regard to of quality of output and lack the ability to manipulate data, such as performing discrete fourier transforms, integrations, PSD calculations, etc. The intent of DYNAPLOT is to provide a higher quality, more versatile means to plot and manipulate dynamic analysis results from MSC/NASTRAN.

DYNAPLOT is divided into two main modules: a Plot Manager and a Plot Driver. The Plot Manager is an interactive menu-driven program that the analyst uses to select what plots and data transforms he'd like to make. The Plot Driver then uses this information to drive a selected output device, such as a terminal, on-line rasterizer, or laser printer. Should the output be directed to a queued device, the Plot Driver runs in a batch mode, producing output while the engineer is freed to pursue other endeavors. Should the output be direct to the engineer's terminal, the Plot Driver runs interactively and provides a built-in graphical editor if the engineer wants to "customize" his plots. DYNAPLOT also is designed to automatically provide (with optional overides) axis labeling, titling, and scale types and ranges. Restarts are easily performed, should an analyst wish to re-direct output, change scales, titles, etc.

Possible transformations include: data smoothing, differentiation and integration, discrete fourier transforms and their inverses, power spectral densities (with windows), shock spectra, scaling/offsetting, data combinations, and autocorrelations. Presently in development is an SDRC Universal file and PEARL interface that will allow an engineer to bring dynamic analysis results into SUPERTAB that are not normally possible, such as RMS intensities and complex data. Additionally, an interface will be made to MSC's new database architecture, when available. Figure 6 shows a typical plot made with DYNAPLOT.

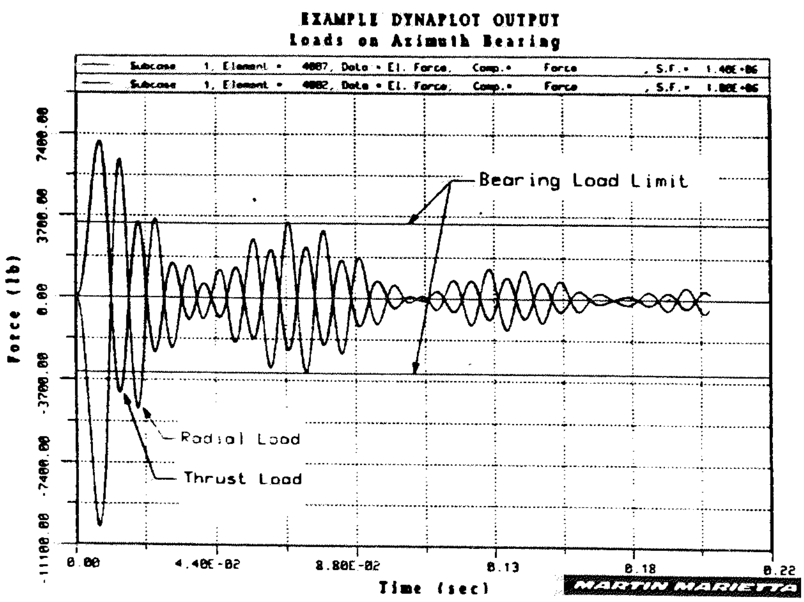

Figure 6 - Example *DYNAPLOT* Output

CONCLUSIONS

MSC/NASTRAN and I-DEAS provide a powerful analysis combination for the engineer. It has been found through experience, however, that a company can increases its analyst's productivity many times over through (sometimes simple) customization of the analyst's computing environment. This paper has documented several of the utilities that we have found to be very useful at Martin Marietta Electronics and Missiles Group– utilities that are in constant use everyday.