University of Maryland, College Park
Department of Aerospace Engineering

Report No. AE-77-1

Alternatives for NASTRAN Maintenance

Modification and Dissemination

by

Harry G. Schaeffer
Dept. of Aerospace Engineering
University of Maryland
College Park, Maryland

Final Report for National Aeronautics and
Space Administration Grant NSG 1193

Report No. AE-77-1

Alternatives for NASTRAN Maintenance Modification and Dissemination

by

Harry G. Schaeffer
Dept. of Aerospace Engineering
University of Maryland
College Park, Maryland

Final Report for National Aeronautics and
Space Administration Grant NSG 1193

SUMMARY

The NASTRAN program is currently maintained by the National Aeronautics and Space Administration and is distributed through COSMIC. Proprietary versions of the program are also maintained by several firms including McNeal Schwendler Corp., Universal Analytics, Sperry Univac, and Computer Science Corp. These proprietary versions are sold or leased and are also available through a number of commercial computer centers including Control Data's Cybernet, CSC's Infonet, University Computing, United Computing, Boeing Computer Services and McDonnel Douglas Automation.

This report considers the justification for continued NASA support of the program and concludes that the user community is adequately served by the commercial software developers. Various alternatives to direct NASA support of the program are considered ranging from no support at one end of the spectrum to subsidizing a non profit user's group at the other. Of all the ternatives that are developed, the user group appears to be most viable.

The report further considers NASA's past and future roles in the development of computerized technology. The need for an institute for computational analysis is identified and NASA's possible involvement is described. The report defines the goals of the proposed institute and recommends that NASA utilize the research funds which currently support NASTRAN to support an activity that has the potential of a much larger impact on the technical community.

1. Introduction

The purpose of this report, the study of alternatives for the maintenance, modification and dissemination of NASTRAN, is to provide the NASA with an outside evaluation of its NASTRAN related activities. Also, since the NASTRAN management recognizes that the project must logically terminate within NASA at some time, the functional form of alternative support facilities is identified and assessed.

In the process of this study it appeared that questions larger than just truly NASTRAN related ones were raised. There is the issue of computerized technology -- and where that activity is leading the technical community. There is the question of education and professional development of individuals to keep abreast of the new computerized technology. And there most certainly is the question of profits in the private sector which may result from NASA supported activities in supporting new software systems.

In light of these larger -- and in the author's view -- more pressing problems this study also considers NASA's past and potential involvement in the development of computerized technology.

2. Computerized Technology

Most of us have some awareness that our technology is becoming more and more computerized. We no longer utilize a set of mathematical tables to determine circular functions, we have a hand-held calculator which can perform the standard arithmetic operations, and which can actually store a set of instructions. Really, a computer in the palm of our hand. And there is a growing concern on the part of educators that the availability of this computerized technology will lead to future generations that don't appreciate or understand the basic arithmetic operations necessary to multiply 2 times 3. Without an understanding of the fundamentals there will be no basis on which to judge whether the displayed result is correct or not.

If there is some concern about the mechanization of that phase of technology, shouldn't we be at least a little skeptical of the direction that technology has apparently mapped out for itself -- the mechanization of all technology. Carrying the hand-held calculator analogy a little further will lead to a hand-held NASTRAN calculator which as a finite element button that can be pushed to analyze a complex structure.

2.1 Definition of Computerized Technology

Before going further it is worthwhile to define what is meant by computerized technology and to define its attributes. Computerized technology may be viewed as a subset of technology in a specific area which has been codified for execution on the computer. The resulting programs thus embody a general solution to a class of analysis problems that may be executed by an engineering analyst. In the area of structural mechanics much of the transfer of technology to the computer has been accomplished by engineers and has lead to a vast array of programs. The resulting programs have not been qualified

against any set of standards, are generally poorly documented, and have varying degrees of transportability.

2.2 Dangers of Computerized Technology

There are real dangers in our head-long drive to develop this computerized technology. There is the danger that the user will have no knowledge or perception of the technology -- and will thus have no technical yardstick with which to judge the validity of the results of the computation. There is the danger that the computerized technology will get out of control of the traditional curia -- the researchers in industry, the government and academia. There is the danger that our educational system will be outdated and out of touch with the technology. There is the danger that engineers will loose their "feel" for the expected response and will rely blindly on the computer.

Once the dangers are exposed we are in a position to examine them and to develop a set of guidelines which will allow us to proceed in an orderly manner to computerize that part of our technology that is amendable to mechanization.

2.3 User Perception of Technology

On the basis of first hand experience in teaching NASTRAN-oriented courses the author's major concern is the lack of knowledge on the part of the user. There is an analogy to letting a small child play with a loaded gun, the trigger can be easily pulled with unforseen results.

The technology built into a program such as NASTRAN covers such a wide spectrum of technological speciality areas that few have the background to understand every aspect of the program. The potential user must be aware, however, of the basic finite element technology in order to model effectively. The user must also have some perception of matrix structural analysis, some

knowledge of the theory of elasticity, and of numerical analysis. However, the typical student in the author's NASTRAN courses have little background in these areas. They are in the class for training in how to turn on all of the NASTRAN bells and whistles but what they really need is education in the necessary engineering fundamentals before they attempt to use the program.

2.4 Dissemination of Technology

The traditional means of disseminating technology have been by means of books and publications and researchers and educators have been those who have traditionally been those responsible for the transfer of technology. Computerized technology has changed these traditions somewhat and there is a real danger that current technology will not be available to those who have traditionally developed the new, advanced technology. They are two reasons for making this statement. First, programs such as NASTRAN are preceived as being too complex for the average researcher to use since they are difficult and expensive to modify. Second, programs that incorporate the current technology are valuable and there is an appreciable cost involved in obtaining the use of the technology.

Structural analysis is a fairly mature technology. Most linear static and dynamic analyses of nontrivial size are performed using a large general purpose program that incorporates the finite element method. The area of current research are nonlinear mechanics, fracture mechanics, and fatigue. The technological software base that is required in order to perform reasonable research in these areas has been developed by independent software developers and is not available to support research in areas that would be most beneficial to the technical community.

NASA's continued support of NASTRAN may have discouraged rather than encouraged research in fruitful areas of engineering mechanics. The program

is not organized in a manner that encourages modification and the program architecture is not appropriate for the solution of nonlinear equations. It would appear that if NASA's long range goal is to produce a software system that would serve as the foundation for continued developments in computational analysis as well as a system that would provide analysis and design capability to the technical community, then NASTRAN support should be discontinued in favor of a more usable software system.

2.5 Education

Computerized technology has created real problems in the educational area. There is really a two-fold problem. The inclusion of computer-oriented courses in the curricula and the education of the practicing engineer. The problems are not unrelated.

Clearly the universities should continue to teach the basics. Just as clearly the universities should provide professional development courses to practicing engineers to provide education about the technology and training in its usage. Our problem is more in reaching the practicing engineer. It is so often the case that a recent graduate will take a position at an establishment that has implemented NASTRAN, where the program is perceived in terms of an almost magic capability for analyzing structures. The viewpoint is taken that the new engineer need only determine the correct switches to turn and the program will do the rest. On the basis of my experience management is willing to entrust the analysis of a very complex structure to our newly graduated engineer who has little or no background in the technology incorporated in the program.

The new engineer then goes through so-called baptism by fire. The input data is prepared and then the dialog between NASTRAN and the user begins. These are errors on the bulk data cards -- which the user fixes. There are unconstrained degrees of freedom -- which the user constrains (perhaps

incorrectly). And then after several aborted attempts NASTRAN actually accepts the data and produces a set of results.

It is useful to consider the state of affairs from a behavior modification and reward point of view. The user has interacted with the program. The interaction has been such that the user has made a mistake and the execution has been aborted, but the user has been provided with diagnostic information that indicates the appropriate correction to be made. Typically, this dialog could take ten-to-fifteen runs during which time the user is becoming frustrated by his inability to correctly format the input and the attendent delays. Then the big day arrives -- the program accepts the revised input and produces results! The user at the time has been conditioned by his interaction to conclude that the results are correct. That conditioning together with the fact that our recent graduate does not have the background to evaluate the worth of the computed results leaves society in a very precarious position. Our new engineer could have just analyzed a critical component of a very sensitive structure.

Its one thing to discover the disease, its another to devise a cure. The solution can be approached by providing a broader education at the undergraduate level to at least teach the student to appreciate the sophistication of today's software and by a concerted effort to involve the practicing engineer with continuing education and professional development courses. In both areas those involved in the education field require new course material and software suitable for the teaching environment. NASTRAN has the capabilities for matrix abstraction and modeling but it is not amenable to the classroom environment. It is too expensive to use, the NASTRAN language is not easy to learn, and the program is not well modularized from an educational point of view.

In summary, we perceive that structural analysis technology is becoming computerized and this trend has had and will continue to have severe repercusions throughout the technical community. Computerized technology is not the problem. The problem is that the form restricts dissemination, retards new research in the area of computational analysis, and doesn't easily support the required educational functions.

2.0 Requirements for Computerized Technology

It is perhaps strange, considering the impact that computerized technology has had and will continue to have, that there are no performance and quality standards for todays software. Enlightened management should recognize this to be a significant problem and should demand the qualification of programs and of users. This qualification process will undoubtedly lead to a few widely used programs and will eliminate the ad hoc redevelopment of the general purpose finite element codes. Since the technical community is effected, the technical socities should also be made aware of the implications in computerized technology and should support certification of users as well as computer programs.

New computerized technology should continue to be developed but only within the constraints of standards. The new computerized technology should be qualified before general release by technical experts in much the way that the ASME boiler code is modified and approved.

This view of computerized technology leads logically to an overview and approval by qualified experts and thus to a centralized organization. This centralized organization may take many forms but since it is a form of resource management and, since resource management is a traditionally government-supported task, the organization should be governmental or quasi governmental. Since the organization will be associated with the setting of standards and the

qualification of computerized technology it would appear that the National Bureau of Standards would be a logical sponsoring organization.

Finally, there should be university involvement in the technology development and the computerization of technology. The technology thus developed should support the educational process, and should support the professional development training of engineers to use the software.

2.7 NASA Role in Computerized Technology

NASA through its support of large software systems for structural analysis including NASTRAN, SAMIS, SAILORS, BALORS, SNAP and SPAR, has contributed greatly to the transfer of technology to the computer. Because of this activity the NASA has the technical qualification as well as the perception of the need for continued support of this information transfer.

It would appear that because of NASA's role in the sponsorship of the computerization of technology it is in a unique position to evaluate the consequences of further support of the present ad hoc system and to define the guidelines to be followed for the future. Considering the cost benefit ratio of NASA expenditures which support the maintenance of NASTRAN, it would seem that these same funds would result in a much larger payoff to the entire technical community if they were reprogrammed to support the development of qualified software.

3. The Nastran Program

3.1 Historical Review

The NASTRAN program was conveived by the NASA as a software tool for the analysis of structural systems using the finite element method. The actual program development was undertaken principally by the Computer Science Corporation and the McNeal Schwendler Corporation under the technical direction of the Goddard Space Flight Center.

The resulting program was released through COSMIC in the late 60's to selected sites for verification and review and the public version was released as level 12 in 1970. Since that time the program has undergone major modifications to enhance both modelling capability and numerical efficiency.

3.2 Program Cost

The program was made available for purchase at a minimal price, approximately $1200 for level 12, and the price has escalated slightly over the intervening time. Level 15.5 now costing approximately $1750. Staring at the newest release, level 16.0, the NASA has changed the program availability arrangement entirely. The current version of the program is no longer sold but is leased at a yearly rate of $4000/year for the first year and $3000/year for each additional year. The change of pricing structure resulted from the NASA's need to satisfy restrictions of the export of technological development. Thus, the newest version of the program will not be made available to foreign firms and individuals for two years and then at a significantly higher lease cost than the rates quoted above.

3.3 Program Maintenance

The NASTRAN maintenance function has been managed by the NASTRAN System Management Office at the Langley Research Center since 1970 with the actual maintenance being performed by a maintenance contractor. The McNeal Schwendler Corporation, one of the original developers of the program, was the contractor through 1972. At that time Computer Science Corporation was chosen on the basis of a competitive procurement to take over the maintenance function.

The change in contractor lead tc a major disruption in the program maintenance for approximately one year and delayed NASA's scheduled release of the much-awaited level 16.0 that was to contain significant enhancements. At the same time the change of maintenance contractor freed MSC from certain contractural restraints on release of advanced features in its own commerical version and has thus allowed MSC to introduce innovations which are not contained in the NASA version.

The present state-of-affairs is that there are a number of programs that are related tc NASTRAN; these are

- The public version maintained by NASA and disseminated by COSMIC.
- The commercial version maintained by McNeal Schwendler Corporation. This version is available directly from MSC and through various data centers including Control Data Corporation, Boeing Computer Systems and McDonnell Douglas Automation.
- The Navy version, based on the public version, but incorporating advanced element and modeling technology. Available only to government agencies by contract with the Naval Ship Research and Development Center (NSRDC).
- The UNIVAC version, based on the public and NSRDC versions. Incorporates most of the technology available in the MSC version and is

available to UNIVAC users as bundled software. (The Sperry Rand version is widely used in Europe; and because of export limitation on level 16.0 their version level 15.5.77 is based on the public version 15.5)

- o The commercial version maintained by Universal Analytics. This version is based on NASTRAN Level 16.0.

Due to the number of organizations involved in maintenance support of separate versions of NASTRAN and because of the absence of a standard-setting organization the versions differ significantly. Thus the input data for the MSC version is not compatible with the other versions. This fact is lamentable considering the great effort that was expended during the development phase to assure compatibility of the NASA supported NASTRAN versions for the different mainframe computers.

3.4 Program Improvement

The NASA mission is primarily involved in program maintenance, but a significant effort was undertaken to upgrade the modelling capabilities by adding new isoparametric elements and by adding new advances in computer science and numerical analysis to improve overall efficiency.

The MSC version is continually updated to respond to user requests but the main improvement was obtained by documenting capability that had been built into earlier levels and not turned on in the public versions. Prime examples would be the inclusion of cyclic symmetry and a new stiffness generation modules.

The Sperry version incorporates most of the hidden capability in level 15.5 and the program has been modified to incorporate rigid elements substructuring capability and cost-saving features that are of importance when using the isoparametric elements.

Basically, there are no changes being incorporated into the program which reflect the advances in engineering mechanics over the last ten years. There is a real need for inclusion of material and geometric nonlinearlity, buckling capability, viscoelasticity, and fracture mechanics.

3.5 User Reaction to NASTRAN

The fact that engineers feel the need for and are willing to pay $400+ for a one-week course on NASTRAN usage is some indication of basic user reaction. They are completely intimidated by the program documentation. There is absolutely no doubt that the documentation must be completely reorganized if the user is to be capable of self-education within a reasonable length of time.

Then, after learning how to use the simple NASTRAN features the typical reactions that students generally have is:

- o A sense of excitement upon learning about all of the current and projected capability.
- o A sense of disappointment in finding that there is no true non-linear capability.
- o A sense of frustration in learning to define the local coordinates for the bar element and in writing constraint relations to define rigid connections.
- o A lack of comprehension about the DMAP feature.

A one-week short course seems to be sufficient to provide the typical engineer having some appreciation of the matrix structural analysis with the background necessary to prepare a model of a structural system and to solve static and normal modes problems. The student has some awareness of the purpose of the Executive Control Deck but he has not been introduced to the intricacies of the NASTRAN-card, the inclusion of rigid format alters and the job control language for the various mainframe computers.

From personal experience, the use of the current level of the program can be a completely frustrating experience, especially when utilizing features which require the use of operating system utilities and the specification of external files. An example would be a simple restart of a checkpointed run using the isoparametric elements and cyclic symmetry for static analysis. This run will require that the user define three external files and merge two rigid formal alters and a restart directory in the Executive Control deck.

The program is perceived to be too large by the typical user, the maze of documentation tends to prove it and the requirement that the structural analyst also be an expert systems programmer confirms the perception. In order to be useful computerized technology should require only that the user is proficient in the technology embodied in the program. The external operating system and its interface to the program should be completely transparent.

3.6 User Reaction to NASA Lease Policy

In a word -- adverse! There is wide-spread skepticism that the lease policy that NASA has imposed on level 16.0 will be viable. Based on conversation with several user organizations there seems to be general, but not unanimous, agreement that NASTRAN will be retained as a analysis tool. The method of implementing that policy varies from company to company, but all revolve about the following three choices:

1. Retain level 15.5 and update either using in-house resources or by retaining the services of a software supplier.
2. Lease the current public version of NASTRAN.
3. Lease or utilize a proprietary version of NASTRAN.

Based on my contacts it would appear that few organizations will take the second approach. It's basically not cost effective to do so since the proprietary versions are competative in price to that of the public version and are perceived to have the advantages of having better maintenance, being more state-of-the-art and of being supported by people who know the program and who are available for consulting.

On the other side of the coin several companies feel that they must have the source code. This is the reason given by a large steel manufacturer for leasing 16.0 rather than the MSC version.

Then there is what is probably a majority of users, those who have level 15.5 and who cannot see any advantages of spending the funds required to obtain one of the proprietary versions or the public version 16.0.

3.7 NASA Support of NASTRAN Project

The NASA will continue to define its own role in the maintenance, improvement, and dissemination of NASTRAN but from a pragmatic point of view the question of why and at what cost should NASA continue to maintain a public version must be raised.

Possible reasons for continued maintenance are:

- o To provide the aerospace industry with a comprehensive and intra-industry compatible structural analysis program.
- o To provide NASA with in-house capability.
- o To satisfy NASA's "moral oblication" to the technical community to provide state-of-the-art software in the public domain.
- o To provide a basic software tool that supports continued research in computational mechanics.

3.7.1 Aerospace Industry

The aerospace industry is not dependent on nor is it wedded to one program for structural design and analysis. All of the aerospace companies have developed at least one large finite element program, if no several, and most use both the McNeal Schwendler Corp. (MSC) and the COSMIC versions of NASTRAN, depending upon which is most cost effective for the job.

Since all of these companies have ready access to, and the funds to pay for, a private version of NASTRAN it would appear that NASA need not support NASTRAN to provide the aerospace industry with a comprehensive analysis tool.

3.7.2 NASA In-House

The various NASA centers have already shown varying degrees of disinterest in using NASTRAN. Langley finds itself with at least three general purpose programs including SNAP, SPAR and NASTRAN and with more research interest in programs other than NASTRAN. Huntsville has actively purused the development of alternate programs and is currently developing non-linear capability under contract to Texas A & M. Goddard has remained primarily a NASTRAN user, but uses the MSC version of the program.

Without considering the other centers a pattern of apparent disinterest can be discerned. NASA need not continue to maintain a public version if the need is that of maintaining in-house capability.

3.7.3 Moral Obligation

If there is a moral obligation one can't be sure exactly what it is and how it can be satisfied. Certainly NASTRAN helped to introduce the general purpose finite element program to the entire spectrum of structural mechanics, and certainly the present users of NASTRAN will continue to need the capability that is represented by NASTRAN. One would question, however, whether NASA

Langley's role should be perceived as that of maintaining of an existing product when the center has traditionally been involved in research.

From that point of view NASA's obligation, if indeed there is one, is to continue to support research and development which will result in increased computational capability at reduced costs. This activity may well be hindered by the present maintenance burden that NASA has continued to shoulder.

3.7.4 Development of Research Software

The cost of utilizing NASTRAN and the difficulty in modifying the code take the program out of the research area. If this were NASA's goal the monies could more profitably be spend on the development of a software system which would be easier to modify.

3.7.5 Support of Software Entrepenuers

It seems reasonable to suppose that software vendors in the private sector would benefit from a decision to discontinue NASTRAN maintenance. This would seem to be in keeping with NASA's past policy of making technology available to the private sector for possible monitary gain. This then doesn't appear to be a valid reason to continue NASA's maintenance support of NASTRAN.

Considering all these factors it appears that the time has come for NASA to terminate direct support of NASTRAN maintenance.

3.7.6 Project Termination

After conclusing that NASA should get out of the NASTRAN maintenance business it is worthwhile to consider potential consequences of such an act. These would be:

- Significant NASA resources would be freed to support other tasks.
- Makes the public version an orphan which may become inoperative after a period of time.
- Require users of public version to:

- o find another general purpose program
- o switch to a proprietary version of NASTRAN
- o increase in-house staff to support the latest available version
- o support a NASTRAN user group to share experiences and the maintenance expense

For a significant proportion of the NASTRAN user community NASTRAN is viewed as a large general purpose program for the static and dynamic analysis of structures. For these users the choice of program is immaterial as long as the input is compatible. Most organizations have developed preprocessors which convert input from one program to another so it must be concluded that the present users will not be left holding the bag as it were. The users always have the option of obtaining another analysis program.

There could be a catch to this argument in that structural designs are qualified by analysis and, if NASTRAN was the analysis program used, it may be necessary to have NASTRAN capability for a number of years. In that event the user has two alternative causes of action.

- o The user may lease or purchase a proprietary version.
- o The user may choose to take on the in-house maintenance of the latest public version of NASTRAN.

The first choice frees the user from the necessity of devoting manpower resources to NASTRAN support but does have the disadvantage that the user organization is dependent on a private firm for analysis software. On the other hand, the decision to maintain NASTRAN in-house will require that the organization have a staff of 2-4 people to perform only the maintenance function. At the present people costs, this represents an annual expenditure of between 75K-150K per year. Considering the large people-costs associated with the maintenance function, the users of the public version may well find it advantageous to form a NASTRAN user group.

4. Alternatives for NASTRAN Support

Due to the wide usage of NASTRAN and the diverse interests of the user community there is undoubtedly a great deal of interest in an organizational structure that would encourage the interchange of NASTRAN related information among the users themselves. The present NASA organization doesn't preclude this activity, but then it does not actually encourage it either. Thus, it may well be that there is a great deal of sentiment on the part of the users to have an organization which supports NASTRAN which is much more responsive to their needs.

4.1 Role of NASTRAN Support Organization

The structure of an organization which is responsible for the continued support of NASTRAN is dependent on the functions that are performed and the services that are provided.

The possible functions of the organization would be:

1. Provide consulting service to the user community in the use of NASTRAN to model problems in applied mechanics.
2. Incorporate state-of-the-art developments in computer science, numerical analysis and engineering mechanics into NASTRAN.
3. Develop user-oriented pre- and post-processors.
4. Incorporate and maintain graphics display packages.
5. Perform program maintenance.
6. Disseminate the program.
7. Provide education support to users in the form of seminars, short courses, and colloquia.

Within the context of providing these and possibly other services the organization should have attributes such as:

1. Responsiveness
2. Technical capability in required support areas
3. Management
4. Cost

Of these attributes, those that dictate the form of any organization are responsiveness and cost. Without even interrogating the users the ideal would probably be an absolutely responsive organization that cost absolutely nothing. Just what trade-off between cost and response the user would support is an open question.

4.2 Possible Support Organizations

Candidate organizational structures are as follows:

1. No Change - NASA continues to support present activities at levels sufficient to provide continued service.
2. No NASA-supported organization. NASA withdraws all support- latest version of program would be maintained by COSMIC.
3. Software Institute - a consortium of governmental agencies, universities, research labs and industry would support a software institute. The NASTRAN program and future derivatives would provide software support to all fields of application engineering.
4. Franchise NASTRAN to private company. NASA would in some way franchise a private company to maintain, develop and distribute the official public domain version of NASTRAN.
5. User Groups - Provide NASA support to the establishement of a viable user group which would manage future NASTRAN related functions.

These alternatives are discussed below.

4.2.1 No Change

The present system is not responsive to the user needs. Even if NASA decided to continue supporting the program at the present level it is quite possible that a user group would be organized independent of NASA.

4.2.2 No Support

In this case NASA would make a unilateral decision to withdraw all maintenance support and to distribute the current NASTRAN version through COSMIC. In this case it is quite probably that a user group would be formed.

4.2.3 Software Institute

Of all the possible structures that is the most attractive from a resource point of view. The software institute would in effect be a center which maintains, develops and disseminates engineering software to the technical community. In many ways such an organization would complement and amplify the work of ICASE. NASTRAN's DMAP modules would provide the basic software required to perform the function of the institute.

4.2.4 Franchise

There are at the present time several versions of NASTRAN. It is clear that a number of users are unwilling to utilize software which is available only in executable form and which cannot be modified locally. Thus there is a large demand for a public version which is available at low cost in the form of source as well as executable code.

The goal of this approach would be to provide credibility to a version of NASTRAN which is maintained by a private company. The program would continue to reside in the public sector, incorporating all enhancements provided by the company. The company would benefit by providing consulting and educational services.

4.2.5 NASA Sponsored User Group

It is noteworthy that user groups have not been formed since there is a perceived need for such activities. If appears that the user community is waiting for NASA to define the charter and organization for the user group. This would appear to be a reasonable expectation since the management function currently resides within the NASA while the users are fragmented and have no means of joint communication outside of the NASA channels.

A user group could be formed by NASA in conjunction with industry representatives who would set up the group's charter and by-laws. If the user group were charged with providing continuity of the maintenance function then it is reasonable to expect that NASA would contribute funds equivalent to its present NASTRAN support to the organization.

The user group would be expected to be self supporting after a reasonable period of time. The groups expenses would be covered by charging a fee to the various users with the fee reflecting the services obtained from the group. There is a precident organization called CAM-I which was formed to provide continued support of the APT program that was developed at MIT under Air Force sponsorship. After a period of time the Air Force decided to phase out funding and after a major product improvement phase a not-for-profit organization called CAM-I was set up to service possible user needs. The CAM-I organization probably deserves special attention because it has many goals which are apparently in common with those of a prospective NASTRAN users group.

The ICES STRUDEL user group is a loose federation of ICES STRUDEL users and represents an alternative to the formation of a not-for-profit company. The ICES group was formed after IBM decided to withdraw direct support from future

maintenance of the ICES package. Since the formation of the user group the individual users have been completely responsible for continued program support. The purpose of the user group is to exchange information about program errors and common problems. There is some question whether this organization can provide the type of support that would be required by an industrial facility (TRW has withdrawm from the ICES group and no longer is attempting to use the program after spending several thousands of dollars on development), but may be acceptable to universities and some research organizations.

4.2.6 Independent User Groups

It would appear that an independent user group which is a loose federation of users would not be capable of taking on the functions for the support organization which were presented earlier. It is highly desireable, therefore, for NASA to become directly involved and to lend its prestige to the organization.

5. Recommendation

The basic recommendation is that NASA gradually change its support of the NASTRAN program to the support of a system of computerized technology that would satisfy the guidelines that have been discussed in the report. These are:

1. First and foremost, the software should be in the public domain.
2. The cost associated with the software should be based on the usage. The software should be made available to institutions of higher learning at no cost.
3. The software should be highly modular.
4. There should be a simple higher - level language to allow the user to define a series of operations that operates on a data base to produce desired results.
5. The software should be transferable.
6. The software should support modification and the inclusion of new modules.
7. The user should be capable of using the software with no knowledge of the operating system of the host computer.
8. The software should be self-documented. That is,one or more of the modules of the system should be computer-aided-instruction on the use of the software.
9. The software should be supported by well written documentation which describes the theoretical basis of the computerized technology, its implementation, and a detailed guide describing the use of the modules.

10. The software should satisfy standards for performance, quality and transportability.
11. The software should be completely qualified by a suitable group of experts.

In order to withdraw from the NASTRAN maintenance the NASA should define a time table for gradual withdrawl during which time the following tasks will be accomplished.

1. Nofity the user community that support will be withdrawn by a given date -- and ask the user community to send representatives to a special meeting on the organizational structure of a possible user group. It is recommended that this item be accomplished at the next NASTRAN Colloquium in October, 1978.
2. Modify the NASTRAN program to make it state-of-the-art in terms of computer science, numerical analysis and engineering mechanics technologies. This could require the rewriting of the NASTRAN executive, the NASTRAN higher level language, the matrix generator routines, and the modification of matrix solver, eigenvalue extraction, and ordinary differential equation solution routines. There is a precedent for making these modifications since the Air Force undertook a similar effort on the APT-program before relinguishing control to a user group.
3. Provide funding to a contractor to define performance qualification tests for NASTRAN and within those definitions to quality the program.