BACKGROUND:

The University of Rochester is a private university located in Upstate New York. The enrollment of 4000 undergraduates and 2500 graduate students makes the University of Rochester a moderate size school. Although the Eastman School of Music and the Medical School are the big names on campus, the College of Engineering has a high ranking. The ME Department, composed of 14 professors, will be graduating approximately 40 seniors this year. In the graduate ME program, there is an equal mix of full-time and working part-time students.

How the University of Rochester Obtained NASTRAN:

I have taught a graduate finite element course for four years, using textbook programs for student homework. Despite much lobbying, I could not raise the funds for obtaining NASTRAN.

The Electrical Engineering Department on the other hand, has an on-going research program in the study of electrical fields in the brain. Upon hearing of NASTRAN's capabilities, they convinced the Dean of Engineering to obtain MSC/NASTRAN through the new university lease program in late 1980. They plan to use electrical field analogy to heat transfer to find contours of potential in the human brain.

How is MSC/NASTRAN Used in the Curriculum:

The availability of MSC/NASTRAN on campus meant that the simple textbook finite element programs were no longer necessary in the graduate finite element course. This highly popular course, which is open to seniors, has homework problems of textbook form, as well as actual NASTRAN assignments. The text, Cook's second edition of Concepts and Applications of Finite Elements provides a balanced treatment of theory and application, as well as a good set of problems.

The MSC/NASTRAN Handbook for Linear Static Analysis is the ideal reference for teaching NASTRAN to new users. It doesn't overwhelm the novice as does the Users Manual. The program need not be simple for a novice, but the starting documentation must be clear, convenient, and most of all -- manageable. This offers the great advantage to the user to grow in knowledge of the program and to use advanced features without the need for changing programs, only the documentation.

The major problem with using NASTRAN in the course is the high run costs on the University's IBM system. Even minor 10 degree-of-freedom linear statics problems cost $5/run. This is trivial by industry standards, but it does eat up a course budget quickly. This problem will be alleviated next semester when the College of Engineering will get its own VAX dedicated to computer-aided Engineering.

The finite element course is the most popular in the department with 35 students, about triple the average graduate course. A high percentage of these students are practicing engineers from industry. Some enroll for this course alone.

I believe the strong appeal is due to the mix of theory plus practical application with a commercially available program. Students can start solving real on-the-job problems with the tools at hand.

NASTRAN is also used in the senior Mechanical Design course. Standard textbooks, such as Shigley or Spotts, discuss only the analysis of simple machine components. NASTRAN is demonstrated as a means of solving more complicated systems problems. Last term, many seniors utilized NASTRAN as the analysis technique in their major design project. With only a one-hour lecture, they proceeded to learn enough NASTRAN from the Linear Statics Handbook to run truss and beam models effectively. These same seniors are using NASTRAN as an integral part of their design project this term also.

With the availability of the new VAX, it is expected that NASTRAN will be incorporated into more coursework.

(a) The graduate vibration course can take advantage of the dynamic analysis capability, especially natural frequency analysis and modal techniques.

(b) Plates and shells as well as a new course in composites, can discuss and demonstrate finite element techniques using NASTRAN.

The Overall Computer-Aided Engineering (CAE) Effort:

MSC/NASTRAN is one part (a very major part) of a total CAE package. The University of Rochester's Production Automation

Project has a major research effort underway in Geometric Solid Modelling, with highly successful software products PADL-1 and PADL-2. Solid Modelling, as you may know, is the vital first stage of any CAE effort. Once an engineering part has been "modelled", one can in principle proceed to a finite element analysis or to NC machining.

A research proposal has been submitted to study the automatic finite element mesh generation of solid models. This study will include the effects of stress concentration and load discontinuities. The result will be a research program interfacing PADL and MSC/NASTRAN.

Additional CAE software and hardware will be added to the department shortly, including a commercial CAD system. An interactive finite element preprocessor would be a desireable addition. I look forward to a University lease arrangement for GRASP in the near future.

Student Projects:

Students were given a free hand in the selection of term projects in the finite element course. Several were very practical projects related to studetns work in local industry. Others were very novel applications of NASTRAN which I would like to mention briefly. A portion of the course is dedicated to non-structural applications, using analogies.

(1) A student calculated the lift on an airfoil in potential flow. The stream function for potential flow results in

Laplace's equation which can be solved by analogy with NASTRAN heat transfer capability. Three solutions were required

(a) uniform flow about the body

(b) vortex flow about the body

(c) superimpose (a) and (b) to get zero velocity at the trailing edge.

(2) Another project was the determination of acoustic resonances in a speaker enclosure. In this application the natural frequencies and modes were found using SOL 3. Since pressure is the only degree of freedom at each grid, the formulation uses only 1 displacement/grid (say u_x); all others fixed to zero. The proper choice of pressure boundary conditions simulates openings or fixed walls. The pressure gradients are the stresses

$$\sigma_x = \frac{\partial P}{\partial x} \text{ and } \tau_{xy} = \frac{\partial P}{\partial y}$$

(3) Other problems, such as heat transfer, can be solved using the structural analogy in a similar manner. One student solved a transient heat transfer problem via SOL 31 using modal analysis.

(4) Another student studied the gravitational potential contours in the solar system via analogy to static heat transfer.

(5) Finally, as a result of classroom discussion on analogies, there is now some effort at local industry to study illumination problems using radiation heat transfer in SOL 74. The addition of the viewfactor calculations in version 61 made this effort more attractive.

<u>Conclusions and Recommendations:</u>

(1) MSC/NASTRAN is a very useful tool in engineering coursework. Textbook FE programs cannot give the true flavor of commercial software with plotting and other niceties. The broad capabilities allow for application in a broad cross-section of courses.

(2) The Handbook for Linear Static Analysis is a tremendous help in teaching NASTRAN to beginners. I look forward to other handbooks such as Dynamics in the near future.

(3) The major drawback to using MSC/NASTRAN in a University environment is the relatively high run costs. Effective use requires either a large computer account, or better yet, a "free" department computer such as a VAX. A cheaper University lease would encourage more schools to get involved. After all, everyone benefits from such an arrangement -- the school, the students, local industry, as well as MSC.

(4) There is great appeal in learning to use state-of-the-art commercial software (i.e. MSC/NASTRAN) which can be applied to immediate on-the-job problem solving. This can be accomplished in a course while still providing a sound theoretical background in finite elements.

(5) The "freshness" of the students as displayed in their projects and questions can lead to exciting new applications.