Overview of FMC

The company that has become FMC had its origin in California in 1884. John Bean invented a spray pump to combat a plant disease which was attacking the fruit orchards and formed the Bean Spray Pump Company.

In 1928, the company acquired two manufacturers of fruit and vegetable preparation and processing machinery. The company's name was changed to Food Machinery Corporation.

In 1948 FMC entered the industrial chemical field and the packaging field, expanding our apple-packaging business. To better describe our businesses, FMC again changed its name to Food Machinery and Chemical Corporation.

FMC entered the petroleum equipment field in 1955 by acquiring a manufacturer of swivel joints and marine loading arms.

Our company entered the marine pump business in 1959 and also acquired a manufacturer of agricultural chemicals. The name Food Machinery and Chemical Corporation no longer described the company's broadly diversified businesses and, therefore, in 1961, it was changed to FMC Corporation. Nonrestrictive because it was nondescriptive, the new name preserved the letters FMC which had been used to identify many of the company's products for over 30 years.

FMC is one of the largest producers of machinery and chemicals for industry and agriculture. Even though sales are almost $3.5 billion, FMC sells most of its products to other manufacturers and therefore does not receive the high visibility and recognition of products sold to and used directly by the consumer.

According to Fortune magazine, FMC is the 103rd largest U.S. industrial corporation. With 147 manufacturing facilities and mines in 32 states and in 15 foreign countries, FMC has a worldwide employment of 44,000.

Now that I've given you a brief history of FMC, I'll describe the businesses of the eight groups and their operating divisions.

Let's begin with the Agricultural Chemical Group which develops, manufactures, and markets insecticides, fungicides, and other crop protection chemicals. Every major continent in the world uses FMC crop protection chemicals. Important proprietary products include Furadan, which is used on more than 20 different crops in 70 countries. Farmers use Pounce on cotton and a variety of other crops.

The next group, Construction Equipment, consists of three divisions: the Hydraulic Crane Division, the Cable Crane and Excavator Division, and the Construction Equipment International Division.

The largest manufacturer of cranes and excavators in North America, FMC has five basic product lines: cable crawler cranes, cable truck cranes, hydraulic cranes--both truck and self-propelled--hydraulic excavators, and tower gantry cranes.

The Defense Equipment Group has been in the forefront of defense equipment design and manufacture since 1940 and is the leading producer of armored personnel carriers in the Western world. It has three divisions: Ordnance Division, which specializes in tracked military vehicles; Northern Ordnance Division, which specializes in naval ordnance; and Steel Products Division, which specializes in military track components.

In 1972 FMC developed a new mechanized infantry combat vehicle, the MICV, as the companion vehicle for the new XM1 tank. In 1976 our engineers upgraded it to meet the threat of the Soviets' increasing numerical superiority in tanks. Originally called the M2 Infantry Fighting Vehicle, FMC recently renamed it the Bradley Fighting Vehicle, the BFV.

The Northern Ordnance Division is America's largest producer of heavy naval ordnance equipment for the Navy and foreign nations. Its products include naval gun mounts such as the 5-inch Mark 45 and guided missile launching systems such as the Mark 13.

Six divisions make up the Food Machinery Group: Agricultural Machinery, Beverage Equipment, Citrus Machinery, Food Processing Machinery, Food Machinery International, and Packaging Machinery.

A range of specialty agricultural equipment serves the food growers. This equipment includes minimum tillage land preparation machinery; orchard and row crop sprayers; and fruit, vegetable, and nut harvesting equipment.

FMC provides food processors with individual machines and complete food plants ranging from frozen confection machinery to baby food plants to sterilizers for canned fruits and vegetables.

Actively engaged in agricultural projects for developing nations of the world, our company concentrates on those crops which require further processing and preservation, thereby providing opportunity for utilizing our special expertise.

You might be interested to know that FMC supplies the packaging industry with wrappers and wrapper systems, bag and box makers, and flexographic printing presses. For example, our machines put the plastic holders on your six-pack of beer!

The Industrial Chemical Group, FMC's largest business group, consists of three divisions and the natural resources operation.

The Alkali Chemicals Division sells heavy industrial inorganic chemicals on a commodity basis. The Phosphorus Chemicals Division manufactures and sells chemicals derived from elemental phosphorus. The Specialty Chemicals Division markets products which have been developed by FMC technology and which need technical service support.

FMC pioneered the production of natural soda ash, a method which has completely replaced synthetic production in North America.

50% of this soda ash is used in the manufacture of glass, while the remainder is used in detergents, textiles, pulp and paper, leather processing, drugs, paint, and a multitude of other applications.

One of the world's largest producers of elemental phosphorus--the key raw material for phosphate production--FMC has a plant at Pocatello that is the largest elemental phosphorus plant in the world.

We are also the largest manufacturer of hydrogen perioxide in North America. A versatile chemical, hydrogen peroxide is used in the textile and pulp and paper industries for its bleaching abilities, and in both municipal and industrial waste waters to oxidize hydrogen sulfide and other pollutants.

The Natural Resource Operation assures the availability of minerals for our industrial chemicals and coal and natural gas for powering our plants. The gold deposits our company discovered in Elko, Nevada in 1968 are the basis of an FMC/Freeport minerals joint venture gold mine which is expected to produce 200,000 ounces of gold per year.

The Material Handling Group consists of five divisions and encompasses more than material handling in the traditional sense. Here is a quick overview of the products and capabilities of each division.

The Airline Equipment Division builds ground-support equipment primarily for loading and transporting air freight and baggage. In addition to loaders, the division markets transporters and trailers.

The Marine and Rail Equipment Division builds railroad cars, barges, such as the "Ro-Ro" (roll on, roll off) unit, and other nonself-propelled marine craft for ocean and inland waterway service.

The Material Handling Equipment Division includes practically all industries that convey or process bulk materials such as mining, food processing, forest products, and primary metals.

The business of the Material Handling Systems Division is in large contracts. Major markets are coal and ore mining, bulk material transfer, food processing, power generation, and steel making. Bulk conveying systems involve the integration of numerous FMC products to move, store, and/or process vast tonnages of bulk materials such as coal, ore, cement, and limestone.

The Air Quality Control Operation specializes in flue gas desulfurization for the industrial and utilities markets.

The Petroleum Equipment Group consists of the Wellhead Equipment Division and the Fluid Control Division. We serve the petroleum industry in oil and gas drilling, producing and refining, and in petrochemical operations.

FMC is the world's second largest producer of wellhead equipment and our business is growing rapidly. Wellhead assemblies are used to suspend and seal casing and tubing bores for control of oil flow or gas from the well. They are installed on land wells or on offshore fixed platforms.

The Fluid Control Division is comprised of three business areas: Fluid Control Oil field, Fluid Control Industrial, and Marine Loading Systems. Some of our products are: unions to connect two pieces of pipe quickly for use on drilling rigs and butterfly valves for use in oil fields and industrial applications. The industrial business area includes tank truck loading arms which use the swivel joint to join the pieces of pipe and allow movement in any plane. Marine loading arms are used to load tankers with crude, LPG, and liquified natural gas.

The Special Products Groups represents our unrelated businesses. It is intentionally structured as a loose-knit assembly of small businesses, currently six. The Automotive Service Equipment Division's principal products include wheel balancing equipment, engine diagnostic equipment, computerized wheel alignment equipment, and brake service equipment.

Food and Pharmaceutical Products is another business which participates in the food additive market in addition to its major pharmaceutical. market.

The Marine Colloids Division is the world's leading producer of a completely natural food additive made from carrageenan, which is extracted from red seaweed.

The Outdoor Power Equipment Division manufactures products under the Bolens brand name. We compete across the four major lines, garden and small agricultural tractors, mowers, tillers, and snow throwers, and we are one of the top five companies in each line.

The Sweeper Division is in several different markets: municipal sweepers, industrial sweepers, and industrial brushes.

Turbo Pump supplies pumps to the commercial marine industry. These pumps provide feedwater to the ship's boiler which, in turn, generates steam pressure to the turbines driving the ship's propeller.

Computer resources

FMC, like many large corporations, is very centralized in computing resources, but has long-range goals toward distributed computing. We recognize that many computing functions, especially those using computer graphics, require local processing power.

Our present Corporate Computer Network (CCN) consists primarily of two large data centers in Indianapolis and Dallas. These data centers have a combined capacity of 50 million instructions per second through five main computers, four IBM 3081's and one 3033. Data storage is handled by 550 disk drives with a capacity of 175 billion characters. Tape libraries of more than 50,000 tapes are also used.

The major operating system supported is MVS with the TSO, CICS and IMS interactive subsystems. An IBM 4341 computer is presently being used as a test system with the VM/CMS operating system. Plans call for this VM/CMS implementation to be transferred to the IBM 3033 which will then be dedicated to interactive computing.

The present TSO systems support up to 300 simultaneous users, though not with totally acceptable response times. Well over 3,000 TSO user ID's have been issued. These users (along with the IMS and CICS users) access the CCN through some 3,000 IBM 3270 type terminals distributed throughout North America. A combined capacity of near 2 million bits per second of leased line communications is used. Dial-up service through Tymnet gives our users access from more than 300 cities. TSO users from Europe access our U.S. based computers more cost effectively than they can local service bureaus.

In addition to our centralized system, we have several local computers within our technical departments. Present count shows three Digital Equipment VAX 11/780's and six PDP 11's. Five of these computers are in our Chemical R&D facility in Princeton or in our Machinery R&D facility in San Jose. The other four are in Cedar Rapids, Minneapolis (2) and Conway, Arkansas. All of these local computers have been installed within the last three years.

Also in the last two years, we have installed four ComputerVision CAD/CAM systems with a total of 17 graphics terminals and 19 other Tektronix graphics terminals which access the CCN or local computers.

The FMC computer usage is directed and supported by several corporate departments. The Corporate MIS staff of 300 persons, operates the CCN and develops and maintains the large systems such as materials resource planning and the payroll. I am part of a one year old Technical Computing Systems department (3 people) within Corporate R&D. This department's function is to promote all types of technical computing including that for chemical, machinery design, and manufacturing engineering. This staff function was established after several years of study by corporate task groups and consultants. The following history of structural analysis in FMC is a portion of that transition period.

Shortly after I began working for FMC in the spring of 1979, a corporate task group on Computer Aided Engineering was formed. This task group was composed of members from the MIS staff of which I was a part, from our R&D staff in San Jose, and from engineering personnel from several divisions. This task group's charter was to establish a strategic direction within FMC for computer aided engineering. As part of this charter, a subcommittee was formed to evaluate the use of finite element modeling (FEM) within FMC and to prepare recommendations for improvement.

Prior to this time, FMC had installed the ICES-STRUDL program on the IBM corporate computer. STRUDL was used primarily for frame analysis and had severe problems with the more advanced finite elements. Maintenance and support from the ICES User's Group was almost nonexistent and the consensus of opinion was that a more advanced program was required.

The subcommittee on FEM investigated the full range of programs available and subsequently selected the MSC version of NASTRAN. MSC/NASTRAN was selected for its full range of capabilities, for its large number of user corporations, and for its cost-effectiveness. Also the decision was certainly influenced by our previous experiences. But MSC/NASTRAN was not perfect then and is not today. Its primary downfall was still in the area of pre- and post-processing graphics. For that reason, we also selected SDRC's SUPERTAB program for pre and post processing.

MSC/NASTRAN was installed on an FMC IBM 3033 computer in December of 1979. Concurrently, SUPERTAB was installed on the TSO subsystem of MVS. With the help of consultants from A.O. Smith Corporation, the MSC supplied batch proc was revised to match our standard naming conventions. In a few short weeks, we had our first users at the Construction Equipment Group in Cedar Rapids. We taught our first NASTRAN class in Cedar Rapids during February of 1980.

At the same time, FMC obtained several Tektronix 4014 terminals. A PDP 11/60 minicomputer with SUPERTAB was installed in March of 1980 and the procedures for operating a remote system which submits NASTRAN jobs to the corporate computer were developed. The SUPERTAB capabilities and performance of the minicomputer and TSO were evaluated and reported. We recommended that our users start with TSO and a graphics terminal, but migrate to a DEC minicomputer after reaching usage levels of 50 terminal hours per month.

During the following months through July of 1980, we taught NASTRAN classes to over 90 FMC engineers. In the past year an additional 100 engineers were taught at many locations, since FMC is spread throughout the world. Class sizes averaged about 10 to 15 engineers and included hands-on lab sessions. We also structured the classes so that engineering managers or design engineers could attend the first day of the three day class.

Figure 1 shows the growth in number of active users of NASTRAN at FMC while Figure 2 shows the growth in actual cpu usage for NASTRAN. The capabilities are presently being used by 40 analysts in 15 locations throughout the U.S.

Several different departments are supporting these NASTRAN users. The primary training and support comes from our Central Engineering Lab in San Jose. A staff group that also does contract analysis for our divisions helps the users with any application problems. Always available via the telephone, the staff can also visit the user's location by special request.

Additional support comes from our hotline and customer service staff at the Corporate Computer Centers. The hotline handles any system type problems such as problems with the communications network and computer hardware. An experienced engineer fully qualified in NASTRAN also works in the Customer Service Department. His responsibilities are to handle any systems problems relating to the NASTRAN use of the computer. He is also responsible for developing and maintaining any of the software used.

Our users are also instructed to use the software vendors, MSC and SDRC, only after reviewing a problem with the FMC support staff.

Nastran Interface System

A major effort in support of MSC/NASTRAN and finite element modeling in FMC has been the development of an interface system. This system has historically been called the NASTRAN CLIST because of its original implementation on the IBM TSO system. A CLIST on the TSO system is a macro of all TSO commands with the addition of standard programming functions such as READ, WRITE, GOTO, and logical substitutions. Since the original development, the CLIST capability has been converted to the IBM VM/CMS system where the term EXEC is used. I will refer to both of these systems together as the NASTRAN Interface System (NIS).

Development Objectives

The most important objective in the development was ease of use. MSC/NASTRAN, with all of its complex capabilities is often viewed as difficult to use. In addition, the use of the IBM job control language (JCL) with its peculiar syntax, is also difficult to use. Basically, I think a system is easy to use if it is somewhat self-prompting, has on-line help information, and is forgiving of user input errors. NIS is easy to use in that it's a prompting, menu driven system.

On-line help information is also a guide to the computer system and to NASTRAN. For example, help information on the checkpoint command tells the user that a checkpoint tape will be used and where in the MSC/NASTRAN manuals to refer for more detailed information.

NIS is also easy to use in that it executes a series of TSO commands with single simplified commands tailored for the NASTRAN application. In this sense, the user is relieved of remembering the IBM command syntax.

Another benefit or objective of this development was in facilitating the interfacing of the different programs and data formats. The SUPERTAB program has a different data format, that must be converted and merged into the NASTRAN bulk data file. The output of NASTRAN must also be converted back to the SUPERTAB universal file format. In addition, NASTRAN output plots are of another format.

NIS also facilitates both project and file management. Past experience showed that some NASTRAN analyses consist of many (sometimes hundreds) of computer runs. In addition, each NASTRAN job or project can involve as many as 18 different file types.

Finally, NIS aids in the maintenance and support of all NASTRAN facilities. The system is self-documenting through its on-line help information. Many of the questions a user may have are hopefully answered through the help facility. New capabilities are announced to the user each time he executes the system. In some instances, where operating system parameters change, such changes can be reflected in NIS without the user's knowledge or concern.

NIS Functional Areas

The NASTRAN Interface System assists the user in several functional areas: project initialization, model data preparation, job submittal and execution, post-processing utilities, and project and file management. These functional areas will be demonstrated by following the commands as actually used in the system.

Project Initialization

First, a NASTRAN project must be initialized. After the user types the command "NASTRAN", he is asked to give the project name (FIGURE 3). If the project is new, all possible input and output files are initialized or in IBM parlance, preallocated. This assures the user that physical disk space does exist for the file storage. Default parameters for a simple static analysis are also assumed.

After the project has been initialized or if this is a restart of the project, the user is placed into command input mode. Typing "HELP" in command mode lists all available commands (FIGURE 4). Typing "HH" lists a one line description of each command (FIGURE 5). Typing "Command H" lists a full description of the command (FIGURE 6).

The BEGINNER command demonstrates the minimum number of commands recommended for a beginner's first job. The MOD command lists the latest changes and enhancements. The DEBUG command causes more detailed system error messages that have been suppressed to be printed. The DEMO command shows a sample of typical NASTRAN data input. DEMO can often be used as a refresher for the NASTRAN data format, since it includes each of the typical input records.

Following the instructions of the BEGINNER command, the user proceeds to enter commands to set the options and parameters of the NASTRAN project and the present job. All of the typical system parameters such as maximum cpu time, remote printer number and job priority can be set. NASTRAN options such as checkpoint, resequence and RFalters can be selected. At any time the user can save the project profile which includes all of the options selected or changed during the session. The next time NIS is executed, all these options will be preset.

Model Preparation

Models can be prepared in any or combinations of three modes: EDIT, MSGMESH, or SUPERTAB. Actually EDIT is used for every model since the other modes do not create the complete NASTRAN input. The EDIT command in NIS is really an automated means of executing the TSO EDIT command. For ease of use and consistency, the user indicates only the file type ie B for bulk data. The present project name and input file name are used with the standard file type system qualifier to fully specify the file to be edited.

MSGMESH can be executed through the MESH command. This actually sets up a NASTRAN batch job with the MSGMESH option and storage of the punch file output. The MSGVIEW command can then be used to execute the MSGVIEW program to view the model. While both of these MSC supplied utility programs are implemented, they are not recommended for general use; SUPERTAB is recommended instead.

SUPERTAB Version 4 can be executed through NIS while Version 5 has been implemented separately. SUPERTAB 5 was set up separately for reasons of control and efficiency. Response time was seriously affected in the way SDRC implemented Version 5 on IBM. This version makes use of CLISTS executing FORTRAN programs that create CLISTS to execute other FORTRAN programs. Needless to say, executing such a complicated arrangement from within another CLIST (NASTRAN) was not desirable. In addition, when TSO response is marginal, this mode of implementation becomes almost unacceptable.

Another command called SIZE will calculate the size parameters of a NASTRAN job. The user is asked for number and type of elements, number of grids and other pertinent information. The cpu time, maximum memory and working storage required are then calculated. These calculations are based on MSC supplied formulas and are subject to the same interpretations.

Finally, all of the present job parameters for the model and pending batch job can be listed using the LIST command (FIGURE 7). Options not used are plainly noted. These are listed in plain English for ease of interpretation. This serves as a last checklist before job submittal.

Job Submittal

Prior to actual batch job submittal, the user can run a file check (FILCHK) on all files, This check does not verify the file contents but only file existence. A job is prevented from batch submittal if a specified input file does not exist. Warning messages are given if the user requests an overwrite of existing output files.

The user can now either create the IBM batch JCL or submit the batch job by using the SUBMIT command. Some users use only the JCL creation mode to aid their understanding of the system JCL. Our minicomputer users use these sample JCL sets when they submit different NASTRAN batch jobs.

While the CLIST could create the complete JCL, the NASTRAN batch proc is still retained, primarily for ease of use by minicomputer users.

In addition to creating the JCL, the NASTRAN executive control data is also created. All of the necessary parameters have been input previously. Again the input syntax is assured (especially with the RFalters).

Additional commands for monitoring the batch job execution (STATUS) and for canceling batch jobs (CANCEL) have also been implemented in NIS. In some instances of high priority batch, the batch job finishes without the user leaving the NIS environment.

Output of NASTRAN batch jobs can be routed directly to a printer or held for review in TSO by using the OUTPUT command. Any output held for review can later be printed or placed in files for later post-processing. Needless transmission and printing of large erroneous print files are thus avoided.

Post-Processing

Post-processing of NASTRAN output is accomplished through several means, though primarily by using the NASTRAN post-plotting facilities. A NASTRAN plot file is saved from the batch job and is then viewed on the Tektronix graphics terminal. A modification of the MSC supplied TEKPLOT program is used. Automatic hard copy production of the plots has been implemented. An additional FMC developed program called TEKPRINT allows the user to print any system file on the Tektronix terminal again with automatic hard copy.

The SUPERTAB OUTPUT/DISPLAY program of SDRC is used for post-processing also. A data loader program converts the NASTRAN OUTPUT2 file to the SUPERTAB universal file format. This conversion is executed as a step of the NASTRAN batch job or as a separate job later. OUTPUT/DISPLAY runs on the Tektronix graphics terminal to interactively create views of the displaced model and of stress contours for the shell elements. While the SUPERTAB universal file can be transferred to the minicomputers for post-processing, we find that this is inefficient not only in the transfer of large files, but also in processing such large files on the minicomputer.

To overcome this difficulty of processing on the minicomputer, a series of post-processor programs have been developed. These programs screen the output data for ranges of stress and then print a stress magnitude at the centroid of each plotted element.

Project and File Management

As mentioned previously, the concept of a NASTRAN project has been adopted. Every time a batch job is submitted and a file created or deleted, an entry is automatically made in a project log file. The user can also add his own comments to the log file or view the log file with the LOG command. If used effectively, the user is assisted in documenting his NASTRAN project.

Because of the IBM preallocation of files, commands to expand and decrease file space were implemented. Also commands to AUDIT and DELETE files were written (FIGURE 8). Again, while most of these types of commands can be accomplished directly in the TSO system, this implementation stresses ease of use and user efficiency.

Finally, in a final effort to document the project and allow for future use of the files, an archival feature was included. One command ARCHIVE will cause a batch job to be submitted which will copy all project files to an archive tape. One command (DELETE) will delete the complete NASTRAN project and one command (RESTORE) will restore the project from tape. A similar command (DBASE) is used for copying a NASTRAN database to and from tape.

Future Potential

While FMC presently does the majority of NASTRAN usage via TSO into the MVS batch system, several alternatives are being implemented. The NASTRAN CLIST on TSO has been converted to the new VM/CMS system where it becomes an EXEC. While our present TSO performance is poor, we have good access to all NASTRAN files whether created or used in batch or timesharing modes. The VM/CMS system will be operating on a dedicated IBM 3033 and will be managed to assure consistently good interactive processing.

The problem with VM/CMS is that we lose the direct access to NASTRAN batch files. A file transfer capability had to be added to the VM/CMS EXEC. In addition, numerous changes were made to commands such as AUDIT, DELETE, and ARCHIVE which must access both MVS and VM files. Final testing is underway for this conversion effort.

Our major efforts are being focused toward distributed processing. One Digital Equipment Corporation VAX 11/780 and two PDP 11's are already being used. Two more PDP's are to be installed this month. Two more are on order. We are working to implement a subset of NIS on the VAX and PDP's as well as expand and upgrade our post-processing capabilities. This development will be done in FORTRAN to allow transportability. Since the new CMS system is also a remote processor, operating in a mode similar to the VAX and PDP's, the conversion process will be similar for both.

In summary, after implementing MSC/NASTRAN and SDRC/SUPERTAB two years ago on an IBM centralized processor, a NASTRAN interface system has been developed. This development effort and the associated methodology are evolving into an effective, integrated system for structural analysis. We plan to expand this technology into distributed processing even further in the future.

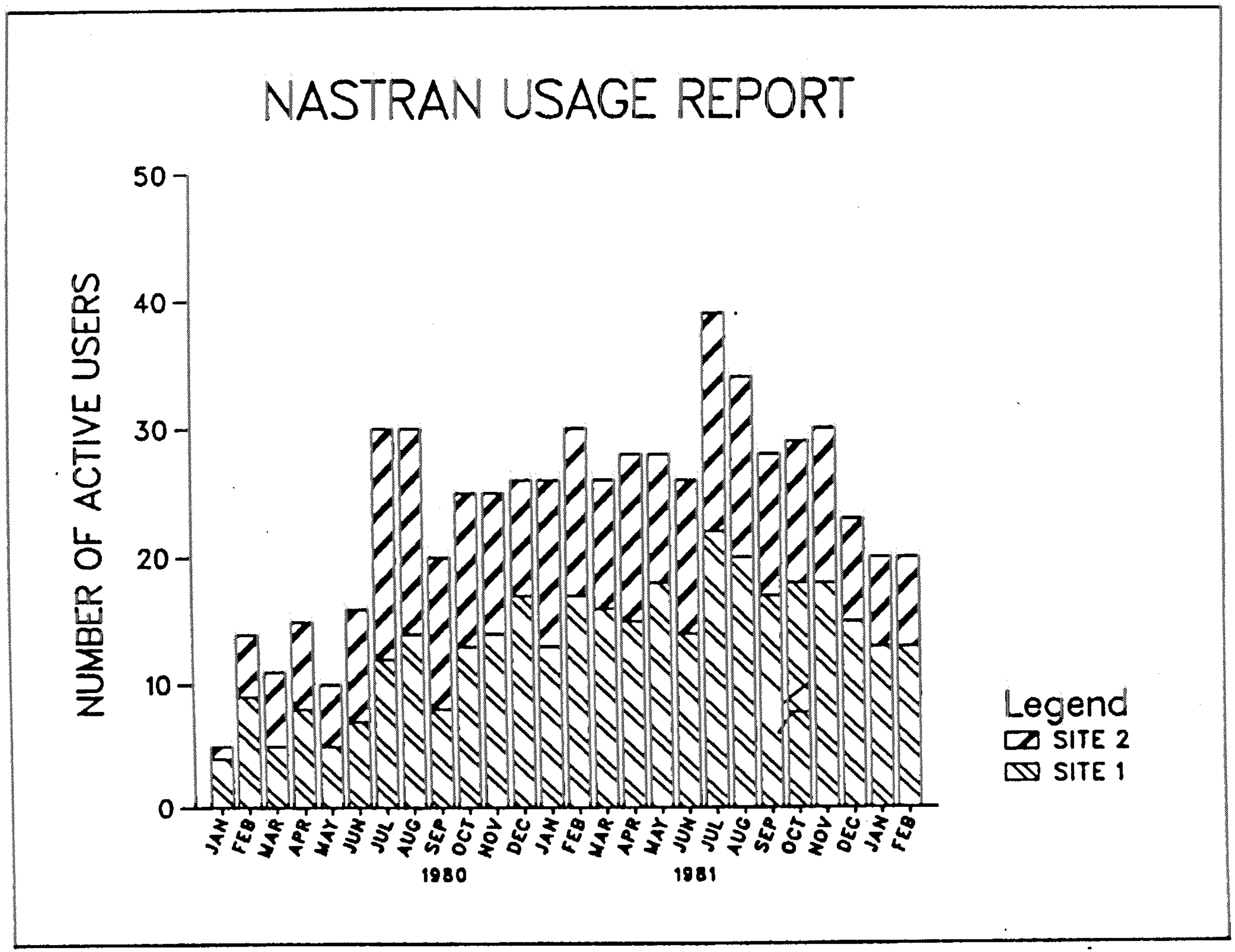

FIGURE 1. ACTIVE NASTRAN USERS

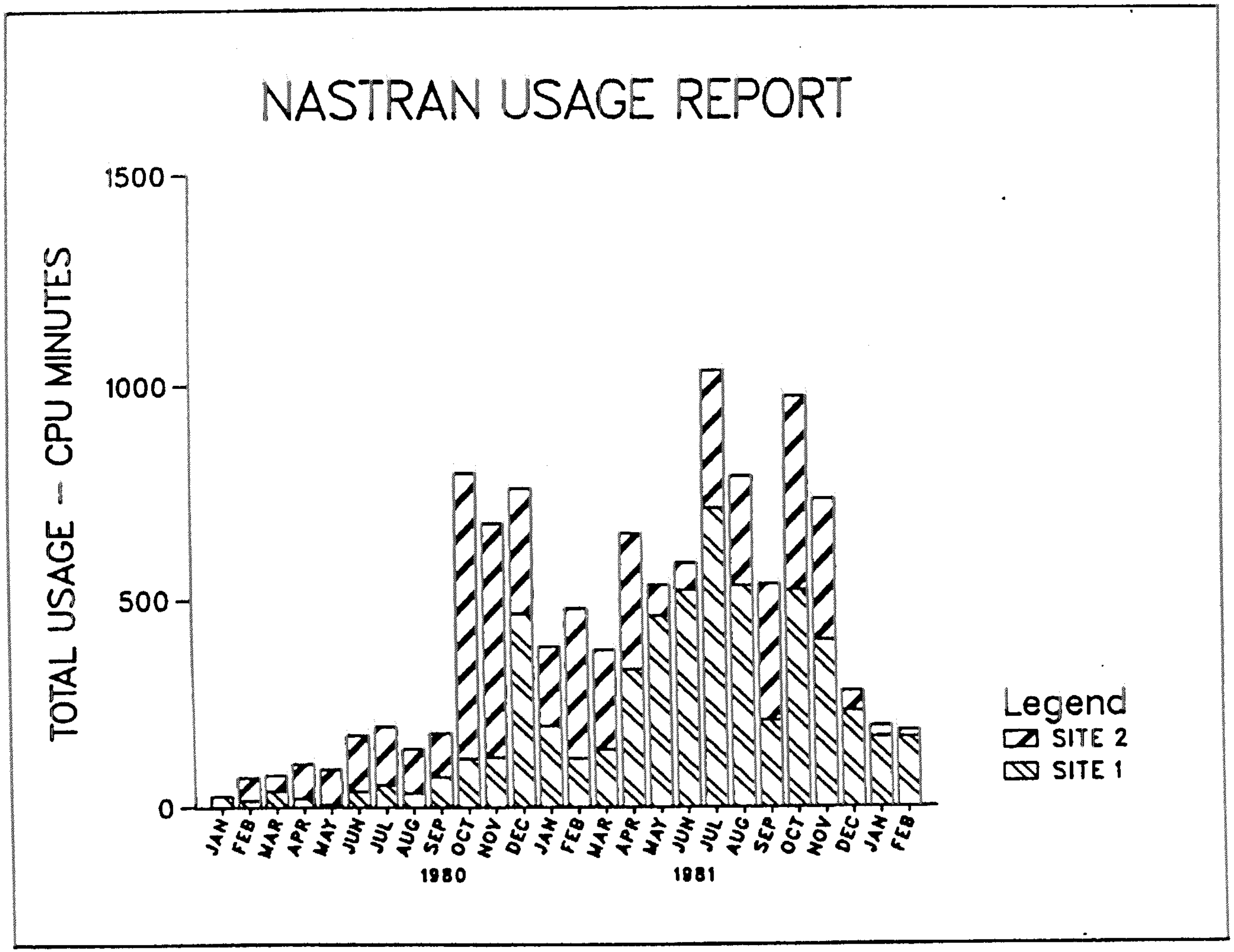

FIGURE 2 NASTRAN CPU USAGE

```
NASTRAN
  ***   NASTRAN CLIST  -  VERSION 2.5  (9/11/81)   ***
  *** ( FMC'S NASTRAN PROJECT MANAGEMENT PROGRAM ) ***

      USER=T899A09   DATE=03/08/82   TIME=10:52:07

PROJECT NAME (MAX 8 CHARACTERS)?TEST

*** 'BILL' COMMAND OF CLIST NOW PREPARES DIVISION BILLING REPORTS.
*** 'SIZE' COMMAND ESTIMATES CPU TIME, COST AND REGION FOR JOB.
*** 'COPY' COMMAND IS ADDED TO THE CLIST FOR COPYING OPERATIONS.

 TYPE 'MOD' FOR LIST OF REVISIONS IN THE CLIST.
 TYPE 'H' FOR HELP

COMMAND?HELP
    THE FOLLOWING COMMANDS ARE AVAILABLE IN THIS CLIST
------------------------------------------------------------------.
ARCHIVE     AUDIT (A)  BEGINNER   BILL       CANCEL     CHKPNT
COMPRESS    COPY       DBASE      DEBUG      DELETE     DEMO
DIAG        DL         EDIT (E)   EXIT       FILCHK     HELP (H)
INPUT (IN)  LIST (L)   LOG        MESH       MOD        MSG
MSGVIEW     NAME       OUT        OUTPUT     PARAM      PLOT
PRINT       PRINTER    PROF       PROJ       PUNCH      RESEQ
RESTORE     RFALT      SAVE       SCAN       SIZE       SOL
SPACE       STATUS(ST) SUBMIT     SUPERTAB   TEKPLOT    TEKPRINT
TIME (T)    TSO
------------------------------------------------------------------.
*** FOR HELP ON ANY COMMAND TYPE THE COMMAND AND H
    EXAMPLE  - AUDIT H
*** FOR ADDITIONAL HELP TYPE  H H
*** FOR LIST OF REVISIONS IN THE CLIST TYPE MOD
*** IF YOU ARE A BEGINNER TYPE BEGINNER

COMMAND?
```

```
NASTRAN
  ***   NASTRAN CLIST  -  VERSION 2.5  (9/11/81)   ***
  *** ( FMC'S NASTRAN PROJECT MANAGEMENT PROGRAM ) ***

      USER=T899A09   DATE=03/08/82   TIME=10:52:07

PROJECT NAME (MAX 8 CHARACTERS)?TEST

*** 'BILL' COMMAND OF CLIST NOW PREPARES DIVISION BILLING REPORTS.
*** 'SIZE' COMMAND ESTIMATES CPU TIME, COST AND REGION FOR JOB.
*** 'COPY' COMMAND IS ADDED TO THE CLIST FOR COPYING OPERATIONS.

 TYPE 'MOD' FOR LIST OF REVISIONS IN THE CLIST.
 TYPE 'H' FOR HELP

COMMAND?HELP
    THE FOLLOWING COMMANDS ARE AVAILABLE IN THIS CLIST
-----------------------------------------------------------------.
ARCHIVE     AUDIT (A)   BEGINNER    BILL        CANCEL      CHKPNT
COMPRESS    COPY        DBASE       DEBUG       DELETE      DEMO
DIAG        DL          EDIT (E)    EXIT        FILCHK      HELP (H)
INPUT (IN)  LIST (L)    LOG         MESH        MOD         MSG
MSGVIEW     NAME        OUT         OUTPUT      PARAM       PLOT
PRINT       PRINTER     PROF        PROJ        PUNCH       RESEQ
RESTORE     RFALT       SAVE        SCAN        SIZE        SOL
SPACE       STATUS(ST)  SUBMIT      SUPERTAB    TEKPLOT     TEKPRINT
TIME (T)    TSO
-----------------------------------------------------------------.
*** FOR HELP ON ANY COMMAND TYPE THE COMMAND AND H
    EXAMPLE  - AUDIT H
*** FOR ADDITIONAL HELP TYPE  H H
*** FOR LIST OF REVISIONS IN THE CLIST TYPE MOD
*** IF YOU ARE A BEGINNER TYPE BEGINNER

COMMAND?
```

FIGURE 4. RESTART PROJECT AND HELP COMMAND LIST

```
H H

--------------------GENERAL COMMANDS----------------------------.

X          - EXIT FROM ANY COMMAND.
EXIT       - EXIT FROM THE NASTRAN CLIST.
TSO        - EXECUTE ANY TSO COMMAND AND RETURN TO CLIST.
HELP (H)   - LIST ALL AVAILABLE COMMANDS.
H H        - EXTENDED HELP. DESCRIBE COMMANDS.
COMMAND H  - ANY COMMAND FOLLOWED BY 'H' EXPLAINS THAT COMMAND.
BEGINNER   - HELP INFORMATION FOR BEGINNER (OF CLIST).
MOD        - LIST LATEST ENHANCEMENTS/CHANGES TO THE CLIST.
DEBUG      - ENTER CLIST DEBUG MODE IF PROBLEMS OCCUR.
TIME       - LIST CLOCK, CPU AND SESSION TIME ON TERMINAL.

--------------------UTILITY COMMANDS----------------------------.

COPY       - COPY FILES TO/FROM PROJECT.
EDIT       - EDIT/CREATE PROJECT FILES.
PRINT      - PRINT PROJECT FILES AT REMOTE PRINTER.
TEKPRINT   - LIST AND HARDCOPY A FILE ON TEKTRONIX TERMINALS.
LOG        - LIST OR ENTER DATA INTO PROJECT LOG FILE.
SIZE       - ESTIMATE CPU TIME AND REGION FOR JOB.
RFALT      - LIST ALL RFALTER NAMES OR CONTENTS OF ANY RFALTER.
DEMO       - CREATE A DEMO NASTRAN DATA DECK.
MSG        - SEND MESSAGE TO OTHER TSO USER.
BILL       - CREATE BILLING REPORTS FOR DIVISION.

--------------------PROJECT/JOB PROFILE COMMANDS----------------.

LIST       - LIST JOB PROFILE FOR PROJECT.
NAME       - ENTER NAME, COMPANY, PHONE NO. TO JOB PROFILE.
SAVE       - SAVE CURRENTLY DEFINED JOB PROFILE.
PROF       - COPY JOB PROFILE FROM ANOTHER PROJECT TO CURRENT PROJ.
PROJ       - ENTER INTO A DIFFERENT PROJECT.

--------------------NASTRAN OPTIONS AND FILE DEFINITIONS---------.
                    (MUST BE DEFINED PRIOR TO JOB SUBMITTAL)

INPUT      - DEFINE INPUT FILE NAME(S) FOR NASTRAN JOB.
OUT        - DEFINE NAME OF OUTPUT FILES TO BE CREATED BY THE JOB.
PRINTER    - CHOOSE DESTINATION OF NASTRAN PRINT OUTPUT.
PUNCH      - INDICATES THAT JOB WILL CREATE PUNCH FILE.
PLOT       - INDICATES THAT JOB WILL CREATE NASTRAN PLOTS.
DL         - INSTRUCTS JOB TO CREATE POST FILE AND RUN DATA LOADER
             FOR SUPERTAB/OUTPUT DISPLAY.
CHKPNT     - INDICATES JOB WILL CHECKPOINT AND/OR RESTART.
DBASE      - INDICATES JOB WILL USE/CREATE DATA BASE.
MESH       - INDICATES JOB WILL USE MSGMESH PREPROCESSOR.
RESEQ      - INDICATES JOB WILL RESEQUENCE GRIDS BEFORE SOLUTION.
SCAN       - INDICATES JOB WILL SCAN DATA FOR ERRORS AND THEN STOP.
SOL        - RESETS NASTRAN SOLUTION NUMBER FOR JOB.
DIAG       - DEFINES DIAGNOSTIC OUTPUT OPTIONS FOR JOB.
RFALT      - SELECTS RFALTERS (RIGID FORMAT ALTERS) FOR JOB.
PARAM      - CHANGES JOB AND NASTRAN RELATED PARAMETERS:
               ACCT NO., PRIORITY, CPU TIME, WALL TIME, REGION, ROOM
               NO., REMOTE PRINTER, LINE LIMIT, WORK SPACE(W1,W2),
               FORTRAN SPACE(F1), DATABASE SPACE(D1,D2).

--------------------JOB SUBMITTAL-------------------------------.

SUBMIT     - CREATE JCL AND/OR SUBMIT THE NASTRAN JOB.
CANCEL     - STOP EXECUTION OF PREVIOUSLY SUBMITTED NASTRAN JOB.
STATUS     - LIST STATUS OF SUBMITTED JOBS.

OUTPUT     - COPY 'HELD' OUTPUT FROM JOB TO FILE AND PRINT.
FILCHK     - CHECK STATUS OF FILES BEFORE SUBMITTING JOB.
DL         - SUBMIT JOB TO RUN DATA LOADER (FOR SUPERTAB OUTPUT
             DISPLAY) USING PREVIOUSLY CREATED POST FILE.

--------------------PROJECT FILE MANAGEMENT---------------------.

AUDIT      - AUDIT NASTRAN FILES IN THE PROJECT.
DELETE     - DELETE MEMBERS OR FILES IN THE PROJECT.
ARCHIVE    - ARCHIVE PROJECT FILES  (TO TAPE).
RESTORE    - RESTORE PROJECT FILES  (FROM TAPE).
DBASE      - ARCHIVE/RESTORE DATABASE FILES TO/FROM TAPE.
COMPRESS   - COMPRESS PROJECT FILES TO FREE UNUSED DEAD SPACE.
SPACE      - RE-ALLOCATE SPACE FOR PROJECT FILES.

--------------------PLOTTING OPERATIONS-------------------------.

MSGVIEW    - RUN MSGVIEW PROGRAM ON TEKTRONIX.
SUPERTAB   - RUN SUPERTAB VERSION 4 (OLD VERSION).
TEKPLOT    - RUN TECK PROGRAM TO VIEW NASTRAN PLOTS ON TEKTRONIX.

---------------------------------------------------------------.
FOR ADDITIONAL HELP ON ANY COMMAND TYPE THE COMMAND AND H
---------------------------------------------------------------.

COMMAND?
```

FIGURE 5.

SECOND LEVEL HELP INFORMATION

```
COMMAND?CHKPNT H
'CHKPNT' COMMAND INDICATES THAT THE NASTRAN JOB WILL
CHECKPOINT AND/OR RESTART A PREVIOUSLY CHECKPOINTED RUN.

 * IF 'SEPARATE' INPUT FILES OPTION IS USED, THEN THE CLIST
   WILL AUTOMATICALLY CREATE THE NECESSARY EXECUTIVE DECK FOR
   CHECKPOINT/RESTART.

 * IF 'COMBINED' INPUT FILES OPTION IS USED, THEN THE USER HAS
   TO INCLUDE THE EXECUTIVE DECK FOR CHECKPOINT/RESTART IN THE
   COMBINED INPUT DATA.

PUNCH OUTPUT CANNOT BE REQUESTED IF RUN WILL CHECKPOINT.

REFERENCES:
   EXECUTIVE DECK:          USER MANUAL: SECT 2.2.1 - 2.2.2
   RESTART PROCEDURES:      USER MANUAL: SECT 3.1.1.1
   CHECKPOINT/RESTART       APPL MANUAL: SECT 7.6.3.4


COMMAND?
```

FIGURE 6. SAMPLE COMMAND HELP FOR CHECKPOINT

```
COMMAND?LIST

LISTING OF JOB PROFILE FOR PROJECT 'TEST'

----------------------------JOB CARD PARAMETERS------------------.
USER NAME, ID , LOCATION     = JOHN:DOE   ,  NAST  ,  DIVISION:CITY
PHONE NO., ACCOUNT NO.       = AAA:000:0000:EXT   ,  '899NASTRAN'
PRIORITY, CLASS, MSGCLASS    = 6  ,  P  ,  Q
CPU TIME, WALL TIME, REGION  = 5  ,  60  ,  450K
----------------------------NASTRAN PARAMETERS-------------------.
W1 , W2 , F1 , D1 , D2       = 50  ,  10  ,  2  ,  50 , 50
----------------------------EXECUTIVE DECK PARAMETERS------------.
SOLUTION NUMBER    = 24
MSGMESH            = NO
CREATE POST FILE   = NO
RESEQUENCE OPTION  = NO
DIAG OPTION        = 8
----------------------------FILE DEFINITIONS---------------------.
JCL AND EXECUTIVE DECK       :  'SAMPLE'
CASE CONTROL DECK            :  'SAMPLE'
BULK DATA DECK               :  'SAMPLE'
PRINT OUTPUT                 :  HELD FOR TSO (CLASS Q)
----------------------------INACTIVE OPTIONS---------------------.
PUNCH FILE                   :  NOT REQUESTED
NASTRAN PLOT FILE (PLT2)     :  NOT REQUESTED
POST FILE FOR SUPERTAB O.D.  :  NOT REQUESTED
DATABASE FILE                :  NOT REQUESTED
CHECKPOINT/RESTART           :  NOT REQUESTED
-----------------------------------------------------------------.
-----------------------------------------------------------------.
IF ABOVE PARAMETERS AND NAMES ARE INCORRECT,
THEN RE-EXECUTE THE APPROPRIATE COMMANDS TO CHANGE.
```

FIGURE 7. LIST COMMAND

```
COMMAND?AUDIT
THE FOLLOWING NASTRAN FILES CAN BE AUDITED:
  I = NASTDATA   B = NASTBULK   C = NASTCASE   J = NASTCNTL
  D = NASTDICT   T = NASTTAPE   N = NASTOUTP   S = NASTSYSO
  P = NASTPLOT   U = NASTPNCH   O = NASTPOST   V = STABUNIV
  W = STABMODL   Q = NASTDB01,2 F = NASTPROF   L = NASTLOG
  R = NASTARCH                  A = ALL PROJECT FILES
  X = EXIT FROM AUDIT           H = HELP

ENTER FILE TYPE FOR AUDIT?I
* AUDITING COMBINED INPUT DATA FILES(NASTDATA) FOR PROJECT 'TEST'
DEMO         DUMMY        HEATP        MESH         MSHA
Q8           WING2
ENTER FILE TYPE FOR AUDIT?P
* AUDITING PLOT FILES (NASTPLOT) FOR PROJECT 'TEST'
MESH         Q8
ENTER FILE TYPE FOR AUDIT?D
* AUDITING CHECKPOINT DICTIONARIES (NASTDICT) FOR PROJECT 'TEST'
NASTDICT FILE DOES NOT EXIST FOR PROJECT 'TEST'
ENTER FILE TYPE FOR AUDIT?X
* END AUDIT

COMMAND?
```

FIGURE 8. AUDIT COMMAND AND FILE TYPES