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EXECUTIVE SUMMARY

FOR THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER DATA BASE REQUIREMENTS STUDY

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Major Offices and Facilities Throughout the World

FOREWORD

This study was administered in the Flight Software Branch, Flight Support Division, MSC with B. L. Brady assigned as Technical Monitor. Through careful planning and coordination, Mr. Brady, assisted by Mrs. Shirley Hinson, added significantly to our insight into and understanding of related MSC functions and organizations and, thereby, the accuracy of the study reported herein.

TABLE OF CONTENTS

Section 1 - Introduction 1-1

Section 2 - Pilot Study Accomplishments 2-1

2.1 Summary of Interviews 2-1
2.2 Pilot DMS Data 2-2
2.3 Pilot DMS Demonstrations 2-2
2.4 Conclusions 2-2

Section 3 - System Requirements 3-1

3.1 Required DMS Functional Capabilities 3-1
3.2 Desirable DMS Functional Capabilities 3-4
3.3 Required Hardware for the DMS 3-5
3.4 Desirable Hardware for the DMS 3-6
3.5 Data Requirements 3-6

Section 4 - System Implementation 4-1

4.1 Management Involvement 4-1
4.2 Manpower Requirements 4-1
4.3 Implementation Considerations 4-1

Section 5 - Summary/Recommendations 5-1

5.1 Data Management Supervisor (DMS) 5-1
5.2 Practically Structured Data Base 5-2
5.3 Programming 5-2
5.4 User Benefits 5-3
5.5 Cost 5-3
5.6 Summary 5-4

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SECTION 1 - INTRODUCTION

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This Executive Summary is based on a study conducted by Computer Sciences Corporation (CSC) for the National Aeronautics and Space Administration (NASA), Manned Spacecraft Center (MSC), to investigate the requirements of a data management system to meet the needs of MSC in mission planning and program and resource management during the 1975 time frame. The study addresses overall system requirements, implementation considerations, and cost/benefit comparisons. During the course of this study, CSC has examined the types of data that MSC must automate to make available both management and technical information in support of the MSC's functions and missions. Also, software and hardware capabilities which can best handle the storage and retrieval of this data have been analyzed.

As MSC's requirements for new types of high volume data continue to grow and the need to review and manipulate this data on a "more data faster" basis increases, it is evident that although a great deal of computing power exists, a number of necessary applications have not been automated, and others are less efficient than desired.

A properly implemented Data Management Supervisor (DMS) would permit the user to quickly describe and construct a data base, query the data base for specific information, display the data on a Cathode Ray Tube (CRT), obtain hard copy reports, and update and maintain the data base. All of these functions could be performed in either a production basis or interactively from a terminal in an on-line time-sharing mode.

Of critical importance to MSC will be the proper structuring of data sets to reflect the required data to serve both management and line users. This necessitates a sophisticated approach to file structuring to meet requirements and control data set volumes. File analysis, data content, and file structuring require software systems capable of efficiently managing large complex data bases and personnel who are knowledgeable of the critical importance of data structuring.

Greater throughput per computer dollar will result from the installation of a DMS. Such areas as increased programmer productivity, greater standardization, reduced program development time, and accessibility of data all tend to substantiate the position that installation of an effective DMS is cost effective.

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SECTION 2 - PILOT STUDY ACCOMPLISHMENTS

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In order to properly manage a complex set of missions such as those in the integrated manned space flight plan, availability of extensive technical and management information will be required. It is essential that this data be current and easily accessible to both project management and technical personnel for pre-mission planning, mission support, and post-flight analysis. Because of the relatively large number of vehicles and frequent flights envisioned for future programs, an automated information management system will be necessary. Such automation can effect a more efficient operation and result in reduction of costs in the areas of program management, mission planning, and support operations. It was necessary to conduct a study to determine the types of data that require automation and to determine the system that can best handle the storage and retrieval of this information.

The first step in the study was to conduct personal interviews with MSC personnel. These interviews acquainted the various MSC groups with the goals and purposes of the study and identified the data processing needs of the various groups. These interviews also provided opportunities to discuss with these users the capabilities of a DMS. An analysis of MSC data and information requirements was then performed based on the information obtained.

A list of currently operational DMS's that were available at no cost to MSC was given to the implementing contractor on August 10, 1970. This list of candidate systems contained three actual DMS systems and three textual data processor systems.

MSC established user requirements as the prime consideration in the selection of the pilot DMS. Other major considerations included cost, compatibility with other system hardware, and terminal capabilities. Trade-offs were made to approach a degree of satisfaction of all requirements. These trade-offs generally considered expediency of implementation of the DMS. As a result of these trade-offs, the NIPS and HYPERTEXT systems were selected by MSC to be used in the pilot study.

2.1 SUMMARY OF INTERVIEWS

During the data base requirements study project, CSC contacted more than 200 users throughout MSC to inform them of the data base requirements study and to determine their interest in participating in the study. Through the use of personal discussions in a structured interview with each potential user, it was possible to determine the data interests and software requirements necessary to support both the pilot system and a future expanded operational system.

On November 2, 1970, the implementing contractor presented to MSC the results of its analysis of various candidate systems in the document "Program Evaluation Report." Based on the implementing contractor's recommendations, MSC selected the NIPS and HYPERTEXT systems to comprise the pilot DMS.

CSC performed an analysis and evaluation of the pilot DMS systems. A preliminary analysis occurred prior to the actual implementation of the systems and consisted of an in-depth study of all available documentation on the two systems. A detailed, hands-on checkout of all the operational functions supported by the DMS's was then performed. The

objectives were to develop proficiency in operating the systems and to discover any idiosyncrasies of the systems that had not been uncovered during the documentation study.

2.2 PILOT DMS DATA

The following MSC user application data files were structured into the pilot DMS data base:

- Labor Distribution
- Accounting
- Procurement 497
- RMD
- Contract Status Report
- Budgetary Control
- Capitalized Equipment
- Engineering Standards Information
- Earth Resources Text and Table Files
- Flight Control Manpower Status
- Skylab Program Operational Data Book
- Statements of Work

The Skylab Program Operational Data Book and Statements of Work files were implemented for utilization by HYPERTEXT. All other files were implemented under NIPS.

2.3 PILOT DMS DEMONSTRATIONS

Utilizing past experience in the management and technical data areas, CSC designed demonstrations of the NIPS and HYPERTEXT systems to show MSC managers some of the capabilities offered by a DMS. Actual MSC data was used to prepare program queries for a representative cross-section of MSC activities to provide demonstrations which were meaningful to the viewers and to help them relate their data requirements to a DMS.

The demonstrations showed how data could be retrieved from the data base, sorted, updated, and displayed to a user. Most groups which viewed the demonstrations expressed a desire for a Center-wide DMS at MSC because of the apparent benefits available to them in such a system.

2.4 CONCLUSIONS

During the conduct of the study several conclusions became apparent. First of all, the availability of data to the users on a timely basis was of prime importance. This requirement presented itself in a number of different forms. Timeliness, availability, and the capability to selectively and randomly review data was high in each user's consideration.

Also, a large number of users are developing or considering independent solutions to this problem because of the lack of an integrated data base management system at MSC. Firm procedures will be required to prevent a proliferation of independent systems involving inefficiency and duplication of effort.

Finally, the pilot DMS was effective in demonstrating that most of these information and data problems can be solved by an effective DMS. As a result of the interviews and demonstrations, a comprehensive list of required capabilities necessary to support users and desirable capabilities to further enhance retrieval and display effectiveness has been compiled.

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SECTION 3 - SYSTEM REQUIREMENTS

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Two categories of capabilities have been defined to support the many users' requirements that were identified during the course of the study. First, required capabilities are those functions that are necessary to support the user by creating a data base, maintaining the data base, and providing optional methods for processing and retrieving information. Second, desirable capabilities are additional functions which further enhance the practicality of the total system by orienting it more to the individual user and the solution of his problems.

Both categories of capabilities were derived through the process of interviewing a cross-section of MSC users and then demonstrating the effects of these capabilities to them on the pilot system.

3.1 REQUIRED DMS FUNCTIONAL CAPABILITIES

There are certain basic capabilities which must be provided by the DMS. The following paragraphs describe those features which are considered essential to successful operation of such a system at MSC.

- Terminal and Batch Processing. A DMS provides both batch and terminal processing capabilities. Applications which do not require instant response or which process a large amount of input data are executed in the batch mode. Applications which require quick answers are done using queries in the terminal mode.

- Data Base Description. A means for describing the data in the data base is provided by a data description language. The language describes such things as field name, field length, record key, record length, file name, file structure type, data security, data type, etc.

- Data Access Security. Every file requires "write" protection which restricts the capability to add data or modify data to those persons authorized to alter the data. Some data must be provided retrieval or "read" protection. Three levels of security will be provided, i.e., field, record, and file. Security codes will be assigned to people authorized to access the data.

- Data Base Creation and Maintenance. The DMS must provide the capability to accept user files from various types of input devices (cards, magnetic tape, disk, etc.) and create data files according to the data base description. Several structural forms must be made available including sequential, indexed sequential, hierarchical indexed sequential, etc.

- Process Many Types of Data. Of critical importance to MSC is the structuring of data to minimize redundancy and reflect the required data to serve management, administrative, and technical users. The following blocks of data comprise the primary types that must be processed.

  Management Data - This type of data relates primarily to the resources management area. It will include such items as accounting data, payroll information, personnel data, procurement data, logistics data, scheduling and planning data, etc.

Technical Data - This data is scientific in nature, i.e., used in engineering calculations or used to describe technical data.

Library Data - This data is generally descriptive in nature, containing a brief amount of information about some larger item. The purpose of this data is to show a user identifying information available on a particular item.

Textual Data - This is documentary data. A document could be entered in free form into a data file and then recalled to be edited and formatted at a CRT terminal.

- Simple Terminal Language with Prompting. The language provided by the DMS for users at a CRT terminal must be easy to learn and of a semantic form familiar to most users. It must prompt the user by asking questions and directing the sequence of entries as a user develops a query.

- Short Terminal Response Time. The primary reason for a DMS and a data base is to provide MSC managers quick, direct access to the data which pertains to their operation. This makes the computer more useful as a tool for decision making.

- Update Data at a Terminal. A DMS must provide update capabilities in both the batch and terminal modes. The batch mode will normally be used for large volume updates, and the terminal mode for small volume updates.

- Queries Using Multiple Search Criteria. The multiple search criteria capability enables a terminal user to enter many different search conditions in one query. Quick retrieval of specific data is thus provided. There should be no limit on the number of search conditions that a user could state in one query. Boolean connectors (and, or, not) would be used to connect the search conditions.

- Terminal User Selection of Displayed Data. A DMS must provide the capability for terminal users to display any data field in the data base. The users must not be limited in the data they can view, except for security limitations. In addition, variable output report format should be provided such that a user need not be concerned about formatting the data that is to be displayed.

- Simultaneous Queries of the Same Data. The DMS must provide capabilities for simultaneous queries of the same data by users at different terminals.

- Keyword Search of Data. This feature allows a user to enter a keyword at the console and to retrieve all the information in a file which related to that keyword. The keyword may be a subject, author, mission number, site number, etc. Capability to use combinations of keywords for search criteria should also be provided.

- Hard Copy of Terminal Displays. Terminal users will need the capability to obtain a printed copy of the contents of a CRT display. Hard copies are needed so users can take viewed results back to their desks for analysis, thus releasing terminals for other users.

- Terminal Arithmetic Operations. Data in areas such as payroll, accounting, logistics, and procurement require the arithmetic operations add, subtract, multiply, and divide. Internal decimal point alignment (floating point arithmetic) must be included with these operations.

- Sort and Merge. The DMS must provide capability to rearrange data that has been retrieved from the data base into a new sequence as requested by a terminal user. The merge routine should be able to combine two or more data files according to a user specified sequence.

- Data Name Synonyms. Some data items are called by different names among the various MSC groups. By means of synonyms, different users can query an item of data using the name familiar to them.

- Inter-File Data Query and Update. The DMS must provide a user with the capability to obtain data from many different files with the same query. If it is necessary for a data item to appear in more than one file, an update of this item should automatically update the item in all files in which it appears.

- Audit Trail of Data Updates. An audit trail is a record of the update actions performed on data in the data base. The DMS must provide the capability to keep a record of all changes made to a data file. If the data base is destroyed, the data base may be recreated using the latest backup tape. Audit trail(s) containing the update actions recorded since this backup tape may then be reentered in the data base.

- Create, Save, and Reuse Terminal Queries. Since the terminal language will be a simple, English type language, nontechnical users will be able to create their own queries. If a user determines that he will be entering the same query repeatedly, the DMS will provide the capability to save such queries.

- Temporary Saving of Answer Sets. The DMS should provide capabilities to store a response to a query and allow that answer set to be recalled as input for a subsequent query.

- Purge of Obsolete Data. The DMS will provide routines to reorganize individual data files within the data base and delete all records that have been flagged as obsolete.

- Editing and Validating of Data. When new data is added to the data base, the DMS will provide a validity check and permit data to be entered into the data base only when certain validation criteria are met.

- DMS Error Recovery Without Aborting. Errors can occur during processing which will cause system failures. If this happens, control should be returned to the DMS, not to the operating system.

- Easy to Modify and Expand DMS. The DMS will be written in modules in order that modifications to one functional area will not impact other areas.

  The DMS should be written in a machine independent language. This will facilitate conversion or modifications when computer hardware is changed or upgraded.

3.2 DESIRABLE DMS FUNCTIONAL CAPABILITIES

For reasons of greater processing efficiency and flexibility to the user, it is highly desirable to include certain capabilities. Although these capabilities are not mandatory to system operation, the increased user effectiveness which they provide is of great value.

- Variable Length Data Fields. At present, items such as addresses, names, remarks, etc., are limited to specific lengths and in many cases the data has to be abbreviated. Conversely, much storage space is wasted by comments and textual data that does not fill the space allocated for it.
- Textual Document Editing and Formatting. This capability allows unedited documents to be input into the data base. The user then edits and formats the documents at a terminal to prepare them for printing.
- Terminal Graphics. The graphics capability allows a user to create drawings and objects on the CRT using diagonal lines and points, to display graphs of statistical information, etc.
- Remote Job Entry. This capability allows a terminal user to call up and execute a job stored in a system library. A job may consist of one or more programs designed to perform specific tasks.
- Geographic Type Data. Earth resources at present is utilizing the GEOREF system but will eventually change over to the UTM system to make earth resources data compatible with outside users in the way they define the coordinates of the area for which the data applies.
- Access Data Using Different Languages. COBOL and FORTRAN are the basic languages utilized by MSC; therefore, the DMS should include the capability to write programs in these languages.
- Statistical Analysis of Data. Statistical analysis will be tied in very closely to the graphics capability. Statistical analysis routines should be callable by the DMS to provide this capability.
- Conditional Processing. This capability allows a DMS to initiate or bypass tasks or jobs based upon conditions encountered during processing.
- Automatic Scheduling of Processing. Most of MSC's computer activity will be programmed into a "scheduler" module and added to the DMS. The MSC applications will then be automatically processed by the DMS according to the scheduling criteria specified for each application.
- Validate Data Base Integrity. The data base will be audited periodically to ensure validity of data. The audit will check data items against edit criteria such as size or range limitations and type of data (alphabetic or numeric). If a data item is dependent on other data items, a check could be made to ensure the item meets all conditions imposed upon it by the other items.
- Lockout During Data Update. Once an update command against an item of data has been issued to the DMS, all queries and other processing requiring this data will be delayed until the update has been completed. This should be

at the record level, thus allowing other users to query all records in the data set which are not in the process of being updated.

- Computer Transferability of the DMS. If the major portions of the DMS are written in a language which is virtually machine independent (such as COBOL), the effort to rewrite them will be greatly reduced if it becomes necessary to transfer the DMS to new computer hardware.

- Inverted Data Files. Inverted files essentially consist of a series of different sort key index sets for any data file. Each sort key index set contains records in a specific sequence and application data record address pointers. In a query, a user will specify the sort key index set which will give him the most direct access to his data.

3.3 REQUIRED HARDWARE FOR THE DMS

Only nominal special hardware and configuration changes over and above those which already exist at MSC are required to support a DMS. However, in some areas, such as direct access storage devices, it will be necessary to increase capacity as data files are added.

- Local and Remote Terminals. The DMS hardware must provide for both remote and local terminal processing. Remote terminal processing requires the use of common carrier lines between the terminal and the computer processing unit. Local terminals normally utilize hard wiring (direct connection) from the computer to the terminal display control unit. Local terminals, however, should also be able to optionally utilize modems instead of the hard wiring. In fact, it is recommended that whenever possible, modems be widely used for local terminals, especially where a terminal location is likely to be changed. This method of data communications provides significant flexibility for placement and relocation of terminals without the necessity of considerable data line, adapter, and control unit hardware replacements or modifications.

  There must be interactive terminal consoles which allow users to specify their processing requirements. There should be a terminal keyboard/CRT with alphanumeric characters and a hard copy device that can produce a printed copy of the entire generated results of a query or the contents of a single CRT display screen.

- Large Core Storage Capacity. Many of the applications at MSC are extremely large, and some application data areas, such as earth resources, will grow to huge proportions through the Skylab and Space Shuttle programs. Queries of these data files could create very large answer sets. Enough core storage must be available to handle such queries and at the same time allow other programs or jobs to execute (multi-programming capability).

- Direct Access Storage Devices. The large volume of current MSC applications data plus the probable increase in size of some applications data necessitates a large random access storage capacity. It is also necessary that a DMS provide for many types of data structures. The most important types are indexed

sequential and hierarchical sequential. These methods allow for direct access to specific data items and the chaining together of like items.

3.4 DESIRABLE HARDWARE FOR THE DMS

To make full use of expanded capabilities of the DMS, certain options should be considered. Through the use of additional hardware capabilities, greater efficiency and utilization may be obtained.

- Terminal Console Special Features. An auxiliary functional keyboard will be provided for text data editing and formatting operations. Once a document has been entered into the system, the functional keyboard allows a user to edit the document and prepare it for printing.

  The light pen provides a terminal user the capability to identify specific locations on the CRT screen at which some operations are to take place. Vector generation capability is also necessary for graphics displays at terminals.

- Terminal Input/Output Devices. There are many printers available today which may be installed as hard copy devices at terminals. Magnetic tapes may be used as auxiliary storage devices and as backup storage devices for the DMS.

  If a MSC group keypunches their own data, it will facilitate their operation to have a card reader/card punch at their terminal for remote entry of their data. Teletypes may be used as a hard copy device and also as a terminal entry device when a more sophisticated device is not economically justified.

- Microfilm. Microfilm conserves storage and greatly reduces processing costs. Microfilm is now being widely used by MSC in many areas such as earth resources and engineering plant drawings. Further use of microfilm could reduce MSC's cost in the storage and retrieval of charts, drawings, photographs, and text data documents.

3.5 DATA REQUIREMENTS

The broad spectrum of activities at MSC makes it a very complex facility. The DMS must be powerful enough to serve the data needs of all areas of MSC. As stated previously, a logically and efficiently structured data base is a critical part of the system. The data base must contain all data needed by management and technical users.

- Management Data. The data needed by managers to plan activities, to schedule work loads, to perform project analysis, and to financially control their phase of the MSC operations must be readily accessible and must also be presented simply and coherently.

- Static and Dynamic Characteristics of MSC Data. Most of the currently active files in the management area were originally designed and created for the Gemini and Apollo programs and will be used for future programs. Most of the files in the technical area that will be contained in the MSC data base are static, but there are some dynamic files (number of records on the file increases constantly). Lunar samples is the largest dynamic file in the technical area. It will continue to grow as more and more tests are made on the

moon rocks. Flight scheduling is also a very active file. Its size varies depending on mission requirements.

- Impact of Space Station and Space Shuttle on Data Volume Through 1975. The requirements for resources management will not increase appreciably because of new programs such as the Space Station and Space Shuttle. Earth resources data, however, is cumulative. The library data will be somewhat dynamic, too, since more papers, documents, and literature will be published as a result of these programs.

  Data for the scheduling of flight activities for the Skylab and Space Shuttle missions will also be in the MSC data base. This technical data will have a high level of activity, and the volume will fluctuate significantly depending on the number and complexity of the flight activities during Skylab and Space Shuttle missions. There will also be a large amount of raw telemetry data and engineering data from the Skylab and Space Shuttle missions. Only condensed summaries of this data need be considered for implementation into the Center-wide data base.

- Data Adaptable to Data Base Type Operations. The DMS and Center-wide data base are management tools to be used as aids in decision making. The general guideline for implementing data into the Center-wide data base is to structure that data most needed by MSC managers to aid them in decision making and planning. Logistics, procurement, and accounting files are prime candidates. Flight scheduling data should be among the first to be implemented. Since NASA will be playing a constantly expanding role in the environmental sciences through the Skylab and earth resources programs, most of the environmental data should be structured into the data base.

- Data Item Dictionary. The data item dictionary should have a complete listing of the content and organization of all data items in the MSC data base. There should also be functional area data dictionaries which would contain only those data items relating to particular MSC activities. These smaller data dictionaries will be more meaningful and usable since they will contain only pertinent data items for specific MSC activities.

- Data Source Document Index. In conjunction with the data item dictionary, a data source document index should be provided to describe all input transactions and other submittal forms used by MSC and contractors for entering data items into the data base. A description of each data source document and the data items created or updated in the data base by using that source document will be contained in the index.

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SECTION 4 - SYSTEM IMPLEMENTATION

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4.1 MANAGEMENT INVOLVEMENT

In a major systems endeavor, it is imperative that management participate and involve themselves in its achievement and success. In organizations where the computer systems and the data base are regarded as major resources and as important tools in achieving goals, management must play a strong role. An automated system, to be an effective tool, requires a high degree of management involvement.

The prime management functions of control, scheduling, and decision making must be applied by MSC management throughout the phases of system development, implementation, and operation.

4.2 MANPOWER REQUIREMENTS

The manpower effort required to completely implement the DMS, structure the MSC application data into the data base, and train MSC personnel in utilizing the DMS and data base is shown in Figures 4-1, -2, and -3.

The estimated implementation manpower figures indicate that approximately 336 man months would be required in a one-year time frame to provide the complete implementation. The second and third years will require 144 man months and 108 man months, respectively, to maintain the data base, DMS, and terminal functions. These figures also include the adding of new MSC application data as well as enhancing the DMS functional capabilities. Detailed estimates of manpower and implementation schedules may be found in Section 4 of the Final Report.

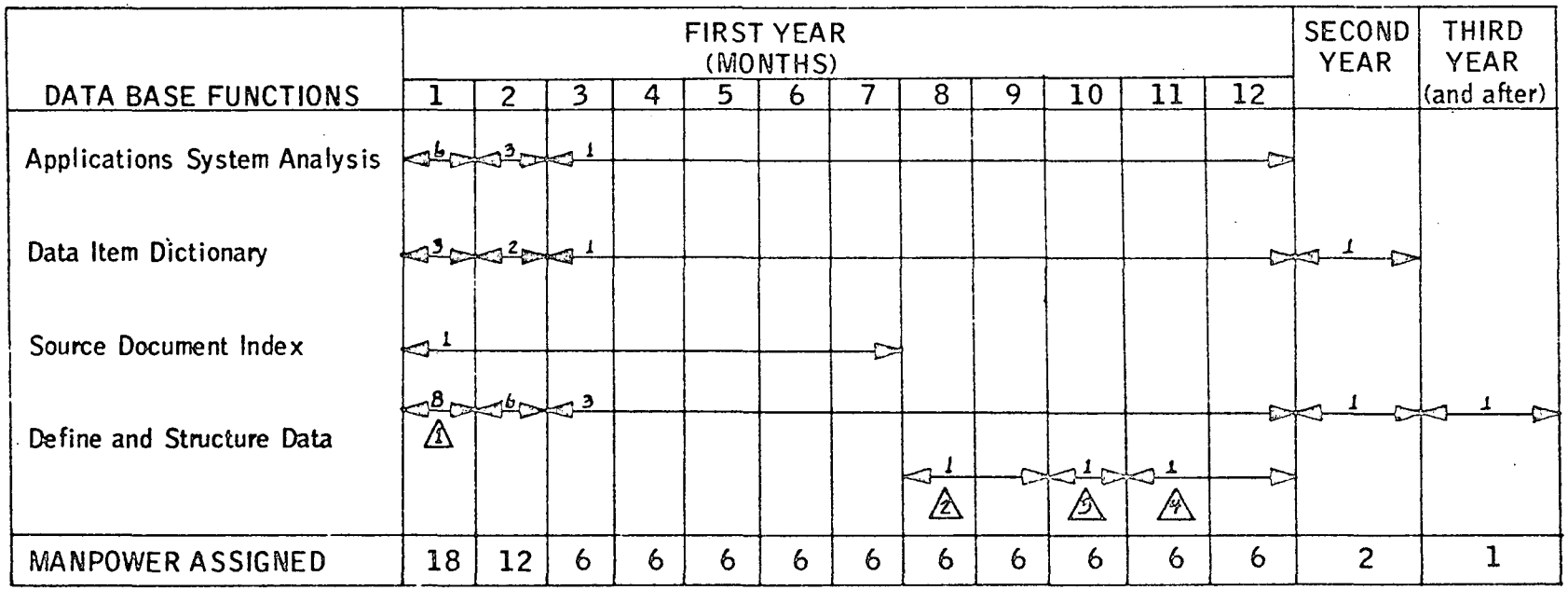
The manpower required to install and modify a currently operating DMS will be much less than that required to write and implement a newly designed DMS. There will also be manpower requirement differences depending on the capabilities provided in the acquired system and the language in which it is written.

An effective DMS should allow MSC to reduce the number of application programmers and analysts required to support MSC's effort. Through the use of a simple, user oriented terminal language, many program requests which normally would be routed to a contractor's programming group would now be done by a nontechnical person at a terminal. Thus, contractor manpower needs would be significantly reduced.

As functional modules of the DMS become operational, MSC personnel in the applications areas being installed will have to be trained in the use of terminals and the terminal language. Computer operations personnel will also have to be trained in the operation of the DMS on the computer.

4.3 IMPLEMENTATION CONSIDERATIONS

The most efficient approach in designing a DMS is to make it modular in nature. The DMS will basically consist of modules to define, create, and maintain the data base; sort and merge data; retrieve data; and generate reports. The DMS should be machine independent where possible, and it should be written in a language which is easily transferred to different computer hardware.

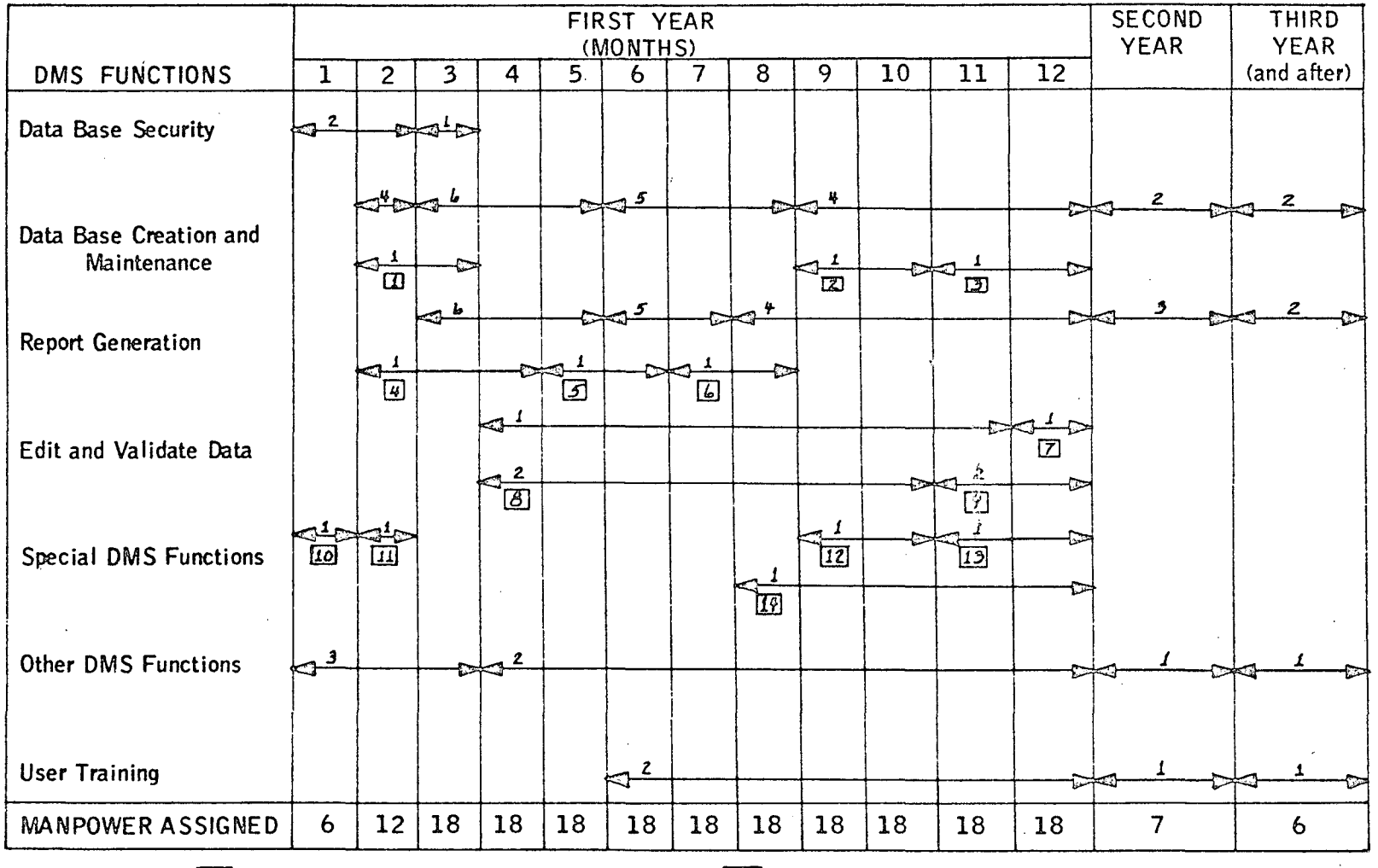


LEGEND:*

1. Data File Descriptions
2. Variable Length Data
3. Data Name Synonyms
4. Geographic Data

*See Final Report, Section 4, for explanatory details.

Figure 4-1. Data Base Functions Implementation

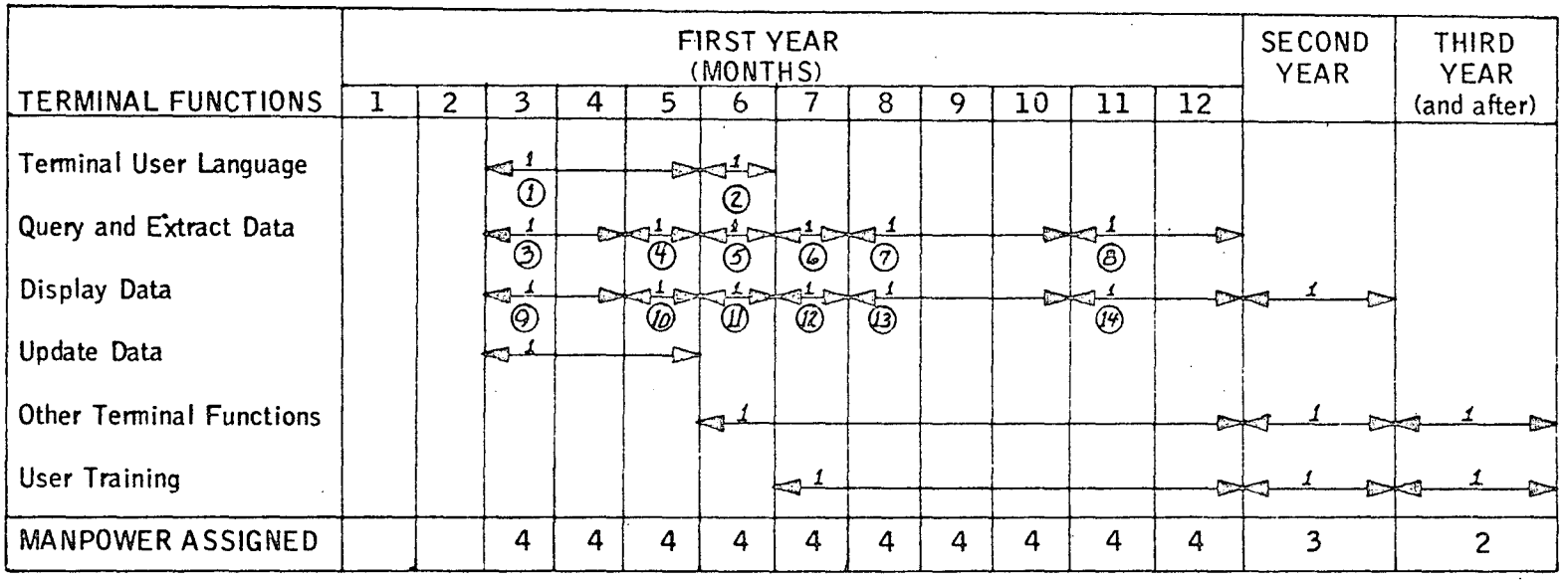


LEGEND:*

1	Process Many Types of Data	8	Textual Document Editing and Formatting
2	Audit Trail of Data Updates	9	Validate Data Base Integrity
3	Lockout During Data Update	10	Easy to Modify and Expand DMS
4	Access Data Using Different Languages	11	Computer Transferability of DMS
5	Statistical Analysis of Data	12	DMS Error Recovery without Aborting
6	Conditional Processing	13	Remote Job Entry
7	Purge of Obsolete Data	14	Automatic Scheduling of Processing

*See Final Report, Section 4, for explanatory details.

Figure 4-2. DMS Functions Implementation



LEGEND:*

(1)	Simple Terminal Language With Prompting	(8)	Create, Save, and Reuse Queries
(2)	Short Terminal Response Time	(9)	User Selection of Displayed Data
(3)	Keyword Search of Data	(10)	Sort and Merge Data
(4)	Arithmetic Operations	(11)	Hard Copy of Displays
(5)	Queries Using Multiple Search Criteria	(12)	Saving of Answer Sets
(6)	Simultaneous Queries of Same Data	(13)	Inverted Data Files
(7)	Inter-File Query and Update	(14)	Graphics

*See Final Report, Section 4, for explanatory details.

Figure 4-3. Terminal Functions Implementation

Logic modules to handle the needs of the various applications such as earth resources, logistics, procurement, etc., will be written separately but will utilize the capabilities of the DMS. These applications modules will be programmed and installed according to the applications priority list. Building a DMS in this fashion will reduce conversion costs and enable functional modules of the DMS to be used as they are installed and made operational. It will also serve to test and check out the DMS under an operational type environment.

Several benefits will accrue to MSC if a currently operational DMS is acquired and modified to fit MSC's needs. Some systems are public domain, so it is quite probable that MSC could install one of these systems at a substantial lower cost and reduced time frame.

A careful analysis of data must be made to determine which data is to be placed into the data base. The analysis of data should begin before any programming is done on the DMS. In fact, some data analysis was performed for the pilot study which will be beneficial for a larger data analysis to construct the Center-wide data base.

A DMS requires an extensive user educational program. Users must be trained in the use of the DMS language, terminal language, terminal operations, data item dictionary, source data document index, DMS computer operations, and DMS batch operations. Users should receive the training they need to properly utilize the DMS as a tool to fulfill their job functions. Training manuals, classroom teaching, and private consultations with users must be provided.

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SECTION 5 - SUMMARY/RECOMMENDATIONS

SECTION 5 - SUMMARY/RECOMMENDATIONS

During the course of the study, it became apparent that techniques must be implemented which would make information processing at MSC more responsive to the users' requirements. An effective solution to this problem is the implementation of a Data Management Supervisor (DMS), coupled with a comprehensive and well structured data base.

One of the prime advantages that accrues from the use of a DMS is the increase of capabilities offered the user in solving his information problems. Other advantages are in the areas of improved programming techniques, certain cost reductions, and improved processing efficiency.

5.1 DATA MANAGEMENT SUPERVISOR (DMS)

The advanced techniques of file management and retrieval made available by a DMS will be required by MSC to support the ever-increasing demand for information.

Standardized program routines, such as report formatting, data editing, data retrieval, and updating, will provide a system more oriented toward enhancing responsiveness to many different types of users. For the programming staff, ease and quickness of program maintenance and modification are significant factors.

Through the earth orbital program and its related scientific applications, NASA will produce more pertinent data on our environment, the movement of the earth land and ice masses, and various weather models than heretofore imagined. This massive volume of data will require techniques for its maintenance and worldwide dissemination superior to those currently utilized.

Flight scheduling is one of the most active areas at MSC. It will become even more active during the Skylab and Space Shuttle programs. The data files required to handle flight scheduling are large. When changes to the flight schedules are made, rapid access to the data files is necessary. One minor change could cascade into many changes throughout the entire schedule. Real-time, direct access to the data is especially mandatory while the missions are in progress.

The earth resources area has the potential of becoming one of MSC's largest and most active areas. Millions of items of data will be structured into the earth resources data set in the data base. This data is available to the general public, and the demand by the public for this data will expand. Already, large educational institutions, research foundations, and industry have made requests for this data.

All of these areas have a need for a DMS at the present time. This need will become even more critical as MSC efforts are phased out of the Apollo program into the Skylab program.

Some MSC groups, such as earth resources, flight scheduling, and logistics, have an urgent need for a DMS. Though the need for a DMS is greater in some groups than in others, practically all of the groups who were interviewed or who attended the demonstrations expressed a desire for MSC to install a DMS with a Center-wide data base. A few MSC groups even used the pilot DMS to do some of their production work.

A modular concept should be used in designing a DMS. Separate modules will be written to perform the various functions such as defining the data base, creating it, maintaining it, sorting data, retrieving data, and reporting data. Whenever changes to any area are required, a new module incorporating the changes can be implemented.

A machine independent language for the DMS is an extremely desirable design feature. The major functional modules of the DMS should be written in a high level language such as COBOL. By doing this, a change in computers will require relatively minor modifications to the DMS.

5.2 PRACTICALLY STRUCTURED DATA BASE

If is of critical importance that the data sets within the data base are uniquely structured to take full advantage of the capabilities provided by the DMS in meeting users' requirement.

It would be unreasonable to assume that all data could be included in a data base since the capacity to store this volume of data would be unrealistic, and such a volume would downgrade the effectiveness of any system. It would also be unreasonable to assume that all of the data could be structured and stored in the same manner. Therefore, structuring of files must be versatile enough to accommodate the many different types of requirements.

5.3 PROGRAMMING

A powerful programming language will be provided by the DMS. This language will enable programmers to quickly design and implement complex application systems.

The great advantage provided by the DMS is the vast library of specialized program module routines that can be utilized by the DMS programmer. These specialized functional modules include routines such as file creation, file update, editing, encode/decode table look-up, statistical analysis, file sort and merge, data extraction, report formatting, report generation, graphics, etc.

Most of the MSC applications can be designed and oriented to utilize the DMS terminal capabilities. File maintenance and report generation can be quickly and easily performed utilizing a simple, user oriented terminal language provided by the DMS. This language, being specially designed for use by nontechnical persons, allows managers and staff assistants to rapidly update data and receive individually oriented, highly complex, and meaningful reports.

Application program modifications and expansion can be made easily and quickly through the high level DMS programming language. The DMS programmer can invoke the DMS functional modules to perform the desired processing. The DMS programmer could also include and call up program routines that were written in other programming languages, such as COBOL. This capability allows utilization of existing MSC program modules and routines by specifying their name in a DMS program. The DMS also allows programmers to continue writing new application programs in other languages, such as COBOL.

Many programs will be written at terminals using the DMS terminal language. Once these are checked out and are producing successful output, they will be stored in the system libraries. They can then be executed by simply calling up the program name.

The DMS will generate program modules that have a common design format for the same DMS processing function. The design format will be highly advanced and produce efficient

processing routines. Thus for each specified DMS language processing function, the DMS programmer knows the program logic that will be generated to perform that function.

The standardized program routines that will be generated by the DMS have many advantages. First, it allows each processing function to be designed to produce the most efficient processing. Second, it allows changes to be easily made to the generated programs. It also provides for simple, standardized documentation, since the same processing function would always generate basically the same program design logic. It also facilitates making modifications or expansions to programs written by another programmer.

5.4 USER BENEFITS

The design and construction of the data base will aid the various MSC groups in increased communications and coordinated activities. Proprietary rights to a group's data will virtually disappear unless the data requires security protection. As a result, MSC personnel will gradually think more of Center-wide needs and activities rather than group needs and activities.

The expanded capabilities can be categorized into three broad areas: real-time processing, control of applications and data, and more efficient utilization of hardware and software.

Real-time processing provides a multitude of expanded capabilities, the most important being the man/machine interaction via a remote or local terminal. MSC management will have immediate access to data concerning MSC activities and increased visibility of the many MSC efforts and activities.

Data access security protection will be one of the first DMS functional capabilities implemented. This will ensure that data security protection will be provided before any functional portions of the DMS are released for utilization.

The automatic scheduling of production applications is another significant capability provided. The operational schedule of execution could be specified to the DMS and special override conditions provided. This capability will be of considerable assistance to computer operations in the scheduling of weekly, monthly, and year-end runs.

5.5 COST

Greather throughput per computer dollar will result from the installation of a DMS. The many data structuring techniques provided by the DMS will reduce the amount of time to retrieve data, thus allowing computer applications to be processed much more rapidly. Reduced processing time means reduced costs. It is difficult to estimate the dollars saved by providing real-time access to data. In the past, managers have had to wait 12 to 24 hours for computer run results. The activities of many people were curtailed or greatly hindered by the wait. This is especially true of programmers who have to wait for turnaround on program tests.

Costs will be greatly reduced through utilization of the simplified high level programming capabilities provided by the system and the standard procedures for computer operations for all phases of the DMS activities.

The key to reduced program maintenance costs is the ease of modifications that can be made at two different program levels. At the highest level, using the DMS programming

language, program modifications and expansion can be easily implemented. At another program level, using the standardized logic modules generated by the DMS, program maintenance is also facilitated. This results largely from the fact that the basic logic design format would be known for each of the generated MSC applications functions; e.g., sorting, report generation, etc. Also important is having the generated application programs written in a high level language, such as COBOL. The high level language facilitates program modifications and expansion at the application program level.

An MSC application module (e.g., logistics, procurement, etc.) will be developed and implemented in a much shorter time. The cost savings to MSC is therefore not only in the reduced amount of application program design, implementation, and maintenance, but also in the reduced lead time required for new application implementation.

MSC has an enormous number of application data files which require file maintenance programs to keep the data current and valid. A tremendous file maintenance cost savings will be achieved for MSC through utilization of the DMS programming languages. The size of the data files and the number of the application data files will also be reduced.

There will be an initial cost for implementation of the DMS, data base, hardware configurations, and training. This cost will be minimized by the long-range savings provided when the DMS is functionally operational. The additional data processing capabilities provided by the DMS will also offset the initial cost.

5.6 SUMMARY

In summary, it is recommended that NASA MSC:

- Implement a Data Management Supervisor (DMS) that either embodies the required capabilities as set forth in this study or may easily be enhanced to include the required capabilities.
- Establish an applications/data file priority list for implementation that is compatible with lead times of known MSC missions.
- Immediately start analyzing and structuring data sets which realistically reflect MSC requirements.
- Develop a Center-wide data element and function dictionary which would be used as a management tool to control system quality and as a user tool to obtain maximum responsiveness.
- Approve and implement acquisition of long lead hardware required to support the DMS and data base.
- Develop an MSC-wide management plan that will have the effect of recognizing the data base as an on-going MSC resource and thereby delegate its control to team management decisions rather than individuals and unilateral actions.
- Select a contractor thoroughly familiar with commercial-type processing, all aspects of DMS logic, and complex and varied data base construction to implement the MSC DMS. Contractor familiarity and understanding of user requirements are essential factors to be considered.