Assessment of the State of the Art of Construction Project Data Bases: Assessment of Department of Defense Form 1391 Processor (1985)

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Assessment of Department of Defense Form 1391 Processor

Committee on Assessment of the State of the Art of
Construction Project Data Bases
Building Research Board
Commission on Engineering and Technical Systems
National Research Council

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1984 - 1985

National Research Council
Commission on Engineering and Technical Systems
Building Research Board

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EXECUTIVE SUMMARY

The construction industry is moving into an era of large scale, computer data bases for the management of construction programs. A leader in the development of this area of technology has been the U.S. Army, working through the Corps of Engineers Construction Engineering Research Laboratory (CERL). The National Research Council, working through the Building Research Board (formerly known as the Advisory Board on the Built Environment), formed a committee to review the current state of the art of data base development, it utilization in the building industries, and to evaluate a pioneering system utilized by the Army Corps of Engineers.

The stated objectives of the committee were:

1) To document the state of the art of large scale data management systems capable of being applied to the construction industry,

2) To assess the performance of the Army's DD Form 1391 Processor as a working model of this type of system, and

3) To make recommendations to the Army regarding the potential for redesign and upgrading of the Processor to bring it up to the present state of the art.

This study concentrates on data base management as it applies to building construction programs, i.e. buildings--such as those used for residential, institutional, commercial, light industrial purposes--are the object of concern, as opposed to large scale engineering projects, like nuclear power plants, utilities, or highways.

For any single building, there is a large body of data developed over its life cycle. This data is generated in scattered data subsets that need to be properly captured, stored, and managed in one integrated data base. The need for an integrated data set--a true data base--arises in response to making it effectively responsive to different users at different stages of the building construction process (see Figure 1-1).

The integrated building program data base needs to be comprehensive but not exhaustive. Comprehensive in that it provides the framework for all the building program data from initial programming activities to eventual demolition or abandonment of the building, but not exhaustive in that every piece of data produced for a building does not need to be captured by the data base. Consequently, the data base will not store all of the data generated by the various applications programs used in the building process, but only the data deemed appropriate in relation to the total program. For example, in structural load analysis calculation, primary information such as live and dead loads, wind loading, and the structural calculation information (bay sizes, column and beam sizes, locations) would be part of the comprehensive data base, but secondary information generated by the actual load calculations for any structural member would not. This data can be recreated, if desired, from the data maintained in the integrated building program data base.

The building process, from project conception through recycling, requires data of many types and in many different formats. The precursor to the successful development of a building program data base and an integrated data base management system is a comprehensive delineation (a taxonomy) of the types of data and the process steps in which the data is utilized.

In the building process the participants have a need for two basic types of data:

- General Data--generic information that does not require project definition to create; available at any time and applicable to any building project.
- Project Data--can only be generated when a specific project(s) is (are) defined.

Although there are several definitional schemes for categorizing a computer system, none of which are generally accepted or without significant mis-classification, it seems more useful to classify a computing resource as global, regional or personal. These three terms are generally analagous to mainframe, mini, and micro.

The global computing resource is an open, owner provided, universally accessible service. It provides the base computing resource for all the construction projects in which an owner has an interest (e.g., all Corps of Engineers projects).

Regional computing resources are established to support specific communities of interest where a "small" group, using a constrained subset of computing resources can be identified and shown to be cost effective.

Personal computing is a relatively new, although burgeoning source of computer resource for individual professionals. The desire for highly personalized, customized computing environments is typical of the reason for establishing this resource.

The graphic display of data, including construction related data, is nearly as old as the modern digital computer. Its widespread use in the construction enterprise is just now being experienced. The increasing capability and decreasing cost of microcomputers have brought this capacity to even the smallest design, engineering and contracting firms.

The use of an integrated data base would provide the following benefits:

1. Better buildings will result simply because more information, representing a better understanding of building design, procurement, construction and operation would be available.
2. Better operation will result because the accumulated project data base will provide the facility manager with a model for the facility.
3. Improved value will result because more data can be explored, providing greater economy and better quality.

4. Better communications will result reducing conflicts and misunderstandings.

5. Project data retention will improve the knowledge base that can be drawn on to improve future projects.

6. Building process time will be reduced because the participation of all actors in an integrated data base will result in better coordination between building phases.

The Army DD 1391 Processor

The DD Form 1391 (the "Form") is used by the Department of Defense to submit to Congress requirements and justifications in support of funding requested for individual military construction projects over $200,000. The DD Form 1391 Processor system (the "Processor") is an interactive computer program which assists users in preparing, submitting, reviewing, correcting, printing, and archiving the Forms and associated data. The Processor was developed by CERL in 1976, and has been available to the Army community at large since 1980. The Processor's main functions are to:

1. Provide interactive teleprocessing assistance in preparing and editing Forms, as well as submitting and distributing them electronically;
2. Calculate space allowances, estimate the cost for primary facilities and verify project requirements using data files stored in the system;
3. Provide for on-line retrieval and updating of background data files;
4. Provide a single source of official Forms for all concerned organizations from the installations to the staff and secretariat level of the Department of the Army (DA);
5. Facilitate the preparation, submission, and review of the Form throughout the Army.

The primary users of the Processor system are the Office of the Chief of Engineers (OCE), Major Army Commands (MACOMs), Major Subordinate Commands (MSCs), Army installations, and U.S. Army Corps of Engineers (USACE, or CE) operating districts and divisions. Information forwarded to the Congress is of Department of the Army (DA) and Department of Defense (DOD) interest. There are approximately 350 such Army activity users, located mainly in the continental U.S., but also found in the other states and territories, as well as in European countries, Saudi Arabia, Korea, Japan, and the Canal Zone. Before January 1984, less than 200 of those activities were actually using the Processor; its use has since become mandatory for preparation and review of the Forms.

The evolution of the Processor--from Form checker to Form generator, Form processor, and data transfer system--was not a planned effort. Several factors have been cited as contributing to the Processor's haphazard development and to some of its present problems. A few of those factors are: lack of project personnel continuity, a very rapid evolution, and a piecemeal approach to the many modifications that took place.

A cross-section of individual users made direct presentations to the Committee or were contacted through personal and telephone interviews by

Building Research Board (BRB) staff, in conjunction with a mail survey addressed to a larger sample of users. Direct presentations to the Committee were the primary source of information regarding evaluation and perceptions about the system by users at higher levels. Presentations were made by 12 individual users, representing five different Army activities (OCE, OACE, CERL, Hunstville Division, and CE Savannah District). Those users were selected primarily on intensity of computer utilization for Form processing and review, and on their position in the hierarchical review process for MCA program development.

Personal and telephone interviews by BRB staff complemented those presentations, as well as helping to test the mail-out survey sent to an estimated 190 distinct Army activities--Processor users--providing a broader base than personal interviews could allow. Approximately 105 of those users were installations, and the others distributed between Army commands (both MACOM and MSC levels) and CE districts.

Ninety seven users were selected for that survey, and fifty five users returned the surveys.

The comittee's observations and recommendations are contained in the body of the report, and those related to the DD 1391 Processor are summarized below. This report consists, first, of a general discussion of data base design, a review of current applications and practices, and expected developments in the state of the art. Second, the report addresses the Processor and its evaluation by a broad range of users. Technical appendices support the description of the committee's evaluation of the DD 1391 Processor.

CONCLUSIONS AND RECOMMENDATIONS ON DD 1391 PROCESSOR

Conclusions

- The Army needs an automated system to track the large volume of new projects generated each year.
- The DD 1391 Processor is a good beginning, but needs improvement and has the potential to be more than a project tracking system.
- The "user friendliness" of the present system raises serious problems in response time and in training requirements for users.
- The Processor will not achieve full capability until everyone involved with the DD 1391 process uses the system.
- The Processor calculates costs based on "ball park" estimates, which are not intended to be the costs sent to Congress, however, the time schedule does not always allow any other method of calculating costs. This raises the question of how to improve the cost estimating portion of the Processor.

Recommendations

- The Processor should be one component of a more comprehensive data base for overall program planning, design, construction and space management efforts.

1

BACKGROUND

Advanced technology is taking an increasingly important role in the building construction process. Federal agencies, particularly the Armed Forces, are at the forefront of adopting this technology to their needs since they are among the largest builders in the country. The state of the art of computer based systems for managing construction project data bases has advanced considerably beyond the early pioneering efforts by the Army. The changes and the questions that have arisen regarding the Processor's effectiveness indicate a need to assess that system to determine its role and suitability for the control and management of construction data and costs.

The construction industry is moving into an era of large scale, computer data bases for the management of construction programs. A leader in the development of this area of technology has been the U.S. Army, working through the Corps of Engineers Construction Engineering Research Laboratory (CERL). The U.S. Army maintains a large inventory of proposed and ongoing construction projects. In order to track this work through the approval cycle, each project manager is required to maintain and update a Department of Defense (DOD or DD) 1391 form describing basic project data with particular emphasis on costs. The forms are used for planning, management, budgeting and cost control. Historically, these forms were prepared, summarized and communicated manually.

In 1980 a computerized system--known as the DD Form 1391 Processor, or the "Processor"--was put in place to help in the preparation of forms and to monitor and collect data from them. The Processor, which represents a pioneering effort by the Army, is a worldwide data system which has undergone continual growth and change since its deployment. While reducing transmission time (now electronic, previously U.S. mail), improving document consistency, and automating many manual functions, some concern as to the adequacy of the Processor system has been expressed by users. The Processor is a large data management system which has changed in purpose and expanded in scope since its inception. Its users vary from field personnel in military installations to middle and senior level management (Major Army Commands, Office of the Corps of Engineers, and so on), and the terminal equipment used varies from antiquated teletype machines to microcomputers. This variety in application and use has led to varying opinions regarding the effectiveness of the Processor in its role as a data manager.

ORIGIN OF THE STUDY

The committee was formed on April 15, 1984 in response to a contractual agreement between the National Academy of Sciences and CERL.

The Building Research Board (previously called the Advisory Board on the Built Environment) formed a committee of seven experts to document the state of the art of large scale data management systems capable of being applied to the construction industry. The stated objectives of the committee were to:

1) Document the state of the art of large scale data management systems capable of being applied to the construction industry,
2) Assess the performance of the Army's DD Form 1391 Processor as a working model of this type of system, and
3) Make recommendations to the Army regarding the potential for redesign and upgrading of the Processor to bring it up to the present state of the art.

However, the committee decided in its first meeting to revise these objectives to some extent. They decided that the interim report (delivered in July 1984, because the senior management of the Corps of Engineers was scheduled to undergo major changes at that time) would include as much information as they had been able to assemble by that date, and also contain preliminary observations of the committee. They felt that this should enable the client agency to anticipate policy changes that might be required with the issuance of the final report. The committee also decided it would concern itself with the role of the Processor in the Army's entire construction program data base system, and not confine its efforts to analyzing the Processor alone. This was in line with the revised scope of work which the National Research Council had approved.

SCOPE OF THE STUDY

The present study is an assessment of the state of the art of computer data bases used for building construction programs. Buildings--such as those used for residential, institutional, commercial, light industrial purposes--are the object of concern, as opposed to large scale engineering projects, like nuclear power plants, utilities, or highways.

The advent of extensive computer usage and increasing capability per unit cost allows--or imposes, depending on the circumstances--a redefinition of the entire building construction cycle, of how to effectively achieve, with the available resources and technologies, the best building results. Federal agencies, particularly the Armed Forces, are at the forefront of adopting new technologies to their needs. This report focuses on the U.S. Army's computer needs and capabilities, particularly their activities carried out through the Military Construction, Army (MCA) Program--the largest client of the building industry in the United States.

For any single building, there is a large body of data developed over its life cycle. This data is generated in scattered data subsets that need to be properly captured, stored, and managed in one integrated data base. The extended usefulness of that data base is intimately tied to the practical integration of what would otherwise be (or continue to be) the separate, scattered, hard-to-retrieve data subsets generated by different players in the process--owners, designers, contractors, building occupants. The need for an integrated data set--a true data base--arises in response to making it effectively responsive to different users at different stages of the building construction process (see Figure 1-1). These considerations will guide the assessment of the state of the art and the development of practical advances towards satisfying those needs. The report evaluates a specific Army system--the DD Form 1391 Processor--as an early model for this type of effort, and assesses the performance of the Processor system as now being utilized by the Army.

This report consists, first, of a general discussion of data base design, a review of current applications and practices, and expected developments in the state of the art. Second, the report addresses the Processor and its evaluation by a broad range of users. Finally, the report presents conclusions and recommendations regarding the use of computer data bases for building construction programs for the U.S. Army and for the building industry at large.

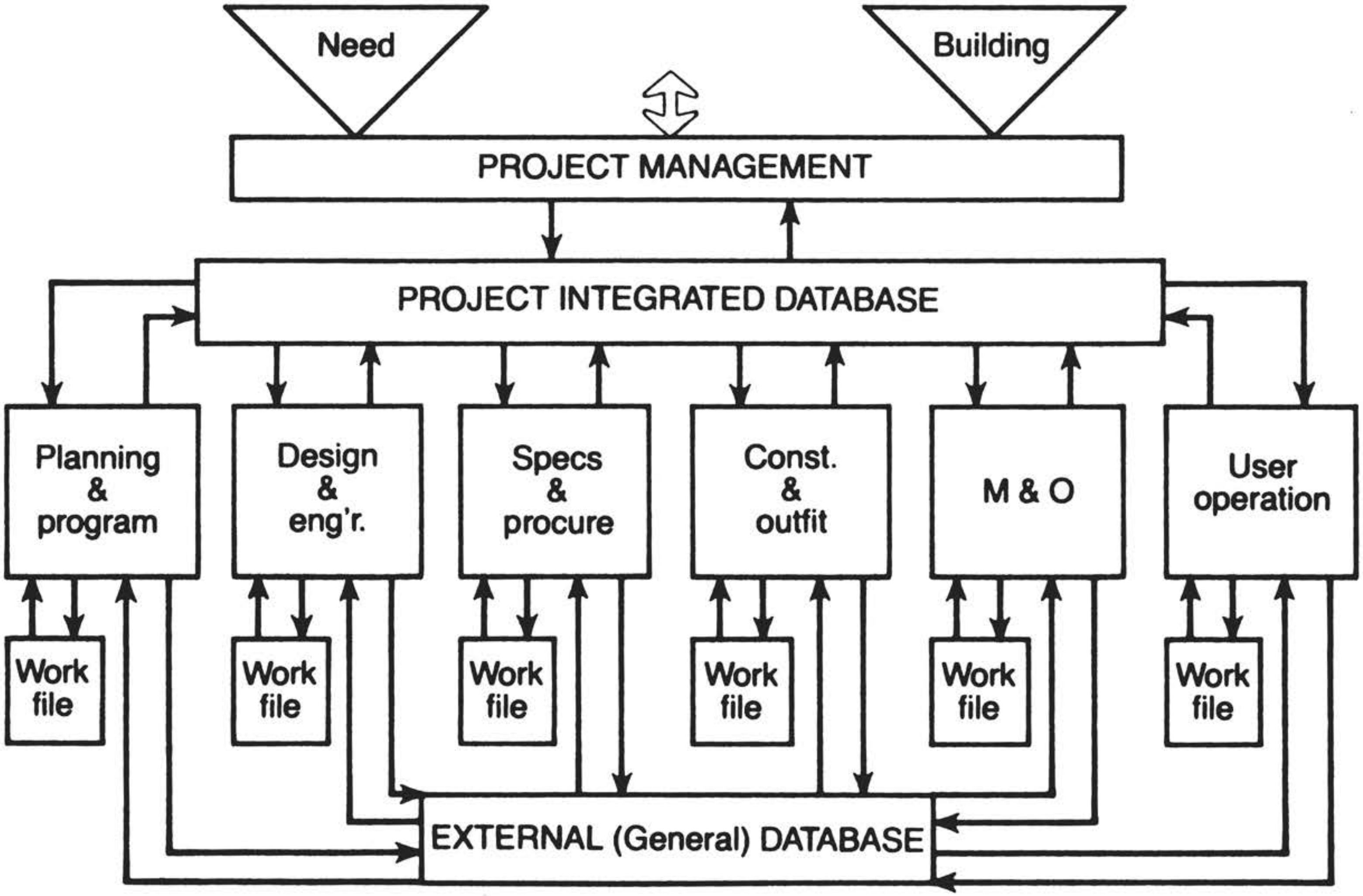

FIGURE 1-1 Different stages of the building construction process.

2

STATE OF THE ART OF DATA BASE MANAGEMENT

THE NATURE OF DATA BASE MANAGEMENT SYSTEMS

Data Base Management is a discipline of computer science concerned with applications of computer technology that provide general solutions to problems of data sharing in a computing environment. Data Base Management Systems are software packages which, when coupled with appropriate management practices and procedures, provide mechanisms by which disparate classes of computer users may share access to a central store of data.

Definitions

A computerized data base system can be thought of as a mechanism which brings together the following four elements:

USER The producer or consumer of data base content. A DBMS views users as invocations of computer programs. The term end user is employed to represent the invoker of a program, where the program may be generalized, as an ad hoc query language, or specifically tailored by a third-party programmer to the express needs of a particular end user or class of end users.

DATA BASE (DB) A minimally redundant collection of interrelated data items, representing the shared operational data for the set of postulated or existing computer programs which can be logically connected through common data requirements.

DATA BASE MANAGEMENT SYSTEM (DBMS) The set of supervisory, definitional, and storage facilities which allow for the management of data as a shared resource of an enterprise.

DATA BASE ADMINISTRATOR A person or group which defines and implements the body of rules and procedures governing the use of a data base and the capabilities and performance of the DBMS.

Objectives

The primary objectives of DBMSs as a class are to provide:

(1) Bridges by which differing information requirements can be satisfied from the same set of data,

(2) Efficient access to a data element or set of data elements,

(3) Effective report generation and presentation capability, and

(4) Assurances of information availability, ensuring the consistency, integrity, and security of data placed under their control.

Supporting Differing Information Requirements

Information requirements differ among users of a data base when there are differing perspectives on the meaning of the data in question or differing uses to which the data must be put. Information requirements may differ in many ways, as for example: in presentation medium (paper vs. computer display device), in the level of detail, in temporal relationships (the size of a building may change during the design process, but the size of a completed building as of some calendar day must forever have the same value).

Assuring Information Availability

There is no standard term for the set of goals implied by our words "information availability". The ideal objective is that no individual user of data in the data base should ever have to make any critical decision based on incomplete or invalid information, when the DBMS should have been able to supply the data required, but did not. This objective is usually subdivided into three or four other categories which strive to ensure:

1. Data consistency. This aspect of availability control is concerned with providing mechanisms by which the designers of a data base can ensure that at any instant in time, related data items represent the same underlying knowledge of the enterprise being modeled in the data base. As an example, if two records in the data base both describe the same building (one in terms of floor space, and another in terms of building cost to date), and a new floor has been added to the building, then no user could inadvertently retrieve the record containing the previous floor space value with the record containing the new construction cost value.

2. Data integrity. Data integrity controls allow data base designers and administrators to specify the DBMS, mechanisms by which only correctness preserving transformations on the data are allowed. An example would be that of guaranteeing that no record could be added or updated in the data base which used an undefined category code in the description of a building.

3. Data security. Data security controls are provided to ensure that only authorized access, entry, transformation, or destruction of the data will occur.

4. System availability. This is probably the most generally accepted objective of a DBMS. The primary requirement from the perspective of the end user is to be able to specify the operations on

data which satisfy his information requirements, and that the data system be able to update or supply data within the time boundaries implied by the particular work task which the end user must perform. If the system is unavailable to perform any critical data transfer function, then it has, for those users for which the data transfer was critical, failed in its intended function.

Attributes and Components of a DBMS

Every commercially available DBMS seeks to meet the above objectives in individual, and often proprietary ways. Figure 2-1 illustrates a typical allocation of function among the components of an idealized (and very much simplified) data base management system. The figure will be used to guide the following discussion of DBMS attributes. While the placement of functions supporting them may vary from that shown in the figure, in general every DBMS has as a minimum the following attributes:

- a data manipulation language;
- a transaction management function;
- stored definitions of the relationships among data items and among records (called variously: schemas and subschemas, directories, or internal dictionaries);
- validity control mechanisms;
- computing environment; and
- data base administration, tuning, and monitoring aids.

Data Manipulation Language

The data manipulation language (DML) translates user information requirements into physical access to the data base. Often a DBMS will support multiple DMLs by subdividing data manipulation functions (retrieval language, data definition language, file maintenance language, report generation language, etc.) or to support different classes of users. Examples of the latter would be systems which support:

- Programmers with a DML embedded in a standard computer environment language, e.g., COBOL.
- Trained, frequent users with a formal, structured DML.
- Infrequent, or casual users with natural-language or graphics oriented languages which require little or no training or practice to use.

In the idealized framework of Figure 2-1, the data manipulation function is nested at the third level (data management) of the system structure. It is the additional functions implied by this higher degree of nesting which tends to separate true data base management systems from the simpler, and usually less expensive, class of software products called file management or file query systems. Reading from

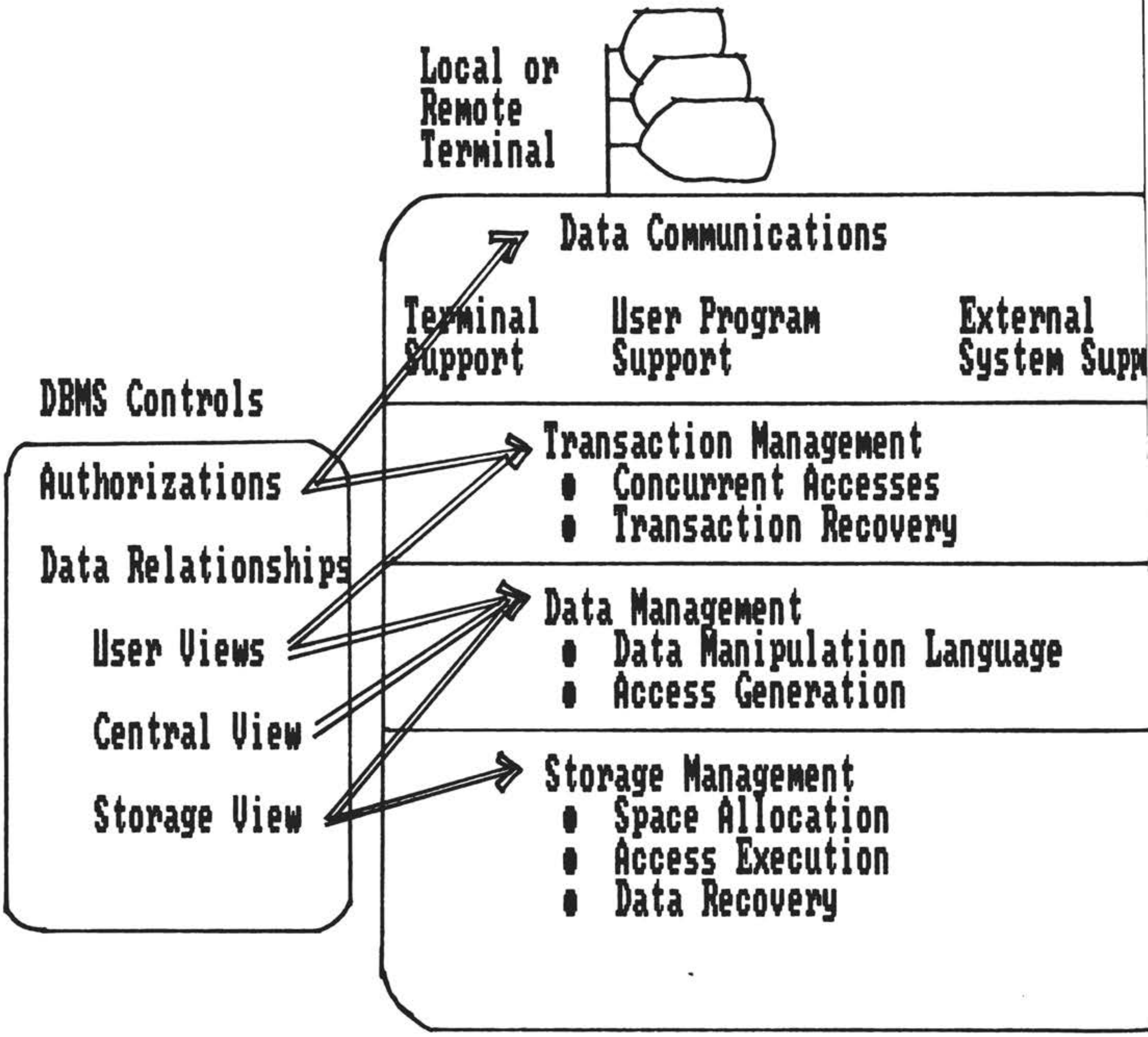

FIGURE 2-1 Components of a data base management system (DBMS).

the bottom up, the figure can be interpreted as a schematic for the evolutionary history of computer based data management, with the storage management component represented by access methods or device drivers, the data management component being added to form file management systems, the addition of transaction management providing the earliest true DBMSs and data communications facilities giving rise to DMBSs of increasing sophistication and complexity.

The existing components of simpler data management systems are not necessarily the same as their counterparts in full systems, for as the functional requirements of these systems increase, the systems tend to include expanded and improved implementations of the earlier components. At times, changes are driven by the necessity of supporting functions implemented in higher layers, but newer insights in programming and data base theory, and advances in hardware technology are as often responsible for the differences between earlier and later implementations. As an example, note the function labeled "Access Generation" in the "Data Management" component of Figure 2-1. Access Generation translates an access request specified by a set of DML statements into an efficient internal program for accomplishing the desired operations on the data base (that "internal program" is then executed by the Access Execution function of the next lower component). The Access Generation function is not an explicit element of every DBMS architecture. Its existence is in reaction to a continuing evolution in Data Manipulation Languages. Data Manipulation Languages have grown increasingly more independent of the mechanisms used in the DBMS to store and manipulate the data base.

The access generation function provides the bridge between the resulting two independent views of the data content of the system: the higher level view used in the DML, and the lower level view used by the storage management component. For those users who must directly invoke DBMS services, the DML supported by the DBMS is the first determinant of data availability. The degree to which the DML or DMLs have the expressive power and simplicity to allow an operation on the data base to be quickly defined and executed by the user determines, from the user's perspective, how quickly the system can be said to be available to support the user in the discharge of a task.

However, not every user of the DBMS must know how to use one of the supported DMLs. In most cases, large data base systems tend to employ preprogrammed data manipulation functions to support the majority of interactions with the DBMS. Reasons for doing this are manifold, but the most common justification is that by placing a predefined (and restricted) function between the end user and the DBMS the behaviour of the system is much more predictable. In a shared access environment, a careless or naive data manipulation request can monopolize system resources, and thereby jeopardize system availability for the other users of the data base. This problem is of less consequence when the online community of end users is small, since the system operators can usually detect the situation and abort the offending transaction. In larger data base systems, isolating the offending transaction, and determining that it is in fact performing pathologically can be quite difficult.

In this arena, the access generation function again comes into play. The size of the user community that an online DBMS can support through direct DML invocations is determined by the ability of the access generation routines to identify and forestall execution (or at a minimum trigger a warning to someone in authority) of data manipulation requests which have the potential of using more than their fair share of the system resources. The "fair share" may vary over time, and in peak load periods it may be necessary to completely block execution of those transactions which would seriously strain the capacities of the system. This ability to schedule transactions and balance the system load over time is the responsibility of the Transaction Management component.

Transaction Management

The Transaction Management component most directly supports the consistency objective. As the term is used here, a transaction is any set of related operations on data which must be treated by the DBMS as an elementary unit. The example in the introduction to this section which discussed the addition of a new floor to a building illustrates this notion. Until the last record has been updated, no user should be able to access any part of the data supplied to the data base by that transaction. And if the transaction fails, the transaction manager must ensure that the data base still contains a consistent set of facts.

The transaction manager is also responsible for mediating between concurrent, potentially conflicting transactions, and in essence providing an environment in which each user can be presented with a view of the system which isolates him from competing activities in the system. In this role, the transaction manager may need to restart transactions which have failed during execution, and if it can be done safely, to do so without end user awareness of the failure.

Stored Data Definitions

In Figure 2-1 the stored data definitions appear under DBMS Controls and are labeled "views". They are supplied through the DML, and include definitions of the format and content of data items (fields), how the items are to be organized into records, the relationships that the DMBS must maintain between records, and the allowable operations on fields and records.

They provide the framework within which the DML, Access Generation, and Access Execution elements can cooperate to perform the data manipulation requests authored by the system's users.

Validity Control Mechanisms

The validity controls are charged with maintaining the information validity objectives. Validity controls must be woven through the whole fabric of the DBMS and cannot therefore be easily identified within individual components. Two aspects of validity control are bound to specifications supplied through the DML and stored within the DBMS Controls component:

1. Security specifications control access to the data, defining the actions that individual users are authorized to perform, and the elements of the data base against which such actions are authorized.
2. Integrity specifications and constraints provide methods for identifying and preventing actions which would introduce incorrect data into the data base.

Another aspect of validity control, maintaining data consistency, has already been reviewed, but a fourth aspect still merits discussion, System Reliability. The measure of system reliability in a DBMS is the degree to which it can be guaranteed that no data will be lost due to DBMS component failures. The DBMS is the window through which users perceive the computing environment. From the users perspective therefore, the DBMS is indistinguishable from its operating environment, including the hardware and operating system within which it resides.

To be reliable, the DBMS must be able to maintain data consistency in the face of any failures of its own software, in the operating system, in the hardware, or even among the administrative procedures and personnel which support it. It is these computing and administrative resources, then, which supply the balance of the DBMS components.

Computing Resources

Usually, a DBMS is thought of as an independently produced, and autonomously executing (and usually very large) computer program. But as the foregoing discussion implies, the DBMS must be intimately linked to the computing environment in which it is to operate. This computing environment includes:

1. The hardware resources: terminals, data storage devices (conventionally, disks), the general purpose computer processing unit(s), and devices which tie together all of the above (teleprocessing lines, modems, channels, control units), and
2. The operating system which provides a measure of device independence for programs executing on the system.

Many DBMS will include customized extensions to the operating system to facilitate recovery strategies, improve the overall responsiveness of the DBMS software components, or bypass operating system features which are counter-productive in a data base environment. Among examples of this last would be custom written device drivers or access methods for disk management, often included in the deliverable software of a DBMS.

Less common, but growing in importance, are custom hardware components. Among the possibilities here are specialized storage devices, to facilitate storage ot extremely large volumes of data or buffer data transfers to disk for quicker accesses, and special purpose data base computers which contain large portions of the DBMS software implemented in special electronic circuitry, controlled by microcode.

Data Base Administration Tools*

Tools are an important part of the software provided with a DBMS. A minimal set would include programs to assist the system support staff in recovering lost data after a system failure, and programs to aid in monitoring and adjusting the performance of the system to adapt to changes in processing requirements, processing priorities and system load.

DATA MODELS

Another Definition

The term data model rose from obscurity in the early 1970s when the first formalism which defined one was popularized as the "Relational Model of Data." A data model is a set of rules which define ways to organize information so that it can be stored and retrieved in predictable ways. More importantly for this discussion, a data model determines the nature and complexity of the DML which a user must employ to perform storage and retrieval operations (from the users perspective, the converse could be stated, and would probably come closer to the truth: the DML determines the data model.)

The three most popular data models today are the relational, the hierarchical, and the network model. These three models all start with the assumption that facts are collected, as data items or fields, into what are generally referred to as records. A field is the label of an elementary item of information in the data base. Items can consist of text strings, numbers, graphic entities (like line segments), or anything else which can be encoded into computer storage. Records provide the labels for closely related groups of fields. The distinction between the three data models in this discussion boil down to differences in the ways relationships between records may be represented.

Rather than present all of the rules, Figures 2-2, 2-3, and 2-4 show schematic representations of the same data content as it might be stored in data bases structured in accordance with these three models. The data base in question contains records describing six employees, organized into two departments. Each of the departments is managed by an employee who must not be a member of the department managed. No employee may be a member of more than one department.

Relational Data Base Model

In Figure 2-2, Relational Data Base Model, the data has been stored in three separate tables, with each row containing a record, and each column in each record containing a single data item value. All items in a column contain the same type of fact.

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*Data Base Administration is described more fully later in this chapter.

FIGURE 2-2 RELATIONAL MODEL

(empdept)

empid	deptno
1	1
2	2
3	1
4	2
5	2

(dept)

deptno	mgrid
2	1
1	9

(emp)

empid	empname
1	Bill
2	Maree
3	Ed
4	Maree
5	Terry
9	John

FIGURE 2-3 HIERARCHICAL MODEL

(dept)

deptno	mgrid
2	1

(emp)-

empid	empname
2	Maree
4	Maree
5	Terry

(dept)

deptno	mgrid
1	9

(emp)-

empid	empname
1	Bill
3	Ed

(dept)

deptno	mgrid

↓

(no place for people with no department)

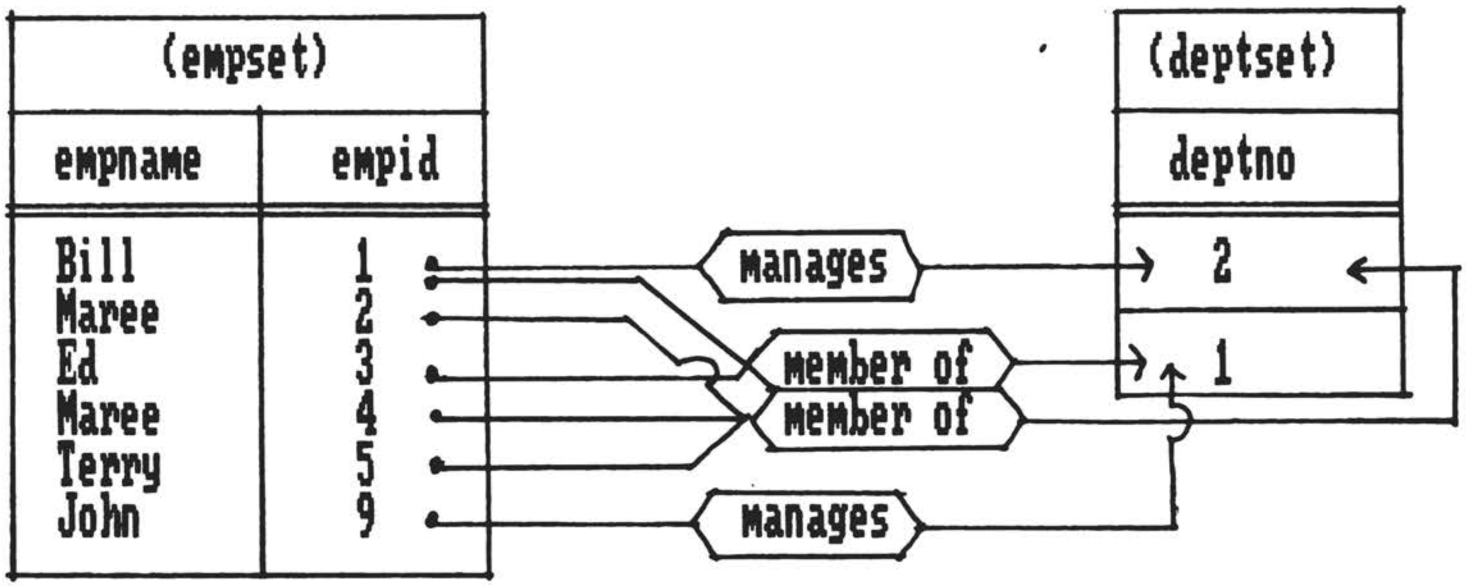


FIGURE 2-4 Network model.

The first table, named empdept, contains 5 records, recording the fact that 2 employees, identified by unique employee identification numbers, are members of department 1, and 3 are employees of department 2. The second table, dept, records the employee ID of the managers of the two departments, and the third table, emp, records the first name of each employee. Using an appropriate (relational) DML, users can determine relationships between records by matching the records on those items which have the same types of data in them. In essence, matches are allowed between items in the columns labeled empid and mgrid, or between the two deptno columns in empdept and dept respectively, but the DML should restrict attempts to match deptno with empid.

Hierarchical Data Base Model

Figure 2-3 shows an hierarchical structure containing most of the same information. An hierarchy is a structure allowing two or more record types to be asymmetrically related, such that no data can be stored in any lower level record unless and until a data record exists at the level above it. Relationships between record types within a particular hierarchy are implicit: if subordinate records exist, then by definition they are related to the other records in the hierarchy. There is no common definition of the requirements which an hierarchical DML must fulfill, mostly because, unlike the relational approach, very little work has been done on developing a correspondence between formal logic and the hierarchical model. In general, however, hierarchical DMLs do not allow specification of more than one hierarchical structure in any single access to the data base. The implications of this are that, while the example doesn't show it, a second hierarchy would have to be defined if it was required to represent situations in which an employee was not a member of any department, as is the case for employee 9 in the preceding example. This additional complexity, in essence requiring users to know of the existence of different structures and having to choose the correct one before specifying a query, makes hierarchical data bases difficult to use.

On the other side of the ledger, the constraints imposed by the model can sometimes be useful in preventing inconsistencies from being introduced. For instance, the hierarchical structure shown would not allow an employee record to be added for department 3, if no such department existed. The structure of relational tables in Figure 2-2 would not, by itself, prevent such a record from being added to empdept.

Network Data Base Model

Figure 2-4 represents a network implementation of the same data base. We have not shown the full implementation structure in order to simplify the example. The labelled lines between records show explicitly how employees are tied to individual departments. A full implementation schematic would have required an additional set of lines (probably labelled has-member and is-managed-by, or something equivalent) to show the inverse relationships between each employee and each department. In this example we have recovered the fact that employee 9 exists, even though the employee is not a member of any department. The advantage of the network structure over that of the hierarchical is that all implemented relationships can exist in a single view of the data base. The primary distinction in their DMLs is that the network DML would require the user to specify a path to the particular data element desired. Since there are four paths between employees and departments (member of and manages and their inversions), in a complex data base, it can be a heavy burden on the user to know the paths and to ensure that the data path followed actually represents the relationship he thinks it does.

Additional Observations

It should be stressed that the data models discussed above do not describe the way data is actually stored in the computer. In a modern DBMS environment, it is possible to define DMLs in all three models to access the same database. There are already several commercially available systems which claim to support at least two of them. We have not examined physical storage models in this report, but in general, they are not directly relatable to any of the models described above. To determine the physical storage model supported by a particular DBMS, one would need to examine the language used to communicate with the equivalent of the Access Execution function shown in Figure 2-1, and that function is usually very well hidden.

DATA BASE ADMINISTRATION

A large, shared data base must have a body of rules and procedures governing its use and growth. The rules which govern usage of the data base are implicit in the contents of the DBMS controls (see Figure 2-1). But these implicit rules must be changed over time to reflect the relationship between explicit policy, established through some managerial mechanism, and the dynamics of a data processing installation. As a simplistic example, the policy established by management might be:

> "For 90% of the cases, the cost estimation parameters must be supplied to the Cost Estimating Program within .5 seconds of the program's request for the data, and in no case must the delay ever be more that 5 seconds".

If the system is successful, it will become more heavily loaded over time, with more programs or end users competing for system resources. If the system is to continue to meet the above policy (specifically in this case, a service level objective), it might be necessary to raise the Cost Estimating Program's execution priority, change the physical location of the data on disk, redefine the data structures used to store the parameters, limit access to the system from competing (and presumably less influential) programs or end users, or install additional hardware.

In any data processing environment, users' requirements for data storage and retrieval change over time. Requirements changes seem to come faster in a data base environment, because that environment itself tends to serve as a catalyst which encourages discovery of new uses for the data stored on the system. Since the data base environment is one where the functions which have been developed to meet those requirements will overlap due to data sharing, adapting the system structure to accommodate changing demands and requirements must be centrally controlled. Furthermore, as the user community gains experience with the data base, and the availability of information whose very existence might not even be generally known in a non-data base environment, the pace at which additional demands are placed on the system will accelerate.

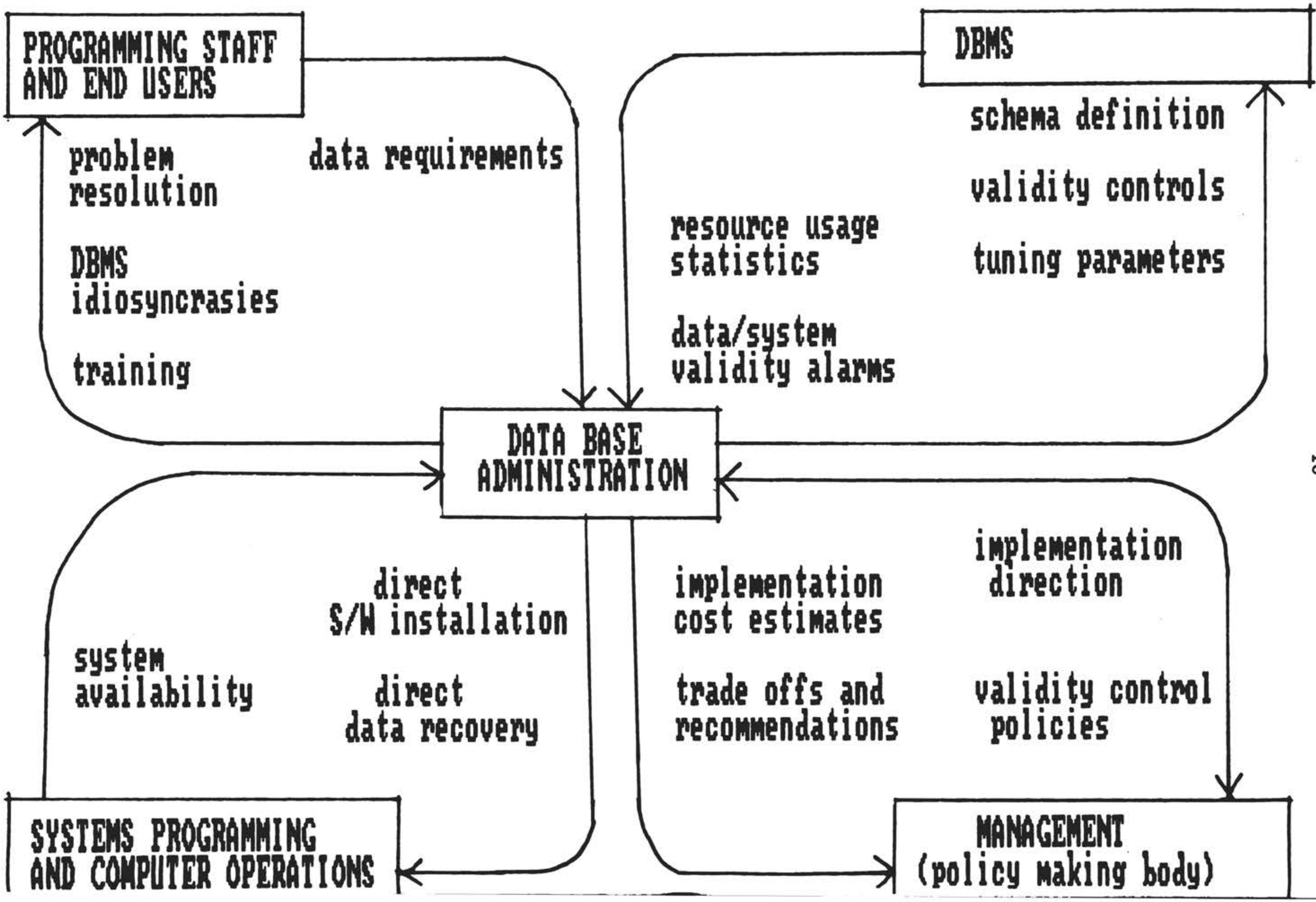
The central point for ensuring that the data base system meets and will continue to meet its objectives is the Data Base Administrator (DBA). The DBA's role is that of a trustee for the data base, much as a banker is a trustee for other people's money. And as in a bank, the administrator is usually supported by a staff. As a group, they comprise the data base administration department.

As depicted in the information flow diagram in Figure 2-5, the data base administration department is the central liaison point for all departments and individuals in the enterprise which must deal with some aspect of the central data base or the DBMS which controls it. In Figure 2-5 the arrows represent the direction of information flow and the labels next to the arrows indicate the types of information flowing between the data base administration staff and, reading clockwise, the DBMS computer programs, the enterprise management authority, the computer operations staff and systems programmers, and the end users of the DBMS and data base.

Figure 2-6 presents essentially the same information from a different perspective. It summarizes the four general areas of responsibility of the DBA department, irrespective of the functional area being supported:

- Design--creating and modifying the data base structures and DBMS software.
- Tuning--optimizing DBMS software and data structures for efficiency.
- Consultation--to users on the use of the DBMS and data base relationships; to management on current and expected requirements for improvements in DBMS software, hardware, and tools.
- Implementation--as directed by management, of data base access control (security) and data validity policies, and of DBMS software.

The composition of the department may change over time. In particular, the relative importance of data base design activity will require more strength in that arena during the development stages of the system. But throughout the life of the system, all of the skills implied by the above list must be available to the DBA in some degree.


PROGRAMMING STAFF AND END USERS
DBMS
problem resolution
data requirements
DBMS idiosyncrasies
training
schema definition
validity controls
resource usage statistics
tuning parameters
data/system validity alarms
DATA BASE ADMINISTRATION
implementation direction
direct S/W installation
implementation cost estimates
system availability
direct data recovery
trade offs and recommendations
validity control policies
SYSTEMS PROGRAMMING AND COMPUTER OPERATIONS
MANAGEMENT (policy making body)

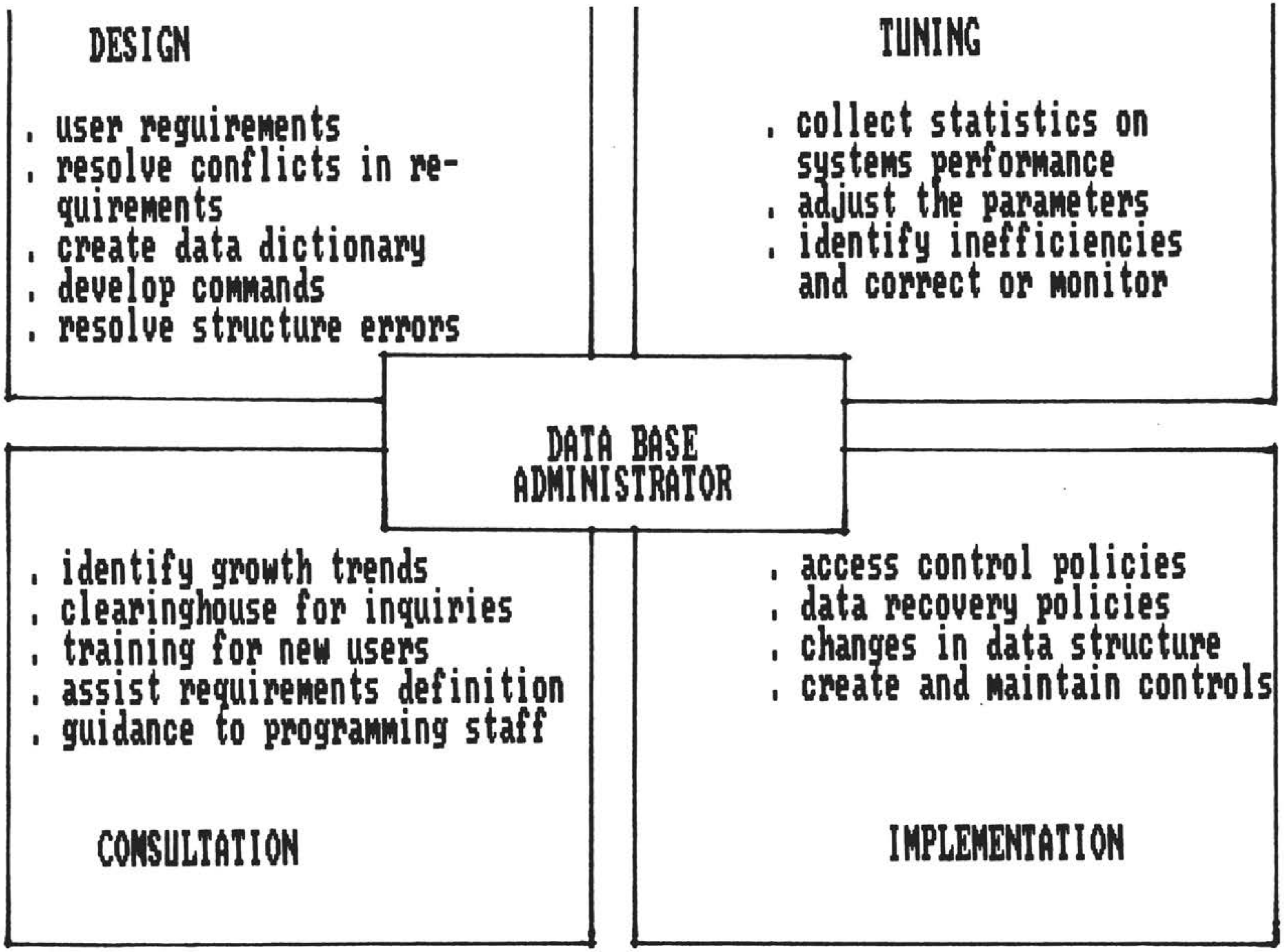


FIGURE 2-6 DBA responsibilities.

Data Base Design

The emphasis in data base design is to ferret out the elementary information concepts which the data base is intended to capture. Data base design is driven by user data requirements, and must therefore, in the early stages of a system's development, hinge on the ability of the user community to state their requirements in a precise and explicit form. It is unlikely that in any assemblage of users of a large data base, the requisite skills for such precise definitions of requirements will ever be universally available. Therefore, the DBA must supply those skills, as consulting services, to the user community. In addition to assisting the user community in defining their requirements, this aspect of the DBA's role would include acting as a mediator or negotiator to resolve conflicting user requirements.

Once identified, the data requirements for the system would be captured in a global data dictionary, which might be part of the DBMS, but could as well be a document which relates all of the individual user requirements to the set of universal information concepts which the DBMS will be expected to manage. In later stages of design, the DBA organization will convert these abstract definitions of data entities and relationships to commands to populate the set of information required for the particular DBMS to be used.

System Tuning

In their role as system tuners, the DBA department collects statistics on system performance, from the DBMS or computer operating system, and adjusts the parameters of the database system to optimize the DBMS performance for the end users. As a parallel activity, the DBA identifies potential inefficiencies in user transactions against the data base, and takes action to correct the situation or monitor it more closely.

Consultation

As the organizational center of competence for the data base, the DBA staff is expected to provide training to end users, operations staff, and programmers in the use of the DBMS and the structure of the data base. In addition they act as a clearing house, or publicly available point of contact, for resolution of inquiries about the DBMS and data base and for problem identification and resolution with respect to DBMS and data base structure errors. Finally, they are responsible for identifying growth trends in system resource requirements, establishing strategies for dealing with system growth, examining candidate data base related hardware and software alternatives, and providing make or buy supporting data to management for review.

Implementation

Because of their sensitive nature, additions or other changes to the DBMS controls are tightly managed. The DBA staff alone is responsible for implementing: access control (security) policies, data recovery policies, and changes to data structures occasioned by changes in system requirements. In addition, they are responsible for creating and maintaining those DBMS controls which enforce the data consistency and integrity policies. If decentralized access to the DBMS controls is required, the DBA is responsible for placing the appropriate tracking and security controls on the system to minimize the possibility of erroneous or unauthorized changes occurring in system definitions. In addition to the DBMS controls, the DBA staff is expected to provide guidance to the systems programming staff in installation and maintainance of externally acquired and internally developed DBMS software and tools.

3

BUILDING PROGRAM DATA BASES

THE NATURE OF BUILDING PROGRAM DATA

The building process, from project conception through recycling, requires data of many types and in many different formats. The precursor to the successful development of a building program data base and an integrated data base management system is a comprehensive delineation (a taxonomy) of the types of data and the process steps in which the data is utilized. This section outlines the steps in the building process and identifies the type of data that are required to carry out each step. The information presented is intended to give a brief overview of building data needs rather than to rigorously identify all the data requirements of the building process.

In the building process the participants have a need for two basic types of data:

- General Data--generic information that does not require project definition to create; available at any time and applicable to any building project.
- Project Data--can only be generated when a specific project(s) is (are) defined; represents two important subtypes:

  Project-Specific Data--produced as a result of an application of the building and design process.

  Experiential Data--aggregated from experience with a specific building project or a set of projects over time as the building is operated and maintained.

The decision making process which this data supports consists of a number of discrete steps which can be defined in different ways. For the purposes of this report the six steps defined in a previous work of the Building Research Board (1984 Report from the Workshop on Advanced Technology For Building Design and Engineering) have been used (see Figure 1-1). These steps consist of:

1. Planning and programming the facility needs,
2. Design and engineering development of a solution,
3. Preparation of specification and procurement contract documents,
4. Construction and outfitting of the facility,

5. Maintenance and operation of the completed project, and
6. Use and modifications of the facility.

Planning and Programming

In this step the idea for a building project or the perception of a building need is generated. This need or the perception of a need that could be filled usually comes from the owner/agent/investor. The conception will be expanded to include more or less detailed sets of requirements for space and supporting systems. Data produced here will generally be of the project specific type. In order for a project to proceed beyond the conception stage the owner/agent/investor must be certain that the market exists for the building and, if in the private sector, that risk is acceptable. (This step of market analysis could be shown as a separate and discrete step.) If the owner is in the public sector, it will be necessary to determine whether or not legislative support is likely to be available. If the market exists, the owner/agent/investors must also determine that the community in which it is to be built has land available for it and that zoning laws will allow it. The data type produced will be primarily project specific data, but access to general data on market conditions, vacant parcels of land, and regulations will also be required for analysis.

Design and Engineering

Once the potential for market acceptance of a project concept is established, it becomes acceptable to expend resources and fully define the scope of the project. Development of a project program and a preliminary design are essential parts of this step (and could be shown as a separate and discrete step in a more detailed analysis). The detail to which the preliminary design is developed depends on the financial feasibility requirements and the problems encountered in the market. To produce the financial feasibility analysis for a privately owned building project, general data is drawn on and project specific data is produced. During the financial analysis data is assembled to produce a cost estimate and to establish availability of financing. This information is weighted in various ways to determine the project's financial feasibility. A developer or manufacturer may look at return on investment while a public agency may weigh the impact on taxes against the public need and the next election. Both general and project specific data are used. If the risk is acceptable, the owners/agents/investors will proceed with the projects, assuming the need still exists. Detailed design which follows from the preliminary design has a heavy need for general technical data particularly in the form of codes and standards. The project program must be finalized and construction documents prepared based on this data.

Specifications and Procurement

This step in the construction process requires identifying potential bidders, transferring project specific data to them, preparing cost estimates, and transferring these estimates back to the owner/agent/investor. General data such as labor and material costs support this step. Equally as important is the bidder's experiential data.

Construction and Outfitting

The construction process can be viewed as the management of general and project data to coordinate the use of men, materials, and time to deliver a completed building project to the owners/agent/investors. General data such as weather, labor costs and material availability are focused on a specific project through the information provided in project data such as the construction documents and specifications. Although this task in the construction process is very project specific, it too must draw on general data to be implemented. In addition to the construction of the building, the outfitting of the building with furniture, furnishings and equipment occurs during this step. Data requirements will include occupancy requirements and permitting procedures, leasing and rental rates and tax requirements. Project data will include leasing agreements, required operating conditions, operating schedules and manuals, furniture and equipment inventories, maintenance records and monitoring procedures.

Maintenance and Operation

This building process step requires that the first four steps of the process have sufficient project specific data captured to provide the information needed by the building engineering staff, the space management staff, and others concerned with the building operation to enable them to do their jobs. Equipment maintenance schedules or the building security plans are examples of the project-specific data that is needed. During this stage much experiental data will also be generated.

User Operation

In addition to the maintenance and normal operation of the building, there is the need for the actual users of the building (e.g., employees, program managers, visitors, etc.) to have sufficient information to support their needs. This can range from providing information to employees on emergency procedures to be used in case of fire, to information provided to visitors on how to find a specific location within the building (e.g., few buildings today provide information to the visitor on where to find public restrooms). It becomes important to the owner/agent/investor of the building process to capture, for the project data base, any information about the performance of the building in order to make decisions about major modifications to the building or to modify the design criteria used for future buildings. This need for systematic collection of experiential data as feedback to future decision making is one of the major benefits that may be obtained from having a project integrated data base.

Table 3-1, Building Process and Program Data, summarizes the steps of the building process outlined above and suggests how they are related to project specific data and general data software support. The key element in this diagram is that the various participants in the process are not required to integrate their data needs and uses across disciplines, but that the overall project management protocol provides a means (probably through a "neutral" computer language) to capture, for the specific project data base, any information created.

The committee therefore recommends that the first step in the development of any building program computer data base be the development of a comprehensive data dictionary. Such a dictionary would establish common use definitions and format for building process data. The Table 3-1 indicates some types of functional data needs. Where appropriate each step is broken down into substeps. The committee would like to remind the reader that this outline is intended to stimulate thought and not provide the definitive listing of all elements of building data.

INTEGRATED BUILDING PROGRAM DATABASES

Goals and Objectives

The complexity of buildings has greatly increased over the past several years. Increased analysis requirements have caused a dramatic expansion in the quantity of data associated with a building program and have introduced more participants into the building process as new fields of specialization have been created. More information to analyze and more participants with whom to coordinate the information has left the industry searching for ways to cope with this situation.

During this period of the increasing complexity of the building process, computer based information processing expanded as the cost of computing was reduced. Participants in the building process began to automate portions of their tasks to assist them in handling the increasing data requirements and more complex analyses. However, no particular industry strategy guided this process. As hardware and software vendors, engineers and architects, builders and manufacturers, and many others perceived market opportunities in the building industry, they created products to satisfy those opportunities. The lack of a data base strategy for the overall industry has resulted in many varied software applications, operating on a variety of hardware, without the ability to electronically share data. The applications helped the individual participants in the building process improve the efficiency with which they performed their tasks, but did not provide for coordination between participants.

The software application developers had no incentive to provide a comprehensive data base structure for the entire building process. The fragmented nature of the industry allows each task to be addressed by

TABLE 3-1 Building Process and Program Data

STEPS/Substeps	GENERAL DATA	PROJECT DATA
1 PROJECT CONCEPTION	(see market study)	Proprietary business information
2 MARKET STUDY/CONCEPT FEASIBILITY		
• Establish market need	Census data Consumer needs Vacancy rates	General project description
• Identify building sites	Local master plans Zoning law Land use maps Topographic maps	Initial size estimate
• Determine community acceptance	Government policy Public need	Media reports Environmental impacts Survey data
3 DEFINE PROJECT SCOPE		
• Select design team	Professional Qualification	Selection criteria Selection procedure
• Develop project program	Space standards	Minimum requirements Past projects
• Schematic design	Site conditions	Relational diagramming
4 DETERMINE FINANCIAL FEASIBILITY		
• Cost estimate and financial analysis	Interest rates Price indices Labor & material costs Tax law	Project parameters
• Loan Placement	Loan institutions Loan requirements Funds availability	Loan amount
• Formation of partnership and syndications	SEC rules Prospectus guidelines	Agreement forms
5 GO-NO-GO DECISION	All data assembled to this point	
6 DETAILED DESIGN		
• Formalize program and confirm need	Market information	Owner needs Financial requirements
• Design development	Codes and standards Weather data Graphic standards	Project experience
• Preparation of construction shop drawings	Product information	Specifications documents and
7 CONSTRUCTION CONTRACTING		
• Bid notice		Bid form
• Bid response	Labor and material costs	Experience
• Contractor selection		Experience Evaluation criteria
8 CONSTRUCTION	Labor pools Material suppliers Code requirements	Contract documents
9 PROJECT START-UP AND OPERATION		
• Approval to place in service	Legal requirements	Project status
• Lease space	Multiple testing service Credit bureau Tax law	Space available
• Facility start-up		Required operating conditions
• Operation & maintenance	Maintenance levels	Operating schedule Maintenance levels and routine O&M history
10 RECYCLE/DECOMMISSION DECISION	Update and repeat first five process steps	

a particular software application with no regard for tasks which may precede, coincide or follow the task. Many specific task oriented software applications are available such as STRUDL for structural load analysis, BLAST for energy analysis, GDS for drafting, and PROJECT II for project management. Also, each task may have multiple software applications available. Some of the available applications programs for energy analysis, as an example, are BLAST, DOE II, TRNSYS, TRACE and AXCESS. However, data developed by these varied software packages or data required as input by them is structured differently. Consequently, one participant in the building process cannot easily share data electronically with other participants. While each participant has been automating their particular tasks in the building process to assist handling the increased analysis demanded by the more complex buildings, no one has been coordinating the overall automation effort for the industry. As a result, with all the software and hardware available for a multitude of tasks, little has been done to improve the ability to electronically share data through a common data base and any synergy possible from sharing data through some "common language" has been missed. This could be expected since the sharing of data through a comprehensive data base is principally in the interest of the owner, and the owner is not generally powerful enough to dictate the building industry's methods.

The building data base will include three different types of information:

1. In the form of text in project documents, bid documents, and specifications being too obvious examples;
2. In graphical format, the building site and plans being obvious examples; and
3. Numerical data normally displayed tabularly, accounting and financial information being the ready example.

A comprehensive building program data base is proposed as a means of accomplishing the electronic sharing of data. The objective of this data base is to provide a common framework for the interface of data relevant to the building program process regardless of what software application developed it or when it was developed. The sharing of data through a comprehensive data base can be effective in promoting information exchange between participants in the building process. Information flow is critical to the efficient execution of any building program. If effective information flow can be achieved, then resources (time and money) are used more efficiently, people are more productive, product reliability is increased, and conflicting data are eliminated. Also, data collected in a common data base can more readily be utilized as historical data in the development of statistical models.

The general flow of information in the building program process is characterized by one participant using information about the building prepared by another participant to analyze alternative solutions for the building, make appropriate decisions and pass the resulting building data to other participants. The objective of the integrated building program data base is to provide a common definition for data element types in the building program which are not part of a particular participant's analytical processes but are a part of the basic building program information. The integrated building program data base exists independently of the particular software applications analyzing and/or solving various building program tasks. It sets a "neutral language" by which these software applications can access data prepared from other tasks and, in turn, place data that has been generated at that stage in a common building program data base.

Using this neutral language, software applications can operate independently, as they have, with each participant maintaining the particular software packages desired. But, the useful data for the integrated data base can be transferred. This does not mean that each software application must utilize a common data format, only that it must be able to interface with the "neutral language" to form an integrated data base.

The integrated data base must be flexible. A static data base design will not provide for the future needs of the industry and would soon be discarded as useless. The integrated building program data base must anticipate change in the building industry. There must be the ability to add to the data base dictionary as the building industry changes. Historically, changes to the building industry are not radical or numerous, but there is a continuous stream of changes. Any change could effect the data base. Expandability is the essential element in flexibility, but there must also be the ability to redefine data if necessary. The data base must anticipate changes in the process, materials and participants.

The loss of information in the building program process can be greatly reduced through the use of an integrated building program data base. To assure that the data in the data base is available when needed, the integrated data base should provide for the data to be captured at the earliest possible moment. The sooner the data are captured the sooner it is available to the other participants and the less likely it is to be missed. It is recognized that this data will possibly undergo several changes during the life of the building program, consequently the data base design should allow appropriate participants to change data and automatically set flags on data elements that are interrelated to the changed data or automatically update the interrelated data.

APPLICATIONS IN THE BUILDING INDUSTRIES

There is not one industry for building, but at least five industries with separate structures, organizational goals, labor pools and financial incentives. These industries range from the speculative home builders to the industry that constructs large-scale civil works projects. The emphasis of this report is placed on the conventional set of relationships between clients, designers and builders as generally applied to the construction of public buildings or the construction by large private owners.

The current state of the art of computerization in the industries of building appears to be best categorized as a series of independent systems, both hardware and software, developed primarily to aid a particular phase of the generation/design process and often a particular user. These systems can be linked by a common data base, which attempts to enhance the efficiency of each individual software package. The state of software development in each phase of the building process is discussed below.

Planning and Programming

There are a multitude of software packages currently available to assist with determination of the economic feasibility of any project. The results of utilization of such packages serve as a prime determinant in site selection, building size, total cost and payback period. The majority of these types of packages have been developed by economists and accountants to provide clients with hard cost data upon which to base a decision to build.

Design and Engineering

Moving into the design phase of any project, there are systems available which are comprised of modular software programs which directly assist in the generation of facility design solutions. One such system, representative of the type of system currently available in the marketplace is "The Integrated Design Series," developed by Calcomp[1] of Anaheim, California. The system supports multiple workstations that operate independently or as part of a network. Information transfer is managed either by the workstations themselves or by a centralized peripheral manager which also controls output devices and multiple disk drives. The system is compatible with drum, beltbed, flatbed or electrostatic printers and digitizing equipment which can capture data from existing documents.

The Calcomp system combines the following functions into one packaged software system:

- Site Planning and Preparation
- Structural Design
- Architectural Design
- Architectural Production
- Architectural Costing
- Report Writer
- Facilities Planning and Management
- Automatic Stacking and Blocking
- Thermal Analysis
- Mechanical Ductwork
- Electrical Design
- Solid Modeling

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[1]Mention of specific products and companies does not imply endorsement, but is intended to be helpful to the reader who wishes to explore such developments in greater depth.

The system has been perfected to the point where information from one software package can be accessed and utilized by another function; for instance, information about furniture and equipment from the Facilities Planning and Management Package is available to the Thermal Analysis Package which utilizes some of the data to determine HVAC requirements. In turn, the HVAC requirements calculated by the Thermal Analysis Package are accessible to the Mechanical Ductwork Package, which automatically generates ductwork drawings.

The following capabilities are combined into another system, operated by Leo Daly Associates of Omaha, Nebraska (a large architectural/engineering firm which employs approximately 500):

- BDS--three-dimensional Building System Design
- GDS--General Drafting System
- SPECS--Master Spec Edit
- STRESS--Structural Engineering System Solver
- HCIII-- " " " "
- POSTEN-- " " " "
- ANSYS--Structural Engineering System Solver
- PLOT 7--Shear, Moment, deflection of Continuous Beams
- PCAVC--Ultimate Strength, Conc Columns
- AHV--Also programs for Coils, Fans, Ducts
- SUPERDUCT
- Lighting Fixture Economic Analysis--Also Lighting and Lumen Analysis Program
- SCKT--Short Circuit Analysis
- FDR--Feeder Calculation Program
- COGO--Civil Engineering Coordinate Geometry
- Digital Terrain Model
- Project Cost History
- Construction Progress Schedule
- CPM
- DATATRIEVE
- Energy Cost Analysis Programs

The data collected for and generated by each of these functions can be passed from one system to another, but the entire system does not operate interactively, e.g., more than one software function does not operate on the data at one time.

CAD systems can also produce data for input into analysis programs and into material tracking systems, but once again, data is transferred from one system to another for utilization. Likewise, in construction tracking and productivity measure systems, most are independent systems, which, at best, get their data from a computer file which is passed between systems.

There have been major recent advances in linking Computer-Aided Design Systems to Three-Dimensional (3D) Modeling, which in turn, also issue material and labor take-offs and aid in management of scheduling and costs. The literature of one such system, developed by Bechtel Power Corporation, states "The 3D design model is 'built' by designers from each discipline ensuring consistency and good coordination. Once the model has been verified and checked for interferences, a drawing extraction process is used to generate material requirements." The same literature goes on to state, "As the model is constructed, material is automatically stored. This data may be extracted at any time, referenced against specifications to obtain stock codes and then reported or passed through other computers as an input to material control programs. The system also allows entry of implied, non-modeled items, such as bolt sets, to ensure completeness of material take offs. Weight determination is carried out in a similar manner, with center of gravity calculations being performed at report time."

In addition, computer images with the quality of color photographs can be created by sophisticated modeling techniques utilizing a high resolution display screen--1280 by 1024 pixels--representing the state of the art in the creation of realistic images. When it becomes possible to create realistic photographic quality images through the use of computer graphics, a new mode of practice is possible for both the designer and the client. The photographs will provide all parties in the construction process with an easily comprehended means of communication. This could potentially change the way that construction documents are produced and utilized in the field.

In the realm of lower cost CAD systems, software is now available to include data base extraction, including bills of materials. Software also includes the ability to generate perspectives automatically and to extract and manipulate data from drawings. It is now possible to download data files into programs such as Lotus 1-2-3 to utilize the spread sheet capability for cost calculations. Drawings can be transferred via telephone lines from architect to engineer for coordination on a concurrent basis. There may be a role for personalized data bases based on a relational data base framework such as the "query-by-example" framework. The possibility also exists to network several workstations enabling work to be produced concurrently on structural, mechanical, electrical, interiors and so on while using the same floorplan. In order to verify the coordination between disciplines, the levels on which each specialty worked can be superimposed over each other.

In a recent report produced by the American Institute of Architects, a listing for a typical set of the required hardware for a low-cost CAD system totaling less than $15,000 was indicated. Such low costs are making CAD available to many more firms than just a short time ago.

The Corps of Engineers, working with the University of Michigan's Architectural Research Laboratory, has been developing a similar approach to computer-aided design termed CAEADS--Computer-Aided Engineering and Architectural Design System. A recent report regarding this system terms it "a collection of interactive computer programs for the specification, analysis and documentation of building designs." The current system includes:

- ARCH:SKETCH--Architectural Plan Sketching Program
- ARCH:HVAC--Mechanical System Definition Program
- ARCH:SITE--Site Plan Sketching Program
- ARCH:CALC--Electronic Worksheet for Design Evaluation
- ARCH:MODEL--Geometric Modeling Relational Data Base System
- ARCH:DRAFT--Computer-Aided Drafting System

In addition, the following subsystems are under development:

- ARCH:STRUCTURE--Structural Design Definition Program
- ARCH:LIGHTING--Lighting System Definition and Analysis Program
- ARCH:MASSING--Three-Dimensional Graphic Output Program
- ARCH:ACOUSTICS--Acoustic Analysis Program

This system also has a grouping of allied software products which interface with other programs:

- DIS--Design Information System
- ABES--Automated Budget Estimating System
- CACES--Computer-Aided Cost Estimating System
- DD Form 1391 Processor
- EDITSPEC--Computer-Aided Specification Preparation System
- BLAST--Energy Analysis
- HANDICAP--Handicap Access Evaluation

A majority of these programs were not prepared for CAEADS, but were assembled into the system after development for other purposes. This creates some data interface problems, so that while data is shared, it has not, as yet been truly integrated. However, CAEADS is attempting to integrate many aspects of the design process into a common interdisciplinary computer-aided design system.

The Air Force Engineering and Systems Command (AFESC) is developing a cost control system, the Construction Cost Management and Analysis System (CCMAS). CCMAS is intented to assist the Air Force, as building owners, in controlling the cost of their facilities. This cost management system is integrated for all program stages and will be able to prepare cost analyses for any stage of the building program. CCMAS will be able to handle major construction programs of the Air Force (such as the MX) and provide cost reports at the detail line item level, such as tons of steel, or summarize at various levels, such as: facility cost, fiscal year cost, or total program costs.

Construction Process

Within the actual construction process, computers are primarily used to handle accounts payable, accounts receivable and job cost information. In a recent article in The Builder (July 1984), it was reported that the most popular applications for expansion are word processing, scheduling and market analyses. There are very few instances, however, of computers being utilized by construction firms to maintain project data base information at actual construction sites. Bechtel Power Corporation is an exception by using computers to track material deliveries, inventories and site locations. They have also developed a data dictionary in which the data elements are defined and input requirements are specified. The success of the process is totally dependent upon the timeliness and quality of the data provided.

In addition to the above uses, computers are heavily used for word processing, messaging systems and project accounting. At times, these functions are run on the same computers as CAD systems. Word processing interfaced with CAD produces the ability for report generation directly from the construction documents. Thus, the state of the art in both the private and public sectors is progressing toward an integrated data base for the building process. Since an integrated data base has not yet been achieved, a look at the opportunities and advantages which would result from such a creation might prove beneficial. The following points were extrapolated from A Report from the Workshop on Advanced Technology for Building Design and Engineering.[2]

The use of an integrated data base also offers opportunities for innovation such as:

1. Retention of data between phases and transmission over boundaries for use by all participants involved in data creation,
2. Re-alignment of traditional industry relationships to overcome standing conflicts,
3. Overcoming industry attitudes to data interchange and use,
4. Introduction of a role for project data base management and administration,
5. Potential for minimizing liability through improved design and rapid access to current state-of-the-art technologies.

Maintenance and Operations

In the area of the building process computers are commonly applied by building owners to establish building management information systems (MIS). These systems support maintenance and operations by supplying integrated maintenance procedures and schedules and by prompting the operators as to what maintenance is required at any point in time. The more sophisticated systems will allow you to collect historical data, perform operational analyses, and make repair or replace decisions.

The computer can also aid directly in the operation of a building by being tied into sensors and controls that allow it to monitor such things as comfort conditions, security, and life safety. This monitoring and control of a building creates a performance history that can be captured in the MIS.

User Operation

Computers have not currently gained much application for user operations in buildings. However, the potential exists to provide users access to building use data via computer terminals and to monitor the space use of buildings by their occupants so that future design could be improved.

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[2]Washington, D.C.: National Academy Press, 1984.

4

CONCLUSIONS AND RECOMMENDATIONS ON GENERAL DEVELOPMENTS

CONCLUSIONS

Data Base Management is a discipline of computer science concerned with applications of computer technology to providing general solutions to problems of data sharing in a computing environment.

The complexity of buildings has greatly increased over the past several years. Increased analysis requirements have caused a dramatic expansion in the quantity of data associated with a building program and have introduced more participants into the building process as new fields of specialization have been created.

The lack of a data base strategy for the overall industry has resulted in many varied software applications, operating on a variety of hardware, without the ability to electronically share data. These applications have helped the individual participants in the building process improve the efficiency with which they perform their tasks, but has not provided for coordination between participants.

While each participant has been automating their particular tasks in the building process to assist handling the increased analysis demanded by the more complex buildings, no one has been coordinating the overall computerization effort for the industry.

Data collected in a common data base can more readily be utilized as historical data in the development of statistical models.

The integrated building program data base needs to be comprehensive but not exhaustive. Comprehensive in that it provides the framework for all the building program data from initial programming activities to eventual demolition or abandonment of the building, but not exhaustive in that every piece of data produced for a building does not need to be captured by the data base.

State of the Art of Systems

The current state of the art of computer use in the industries of building appears to be best categorized as a series of independent systems, both hardware and software, developed primarily to aid a particular phase of the generation/design process and often a particular user. These systems can be linked by a common data base, which is currently not fully integrated, but which attempts to enhance the efficiency of each individual software package.

There have been major recent advances in linking Computer-Aided Design Systems to Three-Dimensional (3D) Modeling, which in turn, also issue material and labor take-offs and aid in management of scheduling and costs.

State of the Art of Software

The only real impediment to accelerated use of computers in the building industry is the lack of good software and the relative high cost of developing it compared to hardware cost. However, in the near future we should see advances in computer software and in hardware technology that will permit greatly expanded building applications.

We can expect more opportunities for common applications software through the global, regional and personal computing levels as more sophisticated operating systems become available on mainframes and personal computers.

Computer-based techniques for editing and formatting text are well developed--one might say that the state of the art is quite advanced.

The state of the art in the use of computer-based graphics will only be reached when a standard data model and organizational protocol are accepted by all parties to the building enterprise. Such a condition is likely only if the owner pre-specifies such for the participants of the project.

The principle changes expected in software over the next 5-10 years will be driven by the proliferation of personal computers. The user interface for global and regional computing resources can be expected to improve significantly because personal computers are increasingly the mode of interface.

We look for continued development of integrated design and drafting software for architects and engineers from a number of vendors. However, it is not reasonable to expect that software houses will produce integrated software to address the entire building enterprise. The dominant parameter in increased computer use will continue to be the development of specific applications software. Those software packages with a large installed user base are likely to increase their market share and generate de facto data and file transfer standards for the construction industry. It appears that in-house software development by design professional firms will continue because of the lack of suitable software in the market place.

State of the Art of Hardware

Supercomputing has not been an issue for applications in the building industry and is not likely to become so in the near future. More importantly, spin-off developments from this effort are not likely to impact the building industry in the next five or ten years.

We look for major improvements in the area of communications.

We expect modems operating at 2400 to 9600 bps to soon supplant the low band width devices now standard and we foresee a trend to more reliable, synchronous protocols.

The development of local area communication networks and the necessary gateways to external networks should cause a shake-out among competing file transfer protocols. This too will accelerate the move toward national available data bases.

We can expect the near term development of true, high resolution graphics on microprocessors. The major problems that will need to be addressed are primarily the peripheral devices. High quality drafting devices are likely to remain too expensive to be considered peripherals for personal computers.

It seems likely that raster devices will replace vector devices in nearly all applications--displays as well as hard copy output.

There are a large number of potential applications for voice systems in the building industry. Continued developments in synthesis and speech systems can be expected but no short-term (5-10 years) impact on the building industry can be expected.

The Japanese initiative in the field of artificial intelligence, and the competition it has spawned in the United States, suggest that the building industry can expect some short term spin-off applications. Many of these will come in the form of improved, more iconic, user interfaces. Perhaps the largest impact on the building industry will come in the form of expert systems aiding in, for example, code compliance, engineering constraints.

The cost of computer hardware will continue to fall, permitting still larger applications at even more cost effective ratios. The research and development of the computer industry will continue to support the development of hardware advances, so that there are no constraints with respect to hardware capability or costs.

In general, the present requirements of construction management programs would not be a technical challenge to the current state of the art of commercially available DMBS software packages. This is true so long as the issue is restricted to consideration of data bases which would be centrally stored and managed by a single computer system.

The fragmented nature of the construction industry makes it unlikely that any DBMS or data base design would appropriately serve the needs of every organizational user that wished to use a data base system for tracking their construction program. In smaller organizations the emphasis would have to be on ease of use and minimum requirements for computer skills, and would not likely, as a consequence, be multi-user systems. Many packages exist for single user systems which have easy to use DMLs tied to simple file systems, and there is a broad range of mini computer packages which have some true DBMS capabilities and can support simultaneous retrievals from multiple terminals.

For larger organizations, primarily government agencies, the mainframe based DBMSs are necessary. There would be questions about the need for distributed data base systems in these environments. The advantage of distributed systems is that the data can be placed physically closer to the end users. In a DBMS environment, the distributed system acquires a larger role. It must not only store data closer to the most worthy user (where worthy itself has some obvious ambiguity), but must continue to shield all users from concerns about the location of data in the data base. In other words, the only difference an end user should see between the behavior of a distributed as opposed to a centralized DBMS, is the possibly improved response time for queries to local data. Also, the end user may not know whether a query involves purely local data or not. The resulting complexity of distributed approaches to data base management has so far proven intractable in practice, to the end that as of this writing, there are no viable commercial DBMS which support true distributed data base management, and research efforts, while showing some promise, are still a long way from proving that true distrubuted DBMS are even theoretically possible.

RECOMMENDATIONS

Data base management technology must be advanced to make feasible integrated building processes data base. This should be a joint effort of the computer industry, the building industries, and the owners/ operators of buildings. The committee recommends that the first step in the development of any building program computer data base be the development of a comprehensive data dictionary. Such a dictionary would establish common use definitions and format for building process data.

A comprehensive building program data base is proposed as a means of accomplishing the electronic sharing of data. The objective of this data base is to provide a common framework for the interface of data relevant to the building program process regardless of what software application developed it or when it was developed. The sharing of data through a comprehensive data base can be effective in promoting information exchange between participants in the building process.

The integrated data base must be flexible. A static data base design will not provide for the future needs of the industry and would soon be discarded as useless. The integrated building program data base must anticipate change in the building industry. There must be the ability to add to the data base dictionary as the building industry changes.

The loss of information in the building program process can be greatly reduced through the use of an integrated building program data base.

The sooner the data are captured the sooner it is available to the other participants and the less likely it is to be missed.

Integrated text and graphic devices (of laser quality) are more likely to become the dominant technology. If this happens, the building industry will need to re-think its conventional documentation (through standard design drawings) strategies.

These developments should be a joint effort. The computer industry should concentrate on the improvement of generic data base management technologies and the associated hardware; the building industries should work on the definition of the building processes and the development of a data dictionary; and the owners/operators should develop standards and requirements for the data base management system. The Building Research Board of the National Research Council should act as a catalyst in the development of this effort by enlisting the participation of the large programs of federal agencies.

5

DD FORM 1391 PROCESSOR

SYSTEM DESCRIPTION

The DD Form 1391 (the "Form") is used by the Department of Defense to submit to Congress requirements and justifications in support of funding requested for individual military construction projects over $200,000. The DD Form 1391 Processor system (the "Processor") is an interactive computer program which assists users in preparing, submitting, reviewing, correcting, printing, and archiving the Forms and associated data, in accordance with Army Regulation (AR) 415-15, "Military Construction, Army (MCA) Program Development." The Processor was developed by CERL in 1976, underwent initial fielding in 1979 by the U.S. Army Huntsville Engineer Division (Huntsville Division), and has been available to the Army community at large since 1980. According to AR 415-15, the Processor's main functions are to:

1. Provide interactive teleprocessing assistance in preparing and editing Forms, as well as submitting and distributing them electronically;
2. Calculate space allowances, estimate the cost for primary facilities and verify project requirements using data files stored in the system;
3. Provide for on-line retrieval and updating of background data files;
4. Provide a single source of official Forms for all concerned organizations from the installations to the staff and secretariat level of the Department of the Army (DA);
5. Facilitate the preparation, submission, and review of the Form throughout the Army.

Most Army military construction programs are supported by the Processor. The system currently accomodates project preparation and tracking for the following major programs:

- Military Construction Army (MCA) and minor MCA projects
- Army Family Housing (AFH)
- Non-Appropriated Funds (NAF)
- Maintenance and Repair (M&R)
- Production Base Support (PBS)

Army National Guard projects are planned for inclusion in the near future, Army Reserve projects later on. A sample of a filled out Form is presented in Appendix A, which describes several features of the Processor system.

Processor Files

There are approximately 6,000 current Forms accessible through the system, and approximately 400 forms are completed and archived annually. Growth in the number of Forms actively managed and periodically retired is expected. Extensive support files embedded in the Processor include:

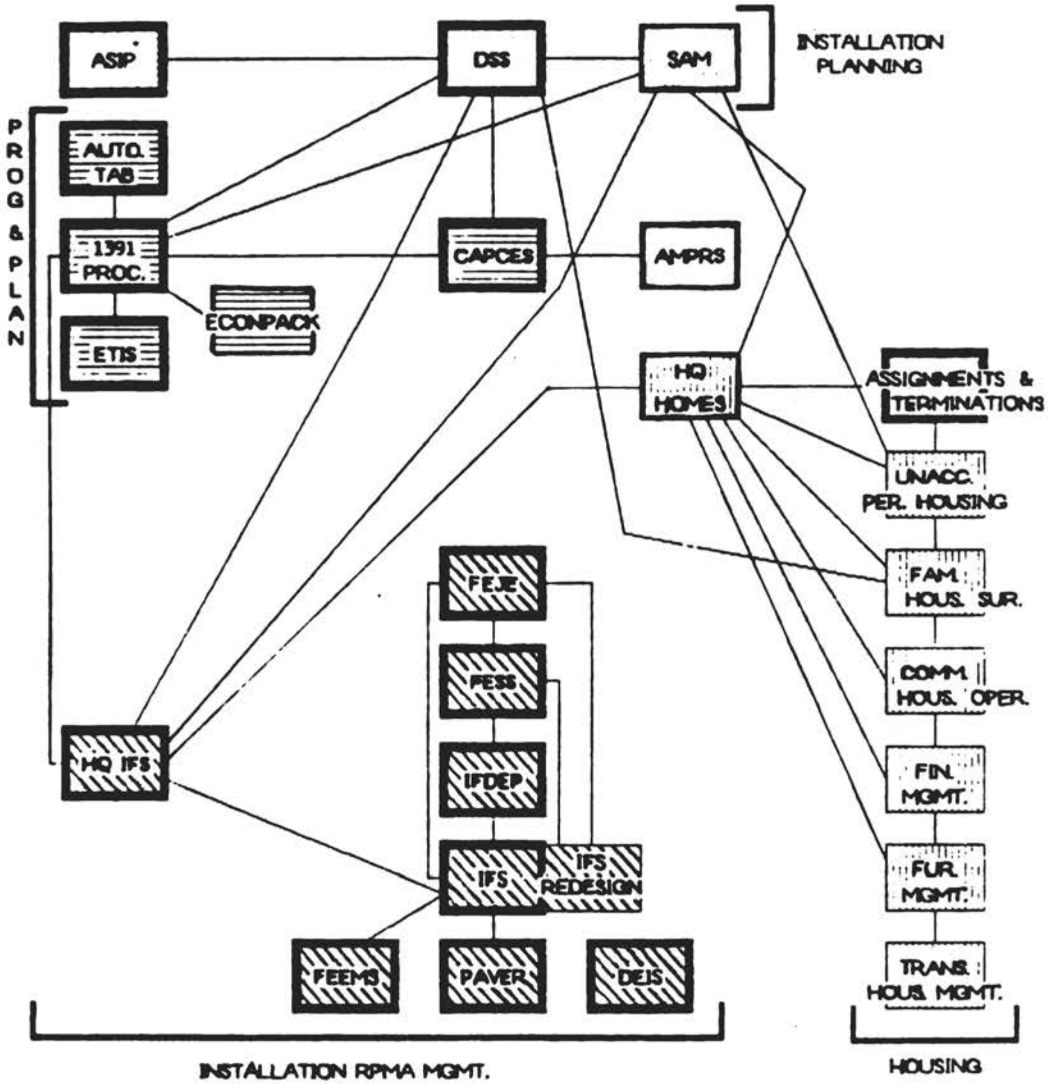
- Space allowance criteria for various AR 415-28 Facility Classes and Construction Category Codes, provided by table lookup or formula;
- Empirical cost estimates based mainly on AR 415-17 (Cost Estimating for Military Programs), for computing facility cost per square foot in terms of size, location, construction time midpoint (cost growth), technological complexity, construction type (permanent, semipermanent, temporary), modernization, and cost data reliability;
- Project requirement and deficiency based on several factors, including the projected military strength from the Army Stationing and Installation Plan (ASIP), data from AR 210-20 DA Form 2369 (Tabulation of Existing and Required Facilities - TAB), and data from AR 210-18 DD Form 1657 (Determination of Bachelor Housing Requirement).

The Processor system is available, along with several others, within the framework of the Military Construction Programming Administration and Execution System (PAX). The relationship of the Processor to other OACE applications is presented in Figure 5-1, which displays OACE's automation network. In Appendix B, a brief description of other important PAX systems is presented.

Data transfer between PAX systems, and even access to data from its support files, is not automatic. Out of a minimum of 55 interfaces between six major support files and 18 major project systems (identified by a CERL-sponsored project, Data Traffic Management System), only two interfaces so far have been completed. One is the interface between the Processor and the Construction Appropriations Control and Execution System (CAPCES), the other between CAPCES and the Automated Military Program System (AMPRS).

System Architecture

The organization of the full Processor and of its existing related routines is presented in Figure 5-2. The System Performance Monitor is currently limited to examining Processor Monitor Commands.



	ACRONYM	NAME
o	AMPRS	Automated Military Program System
o	ASIP	Army Stationing and Installation Plan
o	CAPCES	Construction Appropriations Programming, Control, and Execution System
o	DSS	Directed Stationing System
o	ECONPACK	Economic Analysis Package
o	ETIS	Environmental Technical Information System
o	FEJE	Facilities Engineering Job Estimating System
o	FESS	Facilities Engineering Supply System
o	HQ HOMES	Housing Operations Management System
o	HQ IFS	Headquarters, Integrated Facilities System
o	IFDEP	Integrated Facilities Data Entry System
o	IFS(REDESIGN)	Integrated Facilities System (Redesign)
o	PAVER	Pavement Maintenance and Repair System
o	SAM	Stationing Analysis Model
o	TAB	Tabulation of Existing Facilities (DA 2369)
o	1391 PROCESSOR	Automated DD Form 1391 System

FIGURE 5-1 OACE automation network (OACE, 1984).

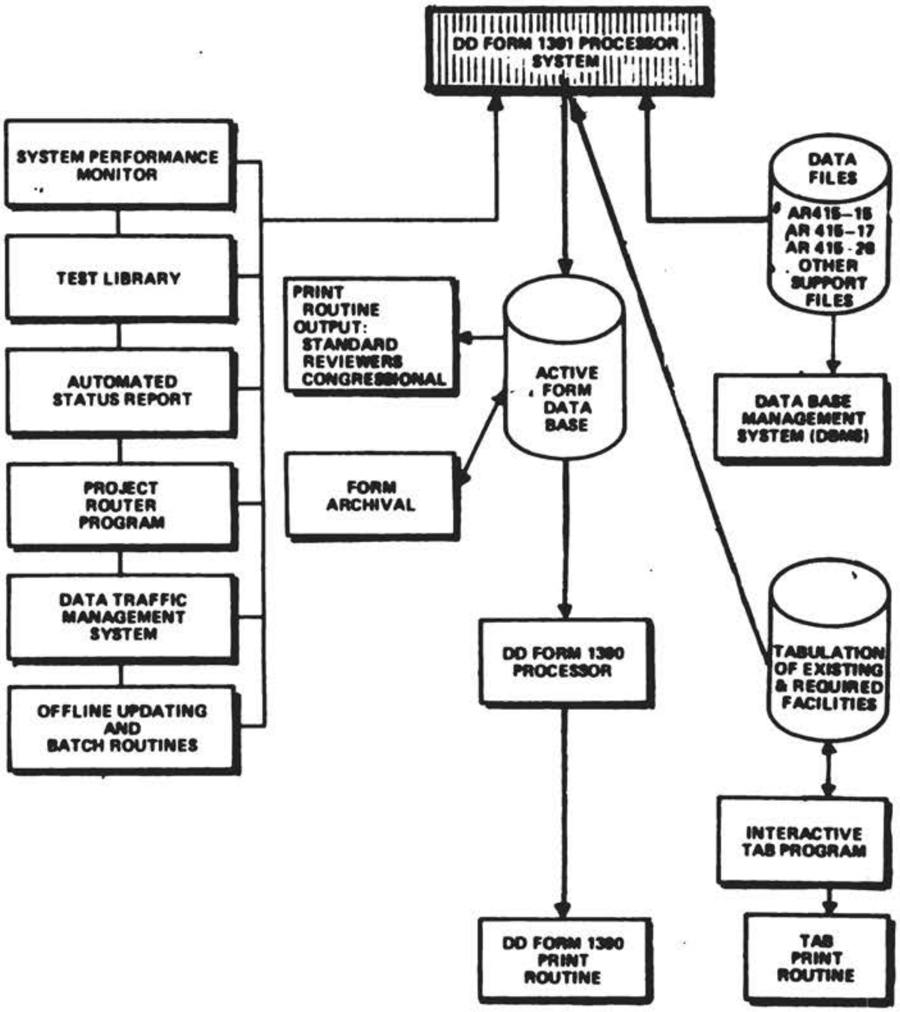


FIGURE 5-2 DD Form 1391 Processor system architecture (Huntsville Division, 1984).

USERS

The primary users of the Processor system are the Office of the Chief of Engineers (OCE), Major Army Commands (MACOMs), Major Subordinate Commands (MSCs), Army installations, and U.S. Army Corps of Engineers (USACE, or CE) operating districts and divisions. Information forwarded to the Congress is of Department of the Army (DA) and Department of Defense (DOD) interest. There are approximately 350 such Army activity users, located mainly in the continental U.S., but also found in the other states and territories, as well as in European countries, Saudi Arabia, Korea, Japan, and the Canal Zone. Before January 1984, less than 200 of those activities were actually using the Processor; its use has since become mandatory for preparation and review of the Forms.

The relationships between the major players in the Form cycle are displayed in Figure 5-3. Installations initiate the process by submission of Forms, which are aggregated at MSC and MACOM levels and reviewed at each stage by the appropriate CE Division or District. Forms are submitted to OCE for final revision, aggregated at DA level, and presented, in a slightly different format (the "Green Book") for Congressional review. A more detailed description of the process is shown in Figure 5-4, "MCA Program Development Flow Chart".

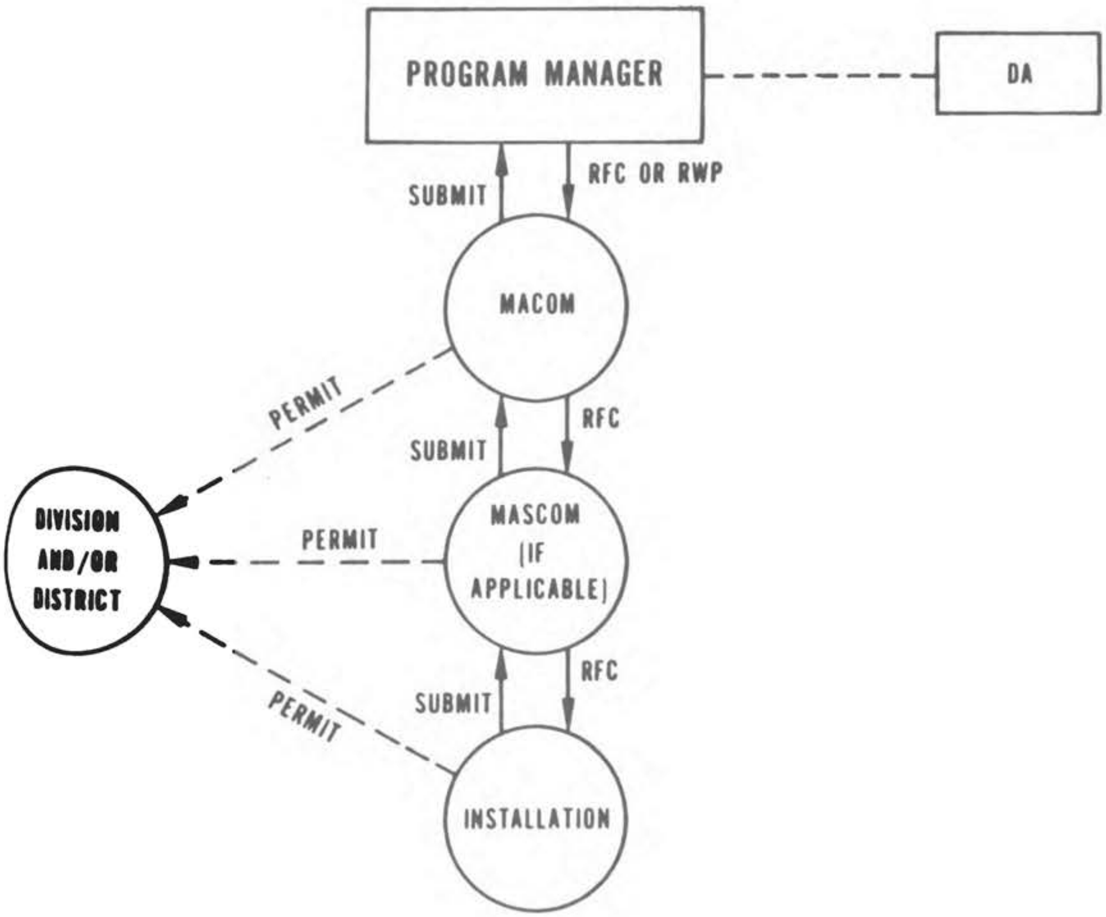
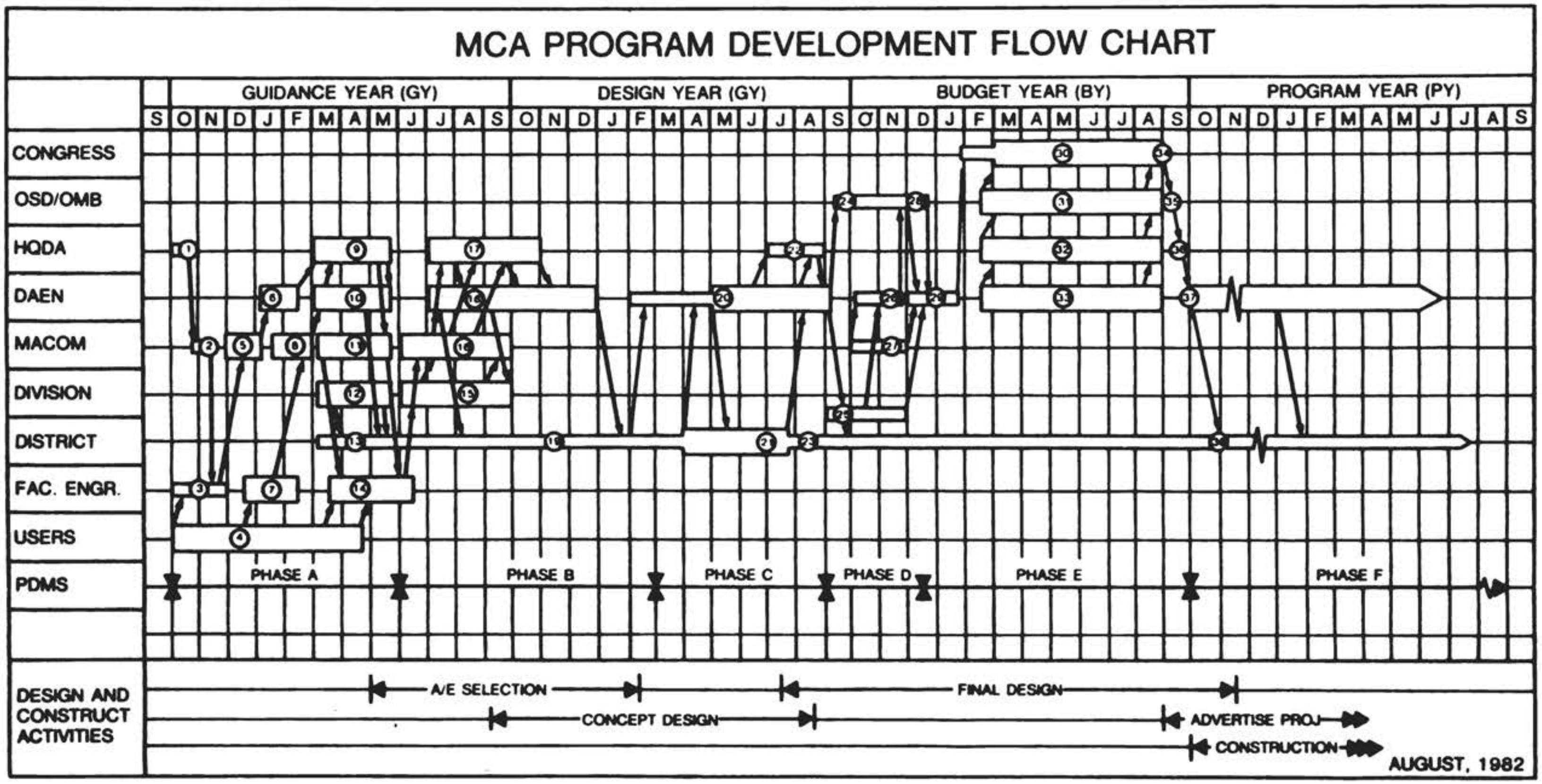


FIGURE 5-3 DD Form 1391 schematic review process (Huntsville Division, 1984).



1 POM Guidance and MCA Program guidance to MACOMs
2 MACOM guidance to installations
3 Facility Engineers prepare prioritized construction lists and submit to MACOM
4 Using Agencies provide functional requirements of projects in program
5 MACOMs submit (with the PARR) prioritized construction lists to DAEN
6 DAEN develops Army-wide priority list and submits to CRRC
7 Installations submit prioritized front page 1391s to MACOM
8 MACOMs submit front page 1391s to DAEN
9 CRRC formulates ARMY-WIDE PRIORITIZED PROGRAM, releases projects for code 1 activities, and provides guidance to MACOMs
10 DAEN directs Code 1 activity to District
11 MACOMs provide guidance to installations, request full 1391 and PDB preparation
12 Divisions review program, progress, schedules of Districts
13 Districts initiate Code 1 activity, prepare for initiation of design
14 Installations prepare, submit full 1391s and PDBs to MACOMs and Divisions
15 Divisions review 1391s, PDBs, and provide comment to MACOMs
16 MACOM prepares MACOM FYP, submits program to DAEN
17 CRRC develops DA program, releases projects for design
18 Technical Review, release by DAEN Concept Design
19 Districts initiate concept design (Code 2) send PCCD to DAEN
20 Adjust project costs (incl concept level costs) submit to CRRC, direct final design, prepare program/budget submit to OMB/OSD
21 Submit concept level cost data to DAEN
22 Final CRRC review, adjustment-PBC, CSA review/approval
23 Districts accomplish final design (Code 8) of BY Program
24 OSD/OMB review, adjustment, approval
25 Districts prepare, submit Supplemental Justification Data to DAEN
26 Review, consolidate and submit Supplemental justification data for prior years Planning and Design to OSD
27 MACOMs prepare, submit Supplemental Justification data to DAEN.
28 Review, release, Supplemental Justification Data for inclusion in "President's MILCON Budget
29 Prepare all approved data for inclusion in President's MILCON Budget.
30 Congress reviews Budget submission, Hearings held, questions issued
31, 32, 33 OSD, HQDA, DAEN testify, answer questions, provide data to Congress.
34 Authorization and Appropriation Bills produced, effective 1 October
35 Apportionment by OMB on or after 1 October
36 Allocation by USAFAC in October
37 Allotments to Districts by DAEN begin in October
38 Construction Begins

Costs

Processor users are billed for actual session charges (processing and storage) under their system User ID. In addition, users are billed a surcharge consisting of PAX system permanent storage costs, customer service, documentation maintenance, user program assistance, and other services. The only piece of actual costs available to users at the installation level--which are not billed directly for these costs, centralized at MACOM level--are the actual session costs.

The total expenditures for the Processor alone (exclusive of other PAX applications) in FY 83 were $1,894,801 (OACE, 1984), distributed among approximately 190 Army activities. The heavier usage occurred at the MSC and MACOM levels, as reviewers for all submitted Forms from installations under their control; they account for 40 percent of all the expenditures, which range individually from $20,000 to $40,000. The majority of the other users (primarily installations) presented on average annual individual expenditures expenditures in the $4,000-8,000 range.

Service Levels and Computer Terminal Requirements

Whereas the responsibility for the maintenance of the Processor system and execution of proposed changes rest with the Huntsville Division, the provision of worldwide computer services for PAX system users has been acquired from Tymshare, Inc., since 1980.

The level of the service requires that a user successfully communicate with Tymshare after no more than two attempts within any one-hour period, and that the response time for any given computer command does not exceed 4 seconds for users in the continental U.S., and 6 seconds for overseas users.

To access the system, in addition to an User ID/Password, a user needs a standard voice grade telephone line (with busy circuits, however, normally reducing the quality of transmission) and a standard configuration ASCII terminal with an acoustic coupler/modem compatible with the telecommunications protocol. The available rates for data transmission are 110, 300, and 1200 baud. In order to reduce actual connect time and to minimize line transmission problems, batch execution capability has recently been offered, allowing text data to be downloaded into a user's terminal, processed locally (if the necessary word processing capability exists), transmitted overnight to the system, and updated at the central data files.

The standard terminal used in the past three to four years has been a line editing printer terminal. Army activities have been recommended to buy, or upgrade their systems with, smart terminals with CRT, printer, and word processing.

PROCESSOR REDESIGN ACTIVITIES

The evolution of the Processor--from Form checker to Form generator, Form processor, and data transfer system--has not been straightforward, as their developers and users can testify. Several factors have been cited as contributing to the Processor's haphazard development and to some of its present problems. A few of those factors are: lack of project personnel continuity, a very rapid evolution, and a piecemeal approach to the many modifications that took place. An historical overview of the development of the Processor is found in Appendix C.

The Army identified a redesign of the system as necessary in order to:

- Improve ease of use, accomodating the actual operating practices and procedures of the users;
- Incorporate present and future requirements;
- Improve system efficiency, ensuring ease of maintenance and modification of system software; and
- Reduce operating costs.

The present study, as can be seen in Figure 5-5, is considered part of the evaluative stage of the redesign activities.

Applications in the Military Construction Process

From the standpoint of the U.S. Army Corp of Engineers, there are a multitude of participants who would benefit from access to integrated data. Each participant has different data needs to accomplish their task in the building program. A brief summary of the tasks/data needs includes:

Congress and OMB
Macro view of nations total budget for fiscal year and allocation of the budget to military. Macro view of defense mission and priorities established by the Department of Defense, summaries for each building program project in the Military Construction Program budget.

Department of the Army
Macro view of Army defense mission to establish priorities within budget constraints' review building programm of each MACOM for compliance with mission, summary data on size and condition of existing physical plant, summary data on buildings currently under design or construction (schedule and costs).

MACOM
Establish priorities in overall MACOM building program to meet mission objectives, review building program of each installation to meet MACOM mission objectives, summary data on size and condition of existing MACOM physical plant, summary data on MACOM buildings currently under design or construction (schedule and costs).

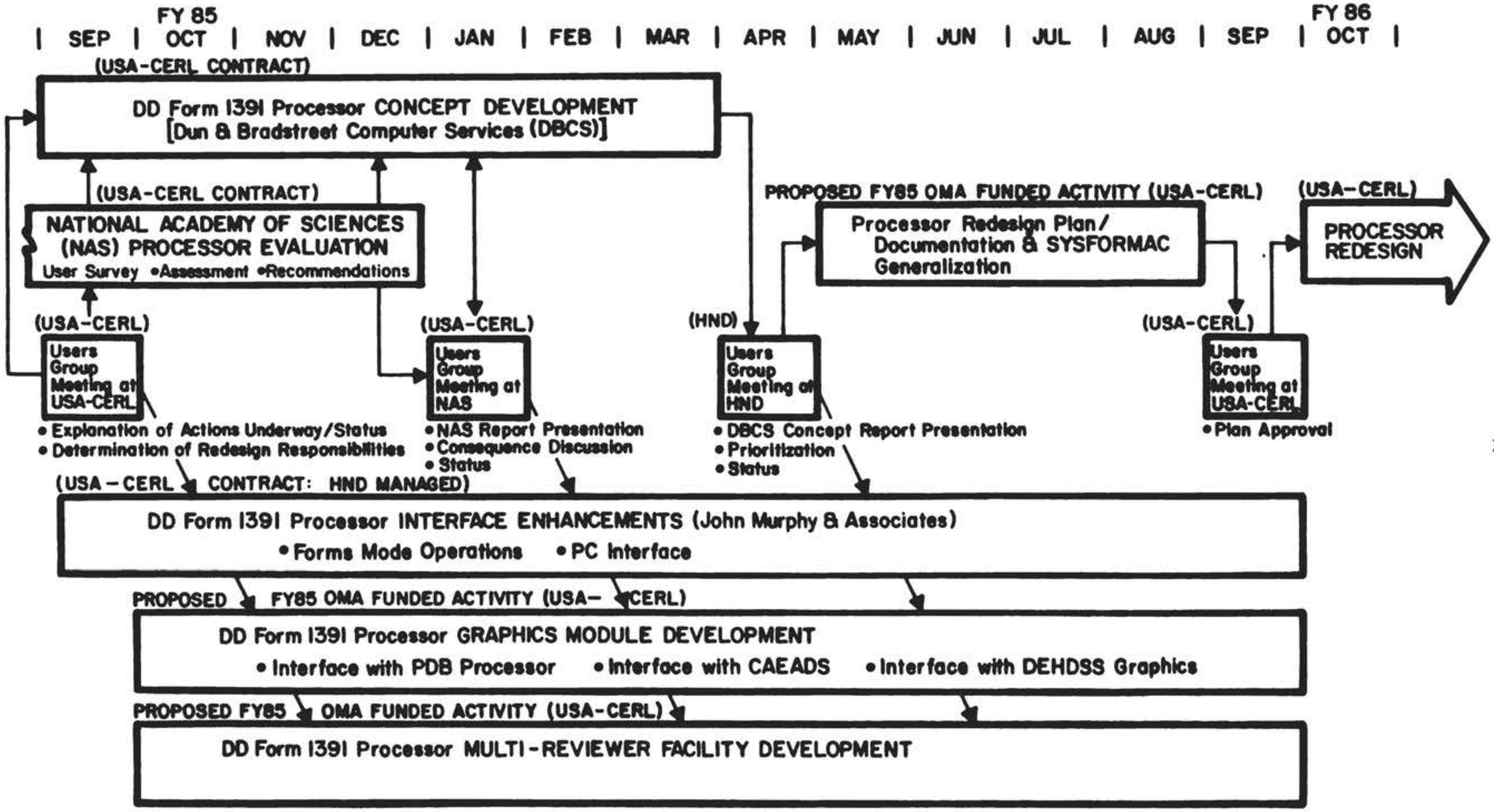


FIGURE 5-5 DD Form 1391 Processor redesign activities (OCE, 1984).

Installation
Data on existing facilities at installation, such as: size, occupancy, condition data on existing land use; coordinate installation users translation of mission into space and dollar requirements; status of building projects under design or construction at installation.

User
Data to translate mission requirements into space requirements, data to translate space requirements into costs, data on existing facilities at installation, such as: size, occupancy, condition, data on existing land use, status of building projects under design or construction.

OCE
Review each proposed building project in budget for compliance with Army criteria and costs, establish criteria for Army design and construction, establish procedures and cost guidance for users to prepare budget estimates, macro level management of the Army Military Construction Program.

COE Division
Review proposed building projects in budget within its jurisdiction for compliance with Army criteria and costs.

COE District
Review proposed building projects within its jurisdiction for compliance with Army criteria and costs, provide management of the design and constructicn for each project, translates space requirements into building program statement.

Architect/Engineer
Building program requirements, building budget, Army design criteria, site information, materials performance and costs.

Contractor
Building plans and specifications, labor supply and cost, materials supply and cost, equipment requirements and cost, construction schedule.

Building Owner
Operations and maintenance information, as-built information, equipment guarantees, maintenannce schedules, replacement scheduling.

6

USER EVALUATION OF DD FORM 1391 PROCESSOR

SUMMARY OF EVALUATION PROCESS

A cross-section of individual users made direct presentations to the committee or were contacted through personal and telephone interviews by Building Research Board (BRB) staff, in conjunction with a mail survey addressed to a larger sample of users. Direct presentations to the committee were the primary source of information regarding evaluation and perceptions about the system by users at higher levels of the MCA review process. Presentations were made by 12 individual users, representing five different Army activities (OCE, OACE, CERL, Hunstville Division, and CE Savannah District). Those users were selected primarily on intensity of computer utilization for Form processing and review, and on their position in the hierarchical review process for MCA program development.

Personal and telephone interviews by BRB staff complemented those presentations, as well as helping to test the mail-out survey sent to a larger number of users. Eight individual users were contacted at different Army organizationl levels--MACOM, MSC, CE District, and installation.

A mail survey was conducted as a means of reaching a section of the estimated 190 distinct Army activities--Processor users--broader than personal interviews could allow. Approximately 105 of those users were installations, and the others distributed between Army commands (both MACOM and MSC levels) and CE districts.

Ninety-seven users were selected for that survey. In selecting that sample, the primary factor used was individual activity expenditures in FY 83 for computer usage (session costs and system surcharges) related to the Processor alone. Fifty-five users returned the surveys.

The topics covered in the survey--aimed at the individuals in charge or responsible, at their installations or activities, for tasks related to MCA and Form manipulation--include a measure of overall user perception of the Processor, perceived costs and time savings of the system, and user perceptions about the range of system facilities, training support and documentation, and suggestions for system improvements.

MEETINGS WITH PROCESSOR USERS

The committee has had four meetings related specifically to the Processor. The meetings, combined with staff work, were scheduled to provide an understanding of the configuration of the Processor, how it relates (or does not relate) to other Army engineers' database files, and how it is viewed by a cross section of users.

A broad perspective of the system, in a very short time, was made possible through selected key individuals presenting their views of key nodal points in the Military Construction Army (MCA) process. These presentations, reflecting the views of a relatively small number of people, represent nonetheless the perceptions of personnel responsible for the most important decision nodes in the MCA review process prior to submission to Congress. Those individuals also represent, through their offices, a substantial amount of the workload carried out through the 1391 Processor. A brief summary of each of the four meetings follows.

Meeting No. 1: April 16, 1984

The first meeting was devoted to discussing the proposed scope of the project and to hearing several users of the system. It was decided that the committee would concern itself with the role of the Processor in the Army's whole construction program planning database system and would not confine its efforts to analysing the ability of the Processor and its input database files to complete a DD Form 1391.

The first part of the presentations was conducted by representatives from CERL. Messrs. Alan Moore, Simon Kim, and Roger Lapp, described the project background and gave a brief history of the Processor development, and the Army agencies involved with it.

Mr. Moore also described the cost concerns of various users of the system (in terms of computer connect time and staff support) and summarized some of their comments on its value. The Office of the Assistant Chief of Engineers (OACE) was cited as one of the users looking favorably on the overall value of the Processor. That office was characterized as a heavy Processor user which benefits from the information retrieval capabilities available or made possible through the Processor. OACE would be dependent on the Processor, essentially, to provide updated and readily available information prior to, and during, Congressional review of proposed military construction. The Engineering Support Branch of the Office of the Corps of Engineers (OCE), another key actor in the system, was characterized as holding a much more critical view of the advantages of the Processor; their major criticism seems to be leveled at excessive demands put on staff time to operate and extract information from the system. Mr. Moore stated that the Army objective, as far as the Processor is concerned, is to provide a tool for preparing and submitting Forms, as quickly as possible, for Congressional approval, rather than as tool used for documenting project requirements for transmission to Architectural/ Engineering (A/E) firms.

Mr. Roger Lapp also presented more information on the 1391 Processor project development and on present and potential users of the system. Mr. Lapp emphasized that the weakest link in the system, a break-up point, occurs between the Department of the Army (DA) and OCE; the Processor does not help analysis at this review level.

Mr. William Rackley (OACE) gave a summary of OACE goals and strategy for automation of the overall program planning process and the role of the 1391 Processor in it. Summarizing the comments of major groups of users on the Processor's value, he stated that the Engineering and Construction Branch (OCE), the major technical reviewer, believes it takes too much time to use the system; that OACE likes the system as the best available (even though it is not necessarily the best); and that Army commands and installations present mixed responses to the system.

He mentioned that key complaints against the Processor include the lack of full screen interactive capabilities (most users are limited to line editing, printer terminals) and lack of automated integration between the 17 application areas (software packages) that deal with different but overlapping aspects of military construction programs. The delay in updating review comments into the system also causes problems for original users (proponents of building construction projects the Forms).

Mr. William Simpson (U.S. Army Huntsville Engineer Division) presented an overview of responsibilities of the Huntsville Division in maintaining the 1391 Processor, of problems encountered during implementation of the system, and of factors furthering acceptance of the system. Problems encountered in the first years of fielding included difficulty of system users acquiring adequate terminals, poor quality telephone lines for data transmission, and incomplete or slow updating of the Forms after reviewer modification.

One factor which assisted initial user participation was centralized funding during approximately the first year of fielding. Another positive factor for system acceptance was that it remains the best place to find data relative to the Forms, and in the least amount of time. Mr. Simpson also commented on the issue of changes in the Form over time and their consequent impact in the Processor's software code. Six months were required, for instance, for the last implemented change (a modification in Block 9 of the Form). Congress has requested, since the inception of the Processor, approximately 30 changes in the format of the Form; the cost impact of the requested changes has never been addressed.

Other pressures on the Processor's performance can be traced, according to Mr. Simpson, to the accommodation of an increasingly large number of OCE projects submitted annually and to new system users; both result in system changes which can be slow to implement and affect the original users. From an operations maintenance viewpoint, he reiterated that Huntsville Division is constantly challenged to incorporate into the system critically required enhancements while striving to reduce and minimize convoluted code and inefficiencies in program software.

Mr. Simpson considered the Processor essentially an evolutionary system, with continuous comments coming from 400 or so individual users. There is a tracking/ monitoring system at Huntsville, to deal with those comments and gradually implement changes; tolerance of the system, because of that, is generally positive, provided the users perceive that something is being done.

Mr. John Sheehey (OACE, Program Development and Budget Branch) presented an overview of the steps to be taken by Processor users proposing new military construction for Congressional approval (the MCA Program Development Flow Chart from AR 415-15, presented in Figure 5-4) and a general description of the preparation of the Forms for Congressional review (the "Green Book" format). Data for the Green Book still is separately prepared, and will probably be automated by the end of 1984. The book contains basically the revised Forms (after all reviews), plus program and fund statements, arranged by states (and overseas activities), Army installations, and Army major commands.

Mr. Sheehey also made several comments about OCE user concerns and attitudes towards the Processor. OCE users have been generally reluctant, for instance, to use the available facilities of the Processor; until recently they were dependent on his office even for obtaining printouts of the Forms. His personal view was that the system is good and that constant users tend to react favorably, usually adopting the attitude that things could, however, be made better.

Meeting No. 2: May 9, 1984

The second meeting consisted of general committee discussions, two presentations by U.S. Army representatives, and one presentation on data base management systems (DBMS) by committee member Mr. Longstreth. The commitee discussions revolved around two issues: (1) the Army construction program database (as well as particular procedures for building-cost estimation) and (2) interview procedures (for other system users) and performance criteria (for gauging user perceptions about the system). The second discussion topic centered on the definition of boundaries for the Army construction database and on the different user groups and their perspectives.

Mr. Marcel Drimer (OCE Engineering Division, Engineering Support Branch) discussed the role of his office in the review and approval of all Forms proposed by installations, as well as those from other similar programs such as Family Housing. Projects submitted through Forms are those with costs above $200,000. He defined the Program development cycle as quite turbulent, with many changes, revisions, and resubmission of projects.

His office reviews and changes, if deemed necessary, original cost estimates proposed for the Forms. After reading the Forms he determines the experts from Engineering Division that should review particular Forms. He considers the color-coded responses (a different color for each branch in Engineering Division) extremely helpful to determine authorship of review comments at subsequent stages of program development of a given project.

Correction of each document in the Processor takes approximately 45 minutes, on average, which cost, according to him, $75 in computer connection charges. Mr. Drimer explained also that, due to budgetary and time constraints, his office does not include review comments relative to each proposed project into the Processor; he assumes that this is done at OACE's Program Development and Budget Branch during preparation of the Green Book for Congressional review.

Mr. Bryan Tauchen (U.S. Army Huntsville Engineer Division) presented an overview of how an installation prepares a DD Form 1391 using the Processor, as well as special features available to managers for monitoring projects submitted through the system. He proceeded to show, on a portable terminal, the preparation of one Form through the Processor.

Meeting No. 3: May 30, 1984

The third meeting consisted of a general committee discussion about the outline of the requested Interim Report, and of presentations by other Processor users. Thomas Abraham (Committee Chairman) and John Eberhard (BRB) reported on a meeting held on May 25, 1984 with Mr. Allen Carton (Deputy Assistant Chief of Engineers for Planning, Programming and Congressional Affairs).

At that meeting, Mr. Carton stated that his office is highly dependent on the computer-based Processor information in order to prepare the budget documents for Congressional review and to make comparisons of the justification information contained in the Forms. However, the need for his office to have the data in computerized format does not mean that it has to be entered by the individuals at the various installations. For his purposes the data could be entered from the manual Forms by a contractor or by someone on the staff in Washington, D.C.

It would also seem quite acceptable to have the Forms prepared on word processing equipment off-line, and then loaded onto the communications network in batch mode rather than through the present interactive mode. The OACE requires the data as rapidly and efficiently as possible and believes that current data should be available for use by all levels at all times. If the computer is simply used to transmit additional information from the field as a faster mailman, the OACE feels it may not be worth the additional cost.

Mr. Fred Kitchens (U.S. Army Corps of Engineers, Savannah District) gave an illustrated presentation on the role of the Processor in a typical district-level office. He also developed a more detailed presentation of the overall database requirements for a district office, and explained some of the work they were doing in the Savannah district to expand computer utilization in their technical and managerial environment. For example, an interactive data base of Fort Jackson, S.C., has been developed to provide an Automated Installation Graphics System for master planning, for programming and site development of future facilities, and for maintenance and repair functions during the operation phase of the facilities. The data base is viewed as beneficial to the installation, MACOM, and CE, in its support to the installation as well as fulfilling its design and construction mission.

From the standpoint of managing the military mission at the district level, he indicated that it is important to have uninhibited access to various sources of information such as the Jackson data base, programming documents through the Processor, the Automated Military Project Reporting System (AMPRS), automated specification and other design systems, and so on.

He indicated that at the district level it would be particularly useful to know what changes have been made in the Forms as they are processed through channels. Mr. Kitchens also stressed that much of the value of the Processor is lost to the District since OCE does not update the system to reflect comments resulting from their technical reviews. The delay caused by mail transmission of the annotated hard copies (4-5 days, under favorable conditions), particularly when multiplied by several hundred projects, destroys much of the usefulness of the Processor, at least from a District's standpoint.

Mr. Tom Gray (OACE, Program Development and Budget Branch) briefly presented to the committee his perception of the role of the Processor in the overall Army construction program. He emphasized the need for a centralized coordination of the final format for the Forms and of the words used in justifying new facilities, in order to be sensitive to the interests of Congressional committees involved in the budget approval process.

Meeting No. 4: September 6, 1984

The fourth meeting consisted of two presentations--one by a former, and another by a present, U.S. Army representative associated with review of Forms--and of general committee discussions. The latter centered on the structure and contents of two reports: the separate report on applications, in the building industry, of computerized voice technologies, and the present commitee report.

Mr. Lee Garrett (formerly U.S. Army Military Construction Director, with responsibility for reviewing the Forms) made a presentation on the evolutionary characteristics and purposes of the Processor, as originally intended and as it presently stands.

The initial system that his office sponsored, in conjunction with CERL, evolved from a Form checker to a Form generator, and subsequently from a Form processor to a data transfer system--the present trend. The goal of the Processor's sponsors was to have the Forms "created well, handled rapidly, passing through the system [without major problems]."

Mr. John Riemer (OCE, Cost Estimating Section) made a presentation on cost estimation and information processing related to Army construction planning and programming. He analysed some of the operational changes in the review process performed by his office (like the decrease from 10-12 to 4 reviews per project, as a result of better-quality documents prepared through the Processor), and the lack of personnel and computer equipment to support some of the tasks for review of the Forms.

SURVEY OF USER PERCEPTIONS ABOUT THE PROCESSOR

Fifty-five users responded to the mail survey directed to 97 Army activities (a subset of the estimated 190 total de facto Processor users in FY 83). Approximately half of those 190 users were installations; they were given a higher representation share (approximately two thirds) in the selected subset of users to compensate for the greater difficulty of reaching them. The response rate of 60 percent was generally uniform across the installation, CE district, and Army command levels. A description of the survey process and the text of the survey are presented in Appendix D.

Overall Performance of the Processor

Users were asked to rate the overall performance of the Processor (in terms of their office responsibilities in [preparing/reviewing] Forms) in a scale ranging from 1 to 7, where 1 represents "Satisfactory" and 7 represents "Unsatisfactory". The results are presented in Figure 6-1.

The numbers on Figure 6-1 imply an acceptance of the Processor system, in terms of its purpose or perhaps of its potential; however, dissatisfaction with aspects of the system is clearly present, as had been indicated by other users at committee meetings. The remaining pages of this chapter will illustrate the issues raised by users, in terms of satisfaction with the system, specific comments on possible improvements to the Processor, and perception on cost and time savings.

Satisfaction with Specific Processor Features

The ability to quickly transfer electronically Forms was cited by a third of the survey respondents as one of the best features of the Processor, followed by PAX electronic mail capabilities. Also mentioned by at least five users as positive features of the Processor:

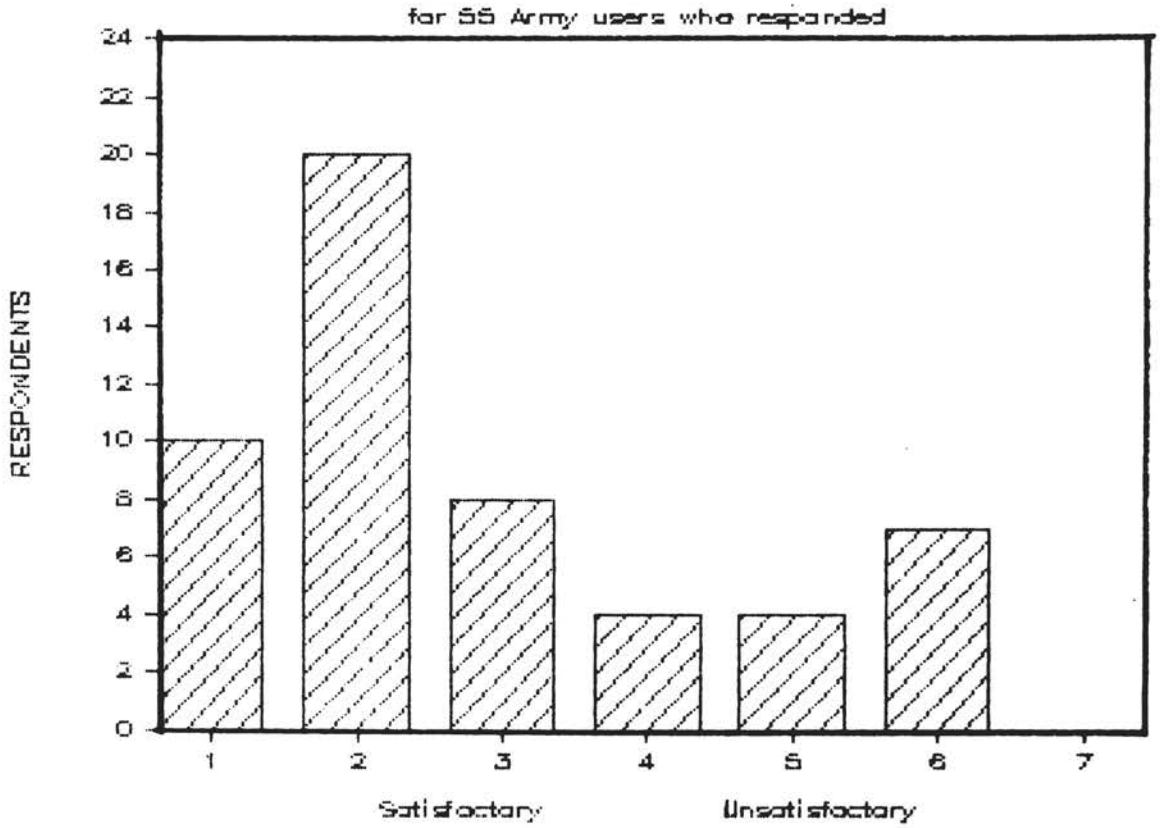
- Cost estimating capabilities;
- "Improved quality of documentation by faster [error correction through] word processing";
- Quick Form creation and review; and
- Ease of use.

The less desirable features of the Processor, mentioned by at least five users, are:

- Telecommunication network problems ("line garbage", due usually to poor-quality or busy telephone lines);
- Slow response times;
- Antiquated, slow hardware;
- Poor word processor/editor; and
- "Too many steps [message and prompts] before going into [the Processor]".

A sample of comments to illustrate users' reactions, both favorable and less so:

- "Provides an excellent method for obtaining the most up-to-date information concerning a specific project"



SATISFACTORY FEATURES INDICATED BY USERS

- Ability to do cost estimates
- Improved quality of documentation
- Quick DD1391 form creation and review
- Ease of use

UNSATISFACTORY ASPECTS INDICATED BY USERS

- Poor quality telecommunications network (line garbage)
- Slow response time of system
- Antiquated hardware at user's location
- Poor word processor/editor capability
- Too many messages and prompts in the system

FIGURE 6-1 Results of DD1391 Processor user survey.

- "Minor changes can be made w/o retyping the entire package, duplicating many copies, then redistributing."
- "It's like having a Howitzer when our projects need a '22'. Powerful! But overpowering for our needs."
- "While it was 'sold' on better, more accurate 1391s [sic], it actually has added to workload due to rapid change and transmission capability."
- "I am perfectly satisfied with the system as it is, since it is working [unlike] other Management Information Systems. Additionally, let's hope it isn't made more sophisticated, which may make it so complex that it will discourage its timely use by installation personnel."

Suggested Improvements to the Processor

Expansion of System Capabilities

More than ten users specified expansion of the Processor's capabilities as the improvement they would like to see. They would probably like to see an extension of the scope of the system to "include DD Forms 1390, DD Forms 1657, other forms required as supporting documents which now must be manually prepared and submitted by mail." Users would also like to have "access to other programs such as empirical costs, environmental, calendar, economic analysis, special requirements paragraphs." Users would like the system to have a greater "data base in criteria mode," "more unit costs in data base," and a "subroutine for (FSP's) Facility Support Plans." Another desired improvement was to have the Processor "interactive with ASIP, MTOE, TAB, IFS, and Master Plan [other OCE-supported programs]."

Project Approvals and Reviewers' Use of Processor

Several comments dealt with the issues of project approval indicator and hard copies of Forms. A need was expressed for an "Approved" sign, or a "locked-in" indicator of official approval at each stage of the Form proposal and review cycle. Signed hard copies are apparently still requested by "[one of the MACOMs] and DA, especially for MMCA, EMMCA & UMMCA projects which are not submitted through the [Processor] and which require transmittal letters." Another suggestion was a requirement that "the MACOMs, OCE & DA use the Processor [for reviews]," helping ensure that their comments are updated and immediately available to others in the MCA process.

Printing of Forms

Users would like control over format of data output, easier ways of moving from the "[Form] editor to the print processor", and the ability to print "certain pages of certain blocks without printing the entire block." They would also like to be able to "print out [the Form] complete, eliminating acetates overlays [with the standard field and Form descriptions]," and "to induce pagination to avoid cutting charts into two halves on adjacent pages."

Word Processing

The cumbersome line editor available through the Processor was the subject of several complaints, as mentioned before, but apparently some users were not aware that it had just been made possible, as they were suggesting, to use a word-processing workstation for off-line preparation of Forms, with subsequent batch data transfer into the Processor. Features of a revised text editor should ideally include "tabulation of columns on online terminal", "a visual screen with the [Form] overlay on it [since this] would help on where to break the words."

Difficulties in Obtaining Equipment

Installations, in particular, seem to have problems in justifying new expenditures in computer equipment, particularly in view of a certain number of dedicated, stand-alone systems (for specific OCE computer programs) that installations have had to acquire in the past. One complaint was that "at present, to obtain a PC at [an] installation would exceed 4 years (not worth the effort); [their printer terminal] took 2 years." The suggestions of how to solve the problem range from to "provide at DA expense the installations with PC's" to request that the "Army make a policy statement about type of terminal to be used by every installation, and then teach with that machine."

Graphics Capabilities

The inclusion of graphics capabilities was suggested for "possible merge with existing automated master plans/interactive graphics analysis systems (IGAS)"; for processing "site plans, facility sketches," details, and so on.

Data Transfer Between OCE Programs

The Processor, according to several users, improved the production and review of Forms, but with "much more capability as yet undeveloped [because they] still have to do too many things manually" to transfer data "between the [Processor] and other systems (CAPCES) and no one has the manpower to do this on a real time basis."

Cost and Time Savings

In terms of perception of tangible or intangible cost and time savings due to the introduction of the Processor in the MCA program, there are, as might be expected, three distinct groups of users: the believers in those savings, the nonbelievers, and the "balanced cost/ benefits" group--those that perceive gains in any one area offsetting losses in another. MACOMs and CE districts, as opposed to installations, have a base of computer costs for comparison, but, in spite of numbers presented to support their view, their answers remain educated guesses, because personnel time savings seemed extremely difficult to evaluate.

Decreased Costs

According to the first group of users, "the big savings is [sic] in time spent editing the [Forms]," with the "costs of corrections, updates, reproduction, distribution, etc, [...] reduced by 65%." The cost of "preparation/review is about the same," and for "a single, one-time input the [Processor] is slower." The actual cost for manual preparation or first-time entry into the Processor "comes from the time it takes to type the 1391's [sic] which is a lot. In other words, it affects people in a 'manpower' type of situation." One user estimated that, for Form preparation in the Processor, "there is a 20% time savings [sic] vs. manual, which means less time costs, but does not account for costs of [the Processor]." Another user presented the following break-down of time expenditures (man-hours per Form) for alternative ways of preparing the Forms:

- 80 hours for manual preparation
- 40 hours with line editing, printer terminal
- 20 hours with smart terminal/word processor
- 16 hours with batch capability and word processor

Increased Costs

According to the second group of users, costs have increased: "in the past, 1391s [sic] were typed by a 'low cost' secretary who could correct spelling and punctuation. [Whereas] now they are prepared by executives with limited typing skills." The Processor was considered by one user as a "[duplication] in preparation of forms [since they] are prepared manually, input into the Processor system and submitted." This user also mentioned that due to "interferences and communications problems most online Processor work has to be performed during off-duty hours, overtime (nights and weekends) [resulting] in additional costs."

Another user confirmed that "input to the system is slow because of setup time, poor communications, and work processing limitations. When communications are bad, no useful work can be done at all." For occasional users, the major problem might be that they "do not use terminal on a daily basis and it may be a month or two before [they] use it again," by which time they "forget some of the rules for inputting into [the Processor or editing Forms]." At the installation level, "the lack of trained people on processor [sic]" seemed to be another factor increasing the time costs of personnel involved in the preparation of Forms.

In terms of direct computer costs, according to one user, the Processor cost them $30,000 per year, as opposed to $10,000 before, presumably only in personnel costs; this was echoed by another user that affirmed "[Processor] costs $20,000 more than typing--typing only $10,000." Another said that the Processor "appears to increase our cost of preparing the [Forms] by $10,000 to $15,000 per year." One user presented "before" costs (personnel) of $6,000, jumping to "after" costs of $26,000 (including personnel).

Unchanged costs

According to the third group, total costs for preparation of Forms have not changed significantly: the Processor "cost is an approximate trade-off of extra employee time and mail cost," with "[enhancements] to the Processor system [having] the potential to save money." In the view of another user, computer time is an added cost, offset by non-quantifiable benefits as "quality and timeliness of product and ability to provide detailed information not previously available in useful time."

A comparative view across MCA levels stated that "time savings are minimal and normally confined to employee time required for duplicating documents, preparing transmittal letters, and mailing. The significant time savings is to higher headquarters and in mail time, [allowing for] a better review process." Summarizing the views of many others, at both the proponent and review levels, one user concluded that there is a "much faster access to current [Forms], but [that] it is also much easier to revise one and more difficult to maintain control of it".

7

CONCLUSIONS AND RECOMMENDATIONS ON THE 1391 PROCESSOR

Expected Developments in The State of the Art

The next 2-3 years should see developments in the state of the art that will permit the integration of all individual project data into a series of accessible data bases, providing shared access during the design/construction/operation of individual buildings. Major efforts, however, are needed to develop industry standards for such things as numbering systems, data dictionary definitions and systems which will allow historical and cross industry comparisons.

The advent of a microcomputer at each construction site will provide incentive to accelerate this process.

A recent article in Engineering News Record (May 31, 1984) states:

> The power of the project data base could bring revolutionary change to the way architects, engineers and contractors do business. A data base begins at project inception, continues to grow during preliminary design, through construction and into maintenance.... The data base begun during concept would be passed from player to player, ending finally with the owner to provide as-built drawings and operations and maintenance information. Technologically, this concept is possible.... But the coming of expert systems--software that uses human experience to sort through information--may make the first experiments in shared data possible for construction's pathfinders very soon.

With the advent of this process, we will be able to utilize and share the same data, from beginning to end.

Specific Conclusions About the DD 1391 Form Processor

The Army needs an automated system with which to propose and track new projects. With more than 10,000 projects in the system at any one time, it is difficult to imagine a manual system that would be effective. The DD 1391 Form Processor is a good beginning in this direction, however, due in part to its piecemeal growth, it is cumbersome and lacks flexibility. The DD 1391 Processor has the potential to do much more than it is currently utilized to do. It could provide significant value in terms of historical data, correlations between projects, management control, and review process information/status.

There are some issues related to the value of the system that the committee believes deserve further consideration by the Army. These have to do with the timeliness, accuracy, project correlation, and availability of historical data. The committee believes that some value should be assigned to the amount of time saved in the review/approval process, but finds this a difficult area to quantify themselves. It would seem that some form of feedback to the originators of the DD1391 forms should be available within the system in order that they have accurate information available at all times. The value to the total construction data process in terms of increased accuracy of the electronic system over a manual system is inherent in this feedback process. There is apparently limited ability to achieve any correlations between projects within the system in terms of the justification presented to Congress. The present system works primarily because of the skills of a single individual in Washington in determining needed correlation between projects. However, the value of the system could be greatly enhanced in the future if means of extending this individual expertise could be incorporated in the Processor itself. Recent advances in artificial intelligence research, particularly the maturing of expert system's development and implementation methodologies, can probably be used to advantage in producing intelligent dialogues to reduce the level of individual expertise required to perform these correlations. Development of such intelligent dialogues (expert systems) could also include substantially more use of historical data to more efficiently justify and project costs, and to more efficiently produce project schedules.

The Processor does present great potential for utilization as a tool for initiating a project and validating the data input at the very inception of the project. Since these data are used throughout the life of the project, it seems useful to support the user in entering correctly the first time.

The user "friendliness" of the system raises serious problems with response time, errors which appear in the copy produced by the system, and the knowledge and training required in order to utilize the system adequately.

The most difficult aspect of human factors for the present system is the subjective resistance of some potential users in the review cycle. The Processor will not achieve its full capability until the interface questions associated with this category of user are adequately addressed.

The Processor seems to be subject to "background noise" problems that introduce small glitches into the data. These problems could be minimized if the Processor used dedicated data communications channels with higher level communications line protocols and data link control software. Use of the Processor requires a terminal for each user, but it would seem wise to consider terminals with more capability than what might be required for the 1391 process alone. Intelligent terminals would enable users to perform many other management tasks, thus changing the basis for cost justification of the terminal itself while at the same time improving the Processor system.

It also seems likely that the user charges paid by each installation for the use of the 1391 Processor might become a central charge account in order to avoid the complaints from field installations users that they have a new cost associated with the system that they never had to bear before. The central charge account (especially if combined with a new data management office) might also help to alleviate the question of gaining the cooperation of the technical staff who presently do not use the system. The addition of a technical feature which allowed color-coding (or some other satisfactory method) for indicating which stages of processing have been completed for the 1391 would seem desirable. Tracking and comments records added to the present system would help greatly in dealing with users complaints about lack of feedback on the progress of submittals, heard by the committee from several sources.

There is also the possibility of expanding the present system to include an announcement to the private sector about projects in process. This could be done through existing information utilities such as DIALOG* and could help pioneer the way for a national construction information and cost data base.

As implemented the Processor suffers from the lack of a sharing of common data between software programs. Each organization must take the output from one program and create new input to the next program. A central data base management system relating all the individual files seems a must in any system's redesign. The Processor also should take into consideration the variety of different user functions--initial data input, review of data and modification of data. This further suggests that an intelligent terminal be provided to all users in the field, and graphic terminals be made available to the technical program reviewers in the OCE along with graphic data needed for their reviews.

While building cost data are not a significant portion of the DD1391 forms, there is some requirement for such data. The committee observes that the text format for the input data does not allow for a ready transformation into an algorithm for asking many important information questions. However, cost preparation is a well defined process with cost modifier tables to serve as a data base, and has been automated in the Processor.

The 1391 calculated costs are "ball park" estimates. They are prepared using the cost tables and algorithms of the 1391 Processor and are not intended to be the costs used when DD Forms 1391 are sent to Congress. The Congressional submittals are supposed to be the Architect-Engineer cost estimates (based on the thirty-five percent drawings). However, the time schedule does not always allow this and the costs calculated by the Processor are often used in the DD Forms 1391 sent to Congress.

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*Mention of specific products and companies does not imply endorsement, but is intended to be helpful to the reader who wishes to explore such developments in greater depth.

The Processor represents the first attempt to quantify a project in terms of scope and dollars. It represents a critical step in the construction cycle. Thinking in terms of the cost data for a project, it is important to be able to quickly trace the evolution of a project and its costs when managing the project. A single data base with all of the project data would allow evaluation of the project at any point in the project life cycle. As a management tool to track and control the project cost and scope this could be useful. If project scope, along with specific project considerations (e.g. site problems) and costs for all project phases completed could be reviewed at the same time, then a manager could determine if the project was under control.

A primary conclusion of the committee is that a more comprehensive data base should be developed by the Corps of Engineers for their overall program planning, design, construction and space management efforts. The technical questions associated with providing the end users with a "friendlier" system are independent of the actual data base design issues, and can be explored separately, as long as the design of the data base provides the data each user needs.

APPENDIX A

DD FORM 1391 PROCESSOR FEATURES

Documentation for Army Regulation 415-15 includes:

- Front page DD Form 1391 and continuation page DD Form 1391c (Blocks 1-11);
- Project supplemental data (DD Form 1391c, Blocks SA-SF);
- Detailed project justification (Paragraphs 1-18);
- Quantitative data (supporting detailed justification Paragraph 3 and Block 11);
- Special requirements paragraphs (SRP 1-10); and
- Remarks, review comments, and history of form changes.

Table A-1 presents the relationship between Processor blocks (fields) and the actual Form. A sample of a DD Form 1391 filled out is included at the end of this Appendix as Figure A-1.

EDITOR

Forms are prepared (text is entered and modified) through a built-in text editor (word processor) with commands such as: bottom, change, comment, delete, detail, display, first, goto, help, input, last, line-no, locate, next, print, quit, remark, replace, save, substitute, top, up, and verify). Non-text fields (cost data, for instance) utilize different individual editing procedures.

MONITOR

There are seven levels of access authority (read, permit, submit, review, write, and two return without prejudice related) limiting monitor commands usage in Forms manipulation. Monitor commands are:

- General: cancel, check cost, criteria, delete, directory, directory retained and submitted, directory of archived Forms, directory of deleted or dropped Forms, display, help, increase, message, permit, prepare, quit, rank, recall, requirement, retrieve, return, review, submit, and tabdata.

- Installation only: delete, prepare.
- MACOM and Installation only: submit.
- MACOM and OCE only: directory returned, freeze, insert, return for correction, and unfreeze.
- OCE only: archive, insert, project number, limbo, retrieve deleted or dropped Form, purge, and return with prejudice.

TABLE A-1 Relationship Between Processor Blocks/Fields and Actual Form

PROCESSOR	BLOCK/FIELD	Actual Form Block Name
BLOCK 1:	COMPONENT	Block 1: Component
FIELD 2.A:	DATE	Block 2: Date
FIELD 2.B:	FISCAL YEAR	Block 3: Fiscal Year
FIELD 3.A:	INSTALLATION	Block 3: Installation
FIELD 3.B:	LOCATION	and Location
FIELD 4.A:	PROJECT TITLE	Block 4: Project Title
BLOCK 5:	PROGRAM ELEMENT NUMBER	Block 5: Program Element
BLOCK 6:	CATEGORY CODE NUMBER	Block 6: Category Code
BLOCK 7:	TEMPORARY PROJECT NUMBER PERMANENT PROJECT NUMBER	Block 7: Project Number
BLOCK 8:	PROJECT COST	Block 8: Project Cost
FIELD 9.A:	PRIMARY FACILITY	Block 9: Cost Estimates
FIELD 9.B:	SUPPORTING FACILITIES	
FIELD 9.C:	CONTINGENCY FACTOR	
FIELD 9.D:	S AND A PERCENT	
FIELD 10.A: FIELD 10.B:	TYPE OF CONSTRUCTION TYPE OF DESIGN	Block 10: Description of Proposed Construction
FIELD 10.C:	DESIGN CAPACITY	
FIELD 10.D:	GROSS AREA	
FIELD 10.E:	COOLING CAPACITY COST	
FIELD 10.F:	DESCRIPTON OF WORK TO BE DONE	
FIELD 11.A:	U/M	Unit of Measure
FIELD 11.B:	TOTAL REQUIREMENT	Line A of Quantitative Data Line 1 of Block 11
FIELD 11.C:	EXISTING SUBSTANDARD	Line B of Quantitative Data Line 1 of Block 11
FIELD 11.D:	EXISTING ADEQUATE	Line C of Quantitative Data Line 1 of Block 11
FIELD 11.E:	FUNDED NOT IN INVENTORY	Line D of Quantitative Data
FIELD 11.F:	ADEQUATE ASSETS	Line E of Quantitative Data
FIELD 11.G:	UNFUNDED PRIOR AUTHORIZA-TION	Line F of Quantitative Data
FIELD 11.H:	INCLUDED IN PRIOR YR PGM	Line G of Quantitative Data
FIELD 11.I:	DEFICIENCY	Line H of Quantitative Data
FIELD 11.K:	RELATED PROJECTS	Related Project of Quantitative Data
FIELD 11.L:	PROJECT	Block 11
FIELD 11.M:	REQUIREMENT	
FIELD 11.N:	CURRENT SITUATION	
FIELD 11.O:	IMPACT IF NOT PROVIDED	
FIELD 11.P:	NATO INFRASTRUCTURE	
SA-SF	SUPPLEMENTAL	SUPPLEMENTAL DATA PAGE
D1-D18	DETAILED JUSTIFICATIONS	PARAGRAPHS 1-18
SR1-SR10	SPECIAL REQUIREMENTS PARAGRAPHS	PARAGRAPHS SR1-SR10

SOURCE: Army Regulation 415- 15 (1 December 1983).

1. COMPONENT	FY 1985 MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		03 DEC 80

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Fort Sill Oklahoma	Trainee Barracks

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)
	721 81	265000	24,553

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
PRIMARY FACILITY				17,791
ENL Bks w/Mess	SF	171,610	56.40	(9,679)
Seismic Zone 1 (Add 1.0%)				(97)
Enl Pers Dine	SF	16,700	147.21	(2,458)
Adm & Sup Bldg	SF	13,500	75.57	(1,020)
Bn Admin & Clrm	SF	18,945	73.00	(1,383)
Covered Training Area	SF	[illegible]4,000	[illegible]9.81	(2,150)
Addn to Central Energy Plant	SF	2,800	[illegible]8.64	(1,004)
SUPPORTING FACILITY				4,479
Electrical	LS	--	--	(389)
Water Lines	LS	--	--	(134)
Total from Continuation page				(3,956)
SUBTOTAL				22,270
CONTINGENCY PERCENT (5.00%)				1,114
TOTAL CONTRACT COST				23,384
SUPERVISION INSP & OHEAD (5.00%)				1,169
TOTAL REQUEST				24,553
INSTALLED EQUIPMENT-OTHER APPROP				(0)

SAMPLE

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The primary facility is permanent reinforced concrete and masonry construction. The work is new construction, site adapted from two similar buildings on the installation. The structure is noncombustible housing barracks for 1100 trainees and 36 enlisted personnel. In addition, the complex will include classrooms; administration and storage; dining facility; battalion headquarters; covered training areas and an addition to the central energy plant. The central energy plant will be coal fired providing high temperature hot water heating systems and 480 tons chilled water air conditioning. The project will include required utilities services, communications, fire protection and alarm systems, paving, walks, curbs, gutters, storm drainage and site improvements. Not sited in a flood plain. Demolition of existing buildings is not required for site clearance. Accessibility for the handicapped will be provided.

11. REQUIREMENT: 8,383PN ADEQUATE: 2,504PN SUBSTD: 6,893PN

PROJECT :
Construction of a 1100 trainee barracks with dining, admin and classroom facilities at Fort Sill, Oklahoma.

DD FORM 1 DEC 78 1391 PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED PAGE NO.

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FIGURE A-1 Sample of a DD Form 1391 filled out.

1. COMPONENT	FY 19 85 MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		30 JUL 82 03 DEC 80

3. INSTALLATION AND LOCATION
Fort Sill
Oklahoma

4. PROJECT TITLE	5. PROJECT NUMBER
Trainee Barracks	265000

9. COST ESTIMATES (CONTINUED)

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
SUPPORTING FACILITY (TOTAL CONTINUED)				3,956
Gas Distribution	LS	--	--	(8)
Sanitary Sewer	LS	--	--	(53)
Chilled Water Lines (8")	LF	2,000	59.23	(118)
High Temp Water Lines	LS	--	--	(478)
Fuel Storage	EA	2	62142.	(124)
Roads and Parking	LS	--	--	(670)
Railroad Spur	LF	6,500	88.31	(574)
Walks	SF	12,000	3.82	(46)
Curb and Gutter	LF	9,000	11.31	(102)
Storm Drainage	LS	--	--	(162)
Drilled Piers (20" dia)	LF	[illegible]	35.54	(533)
Site Work	LS	--	--	(610)
Communications	LS	--	--	(431)
Demolition	LS	--	--	(47)

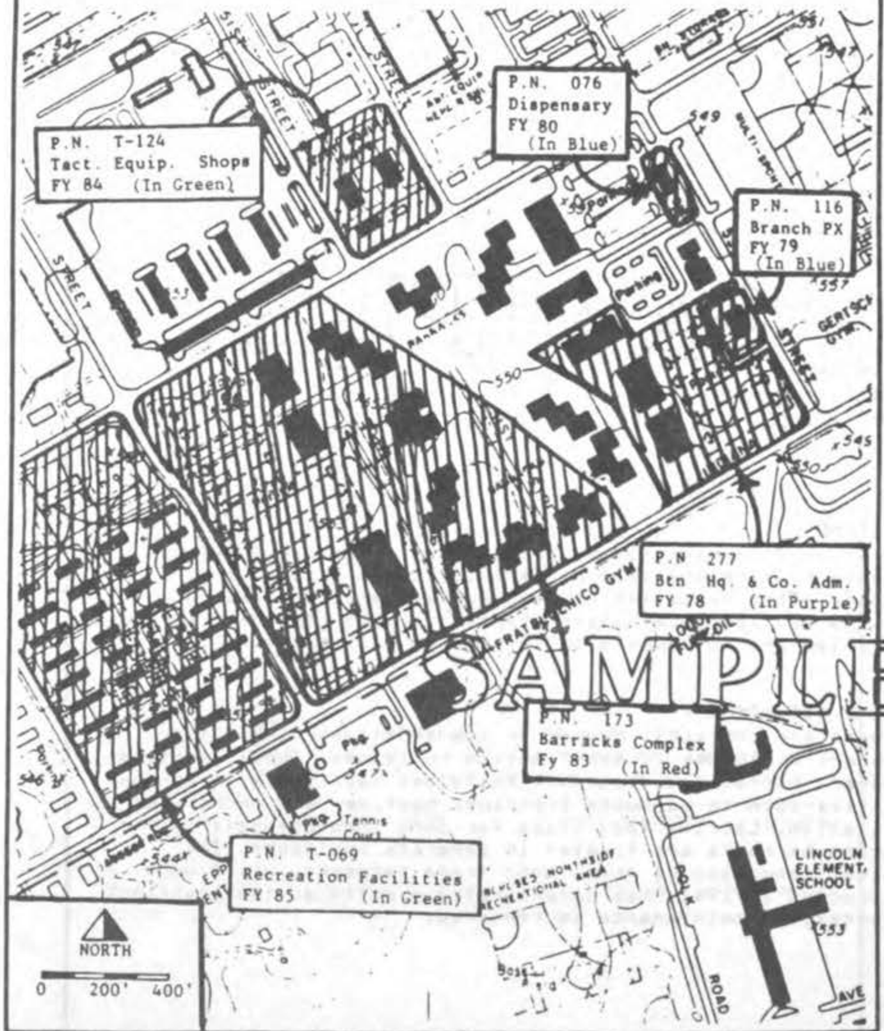
REQUIREMENT :
This project is required to provide the third increment of adequate housing and support facilities for Basic Combat Trainees. This installation has been assigned the mission of training BCT companies which started in 1975. Adequate permanent facilities are not available to support this mission.

CURRENT SITUATION :
Trainees are currently housed in inadequate permanent and temporary World War II mobilization buildings. These existing temporary barracks and support buildings lack the most minimal amenities such as adequate lighting, heating, and mechanical ventilation. Latrine facilities for more than one-half of the existing barracks are located in separate buildings. The physical condition of these wood frame barracks, which were constructed in 1941, has deteriorated greatly so that constant and excessive maintenance is required.

FIGURE A-1 (Continued)

1 COMPONENT ARMY	FY 19 83 MILITARY CONSTRUCTION PROJECT DATA	2 DATE 28 Oct 80
3 INSTALLATION AND LOCATION Fort Campbell, Kentucky		
4 PROJECT TITLE Barracks Complex		5 PROJECT NUMBER 173

GENERAL SITE PLAN SHEET NUMBER 9 OF 12; 1 MAY 1979



DD FORM 1 DEC 76 1391c PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED PAGE NO

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FIGURE A-1 (Continued)

APPENDIX B

ADDITIONAL PAX SYSTEMS

PAX is the acronym for the U.S. Army Corps of Engineers Military Construction Programming, Administration, and Execution System. In addition to the DD Form 1391 Processor, it includes several other systems used to manage military construction programs.

Automated Criteria Tracking System (ACTS)

ACTS is a multi-command, automated information system used with the Processor that provides consolidated space planning criteria information. The system references by facility category code for peacetime, mobilization, and theater of operations criteria, and identifies OCONUS exceptions. ACTS includes the USAREUR Space and Planning Criteria Manual.

PAX Electronic Mail System (PAXMAIL)

PAXMAIL is an electronic mail system, tailored to operate in the Military Construction Programming, Administrative and Execution System (PAX) environment. It supports engineer organizations throughout the world.

The system presently operates in the continental United States, Alaska, Hawaii, Japan, Korea, Germany, and Puerto Rico. PAXMAIL users can create messages and transmit or retransmit them to one user or preset groups of users. It can provide information copies to one or more users, store messages sent or received, and can transmit files from the Processor, CAPCES, ECONPACK, and ACTS. PAXMAIL contains a user directory for locating the PAX ID of the intended recipient. It can delete messages and edit stored files.

Economics Package (ECONPACK)

ECONPACK is an economic analysis program that performs life cycle cost comparison on proposed MCA projects and alternatives. Using cost data from its input block, ECONPACK computes the discounted net present value for each alternative under consideration. The output is a summary listing of the costs, a by-item listing, and a graphic display of the year by year cumulative cost. In situations where the economic lives of the alternatives are different, it will compute the Uniform Annual cost. The system has a sensitivity feature which will vary any one factor or group of factors to produce a change in the ranking of alternatives. it was designed to provide installation and MACOM personnel with automated assistance in preparing economic analyses for MCA. The resulting analysis can be transferred directly into the justification paragraphs in the DD 1391 Processor.

Data Traffic Management System (DTMS)

DTMS is an interface program used with the Processor to provide electronic and interactive exchange of information between systems on separate telecommunications networks and different computers.

Construction Appropriations Programming, Control, and Execution System (CAPCES)

CAPCES enables users to manage and track approximately 15,000 individual projects in the Army construction program. CAPCES manages and controls projects through the planning, programming, budgeting, and execution phases (fiscally and physically). The system provides project and program status reports to Congress, OMB, OSD, DA, USAREUR, and EUD. It is interactively updated by several divisions of the Office of the Assistant Chief of Engineers and the Engineering and Construction Divisions of OCE. It provides a means to manage and defend the MCA program through a multiyear process resulting in the authorization, appropriation, and construction of needed Army facilities.

Automated Design and Construction Directive Distribution System (DIRECTIVES)

DIRECTIVES provides the formal distribution system for directives authorizing the expenditure of funds to design or construct MCA projects. Forms are input by OCE, with action copies going to EUD and information copies going to USAREUR.

Headquarters Integrated Facilities System (HQIFS)

The HQIFS umbrella system incorporates all real-property-assets-related data into a common data base. The system provides read-only access to the real property assets data for Army installations. Its principle data source is installation IFS. HQIFS feeds data to the Real Property Inventory/Building Information Schedule (RPI/BIS) and provides reports to MACOM and higher headquarters. It is useful for planning and verifying construction projects and for mobilization planning and stationing.

Stationing Analysis Model (SAM)

SAM will be an on-line, interactive, data-base-managed system designed to analyze stationing scenarios (peacetime or mobilization) for their facilities impacts. SAM will answer queries, and it will have two versions--classified and unclassified modes. SAM will be evaluated separately from this test, through an independent study.

APPENDIX C

HISTORICAL DEVELOPMENT OF DD FORM 1391 PROCESSOR

Many individuals contributed their talents at one time or another. However, lack of project personnel continuity, rapid evolution, and a piecemeal approach to modifications to improve functional operation, cost effectiveness, and user response have contributed to a disunity of overall design. The evolution from a checker to a Processor, transformation from the old to new versions of AR 415-15, expedient corrections, numerous additions, and rapid conversion in data base management systems from RAMIS II to FOCUS have resulted in a patchwork, convoluted Processor, inherently inefficient in many respects and difficult to maintain. Added routines and intensive usage (more growth is planned) have both contributed to slower operation.

DD FORM 1391 CHECKER

The DD Form 1391 Processor was originally conceived as the DD Form 1391 Checker, a device for assisting OCE to check MACOM submitted forms. The development of the DD Form 1391 Checker began in October 1976 at the U.S. Army Construction Engineering Research Laboratory (USACERL) when easy to use automated technology was very limited (e.g. video display terminals with full screen editing were not generally available). Midway through initial development, it became obvious that inclusion of all the checking routines and data produced a Processor that could be easily used for forms preparation by installations. Equally obvious was that if installations had a first-rate tool for preparation and if MACOMs could properly check the submitted forms, OCE managerial review and correction would be minimal, as it should be. Thus, the idea of a Processor was born and the developmental viewpoint veered accordingly.

AR 415-15 REVISION

For some years, the governing AR has been in the process of revision, review, and approval. By the close of 1979, the revised (current) form of the AR was reasonably firm. However, the Processor was designed for the old 25 block "front page," and not the new 11 block form, with quantitative data (Blocks 23 and 24) separated.

Internally, the Processor and its documentation still reflect the 25 block viewpoint. The most recent version of AR 415-15 has been issued in 1 December 1983.

DEPLOYMENT

The demonstrations of the capability of the initial Processor were deemed satisfactory and a decision was made to deploy it nationwide by 31 March 1980. There was the problem of converting it from the 25 block to 11 block format, but this was done rapidly by relinking internals and changing the print routine. However, there was another problem; the demonstration version of the Processor contained only mock data and lacked the infrastructure needed to support an integrated data base. Cost, criteria, and TAB data were virtually absent, and there were no mechanisms for acquiring, loading, updating, and transforming (in the case of criteria) the data. Also needed was a DD Form 1657 Processor and print routine, conversion of help commands to agree with the new AR, an additional detailed justification paragraph, project supplemental data, and other items. Also, many functional problems surfaced. A list of 50 deficiencies was made at the beginning of February 1980 and all deficiencies were to be corrected within 4 months.

CERL AND COMSI REVISIONS

USACERL assembled a team to address the identified deficiencies. Assistance was provided by a General Services Administration (GSA) Region 5 contractor, COMSI. By the end of June 1980, the Processor functioned reasonably well, although the data files would require much longer to establish. USACERL participation continued through 15 April 1982 and COMSI still was working in July 1982. During the period following June 1980, piecemeal changes were made continuously, as needed.

USAEDH MAINTENANCE

The U.S. Army Engineering Division, Huntsville (Huntsville Division), eventually to become the assigned responsible agency or Processor maintainer in early 1981, began its participation in December 1979. The first year's work was to acquire and load data. The Huntsville Division now has eight Government and two contractor employees engaged in maintenance. Since the Division assumed the role of maintainer, it has executed all changes desired by the proponents.

D&B COMPUTING SERVICES

D&B Computing Services (DBCS), formerly known as National CSS (NCSS), provided computer support continuously, until June 1982.

Expert technical analyst and programming services were also provided in many peripheral areas, such as adding word processing to the Processor, files conversion, algorithms for improving operational efficiency, and development of the Performance Monitoring System. DBCS completed a study of the overall performance of the Processor in March of 1982 and continues to provide contract design support.

TYMSHARE, INC

In January 1980, a decision was made to acquire worldwide computer services competitively. The Processor was included with a similar procurement for the Construction Appropriations Programming, Control, and Execution System (CAPCES), a procurement which was eventually to include the Automated Military Progress Reporting System (AMPRS II). A contract was awarded to Tymshare, Inc., on 5 February 1982. Tymshare then began converting the Processor data from RAMIS II to FOCUS file structures, completing its conversion by the end of June 1982.

APPENDIX D

MAIL-OUT SURVEY ORGANIZATION

Given the wide range of individuals directly involved in MCA program development--estimates can vary from 400 to 1000 people--there are advantages and disadvantages intrinsic to each particular method used for soliciting user opinions about the Processor. Personal and telephone interviews, in comparison to the individual presentations, allowed a somewhat broader range of contacts, with the same latitude for probing different or new topics related to user perceptions of the Processor. A limitation of this method was a somewhat restricted access to users outside the Washington Metropolitan area. That group greatly outnumbers users inside the Metropolitan area, which contains nonetheless highly significant users (with average monthly computer expenditures for the Processor of $5,000 or more).

Electronic and regular mail surveys were chosen as the best method to reach, albeit in a more restrictive format, a broader range of users. The time effectiveness of electronic mail, in particular, marks it as a satisfactory method for reaching this particular set of individual Army activities. Disadvantages of the method include a restricted range of questions that can be submitted at any one time, and potential misintepretation of question wording.

DEFINITION OF USER GROUPS

The first step in the evaluation of user perceptions of the Processor was to define the concept of "user". For the purposes of the present evaluation, any Army activity involved in MCA programming and preparation or review of Forms through the Processor is an activity-user, or simply, user. This definition of "activity user" has not been restricted to installations, as it might be implied by specific documents such as the MCA Program Development Flow Chart (in Army Regulation 415-15); it includes also Major Army Commands (MACOMs), Major Army Subordinate Commands (MSCs), and Corps of Engineers Districts and Operating Divisions. Therefore, approximately 190 Army activities were identified as 1391 Processor users.

For the selection of a specific sample of users, among those 190 Army activities, the primary factor considered was the amount of work actually carried out through the Processor. In practical terms, that concept was translated for each user in terms of FY 83 expenditures for the Processor alone, derived from cost data for computer charges compiled for individual user IDs by OACE's PAX Control Office (DAEN-ZCP-M). Also included, as a complement to that data, were 1391 Processor expenditures for the first six months of FY 84 (October 83 to March 84) and total expenditures (for the Processor and other applications) for the first six months of FY 84.

Table D-1 presents a breakdown of Processor costs for September 1983 (last month of FY 83). For this month, out of 190 total users, 71 percent (136 users) spent less than $1,000/month. The average

TABLE D-1 Expenditure Categories for Processor Users (September 1983)

1.1 USER AND EXPENDITURE TOTALS PER CATEGORY

	No. of users	Percent	Expenditures	Percent	Average
< $1000	136	71%	42,515	18%	292
$1000-1999	20	11%	28,776	13%	1,439
$2000-4999	23	12%	68,684	30%	3,104
> $5000	11	6%	90,147	39%	8,195
TOTAL	190 *	100%	230,122	100%	1,211

*NOTE: 190 is an approximation

1.2 EXPENDITURE CATEGORIES FOR INSTALLATIONS

	Number of users	Expenditures	Average
< $1000	67	30,024	448
$1000-1999	17	25,105	1,477
$2000-4999	15	44,988	2,999
> $5000	6	39,494	6,582
TOTAL	105	139,611	1,330

1.3 EXPENDITURE CATEGORIES FOR DISTRICTS

	Number of users	Expenditures	Average
< $1000	26	4,513	174
$1000-1999	1	1,323	1,323
$2000-4999	3	8,484	2,828
TOTAL	30	14,320	477

1.4 EXPENDITURE CATEGORIES FOR COMMANDS

	Number of users	Expenditures	Average
< $1000	43	7,978	186
$1000-1999	2	2,348	1,174
$2000-4999	5	15,212	3,042
> $5000	5	50,653	10,131
TOTAL	55	76,191	1,385

SOURCE: OACE-PAX control office (DAEN-2CP-M) monthly expenditure for this group was $292. This was considered an adequate threshold level for selection of a sample of actual Processor users, as measured by computer expenditures. Therefore, 97 PAX users were selected, representing an equivalent number of activity users above that threshold level. Approximately 60 of those activities are at the installation level, 15 at both MACOM and MSC levels, and the remaining ones at the CE District level.

Those 97 activities were contacted by eletronic mail (PAXMAIL) in order to gather a minimum of information about the Army activities in question. The information requested consisted, essentially, of the number of personnel involved in preparing or reviewing Forms, or entering the related data into the Processor, or both; secondly, of computer equipment available for each activity for tasks related to MCA and Form manipulation. When available, information was also requested on activity workload in terms of either projects submitted or reviewed in FY 83 and in the first six months of FY 84. The text of the survey follows.

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL
Advisory Board on the Built Environment
2101 Constitution Avenue
Washington, D.C. 20418

Hello, we are from the National Academy of Sciences, and we are following up with additional questions to the first PAX mail message sent 22 May 1984. As indicated at that time, we are doing a study for the U.S. Army Construction Engineering Research Laboratory (CERL), designed to evaluate the state of the art of computer databases. As part of that study, we have been asked to survey Army Engineer personnel who use the DD Form 1391 Processor.

This form is to be completed at your (INSTL/ DIST/Operating DIV/ MASCOM/ MACOM) by the office that deals with Military Construction Army programming and the DD 1391 Processor. Please write below the name and the address of the person filling out this form, if not the same as listed i the label below.

This form can be informally filled out (no typing necessary) in the spaces provided. This survey should take between 20-30 minutes to be answered. Please mail it back to us at the address above. You can use, for that purpose, the self-addressed, stamped envelope included with this form. The suspense date for the return of this form is:

JULY 6, 1984

PERSON FILLING OUT THIS FORM
Name ....
Telephone (commercial only) (.......) .... - ....
Address ....

1391 SURVEY 3 2

1 FAMILIARITY WITH COMPUTERS

1.1 - Do you personally use computers in your work? [i.e., for applications as word-processing, CAEADS, IFS, personal computing, etc.] If yes, how many hours per week?

1.2 - Do you use computers outside your office, for activities NOT related to your work?

1.3 - If you do not use computers either in the office or outside it, have you had any prior experience with computers? [i.e., word-processing, personal computing, etc.] If yes, could you describe it?

1.4 - Are you familiar with Army computer-based systems other than the DD1391 Processor? If yes, which ones? Do you or others in your office use those systems?

2 USE OF DD 1391 PROCESSOR

2.1 - How would you rate the overall performance of the DD 1391 Processor, in terms of your office responsibilities in [preparing/reviewing] DD Form 1391? Please circle the appropriate number.

SATISFACTORY 1 2 3 4 5 6 7 UNSATISFACTORY

2.2 - What do you consider the best features of the Processor?

2.3 - What do you consider its less desirable features?

2.4 - Does your office use facilities of the Processor (like CEDIT, GETMAIL, MOVETERM, etc.) other than the DD1391 command? If yes, which ones?

2.5 - Are there any improvements or additional features you would like to see offered through the Processor? If yes, which ones?

2.6 - Would graphics capabilities be helpful? If yes, how?

[The next question is for INSTL only]

2.7 - Does your office normally prepare all of the DD Form 1391 it submits? If not, who else does it, and what percentage of your workload does that represent?

3 COSTS & TIME

3.1 - In comparison with manual [preparation/review] of DD Form 1391, how does the Processor perform, in terms of cost to your office? Could you give some examples of before-and-after costs?

3.2 - In comparison with manual [preparation/review] of DD Form 1391, does the Processor save time or not? Can you give some examples?

4 TRAINING SUPPORT AND DOCUMENTATION

4.1 - Have you or any of your personnel had any training by HND (formal, on the job, etc.) to use the 1391 Processor? If yes, what kind of training?

4.2 - Do you use the hotline to Huntsville -- a help service to users -- for Processor-related problems? If yes, how do you rate it, and why?

4.3 - Do you ever consult the user's manual for the Processor? If yes, how do you rate it in terms of difficulty or simplicity of use?

5 ADDITIONAL COMMENTS

5.1 We would appreciate any other comments you might wish to make wit regard the 1391 Processor and the services it provides to your office in carrying out MCA-related activities.

Thank you very much for your time. If you have any further questions or information you would like to share with us, please contact Fred Lacerda at: (703) 334 - 3376
FTS 737 - 3376