

UNIVERSITY FACILITIES JOB COST SYSTEM: REQUIREMENTS AND  
DESIGN

By

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A MASTER'S REPORT

submitted in partial fulfillment of the  
requirements for the degree

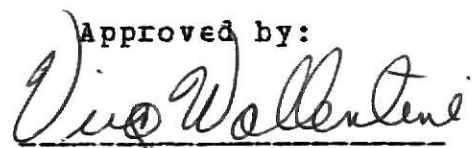
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## CHAPTER I

### INTRODUCTION

In December 1981 the author joined a Data Processing team to help determine the requirements and design of a Job Cost System for University Facilities. This Report summarizes: 1) the effort to determine these requirements, 2) the design of specific system details, 3) the author's participation in the project as a partial fulfillment of the requirements for a Master's degree, and 4) a critique of the project.

This report begins with a detailed, concise description of the project's background, to include general information about University Facilities and a before-and-after comparison of University Facilities' previous Job Cost System as contrasted with the proposed automated system. The requirements of the automated system are then examined in detail. This is followed by a discussion of the overview of the system, to include design information and an evaluation of the design. The report concludes with the author's summary and general impressions of the project as a whole.

PROJECT BACKGROUND

University Facilities has the responsibility for all maintenance, custodial, grounds, support services, and construction work performed on the Kansas State University campus. This includes over 90 buildings and 315 acres. The Veterinary Medicine complex and the new Sports complex are also maintained by University Facilities and still use the Job Cost System, but each has a separate staff.

University Facilities has 525 full-time employees and 428 student workers. These are divided into four major categories. 1) maintenance staff, 2) grounds staff, 3) support services staff, and 4) construction staff.

The maintenance staff includes all custodial employees (those who perform janitorial services), building maintenance employees (who perform building maintenance and repair), and power plant employees (who oversee campus heating, cooling and electricity). The grounds staff works with the Department of Horticulture to ensure that: 1) all lawns are mown, 2) shrubbery and trees are trimmed, and 3) any special planting or related activities are done. The support services staff includes the employees of Security and Traffic (responsible for all campus security, parking lot maintenance, parking permits, and traffic-law compliance), fire safety (responsible for fighting all fires and fire inspections), those of garage and carpool (responsible for maintenance and registration of all university-owned vehicles), and the storeroom personnel (who maintain inventory for

University Facilities). The construction staff is responsible for all remodelling work done on campus. The staff includes workmen (carpenters, electricians, plumbers) and eight employees responsible for generating architectural drawings for staff use.

University Facilities uses this large staff to maintain the campus, and to satisfy departmental and administrative requests. Five thousand job requests are made annually, and job assignments are made through the Job Cost System of University Facilities. At the present time, University Facilities has a large manual system. This system must record work completed, inventory and equipment use information, and bill the departments for the work done.

When a job request is received, a job number is assigned. Presently, the number encodes information about job type, payee type, and major function. As the number falls within specified ranges it is considered: 1) a departmental request, 2) a job for the Veterinary Medicine complex or 3) a standing order (this signifies custodial work). The range also indicates the job's source of funding and its major function. The major function denotes the general purpose of the job, such as a grounds task or departmental request. This procedure is often difficult to follow. With the proliferation of jobs, it can be difficult to stay within the appropriate ranges.

Following the assignation of the job number, the necessary staff is assigned to the job. It is the staff's responsibility to check out the necessary inventory items using the previously

assigned job number. The employees fill out time sheets stating the number of hours worked, and when doing short jobs, fill out many time sheets on a daily basis (one for each job). All of these time sheets are turned into accounting, and, as with inventory check out sheets, are charged to the appropriate job. Any miscellaneous costs must also be charged to the job. All charges are kept in a set of ledgers, and monthly invoices are made from these. A department may have more than one job being done, and a separate invoice is made for each job. Departments often pay for all jobs at one time. Accounting must therefore search the ledgers to find out which jobs to credit. The billing is done on the first of the month, and all updating of the ledgers must stop on the fifteenth to allow the invoices to be calculated and written. A staff of three is assigned to handle all this paperwork. As a consequence, University Facilities is generally four to six weeks behind in updating its accounts. It is also impossible to give the current status of a job or answer questions about it without conducting an extensive search of the files and ledgers. Such searches often take days to perform.

University Facilities decided, in the Fall of 1981, to explore the possibility of automating its system. A request was made to Data Processing to determine the feasibility and cost of automation. The author joined the Data Processing team, which began in December 1981 to define the requirements. Work continued through the spring, and the firm bid was sent and accepted in June, 1982. The proposed automated system should be

fully operational by July, 1983.

Owing to the general inexperience of its staff in dealing with computers, University Facilities requested that ease of use be a prominent feature of the system. For this reason, the proposed system is intended to be user-friendly. As much as possible, the automated system mirrors the same step-wise procedure as the previous system. Before finalizing any of the components or steps of the new system, the Data Processing team discussed these with the prospective users to ensure that the steps would fit their requirements and be easy to use.

CHAPTER IIREQUIREMENTS

At the outset of the project University Facilities' main requirement was to have a system that would be easy to use and would handle all present record-keeping. An Inventory system was desired, as well as files for Employees and Equipment. This Chapter will outline the defined requirements, and the absence of some very important requirements.

More specific requirements evolved during the ensuing six months. They were made known as a result of interviewing all University Facilities department heads to determine what was wanted from a system as well as what would actually be used. All interviewees were heavily dependent on paper reports, so convincing them of the convenience, economy and immediacy of on-line information was a task which assumed primary importance.

It was eventually decided that assigning the Job number and calculating budget estimates would remain a manual process because of the difficulty in estimating costs. The Job number would have no significance, and would have two parts. The first two fields would contain the last two digits of the year, and the last four fields would be a unique combination of numbers. Using the year as part of the Job number ensures that the other numbers can be reused in the future, and the Job number wouldn't have to be larger than six fields.

University Facilities wanted to be able to access the system in many different ways. A list of jobs (and the details of each job) by starting date, department, building, number, and major function was desired. Most staff members experience great difficulty in remembering a job number, so the system had to be flexible enough to access the job by Building, Department, Craft Codes, and Major Function.

In addition, the Craft Codes (recorded in Appendix A) needed to be kept short and meaningful, and unchanged from year to year. Also, a system had to be designed that would require minimal input from employees to avoid an overabundance of memory work on their part. The amount of time needed to fill out time and inventory sheets also had to be reduced.

University Facilities has some problems that they want the proposed system to solve. The solution of these problems were defined as part of the requirements.

Several problems exist with the current inventory system. Storeroom clerks have no way of telling when an item needs to be reordered, and consequently supplies frequently run out. Also, when an item is reordered, no easy way exists to quickly determine the item's supplier. Difficulty also results from the ordering of special items (such as air conditioning units), and in keeping track of such items. There is also a problem with the inventory numbers. The staff member requesting the inventory item must rely on his memory because there is no catalog listing inventory items and their numbers available.

The current inventory system is kept on a FIFO accounting system with fifteen percent added to the wholesale price before the item is charged out. During discussion of the difficulty in maintaining a FIFO system, it was decided to keep the higher price for each item and not worry about changing prices for each shipment. This is more expensive for the user of the item, but is infinitely easier to maintain. University Facilities has the option of manually lowering the price, but the system would check the old price against the new price of the reordered item and keep the higher price.

Presently, all employee files are kept in a ledger by name. Most of the employees belong to a union, and when pay rates change, every entry must be changed. University Facilities wanted the capability of easily changing the pay rate of every employee within a certain Craft Code. The ability to access the file by name, employee number (not Social Security), or Craft Code was desired. Employees don't change crafts often, but when they do, the employee number was changed to uncomplicate the file according to the previous system. University Facilities wanted to continue this practice.

University Facilities also wanted an easily accessible file containing all equipment pieces, their unique numbers and costs. This would facilitate locating all equipment, and would avoid the memory work involved in remembering the different cost rates of usage. As evidenced from the discussion of the above-mentioned difficulties with University Facilities' previous Job



Cost System, a clear and present need existed for an automated system.

To respond effectively to the previously identified problems, the proposed system must: 1) be an on-line system, with batch reports issued periodically, 2) be able to access information in many ways, 3) be user-friendly; to ensure this, it must require only minimal input from the University Facilities staff. The Inventory system must be able to include reorder and special-order information, and also be able to reference inventory items easily. Finally, the Employee and Equipment files must be set up to ensure easy access to the information contained in them.

The requirements of the proposed system should have included the following: 1) the cost of operating the system after implementation, 2) the size of the proposed system, 3) the security of the system, and 4) maintenance of the database in the system. Each of these items is discussed in the following paragraphs.

The cost of operating and maintaining the proposed system was not discussed when system requirements were defined. This, of course, is a serious omission in the development of the overall concept of the proposed system. University Facilities has no idea of potential system maintenance costs. This could very well lead to some rather unpleasant surprises.

The proposed system is very large. No estimate of the actual size of either the code or the database was given. This could

pose problems in the event that University Facilities should want to buy its own computer. By designing and implementing the system to operate on a large computer, University Facilities will be unable to use a small computer, as it might want to do in the future. Also, the system may eventually exceed the proposed system's intended storage space and could conceivably interfere with other University Data Processing activities.

In addition, no provision was made in the system requirements for security in accessing the system. Without security requirements and measures, there will be no limitation as to who has access to the various files. Unauthorized personnel would be allowed access to any part of the system if security measures are not required, designed, and implemented. This would mean that the files could be inadvertantly altered. Also, information could be leaked, and deliberate changes made to important records (e.g. job balances).

No mention was made in the development of the system requirements of how the database and code could be modified and maintained for future use. A clear need exists for some plan of database maintenance to ensure that the system doesn't become useless or difficult to manage with the passage of time. Also, as University Facilities becomes accustomed to the proposed system, the staff may want to modify the system to incorporate new information.

The proposed system requirements define many general requirements. As far as they go, they are useful in designing

the proposed system. However, the absence of the cost, size, security, and formal requirements could create serious problems when the proposed system is designed. The design wouldn't reflect these requirements, and would not produce a feasible, secure system.

### CHAPTER III

#### DESIGN OF THE SYSTEM

After University Facilities' requirements had been determined, the Data Processing team began designing the system. Using the specified requirements (recorded in Appendix B), files were set up containing the required information. These files include the Job, Inventory, Employee, Equipment, Inventory Pending, Department, Chronological, Transactions, Coordinator, Building, Craft Codes, and Major Function files. The details of each file is explained on the following pages. These files make up the major portion of the design of this system, and evolved into a large database. The design also includes "menu" screens for prompting the data entry operator. The database will be implemented on IDMS, and will be an on-line system. Batch reports will be printed periodically, but most access to the system will be through IDMS on-line commands. Also included in this Chapter are the author's changes to the design and a critique of the design.

The design of the database evolved from determining the relationship between the files, the keys, and composing a tentative schema. The team examined the information desired by the University Facilities staff, and determined the possible combinations of files needed. This determined the relationships needed between the files. The team then used the file combinations to determine the database keys, and the relationships and keys determined the tentative database schema.

The database schema shows the relationship among the files. The Employee, Equipment and Transaction files are not owned by and do not own any other files. The Job file is owned by the Coordinator, Chronological, Department, Building, and Major Function files. The Inventory file owns the Inventory Pending and Craft Codes files. A pictorial representation of the database schema is shown in Figure 1. This schema satisfies University Facilities' requirements for access points from the proposed system.

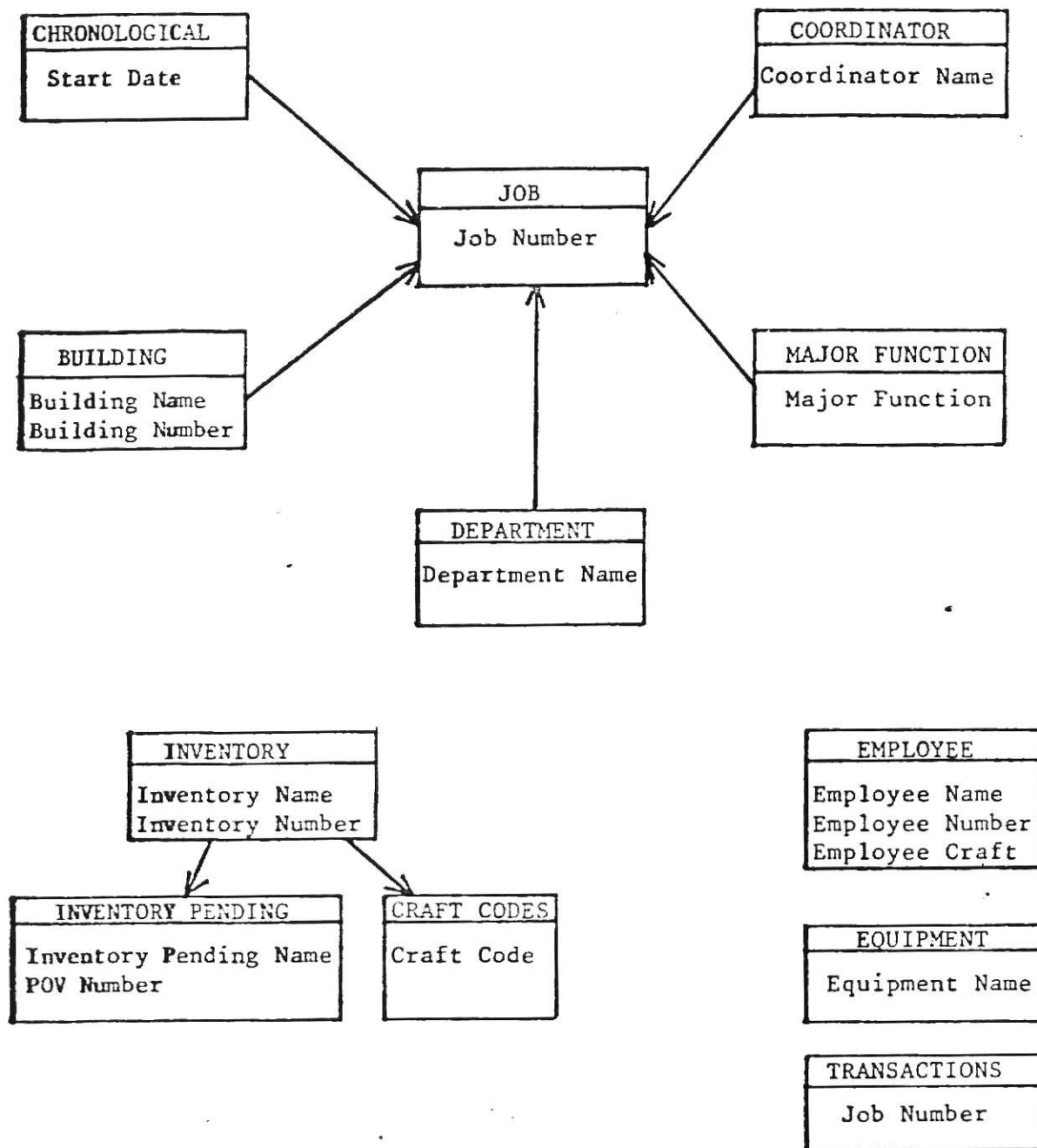


FIGURE 1.  
DATABASE SCHEMA

The "menu" CRT screens were also designed. These menus (recorded in Appendix C) prompt the staff member entering data. In this way, no necessary information can be left out of the record. Upon completion of the screen design, the team presented the screens to the University Facilities staff. Changes were made where necessary. These CRT menu screens played an important part in ensuring a comprehensive definition of necessary requirements. They were the first tangible information that the University Facilities staff had in determining the information available for retrieval from the system.

#### JOE

The Job file is the biggest and most complex of the system. When a request for a job is received, a unique job number will be manually assigned. The job record will contain that unique job number, plus the name of the department requesting the job, a description of the job, and the name of the coordinator from University Facilities in charge of the job.

The major function identifies the general nature of the job and its source of funding. A choice of twelve major functions is available (recorded in Appendix D). These include building maintenance, grounds, sports complex, architecture, departmental requests, and the Veterinary Medicine complex. Most functions are funded by the Kansas Board of Regents. As part of the system, a file is set up to keep a running total of each major function and how much of the budgeted amount is expended.

The Job file also keeps a record of the estimated and actual employee costs by craft (e.g. carpentry, and painting). This enables a breakdown of each job by craft. A separate file is maintained for all of the Craft Codes. This aids in future planning and hiring.

Estimated and actual cost figures must also be kept for the equipment and inventory used, with a pending field for special-order inventory items. A special field for other miscellaneous costs (such as chair rental) must also be kept because these costs are not specific Employee, Inventory, or Equipment costs.

Some large jobs are billed monthly. Smaller jobs are billed only upon termination of work. A flag in the job record indicates which billing method is used. When a job is finished and the bill paid, the job is considered closed. A flag indicating the closed job is used so that a future active job search will ignore the job. However, the job remains in the file for the year in which it occurred. Fields exist to show the date of last billing, date of completion (estimated and actual), and the date of user request. A certain number of jobs are reimbursed by the state of Kansas. All others are paid by various sources, such as departments and foundations. A flag signifying which method of funding used is required. This flag is used to calculate employee and equipment costs, as different rates apply to reimbursable jobs. This flag is called the Hard/Soft flag. In addition, departments use requisition forms to request jobs. The number of each requisition must also be



kept in the system for reference to the original request.

### INVENTORY

At the present time, the inventory of University Facilities contains over 12,000 items. In the ledger, each of these items has a unique inventory number, description, price, and supplier code. The proposed system expands these categories to include a reorder point, units on order, a locator number, and a special code identifying the craft (such as plumbers) usually using the item. The special code will help reduce the risk of requesting the wrong item by number (such as a carpenter requesting an air conditioner). It will also ensure that less incorrect inventory items go to a job by making the number available in writing and not relying on the memory of the staff member requesting the item. Presently, many items are not reordered until the supply is depleted. The clerk must then special order the item at a higher cost. Specifying a reorder point should correct this problem. With the large volume of paperwork involved in the present system, clerks often aren't sure an item has been reordered or from whom. With a record of units on order, guesswork is eliminated. The locator number will be used to ease the problem of finding the requested item. The storeroom floor plan will be divided into grids and grid numbers will be assigned to each item based on its location in the floor plan.

A very important part of the inventory system is the Pending file. When a special item is needed for a job, it must be ordered. To keep track of these special orders, a file is set

up to record these items. When the item is received, it is deleted from the Pending file, assigned to the inventory, and then charged to the job.

The proposed system also includes a provision to update the list prices of inventory item. To facilitate the implementation of this system, the higher price of an item is used. When a new shipment of an item is received, the new price is compared with the old price. The higher price remains as the price of the item. This eliminates the records needed for LIFO and FIFO accounting systems, even though it is more expensive for the customer. The system will then add fifteen percent to the wholesale price, after which that retail price is entered in the inventory file.

An inventory catalog is produced periodically with cross-references for each craft of workmen (such as electricians and painters). This helps to ensure that workmen request correct inventory items, and also shows which items are available.

#### EMPLOYEE

The Employee file contains information about each employee. However, it is not used to calculate payroll, but is a reference file for University Facilities' use. Each employee has a unique employee number (not the Social Security number), and a craft code. Each craft (such as carpentry) has a unique code, and all belong to unions. All employees are categorized by Craft Codes, and no employee can have more than one code.

Each employee record has a class to determine whether the employee is a student , regular worker or consultant. Within each class, pay rates are determined. The employee must have two different class rates of pay. The Hard/Soft flag in the Job file determines which one of these is used to charge the job.

The record also contains the status of the employee (active, inactive), the date he was hired, and the date his position was vacated. If the employee changes jobs, he is given a new employee number, and a new record is set up. To facilitate finding an employees's entire employment record with the University, a field has been set up to insert his previous employee number.

#### EQUIPMENT

Each piece of equipment at the University has been given a unique number. The equipment file contains this number, plus equipment's class (e.g. backhoes), and a description. The file also contains two class rates, one of which is determined by the Hard/Soft flag in the job record to be the basis of the per-hour usage charge.

#### OTHER FILES

To further keep track of jobs, the proposed system also contains files to chronologically record all job requests and all transactions. A file will be built containing the names of all departments. This will include the department's number, name, and address. Also included is a file of all University

buildings, with the building's name, number and grid number. The campus will be divided into grids, and unique numbers will be assigned to all buildings and sections of land on campus. The abovementioned grid system will aid in the identification of campus areas, and will permit enhanced future planning. A complete listing of all files and their fields with field type and length is recorded in Appendix E.

#### CHANGES

The following three paragraphs detail the major differences between the design produced by the Data Processing team and the database put forth in this report. These changes were made in an effort to allow the design to more precisely conform to system requirements.

The design described in this report contains all necessary data and relationships, but is simpler than that generated by the Data Processing team. The team design contained a separate file for the Veterinary Medicine complex Craft Codes. The Veterinary Medicine complex staff has another Craft Code (refrigeration) that the University Facilities staff doesn't use. The University Facilities staff does have a Craft Code for air conditioning however, and the refrigeration code could be kept with that Craft Code. This simpler design would free all the storage previously associated with a separate file. The University Facilities staff indicated that refrigeration maintenance is not a major task and is performed rarely.

The relationships between files have also been changed to meet the requirements of the proposed system. In the original database design, no provision was made for referencing the job by Coordinator, as the requirements state. This Coordinator file has been added to the database shown in this report.

The Inventory Pending and Craft Code files have been moved to access the Inventory file instead of the Job file. The Inventory Pending file records all special-order items and the source from which each order is made. The Craft Code file maintains a record of all inventory items associated with each craft. These files should not be connected with the Job file.

The design generated by the Data Processing team and the changes detailed in this report evolved over a period of seven months. The design was altered many times, and wasn't designed according to database theory. The Data Processing team did not have much knowledge of Database theory and design. The system was designed with COBOL and indexed files in mind. If Database theory had been used, the time involved in designing the proposed system would have been much less. Much time was spent changing relationships because either requirements were changed (or defined) or the relationships between files didn't fit the requirements. The final design might not have been very different, but the time and effort involved would have been less. It is a very large database, with data being retrievable in many combinations.

The proposed system should have been designed by using structured design techniques. The overall design should have been planned by using data flow diagrams and activity diagrams. The module specifications then should have been designed from the diagrams, and the module design should have been developed from the specifications.

The data flow and activity diagrams are developed to aid the team designing the proposed system. The data flow diagrams show where the data is used and can determine the need for other data or show that there is no need for some of the data. The activity diagrams show the steps of the proposed system. This aids the team in ensuring that all of the required steps are incorporated in the design. The team should use the data flow and activity diagrams to trace or walk through the system. This entails inspecting each step and each data element to ensure that all requirements have been met, and no data or step is redundant. This also helps to ensure that the design is logically correct.

The module specifications are developed from the data flow and activity diagrams. These module specifications include the input, output, and functional specifications. The activity diagrams are the most useful because the modules are already determined. Each module is examined, and specifications are determined for the module. This further ensures that the requirements are met, and helps in module design.

The module design is determined from the specifications for each module. This design (typically in pseudocode) is used to implement the module, and interface it with the proposed system. The module design is the last step in the design process, and implementation is done after this step has been completed.

All of these design steps should have been followed, and were not. Using any of the steps without the others encourages an incorrect system. The complete design process was not followed for the proposed system, and a correct system is highly unlikely. The Data Processing team intends to implement the proposed system without using these design steps.

CHAPTER IVACTIVITIES OF THE AUTHOR

When the author joined the Data Processing team, the project was still in its infancy. Most of the work was performed in weekly meetings. Most of design was completed in mid-June.

With the team, the author helped define the system requirements by interviewing the University Facilities staff to determine their needs. After determining what the staff wanted in the new system, the author examined the information now being used and attempted to ascertain whether all the requested data would in fact be used. It was determined that although the University Facilities staff wanted a great deal of new and additional information, much of it was not needed. The author, in tandem with the Data Processing team, was able to persuade University Facilities to readjust some of its inflated expectations. In one case, this took the form of drastically reducing the amount of desired printout by offering weekly exception reports. These weekly exception reports will print out only those jobs which are over budget, and ignore all other jobs. This will reduce the printout from a possible 85 pages (listing every job in one year) to 2 or 3 pages.

The design of CRT screens and files was then undertaken to ensure a user-friendly system. The author also helped design the output reports (recorded in Appendix B-Outputs), and began



determining the fields required for each item. This included making sure that all numeric fields would be large enough to preclude future system modifications.

The database was then designed, and modified extensively to ensure University Facilities' ability to reference this system in many ways. The system will be implemented on IDMS, even though the database was not specifically designed for IDMS.

## CHAPTER V

### CONCLUSION AND CRITIQUE

The author was very pleased to have been given the opportunity to work on this project. It provided insight into the problems and frustrations of working with people and current systems. It demonstrated the types of systems widely used in the "real world", and provided an opportunity to interact with Data Processing personnel.

In working with the Data Processing team, the author noticed an inordinate preoccupation with implementation. Changes in requirements and design were repeatedly precipitated by erroneous assumptions about implementation. Furthermore, the requirements were not complete when the design was developed, so more revisions were needed. As the author's university studies have indicated, this process could have been completed much more rapidly if the correct steps had been followed. Part of the difficulty was the result of the fact that the team had little knowledge of data base theory. This increased the problem of designing the data base.

The proposed system should have been defined and designed through a series of steps. The requirements should have been formally defined, completed, and written before the process proceeded. This would have averted the waste of considerable amounts of time and effort because of the continual changes and

the time spent on deciding which set of requirements were the current set. Because the system requirements were never formally defined, this report contains the most complete set of requirements generated. Unfortunately, these requirements won't be used in the system documentation.

After the requirements had finally been specified, the design should have followed a structured design step-wise progression. All effort was expended on the implementation of the database, while no design was provided for setting up, maintaining, and outputting data from that database. Further, the design of the code necessary to facilitate the use of the database and the menu screens was totally ignored. This design was far too crucial to the success of the system to be so neglected.

Additionally, the design of the database didn't coincide with accepted design techniques. Files were designed without regard to keys, redundant data, and the amount of storage required to maintain the database. Many of the files have more than one key to increase flexibility, but no thought was given to the extra code or storage space needed to ensure that flexibility.

After the database and the menu screens were designed, the team did not check the accuracy of the proposed design by comparing it with the requirements and conducting many walk-throughs. The author found errors in the proposed database relationships as well as inconsistency in the fields within the files of the proposed system. Such errors and inconsistencies will make the proposed system difficult for the user if

implemented because it may cause errors in the database. The errors and inconsistencies of the design could have been avoided if the Data Processing team had walked through the design many times comparing it to the requirements.

Another problem besetting this project was a flagrant lack of communication between the Data Processing team and the University Facilities staff. Although the two staffs met regularly, little real progress was achieved. Requirements were changed often because the University Facilities staff didn't understand the intent of the Data Processing team. Conversely, the Data Processing team often misinterpreted the desires of the University Facilities staff. Both oral and written communication was misunderstood and misinterpreted. Far too much time was spent trying to properly identify the needs of University Facilities. Much of this difficulty in communications was the result of the lexicon of the Data Processing team. Too often "buzz" words and technical terms were used indiscriminately and without clarification. This led to an almost constant undercurrent of confusion.

This situation could have been avoided if several procedures had been used. Data flow and activity diagrams should have been used, and the Data Processing team and the University Facilities staff should have jointly walked through these diagrams to determine if the requirements had been met. The Data Processing team should also have clearly explained all terms and processes that the University Facilities staff didn't understand. The

written communication should have been in the form of memos, and should have been dated. No clear indication was given of when the communication was sent or by whom. These memos should contain a reference to the part of the proposed system in question, and the name of the person sending the memo or requesting the change. The presentation of the menu screens could have been given to the staff members involved with the particular screen and avoided hours of debate between staff members not involved with the particular screen.

When the firm bid was finally sent to University Facilities, no formal proposal accompanied the bid. This situation leaves both University Facilities and Data Processing needlessly vulnerable to changes in the proposed system. With no formal proposal, unacceptable limitations and repeated misunderstandings are all but inevitable.

Finally, no documentation of any kind is planned to accompany the proposed system. Because changes came with such rapidity (again, the result of hasty building on an unsure foundation), a recurring task of the Data Processing team was determining the most current version of the system. The proposed system will be invariably difficult to implement and maintain if documentation isn't written in the very near future.

The minimal documentation that should accompany the proposed system is a complete set of formal requirements, the data flow and activity diagrams, the database schema, menu screen diagrams, and the file contents with the type and length of each

data element. After the proposed system is implemented, documentation will be required to maintain the system in the future. The data flow and activity diagrams easily show each part of the system. If the system doesn't logically work, or needs to be modified, it is much simpler to look at these diagrams to determine the part of the system which needs to be changed than to determine the part of the code that must be changed. The database schema and the menu screen diagrams are also needed as a reference and in case of modification. The file contents with each data element's type and length are needed to ensure that all data entered or referenced in the system is correct and is of the right type or length. All of this documentation should be used as a reference for the University Facilities staff or the Data Processing team member implementing and maintaining the proposed system.

As shown many flaws were manifest in the definition of the system requirements and in the proposed system's subsequent design. The real tragedy is that, without exception, all of these problems could have been avoided with careful planning and the proper application of current, accepted requirements, design, and database theory.

The proposed system is very large and complex, and will require the work of many people. It has been designed to perform many different operations in a very simple manner. Hopefully, it will greatly increase the productivity of the University Facilities staff. Unfortunately, the proposed system

will probably never function as University Facilities expects because too many steps were either shortchanged or omitted in both the requirements and the design phases.

APPENDIX A

## CRAFT CODES

| CRAFT              | CODE |
|--------------------|------|
| Carpentry          | 01   |
| Electrical         | 02   |
| Plumbing           | 03   |
| Refrigeration      | 04   |
| Locksmith          | 05   |
| Construction       | 06   |
| Moving and Hauling | 07   |
| Painting           | 08   |
| Metal Shop         | 09   |
| Custodial          | 10   |
| General Labor      | 11   |
| Power Plant        | 12   |
| Roofing            | 13   |
| Architecture       | 14   |
| Grounds            | 15   |
| Sports Complex     | 16   |



APPENDIX B

REQUIREMENTS OF THE SYSTEM

## REQUIREMENTS OF THE SYSTEM

INFUTS

Listed below are all valid entries in the Job Cost System. For each action, required inputs are listed. These will be listed on the screen to aid the operator in remembering the necessary items. All of these entries are placed in a transaction file, and run at night as a single batch job.

Setting up the new Job record

Job number

Department

Description

Coordinator

Major Function

Employee Costs Estimated

Listed by craft and only necessary crafts are used

Carpenter

Electrical

Plumbing

Refrigeration

Power Plant

Architecture

Sports Complex

Grounds

Locksmith

Construction

Moving and Hauling

Painters

Metal Shop

Custodian

General Labor

Roofing

Equipment Costs Estimated

Inventory Costs Estimated

Other Costs Estimated

Billing Flag Monthly or End of Job

Date of Completion Estimated

Date of User Request

Hard/Soft Flag

Requisition Number

Updating Job Record

Employee

Date

Job Number

Description of work done

Employee Number

Hours Worked (quarter Hour Intervals)

Building Number

Inventory used

Date

Job Number

Description of Item

Inventory Number

Number of Units

Craft Code of Employee Requesting Item

Equipment Used

Date

Job Number

Description of Equipment

Equipment Number

Hours Used (Quarter Hour Intervals)

Other

Date

Job Number

Description of item

Amount Charged

Pending Addition

Date

Job Number

Description of Item

Craft Code

POV Number

Pending Amount

Pending Receipt

Date

Job Number

Description

Craft Code

POV Number

Amount to be taken out of pending

Amount to be put in Actual

Receipts on Job

Date

Job Number

Description (Invoice Number, Receipt Number)

Dollar Amount

OUTPUTS FOR THE SYSTEM

What follows are all batch reports, and are run as labelled .  
 They will be printed on a 132 column computer sheet so this spacing is not that of the actual reports. Following the report, are the files and their database keys that allow access to the information so that the report can be generated.

INVOICE

|  |                  |
|--|------------------|
| INVOICE                                      | Invoice Number   |
|  | Invoice Date     |
| Pay to University Facilities<br>Dykstra Hall |                  |
| Previous Balance                             | \$\$\$\$\$. \$\$ |
| Less Payments                                | \$\$\$\$\$. \$\$ |
| Plus Charges                                 | \$\$\$\$\$. \$\$ |
| Total  |                  |
| Due.....                                     | \$\$\$\$\$. \$\$ |

|                  |                  |                  |                  |                  |                  |
|------------------|------------------|------------------|------------------|------------------|------------------|
| JOB NUM          | EMPLOYEE         | EQUIPMENT        | INVENTORY        | OTHER            | TOTAL            |
| XXXXXX           | \$\$\$\$\$. \$\$ | \$\$\$\$\$. \$\$ | \$\$\$\$\$. \$\$ | \$\$\$\$\$. \$\$ | \$\$\$\$\$. \$\$ |
| \$\$\$\$\$. \$\$ |                  |                  |                  |                  |                  |

|                    |                  |
|--------------------|------------------|
| INVENTORY BY CRAFT |                  |
| XX                 | \$\$\$\$\$. \$\$ |
| XX                 | \$\$\$\$\$. \$\$ |
| INVENTORY TOTAL    | \$\$\$\$\$. \$\$ |

The above format is used for all of jobs that a department has.  
 \*\*\*\*\*  
 DEPARTMENT TOTALS FOR ALL JOBS

|           |                  |
|-----------|------------------|
| Equipment | \$\$\$\$\$. \$\$ |
| Employee  | \$\$\$\$\$. \$\$ |
| Inventory | \$\$\$\$\$. \$\$ |
| Other     | \$\$\$\$\$. \$\$ |
| Total     | \$\$\$\$\$. \$\$ |

Job file - Job number for each job

WEEKLY JOB SUMMARY (OVER BUDGET JOBS)

| JOB<br>NUM | JOB<br>DESC | EMPLOY<br>BUD | ACT    | EQUIP<br>BUD | ACT    | INVENTORY<br>BUD | PND    | ACT    | TOT    | OTER<br>BUD | ACT    | TOTAL<br>BUD | ACT    |
|------------|-------------|---------------|--------|--------------|--------|------------------|--------|--------|--------|-------------|--------|--------------|--------|
| XXXXXX     | XXXX        | \$\$\$        | \$\$\$ | \$\$\$       | \$\$\$ | \$\$\$           | \$\$\$ | \$\$\$ | \$\$\$ | \$\$\$      | \$\$\$ | \$\$\$       | \$\$\$ |

Job file - Job number

MAJOR FUNCTION BY BUILDING (YEARLY)

| MAJ FUNC     | BLDG | BLDG NAME    | BUDGETED    | ACTUAL      | VARIANCE    |
|--------------|------|--------------|-------------|-------------|-------------|
| XXXXXXXXXXXX | XX   | XXXXXXXXXXXX | \$\$\$\$\$. | \$\$\$\$\$. | \$\$\$\$\$. |
| \$\$\$\$\$.  |      |              |             |             |             |
|              | XX   | XXXXXXXXXXXX | \$\$\$\$\$. | \$\$\$\$\$. | \$\$\$\$\$. |
| \$\$\$\$\$.  |      |              |             |             |             |
|              |      | TOTAL        | \$\$\$\$\$. | \$\$\$\$\$. | \$\$\$\$\$. |
| \$\$\$\$\$.  |      |              |             |             |             |

Major Function file - Major Function  
Building file - Building number

STOREROOM FINANCIAL STATEMENT (MONTHLY)

| CURRENT MONTH      | YTD         |
|--------------------|-------------|
| Sales              | \$\$\$\$\$. |
| Less Cost of Sales |             |
| Beginning Inv      | \$\$\$\$\$. |
| Purchases          | \$\$\$\$\$. |
| Sub-Total          | \$\$\$\$\$. |
| Less End Inv       | \$\$\$\$\$. |
| Cost of Sales      | \$\$\$\$\$. |
| Gross Profit       | \$\$\$\$\$. |

Inventory file - Inventory sales accumulated

INVENTORY LIST (QUARTERLY)

| INVENTORY | CAT | UNIT | UNIT | SELL | ON    | ON   |
|-----------|-----|------|------|------|-------|------|
| ORDER     |     |      |      |      |       |      |
| NUMBER    | LOC | DESC | TYPE | COST | PRICE | HAND |
| POINT     |     |      |      |      |       |      |

|        |     |       |    |    |        |        |     |     |     |
|--------|-----|-------|----|----|--------|--------|-----|-----|-----|
| XXXXXX | XXX | XXXXX | XX | XX | \$\$\$ | \$\$\$ | XXX | XXX | XXX |
|--------|-----|-------|----|----|--------|--------|-----|-----|-----|

Inventory file - Inventory number

CATALOG (6 MONTHS)

| NUMBER | LOC | UNIT | DESCRIPTION             | EST PRICE        |
|--------|-----|------|-------------------------|------------------|
| XXXXXX | XXX | XXX  | XXXXXXXXXXXXXXXXXXXXXXX | \$\$\$\$\$. \$\$ |

Inventory file - Inventory number

REORDER LIST (TWICE PER WEEK)

| NUMBER | LOC  | DESC     | ON<br>HAND | ON<br>ORDER | ORDER<br>DATE | ORDER<br>POINT |
|--------|------|----------|------------|-------------|---------------|----------------|
| XXXXXX | XXXX | XXXXXXXX | XXXX       | XXXX        | XX/XX/XX      | XXXX           |

Inventory file - Inventory reorder point

ADJUST ORDER POINT (QUARTERLY)

| NUMBER | LOC  | DESC   | ORDER<br>POINT | ---- | NUMBER OF ORDERS BY MONTH---- |    |    |    |    |    |    |    |    |    |    |
|--------|------|--------|----------------|------|-------------------------------|----|----|----|----|----|----|----|----|----|----|
|        |      |        |                | 01   | 02                            | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
| XXXXXX | XXXX | XXXXXX | XXXX           | XX   | XX                            | XX | XX | XX | XX | XX | XX | XX | XX | XX | XX |

Inventory file - Inventory number



REQUIRED ACCESS KEYS OF THE SYSTEM

The following items are the access points that are required for the proposed system. These will eventually become the database keys. Also included are the files which can be accessed with these keys.

| KEY                      | FILE              |
|--------------------------|-------------------|
| Start date               | Chronological     |
| Job number               | Job               |
| Building name            | Building          |
| Department name          | Department        |
| Major Function           | Major Function    |
| Coordinator name         | Coordinator       |
| Craft Code               | Craft Code        |
| Equipment name           | Equipment         |
| Employee name            | Employee          |
| Employee number          | Employee          |
| Employee craft           | Employee          |
| Inventory number         | Inventory         |
| Inventory Pending number | Inventory Pending |
| POV number               | Inventory Pending |

APPENDIX C

SCREEN MENUS

The following are menu screens to aid the data entry operator ensure that no necessary information is omitted. The Job Control Menu screen is the first of the series of screens. The operator moves the cursor to the item wanted, and enters it. The appropriate screen then appears, and the operator enters the necessary information. The following screens are detailed samples of the screens that will be used in the proposed system.

#### JOB CONTROL MENU

##### ADD & UPDATE

EM    EMPLOYEE EDIT & UPDATE  
 DP    DEPARTMENT EDIT & UPDATE  
 BL    BUILDING EDIT & UPDATE  
 FU    MAJOR FUNCTION EDIT & UPDATE  
 JB    JOB SET UP  
 JR    EST JOB COSTS BY CRAFT  
 EQ    EQUIPMENT EDIT & UPDATE

##### BROWSES

NS    EMPLOYEE NAME SEARCH  
 JC    JOB COST STATISTICS  
 JD    JOBS BY DEPARTMENT  
 JB    JOBS BY BUILDING  
 JF    JOBS BY MAJOR FUNCTION  
 JA    JOBS BY START DATE

##### DELETE TRANS

XE    DELETE EMPLOYEE  
 XD    DELETE DEPARTMENT  
 XB    DELETE BUILDING  
 XF    DELETE FUNCTION  
 XJ    DELETE JOB

## UPDATE EMPLOYEE FILE

|                   |                |
|-------------------|----------------|
| NAME              | _____          |
| CRAFT             | _____          |
| CLASS             | __ (U,C, OR S) |
| STATUS            | __ (A OR I)    |
| DATE HIRED        | __ __ __       |
| DATE VACATED      | __ __ __       |
| PREV EMPLOYEE NO. | _____          |
| SOFT RATE         | _____          |
| HARD RATE         | _____          |

UPDATE DEPARTMENT FILE

DEPARTMENT NAME \_\_\_\_\_  
 BUILDING ADDRESS \_\_\_\_\_  
 DEPARTMENT HEAD \_\_\_\_\_  
 DEPARTMENT PHONE \_\_\_\_\_

UPDATE BUILDING FILE

BUILDING NAME \_\_\_\_\_  
 BUILDING GRID \_\_\_\_\_

EQUIPMENT UPDATE

DESCRIPTION \_\_\_\_\_  
 STATUS \_ (A OR I)  
 SOFT RATE \_\_\_\_\_  
 HARD RATE \_\_\_\_\_

## JOB SETUP OR UPDATE

JOB NUMBER \_\_\_\_\_  
DESCRIPTION \_\_\_\_\_  
COORDINATOR \_\_\_\_\_  
DEPARTMENT \_\_\_\_\_  
FUNCTION \_\_\_\_ HARD/SOFT \_\_\_\_ BILL TYPE \_\_\_\_ CLOSED \_\_\_\_  
REQUEST DATE \_\_\_\_ EST COMPLETED DATE \_\_\_\_

## EQUIP COSTS

## OTHER COSTS

DESC \_\_\_\_\_  
COSTS \_\_\_\_\_

DESC \_\_\_\_\_  
COSTS \_\_\_\_\_

## LABOR COSTS

| CRAFT   | COST  | CRAFT   | COST  |
|---------|-------|---------|-------|
| CARPEN  | _____ | LOCKSM  | _____ |
| ELECT   | _____ | CONSTR  | _____ |
| PLUMB   | _____ | PAINT   | _____ |
| REFRIG  | _____ | MOVING  | _____ |
| METAL   | _____ | CUSTOD  | _____ |
| GEN LAB | _____ | ROOFING | _____ |
| FIELD   | _____ | GROUNDS | _____ |
| ARCH    | _____ | POWER   | _____ |

## INVENTORY COSTS

DESC \_\_\_\_\_  
COST \_\_\_\_\_

JOBS BY DEPARTMENT

DEPARTMENT NAME \_\_\_\_\_

| JOB NUM | DESC  | START DATE | EST COM DATE |
|---------|-------|------------|--------------|
| _____   | _____ | _____      | _____        |

JOBS BY START DATE

| JOB NUM | DESC  | EST COM DATE | EST COST |
|---------|-------|--------------|----------|
| _____   | _____ | _____        | _____    |

JOBS BY COORDINATOR

COORDINATOR NAME \_\_\_\_\_

| JOB NO | DESC  | ST DATE | COM DATE | EST COSTS | ACT COSTS |
|--------|-------|---------|----------|-----------|-----------|
| _____  | _____ | _____   | _____    | _____     | _____     |

APPENDIX D

MAJOR FUNCTIONS

BUILDING MAINTENANCE

BUDGET

GROUNDS

SPORTS COMPLEX

CUSTODIAL

ARCHITECTURE

UNAPPROPRIATED

POWER PLANT

DEPARTMENT STANDING ORDERS

DEPARTMENT REQUESTS

FIRM BID

VETERINARY MEDICINE COMPLEX



APPENDIX E

CONTENTS OF FILES AND TYPE AND LENGTH

## CONTENTS OF FILES, TYPE AND LENGTH

JOB

|                |             |
|----------------|-------------|
| JOB_NUM        | PIC X(6)    |
| JOB_DEPT       | PIC X(20)   |
| JOB_BLDG       | PIC X(20)   |
| JOB_GRID       | PIC X(4)    |
| JOB_REQ_NUM    | PIC X(4)    |
| JOB_MAJ_FUN    | PIC XX      |
| JOB_DESC       | PIC X(20)   |
| JOB_COORDIN    | PIC X(20)   |
| JOB_HARD/SOFT  | PIC X       |
| JOB_CLOSED     | PIC X       |
| JOB BILLING    | PIC X       |
| JOB_REQ_DATE   | PIC XXXXXX  |
| JOB_ST_DATE    | PIC XXXXXX  |
| JOB_COM_DATE   | PIC XXXXXX  |
| JOB_LAST_BILL  | PIC XXXXXX  |
| JOB_CLOSE_DATE | PIC XXXXXX  |
| JOB_COSTS_EST  |             |
| EMPLOY         | PIC 9(7)V99 |
| INVEN          |             |
| INV            | PIC 9(7)V99 |
| PND            | PIC 9(7)V99 |
| EQUIP          | PIC 9(7)V99 |
| OTHER          | PIC 9(7)V99 |
| JOB_COSTS_ACT  |             |
| EMPLOY         | PIC 9(7)V99 |
| INVEN          |             |
| INV            | PIC 9(7)V99 |
| PND            | PIC 9(7)V99 |
| EQUIP          | PIC 9(7)V99 |
| OTHER          | PIC 9(7)V99 |
| JOB_RECEIPTS   | PIC 9(7)V99 |

## INVENTORY

|                 |             |
|-----------------|-------------|
| INV_NUM         | PIC XXXXXX  |
| INV_DESC        | PIC X(20)   |
| INV_LOC         | PIC XXX     |
| INV_CAT_TYPE    | PIC XX      |
| INV_UNIT_COST   | PIC 9(7)V99 |
| INV_UNIT_SELL   | PIC 9(7)V99 |
| INV_REOR_PT     | PIC 9(5)    |
| INV_UNIT_HAND   | PIC 9(5)    |
| INV_UNIT_ON_ORD | PIC 9(5)    |
| INV_LAST_ORD    | PIC XXXXXX  |
| INV_LAST_ORD_NO | PIC XXXXXX  |
| INV_MON_ORD_CT  | PIC XXXXX   |
| INV_BEG_INV     | PIC 9(7)V99 |
| INV_PURCHASES   | PIC 9(7)V99 |
| INV_END_INV     | PIC 9(7)V99 |
| INV_SALES       | PIC 9(7)V99 |

## EMPLOYEE

|               |             |
|---------------|-------------|
| EMP_NUM       | PIC XXXX    |
| EMP_CRAFT     | PIC XX      |
| EMP_NAME      | PIC X(20)   |
| EMP_CLASS     | PIC X       |
| EMP_STATUS    | PIC X       |
| EMP_DATE_HIRE | PIC XXXXXX  |
| EMP_DATE_VAC  | PIC XXXXXX  |
| EMP_PREV_NUM  | PIC XXXX    |
| EMP_HARD_RATE | PIC 9(3)V99 |
| EMP_SOFT_RATE | PIC 9(3)V99 |

## EQUIPMENT

|               |             |
|---------------|-------------|
| EQP_NUM       | PIC XXXX    |
| EQP_DESC      | PIC X(20)   |
| EQP_HARD_RATE | PIC 9(3)V99 |
| EQP_SOFT_RATE | PIC 9(3)V99 |

## DEPARTMENT

|            |             |
|------------|-------------|
| DEPT_NUM   | PIC XXX     |
| DEPT_NAME  | PIC X(20)   |
| DEPT_BLDG  | PIC XXX     |
| DEPT_ADDR  | PIC X(20)   |
| DEPT_HEAD  | PIC X(20)   |
| DEPT_PHONE | PIC XXXXXXX |

## BUILDING

|           |           |
|-----------|-----------|
| BLDG_NUM  | PIC XXX   |
| BLDG_NAME | PIC X(20) |
| BLDG_GRID | PIC XXXX  |

## CRAFT

|             |             |
|-------------|-------------|
| CFT_JOB     | PIC XXXXXX  |
| CFT_EST_INV | PIC 9(7)V99 |
| CFT_ACT_INV | PIC 9(7)V99 |
| CFT_PND_INV | PIC 9(7)V99 |

## PENDING

|             |             |
|-------------|-------------|
| FND_DATE    | PIC XXXXXX  |
| FND_POV_NUM | PIC XXXXXX  |
| FND_JOB_NUM | PIC XXXXXX  |
| FND_DESC    | PIC X(20)   |
| FND_CRAFT   | PIC XX      |
| FND_AMT     | PIC 9(7)V99 |

UNIVERSITY FACILITIES JOB COST SYSTEM: REQUIREMENTS AND  
DESIGN

By

ELIZABETH B. WELD

A.B. Wofford College, 1977

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ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the  
requirements for the degree

MASTER OF SCIENCE

Department of Computer Science

KANSAS STATE UNIVERSITY  
Manhattan, Kansas

1982

## ABSTRACT

This report describes the requirements and the design for the Job Cost System of University Facilities. Included are the requirements specifications, the data base schema, file descriptions, a synopsis of my activities, and a conclusion and critique of my Master's Project.

In November, 1981 University Facilities decided to determine the feasibility of an automated Job Cost System. I participated in a Data Processing team that defined the requirements and designed an automated system.

The Data Processing team conducted interviews with University Facilities staff members, and examined other similar systems to determine if there were any features that University Facilities might want to incorporate into this system. This process of determining the requirements took six months.

The system was then designed, and became a very large data base. The bulk of the system involves manipulating the data base, with batch reports being generated periodically. These reports are the only extra code that is needed in the system. This will be an on-line system when implemented, and will be a very powerful system.