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Automated timekeeping and project information system using bar coding techniques

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Automated timekeeping and project information system
using bar coding techniques

by

Yvan Augusto Rodriguez

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE

Department: Civil and Construction Engineering
Major: Civil Engineering (Construction Engineering
and Management)

Approved:

Signatures have been redacted for privacy

Iowa State University
Ames, Iowa

1992

To Isbelia,
who fulfills all my needs.

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I. INTRODUCTION

Project cost control in the construction industry requires the gathering, processing, and reporting of a considerable amount of information in a timely manner (Oberlender, 1989). Frequently, extensive manual collection of information for project control purposes is executed at the site level; this leads to countless hours of work and often times results in inaccurate and obsolete information. Thus, there is a need for more efficient information systems for measuring and reporting construction project status. This thesis investigates improvements to one aspect of the project cost control system as it relates to improving construction site timekeeping procedures.

A. Problem Statement

Several problems related to existing and common procedures for timekeeping and cost control processes have been identified. These problems can be summarized as follows: (1) Inefficient manual data-collection methods. Actual manual collection methods are time-consuming and often complex to achieve. Usually, management relies on the accounting department to know the cost status for the performing project. However, accounting departments do not process and generate the necessary reports as quickly as management personnel require; and thus, by the time cost reports are produced,

important project performance information is not necessarily current. (2) Inaccuracy of data. Information generated at the site level is read, reproduced, and transmitted through several levels within a company before it is entered into a computerized system. During this process, information could be misinterpreted and changed, leading to inaccurate portrayal of the job. Finally, (3) inadequate report generation. The numerous and complicated tabular reports and the necessary time to generate those reports lead to confusing interpretations and slow responses to potential labor cost problems.

B. Research Objectives

With these problems in mind, research was conducted with the objectives of (1) finding a real-time project tracking system that charges person-hours and quantities of work-in-place at the time it occurs, rather than after the work is completed; (2) reducing errors in timekeeping and cost control data; (3) providing reports in an easy-to-understand format; and (4) identifying innovative factors for payroll data collection and labor cost control procedures.

C. Research Approach

Once problems were identified and objectives stated, an automated system was planned to collect relevant labor information from construction sites. Several automatic

identification technologies were studied and a hand-held computer capable of scanning bar coded information was used in developing a prototype system.

After developing this model, the system was field-tested, and a few modifications were required. Improvements and graphical representations were achieved, and beneficial results were perceived.

D. System Development and Description

To improve the current shortcomings with existing project control methods, an Automated Timekeeping and Project Information System (A.T.I.S.) using Bar Coding Techniques was developed for tracking, processing, and reporting labor and quantity information.

This system allows the collection of labor and quantities of work-in-place data directly from the site to a hand-held computer. Relevant information is entered into the unit by scanning bar code labels for worker names, cost codes, hours, memos, and quantities. After entering the information daily, the hand-held computer is linked to a personal computer (PC), and all data are transferred. Once the information is transferred to the PC, several tabular and graphical reports can be generated, and useful information is readily available to management personnel.

With this system, the information originated at the site level is entered, processed, and reported in an accurate and

timely manner. Therefore, the uncomplicated report style allows identifying and solving any problem related to labor costs, when the problem occurs.

Although the system is currently used by a general contractor firm, several enhancements are needed to fully collect all the essential data (e.g., materials and subcontractors costs) to control all the costs related to any construction project. Hence, this work could lead to future research in the area of innovative computerized project control systems in the construction industry.

enhancements
needed

E. Limitations

One of the limitations of the system is its inability to transfer the information from the PC to a central-based computer. This feature would strengthen A.T.I.S. for company-wide uses, and would offer centralized control over several projects in existent mainframe designs. Additional improvements would be in (1) adaptability to changes in worker's salaries and (2) availability for automated printing of bar code labels and person-hours reporting.

F. Thesis Organization

This thesis is organized into six chapters. Chapter I provides an introduction to the problem and the purpose of this work. Also, this chapter gives a brief description of the automated system and the organization of the thesis.

Chapter II provides a literature review, including some basic concepts for project cost control, an explanation of current timekeeping systems, a brief description of automatic identification technologies, the selection of bar coding techniques among others, the anticipation of several advantages of bar coding in timekeeping applications, a description of previous uses of this technique in the construction industry, and the review of other possible applications of bar coding techniques in the construction industry.

Chapter III describes the research methodology followed in developing the automated project control system, and it is grouped as follows: an explanation of the system; a description of how the information is collected, manipulated, and used for generating reports; and an explanation of the system field testing as a validation procedure.

Chapter IV gives the results of this research and is divided into four sections. The first section deals with the observed time benefits and advantages of the automated timekeeping system. The second and third sections describe the tabular and graphical reports generated by the system. Finally, a summary of these findings is presented.

Chapter V reviews the author's recommendations for improving the automated labor cost control system. The limitations, enhancements, and incorporation of other

resources to the system are also presented. This is followed by suggestions for future research.

Chapter VI provides a summary and the conclusions of the study. Then, a list of the works cited and consulted is presented, followed by acknowledgments to persons and institutions that helped in the completion of this study.

Finally, several appendices of this work are displayed. Among them are the menu trees for either the PC or the handheld computer programs, the structure of the database files used, and the programs written in developing the system.

II. LITERATURE REVIEW

A. Basic Concepts for Project Labor Cost Control

Although the intent of this work is not to provide new theories or concepts for controlling cost on a construction project, it is necessary to understand the principles of cost control related to construction projects to improve the process of tracking, processing, and reporting the time and quantity of information obtained from the site. Moreover, this thesis was conceived with tracking just labor costs. Further research could include the remaining resources encountered in a project, such as materials, equipment, subcontractor payments, change order, and capital requirements.

Control is one important function of management (Rasdorf and Abudayyeh, 1991), and a proper execution of control will help ensure a successful outcome for the project. During the initial phases of a project, planning is the dominant management function and represents about 20% of the project cycle time; but once the project is in the construction phase, control becomes the dominant function for the remaining 80% of the project's life (Harrison, 1985).

Although planning and control have similar importance as other management functions, the latter takes more time and effort. As mentioned before, control becomes the primary management function during a large segment of a project's

life, and substantial effort is spent collecting data on a project's cost, resource use, etc.; analyzing actual costs against planned ones; identifying areas where special attention is required; and making decisions based on the analysis results. For these reasons, an effective, accurate, and timely control is imperative for satisfactory project performance.

Generally, project control can be defined as

the processes required to define the objectives of the project and the resources used to meet these objectives, the policies and activities required to provide these resources, the efficient use of these resources, and the efficient and effective conduct of specific tasks to achieve the project objectives (Sanvido, 1989, p. 403).

Cost control relates to monitoring expenses within the existing budget while providing a quality product within the time limit specified (Humphreys, 1991). This general idea is applicable for cost controlling of one, two, or all the resources found in a construction project.

As part of cost control, project budgeting

consists of converting the capital cost estimate into accountable cost centers by physical or process area and classifications of work. The project budget indicates the estimated cost, quantities, and manhours to perform the task of work (Mendel, 1989, p. 97).

The accountable cost centers are also called code of accounts or cost codes, and any company should maintain the same cost codes for project after project, so its employees

should become familiar with these codes, or at least with the most important ones.

The levels of preparation and detail found in the cost of accounts will vary from company to company, as well as the levels of management that status reports will be submitted. Furthermore, each cost account will embrace a particular activity of work or a group of activities. Table 2.1 shows a code of accounts under the CSI¹ format which are the most widely accepted in the building construction industry.

Also, a job cost report presents all the information from the estimate to the actual information performed. Thus, any variance from these two can be identified and necessary actions can be taken.

Other components of cost control are the reporting, analysis, and variation (Humphreys, 1991). The progress reporting time basis varies from company to company. However, it is usually performed on a weekly basis (for example, weeks starting on Thursdays and finishing on Wednesdays). It is the job of the site personnel to track and submit periodically the progress and time spent on each cost account. Humphreys (1991) also recommends six methods for measuring project progress: units completed, incremental milestone,

¹Sixteen divisions of the Masterformat System of classification were developed by the Construction Specifications Institute.

Table 2.1. Sample of a code of accounts under the CSI format^a

Cost codes	Description
DIVISION 01 - GENERAL REQUIREMENTS	
0170	Project closeout
DIVISION 02 - SITE WORK	
0210	Clearing
0220	Earthwork
0280	Landscaping
DIVISION 03 - CONCRETE	
0330	Cast-in-place concrete
DIVISION 04 - MASONRY	
0420	Unit masonry
DIVISION 05 - METALS	
DIVISION 06 - WOOD AND PLASTICS	
0610	Rough carpentry
0620	Finish carpentry
DIVISION 07 - MOISTURE-THERMAL CONTROL	
0750	Membrane roofing
DIVISION 08 - DOORS, WINDOWS, AND GLASS	
0820	Wood and plastic doors
0860	Wood and plastic windows
DIVISION 09 - FINISHES	
0925	Gypsum wallboard
0955	Wood flooring
0965	Resilient flooring
0990	Painting
DIVISION 10 - SPECIALTIES	
DIVISION 11 - EQUIPMENT	
DIVISION 12 - FURNISHINGS	
1230	Cabinets and storages
DIVISION 13 - SPECIAL CONSTRUCTION	
DIVISION 14 - CONVEYING SYSTEMS	
DIVISION 15 - MECHANICAL	
1540	Plumbing
1570	Liquid heat transfer
DIVISION 16 - ELECTRICAL	
1650	Lighting
1690	Controls and instrumentation

^aTaken from Means Estimating Handbook, 1990.

start/finish, supervisor opinion, cost ratio, and weighted or equivalent units.

Units completed procedures could be applied to those cost accounts involving repetitive production of pieces of work simple to measure. Also, each piece of work requires roughly the same level of effort while performed. The incremental milestone method applies to any control account which involves several steps performed in sequence to complete the task being controlled. Start/finish procedures are used in those cases where intermediate milestones are difficult to calculate, and/or where the time/effort required is complicated to evaluate. In the supervisor opinion procedures, the supervisor makes a subjective perception of percent complete. Cost ratio methods are applicable to tasks that involve a long period of time, are continuous during the life of the project, and are estimated and budgeted on lump sum of dollars or work-hours rather than on the basis of production. Examples are tasks concerning project management, quality assurance, and contract administration. Finally, weighted or equivalent units procedures are suitable for tasks representing a major effort over a long period of time which are divided in two or more overlapping subtasks, each having a different unit of work measurement.

To analyze project cost performance, relevant information such as previous committed cost, total-to-date, current estimated cost at completion, percent expended, original

budget, over (or under) budget, and percent deviation should be reported (Humphreys, 1991). These terms are presented and calculated in the chapter concerning results for the current research. Thus, an easier understanding of these terms can be achieved.

Methods for analyzing project cost performance are based upon earned value concepts.

The earned value concept is based on the measurement of the budgeted value of work actually carried out, and its comparison with the budgeted value of the work that should have been carried out and what it actually cost (Harrison, 1985, p. 248).

Under this idea, a direct relationship is validated between percent complete of a cost code and the budget for that cost code, and is expressed as:

$$\text{Earned value} = (\text{percent complete}) \times (\text{budget for that account}).$$

Similarly, multiple accounts or overall progress can be determined by:

$$\text{Percent complete} = \frac{\text{earned work-hours}}{\text{budgeted work-hours}} \vee \frac{\text{earned dollars}}{\text{budgeted dollars}}$$

(Humphreys, 1991).

These two formulae provide an approach for calculating percent complete of an account or various accounts. They are helpful in determining cost performance, as will be demonstrated in a following chapter. Next, two basic project control terms are defined:

BCWP, or the budgeted cost for work performed, represents the budgeted cost of all the work actually concluded during a particular time period.

ACWP, or the actual cost of work performed, represents the costs actually consumed in performing the work within a particular time period.

By knowing these terms, several new terms can determine variances, indexes, and projections to evaluate either a particular cost code, several of them, or the overall project.

The cost variance, **CV**, is determined by:

$$CV=BCWP-ACWP.$$

The cost performance index, **CPI**, is determined by:

$$CPI=BCWP/ACWP.$$

It is important to remark that a positive variance and an index of 1.0 or greater symbolize a favorable performance.

Cost performance index, **CPI**, could be also determined by:

$$CPI=ACWP/BCWP.$$

In this case, **CPI** will determine the percentage above or under the budget.

Then, projections of total costs by the end of the project can be determined for a cost code, a group of cost codes, or the overall project by adding up actual variances to budgeted costs, or by multiplying actual performance indexes by budgeted costs.

Ideally, costs and schedule performance analysis should be integrated into a unique control system. However, this study does not deal with project schedule controls. Similar equations exist for reporting and analyzing schedule performance, and they could be introduced in future research.

Finally, after the project has been completed, final costs are recorded and used as historical data for estimating similar future projects.

As a summary, Table 2.2 presents a list of the key elements needed to understand and develop an effective cost control system for a construction company. The terms from Table 2.2 that apply to this work were briefly described before.

From all the key elements of cost control, this research deals directly with the costing and reporting components. As mentioned before, this research focused on labor costs only. The collecting and reporting of information are also improved by using bar coding techniques and easier to understand graphical reports. Moreover, this work could develop a general system that integrates and improves the way information is gathered, processed, and summarized for all the elements of cost control.

Next, current timekeeping systems are explained. Several inefficiencies of such systems are presented, so several automatic identification technologies can be offered to improve those existing timekeeping systems.

Table 2.2. Key elements of cost control^a

-
1. Project setup
 - a. Budget estimate (trackable)
 - b. Code of accounts
 2. Costing
 - a. Labor cost
 - b. Material cost
 - c. Construction equipment and tools cost
 - d. Subcontract's cost
 - e. Overhead and indirect cost
 3. Reporting
 4. Analysis
 5. Variation
 6. Finalization
 - a. Final cost report - history
 - b. Capital distribution - client use
-

^a(Humphreys, 1991).

B. Current Timekeeping Systems

Many contractors still use inefficient means to collect data by manual methods of transferring cost data from the field to the home office (Songer, Considine, and Ibbs, 1989). In these cases, the process often comprises transferring and transcribing the same data among different layers of site and home office personnel, making the actual system inaccurate and time consuming. Information generated at the site level, is usually passed through different people before entered into a computerized system. In this process, errors are prone to

occur, and inaccurate data get into the system. When this happens, reporting, analysis, and decisions based on these data become meaningless.

An actual time sheet is shown in Figure 2.1. In tracking labor cost data, site personnel (usually, the foremen) fill out the time sheet on a daily basis. Then, the superintendent consolidates and calculates the time spent for every worker on each cost account for the week, and sends the information to the main office. Once in the main office, the information is again checked, and finally, keyed into the payroll system. A similar procedure is followed for inputting quantities of work-in-place into the computerized system. Usually, it takes several days for the main office personnel to deliver and distribute the proper reports to the different management levels.

This process is illustrated in Table 2.3. With this system in place, vital information concerning labor costs (for example, total-to-date costs, current estimated cost at completion, variance of costs from budget, projected costs at the end of the project, etc.) and quantities of work-in-place are not received on time, and the likelihood for mistakes is high. In these cases, an automated system can improve the quality of the information. The data must reach a computerized device in a timely manner, and the accuracy of the information must be as reliable as possible. To accomplish these tasks, several automatic identification

DAILY TIME SHEET

COMPANY'S NAME: _____

PROJECT: _____
DAY: _____
DATE: _____

COST
CODES

--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

NAME	EMP #	MEMO	HOURS																	
			OT REG																	

Figure 2.1. Sample of a daily time sheet

Table 2.3. Manual cost control data collection

For every week, the following steps are typically performed:

1. Daily Time Sheet. Foreman accounts for person-hours and quantities for all assigned cost codes.
2. Weekly Summary Sheet. Superintendent calculates and consolidates weekly data.
3. Weekly Summary Sheets are sent to main office. Usually, a person delivers the information; but, in some instances, this is accomplished via modem.
4. Weekly Summary Sheet Consolidation. Accountant checks and consolidates weekly information.
5. Information is input into payroll and the information system.
6. Labor weekly report is received by the site manager after several days.

technologies are explored, and a deeper study of bar coding techniques, as the automatic identification technology chosen for this research, are also presented.

C. Automatic Identification Technologies

Currently, there are several technologies for accurately and rapidly collecting data. Understanding each of these automatic identification technologies (A.I.T.) allows the choice of the appropriate technology for any application. Although this work focuses on bar codes, a brief study of other technologies will also lead to several other potential uses of computerized data collection devices and further research as well.

Traditionally, data are entered into a computer system by manually keying in information that has been gathered on sheets of paper. (Studies show that the error rate with this manual method is approximately one error for every 300 characters entered (Palmer, 1992). However, with automatic data collection techniques, users can expect an error rate better than one in one million (Cost Justifying Automated Data Collection, 1990). Moreover, by using automatic data collection, or identification technologies, there is practically no delay between when the data is read into a system and when the data potentially can be made available to managers, technicians, or others (Cost Justifying Automated Data Collection, 1990).)

Thus, the need for a system that captures better and faster data originated by technologies that collect data in a real-time fashion at the point of origin. One of those technologies is bar coding, and it is considered the most popular and cost effective (Sadhvani and Tyson, 1990). Bar codes have become commonly used in retail stores and industrial settings all over the United States, but they are only a small portion of the technology called automatic identification. This technology includes devices that electronically read typewritten and graphical documents, sort mail envelopes, identify trucks moving at high speeds, and allow cash withdrawals from banks all over the United States. Automatic identification technologies can be defined as

"different ways of automatically identifying objects, people, and places so that computers can help people make better business decisions" (Sharp, 1989, p. xi).

The best places for these technological devices can be found in companies that are using computers to help make decisions. Automatic identification devices provide computers with the information faster, more accurately, and less costly compared to more manual techniques (Sadhvani and Tyson, 1990).

Another benefit from automatic identification systems is accurate information. The accuracy of the computer output is no better than the accuracy of the worst data input technique used by the computer, and the more data the system requires, the greater is the chance to make errors during the data entry process (Sharp, 1989).

Automatic identification equipment provides computers with more accurate data and it relieves employees of the tedious manual data entry process. Sharp (1989) also states that an operator scanning a stack of ten-character bar code labels at the rate of one per second completes the job about twice as fast as a secretary typing an average of 70 words per minute.

Among the automated identification techniques are bar coding, radio frequency identification and data communication, voice recognition, optical character recognition, magnetic stripes, smart cards, touch screens, and pen computers.

Bar codes are the most often used automatic identification technology. Table 2.4 presents a comparison among several common automatic identification technologies, based on the assumption that a human operator captures the data on a label attached to a carton (Palmer, 1992). Also, the substitution error rate, or SER, is a parameter used to evaluate automatic identification techniques. SER is also known as the error rate and describes the probability that a given character contains an error (Palmer, 1992).

As shown in Table 2.4, the advantages of bar codes over other technologies are price, accessibility of a wider range of bar code related-products, and the speed and accuracy of the bar code approach is usually better than other A.I.T. For these reasons, bar coding techniques were the automatic identification system chosen for developing A.T.I.S., so they deserve a more in-depth study.

1. Bar codes

Bar codes can be defined as "a self contained message with information encoded in the widths of bars and spaces in a printed manner" (Adams, 1990, p. 4).

The first commercial uses of bar codes were seen in 1960 as a procedure for tracking railroad cars (Adams, 1990). Since then, the use of bar codes has become intensely popular in the grocery and material handling industries. The success of this technology can be attributed to the fact that bar code labels are cheaply produced with standard printing techniques.

Table 2.4. Comparison of some data entry techniques

System	Time to Enter a 20 Character Data Field	Substitution Error Rate	Cost of Label	Cost of Reading Equipment	Advantages	Disadvantages
Manual Keying	10 Seconds	High	Low	Low	Low initial equipment costs.	Requires human operator. Poor speed and error rate. Poor flexibility.
OCR	4 Seconds	Medium	Low	Medium	Can be read by humans.	Poor error rate. Inflexibility of reading equipment.
MICR	Normally Machine – Scanned	Medium	Medium	High	Can be read by humans.	Expensive. Inflexibility of reading equipment.
Magnetic Strip	4 Seconds	Low	Medium	Medium	Large amounts of data can be encoded. Data can be changed.	Affected by magnetic fields. Requires contact. Inflexibility of reading equipment.
Voice Recognition	20 Seconds	High	Low	High	"Hands off" operation.	Requires human operator. High error rate. Equipment must be "trained" for different operators.
Machine Vision	Normally Machine – Scanned	Depends on Marking Technique	Variable	Very High	Can be part of inspection system.	Expensive. Not suited for general applications.
Radio Frequency	2 Seconds	Low	High	High	Label does not need to be visible.	Expensive labeling.
Bar Code	4 Seconds	Low	Low	Low	Flexibility of printing and reading equipment.	

Taken from Palmer, 1992.

Also, they are easily and accurately read by inexpensive reading devices, and standardization allows labels to be read from different brands of reading devices (Sharp, 1989).

Several advantages can be found with the implementation of the timekeeping and information system using bar coding techniques: simplified timekeeping operations, fewer changes in payroll and labor reports, more accurate data available for future bids, timely identification of cost overruns on the project, ease of interfacing with almost any type of computer system, widespread use as an accepted technology, and reasonable cost.

A symbol, according to the New Lexicon Webster Dictionary of the English Language (1989), is a sign or object accepted as recalling, typifying or representing a thing, quality, or idea. "A bar code symbol usually includes a combination of bars and spaces that represent letter and/or numbers" (Adams, 1990, p. 3).

A bar code is a symbol, and stores information in a pattern easily read and printed by machines. "The information is coded in the widths of the bars and spaces of the printed symbol" (Adams, 1990, p. 3).

Because there are many different ways to arrange black bars and white spaces, there are many different bar code symbologies. They count more than sixty, but about twelve are the most common today. Although there is a large number of different symbologies, these symbologies share some

characteristics. All are made up of dark bars and contrasting white zones of varying widths. Each symbol has a quiet zone which precedes and follows it. To be read, the bar code label must be completely scanned. Some can be read regardless the direction scanned. All provide a clear distinction between bars and spaces, and they are tolerant of a variation in scanning speeds (Adams, 1990).

When reading a bar code, the scanner passes a light over the bars and spaces with the light reflecting into the scanner in different intensities. The dark bars absorb light and the light spaces reflect light. Then, the difference in reflection is translated into electrical signals and converted into characters (Smeby, 1988).

Some of the most common codes are shown in Figure 2.2 and are listed below (How to Stay on Top of Bar Codes, 1990).

a. Universal product code (UPC) The grocery industry formally established the UPC symbology as the standard bar code symbology for product marking. This is the familiar bar code commonly seen on packages and coupons. It incorporates only numeric characters and commonly a fixed length of 12 digits. However, this code has exact tolerances between bars and spaces, making it more difficult to print on just any equipment except advanced printing presses. Five versions (A-E) of UPC are currently in use.

b. European Article Numbering (EAN) It is the European version of the UPC symbology, and two versions are

Universal Product Code (UPC)



Code 128



Interleaved 2-of-5 (I 2 of 5)



Codabar



Code 39 (3 of 9)



Figure 2.2. Common bar code symbologies

currently used. EAN-13 and EAN-8 differ mainly in the number of digits that each one can carry out.

c. Code 39 This code is also known as code 3 of 9, and is one of the most popular codes for nonretail applications. Code 39 has nine elements for each character of data with three of the nine being wide. It allows alphabetic characters as well as numbers, and some mathematical symbols. An extended version is also available, so the full ASCII 128 character set can be created. The labels can be read in either direction, have variable length, economical software is available for making cheaper in-house labels, and the labels can be read with a wider variety of scanners. Consequently, this is the adopted bar code symbology by A.T.I.S.

d. Codabar Codabar was originally proposed as a symbology for a wide range of nonretail applications, and one of the largest users of codabar is Federal Express. It allows numeric characters only, except for its start and stop characters, which are lower cases a, b, c, or d. Uses variable length, but up to 32 characters, and bi-directional scanning. Because of the many specifications, the equipment needed to read this type of code is expensive.

e. Code 128 It encodes the full ASCII 128 character set, and uses variable length and bi-directional scanning. It is one of the fastest growing codes in popularity, and probably it will become the most widely used in the future (Unteregelsbacher, 1992).

f. Others There are less popular codes like Code 93, Code 49, Code 16K, PDF417, Plessey Code, Code 11, and Telepen.

From the previous list, code 16K and PDF417 appeared just recently. They are two-dimensional symbologies and contain a larger amount of information on their labels. PDF417 is also called portable data file 417, and a few applications are actually being tested (Sharp, 1992).

As mentioned, several other automatic identification technologies exist. Some of them are briefly explained as follows.

2. Radio frequency identification and data communication (RF/ID, RF/DC)

Radio frequency data communication, RF/DC, consists of wire-less, computer terminals that are connected to the host computer by real-time, on-line radio link (Industrial Engineering, 1992). These terminals can be hand-held computers or mounted equipment. Currently, RF/DC offers a spread spectrum, or signal transmitted over an extensive range of frequencies, so signals can be transmitted through different frequencies. Advantages include the fact that the spread spectrum does not require licensing, it has lower power requirements, and faster data transmission rates. This technology is presently in high demand and is widely integrated with bar coding.

Radio frequency identification employs an identification tag or transponder that sends and receives bi-directional

radio signals to a reader, then to a host computer. In this system, tags are attached to the pieces being identified. When a piece passes by the reader, an antenna located in the reader creates a magnetic field, and the tag uses this energy for transmitting the information to the reader. This information is received by the reader and sent to the host computer.

3. Voice recognition

Voice recognition permits entering data into a computer when the user's hands or eyes are busy. Units allow the operator to speak to the computer and words are processed and converted into electronic impulses. Voice recognition is often integrated with other technologies such as bar codes and RF/DC. In these integrated systems, voice recognition is mainly used for quantity data entry.

4. Optical character recognition (OCR)

This is also a symbology system and reads the two-dimensional numerals or letters. These human readable characters are read by a scanner with a light source. Then, the data are converted into electronic impulses for the computer (Industrial Engineering, 1992).

5. Magnetic stripes

Magnetic stripes use a plastic card with a magnetic tape to store data. A simple magnetic stripe can hold more information than any other automatic data collection device. They are mainly used to contain large amounts of information

or for security purposes (for example, to enter a building). Banks, credit card, telephone, and railroad companies are using magnetic stripe technology regularly.

6. Smart cards

Smart cards are credit card size, and have an integrated circuit chip containing memory and an optional microprocessor embedded in a flexible piece of plastic. They are programmable and have large databases. Some have their own keyboard, liquid crystal display, and internal batteries. Smart cards have been used for multiple services (for example, a card used as a bank card, meal card, and vending machine card) (Industrial Engineering, 1992).

7. Touch screens

These are computers that accept input from the user from finger contact or other pointed means with the computer screen. The computer divides and locates codes into the available space on the screen. Then, it identifies and processes the numeric and letter characters that correspond to the touched location.

8. Pen computers

Light pens are portable devices that allow users to collect, store, display, transfer, and print data. Numbers, texts, signatures, or graphics are collected into a portable computer with a pen attached to it. By using the pen, the computer recognizes the handwriting and converts it into text. Also, the pen can be used as a pointed device. These

computers can use either a DOS-like or WINDOWS environment. Several applications are ready to be used.

9. Other identification technologies

Several other technologies have been developed for data collection purposes. Touch memory chips, or memory buttons, are chips that can be attached any place. They are stainless steel labels that read or write with an instantaneous contact.

Magnetic ink character recognition (MICR) is a technology commonly used in the marking of U.S. bank checks, where a highly stylized font is printed using an ink with magnetic properties (Palmer, 1992).

Biometrics identification, or identification of a person based on matching one of his/her physical attributes to an electronically stored template of that attribute, is currently used where the greatest level of security must be maintained. Biometrics identification is found predominantly in government, financial, and other high-security facilities. Recent uses of biometrics were implemented for the summer Olympics in Barcelona to allow athletes in and out of the Olympic village. Some biometric technologies include retinal pattern, hand geometry, fingerprint, vein scan, and signature dynamics identification (David, 1992).

Optical mark reader (OMR) devices read marks on forms made by pens, pencils, and bar codes. This technology is widely used in grading standardized tests.

Holograms allow security systems and bar codes to be combined. By printing bar code labels using a holographic technique, the label can be seen only by the laser of a bar code reader. Also, more durable bar code labels can be produced if using three-dimensional holographic pictures. However, the cost of producing holographic bar code labels makes this technique infeasible for most applications (Goodwin, 1991).

There are other data collection devices, or integrations of the above mentioned systems. However, almost all automated data collection systems include any of the technologies mentioned above. Moreover, bar coding was the technology chosen for this research, and some benefits from previous experiences in different industries will be explained. Also, current and potential applications of bar coding techniques in the construction industry will be explored.

D. Current and Potential Bar Coding Applications in the Construction Industry

The use of bar code technology in the construction industry is relatively new, compared to other industries such as the automotive, retail, electrical, and defense industries (Stukhart and Cook, 1990).

Stukhart and Cook (1990) stated that the acceptance of the bar code technology in other industries could lead to wider uses of bar codes in the industrial construction

industry, especially for materials management. Besides efficiency and accuracy benefits, bar code technology for data collection usually offers the first step in automation of the construction site for the industrial construction industry (Stukhart and Cook, 1990).

By 1990, a survey conducted by Texas A&M University found a minimal use of bar code technology for materials management in the industrial construction industry. However, a considerable interest in using the bar code technology was also presented (Stukhart and Cook, 1990).

A few examples are published related to the use of bar codes in the construction industry. Most of the work has been done mainly as pilot or research studies, and cases where beneficial results in accuracy, efficiency, and relevant cost savings are recorded in a small number of tested applications.

Special focus has been made in manufacturing, scheduling, and distributing functions, but bar code technology could help the construction industry in improving several inefficient processes (Blakey, 1990).

Labels and adhesives have been tested on different construction sites, and applications of bar coding techniques for tool and consumable resources are suggested as feasible uses of this technology for warehousing and tracking maintenance records purposes (Bernold, 1990b).

Equipment and materials tracking are other areas where bar codes have helped the flow of timely and accurate

information. But again, this refers to a pilot yard control system (Bernold, 1990a).

A labor tracking, or time attendance application, was successfully implemented in a new chemical plant with a 550-person peak craft force (Rose, 1988). The need for an effective procedure to enter daily employee data into a computerized payroll system lead to the use of a badge slot bar code reader located at the construction site's clock house. Then, after badging in all the construction workers, several reports were printed and distributed to several areas, and payroll calculations were made automatically. A tool and consumables system using bar codes was also implemented, and a better control over inventory was accomplished. In addition, a decreased usage of consumables and losses of small tools was perceived (Rose, 1988).

An automated construction field data management system was proposed to reduce the time spent by the Indiana Department of Transportation's field personnel (McCullough, 1991). Supervisors usually spend 4-5 hours daily processing paperwork, distracting them from performing their main tasks of supervising construction activities. Bar code usage was proposed to be used instead of forms with reoccurring fields of data. In addition, bar code labels could be used for testing sampling purposes. Samples could be easily identified and tracked through the testing process, and improved data

entry speed and fewer number of errors could be achieved (McCullouch, 1991).

It is important to mention several other potential fields in the construction industry where bar code techniques could improve the process of gathering and managing data. These applications can be shown in Table 2.5 (Bell and McCullouch, 1988; Rasdorf and Herbert, 1990).

Although several applications and ideas of uses for bar codes in the construction industry were explained, few represented developed and put-in-place systems. A time attendance system was successfully implemented, but a timekeeping application using bar coding techniques has not been tested and proven in the construction industry before. Also, this research integrates an effective and accurate data collection technique with more adequate and easier to understand graphical reporting. This report is strengthened by a factual test of the system in a construction site, with positive results, as will be explained in a subsequent chapter.

As shown in Table 2.5, several applications were suggested. However, the industry is still in need of more applications for improving the gathering, processing, and reporting processes.

Bar coding techniques have helped several other industries (retail, grocery, manufacturing, defense,

Table 2.5. Potential applications for bar coding techniques in the construction industry^a

-
1. Quantity takeoff
 2. Field material control
 3. Warehouse inventory and maintenance
 4. Tool and consumable material use
 5. Timekeeping and cost engineering
 6. Purchasing and accounting
 7. Scheduling
 8. Document control
 9. Office operations
 10. Other fields where data collection is required
-

^aTaken from Bell and McCullouch, 1988.

automotive), and a description of several successful cases follows.

E. Anticipated Benefits of Bar Coding in Timekeeping Applications in Other Industries

Anticipated benefits of bar coding in timekeeping applications can be better explained by looking at previous experiences in other industries. Bar codes have been used in the retail and grocery industries for several years, and affirmative results in timekeeping and other processes have helped the acceptance and propagation of this technology among several other industries such as manufacturing and defense. Similar outcomes are expected in implementing bar codes in the construction industry.

Bar codes offer an accurate and timely strategy for any data input process. Scanning a bar code can be accomplished twice as quickly as manual data processing. Thus, the necessary information for management functions is reported and analyzed in a quick and efficient manner.

Bar codes offer a cost effective technology. Labor savings in computerized data processing over manual techniques, and the relatively low cost for a bar code implementation justify the investment and time spent in implementing such a technology. A consultant firm dealing with bar code technology, and from the experience of working with thousands of companies, alleges that for most businesses, the payback period is usually less than one year (Cost Justifying Automated Data Collection, 1990).

Table 2.6 shows a summary of the most relevant anticipated benefits of bar codes, as mentioned before. Specific benefits of bar code applications for industrial and automotive uses can be found and are also explained.

A company replaced its old time clock system for a computerized bar code approach. With the original system, employees punched in when they arrived in the morning, out for lunch, in again after lunch, and out when they left for the day. Also, people were queued up in line for using one of the two clocks, and employees spent some time finding their card from a rack, punching the card, and returning the card to its initial location.

Table 2.6. Benefits of bar codes

1. Accuracy of data entry
 - a. Error rates
 - Keyboard, 1 error/(300-500)
 - Bar code, 1 error/million
 2. Speed of data input into computerized system
 - a. Twice as quickly as manual data input (keyboard)
 3. Timeliness of reporting and analysis of processed data for more effective control
 4. Cost benefits of computerized versus manual processes
 5. Elimination of extensive paper work
-

Payroll procedures were also affected by this system. The information was not reliable, and three clerks took a significant portion of their time deciphering and consolidating the time cards for the 270 employees.

The new system utilizes four wall-mounted slot bar code readers connected directly to the company's mini-computer. Here, each employee carries a small 1 by 2 inch laminated badge with a UPC bar code label containing the worker's pay number information. The employee passes the card over one of the four scanners and the information is automatically entered into the main computer. With the new system, entry and exit are faster, and there is no queuing time. Paychecks are now 100 percent accurate and one clerk is required to control the time attendance process.

Moreover, the company improved the control over absenteeism, employee performance on tardiness and leaving early, efficiency of the system, and accuracy of information (especially accurate and prompt paycheck distribution). In addition, an investment of about \$15,000 was recovered in less than a year (Graves, 1987).

Another company experienced problems when an expansion was necessary and manually tracking of work-in-process status was time consuming and inaccurate. Using a PC-based system and bar codes, job tasks and operations performed were scanned into the computerized system. Again, the system gained acceptance among workers, and the system had a payback of less than one year. Improved quality data was another benefit. An average of 20 reporting errors per day was reduced to just two or three per day (Twedt, 1984).

Even in the automotive industry, bar codes have obtained significant benefits. A producer of medium and heavy-duty trucks in North America needed a system for collecting timely and accurate operating data while maintaining simple operator interface. After implementing a bar code system for time and attendance data, purchasing invoice data, and tool inventory data, this company has gained the following benefits: improved system accuracy, elimination of key-entered data, and information available to on-line decision-makers (Plotke, 1989).

Initially, companies started using bar coding techniques for individual applications, but immediate outcomes and acceptance of bar codes have led the implementation of bar codes in places where accurate and timely information are needed.

As previously mentioned, bar code systems have helped many manufacturing companies to track work-in-place (WIP), job costs, time attendance, and job productivity. Knowing what has been accomplished previously in automatic data collection in the construction industry and having described the theory behind labor cost control, the next chapter will explain the research methodology followed in developing A.T.I.S.

III. RESEARCH METHODOLOGY

A. Automated Timekeeping and Project Information System

Several important steps and considerations must be studied before automating a process. The process being automated must include data collection and information processing considerations. Also, the idea is to improve an existing process, and not create a new, automated process (Allen, 1991). The inefficient process must be revised, and a simplification should be presented. Furthermore, the automation of a process will show better results if the automation begins on a small scale. A pilot study is indispensable, thus certainty and a rapid payback will persuade even the skeptical. Automation provides a better control over the process and a better use of resources. Also, automation should deliver the information and friendliness for those who will use the system--the end-users. After identifying the process to be automated, a study of different technologies must be considered before selecting the appropriate one.

There is another factor involved in automating a process. The path between the data collection and the decision-makers must be understood, so the system can be improved along any of the several steps in that mechanism. Table 3.1 shows the path between data collection and decision-making.

Table 3.1. Path between data collection and decisions^a

Step 1.	Production, operations	→	Data
Step 2.	Data	→	Data collection system
		→	Data/information
Step 3.	Data/information	→	Control Systems
		→	Information
Step 4.	Information	→	Managers/supervisors
		→	Decisions

^aAdapted from Twedt, 1984.

The need for a real-time and accurate control system led to research for developing an automated timekeeping and information system. Also, in developing A.T.I.S., the system was tested on a pilot construction project. The manual timekeeping process was understood, and special attention was placed with respect to those who were going to use the automated system.

Originally, the system was intended to cover the timekeeping operations for a construction company. The system would track all the relevant information related to worker names, cost codes, and expended hours. Data would be entered directly from the site to a hand-held computer using bar coding techniques. Then, the hand-held computer would be linked to a personal computer (PC), and all the data would be transferred. This system would be used by the accounting department to simplify the payroll process.

As an ideal situation, the hand-held computer could be connected to the personal computer using radio frequency data communication technology. Thus, real on-line communication

could be achieved. However, radio frequency equipment is expensive, and the existing cabled link between the hand-held computer and the PC offers sufficient capabilities for a significant improvement in timekeeping procedures.

In the first phase, the equipment was obtained and a prototype timekeeping system was designed. Several programs were developed and the interface among the several components was understood. Code 39 was chosen as the bar code symbology. This symbology was mainly selected because it offers alphanumeric characters along with the advantages mentioned before. Finally, daily reports were added to the system and a validation was received.

After completing the first phase, the system was offered to a general construction contractor located in Des Moines, Iowa. During the field testing of the system, several improvements and features were added. The current automated system for labor cost control comprises the input and work by several persons. Currently, A.T.I.S. contains ideas and reflects the experience and knowledge from this author, professors, project superintendents, project managers, accountants, information system personnel, vice presidents, and others that in one way or another influenced the development of the system.

The system can be divided into unique modules. The first module comprises the data collection portion. Labor and quantities of work in place are collected using a hand-held

computer and bar code techniques. Once, the data are in a computer, the data are processed, and different relevant reports are generated. Report designs vary according to the level of management where the information is required.

Table 3.2 suggests the several steps in developing the automated system.

For the remainder of this chapter, components and costs of the bar code system will be explained. The data collection device is displayed. Then, the manipulation of the input data

Table 3.2. Steps involved in developing the automated system

1. Identify common problems in timekeeping procedures.
2. Formulate objectives of system.
3. Choose a course of action, as:
 - A. Select equipment to use.^a
 - B. Design a bar code template in which cost codes, worker names, etc., are shown.
 - C. Develop the software for the data entry method.
 - D. Understand the interface between the device used to get information (hand-held computer) and a PC.
 - E. Develop pertinent reports.
 - F. Field validate the system.
 - G. Enhance system.^b
 - H. Use system in a larger scale.^b

^aThis step was accomplished in a previous research.

^bTo be achieved in the future.

and the report generation process are explained. Finally, the field testing procedure is presented.

As shown in Figure 3.1, the components used for jobsite data acquisition are a CMT hand-held computer with a bar code wand (model MC-V¹), and a laminated template with all the bar code labels for worker names, cost codes, and hours worked.

The CMT hand-held computer has the versatility and functionality of a PC in a package and is small and compact. This small computer possesses an 80C88 CPU, DOS-like operating system, internal memory with a storage capacity of one megabyte, and a database program compatible with dBASEIII+. Also, the CMT hand-held computer has built-in RS-232 interfaces, so the hand-held computer can be connected to other computers and several different types of external devices such as printers, plotters, modems, calipers, and other RS-232 compatible measurement devices. It is dust-proof and water and shock-resistant. A built-in heater may be powered to permit operations in temperatures down to -40°F.²

The rest of the necessary equipment consists of a personal computer with dBASEIII+³ and LOTUS 123⁴ (for this

¹CMT MC-V is a trademark of Corvallis Microtechnology, Inc.

²Information taken from vendor brochures.

³dBASEIII+ is a trademark of Ashton-Tate.

⁴LOTUS 123 is a trademark of Lotus Development Corporation.

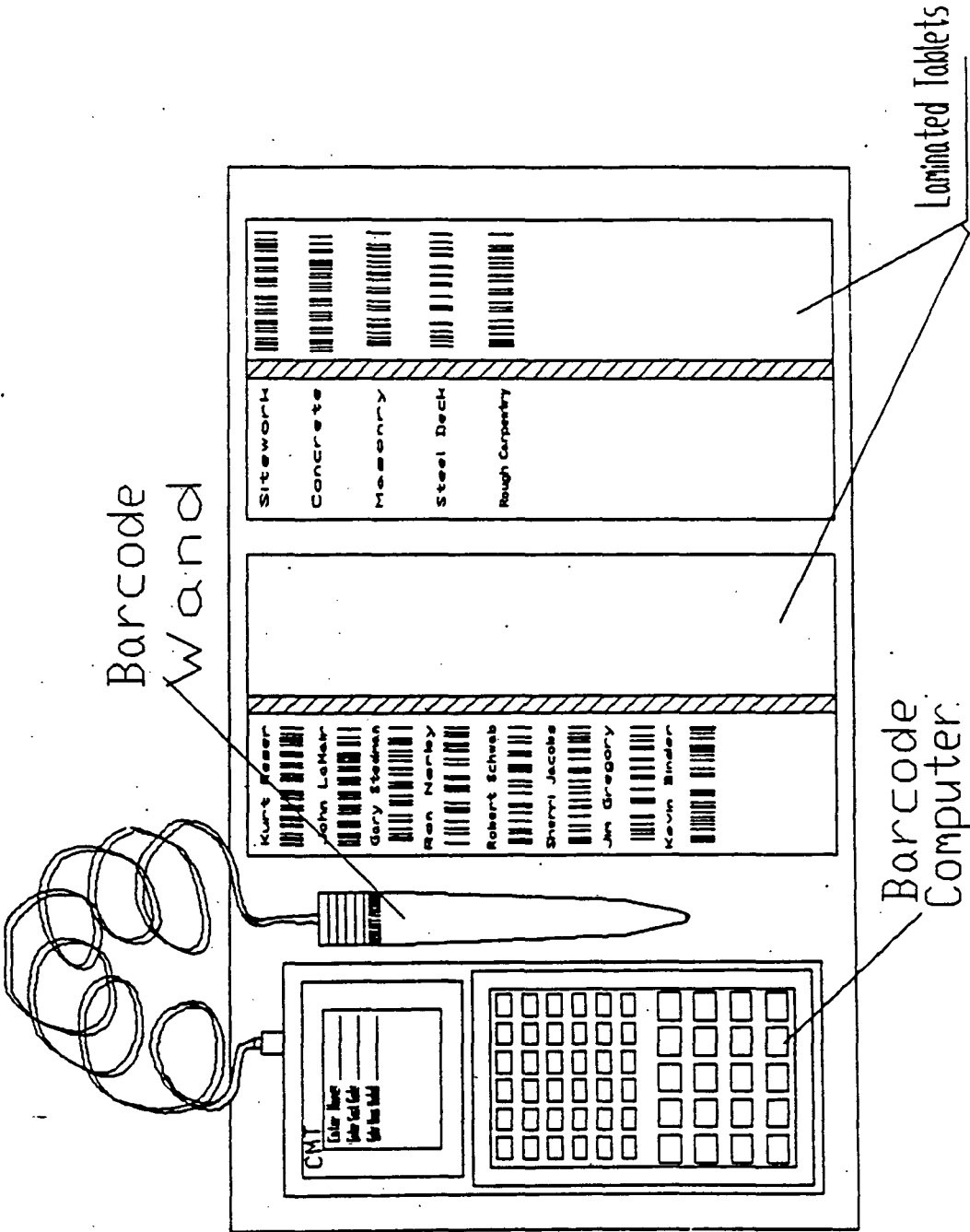


Figure 3.1. Data collection system components (Cummings, Desai, and Postma, 1991)

research, LOTUS 123 v2.2 with IMPRESS⁵, and LOTUS 123 v2.3 were used) and a dot matrix, inkjet, or laser printer. The bar code labels can be obtained from specialized companies, or by in-house available inexpensive bar code label software.

Overall, the total system is relatively inexpensive. In general, the programmable computer costs about \$1500, the light pen wand about \$300, additional accessories like the M-BASE⁶, database compatible with DBASEIII+, the hardware and software to communicate the hand-held computer with a PC, and the software for making bar code labels is about \$400. Finally, an estimate for the system's cost would be approximately \$2,800 without the personal computer, printers, dBASEIII+, LOTUS 123, and the developed programs in both the hand-held computer and the PC.

The database software, dBASEIII+, was chosen for receiving and processing the information from the hand-held computer for the following reasons. First, this software is compatible with the database software available for the hand-held computer. Second, dBASEIII+ was chosen over LOTUS 123 for better sorting, reporting, and management of extensive amounts of data. Also, dBASEIII+ can hold approximately one billion records, and programming capabilities are "user friendly". Menu-driven programs can be developed in

⁵IMPRESS is a trademark of ALEGH 2.

⁶M-BASE is a trademark of Corvallis Microtechnology, Inc.

dBASEIII+. Finally, interchanging data from dBASEIII+ to LOTUS 123 is a straightforward process, so that graphic capabilities can be added to the system.

B. Data Collection Device

Data collection was the first process investigated for developing the automated timekeeping and information system, and the initial task was to choose the hand-held unit. A hand-held unit would provide portability to the system. Several devices were tested in a previous study, and the actual CMT hand-held computer was selected. For the hand-held computer, a program written in M-BASE allows the user to scan the necessary information from a bar code template.

Special care was placed in preparing the bar code template. Low density (CPI), carbon ink as the media for producing the labels, proper verification, and bar code height are considered some of the most important elements in creating the labels (Meyers, 1988).

The bar code template was created to show only the cost codes and worker names intended to be registered for a short period of time. This technique requires only a few pages of bar-code information. Every two to three weeks, the templates are updated. It is important to have a master folder with all the bar codes for worker names, cost codes, and other relevant information; thus, the user can scan in any bar code information left out of the template.

In using the system, the timekeeper enters the information for a specific project. Presently, the system can handle up to 99 projects. The timekeeper follows the menu-driven program, and daily information such as number of hours spent for every worker on each particular cost code is entered into a database.

For this application, three different modes of time spent can be accounted. A.T.I.S. tracks regular hours, overtime hours as one-and-a-half, and double time. In addition, while entering the information for a particular worker, the cumulative daily time for that person is presented at the bottom of the screen. The structure and sequences followed in the data collection operation are shown in Appendix A, "Menu tree for M-BASE, on hand-held computer."

A similar procedure is followed in entering quantities to the system. Here, the system asks for quantities put-in-place for a specific period of time for the desired cost codes.

The time data can be entered directly from the site into the hand-held computer. The timekeeper can scan the worker's data daily, twice a day, or three times a day, and quantities are usually entered for every accountable period of time, commonly one week. This information is then ready to be downloaded to a PC for processing reports and payroll purposes.

C. Manipulation of Input Data

Once the information is entered into a computerized device, it is possible to transfer that information into any computer. By using a communication protocol supported by Columbia University called KERMIT, the transfer of information is done from the hand-held computer to a PC. The information is transferred in the form of dBASEIII+ database files. Moreover, software used are dBASEIII+ and M-BASE in the PC and hand-held computer, respectively.

For each project, six databases are used simultaneously to accomplish the data gathering, processing, and reporting. One database holds each project's information (each project code and description). Two other databases provide time and worker information. Two more contain quantities and cost code descriptions. Finally, the sixth database contains the estimated budget for each cost code.

The structure and examples of the database files are presented in Appendix B. Also, the structure and sequences followed in the data transferring, processing, and reporting processes are shown in Appendix C.

DBASEIII+ offers a suitable medium for processing large amounts of information. On the other hand, it does not provide graphical capabilities, and graphical reports are needed for better cost control. Thus, it is necessary to interface dBASEIII+ with a graphical software package.

Standardized data format permits the use of the same data in different software.

As a limitation, the automated system was set to handle weekly quantity invoices. However, a minor programming change will generalize the system to manipulate any specified period of time.

Dollars spent and quantities put-in-place for each week are then interchanged from dBASEIII+ to a spreadsheet previously constructed in LOTUS 123; therefore, several graphics can be generated. This maneuver of data is made automatically by following the menu environment, and the processing of the initial data input from the hand-held computer is accomplished. At this point, the information is already in the appropriate PC software, and diverse tabular and graphical reports are generated.

D. Report Generation

The report generation operation is divided into two packages. One package contains the information for the accounting department, and the other package provides information for cost control purposes.

In developing the reports, construction site and accounting personnel played an important role. Most of their ideas and comments were considered in the design of the report formats. Consequently, reports are fit to present the

information that decision-makers and end-users in general will need.

As one of the objectives of this research, the report generation and graphical capabilities provided an easy way to understand and analyze labor cost performance for a given project.

Appendixes D through F show the programs written for the hand-held computer and the PC. Although the purpose of this thesis is not to provide a user's manual for the system, it is necessary to present at least the tools used in implementing the application. Also, showing the programs will facilitate following studies or enhancements related to this endeavor. Explanations of the two package reports are presented.

1. Payroll

Reports for accounting purposes are mainly tabular. For this purpose, a good package should contain several types of reports.

A report showing pertinent information for each worker for a specific period of time should be presented. It should show the general identification information for the worker and project. Then, time expended over a certain period of time should be provided by day and cost code. This allows payroll individuals to identify how much time each particular worker spent for every day and for every cost code. Finally, totals for each worker must be presented.

Another report should present quantities put-in-place during the specified period of time for each cost code. Here, cumulative numbers and notes will help also. Finally, summaries of time and cost for workers and cost codes should be presented for checking the correctness of the information.

2. Project control

In controlling labor cost a construction project, graphical representations of the performance of the project will present a better picture for prompt responses and actions. Graphics showing savings or losses over time present the best representation of project performance. These graphics locate negative or positive trends for either the overall project performance or individual critical cost codes. Variances and indexes of actual against estimated productivity must be presented, and projections can be studied.

First, the study will reflect overall project performance. Then, particular attention should be given for those cost codes or activities that are affecting the overall project performance. Reports for the accountable period of time and daily reports contribute to better project performance analysis. Also, summarized reports discriminating by cost code and worker result in an easy and accessible information reporting system. Along with the quantities put-in-place, a productivity report for the week, or other period of time, will provide a detailed labor cost report for the work performed. These empirical ideas were considered while

designing the tabular and graphical reports for the accounting department and for the project site staff.

A.T.I.S. is currently been used, and several corrections and enhancements were possible during this phase of implementation. Identification of weak points, and a validation of the automated system was also accomplished during this implementation.

E. Field Testing of the System

In implementing an automated system, one of the critical steps is the validation of the system. Any intended process improvement will reflect its usefulness by proving and testing the proposed system in the authentic environment. As the final step for this project, the system was proven in a general contractor construction company for over a period of four months, and is still used after this work was completed.

A science center for a university located in Des Moines, Iowa, was chosen as the pilot study center for A.T.I.S. The project, with an estimated one million dollars in labor costs, used approximately one hundred fifty unique cost codes and employed more than one hundred workers. The project, with an expected duration of two years, is scheduled to finish during mid-1993. One of the main reasons for choosing this project was the awareness by the site personnel for computer devices. Site personnel know the importance, usefulness, competitive advantage, and future increased uses of computer in the

construction industry. Also, they have been supportive since the beginning of this study.

During the beginning of the field validation, the system offered the automation for timekeeping operation. Several days were spent in understanding this process and meeting with the people who would benefit the most by the automated timekeeping approach. The system was well accepted and room for further expansion was perceived. Meaningful and appreciated input from the construction site personnel were used to generate the system, resulting in pertinent reports and other useful information.

The field test also determined how flexible the system was and how easily it could adapt to different conditions and situations. In addition, the system was proven for effectiveness, quickness, and accurate responses.

Though the system is still in use, several enhancements are needed still and additional features are intended to be appended for creating an even more useful system.

As a variation of the proposed automated system, the time spent for every day was scanned in the hand-held computer from daily time sheets given by the general foreman. The construction site personnel wanted to keep filling out the daily sheets, so they could retain a hard copy for their files. A different situation would be presented if the automated system were put in place since the beginning of the project.

The results of this research are presented in the next chapter. Some observed benefits are explained and several reports are illustrated.

IV. RESULTS

A. Observed Time Benefits and Other Advantages of the Automated Timekeeping System

The field test of the automated timekeeping and project information system confirmed the anticipated benefits expected at the beginning of this research. The automated system provided an easy, accurate, timely, and effective approach for collecting, processing, and reporting data for labor cost control purposes.

The automated timekeeping and information system approach is shown in Table 4.1. This table shows the actual steps for collecting and processing time and quantity information, and its differences from Table 2.3 (manual cost control data collection).

Moreover, the automated data collection approach saved approximately 5 hrs/week/project in time savings for the superintendent and accountant for the tested construction project. They spent roughly 6 hrs/week/project consolidating, checking hand writing, traveling from the site to the main office, and key entering time and quantity information. However, by using the procedure pictured in Table 4.1, less than an hour was spent in entering the data into a computerized system. This result is supported by comparing the approaches shown in Tables 2.3 and 4.1.

Table 4.1. Automated cost control data collection process

Every week the following steps are performed:

1. Daily Time Sheet. Same as for the manual approach.
 2. Data Input. Daily information (time and quantities) are input into a personal computer.
 3. Weekly summary information is checked.
 4. Information is sent electronically to main office (mainframe).^a
 5. Labor weekly report is generated the same day.
-

^aThis step is not accomplished yet, but it is the logical next enhancement for the system.

Other qualitative benefits using the automated approach were not considered, such as the accuracy, the value of reports, and timeliness benefits.

In collecting the time information on a project (approximately 20 workers, and 10 cost codes were entered daily), an average of 0.53 hrs were spent weekly. This is an average of 6.4 min/day per project. Figure 4.1 shows the time spent per day over the period of time the system was used in the field for the information collected for a project. These values were tracked automatically using the internal clock of the CMT hand-held unit.

In general, Table 4.2 summarizes the benefits derived from the automated timekeeping system.

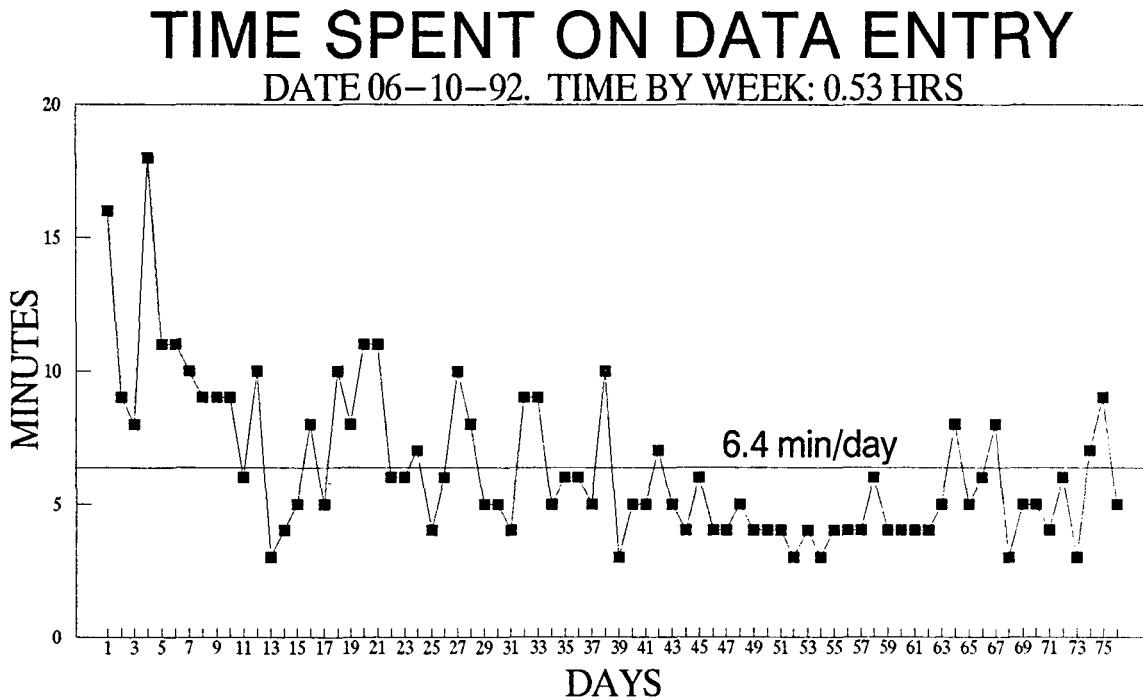


Figure 4.1. Time spent on automated data entry

Table 4.2. Automated system benefits

1. Reduces the chance for errors.
2. Simplifies the timekeeping system.
3. Simplifies the payroll procedure.
4. Increases accuracy:
 - Of person-hours and costs for each unit of work.
 - For future estimating purposes.
5. Provides a better display of project performance:
 - Actual to estimated.
 - Daily, weekly, trends, etc.
6. Reduces the time of information flow from operations to decision-makers.

The bar codes captured the curiosity of several people involved on the construction project. They immediately related this to the labels they had frequently seen in grocery stores. In other words, the system did not evoke fear or apprehension; instead, it provided a means to learn more about this technology.

Report generation is one important point of A.T.I.S., and an explanation of the several reports generated by the system will guide toward a complete knowledge and understanding of it.

B. Tabular Reports

As mentioned before, tabular reports constitute an important component for accounting and control purposes. Site personnel played a relevant role in the design of these reports, and several attempts and modifications induced to these reports.

The reports reflect general ideas, and names were changed for confidential purposes. Only standardized names for the industry were kept as part of the tables and figures.

1. Daily time information

The daily reports offer the most detail. These reports show the facts that happened for a particular day. Two types of daily tabular reports can be generated.

a. Detailed daily cost code report This report, shown in Table 4.3, presents basic daily information sorted by

Table 4.3. Detailed daily cost code report

PROJECT: S-92, THESIS. REPORT FOR TUESDAY, 04/07/92

WORKER CODE	NAME		REGULAR TIME	OVER TIME	DOUBLE TIME	TOTAL COST
-----	-----		-----	-----	-----	-----
** Subtotal	for 01-0080					
002	RODRIGUEZ	YVAN	2.00	0.00	0.00	29.80
** Subtotal	**		2.00	0.00	0.00	29.80
** Subtotal	for 01-0710					
001	CARL	PETER	6.00	0.00	0.00	84.03
001	SEIJAS	JOHN	4.00	0.00	0.00	54.02
001	PEREZ	RAMON	7.00	0.00	0.00	94.54
** Subtotal	**		17.00	0.00	0.00	232.59
** Subtotal	for 01-0870					
004	MONTIEL	RAY	8.00	2.00	0.50	182.16
** Subtotal	**		8.00	2.00	0.50	182.16
** Subtotal	for 02-2330					
001	SEIJAS	JOHN	3.00	0.00	0.00	40.52
** Subtotal	**		3.00	0.00	0.00	40.52
** Subtotal	for 03-1142					
001	CARL	PETER	2.00	0.00	0.00	28.01
002	RODRIGUEZ	YVAN	2.00	0.00	0.00	29.80
002	MITCHEL	LEE	8.00	2.00	0.00	152.90
002	GIBBS	DANNY	8.00	2.00	0.00	152.90
002	OLSON	JAMES	8.00	0.00	0.00	111.20
** Subtotal	**		28.00	4.00	0.00	474.81
*** Total	***		58.00	6.00	0.50	959.88

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cost code. It shows the time spent (regular, one and a half, and double time) for every cost code performed on that day. That information is also presented for every worker, and is grouped by worker code (for example, carpenters, laborers, and operators). Knowing the salary rate for each individual allows determination of total costs for each worker. Subtotals are located in the table for every cost code, and a total for the day is placed at the bottom of the table.

b. Daily worker's cost code report This report, presented in Table 4.4, groups the information mentioned above sorted by worker's cost codes. This table shows costs and time spent by carpenters, finishers, and other craftsmen.

2. Weekly time information

It is necessary to represent the information for each accountable period of time. Weekly information helps in preparing payroll, keeps track of expenditures for a particular cost code, and presents quantities and productivity information for the overall project or for particular cost accounts.

a. Summarized weekly cost code report Table 4.5 presents weekly information for each particular cost code and is grouped by time and total costs. For the application performed, an additional column was added. This column, total costs, reflects the amount of money spent for a particular cost code in a specified week, or period of time, including costs for benefits related to unionized contracts, or other

Table 4.4. Daily worker's cost code report

PROJECT: S-92, THESIS.

REPORT FOR THURSDAY, 02/20/92

WORKER CODE -----	REGULAR TIME -----	OVER TIME -----	DOUBLE TIME -----	TOTAL COST -----
** Subtotal for 001 ** Subtotal **	24.00	0.00	0.00	328.12
** Subtotal for 002 ** Subtotal **	48.00	0.00	0.00	681.20
** Subtotal for 003 ** Subtotal **	10.00	0.00	0.00	142.30
** Subtotal for 004 ** Subtotal **	8.00	0.00	0.50	136.62
** Subtotal for 005 ** Subtotal **	32.00	0.00	0.00	468.40
** Subtotal for 006 ** Subtotal **	8.00	0.00	0.00	121.10
*** Total ***	130.00	0.00	0.50	1877.74

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Table 4.5. Summarized weekly cost code report

		REG	OVER	DOUBLE	TOTAL	TOTAL
		TIME	TIME	TIME	GROSS	COSTS
		----	----	-----	-----	-----
** Subtotal for 01-0080	** Subtotal **	6.00	0.00	0.00	89.00	114.38
** Subtotal for 01-0095	** Subtotal **	16.00	0.00	0.00	238.84	298.12
** Subtotal for 01-0740	** Subtotal **	4.00	0.00	0.00	57.42	70.14
** Subtotal for 02-2240	** Subtotal **	42.00	0.00	0.00	580.20	707.40
** Subtotal for 02-5170	** Subtotal **	83.00	0.00	0.00	1208.43	1472.19
** Subtotal for 02-8801	** Subtotal **	10.00	0.00	0.00	149.00	191.30
** Subtotal for 03-1570	** Subtotal **	27.00	0.00	0.00	411.97	498.95
** Subtotal for 05-5010	** Subtotal **	8.00	0.00	0.00	136.40	146.16
*** Total ***		196.00	0.00	0.00	2871.26	3498.64

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contracts where extra money is given to workers for hours worked.

b. Summarized weekly worker report Table 4.6

summarizes a time and cost report for each worker for the specified period of time. This report is useful for verifying paychecks. The superintendent or foreman can check the exact amount of time and money paid.

c. Detailed weekly worker report Table 4.7 shows a

report that is mainly used for accounting purposes. The complete information for each worker is sorted by every day of the week by every cost code. Memos are also displayed, so special circumstances can be explained in the table (e.g., the craftsman worked only 24 hours for the week, but was on vacation Tuesday, 04/14/92, as shown in Table 4.7).

3. Weekly quantity report

For the period of time reported, quantities put-in-place and cumulative (job to date and actual quantity) are displayed (refer to Table 4.8). Each cost code performed during the week is presented in this table.

4. Weekly productivity report

A weekly productivity report can be generated with costs, quantities, and estimated values. This report, Table 4.9, shows the saving or losses incurred during the certain period of time. This is accomplished by using unit price comparisons. Additional information is presented at the bottom of the table. Sometimes a cost code is quantified

Table 4.6. Summarized weekly worker report

PROJECT: S-92, THESIS.		WEEK ENDING: WEDNESDAY, 05/06/92			
	WORKER NAME -----	REGULAR TIME -----	OVER TIME -----	DOUBLE TIME -----	TOTAL COST -----
** Subtotal for	CARL, PETER				
** Subtotal **		16.00	0.00	0.00	224.09
** Subtotal for	SEIJAS, JOHN				
** Subtotal **		16.00	0.00	0.00	216.09
** Subtotal for	VAN, DAVID				
** Subtotal **		8.00	0.00	0.00	108.05
** Subtotal for	JOEL, LARRY				
** Subtotal **		8.00	0.00	0.00	108.04
** Subtotal for	RODRIGUEZ, YVAN				
** Subtotal **		8.00	0.00	0.00	119.20
** Subtotal for	MITCHEL, LEE				
** Subtotal **		8.00	0.00	0.00	111.20
** Subtotal for	GIBBS, DANNY				
** Subtotal **		8.00	0.00	0.00	111.20
** Subtotal for	OLSON, JAMES				
** Subtotal **		8.00	0.00	0.00	111.20
** Subtotal for	MONTIEL, RAY				
** Subtotal **		16.00	0.00	1.00	273.24
***Total ***		96.00	0.00	1.00	1382.24

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Table 4.7. Detailed weekly worker report

SS#: 123-45-6789. NAME: RODRIGUEZ, YVAN WEEK ENDING: WEDNESDAY, 04/08/92

CRAFT CODE: 002. RATE: 14.900

JOB# OR ACCT #	COST CODE	TOTAL HOURS		THUR	FRI	SAT	SUN	MON	TUES	WED	TOTAL HRS BY RATE
S-92	01-0080	4.00	RT	--	2.00	--	--	2.00	--	--	2.00
			T&1/2	--	--	--	--	--	--	0.00	
			DT	--	--	--	--	--	--	0.00	
S-92	01-0650	2.00	RT	--	2.00	--	--	--	--	--	29.80
			T&1/2	--	--	--	--	--	--	0.00	
			DT	--	--	--	--	--	--	0.00	
S-92	03-1142	3.00	RT	--	--	--	--	3.00	--	--	44.70
			T&1/2	--	--	--	--	--	--	0.00	
			DT	--	--	--	--	--	--	0.00	
S-92	03-1400	8.00	RT	8.00	--	--	--	--	--	--	119.20
			T&1/2	--	--	--	--	--	--	0.00	
			DT	--	--	--	--	--	--	0.00	
S-92	03-1417	13.00	RT	--	2.00	--	--	3.00	--	--	74.50
			T&1/2	--	0.50	7.50	--	--	--	178.80	
			DT	--	--	--	--	--	--	0.00	
S-92	03-3993	2.00	RT	--	2.00	--	--	--	--	--	29.80
			T&1/2	--	--	--	--	--	--	0.00	
			DT	--	--	--	--	--	--	0.00	
			RT	8.00	8.00	0.00	0.00	8.00	0.00	0.00	357.60
			T&1/2	0.00	0.50	7.50	0.00	0.00	0.00	0.00	178.80
			DT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MEMOS:

ON VACATION TUESDAY, 04/14/92

	TOTAL HRS	RATE	GROSS BY RATE	TOTAL GROSS
RT	24.00	14.900	357.60	
T&1/2	8.00	22.350	178.80	536.40
DT	0.00	29.800	0.00	

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Table 4.8. Weekly quantity report

LABOR QUANTITY REPORTING FORM

Project: S-92, THESIS.

WEEK ENDING: WEDNESDAY, 06/10/92

COST CODE	DESCRIPTION	UNIT	CURR. PER. ACT. QTTY.	JTD ACT. QTTY	NOTE
01-0080	LAYOUT	WK	1.00	32.00	
01-0650	O.S.H.A.	WK	1.00	32.00	
01-0710	CONST. CLEANUP	WK	1.00	32.05	
01-0740	WHSE IN/OUT	WK	1.00	41.00	
01-0870	HOIST OPERATION	WK	0.50	39.00	
02-1330	REMOVE SIDEWALKS	SF	950.00	1500.00	
02-2220	HAND EXCAVATION	CY	3.50	10.00	
02-5170	4" SIDEWALKS	SF	192.00	1352.00	
03-1400	SITE STAIRS	LF	334.00	853.00	
03-3751	EMERG. GEN. PAD.	EA	0.50	0.50	
03-3991	PLACE & FINISH S.	SF	288.00	10600.00	
06-1000	ROUGH CARP.	GS	1000.00	11188.00	
08-1101	HM. FRAMES SINGLE	EA	31.00	82.00	

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Table 4.9. Weekly productivity report

LABOR. UNIT COSTS REPORTING FORM

Project: S-92, THESIS.

WEEK ENDING: WEDNESDAY, 06/10/92

COST CODE	DESCRIPTION	UNIT	CURR. PER. ACT. QTTY.	LABOR COSTS	UNIT COSTS	ESTIMATED UNIT COSTS	BALANCE SAVE/LOSS
01-0080	LAYOUT	WK	1.00	77.92	77.92	109.89	31.97
01-0650	O.S.H.A.	WK	1.00	0.00	0.00	54.95	54.95
01-0710	CONST. CLEANUP	WK	1.00	272.17	272.17	390.20	118.03
01-0740	WHSE IN/OUT	WK	1.00	0.00	0.00	80.00	80.00
02-5170	4" SIDEWALKS	SF	192.00	688.28	3.59	0.56	-580.76
03-3751	EMERG. GEN PAD.	EA	0.50	1103.00	2206.00	750.00	-728.00
03-3991	PLACE & FINISH S.	SF	288.00	286.11	1.00	0.38	-177.81
06-1000	ROUGH CARP.	GS	1000.00	96.65	0.10	0.25	153.34
08-1101	HM. FRAMES SINGLE	EA	31.00	562.48	18.14	17.61	-16.73
TOTALS FOR QUANTIFIED COST CODES (\$):				3086.60			-1065.02
TOTALS FOR THIS PERIOD (\$):				3947.94			-1926.36

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after a considerable measurement of work, but costs are traced when the work related to that cost code begins. This explains the existence of the two total lines.

5. Overall labor cost performance report

The overall labor cost performance exhibits all the useful information for each particular cost code and totals for the overall project (refer to Figure 4.2). Comparisons between estimated and actual quantities, estimated and actual unit costs, and estimated and actual costs reflect savings or losses for every cost code and the overall project. This is a to-date project report, and it is accomplished using a LOTUS 123 spreadsheet with data automatically received from the dBASEIII+ database program on the PC. This relevant information is used for management purposes, and actions on problematic cost codes can be obtained.

However, there is still a need for graphical reports. These graphical reports allow trend analysis and provide better tools for managerial decisions.

C. Graphical Reports

Graphical reports can be accomplished by transferring information from dBASEIII+ to LOTUS 123. The transmitted information is saved in a spreadsheet. Figure 4.3 is part of a spreadsheet displaying the most relevant information needed for reporting purposes. In creating the graphical report macros (presented in Appendix F) are used, and the calculation

ACTUAL										
WEEK 0 01/01/92	WEEK 1 02/26/92	WEEK 2 03/04/92	WEEK 3 03/11/92	WEEK 4 03/18/92	WEEK 5 03/25/92	WEEK 6 04/01/92	WEEK 13 05/20/92	WEEK 14 05/27/92	WEEK 15 06/03/92	WEEK 16 06/10/92
4,457.75	646.76	369.20	256.34	459.25	108.86	326.58	1,033.48	114.38	77.92	37.46
17.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4,520.92			1,236.55	222.72	300.96	164.72	315.68	298.12		0.00
0.30			0.00	0.10	0.00	0.00	0.10	0.00		0.10
0.00										
0.00										
33.44										
2.00										
1,584.00										
2,200.00										
106.12										
7.00										
858.80	119.05	354.90	538.43	340.47	194.49	173.20	836.79	0.00	0.00	103.71
17.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
231.81	609.13		229.81	916.27						
256.00	1,773.00		0.00	3,200.00						
49.58	226.82		0.00	187.64	0.00					0.00
0.00	1.00		1.00	1.00	1.00					1.00
0.00										
0.00										
774.40			0.00							0.00
4.00			1.00							1.00
5,989.19	724.24	972.02	393.32	725.24	905.93	213.86	685.90	0.00	272.17	278.42
17.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3,497.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.14	0.00	0.00
26.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.00										
0.00										
10,346.96	919.97	1,046.76	1,043.76	1,109.19	889.16	911.55	837.45			
14.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
197.00										
0.00										
0.00										
0.00										
0.00										
0.00										
1,045.80							214.44		42.57	
180.00							960.00		0.00	
0.00							34.57			
0.00							0.00			
0.00										
700.00										
5,398.40										
140.00										
285.84										
9,528.00										
0.00										
0.00										
451.75										
695.00										
846.00										
10,600.00										
6,154.60	266.81	32.67								
9.00	0.00	0.00								
39.00										
780.00										
4,547.27										
263.00										
0.00										
0.00										
0.00										
0.00										

process is facilitated. Costs and quantities for particular cost codes for the specified week are appended and placed on the columns at the right side of the spreadsheet; thus, updating the spreadsheet is easily achieved.

Earned value concepts are used for the proper evaluation of the project and cost code performance. Individuals and overall project performance are then established.

1. Overall labor cost performance

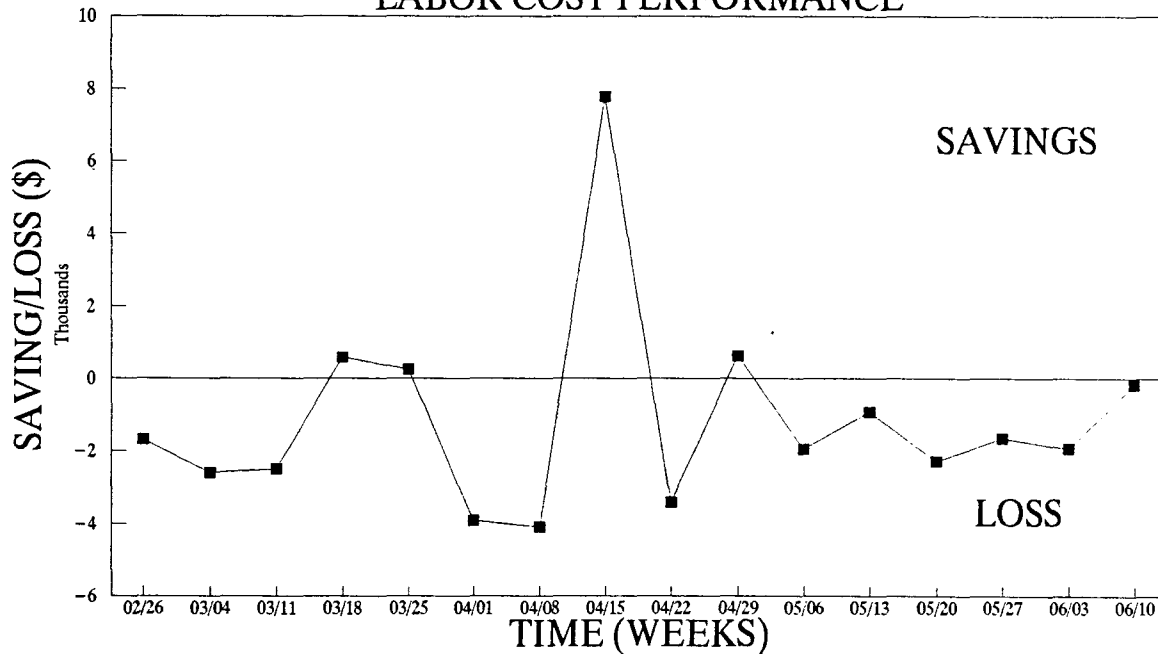
The overall labor cost performance is displayed in Figure 4.4, and it shows savings and losses for the overall project for every week. Trend analysis can be performed and actions can be developed using this graphic tool. The project savings or losses can be displayed over time.

In addition, a summary performance table is located in the middle section of the figure. Total estimated, job-to-date estimated (BCWP), and actual job-to-date (ACWP) values are taken from the spreadsheet. Percentage of completion, cost variance (CV), cost performance index (CPI), and projections are computed (for example, the project in Figure 4.4 has a CPI of 1.16, meaning the project is 16% over budget).

Finally, problematic and satisfying cost codes are at the bottom of this figure. To be considered as one of these, the cost code must meet the following three criteria: (1) The percentage of savings/losses is higher than 20%, (2) the cost completion is under 75% of estimate, so there is still time

Project and Company's Name

LABOR COST PERFORMANCE



OVERALL LABOR REPORT.	COSTS TABLE (IN DOLLARS)						
	TOTAL ESTIMAT.	JOB TO D. ESTIMAT. BCWP	JOB TO D. ACTUAL ACWP	PHYSICAL % COMPL	VARIANCE CV	PERFORM. INDEX CPI	PROJEC- TED AT FINAL
WEEK ENDING: 06/10/92	417131	238621	276276	66.2	-37655	1.16	482955 454786

NOTE ON PROJECTIONS BY THE END OF PROJECT

THE FIRST VALUE ASSUMES THAT THE VARIANCE RATIO WILL BE THE SAME AT THE END OF THE PROJECT

THE SECOND VALUE ASSUMES THAT THE PROJECT WILL CONTINUE AT PLANNED COSTS

LISTS OF PROBLEMATIC AND SATISFYING COST CODES:

CRITERIA: 1.- PERCENT OF SAVINGS,LOSS OVER BUDGET > 20%
2.- PERCENT OF COMPLETION < 75%
3.- BUDGET > \$2500

PROBLEMATIC COST CODES

01-0080 LAYOUT
01-0650 O.S.H.A.
02-2240 OUTSIDE BACKFILL
02-5170 4' SIDEWALKS

SATISFYING COST CODES

01-0662 BUILD HEAT ENCL
02-6320 DRAINAGE FABRIC

Figure 4.4. Overall labor cost performance

for corrective actions, and (3) the estimated budget is over \$2,500, meaning the cost code has a valuable weight on the cost performance. After identifying problematic and satisfying cost codes, a more detailed look can be accomplished.

2. Problematic cost codes

Having identified the cost codes that have the greatest negative impact on the overall project, more detailed graphical reports of these cost codes can show trends and hidden problems. Figures 4.5 through 4.8 present this detailed information for the problematic cost codes identified before. Again, a similar analysis can be completed and appropriate actions can be taken.

3. Satisfying cost codes

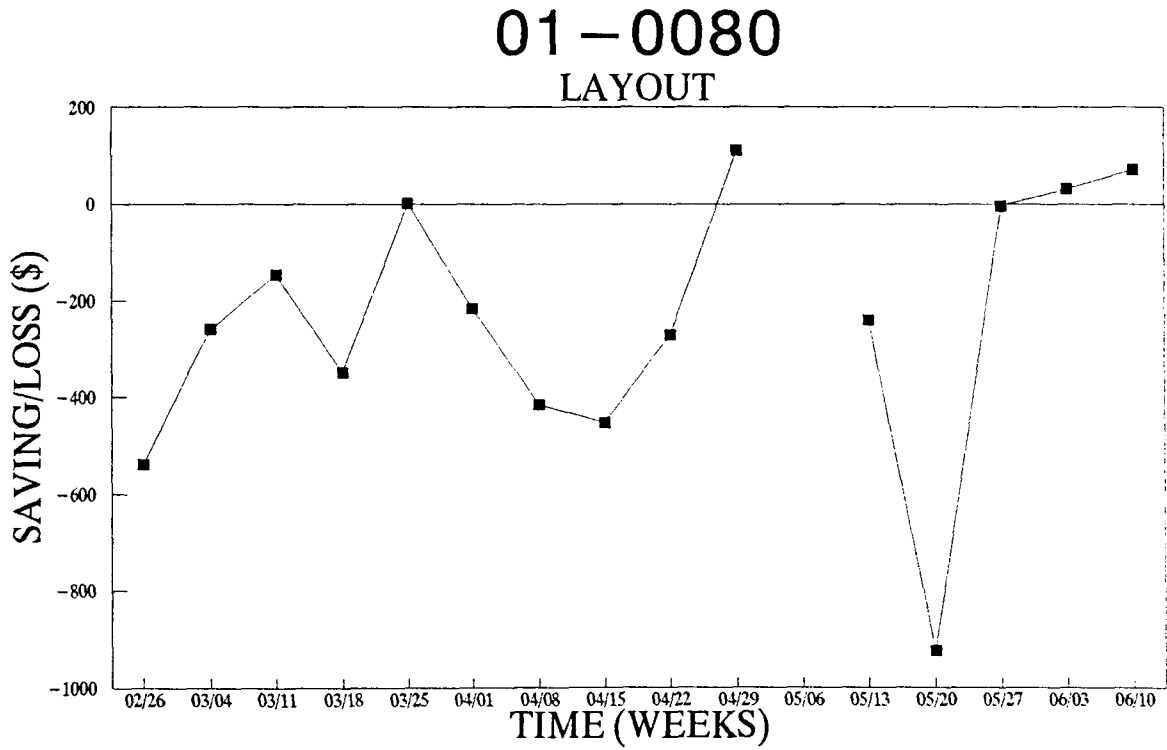
Along the same lines, satisfying cost codes can be graphically reported and trends of performance, and analysis for desired reiteration can be made. Figures 4.9 and 4.10 demonstrate the two cost codes identified in the overall cost performance report.

D. Summary

Positive results were obtained from the field validation of the system, and some benefits demonstrate the usefulness of the automated approach. Tabular or graphical reports show the performance and help control the project. Most tabular reports are valuable for accounting and payroll purposes,

while graphical reports are primarily used for cost control purposes.

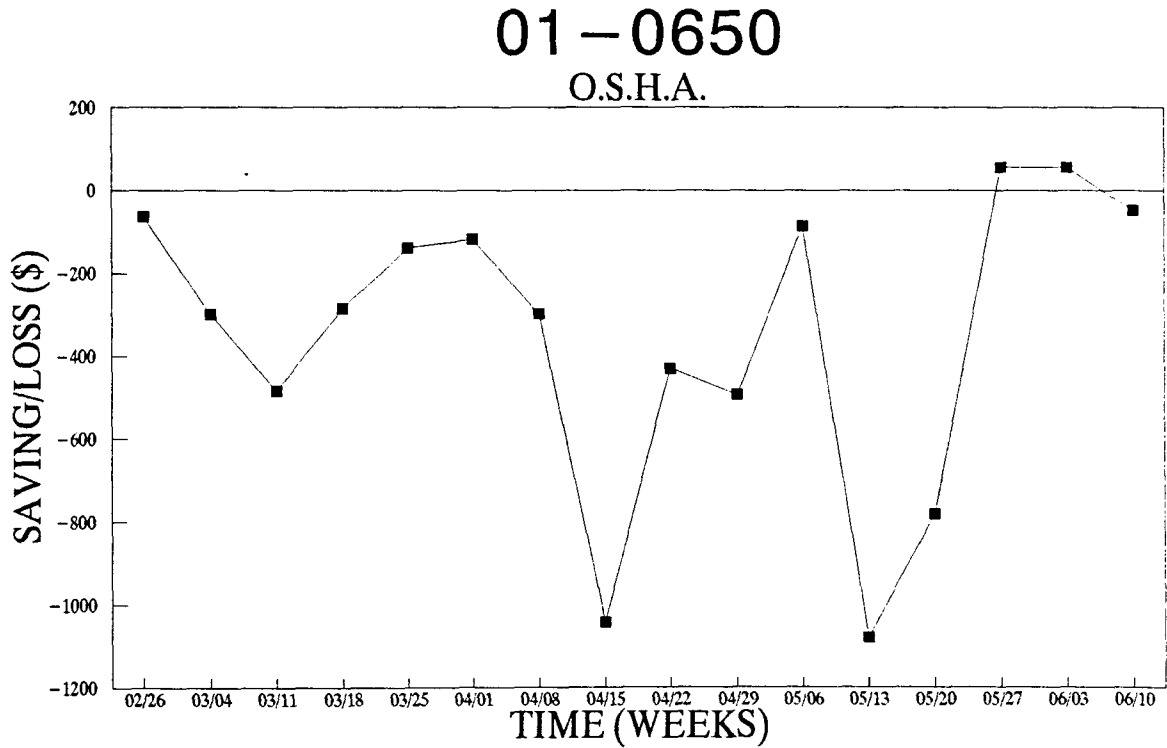
Finally, samples of the different types of tabular and graphical reports were explained.



LABOR REPORT.	QUANTITIES IN: WK			COSTS IN DOLLARS				
	TOTAL ESTIMAT.	JOB TO D. ACTUAL	% COMPL.	TOTAL ESTIMAT.	JOB TO D. ESTIMAT.	JOB TO D. ACTUAL	CPI & VARIANCE	PROJEC-TED/FINAL
WEEK ENDING:								
06/10/92	91	33.00	36.26	10000.0	3626.37	9816.15	-6189.78	16189.78

NOTE ON PROJECTIONS BY THE END OF PROJECT
 THE FIRST VALUE ASSUMES THAT THE VARIANCE RATIO WILL BE THE SAME AT THE END OF THE PROJECT
 THE SECOND VALUE ASSUMES THAT THE PROJECT WILL CONTINUE AT PLANNED COSTS

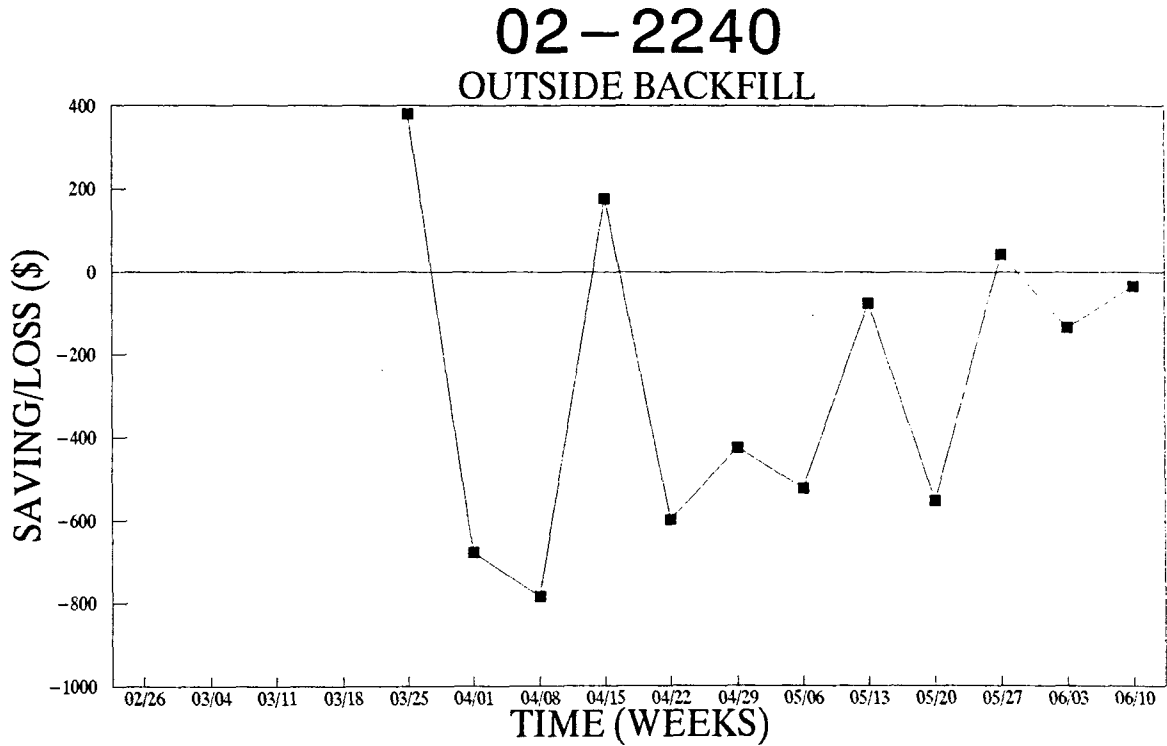
Figure 4.5. Layout



LABOR REPORT.	QUANTITIES IN:			COSTS				
	WK			IN DOLLARS				
WEEK ENDING:	TOTAL ESTIMAT.	JOB TO D. ACTUAL	% COMPL.	TOTAL ESTIMAT.	JOB TO D. ESTIMAT.	JOB TO D. ACTUAL	CPI & VARIANCE	PROJEC-TED/FINAL
06/10/92	91	33.00	36.26	5000.0	1813.19	7280.19	4.02	20075.68
							-5467.00	10467.00

NOTE ON PROJECTIONS BY THE END OF PROJECT
 THE FIRST VALUE ASSUMES THAT THE VARIANCE RATIO WILL BE THE SAME AT THE END OF THE PROJECT
 THE SECOND VALUE ASSUMES THAT THE PROJECT WILL CONTINUE AT PLANNED COSTS

Figure 4.6. O.S.H.A.

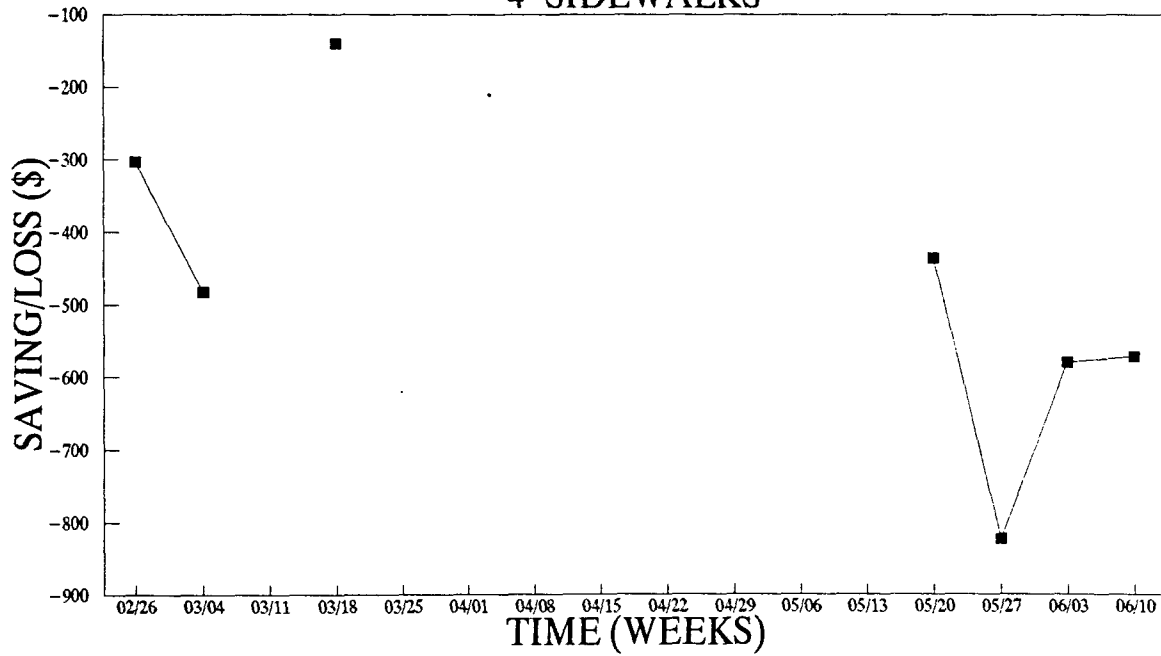


LABOR REPORT.	QUANTITIES IN: CY			COSTS IN DOLLARS				
	TOTAL ESTIMAT.	JOB TO D. ACTUAL	% COMPL.	TOTAL ESTIMAT.	JOB TO D. ESTIMAT.	JOB TO D. ACTUAL	CPI & VARIANCE	PROJEC-TED/FINAL
WEEK ENDING:								
06/10/92	3300	2405.00	72.88	8250.0	6012.50	9218.67	1.53 -3206.17	12649.32 11456.17

NOTE ON PROJECTIONS BY THE END OF PROJECT
 THE FIRST VALUE ASSUMES THAT THE VARIANCE RATIO WILL BE THE SAME AT THE END OF THE PROJECT
 THE SECOND VALUE ASSUMES THAT THE PROJECT WILL CONTINUE AT PLANNED COSTS

Figure 4.7. Outside backfill

02-5170 4" SIDEWALKS

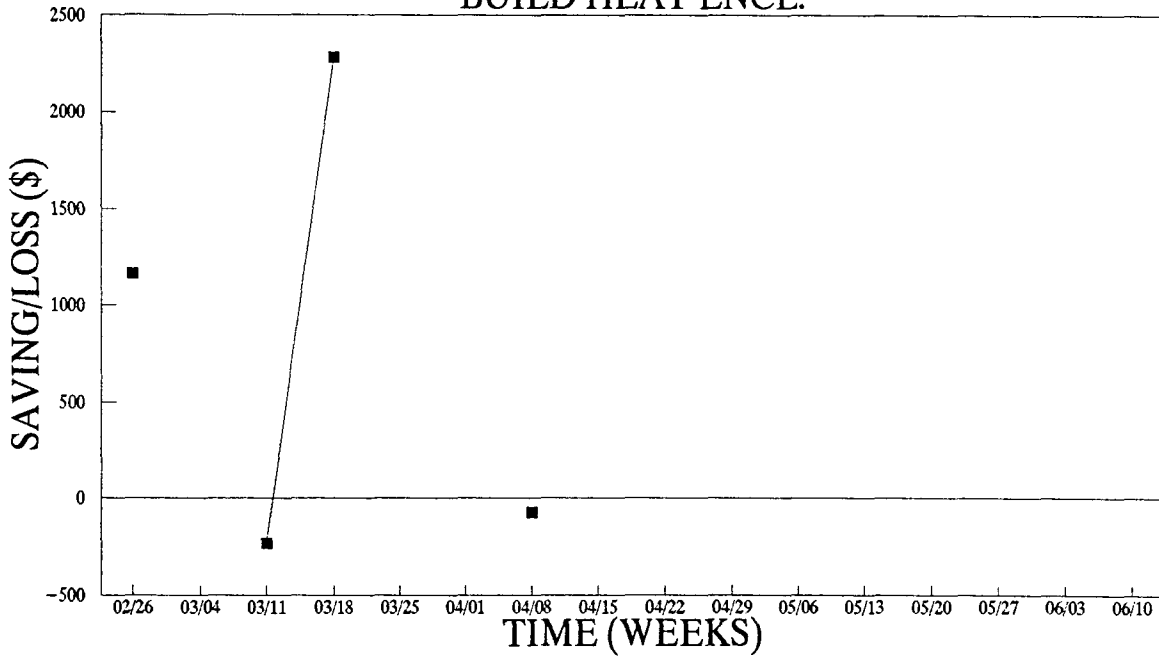


LABOR REPORT.	QUANTITIES IN:			COSTS IN DOLLARS				
	TOTAL ESTIMAT.	JOB TO D. ACTUAL	% COMPL.	TOTAL ESTIMAT.	JOB TO D. ESTIMAT.	JOB TO D. ACTUAL	CPI & VARIANCE	PROJEC-TED/FINAL
WEEK ENDING:								
06/10/92	18554	1352.00	7.29	10390.0	757.10	4093.35	-3336.25	56174.57 13726.25

NOTE ON PROJECTIONS BY THE END OF PROJECT
 THE FIRST VALUE ASSUMES THAT THE VARIANCE RATIO WILL BE THE SAME AT THE END OF THE PROJECT
 THE SECOND VALUE ASSUMES THAT THE PROJECT WILL CONTINUE AT PLANNED COSTS

Figure 4.8. 4" Sidewalks

01 - 0662 BUILD HEAT ENCL.

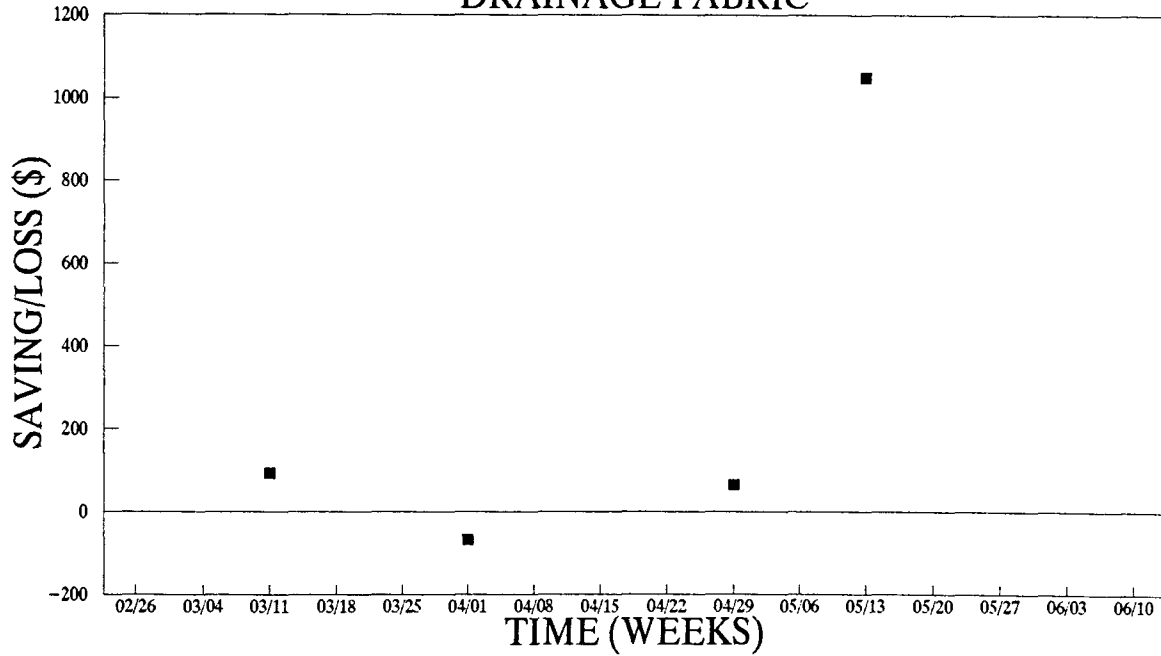


LABOR REPORT.	QUANTITIES IN: SF			COSTS IN DOLLARS				
	TOTAL ESTIMAT.	JOB TO D. ACTUAL	% COMPL.	TOTAL ESTIMAT.	JOB TO D. ESTIMAT.	JOB TO D. ACTUAL	CPI & VARIANCE	PROJEC- TED/FINAL
WEEK ENDING: 06/10/92	13000	5229.00	40.22	12999.0	5228.60	2058.26	0.39 3170.34	5117.11 9828.66

NOTE ON PROJECTIONS BY THE END OF PROJECT
 THE FIRST VALUE ASSUMES THAT THE VARIANCE RATIO WILL BE THE SAME AT THE END OF THE PROJECT
 THE SECOND VALUE ASSUMES THAT THE PROJECT WILL CONTINUE AT PLANNED COSTS

Figure 4.9. Build heat enclosures

02-6320 DRAINAGE FABRIC



LABOR REPORT.	QUANTITIES IN:			COSTS				
	SF			IN DOLLARS				
WEEK ENDING:	TOTAL ESTIMAT.	JOB TO D. ACTUAL	% COMPL.	TOTAL ESTIMAT.	JOB TO D. ESTIMAT.	JOB TO D. ACTUAL	CPI & VARIANCE	PROJEC-TED/FINAL
06/10/92	20600	9380.00	45.53	3090.0	1407.00	265.36	0.19 1141.64	582.77 1948.36

NOTE ON PROJECTIONS BY THE END OF PROJECT
 THE FIRST VALUE ASSUMES THAT THE VARIANCE RATIO WILL BE THE SAME AT THE END OF THE PROJECT
 THE SECOND VALUE ASSUMES THAT THE PROJECT WILL CONTINUE AT PLANNED COSTS

Figure 4.10. Drainage fabric

**V. LIMITATIONS AND RECOMMENDATIONS FOR IMPROVING THE
AUTOMATED TIMEKEEPING AND INFORMATION SYSTEM**

A. Limitations and Enhancement of the Automated System

Some limitations must be mentioned to enhance and extend the capabilities of A.T.I.S. Table 5.1 summarizes several limitations and enhancements needed to offer a wider range of features. Next, a brief explanation will describe how the enhancements can be accomplished.

Although the system could be enhanced by developing the previous suggestions, no chronological or hierarchical order can be followed. These recommendations are independent from

Table 5.1. Limitations and enhancement of A.T.I.S.

1. Changes in salary
 2. Find a system for automated bar code labels printing process
 3. Report person-hours
 4. Put weather conditions on graphics
 5. Down-load information to mainframe
 6. Two or more projects printed simultaneously
 7. Have a light pen attached to the PC
 8. Add statistical analysis of the data
 9. Include scheduling analysis
 10. Develop a training program for users
 11. Develop a user's guide on the application
-

each other, and changing any of them will improve the automated system.

It is common that salaries are increased during the project's duration. However, the current automated system does not keep any changes in workers' salaries. During the field test of the system, and specifically on May 1, a collective raise was given to the workers. In this situation, databases were updated with the new salary information, but the previous wage was left out. The capability for managing several changes in salary during the project duration will help keep track of labor costs at any date or period of time.

Bar code labels are reproduced using a dot matrix printer and a bar code software. Labels are printed using standard text files. However, a text file with the information bar coded was created anytime a template was generated. By using the information already existing in a database, generic text files can be sorted, and bar code labels can be automatically printed.

Labor cost control can be accomplished using cost code control or person-hours control. Companies decide which system they prefer for their labor cost control. However, person-hour data measure a better performance of workers because the information can be used and shared in several distant locations within the company. Person-hour data is less affected by local unit prices and other cost differences.

There are several external factors affecting a project's performance. One of the most important external factors is the weather. Therefore, proper tracking of the weather could facilitate the analysis of cost achievement. A foreman suggested that weather information on the graphics could sometimes help him describe variations on performance from one week to the next.

One of the key points for saving more time and achieving better cost benefits is the transferring of information from the PC to the mainframe. Files from the PC can be sent via modem from the site to the main office. Some companies, especially those with several offices within the U.S., use a mainframe for communicating information from one location to another, and the transfer of information from the PC to the mainframe is vital for this internal communication.

Workers are assigned and moved from one project to another. Finishers usually work on several projects within a specific period of time, and reporting and merging data from several projects simultaneously creates a need to track these workers.

Some companies might want to use their existent construction-site personal computers for timekeeping purposes. In these cases, the data could be directly entered using a light pen attached to a PC.

Schedule analysis should be studied along with cost analysis. In controlling a project, these two elements

represent the performance of the project, and an integrated schedule-cost analysis is needed. Finally, a training and user's guide should be prepared, so the system will be ready for use by site personnel.

In addition to these recommendations and limitations, additional research should be performed. The next section will explain further research and the incorporation of other resources that may be cost controlled.

B. Incorporation of Other Resources to the System for Total Project Cost Control and Future Research

With the incorporation of other resources to the automated system, a total project cost control will be accomplished. Presently, A.T.I.S. is helping to control only labor cost, but materials, equipment, and subcontractors are other entities where cost control is necessary. Field material control, warehouse inventory, and maintenance records are also some other features that can be added to the system.

This work can lead to other research of computer and bar codes used in the construction industry. Also, several other automatic technologies existing currently could be integrated into the current system.

Next, research could extend the capabilities of the automated system, or even test new technologies for data collection purposes. Voice recognition systems, grid pads,

holograms, touch memory, and smart cards are examples of existing new technologies.

Research on a large scale will prove the usefulness of this system. Further research is needed in this area.

The next chapter contains a summary of the automated system and conclusions of this study are presented.

VI. SUMMARY AND CONCLUSIONS

A. Summary

Construction management relies on data, frequently collected at the site level, which can be converted into information (Bernold, 1990b). However, the increased use of computers in the construction industry has led to the processing of extensive amounts of information. In addition, increased quantities of data have also been evolved (Rowings, 1991).

For labor cost control purposes in the construction industry, three problems related to input and output of data into computerized systems were identified. These problems were stated as (1) inefficient manual data-collection methods, (2) inaccuracy of data, and, (3) inadequate report generation.

Currently, on a typical construction project, daily labor time sheets are filled out at the site level, consolidated, and input into a central payroll system. With this manual approach; several levels of personnel at the construction site and main office are required, mistakes are likely to occur, and reports generated for cost control purposes are generated using lengthy and often outdated tabular reports.

Having identified such problems, research was conducted with the objectives of (1) finding a real-time project tracking system that charges person-hours and quantities of work-in-place at the time it occurs rather than after the work

could be completed; (2) reducing errors in timekeeping and cost control data; (3) providing reports in a format easy to comprehend; and (4) identifying innovative factors for payroll data collection and labor cost control procedures.

An Automated Timekeeping and Information System (A.T.I.S.) using bar coding techniques was the solution. Using a light pen, this system allows the timekeeper to scan in bar code labels containing information related to worker names, cost codes, time expended, quantities of work-in-place, and memos directly into a hand-held computer that could be carried out to the job site. Then, the hand-held computer is linked to a personal computer, and the data are down-loaded. The data are processed, and several tabular and graphical reports are generated providing field personnel with fast and reliable information.

Several automatic identification technologies were studied, and bar codes were selected as the technology to use in developing the automated system. Symbology "Code 39" was chosen, and several benefits of bar coding and automatic versus manual processes were explored.

This work presented unique characteristics of the automated system as compared to previous works. The A.T.I.S. integrated different computer devices, database and spreadsheet software, and an automatic data collection technology into a single system. Graphical representation of labor cost performance was also needed. Data collection,

processing, and reporting procedures were accomplished using a portable, hand-held computer and a job site-based personal computer system. Moreover, with some modifications, A.T.I.S. was fully developed and tested by a large general building contractor, who found improvements in data processing time, data accuracy, timely information availability, and reporting capabilities.

The system is divided into three different modules. First, the data collection phase could be achieved. A portable unit using bar code technology is used to collect information from the job site. The collection process could be achieved on an hourly, daily, or weekly basis, giving A.T.I.S. flexibility for different data input needs.

Secondly, the system also provides a menu-driven means for manipulating and processing the input data. The data are initially storage^{ed} into a dBASEIII+ compatible database software in the hand-held computer. Then, the data is conveniently transferred from the hand-held computer to a personal computer (PC) into dBASEIII+ database files. The serial ports (RS-232) and a communication protocol are used. Finally, the information can be automatically transferred into a LOTUS 123 format, and graphical reports can be generated also.

Thirdly, tabular and graphical reports are provided by the system for payroll and project labor cost control purposes. Such reports are timely, hence problems related to

labor cost performance could be identified and solved immediately.

Along with the benefits mentioned before, several other characteristics help the automated system to be acceptable and used by construction companies. Labor cost control can be accomplished using an inexpensive and job site-based system. System portability allows for data to be effectively gathered, and entered into a computerized system for projects located in remote and isolated areas. The system provides accurate and timely information, capability for controlling several projects using the same equipment, and useful and easier to understand reporting competency.

It is important to note that during the field validation of the automated system, and after the first month of use, other projects were offered by the general contractor firm. However, these were not part of the objectives of this research, and time constraints would not help to achieve this extra step.

Some limitation and enhancements of the actual automated system were also presented. Input of data into the system must be done by end-users. In producing this report, the author was the only one entering the data and running the system. Future enhancements include the use of the system by end-users; link between the job site and central office computer system for company-wide cost control operations;

incorporation of material, equipment, and subcontractor costs for total cost control; and cost-schedule integration.

B. Conclusions

The Automated Timekeeping and Information System provided a unique and creative approach in achieving the objectives of this work. First, it proved the integration of different computer devices and several popular software packages with an automatic data collection technology used extensively in the manufacturing and retail industries. Hand-held computers, personal computers, bar coding techniques, and database and spreadsheet packages were merged into a single system. Second, the creation of a graphical representation of labor cost performance offered a better way to understand a project's progress. Third, it showed a procedure to successfully carry out data collection techniques in a portable and job site-based system. And finally, A.T.I.S. offered an applicable system to the construction industry which overcame common problems such as inaccuracy of data, inefficiency of data collection processes, tardiness of information flow concerning labor costs, and extensive and difficult to understand tabular reports.

These characteristics make A.T.I.S. an effective and creative system that dealt primarily with payroll and labor cost control aspects of a construction project. The accuracy and timeliness of labor data entered into a computerized

system provided the required information for payroll purposes, allowing paychecks to be easily produced as soon as the last entry is input into the PC. And, better yet, a graphical portrayal of labor performance could help control labor costs.

Future research could include the stated enhancements to the automated system. Also, other areas with potential applications for bar code technology as data collection technique could be explored, and other automatic identification technologies could be used.

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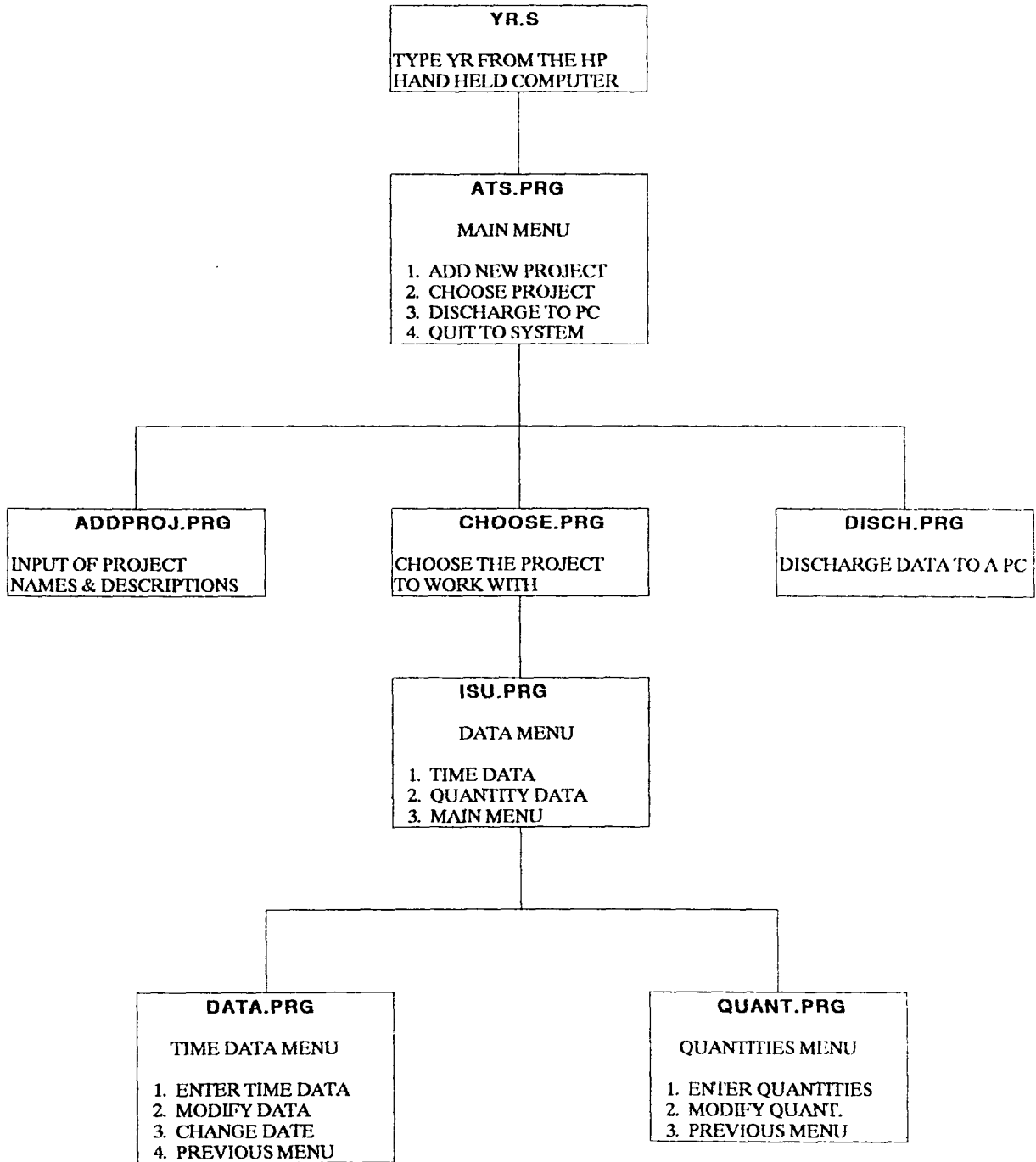
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APPENDIX A: MENU TREE FOR M-BASE, ON HAND-HELD COMPUTER



APPENDIX B: DATABASE FILES

	FIELD NAME	TYPE	WIDTH	DEC
1	PROCODE	CHARACTER	6	
2	DESCRIP	CHARACTER	19	

STRUCTURE FOR THE "PROJECTS.DBF" DATABASE

	FIELD NAME	TYPE	WIDTH	DEC
1	WORKER	CHARACTER	7	
2	COSTCODE	CHARACTER	7	
3	REGULAR	NUMERIC	5	2
4	OVERTIME	NUMERIC	4	2
5	TWOPAY	NUMERIC	4	2
6	INPUTDATE	DATE	8	
7	INPUTTIME	CHARACTER	5	
8	MYMEMO	CHARACTER	19	

STRUCTURE FOR ANY OF THE "PROJEC#.DBF" DATABASES

	FIELD NAME	TYPE	WIDTH	DEC
1	WORKER	CHARACTER	7	
2	SURNAME	CHARACTER	12	
3	NAMES	CHARACTER	8	
4	SS	CHARACTER	9	
5	SALARY	NUMERIC	6	2
6	BENEFITS	NUMERIC	4	2

STRUCTURE FOR ANY OF THE "PROJNA#.DBF" DATABASES

	FIELD NAME	TYPE	WIDTH	DEC
1	COSTCODE	CHARACTER	7	
2	WHAT	CHARACTER	21	
3	UNIT	CHARACTER	2	

STRUCTURE FOR ANY OF THE "PROJCO#.DBF" DATABASES

	FIELD NAME	TYPE	WIDTH	DEC
1	COSTCODE	CHARACTER	7	
2	INIDATE	DATE	8	
3	FINDATE	DATE	8	
4	QUAN	NUMERIC	6	2
5	QMEMO	CHARACTER	19	

STRUCTURE FOR ANY OF THE "PROJDE#.DBF" DATABASES

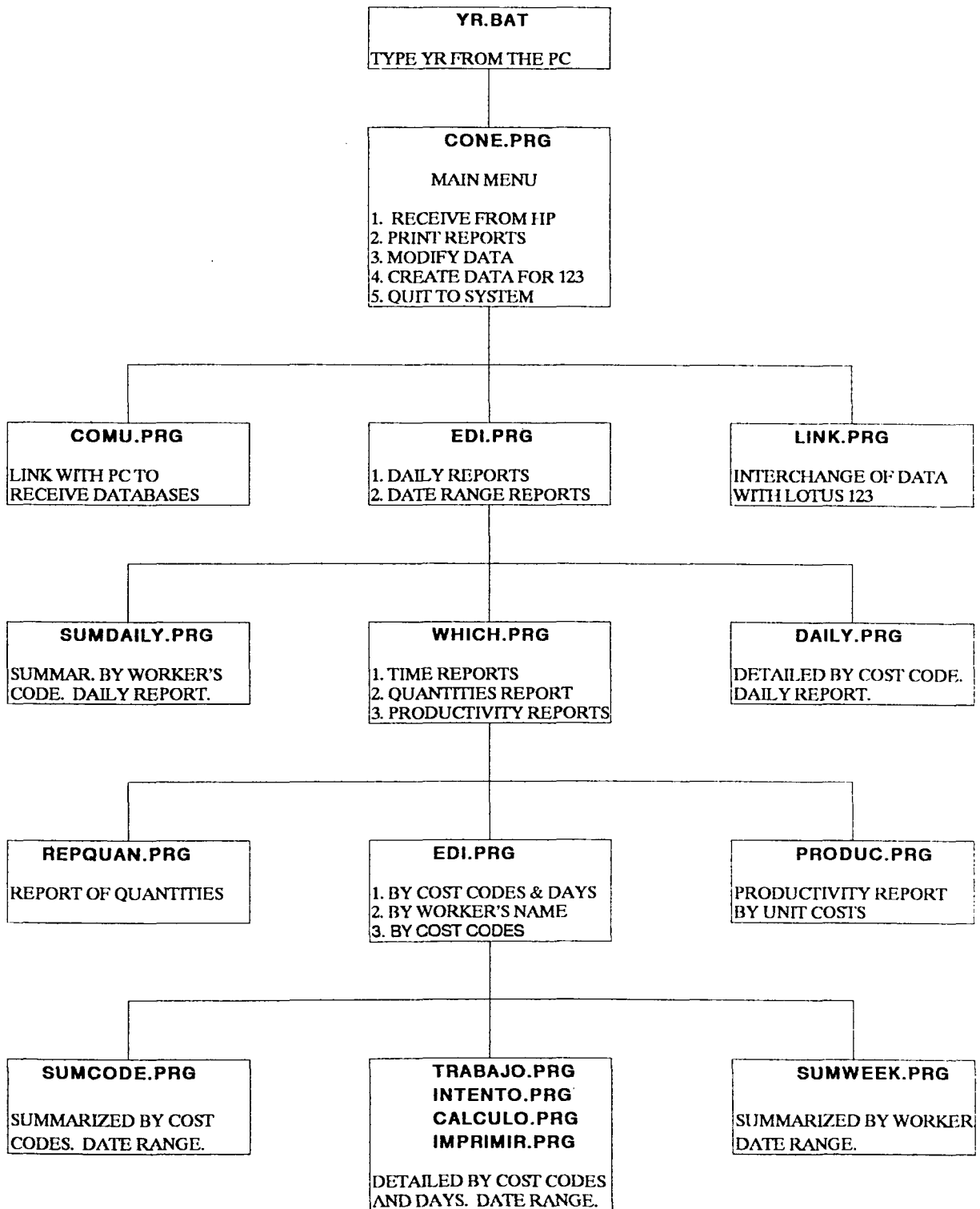
	FIELD NAME	TYPE	WIDTH	DEC
1	COSTCODE	CHARACTER	7	
2	QUANTITY	NUMERIC	6	0
3	MANHOURS	NUMERIC	7	1
4	LABOR	NUMERIC	6	0

STRUCTURE FOR ANY OF THE "ESTIMA#.DBF" DATABASES

	FIELD NAME	TYPE	WIDTH	DEC
1	FECHA	CHARACTER	8	
2	COSTCODE	CHARACTER	7	
3	COST	NUMERIC	9	2
4	QUAN	NUMERIC	9	2

STRUCTURE FOR THE "LINK.DBF" DATABASE

APPENDIX C: MENU TREE FOR dBASEIII+, ON PC



APPENDIX D: PROGRAMS WRITTEN IN M-BASE

```
REM                                     YR.S
REM
REM  Batch file for starting A.T.I.S. in the hand-held
REM  computer
```

```
CTTY COM1:
CLS
EDISK
CLS
DATE
I:
CLS
MBASE ATS
a:
CLS
```



```

*****  ATS.PRG
*
*      MAIN MENU FOR AUTOMATED
*      TIMEKEEPING SYSTEM DONE
*      AT ISU.
*
*      MAIN MENU
*      MANAGING OF PROJECT'S NAMES
*
SET STATUS OFF
SET DEFAULT TO I
SET TALK OFF
SET BELL ON
CTTY COM2: FOR INPUT
CLEAR
QT = "N"
POSSI = 0
DO WHILE POSSI # 4
    @0,0 TO 7,20 DOUBLE
    @0,5 SAY " MAIN MENU "
    @2,1 SAY "1. Add new project"
    @3,1 SAY "2. Choose project"
    @4,1 SAY "3. Discharge to PC"
    @5,1 SAY "4. Quit to system"
    @7,3 SAY "SELECT (1-4):" GET POSSI;
    PICTURE "9"
    READ
    DO CASE
        CASE POSSI = 1
            DO ADDPROJ
        CASE POSSI = 2
            POSSI = 0
            DO CHOOSE
        CASE POSSI = 3
            POSSI = 0
            DO DISCH
    ENDCASE
ENDDO
CLOSE DATABASES
CLEAR
@0,0 TO 7,20
@3,1 SAY "Do you really want"
@4,1 SAY "to quit (Y/N)? ";
GET QT PICTURE "Y!"
READ
IF QT = "N"
    CLOSE DATABASES
    DO ATS
ENDIF
CLEAR
@2,4 SAY "THANK YOU FOR"

```

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```
@3,4 SAY "FOR USING ATS"  
@0,1 TO 6,19 DOUBLE  
WAIT " press any key ..."  
CTTY COM1:
```

```
SET DEFAULT TO F  
QUIT
```

```

***** ADDPROJ.PRG
*
*   PROGRAM TO ADD NEW PROJECT
*   NAMES TO PROJECTS.DBF
*
CLEAR
USE PROJECTS
COUNT TO NUMB
  IF NUMB = 99
    @1,2 SAY "YOU HAVE REACHED"
    @2,2 SAY "  THE MAXIMUM"
    @3,2 SAY " OF 99 PROJECTS"
    @4,2 SAY " AVAILABLE FOR"
    @5,2 SAY "  THIS PROGRAM"
    @0,1 TO 6,19 DOUBLE
    WAIT " press any key ..."
    CLEAR
    CLOSE DATABASES
    POSSI = 0
    RETURN
  ENDIF
APPEND BLANK
  STORE RECNO() TO UBI
  @0,0 TO 7,20 DOUBLE
  @0,3 SAY "ADD NEW PROJECT"
STORE SPACE(6) TO NCODE
  @2,1 SAY "PROJECT No.:" GET NCODE PICTURE "@S6!"
  READ
  IF NCODE = " "
    DELETE
  ENDIF
GO TOP
  DO WHILE .NOT. EOF() .AND. NCODE # " "
    LOCATE FOR PROCODE = NCODE

    IF FOUND()
      CLEAR
      @1,6 SAY "WARNING"
      @3,4 SAY "THIS PROJECT"
      @4,3 SAY "ALREADY EXISTS"
      @0,1 TO 6,19 DOUBLE
      WAIT " press any key..."
      GO UBI
      DELETE

      CLEAR
      PACK
      CLOSE DATABASES
      POSSI = 0
      RETURN
    ENDIF
  CONTINUE

```

```
ENDDO
IF NCODE # " "
GO UBI
  @4,1 SAY "PROJECT DESCRIPT.:"
  @5,1 GET DESCRIP PICTURE "@S19!"
  READ
REPLACE PROCODE WITH NCODE
FILEPRO = "PROJEC"+LTRIM(STR(NUMB+1,2))+".DBF"
FILENAME = "PROJNA"+LTRIM(STR(NUMB+1,2))+".DBF"
FILEDESC = "PROJCO"+LTRIM(STR(NUMB+1,2))+".DBF"
FILEQUAN = "PROJDE"+LTRIM(STR(NUMB+1,2))+".DBF"
USE NAMES
COPY TO &FILENAME
USE WORK
COPY TO &FILEPRO
USE CODE
COPY TO &FILEDESC
USE DESCR
COPY TO &FILEQUAN
ENDIF
PACK
CLEAR
CLOSE DATABASES
POSSI = 0
```

```

***** CHOOSE.PRG
*
*           CHOOSE A PROJECT TO
*           WORK WITH
*
CLEAR
USE PROJECTS
COUNT TO CHO
  IF CHO = 0
    @2,4 SAY "YOU MUST HAVE"
    @3,5 SAY "ANY PROJECT"
    @4,3 SAY "IN MEMORY FIRST"
    @0,1 TO 6,19 DOUBLE
    WAIT " press any key ..."
    CLEAR
    CLOSE DATABASES
    POSSI = 0
    RETURN
  ENDIF
NUMCHO = CHO
ROWCHO = 1
PROJ = 0
  @0,0 TO 7,20 DOUBLE
  @0,2 SAY " CHOOSE A PROJECT"
GOTO TOP
DO WHILE .NOT.EOF()
  @ROWCHO,1 SAY LTRIM(STR(ROWCHO,1))
  @ROWCHO,2 SAY "."
  @ROWCHO,4 SAY PROCODE
  @ROWCHO,10 SAY DESCRIP PICTURE "@S10"
  SKIP
  ROWCHO = ROWCHO + 1
ENDDO
DO WHILE PROJ = 0
  @7,3 SAY "SELECT (1-"
  @7,13 SAY LTRIM(STR(CHO,1))
  @7,14 SAY "):" GET PROJ PICTURE "9"
  READ
  IF PROJ < 1 .OR. PROJ > CHO
    PROJ = 0
  ENDIF
ENDDO
  AW = "N"
  GOTO PROJ
  CLEAR
  @0,0 TO 7,20 DOUBLE
  @1,2 SAY "YOU HAVE CHOSEN:"
  @3,1 SAY "Project No.:"
  @3,14 SAY PROCODE
  @4,1 SAY "Description:"
  @5,1 SAY DESCRIP

```

```
@7,2 SAY "Continue (Y/N)?" GET AW PICTURE "Y!"  
READ  
IF AW = "N"  
    CLEAR  
    CLOSE DATABASES  
    POSSI = 0  
    RETURN  
ENDIF  
DO ISU
```

```

***** ISU.PRG
*
*           DATA MENU FOR ATS
*
* DISPLAYS MENU AND GETS USER'S CHOICE
*
CLOSE DATABASES
CLEAR
VEREMOS = 0
DO WHILE VEREMOS # 3
    @0,0 TO 7,20 DOUBLE
    @0,5 SAY " DATA MENU "
    @2,1 SAY "1. Time Data"
    @3,1 SAY "2. Quantity Data"
    @4,1 SAY "3. Main Menu"
    @7,3 SAY "SELECT (1-3):" GET VEREMOS;
    PICTURE "9"
    READ
*
* ROUTINE IF TIME DATA WAS CHOSEN
*
IF VEREMOS = 1
FILEPRO="PROJEC"+LTRIM(STR(PROJ,2))
FILENAME="PROJNA"+LTRIM(STR(PROJ,2))
SELECT 1
USE &FILEPRO
SELECT 2
USE &FILENAME
SELECT 1
CLEAR
CHOICE = 0
DO WHILE CHOICE # 4
    @0,0 TO 7,20 DOUBLE
    @0,3 SAY "TIME DATA MENU"
    @2,1 SAY "1. Enter Time Data"
    @3,1 SAY "2. Modify Data"
    @4,1 SAY "3. Change Date"
    @5,1 SAY "4. Previous Menu"
    @7,3 SAY "SELECT (1-4):" GET CHOICE;
    PICTURE "9"
    READ
DO CASE
    CASE CHOICE = 1
        DO DATA
    CASE CHOICE = 2
        &&DO MODITIME
    CASE CHOICE = 3
        CLEAR
        RUN DATE
        CLEAR

```

```

        ENDCASE
    ENDDO
    DO ISU
ENDIF
*
* ROUTINE IF QUANTITIES DATA WAS CHOSEN
*
IF VEREMOS = 2
FILEDESC = "PROJCO"+LTRIM(STR(PROJ,2))
FILEQUAN = "PROJDE"+LTRIM(STR(PROJ,2))
SELECT 1
USE &FILEQUAN
SELECT 2
USE &FILEDESC
SELECT 1
CLEAR
CHANCE = 0
    DO WHILE CHANCE # 3
        @0,0 TO 7,20 DOUBLE
        @0,3 SAY "QUANTITIES MENU"
        @2,1 SAY "1. Enter Quantities"
        @3,1 SAY "2. Modify Quant."
        @4,1 SAY "3. Previous Menu"
        @7,3 SAY "SELECT (1-3):" GET CHANCE;
            PICTURE "9"
        READ
        DO CASE
            CASE CHANCE = 1
                CLEAR
                STORE SPACE(8) TO NEXTINI
                STORE SPACE(8) TO NEXTFIN
                QI = "N"
                @0,0 TO 7,20 DOUBLE
                @1,3 SAY "YOU WILL ENTER"
                @2,1 SAY "QUANTITY INFORMAT.:"
                @4,2 SAY "From:" GET NEXTINI PICTURE "99/99/99"
                @5,2 SAY "To:" GET NEXTFIN PICTURE "99/99/99"
                READ
            IF CTOD(NEXTFIN)>=CTOD(NEXTINI)
                @7,2 SAY "CONTINUE (Y/N)?" GET QI PICTURE "Y!"
                READ
                IF QI = "Y"
                    DO QUANT
                ELSE
                    CLEAR
                ENDIF
            ENDIF
        ENDIF
        CLEAR
        CASE CHANCE = 2
            &&DO MODIQUAN
        ENDCASE
    
```



```
ENDDO  
DO ISU  
ENDIF  
ENDDO  
CLOSE DATABASES
```

```

***** DATA.PRG
*
*           START COLLECTING DATA
*           CALLED FROM MAIN MENU
*
CLEAR
DONE = .F.
DO WHILE .NOT. DONE
APPEND BLANK
STORE RECNO() TO POSITION
STORE SPACE(7) TO NEXTWKR
  @0,0 SAY "WORKER CODE:"
  @0,13 GET NEXTWKR PICTURE "@S7!"
  READ
    IF NEXTWKR = " " .OR. LEFT(NEXTWKR,2) # "00"
      DELETE
      DONE = .T.
    ELSE
*
* ROUTINE FOR ADDING PERSONAL INFORMATION FOR WORKERS
*
      SELECT 2
      APPEND BLANK
      STORE RECNO() TO POSIV
      STORE SPACE(12) TO SURB
      STORE SPACE(8) TO NOMB
      STORE SPACE(9) TO SSB
      SUELDO = 0
      BENE = 0
      COUNT FOR NEXTWKR=WORKER TO CHEQUEO
      IF CHEQUEO = 0
        CLEAR
        @0,0 TO 7,20 DOUBLE
        @1,1 SAY "CODE:"
        @1,10 SAY NEXTWKR
        @2,1 SAY "Surnam:"
        @2,8 GET SURB PICTURE "@S12!"
        @3,1 SAY "Name:"
        @3,6 GET NOMB PICTURE "@S8!"
        @4,1 SAY "SS#:"
        @4,5 GET SSB PICTURE "@S9!"
        @5,1 SAY "Rate:"
        @5,6 GET SUELDO PICTURE "99.999"
        @6,1 SAY "Benefits:"
        @6,10 GET BENE PICTURE "9.99"
        READ
        GO POSIV
        REPLACE WORKER WITH NEXTWKR
        REPLACE SURNAME WITH SURB, NAMES WITH NOMB
        REPLACE SS WITH SSB, SALARY WITH SUELDO
        REPLACE BENEFITS WITH BENE

```

```

        CLEAR
        @0,0 SAY "CODE:"
        @0,10 SAY NEXTWKR
    ELSE
        GOTO POSIV
        DELETE
        PACK
    ENDIF
*
* ROUTINE FOR ADDING COST INFORMATION FOR WORKERS
*
SELECT 1
STORE SPACE(7) TO NEXTCOST
@1,0 SAY "COST"
@1,8 SAY "RT"
@1,12 SAY "1.5T"
@1,18 SAY "DT"
ROWNUM=2
COUNT FOR NEXTWKR=WORKER .AND. INPUTDATE=DATE() TO NUMREC
TOTALRT=0
TOTALLOT=0
TOTALDT=0
IF NUMREC>0
    LOCATE FOR NEXTWKR=WORKER .AND. INPUTDATE=DATE()
    DO WHILE NUMREC>4
        TOTALRT=TOTALRT+REGULAR
        TOTALLOT=TOTALLOT+OVERTIME
        TOTALDT=TOTALDT+TWOPAY
        CONTINUE
        NUMREC=NUMREC-1
    ENDDO
    DO WHILE NUMREC>0
        @ROWNUM,0 SAY RIGHT(COSTCODE,5)
        @ROWNUM,6 SAY REGULAR
        @ROWNUM,12 SAY OVERTIME
        @ROWNUM,17 SAY TWOPAY
        TOTALRT=TOTALRT+REGULAR
        TOTALLOT=TOTALLOT+OVERTIME
        TOTALDT=TOTALDT+TWOPAY
        CONTINUE
        NUMREC=NUMREC-1
        ROWNUM=ROWNUM+1
    ENDDO
    @7,0 SAY "TOTAL:"
    @7,6 SAY TOTALRT PICTURE "99.99"
    @7,12 SAY TOTALLOT PICTURE "9.99"
    @7,17 SAY TOTALDT PICTURE "9.99"
ENDIF
@ROWNUM,0 GET NEXTCOST PICTURE "@S5"
READ
    IF NEXTCOST = " "

```

```

                GO POSITION
                DELETE
            ENDIF
        IF NEXTCOST = "M E M O"
            STORE SPACE(19) TO NMEMO
            CLEAR
            @0,0 TO 7,20 DOUBLE
            @2,1 SAY "CODE:"
            @2,10 SAY NEXTWKR
            @4,1 SAY "Enter a short memo"
            @5,1 GET NMEMO PICTURE "@S19!"
            READ
                GO POSITION
                REPLACE WORKER WITH NEXTWKR, COSTCODE WITH NEXTCOST
                REPLACE INPUTDATE WITH DATE()
                REPLACE INPUTTIME WITH SUBSTR(TIME(),1,5)
            REPLACE MYMEMO WITH NMEMO
        ENDIF
        IF NEXTCOST # " " .AND. NEXTCOST # "M E M O"
            NEXTRT=0
            NEXTOT=0
            NEXTDT=0
            @ROWNUM,6 GET NEXTRT PICTURE "99.99"
            @ROWNUM,12 GET NEXTOT PICTURE "9.99"
            @ROWNUM,17 GET NEXTDT PICTURE "9.99"
            READ
                GO POSITION
                REPLACE WORKER WITH NEXTWKR,COSTCODE WITH NEXTCOST
                REPLACE REGULAR WITH NEXTRT,OVERTIME WITH NEXTOT
                REPLACE TWOPAY WITH NEXTDT,INPUTDATE WITH DATE()
                REPLACE INPUTTIME WITH SUBSTR(TIME(),1,5)
        ENDIF
    ENDIF
    CLEAR
    ENDDO
    PACK
    CHOICE = 0
    RETURN

```

```
***** DISCH.PRG
*
*   PROGRAM FOR SENDING DATABASES
*   FROM HP TO A PC
*
USE PROJECTS
COUNT TO HOWM
CLOSE ALL
CONTA = 1
CLEAR
CTTY COM1:
RUN KERMIT X
RUN COPY I:PROJECTS.DBF TEMPO.DBF
RUN DEL I:PROJEC*.DBF
RUN DEL I:PROJDE*.DBF
*
*   COPYING EMPTY FILES
*
DO WHILE CONTA <= HOWM
FILEPRO="PROJEC"+LTRIM(STR(CONTA,2))+".DBF"
FILEQUAN="PROJDE"+LTRIM(STR(CONTA,2))+".DBF"
USE WORK
COPY TO &FILEPRO
USE DESCR
COPY TO &FILEQUAN
CONTA = CONTA + 1
ENDDO
*
*   GETTING PROJECTS.DBF
*
RUN COPY I:TEMPO.DBF PROJECTS.DBF
RUN DEL I:TEMPO.DBF
DO ATS
```

```

***** QUANT.PRG
*
* START COLLECTING QUANTITY DATA
*
CLEAR
DONE = .F.
DO WHILE .NOT. DONE
APPEND BLANK
STORE RECNO() TO POSITION
STORE SPACE(7) TO NEXTCODE
  @1,1 SAY "COST CODE:"
  @1,12 GET NEXTCODE PICTURE "@S7!"
  READ
    IF NEXTCODE = " "
      DELETE
      DONE = .T.
    ELSE
*
* ROUTINE FOR ADDING COST CODE INFORMATION
*
      SELECT 2
      APPEND BLANK
      STORE RECNO() TO POSIV
      STORE SPACE(21) TO WHATB
      STORE SPACE(2) TO UNITB
      COUNT FOR NEXTCODE=COSTCODE TO CHEQUEO
      IF CHEQUEO = 0
        CLEAR
        @1,1 SAY "COST CODE:"
        @1,12 SAY NEXTCODE
        @3,0 SAY "Description:"
        @4,0 GET WHATB PICTURE "@S21!"
        @6,0 SAY "Unit:"
        @6,5 GET UNITB PICTURE "@S2!"
        READ
        GO POSIV
        REPLACE COSTCODE WITH NEXTCODE
        REPLACE WHAT WITH WHATB, UNIT WITH UNITB
        CLEAR
        @1,1 SAY "COST CODE:"
        @1,12 SAY NEXTCODE
      ELSE
        GOTO POSIV
        DELETE
        PACK
      ENDIF
*
* ROUTINE FOR ADDING QUANTITY INFORMATION
*
      SELECT 1
      STORE SPACE(19) TO NMEMO

```

```
@0,0 TO 7,20 DOUBLE
NEXTQUAN=0
@3,1 SAY "QUANT.:" GET NEXTQUAN PICTURE "9999.99"
READ
  IF NEXTQUAN = 0
    GO POSITION
    DELETE
  ELSE
    @5,1 SAY "Enter a short memo"
    @6,1 GET NMEMO PICTURE "@S19!"
    READ
  ENDIF
  GO POSITION
  REPLACE COSTCODE WITH NEXTCODE
  REPLACE INIDATE WITH CTOD(NEXTINI)
  REPLACE FINDATE WITH CTOD(NEXTFIN)
  REPLACE QUAN WITH NEXTQUAN
  REPLACE QMEMO WITH NMEMO
ENDIF
CLEAR
ENDDO
PACK
CHANCE = 0
RETURN
```

APPENDIX E: PROGRAMS WRITTEN IN dBASEIII+


```
REM                                     YR.BAT
REM
REM   Batch file for starting A.T.I.S. in the PC.

C:
CD \
MODE COM1: 9600,N,8,1
CD DBASEIII
DBASE ATS\CONE.PRG
CLS
```

```

***** CONE.PRG
*
*           MAIN MENU ON THE PC
*           WITH MOVABLE "LIGHT BAR"
*
SET PATH TO C:\DBASEIII\ATS; C:\DBASEIII\DATABASE
RUN CD ATS
*
* Merge Code Area 1
LSTPGM="CONE"
* Set Up Working Environment
SET TALK OFF
SET HEADING OFF
SET SAFETY OFF
SET STATUS OFF
SET DECIMALS TO 4
CLEAR
SET BELL OFF
SET SCOREBOARD OFF
*
* Background Color: Black (N)
* Foreground Color: White (W)
* Backlight Color: Red (R)
* LightBar Color: Cyan (BG)
*
SET COLOR TO W/N
* Variables will start with the letter "N" so other variables
in memory
* will not be overwritten.
*
* Initialize User Input Variable To Zero
NEL=0
MENU=.T.
* NXP1 & NXP2 contain user instructions.
NXP1="Highlight option by using "
NXP2= " "+CHR(24)+ " or " +CHR(25)+ " and press ";
      +CHR(17)+CHR(217)
NXP3= "or press appropriate menu number"
* Initialize Menu Choice Variables
NPT1=" 1 - Receive databases from HP HAND-HELD computer "
NSG1="DOWNLOAD INFORMATION FROM DATA COLLECTION"
NPT2=" 2 - Print reports "
NSG2="PRINT REPORTS THAT MATCH A PARTICULAR SPECIFICATION"
NPT3=" 3 - Modify data "
NSG3="MODIFY DATA WITH CERTAIN CHARACTERISTICS"
NPT4=" 4 - Create a LOTUS 123 spreadsheet "
NSG4="CREATE A SPREADSHEET FOR SPECIFIED DATA RANGE"
NPT5=" X - Exit "
NSG5="Exit to DOS"
* Set Number Of Options
NUMOP=5

```

```

* Initialize Choice Indicator To #1
NSG=1
* Initialize Column Position and Options/Column
NLM1= 5
NLM2= 0
NIDDL=40-(LEN(NPT1)/2)
NNIDDL=40-(LEN(NSG3)/2)
  DO WHILE NENU
* Merge Code Area 2
* Set Up Menu Screen
  CLEAR
  @ 1,3 SAY DATE()
  @ 1,23 SAY "AUTOMATED TIMEKEEPING SYSTEM (ATS)"
  @ 2,17 SAY "CIVIL AND CONSTRUCTION ENGINEERING
DEPARTMENT"
  @ 3,29 SAY "IOWA STATE UNIVERSITY"
  SET COLOR TO R/N
  @ 0,1 TO 4,78 DOUBLE
* Merge Code Area 3
  @ 8,NIDDL-2 TO 9+NLM1,(NIDDL+(LEN(NPT1))+1) DOUBLE
  @16,12 TO 18,68
* Display User Instructions/Help Window
  SET COLOR TO N/W
  @ 21,16 SAY NXP1
  @ 21,42 SAY NXP2
  @ 23,22 SAY NXP3
  SET COLOR TO W/N
* Display Menu Choices
  @ 9,NIDDL SAY NPT1
  @ 10,NIDDL SAY NPT2
  @ 11,NIDDL SAY NPT3
  @ 12,NIDDL SAY NPT4
  @ 13,NIDDL SAY NPT5
  NCHOICE=.T.
  DO WHILE NCHOICE
* Merge Code Area 4
* Determine which Help To Display from the Message
  NMP="NSG"+LTRIM(STR(NSG))
  SET COLOR TO BG/N
  @ NUMOP+12,NNIDDL-5 SAY SPACE(LEN(NSG2))
  @ NUMOP+12,NNIDDL-5 SAY &NMP
  NPT="NPT"+LTRIM(STR(NSG))
  SET COLOR TO N/BG
  @ NSG+8,NIDDL SAY &NPT
  SET COLOR TO W/N
  NEL=0
* Keyboard Key Trapping
  DO WHILE NEL=0
* Merge Code Area 5
  NEL= INKEY()
  ENDDO

```

```

      @ NSG+8,NIDDL SAY &NPT
* Check If Valid Key Was Depressed
      IF CHR(NEL) $ "1234Xx"
* Merge Code Area 6
      IF CHR(NEL) $ "1"
        NSG= 1
      ENDIF
      IF CHR(NEL) $ "2"
        NSG= 2
      ENDIF
      IF CHR(NEL) $ "3"
        NSG= 3
      ENDIF
      IF CHR(NEL) $ "4"
        NSG= 4
      ENDIF
      IF CHR(NEL) $ "Xx"
        NSG= 5
      ENDIF
      EXIT
    ENDIF
* Carrage Return Depressed?
      IF NEL = 13
        EXIT
      ENDIF
* Up Arrow Depressed?
      IF NEL = 5
        NSG=NSG-1
        IF NSG<1
          NSG=NUMOP
        ENDIF
      ENDIF
* Down Arrow Depressed?
      IF NEL =24
        NSG=NSG+1
        IF NSG>NUMOP
          NSG=1
        ENDIF
      ENDIF
    ENDDO
* Merge Code Area 7
* Perform Item Selected
      DO CASE
        CASE NSG=1
          CLEAR
          DO COMU
        CASE NSG=2
          CLEAR
          DO EDI
        CASE NSG=3
          CLEAR

```

```
      &&DO EDI  
      CASE NSG=4  
      CLEAR  
      DO EDI  
      CASE NSG=5  
      CLEAR  
      CLOSE ALL  
      RUN CD \  
      QUIT  
    ENDCASE  
* Merge Code Area 8  
  ENDDO  
RETURN
```

```

***** EDI.PRG
*
*       SUBROUTINE FOR EDITING AND PRINTING
*       DATABASE FILES
*
CLEAR
USE PROJECTS
COUNT TO CHO
  IF CHO = 0
    RETURN
  ENDIF
NUMCHO = CHO
ROWCHO = 1
PROJ = 0
  @1,1 TO 3,79 DOUBLE
SET COLOR TO R
  @1,1 TO 3,79 DOUBLE
  @5,22 TO 12,46
  @14,1 TO 16,79 DOUBLE
SET COLOR TO W/N
  @2,7 SAY "CHOOSE A PROJECT FOR EDITING OR PRINTING FROM THE
FOLLOWING CHOICES"
LOCATE FOR PROCODE # " "
DO WHILE NUMCHO > 0
  @ROWCHO+5,24 SAY LTRIM(STR(ROWCHO,1))
  @ROWCHO+5,25 SAY ".-"
  @ROWCHO+5,28 SAY PROCODE
  @ROWCHO+5,36 SAY DESCRIP PICTURE "@S10"
  CONTINUE
  ROWCHO = ROWCHO + 1
  NUMCHO = NUMCHO - 1
ENDDO
DO WHILE PROJ = 0
  @15,32 SAY "SELECT (1-"
  @15,42 SAY LTRIM(STR(CHO,1))
  @15,43 SAY "):" GET PROJ PICTURE "9"
READ
  IF PROJ < 1 .OR. PROJ > CHO
    PROJ = 0
  ENDIF
ENDDO
AW = "N"
GOTO PROJ
CLEAR
SET COLOR TO R
  @1,1 TO 3,79 DOUBLE
  @11,1 TO 13,79 DOUBLE
SET COLOR TO W/N
  @2,30 SAY "YOU HAVE CHOSEN:"
  @6,25 SAY "PROJECT No.:"
  @6,38 SAY PROCODE

```

```

@8,22 SAY "DESCRIPTION:"
@8,35 SAY DESCRIP
DES = DESCRIP
CODE = PROCODE
@12,30 SAY "Continue (Y/N)?" GET AW PICTURE "Y!"
READ
IF AW = "N"
  CLEAR
  CLOSE DATABASES
  RETURN
ENDIF
FILEPRO = "PROJEC" + LTRIM(STR(PROJ,2))
FILENAME = "PROJNA" + LTRIM(STR(PROJ,2))
FILETEMP = "PROJNA" + LTRIM(STR(PROJ,2)) + ".DBF"
FILECODE = "PROJCO" + LTRIM(STR(PROJ,2)) + ".DBF"
FILEDESC = "PROJDE" + LTRIM(STR(PROJ,2))
FILEESTI = "ESTIMA" + LTRIM(STR(PROJ,2))
USE &FILEPRO
*
*       MENU FOR CHOOSING THE KIND
*       OF REPORT TO GENERATE
*
IF NSG#4
  CLEAR
  DAY = 0
  SET COLOR TO R
  @1,1 TO 3,79 DOUBLE
  @5,25 TO 11,60
  @14,1 TO 16,79 DOUBLE
  SET COLOR TO W/N
  @2,16 SAY "CHOOSE THE KIND OF REPORT YOU WANT TO GENERATE"
  @7,27 SAY "1. FOR A SPECIFIC DATE"
  @9,27 SAY "2. WITHIN A SPECIFIC DATE RANGE"
  DO WHILE DAY = 0
    @15,32 SAY "SELECT (1-2):" GET DAY PICTURE "9"
    READ
    IF DAY < 0 .OR. DAY > 2
      DAY = 0
    ENDIF
  ENDDO
  ELSE
  DAY = 2
  ENDIF
*
*       ROUTINE IF A SPECIFIC
*       DATA RANGE WAS CHOSEN
*
IF DAY = 2
  STORE SPACE(8) TO DAT2
  STORE SPACE(8) TO DAT3
  SET COLOR TO BG

```

```

@20,1 TO 22,79 DOUBLE
SET COLOR TO W/N
@21,04 SAY "INITIAL DATE (mm/dd/yy):" GET DAT2 PICTURE
"99/99/99"
@21,45 SAY "FINAL DATE (mm/dd/yy):" GET DAT3 PICTURE
"99/99/99"
READ
  IF CTOD(DAT3) < CTOD(DAT2)
    RETURN
  ENDIF
IF NSG=4
CLEAR
DO LINK
ENDIF
*
*       SUBROUTINE FOR CHOSING THE TYPE
*       OF DATA RANGE REPORT
*
DO WHICH
CLEAR
REP =0
SET COLOR TO R
  @1,1 TO 3,79 DOUBLE
  @5,20 TO 11,64
  @15,1 TO 17,79 DOUBLE
SET COLOR TO W/N
  @2,17 SAY "CHOOSE THE KIND OF REPORT YOU WANT TO GENERATE"
  @6,22 SAY "1. DETAILED: SORTED BY COST CODES AND DAYS"
  @8,22 SAY "2. SUMMARIZED REPORT BY WORKERS"
  @10,22 SAY "3. SUMMARIZED REPORT BY COST CODES"
DO WHILE REP = 0
  @16,32 SAY "SELECT (1-3):" GET REP PICTURE "9"
  READ
  IF REP < 0 .OR. REP > 3
    REP = 0
  ENDIF
ENDDO
DO CASE
CASE REP = 1
USE &FILEPRO
SORT ON WORKER, COSTCODE, INPUTDATE TO MOMENT FOR
INPUTDATE>=CTOD(DAT2) .AND. INPUTDATE<=CTOD(DAT3)
DO TRABAJO
RUN DEL MOMENT.DBF
RETURN
  CASE REP = 2
    DO SUMWEEK
    RETURN
  CASE REP = 3
    DO SUMCODE
    RETURN

```



```

ENDCASE
ENDIF
*
*       ROUTINE IF A SPECIFIC
*       DATE WAS CHOSEN
*
FLAG = 0
IF DAY = 1
DO WHILE FLAG = 0
  STORE SPACE(8) TO DAT1
  SET COLOR TO BG
  @20,13 TO 22,67 DOUBLE
  SET COLOR TO W/N
  @21,28 SAY "DATE (mm/dd/yy):" GET DAT1 PICTURE "99/99/99"
  READ
  GO TOP
  LOCATE FOR DTOC(INPUTDATE) = DAT1
  IF EOF()
    @21,17 SAY "NO DATA FOR THIS DATE AND PROJECT HAS
  BEEN FOUND"
    @23,25 SAY "press any key to continue..."
    WAIT " "
    RETURN
  ELSE
    FLAG = 1
  ENDIF
ENDDO
*
*       SUBROUTINE FOR CHOSING THE TYPE
*       OF DAILY REPORT
*
CLEAR
REP = 0
SET COLOR TO R
  @1,1 TO 3,79 DOUBLE
  @5,20 TO 9,61
  @14,1 TO 16,79 DOUBLE
SET COLOR TO W/N
  @2,15 SAY "CHOOSE THE KIND OF DAILY REPORT YOU WANT TO
GENERATE"
  @6,22 SAY "1. DETAILED BY COST CODES"
  @8,22 SAY "2. SUMMARIZED BY WORKER'S CODE"
DO WHILE REP = 0
  @15,32 SAY "SELECT (1-2):" GET REP PICTURE "9"
  READ
  IF REP < 0 .OR. REP > 2
    REP = 0
  ENDIF
ENDDO
DO CASE
CASE REP = 1

```

```
DO DAILY
RETURN
CASE REP = 2
DO SUNDAILY
RETURN
ENDCASE
ENDIF
```

```

***** COMU.PRG
*
*      COMMUNICATION BETWEEN THE
*      PC AND THE HP HAND-HELD
*      COMPUTER
*
CLOSE ALL
CLEAR
SET COLOR TO N/BG
@2,33 SAY "WARNING!!!"
SET COLOR TO W/N
@3,2 SAY " "
TEXT
    BEFORE TRYING THE COMMUNICATION BETWEEN THE HP HAND-HELD
    COMPUTER
    AND THIS PC, YOU MUST PERFORM THE FOLLOWING STEPS:

        1. BE SURE THAT BOTH MACHINES ARE PROPERLY CONNECTED

        2. SELECT CHOICE No. 3 (Discharge to PC) FROM THE
    MAIN MENU
        ON THE HP HAND-HELD COMPUTER

        3. READY TO CONTINUE
ENDTEXT
SET COLOR TO R
@1,1 TO 14,79 DOUBLE
@16,1 TO 18,79 DOUBLE
SET COLOR TO N/W
AW = "N"
@17,30 SAY "Continue (Y/N)?" GET AW PICTURE "Y!"
READ
SET COLOR TO W/N
IF AW = "N"
    CLEAR
    RETURN
ENDIF
CLEAR
RUN CD..
RUN CD DATABASE
RUN COPY PROJ*.DBF C:\DBASEIII\BACKUP\PROJ*.BAK
RUN REN PROJ*.DBF TEMP*.DBF
RUN C:\KERMIT\KERMIT G PROJ*.DBF
RUN C:\KERMIT\KERMIT F
*
*      SUBROUTINE FOR APENDING
*      PROJECT'S INFORMATION
*
USE TEMPECTS
COUNT TO PRIMERO
USE PROJECTS

```

```

COUNT TO HOWM
DO WHILE PRIMERO < HOWM
    FILEPRO = "TEMPEC"+LTRIM(STR(PRIMERO+1,2))+".DBF"
    FILENAME = "TEMPNA"+LTRIM(STR(PRIMERO+1,2))+".DBF"
    FILEDESC = "TEMPCO"+LTRIM(STR(PRIMERO+1,2))+".DBF"
    FILEQUAN = "TEMPDE"+LTRIM(STR(PRIMERO+1,2))+".DBF"
    COPY FILE WORK.DBF TO &FILEPRO
    COPY FILE NAMES.DBF TO &FILENAME
    COPY FILE DESCR.DBF TO &FILEQUAN
    COPY FILE CODE.DBF TO &FILEDESC
        USE PROJECTS
        GOTO PRIMERO+1
        STORE PROCODE TO NEW
        USE TEMPECTS
        APPEND FROM PROJECTS FOR PROCODE = NEW
        PRIMERO = PRIMERO + 1
CLOSE DATABASES
ENDDO

*
*       SUBROUTINE FOR APPENDING
*       TIME INFORMATION
*
CONTA = 1
DO WHILE CONTA <= HOWM
    ARCHIVO = "PROJEC" + LTRIM(STR(CONTA,2))
    ARCHINA = "TEMPEC" + LTRIM(STR(CONTA,2))
        USE &ARCHINA
        APPEND FROM &ARCHIVO
        CONTA = CONTA + 1
CLOSE DATABASES
ENDDO

*
*       SUBROUTINE FOR APPENDING
*       WORKER'S INFORMATION
*
CONTA = 1
DO WHILE CONTA <= HOWM
    ARCHIVO = "PROJNA" + LTRIM(STR(CONTA,2))
    ARCHINA = "TEMPNA" + LTRIM(STR(CONTA,2))
USE &ARCHINA
COUNT TO PRIMERO
USE &ARCHIVO
COUNT TO SEGUNDO
DO WHILE PRIMERO < SEGUNDO
    USE &ARCHIVO
    GOTO PRIMERO+1
    STORE WORKER TO NEW
    USE &ARCHINA
    APPEND FROM &ARCHIVO FOR WORKER = NEW
    PRIMERO = PRIMERO + 1
CLOSE DATABASES

```

```

        ENDDO
    CONTA = CONTA + 1
    ENDDO
*
*   SUBROUTINE FOR APPENDING
*   QUANTITIES
*
CONTA = 1
    DO WHILE CONTA <= HOWM
        ARCHIVO = "PROJDE" + LTRIM(STR(CONTA,2))
        ARCHINA = "TEMPDE" + LTRIM(STR(CONTA,2))
        USE &ARCHINA
        APPEND FROM &ARCHIVO
        CONTA = CONTA + 1
    CLOSE DATABASES
    ENDDO
*
*   SUBROUTINE FOR APPENDING
*   NEW CODES FOR QUANTITIES
*
CONTA = 1
    DO WHILE CONTA <= HOWM
        ARCHIVO = "PROJCO" + LTRIM(STR(CONTA,2))
        ARCHINA = "TEMPCO" + LTRIM(STR(CONTA,2))
        USE &ARCHINA
        COUNT TO PRIMERO
        USE &ARCHIVO
        COUNT TO SEGUNDO
        DO WHILE PRIMERO < SEGUNDO
            USE &ARCHIVO
            GOTO PRIMERO+1
            STORE COSTCODE TO NEW
            USE &ARCHINA
            APPEND FROM &ARCHIVO FOR COSTCODE = NEW
            PRIMERO = PRIMERO + 1
        CLOSE DATABASES
    ENDDO
    CONTA = CONTA + 1
    ENDDO
*
*   BACK TO ORIGINAL NAMES
*
CLOSE DATABASES
RUN DEL PROJ*.DBF
RUN REN TEMP*.DBF PROJ*.DBF
RUN CD..
RUN CD ATS
RETURN

```

```

***** WHICH.PRG
*
*     MENU FOR CHOOSING TIME,
*     QUANTITIES, OR BOTH
*
CLEAR
TPE = 0
SET COLOR TO R
  @1,1 TO 3,79 DOUBLE
  @5,25 TO 11,60
  @14,1 TO 16,79 DOUBLE
SET COLOR TO W/N
  @2,16 SAY "CHOOSE THE KIND OF REPORT YOU WANT TO GENERATE"
  @6,27 SAY "1. TIME REPORTS ONLY"
  @8,27 SAY "2. QUANTITY REPORTS ONLY"
  @10,27 SAY "3. PRODUCTIVITY REPORTS"
DO WHILE TPE = 0
  @15,32 SAY "SELECT (1-3):" GET TPE PICTURE "9"
  READ
    IF TPE < 0 .OR. TPE > 3
      TPE = 0
    ENDIF
ENDDO
DO CASE
  CASE TPE = 1
    RETURN
  CASE TPE = 2
    DO REPQUAN
  CASE TPE = 3
    DO PRODUC
ENDCASE

```

```

***** SUMDAILY.PRG
*
*   SUBROUTINE FOR DAILY WORKER'S CODE REPORTING
*
CLEAR
DES = RTRIM(DES)
CODE = RTRIM(CODE)
*
*   SORTING DATABASES FOR REPORTING
*
CLOSE ALL
RUN DEL COMBI.NDX
COPY FILE &FILETEMP TO PROJNAME.DBF
USE PROJNAME
INDEX ON WORKER TO COMBI
USE &FILEPRO
SORT ON INPUTDATE, WORKER, COSTCODE TO SUMDAILY
CLOSE ALL
SELE 1
USE SUMDAILY
SELE 2
USE PROJNAME INDEX COMBI
SELE 1
SET RELATION TO WORKER INTO PROJNAME
*
*   REPORTING INFORMATION
*
SET CONSOLE OFF
SET PRINT ON
SET DEVICE TO PRINT
@PROW(),1 SAY 'PROJECT: ' + CODE + ', ' + DES + '.      REPORT
FOR '
+ UPPER(CDOW(CTOD(DAT1))) + ', ' + DAT1
@PROW()+2,1 SAY ' '
REPORT FORM SUMDAILY FOR DTOC(INPUTDATE) = DAT1
@PROW()+6,62 SAY 'REVISED BY _____'
??CHR(12)
CLOSE ALL
RUN DEL SUMDAILY.DBF
RUN DEL PROJNAME.DBF
SET DEVICE TO SCREEN
SET PRINT OFF
SET CONSOLE ON
RETURN

```

```

***** SUMCODE.PRG
*
*   SUBROUTINE FOR SUMMARY WEEK REPORTING
*
CLEAR
DES = RTRIM(DES)
CODE = RTRIM(CODE)
*
*   SORTING DATABASES FOR REPORTING
*
CLOSE ALL
RUN DEL COMBI.NDX
COPY FILE &FILETEMP TO PROJNAME.DBF
USE PROJNAME
INDEX ON WORKER TO COMBI
USE &FILEPRO
SORT ON COSTCODE, INPUTDATE TO SUMCODE
CLOSE ALL
SELE 1
USE SUMCODE
SELE 2
USE PROJNAME INDEX COMBI
SELE 1
SET RELATION TO WORKER INTO PROJNAME
*
*   REPORTING INFORMATION
*
SET CONSOLE OFF
SET PRINT ON
SET DEVICE TO PRINT
@PROW(),1 SAY 'PROJECT: ' + CODE + ', ' + DES + '.      WEEK
ENDING: ' + UPPER(CDOW(CTOD(DAT3))) + ', ' + DAT3
@PROW()+2,1 SAY ' '
REPORT FORM SUMCODE FOR INPUTDATE >= CTOD(DAT2) .AND.
INPUTDATE <= CTOD(DAT3)
@PROW()+6,74 SAY 'REVISED BY: _____'
??CHR(12)
CLOSE ALL
RUN DEL SUMCODE.DBF
RUN DEL PROJNAME.DBF
SET DEVICE TO SCREEN
SET PRINT OFF
SET CONSOLE ON
RETURN

```



```

***** DAILY.PRG
*
*   SUBROUTINE FOR DAILY COSTCODE REPORTING
*
CLEAR
DES = RTRIM(DES)
CODE = RTRIM(CODE)
*
*   SORTING DATABASES FOR REPORTING
*
CLOSE ALL
RUN DEL COMBI.NDX
COPY FILE &FILETEMP TO PROJNAME.DBF
USE PROJNAME
INDEX ON WORKER TO COMBI
USE &FILEPRO
SORT ON INPUTDATE, COSTCODE, WORKER TO DAILY
CLOSE ALL
SELE 1
USE DAILY
SELE 2
USE PROJNAME INDEX COMBI
SELE 1
SET RELATION TO WORKER INTO PROJNAME
*
*   REPORTING INFORMATION
*
SET CONSOLE OFF
SET PRINT ON
SET DEVICE TO PRINT
@PROW(),1 SAY 'PROJECT: ' + CODE + ', ' + DES + '.      REPORT
FOR ' + UPPER(CDOW(CTOD(DAT1))) + ', ' + DAT1
@PROW()+2,1 SAY ' '
REPORT FORM DAILY FOR DTOC(INPUTDATE) = DAT1
@PROW()+6,63 SAY 'REVISED BY: _____'
??CHR(12)
CLOSE ALL
RUN DEL DAILY.DBF
RUN DEL PROJNAME.DBF
SET DEVICE TO SCREEN
SET PRINT OFF
SET CONSOLE ON
RETURN

```

```

***** SUMWEEK.PRG
*
*   SUBROUTINE FOR SUMMARY WEEK REPORTING
*
CLEAR
DES = RTRIM(DES)
CODE = RTRIM(CODE)
*
*   SORTING DATABASES FOR REPORTING
*
CLOSE ALL
RUN DEL COMBI.NDX
COPY FILE &FILETEMP TO PROJNAME.DBF
USE PROJNAME
INDEX ON WORKER TO COMBI
USE &FILEPRO
SORT ON WORKER, INPUTDATE, COSTCODE TO SUMWEEK
CLOSE ALL
SELE 1
USE SUMWEEK
SELE 2
USE PROJNAME INDEX COMBI
SELE 1
SET RELATION TO WORKER INTO PROJNAME
*
*   REPORTING INFORMATION
*
SET CONSOLE OFF
SET PRINT ON
SET DEVICE TO PRINT
@PROW(),1 SAY 'PROJECT: ' + CODE + ', ' + DES + '.   WEEK
ENDING: ' + UPPER(CDOW(CTOD(DAT3))) + ', ' + DAT3
@PROW()+2,1 SAY ' '
REPORT FORM SUMWEEK FOR INPUTDATE >= CTOD(DAT2) .AND.
INPUTDATE <= CTOD(DAT3)
@PROW()+6,65 SAY 'REVISED BY: _____'
??CHR(12)
CLOSE ALL
RUN DEL SUMWEEK.DBF
RUN DEL PROJNAME.DBF
SET DEVICE TO SCREEN
SET PRINT OFF
SET CONSOLE ON
RETURN

```

```

***** REPQUAN.PRG
*
*   REPORTING FOR QUANTITIES
*
CLEAR
DES = RTRIM(DES)
CODE = RTRIM(CODE)
*
*   SORTING DATABASES FOR REPORTING
*
CLOSE ALL
USE &FILEDESC
SORT ON COSTCODE TO QUANTITY
CLOSE ALL
SELE 1
USE QUANTITY
SELE 2
USE &FILECODE
SELE 1
*
* REPORTING FOR A SPECIFIC DATE RANGE
*
IF DAY = 2
SET CONSOLE OFF
SET PRINT ON
SET DEVICE TO PRINT
@PROW(),40 SAY 'LABOR QUANTITY REPORTING FORM'
@PROW()+1,40 SAY '-----'
@PROW()+3,1 SAY 'PROJECT: ' + CODE + ', ' + DES + '.      WEEK
ENDING: ' + UPPER(CDOW(CTOD(DAT3))) + ', ' + DAT3
@PROW()+2,1 SAY ' '
@PROW()+2,1 SAY REPLICATE('-',115)
@PROW()+2,4 SAY 'COST CODE'
@PROW(),20 SAY 'DESCRIPTION'
@PROW(),45 SAY 'UNIT'
@PROW(),60 SAY 'CURR. PER.'
@PROW(),83 SAY 'JTD'
@PROW(),100 SAY 'NOTES'
@PROW()+1,60 SAY 'ACT. QTTY.'
@PROW(),80 SAY 'ACT. QTTY.'
@PROW()+2,1 SAY REPLICATE('-',115)
*
*
COUNT TO NUMR
CONTA = 1
DO WHILE CONTA <= NUMR
    GOTO CONTA
    COSTN = COSTCODE
SUM QUAN FOR COSTCODE = COSTN .AND. INIDATE=CTOD(DAT2) .AND.
FINDATE<=CTOD(DAT3) TO CURR
SUM QUAN FOR COSTCODE = COSTN .AND. FINDATE<=CTOD(DAT3) TO JTD

```

```

*
*   ROUTINE FOR PRINTING INFORMATION
IF CURR # 0
SELE 2
GOTO TOP
LOCATE FOR COSTCODE = COSTN
    @PROW()+2,5 SAY COSTN
    @PROW(),20 SAY WHAT
    @PROW(),46 SAY UNIT
    @PROW(),56 SAY CURR
    @PROW(),76 SAY JTD
SELE 1
    LOCATE FOR COSTCODE = COSTN .AND. INIDATE>=CTOD(DAT2)
    .AND. i
    FINDATE<=CTOD(DAT3)
    IF FOUND()
        @PROW(),95 SAY QMEMO
    ENDIF
ENDIF
*
*
        CONTA=CONTA+1
        IF CONTA <= NUMR
            GOTO CONTA
        ENDIF
        DO WHILE COSTCODE = COSTN .AND. CONTA < NUMR
            CONTA = CONTA + 1
            GOTO CONTA
        ENDDO
ENDDO
@PROW()+2,1 SAY REPLICATE('-',115)
@PROW()+6,75 SAY 'REVISED BY: _____'
CLOSE ALL
RUN DEL QUANTITY.DBF
??CHR(12)
SET DEVICE TO SCREEN
SET PRINT OFF
SET CONSOLE ON
ENDIF
RETURN TO MASTER

```

```

***** PRODUC.PRG
*
*   REPORTING OF PRODUCTIVITY PER PERIOD
*
CLEAR
DES = RTRIM(DES)
CODE = RTRIM(CODE)
TOTAL1= 0
TOTAL3 = 0
*
*   SORTING DATABASES FOR REPORTING
*
CLOSE ALL
COPY FILE &FILETEMP TO PROJNAME.DBF
USE &FILEDESC
SORT ON COSTCODE TO QUANTITY
USE &FILEPRO
SORT ON WORKER TO VEREMOS FOR INPUTDATE>=CTOD(DAT2) .AND.
INPUTDATE<=CTOD(DAT3)
CLOSE ALL
*
*
SELE 5
USE &FILEESTI
SELE 4
USE PROJNAME
SELE 3
USE VEREMOS
JOIN WITH PROJNAME TO NUEVO FOR WORKER = PROJNAME->WORKER
FIELDS WORKER, COSTCODE, REGULAR, OVERTIME, TWOPAY, INPUTDATE,
PROJNAME->SALARY, PROJNAME->BENEFITS
USE NUEVO
SUM REGULAR*SALARY, OVERTIME*SALARY, TWOPAY*SALARY,
BENEFITS*(REGULAR+OVERTIME+TWOPAY) FOR INPUTDATE>=CTOD(DAT2)
.AND. INPUTDATE<=CTOD(DAT3)  i
TO AA1, AA2, AA3, AA4
TOTAL2 = AA1 + AA2*1.5 + AA3*2 + AA4
SELE 2
USE &FILECODE
SELE 1
USE QUANTITY
*
* REPORTING FOR A SPECIFIC DATE RANGE
*
SET CONSOLE OFF
SET PRINT ON
SET DEVICE TO PRINT
@PROW(),40 SAY 'LABOR. UNIT COSTS REPORTING FORM'
@PROW()+1,40 SAY '-----'
@PROW()+3,1 SAY 'PROJECT: ' + CODE + ', ' + DES + '.      WEEK
ENDING: ' + UPPER(CDOW(CTOD(DAT3))) + ', ' + DAT3

```

```

@PROW()+2,1 SAY ' '
@PROW()+2,1 SAY REPLICATE('-',115)
@PROW()+2,1 SAY 'COST CODE'
@PROW(),12 SAY 'DESCRIPTION'
@PROW(),35 SAY 'UNIT'
@PROW(),43 SAY 'CURR. PER.'
@PROW(),63 SAY 'LABOR'
@PROW(),75 SAY 'UNIT COSTS'
@PROW(),90 SAY 'ESTIMATED'
@PROW(),108 SAY 'BALANCE'
@PROW()+1,43 SAY 'ACT. QTTY.'
@PROW(),63 SAY 'COSTS'
@PROW(),89 SAY 'UNIT COSTS'
@PROW(),107 SAY 'SAVE/LOSS'
@PROW()+2,1 SAY REPLICATE('-',115)
*
*
COUNT TO NUMR
CONTA = 1
DO WHILE CONTA <= NUMR
    GOTO CONTA
    COSTN = COSTCODE
SUM QUAN FOR COSTCODE = COSTN .AND. INIDATE>=CTOD(DAT2) .AND.
FINDATE<=CTOD(DAT3) TO CURR
*
*   ROUTINE FOR PRINTING INFORMATION
IF CURR # 0
SELE 5
SUM LABOR/QUANTITY FOR COSTCODE = COSTN TO EST
SELE 3
SUM REGULAR*SALARY, OVERTIME*SALARY, TWOPAY*SALARY,
BENEFITS*(REGULAR+OVERTIME+TWOPAY) FOR INPUTDATE>=CTOD(DAT2)
.AND. INPUTDATE<=CTOD(DAT3)
.AND. COSTCODE = COSTN TO SUMA1, SUMA2, SUMA3, SUMA4
SUMAP = SUMA1 + SUMA2*1.5 + SUMA3*2 + SUMA4
TOTAL1 = TOTAL1 + SUMAP
SELE 2
GOTO TOP
LOCATE FOR COSTCODE = COSTN
@PROW()+2,2 SAY COSTN
@PROW(),12 SAY WHAT
@PROW(),36 SAY UNIT
@PROW(),39 SAY CURR
@PROW(),59 SAY STR(ROUND(SUMAP,2),9,2)
ACTUAL = SUMAP/CURR
@PROW(),75 SAY STR(ROUND(ACTUAL,3),10,3)
@PROW(),89 SAY STR(ROUND(EST,3),10,3)
EARNED = (EST - ACTUAL)*CURR
TOTAL3 = TOTAL3 + EARNED
@PROW(),106 SAY STR(ROUND(EARNED,2),9,2)
SELE 1

```

```

ENDIF
*
*
      CONTA=CONTA+1
      IF CONTA <= NUMR
      GOTO CONTA
      ENDIF
      DO WHILE COSTCODE = COSTN .AND. CONTA < NUMR
      CONTA = CONTA + 1
      GOTO CONTA
      ENDDO
ENDDO
@PROW()+2,1 SAY REPLICATE('-',115)
@PROW()+2,3 SAY 'TOTALS FOR QUANTIFIED COST CODES ($):'
@PROW(),59 SAY STR(ROUND(TOTAL1,2),9,2)
@PROW(),106 SAY STR(ROUND(TOTAL3,2),9,2)
@PROW()+2,1 SAY REPLICATE('-',115)
@PROW()+2,3 SAY 'TOTALS FOR THIS PERIOD ($):'
@PROW(),59 SAY STR(ROUND(TOTAL2,2),9,2)
GRAND = TOTAL3+TOTAL1-TOTAL2
@PROW(),106 SAY STR(ROUND(GRAND,2),9,2)
@PROW()+2,1 SAY REPLICATE('-',115)
@PROW()+6,75 SAY 'REVISED BY: _____'
CLOSE ALL
RUN DEL PROJNAME.DBF
RUN DEL QUANTITY.DBF
RUN DEL VEREMOS.DBF
RUN DEL NUEVO.DBF
??CHR(12)
SET DEVICE TO SCREEN
SET PRINT OFF
SET CONSOLE ON
RETURN TO MASTER

```

```

***** TRABAJO.PRG
*
*       SUBROUTINE FOR WEEK REPORTING
*       SORTED BY COSTCODES AND DAYS.
*
CLEAR
CLOSE ALL
DES = RTRIM(DES)
CODE = RTRIM(CODE)
WOR = 0
SET COLOR TO R
  @1,1 TO 3,79 DOUBLE
  @5,5 TO 9,33
  @12,5 TO 14,33 DOUBLE
SET COLOR TO W/N
  @2,15 SAY "WEEK REPORTING. SORTED BY COSTCODES AND DAYS"
  @6,7 SAY "1. FOR A SPECIFIC WORKER"
  @8,7 SAY "2. RETURN TO MAIN MENU"
DO WHILE WOR = 0
  @13,11 SAY "SELECT (1-2):" GET WOR PICTURE "9"
  READ
  IF WOR < 0 .OR. WOR > 2
    WOR = 0
  ENDIF
DO CASE
*
*       A WORKER REPORT IS GENERATED
*
CASE WOR = 1
  SET COLOR TO BG
  @5,48 TO 14,72
  @16,48 TO 20,72 DOUBLE
  SET COLOR TO W/N
  STORE SPACE(12) TO APELLI
  @17,54 SAY "ENTER SURNAME:"
  @19,54 GET APELLI PICTURE "@S12!"
  READ
  APELLI = RTRIM(APELLI)
  SELE 5
  USE &FILENAME
  LOCATE FOR LEFT(SURNAME,LEN(APELLI)) = APELLI
  SI = "Y"
  DO WHILE .NOT. EOF()
    @6,52 SAY "YOU HAVE CHOSEN:"
    @9,50 SAY RTRIM(SURNAME)+' ', '+NAMES
    @13,50 SAY "Ok to print (Y/N)?" GET SI PICTURE "Y!"
    READ
    IF SI = "Y"
      STORE WORKER TO TRABAJA
      DO INTENTO
      @6,49 CLEAR TO 13,71

```



```
        @17,49 CLEAR TO 19,71
        GOTO BOTTOM
        CONTINUE
    ELSE
        @6,49 CLEAR TO 13,71
        CONTINUE
    ENDIF
ENDDO
```

```
    CLOSE ALL
    WOR = 0
*
*     RETURN TO MAIN MENU
*
CASE WOR = 2
    CLOSE ALL
    RETURN
ENDCASE
ENDDO
```

```

***** INTENTO.PRG
*
* SUBROUTINE FOR WEEK REPORTING
*   FOR COSTCODES AND DAYS.
*
SUELDO=SALARY
STORE LEFT(SS,3)+'-'+LEFT(RIGHT(SS,6),2)+'-'+RIGHT(SS,4) TO
SSN
STORE SURNAME TO FAMILY
STORE NAMES TO NOMBRE
*
*
DES = RTRIM(DES)
CODE = RTRIM(CODE)
*
*   SORTING DATABASES FOR REPORTING
*
SELE 2
USE MOMENT
COPY TO VEREMOS FOR WORKER=TRABAJA
SELE 1
USE VEREMOS
*
SET CONSOLE OFF
SET PRINT ON
SET DEVICE TO PRINT
@PROW(),0 SAY 'SS#: ' + SSN + ' .      ' + 'NAME: ' +
RTRIM(FAMILY)
+ ', ' + RTRIM(NOMBRE) + ' .      WEEK ENDING: ' +
UPPER(CDOW(CTOD(DAT3)))
+ ', ' + DAT3
@PROW()+2,0 SAY 'CRAFT CODE: ' + LEFT(TRABAJA,3) + ' .
RATE: '
+ STR(SUELDO,6,3)

TOT11=0
TOT12=0
TOT13=0
TOT14=0
TOT15=0
TOT16=0
TOT17=0
TOT21=0
TOT22=0
TOT23=0
TOT24=0
TOT25=0
TOT26=0
TOT27=0
TOT31=0
TOT32=0

```

```
TOT33=0
TOT34=0
TOT35=0
TOT36=0
TOT37=0
```

```
SELE 1
LOCATE FOR WORKER = TRABAJA
STORE SPACE(7) TO OLDCOST
```

```
@PROW()+3,0 SAY REPLICATE('-',122)
@PROW()+1,0 SAY 'JOB# OR'
@PROW(),12 SAY 'COST'
@PROW(),31 SAY 'THURS'
@PROW(),44 SAY 'FRI'
@PROW(),56 SAY 'SAT'
@PROW(),68 SAY 'SUN'
@PROW(),80 SAY 'MON'
@PROW(),92 SAY 'TUES'
@PROW(),104 SAY 'WED'
@PROW(),112 SAY 'TOTAL HRS'
@PROW()+1,0 SAY 'ACCT. #'
@PROW(),12 SAY 'CODE'
@PROW()+1,0 SAY REPLICATE('-',122)
```

```
DO WHILE .NOT. EOF()
  IF COSTCODE # OLDCOST .AND. COSTCODE # 'M E M O'
    VUELTA = RECNO()
    TEMPCOST = COSTCODE
  *
  *   GOTO CALCULATION AND PRINTING
  *
DO CALCULO

  GOTO VUELTA
  OLDCOST = COSTCODE
  ENDIF
CONTINUE

ENDDO
```

```
TOTALR = TOT11+TOT12+TOT13+TOT14+TOT15+TOT16+TOT17
TOTALO = TOT21+TOT22+TOT23+TOT24+TOT25+TOT26+TOT27
TOTALD = TOT31+TOT32+TOT33+TOT34+TOT35+TOT36+TOT37
REGU = TOTALR*SUELDO
OVERT = TOTALO*SUELDO*1.5
DOUBLET = TOTALD*SUELDO*2
```

```
@PROW()+2,0 SAY REPLICATE('-',122)
@PROW()+1,22 SAY 'RT'
@PROW(),31 SAY STR(TOT11,5,2)
```

```

@PROW(),43 SAY STR(TOT12,5,2)
@PROW(),55 SAY STR(TOT13,5,2)
@PROW(),67 SAY STR(TOT14,5,2)
@PROW(),79 SAY STR(TOT15,5,2)
@PROW(),91 SAY STR(TOT16,5,2)
@PROW(),103 SAY STR(TOT17,5,2)
@PROW(),113 SAY STR(ROUND(TOTALR,2),6,2)

```

```

@PROW()+1,11 SAY 'TOTALS'
@PROW(),22 SAY 'T&1/2'
@PROW(),31 SAY STR(TOT21,5,2)
@PROW(),43 SAY STR(TOT22,5,2)
@PROW(),55 SAY STR(TOT23,5,2)
@PROW(),67 SAY STR(TOT24,5,2)
@PROW(),79 SAY STR(TOT25,5,2)
@PROW(),91 SAY STR(TOT26,5,2)
@PROW(),103 SAY STR(TOT27,5,2)
@PROW(),113 SAY STR(ROUND(TOTALO,2),6,2)

```

```

@PROW()+1,22 SAY 'DT'
@PROW(),31 SAY STR(TOT31,5,2)
@PROW(),43 SAY STR(TOT32,5,2)
@PROW(),55 SAY STR(TOT33,5,2)
@PROW(),67 SAY STR(TOT34,5,2)
@PROW(),79 SAY STR(TOT35,5,2)
@PROW(),91 SAY STR(TOT36,5,2)
@PROW(),103 SAY STR(TOT37,5,2)
@PROW(),113 SAY STR(ROUND(TOTALD,2),6,2)
@PROW()+1,0 SAY REPLICATE('-',122)

```

```

@PROW()+1,0 SAY 'MEMOS:'
@PROW()+1,0 SAY '-----'
LOCATE FOR COSTCODE = 'M E M O'
DO WHILE .NOT. EOF()
STORE RTRIM(MYMEMO)+' ON '+ UPPER(CDOW(INPUTDATE)) + ', ' +
DTOC(INPUTDATE) TO NOTA
@PROW()+1,0 SAY NOTA
CONTINUE
ENDDO

```

```

@PROW(),56 SAY REPLICATE('-',66)
@PROW()+1,64 SAY 'TOTAL HRS'
@PROW(),82 SAY 'RATE'
@PROW(),93 SAY 'GROSS BY RATE'
@PROW(),110 SAY 'TOTAL GROSS'
@PROW()+1,56 SAY REPLICATE('-',66)
@PROW()+1,56 SAY 'RT'
@PROW(),66 SAY STR(TOTALR,5,2)
@PROW(),81 SAY STR(SUELDO,6,3)
@PROW(),96 SAY STR(ROUND(REGU,2),6,2)

```

```
@PROW()+1,56 SAY 'T&1/2'  
@PROW(),66 SAY STR(TOTALO,5,2)  
@PROW(),81 SAY STR(ROUND(SUELDO*1.5,3),6,3)  
@PROW(),96 SAY STR(ROUND(OVERT,2),6,2)  
@PROW(),113 SAY STR(ROUND(REGU+OVERT+DOUBLET,2),6,2)  
@PROW()+1,56 SAY 'DT'  
@PROW(),66 SAY STR(TOTALD,5,2)  
@PROW(),81 SAY STR(ROUND(SUELDO*2,3),6,3)  
@PROW(),96 SAY STR(ROUND(DOUBLET,2),6,2)  
@PROW()+1,56 SAY REPLICATE('-',66)  
@PROW()+6,72 SAY 'APPROVED BY:'
```

```
??CHR(12)  
SELE 5  
RUN DEL VEREMOS.DBF  
SET DEVICE TO SCREEN  
SET PRINT OFF  
SET CONSOLE ON  
RETURN
```

```

***** CALCULO.PRG
*
* SUBROUTINE FOR WEEK REPORTING
*   FOR COSTCODES AND DAYS
*   CALCULATION ROUTINE
*

      SUM REGULAR TO TOTR FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      SUM REGULAR TO JUER FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      .AND. UPPER(CDOW(INPUTDATE))='THURSDAY'
      SUM REGULAR TO VIERR FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      .AND. UPPER(CDOW(INPUTDATE))='FRIDAY'
      SUM REGULAR TO SABR FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      .AND. UPPER(CDOW(INPUTDATE))='SATURDAY'
      SUM REGULAR TO DOMR FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      .AND. UPPER(CDOW(INPUTDATE))='SUNDAY'
      SUM REGULAR TO LUNR FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      .AND. UPPER(CDOW(INPUTDATE))='MONDAY'
      SUM REGULAR TO MARR FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      .AND. UPPER(CDOW(INPUTDATE))='TUESDAY'
      SUM REGULAR TO MIERR FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      .AND. UPPER(CDOW(INPUTDATE))='WEDNESDAY'
TOT11=TOT11+JUER
TOT12=TOT12+VIERR
TOT13=TOT13+SABR
TOT14=TOT14+DOMR
TOT15=TOT15+LUNR
TOT16=TOT16+MARR
TOT17=TOT17+MIERR

      SUM OVERTIME TO TOTOT FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      SUM OVERTIME TO JUEOT FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      .AND. UPPER(CDOW(INPUTDATE))='THURSDAY'
      SUM OVERTIME TO VIEROT FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      .AND. UPPER(CDOW(INPUTDATE))='FRIDAY'
      SUM OVERTIME TO SABOT FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST
      .AND. UPPER(CDOW(INPUTDATE))='SATURDAY'
      SUM OVERTIME TO DOMOT FOR WORKER=TRABAJA .AND.
COSTCODE=TEMP COST

```

```

.AND. UPPER(CDOW(INPUTDATE))='SUNDAY'
      SUM OVERTIME TO LUNOT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
.AND. UPPER(CDOW(INPUTDATE))='MONDAY'
      SUM OVERTIME TO MAROT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
.AND. UPPER(CDOW(INPUTDATE))='TUESDAY'
      SUM OVERTIME TO MIEROT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
.AND. UPPER(CDOW(INPUTDATE))='WEDNESDAY'
TOT21=TOT21+JUEOT
TOT22=TOT22+VIEROT
TOT23=TOT23+SABOT
TOT24=TOT24+DOMOT
TOT25=TOT25+LUNOT
TOT26=TOT26+MAROT
TOT27=TOT27+MIEROT

```

```

      SUM TWOPAY TO TOTDT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
      SUM TWOPAY TO JUEDT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
.AND. UPPER(CDOW(INPUTDATE))='THURSDAY'
      SUM TWOPAY TO VIERDT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
.AND. UPPER(CDOW(INPUTDATE))='FRIDAY'
      SUM TWOPAY TO SABDT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
.AND. UPPER(CDOW(INPUTDATE))='SATURDAY'
      SUM TWOPAY TO DOMDT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
.AND. UPPER(CDOW(INPUTDATE))='SUNDAY'
      SUM TWOPAY TO LUNDT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
.AND. UPPER(CDOW(INPUTDATE))='MONDAY'
      SUM TWOPAY TO MARDT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
.AND. UPPER(CDOW(INPUTDATE))='TUESDAY'
      SUM TWOPAY TO MIERDT FOR WORKER=TRABAJA .AND.
COSTCODE=TEPCOST
.AND. UPPER(CDOW(INPUTDATE))='WEDNESDAY'
TOT31=TOT31+JUEDT
TOT32=TOT32+VIERDT
TOT33=TOT33+SABDT
TOT34=TOT34+DOMDT
TOT35=TOT35+LUNDT
TOT36=TOT36+MARDT
TOT37=TOT37+MIERDT

```

```

DO IMPRIMIR
RETURN

```

```

***** IMPRIMIR.PRG
*
* SUBROUTINE FOR WEEK REPORTING
*   FOR COSTCODES AND DAYS.
*
@PROW()+2,0 SAY CODE
@PROW(),10 SAY TEMPCOST

@PROW(),22 SAY 'RT'
  IF JUER=0
@PROW(),33 SAY '---'
ELSE
@PROW(),31 SAY STR(JUER,5,2)
  ENDIF
  IF VIERR=0
@PROW(),45 SAY '---'
ELSE
@PROW(),43 SAY STR(VIERR,5,2)
  ENDIF
  IF SABR=0
@PROW(),57 SAY '---'
ELSE
@PROW(),55 SAY STR(SABR,5,2)
  ENDIF
  IF DOMR=0
@PROW(),69 SAY '---'
ELSE
@PROW(),67 SAY STR(DOMR,5,2)
  ENDIF
  IF LUNR=0
@PROW(),81 SAY '---'
ELSE
@PROW(),79 SAY STR(LUNR,5,2)
  ENDIF
  IF MARR=0
@PROW(),93 SAY '---'
ELSE
@PROW(),91 SAY STR(MARR,5,2)
  ENDIF
  IF MIERR=0
@PROW(),105 SAY '---'
ELSE
@PROW(),103 SAY STR(MIERR,5,2)
  ENDIF
@PROW(),113 SAY STR(ROUND(TOTR,2),6,2)

@PROW()+1,22 SAY 'T&1/2'
  IF JUEOT=0
@PROW(),33 SAY '---'
ELSE
@PROW(),31 SAY STR(JUEOT,5,2)

```



```

ENDIF
IF VIEROT=0
@PROW(),45 SAY '---'
ELSE
@PROW(),43 SAY STR(VIEROT,5,2)
ENDIF
IF SABOT=0
@PROW(),57 SAY '---'
ELSE
@PROW(),55 SAY STR(SABOT,5,2)
ENDIF
IF DOMOT=0
@PROW(),69 SAY '---'
ELSE
@PROW(),67 SAY STR(DOMOT,5,2)
ENDIF
IF LUNOT=0
@PROW(),81 SAY '---'
ELSE
@PROW(),79 SAY STR(LUNOT,5,2)
ENDIF
IF MAROT=0
@PROW(),93 SAY '---'
ELSE
@PROW(),91 SAY STR(MAROT,5,2)
ENDIF
IF MIEROT=0
@PROW(),105 SAY '---'
ELSE
@PROW(),103 SAY STR(MIEROT,5,2)
ENDIF
@PROW(),113 SAY STR(ROUND(TOTOT,2),6,2)

@PROW()+1,22 SAY 'DT'
IF JUEDT=0
@PROW(),33 SAY '---'
ELSE
@PROW(),31 SAY STR(JUEDT,5,2)
ENDIF
IF VIERDT=0
@PROW(),45 SAY '---'
ELSE
@PROW(),43 SAY STR(VIERDT,5,2)
ENDIF
IF SABDT=0
@PROW(),57 SAY '---'
ELSE
@PROW(),55 SAY STR(SABDT,5,2)
ENDIF
IF DOMDT=0
@PROW(),69 SAY '---'

```

```
ELSE
@PROW(),67 SAY STR(DOMDT,5,2)
ENDIF
IF LUNDT=0
@PROW(),81 SAY '--'
ELSE
@PROW(),79 SAY STR(LUNDT,5,2)
ENDIF
IF MARDT=0
@PROW(),93 SAY '--'
ELSE
@PROW(),91 SAY STR(MARDT,5,2)
ENDIF
IF MIERDT=0
@PROW(),105 SAY '--'
ELSE
@PROW(),103 SAY STR(MIERDT,5,2)
ENDIF
@PROW(),113 SAY STR(ROUND(TOTDT,2),6,2)

RETURN
```

```

***** LINK.PRG
*
*   ROUTINE FOR LINKING
*   INFORMATION TO LOTUS 123
*
*   ARRANGING DATABASES
*
USE LINK
ZAP
USE &FILEPRO
COPY TO TRANSI.DBF FIELDS WORKER, COSTCODE, REGULAR, OVERTIME,
TWOPLAY FOR INPUTDATE>=CTOD(DAT2) .AND.
INPUTDATE<=CTOD(DAT3) .AND. COSTCODE#'M E M O'
USE &FILEDESC
COPY TO LOTQUAN.DBF FIELDS COSTCODE, QUAN FOR
INIDATE>=CTOD(DAT2)
.AND. FINDATE<=CTOD(DAT3)
USE &FILENAME
COPY TO PROJNAME.DBF FIELDS WORKER, SALARY, BENEFITS
SELE 2
USE PROJNAME
SELE 1
USE TRANSI
JOIN WITH PROJNAME TO LOTCOST FOR WORKER = PROJNAME->WORKER
FIELDS COSTCODE, REGULAR, OVERTIME, TWOPLAY, PROJNAME->SALARY,
PROJNAME->BENEFITS
CLOSE ALL
CLEAR
SELE 1
USE LINK
SELE 2
USE LOTCOST
SELE 3
USE LOTQUAN
*
*   APPENDING INFORMATION TO DATABASE FOR LINKING
*
STORE SPACE(7) TO CODIGO
SELE 2
GOTO TOP
*
*   ADDING OF COSTS AND QUANTITIES INFORMATION
*
DO WHILE .NOT. EOF()
  CODIGO = COSTCODE
  SUM
  (SALARY*(REGULAR+OVERTIME*1.5+TWOPLAY*2)+BENEFITS*(REGULAR+OVER
TIME+TWOPLAY)) FOR COSTCODE=CODIGO TO CUMUCOST
  DELETE FOR COSTCODE=CODIGO

```

```

PACK
SELE 3
SUM QUAN FOR COSTCODE=CODIGO TO CUMUQUAN
DELETE FOR COSTCODE=CODIGO
PACK
SELE 1
APPEND BLANK
REPLACE FECHA WITH DAT3
REPLACE COSTCODE WITH CODIGO
REPLACE COST WITH CUMUCOST
REPLACE QUAN WITH CUMUQUAN
SELE 2
GOTO TOP
ENDDO
*
*   ADDING OF REMAINING QUANTITIES
*
CUMUCOST = 0
SELE 3
GOTO TOP
DO WHILE .NOT. EOF()
  CODIGO = COSTCODE
  SUM QUAN FOR COSTCODE=CODIGO TO CUMUQUAN
  DELETE FOR COSTCODE=CODIGO
  PACK
  SELE 1
  APPEND BLANK
  REPLACE FECHA WITH DAT3
  REPLACE COSTCODE WITH CODIGO
  REPLACE COST WITH CUMUCOST
  REPLACE QUAN WITH CUMUQUAN
  SELE 3
  GOTO TOP
ENDDO
*
*   ORIGINAL SETTINGS AND DATABASE TO LOTUS 123
*
SELE 1
SORT ON COSTCODE TO ALMOST
USE ALMOST
COPY TO C:\DBASEIII\GRAPHICS\LINKED TYPE WKS
CLOSE ALL
RUN DEL TRANSI.DBF
RUN DEL LOTQUAN.DBF
RUN DEL PROJNAME.DBF
RUN DEL LOTCOST.DBF
RUN DEL ALMOST.DBF
RETURN TO MASTER

```

APPENDIX F: MACROS FOR LOTUS 123

\0

```

/REM5..R200~:X
{FRAMEOFF}
{PANELOFF CLEAR}
{GOTO}J225~
WAIT...~{D 2}
THE MACRO IS RUNNING.~
{GOTO}G220~
{WINDOWSOFF}
{BLANK F200..G207}
{GOTO}T200~
/RE{D}{END}{R}~
/RET202..W205~
{GOTO}F201~
ENDING WEEK DATE::~
{R}
/RNCWEEK~~
{D}{L}
ROWNO.:~
{R}
/RNCROWNO~~
{D}{L}
CONT. COLUMNS::~
{R}
/RNCCONTCOL~~
{D}{L}
NUMBER OF WEEKS::~
      WAIT...
{R}
/RNCNUM~~
      THE MACRO IS RUNNING.
{D}{L}
CONT. WEEKS::~
{R}
/RNCCONTROW~~
{D}{L}
ADDRESS::~
{R}
/RNCADATE~~
{GOTO}WEEK~
{PANELON}
{GETLABEL "ENTER END OF WEEK (MM/DD/YY):
",WEEK}
{PANELOFF CLEAR}
{GOTO}T3~
{FOR CONTCOL,1,200,1,HOWMUCH}
{LET NUM,CONTCOL-1}
{GOTO}T3~
{FOR CONTROW,1,NUM,1,SEMANA}
{GOTO}T201~
/GRG
TL

```

```

X..{END}{R}~Q
{GOTO}T200~
/G
A..{END}{R}~
OTF\E1~
TSLABOR COST PERFORMANCE~
TXTIME (WEEKS)~
TYSAVING/LOSS ($)~
QVQ
{GOTO}S4~
/RNCCUMUCOST~{R CONTROW}~
{D}
/RNCCUMUQUANT~{R CONTROW}~
{L}{U}
@SUM(CUMUCOST)~
{L}
@SUM(CUMUQUANT)~
/RNDCUMUCOST~
/RNDCUMUQUANT~
/CM4..R4~M5..R199~
{GOTO}M5~
{FOR CONTCOL,1,196,2,ELIMINA}
/CK200.K200~M200.M200~
/CK200.K200~N200.N200~
/CK200.K200~R200.R200~
{GOTO}E1~:X

ELIMINA /RE{R 5}~
{D 2}

HOWMUCH {IF @CELLPOINTER("CONTENTS")=" "}{FORBREAK}
{R}

SEMANA /RNCTEMPD~~
{D}
{FOR ROWNO,1,194,2,SUMANDO}
/RNDTEMPD~
/RNDXAXIS~
{GOTO}S3~
{R CONTROW}
{IF @CELLPOINTER("CONTENTS")=@S(WEEK)}{LET
ADATE,@CELLPOINTER("ADDRESS")}{FORBREAK}
{R}

SUMANDO /RNCTEMP1~~
{D}
/RNCTEMP2~~
{IF TEMP1<>TEMP2}{CALCULUS}
{IF TEMP1=TEMP2}{IF TEMP1<>0}{CALCULUS}
/RNDTEMP1~
/RNDTEMP2~{D}

```

```

CALCULUS {U}
          {L 7+CONTROW}
          {LET V202,@CELLPOINTER("CONTENTS")}
          {L}
          {LET U202,@CELLPOINTER("CONTENTS")}
          {L 3}
          {LET T202,@CELLPOINTER("CONTENTS")}
          {GOTO}S200~
          {R CONTROW}
          /RNCTEMP~~
          {D}
          /RNCXAXIS~~
          {IF TEMP2=0}{LET TEMP,@VALUE(TEMP)-TEMP1}
          {IF TEMP2<>0}{LET TEMP,@VALUE(TEMP)+
          ((V202-TEMP1/TEMP2)*TEMP2)}
          {LET XAXIS,@LEFT(TEMPD,5)}
          {GOTO}TEMP2~
          /RNDTEMP~

\T      {FRAMEOFF}
          {PANELOFF CLEAR}
          {WINDOWSOFF}
          :PLOPCAQQ
          :X
          :GACT220..AO280~
          :AFCW282..AL288~
          :LFW282..AL288~
          :LRX282..X288~
          :LDY282..AL282~
          :LDY285..AL285~
          :LLAA283..AA288~
          :LLAC283..AC288~
          :LLAE283..AE288~
          :LLAG283..AG288~
          :LLAI283..AI288~
          :LLAK283..AK288~
          {GOTO}W282~OVERALL~{D}LABOR~{D}REPORT.~
          {D 2}WEEK~{D}ENDING:~{U 4}
          {R 2}    TOTAL~{D}    ESTIMAT.~{R 2}
          {U} JOB TO D.~{D}    ESTIMAT.~{D}    BCWP~{U 3}{R 2}
          COSTS TABLE (IN DOLLARS)~{D} JOB TO D.~{D}
          ACTUAL~{D}    ACWP~{U 2}
          {R 2}PHYSICAL~{D}% COMPL.~{U}{R 2}VARIANCE~{D 2}
          CV~{U 2}{R 2}
          PERFORM.~{D}    INDEX~{D}    CPI~{U 2}{R 2}
          PROJEC--{D}    TED AT~{D}    FINAL~
          {LET W288,WEEK}
          {LET Y287,@STRING(K200,0)}
          {LET AA287,@STRING(N200,0)}

```



```

{LET AC287,@STRING(R200,0)}
{LET AE287,@STRING(100*R200/K200,1)}
{LET AG287,@STRING(N200-R200,0)}
{LET AI287,@STRING(R200/N200,2)}
{LET AK287,@STRING(K200*R200/N200,0)}
{LET AK288,@STRING(K200-N200+R200,0)}
{GOTO}W292~
NOTE ON PROJECTIONS BY THE END OF PROJECT~
{GOTO}W294~
THE FIRST VALUE ASSUMES THAT THE VARIANCE RATIO
WILL BE THE SAME AT THE END OF THE PROJECT~
{GOTO}W296~
THE SECOND VALUE ASSUMES THAT THE PROJECT WILL
CONTINUE AT PLANNED COSTS~
{GOTO}W300~
LISTS OF PROBLEMATIC AND SATISFYING COST CODES::~
{GOTO}W302~
CRITERIA::~{R 2}
'1.- PERCENT OF SAVINGS/LOSS OVER BUDGET >
20%~{D}
'2.- PERCENT OF COMPLETION < 75%~{D}
'3.- BUDGET > $2500~
:AFBW292..Y304~
:AUSW292..W292~
:AUSW300..W300~
{GOTO}X310~
PROBLEMATIC COST CODES~
{GOTO}AI310~
SATISFYING COST CODES~
:AFCX310..AK320~
{GOTO}X313~
/RNCCODIGO~~
{R 2}
/RNCDESC~~
{R 9}
/RNCCODIGO2~~
{R 2}
/RNCDESC2~~
{FOR CONTCOL,1,196,2,CUENTA}
/RNDCODIGO~
/RNDDESC~
/RNDCODIGO2~
/RNDDESC2~
:X
:PRT220..AO320~PQ
{BRANCH CHOICE2}

CUENTA {GOTO}E3~
{D CONTCOL}
{LET F213,@CELLPOINTER("CONTENTS")}
{R}

```

```

{LET F214,@CELLPOINTER("CONTENTS")}
{R 5}
{LET F211,@CELLPOINTER("CONTENTS")}
{R 2}
{LET F210,@CELLPOINTER("CONTENTS")}
{R 2}
{LET F212,@CELLPOINTER("CONTENTS")}
{IF F210<0#AND#@ABS(F210/F211)>0.2#AND#F212<75
#AND#F211>2500}{CAMBIO}
{IF F210>0#AND#@ABS(F210/F211)>0.2#AND#F212<75
#AND#F211>2500}{CHANGE}

CAMBIO {LET CODIGO,F213}
        {LET DESC,F214}
        {GOTO}CODIGO~
        /RNDCODIGO~
        /RNDDESC~
        {D}
        /RNCCODIGO~~
        {R 2}
        /RNCDESC~~

CHANGE {LET CODIGO2,F213}
        {LET DESC2,F214}
        {GOTO}CODIGO2~
        /RNDCODIGO2~
        /RNDDESC2~
        {D}
        /RNCCODIGO2~~
        {R 2}
        /RNCDESC2~~

CHOICE2 {GETLABEL "DO YOU WANT TO PRINT THIS GRAPHIC
(Y/N)? ", G207}
        {IF G207="Y"}{BRANCH POSI2}
        {IF G207="N"}{BRANCH NEGA2}
        {CHOICE2}

POSI2   :PLOPQGO
        {BRANCH NEGA2}

NEGA2   :GRZ225..Z225~
        :PORQ
        :LEAW282..AN288~
        :ANW282..AO320~
        /REW282..AO320~
        /RNDWEEK~
        /RNDROWNO~
        /RNDCONTCOL~
        /RNDNUM~
        /RNDCONTROW~

```

```

/RNDADATE~
{BLANK J225..J228}
{BLANK F210..F214}
{GOTO}E1~
{BRANCH FOREVER}

```

\A

```

:X
{FRAMEOFF}
{PANELOFF CLEAR}
{GOTO}J225~
WAIT...~{D 2}
THE MACRO IS RUNNING.~
{GOTO}G220~
{WINDOWSOFF}
{BLANK F200..G206}
{GOTO}T200~
/RE{D}{END}{R}~
/RET202..V205~
{GOTO}F200~
COSTCODE:~
{R}
/RNCCOST~~
{D}{L}
ENDING WEEK DATE:~
{R}
/RNCWEEK~~
{D}{L}
ROWNO.:~
{R}
/RNCROWNO~~
{D}{L}
CONT. COLUMNS:~
{R}
/RNCCONTCOL~~
{D}{L}
NUMBER OF WEEKS:~
{R}
/RNCNUM~~
{D}{L}
CONT. WEEKS:~
{R}
/RNCCONTROW~~
{D}{L}
ADDRESS:~
{R}
/RNCADATE~~
{GOTO}COST~
{PANELON}
{GETLABEL "ENTER COSTCODE: ",COST}
{GOTO}WEEK~

```

```

{GETLABEL "ENTER END OF WEEK (MM/DD/YY):",WEEK}
{PANELOFF CLEAR}
{GOTO}E4~
{FOR ROWNO,1,194,2,COSTCODE}
{GOTO}T3~
{FOR CONTCOL,1,200,1,AVAIL}
{GOTO}NUM~
+CONTCOL-1~
{GOTO}H3~
{D ROWNO}
{LET T202,@CELLPOINTER("CONTENTS")}
{R 3}
{LET U202,@CELLPOINTER("CONTENTS")}
{R}
{LET V202,@CELLPOINTER("CONTENTS")}
{GOTO}F3~
{D ROWNO}
{LET T203,@CELLPOINTER("CONTENTS")}
{R}
{LET T204,@CELLPOINTER("CONTENTS")}
{LET T205,COST}
{GOTO}T3~
{FOR CONTROW,1,NUM,1,ENDWEEK}
{GOTO}S3~
{D ROWNO}
/RNCCUMUCOST~{R CONTROW}~
{LET U204,@SUM(CUMUCOST)}
{GOTO}S4~
{D ROWNO}
/RNCCUMUQUAN~{R CONTROW}~
{LET U205,@SUM(CUMUQUAN)}
/RNDCUMUCOST~/RND CUMUQUAN~
{GOTO}T201~
/GRG
TL
X..{END}{R}~Q
{GOTO}T200~
/G
A..{END}{R}~
OTF\T205~
TS\T203~
TXTIME (WEEKS)~
TYSAVING/LOSS ($)~
QQ
{PREDIC}

AVAIL {IF @CELLPOINTER("CONTENTS")=" "}{FORBREAK}
{R}

COSTCODE {IF @CELLPOINTER("CONTENTS")=@S(COST)}{FORBREAK}
{D 2}

```

```

ENDWEEK  /RNCTEMP2~~
          {D ROWNO}
          /RNCTEMP1~~
          {D}
          /RNCTEMP2~~
          {GOTO}S200~
          {R CONTROW}
          /RNCTEMP~~
          {D}
          /RNCXAXIS~~
          {GOTO}S3~
          {R CONTROW}
          {IF TEMP2=0}{LET TEMP,-TEMP1}
          {IF TEMP2<>0}{LET TEMP,(V202-TEMP1/TEMP2)*TEMP2}
          {IF TEMP1=0}{LET TEMP,(V202-TEMP1/TEMP2)*TEMP2}
          {LET XAXIS,@LEFT(TEMPD,5)}
          /RNDTEMP1~
          /RNDTEMP2~
          /RNDTEMP~
          /RNDTEMPD~
          /RNDXAXIS~
          {IF @CELLPOINTER("CONTENTS")=@S(WEEK)}{LET ADATE
          ,@CELLPOINTER("ADDRESS")}{FORBREAK}
          {R}

PREDIC   {GOTO}W282~
          :PLOLCAQQ
          :GACT220..AO280~
          :AFCW282..AN287~
          :LFW282..AN287~
          :LRX282..X287~
          :LRAD282..AD287~
          :LDY283..AN283~
          :LDY285..AN285~
          :LLAA284..AA287~
          :LLAC284..AC287~
          :LLAE284..AE287~
          :LLAG284..AG287~
          :LLAI284..AI287~
          :LLAK284..AK287~
          :LLAM284..AM287~
          {GOTO}W282~LABOR~{D}REPORT.~
          {D 2}WEEK~{D}ENDING:~{U 2}
          {R 2}    TOTAL~{D} ESTIMAT.~{R}{U 3} QUANTITIES
          IN: ~{R}
          {D 2} JOB TO D.~{D}    ACTUAL~{R 2}{U} % COMPL.~
          {R 2}    TOTAL~{R 2} JOB TO D.~{R 2}{U 2}
          COSTS~{D}IN DOLLARS~{D}  JOB TO D.~
          {R 2}    CPI &~{R 2} PROJEC--{D}{L 8}
          ESTIMAT.~{R 2} ESTIMAT.~
          {R 2}  ACTUAL{R 2}VARIANCE~{R 2}TED/FINAL~

```

```

{LET W287,WEEK}
{LET Y287,@STRING(T202,0)}
{LET AE287,@STRING(U202,1)}
{LET AA283,T204}
{LET AA287,@STRING(U205,2)}
{LET AI287,@STRING(U204,2)}
{LET V205,U205/T202}
{IF U205>T202}{LET V205,1}
{LET W205,V205*U202-U204}
{LET AC287,@STRING(V205*100,2)}
{LET AG287,@STRING(V205*U202,2)}
{LET AK286,@STRING(U204/(V205*U202),2)}
{LET AK287,@STRING(W205,2)}
{LET AM287,@STRING(U202-W205,2)}
{LET AM286,@STRING(U202-(W205/V205),2)}
{GOTO}W292~
NOTE ON PROJECTIONS BY THE END OF PROJECT~
{GOTO}W294~
THE FIRST VALUE ASSUMES THAT THE VARIANCE RATIO
WILL BE THE SAME AT THE END OF THE PROJECT~
{GOTO}W296~
THE SECOND VALUE ASSUMES THAT THE PROJECT WILL
CONTINUE AT PLANNED COSTS~
:AFBW292..W296~
:X
:PRT217..AO296~PQ
{BRANCH CHOICE}

CHOICE {GETLABEL "DO YOU WANT TO PRINT THIS GRAPHIC
(Y/N)? ",G207}
{IF G207="Y"}{BRANCH POSI}
{IF G207="N"}{BRANCH NEGA}
{CHOICE}

POSI :PLOPQGQ
{BRANCH NEGA}

NEGA :GRZ225..Z225~
:PORQ
:LEAW282..AN287~
:ANW282..AN296~
/REW282..AN296~
/RNDCOST~
/RNDWEEK~
/RNDROWNO~
/RNDCONTCOL~
/RNDNUM~
/RNDCONTROW~
/RNDADATE~
{BLANK J225..J228}
{GOTO}E1~

```

```

{BRANCH FOREVER}

\0      {BRANCH FOREVER}

FOREVER {FRAMEON}
        {PANELON}
        {WINDOWSON}
        {MENUCALL ATS}
        {BRANCH FOREVER}

ATS     Append   Insert   Overall  Table   Cost_code
        Edit
        Append weInsert apCalculateCalculatCalculation
        for indiEdit spreadsheet
        {BRANCH A{BRANCH I{BRANCH \{BRANCH {BRANCH \A}
        {GOTO}E1~

INSERT  {FRAMEOFF}
        {PANELOFF CLEAR}
        {WINDOWSOFF}
        :X
        {BLANK F200..G207}
        {GOTO}F201~
        ENDING WEEK DATE::~
        {R}
        /RNCWEEK~~
        {D}{L}
        ROWNO.::~
        {R}
        /RNCROWNO~~
        {D}{L}
        CONT. COLUMNS::~
        {R}
        /RNCCONTCOL~~
        {D}{L}
        NUMBER OF WEEKS::~
        {R}
        /RNCNUM~~
        {D}{L}
        CONT. WEEKS::~
        {R}
        /RNCCONTROW~~
        {D}{L}
        ADDRESS::~
        {R}
        /RNCADATE~~
        {GOTO}A2~
        {LET WEEK,@CELLPOINTER("CONTENTS")}
        {FOR CONTROW,1,200,1,CHEQUEO}

```

```

(GOTO)T3~
(FOR CONTCOL,1,200,1,DERECHA)

CHEQUEO  (IF @CELLPOINTER("CONTENTS")=" "){LET ROWNO,
CONTROW-1}{FORBREAK}
(D)

DERECHA  (IF @CELLPOINTER("CONTENTS")=" "){LET NUM,
CONTCOL}{BRANCH PROCE}
(IF @CELLPOINTER("CONTENTS")=@S(WEEK)){LET NUM,
CONTCOL}{BRANCH SAME}
(R)

SAME     (BEEP 4){BEEP 2}{BEEP 3}{BEEP 4}{BEEP 4}{BEEP 4}
(GETLABEL "Information for this ending week
already exists. Overwrite (Y/N)? ",G207)
(IF G207="Y"){BRANCH PROCE}
(IF G207="N"){BRANCH FINAL}

PROCE    (GOTO)S3~
(R NUM)
/RNCNUEVO~~
(LET NUEVO,WEEK)
/RLC~
(D)
/RE(D 196)~
/RF,2-(D 194)~
/RNDNUEVO~
(FOR CONTROW,1,ROWNO,1,VAMOS)
(FINAL)

VAMOS    (GOTO)B1~
(D CONTROW)
/RNCCOSTNEW~~
(R)
/RNCCOSTO~~
(R)
/RNCQUAN~~
(GOTO)E4~
(FOR CONTCOL,1,194,2,PONER)
/RNDCOSTNEW~
/RNDCOSTO~
/RNDQUAN~

PONER    (IF @CELLPOINTER("CONTENTS")=@S(COSTNEW))
(LOCAL){FORBREAK}
(D 2)

LOCAL    (GOTO)S3~
(R NUM)
(D CONTCOL)

```



```

/RNCTEMP1~~
(D)
/RNCTEMP2~~
{LET TEMP1,COSTO}
{LET TEMP2,QUAN}
/RNDTEMP1~
/RNDTEMP2~

```

```

FINAL      {HOME}
           /RE{END}{D}{R 3}~
           /RNDWEEK~
           /RNDROWNO~
           /RNDCONTCOL~
           /RNDNUM~
           /RNDCONTROW~
           /RNDADATE~
           {GOTO}E1~
           :X
           {BRANCH FOREVER}

```

```

APPEND     {HOME}
           /FCCE{ESC}{ESC}C:\DBASEIII\GRAPHICS\LINKED.WKS~
           {GOTO}C2~
           /RF,2~{END}{D}{R}~
           {BRANCH FOREVER}

```