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# Preventive Maintenance Automated Cost-Effectiveness Review (PACER) Program Users Manual: Prototype Version

by
James H. Johnson

The PACER Program is an automated system that provides Army installation maintenance managers with preventive maintenance (PM) cost-effectiveness comparisons, a prioritized roster of PM tasks, and an upward reporting service for maintenance cost data. PACER is an acronym for PM Automated Cost-Effectiveness Review.

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PACER provides automated cost estimation/computation and PM data collection for key PM managerial and reporting functions. PACER can also help evaluate maintenance cost records and provide projections on useful life and replacement times based on estimated and empirically derived inputs.

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CONTENTS


| | | Page |
|---|---|---|
| | SF298 | 1 |
| | FOREWORD | 2 |
| | LIST OF FIGURES AND TABLES | 4 |
| 1 | INTRODUCTION | 7 |
| | 1.1 Computer Hardware and Operations Software Requirements | |
| | 1.2 PACER Services and Products | |
| | 1.3 Needed User Support | |
| | 1.4 Mode of Technology Transfer | |
| 2 | INSTALLATION AND STARTUP | 10 |
| | 2.1 PACER Program Installation and Adjustments | |
| | 2.2 Installing the Prototype PACER Database | |
| | 2.3 Getting Started | |
| 3 | BASIC PERFORMANCE OPERATIONS | 17 |
| | 3.1 Functional Features | |
| | 3.2 Operating Methods | |
| 4 | PACER PROGRAM PERFORMANCE AREAS | 22 |
| | 4.1 Ordered PM Task Listings | |
| | 4.2 Maintenance Costing of PM for F/E Assets | |
| | 4.3 F/E Replacement Studies | |
| | 4.4 F/E Recordkeeping | |
| 5 | APPLICATIONS FOR THE PRACTICED USER | 27 |
| | 5.1 Improving PM Management Effectiveness | |
| | 5.2 The Cost Effectiveness of PM Activities | |
| | 5.3 Methodology Development | |
| | 5.4 Benefits to RPMA Management | |
| 6 | PACER SOFTWARE FUNCTIONAL FEATURES | 42 |
| | 6.1 Edit PACER Source Data | |
| | 6.2 Perform PACER Operations Functions | |
| | 6.3 Reports Generation | |
| | 6.4 Perform Password Utilities | |
| | 6.5 Quit System to DOS | |
| | APPENDIX A: dBASE LOADING PROCEDURES FOR THE PROTOTYPE PACER DATABASE | 46 |
| | APPENDIX B: DEVELOPMENTAL LISTINGS FOR GENERATING TABLE 4 | 50 |
| | APPENDIX C: MANUAL COMPUTATION FOR A DETAILED PM COST-EFFECTIVENESS STUDY | 53 |

## FIGURES


| Number | | Page |
|---|---|---|
| 1 | The Title Screen for the Prototype PACER Program | 14 |
| 2 | The Main Menu of the Prototype PACER | 15 |
| 3 | Examples of Working Messages When Generating Facility/Equipment Listings | 23 |
| 4 | Example of Special Study Entries for Specific PM Task Numbers | 23 |
| 5 | Selection Screens for Bringing Classes of Assets into PM Cost Effectiveness Studies | 24 |
| 6 | Example of PM Study Parameter Selection Screen | 25 |
| 7 | Key Equipment Information as Stored in the PACER Database (UNITS.DBF) | 26 |
| 8 | Meaning of the Numbering Progression in the CACES Coding System | 26 |
| 9 | Input Screen for System Labels | 26 |
| 10 | Identifying Optimum Levels of Maintenance Performance | 28 |
| 11 | Graph Showing Regions of PM Cost Justification | 30 |
| 12 | General Relationship of Maintenance Cost vs MTBF for a 10-Year Study | 31 |
| 13 | Example of Correlating Data Points That Represent Failure Rates for a Specific Type of Equipment Under Varying PM Levels | 32 |
| 14 | Graphical Boundaries Reflecting the Range of User Uncertainty in Estimating the MTBF and LOS Parameters | 34 |
| 15 | Development Sequence of PM Listings in the Value Assessment Method | 36 |
| 16 | Graphical Representation of Rising Maintenance Cost as an Equipment Replacement Argument | 40 |
| 17 | The Utilities Menu of the PACER Program | 43 |
| 18 | A Reports Menu as Planned for PACER | 43 |
| 19 | Password Utilities Menu | 44 |
| 20 | User Access List Control Menu | 45 |

## TABLES


| | | |
|---|---|---|
| 1 | Standard Keys Used to Move Between Menus | 20 |
| 2 | Sequential Keys Used for Data Entry (Utilities Menu) | 20 |
| 3 | Keys Used for Data Editing (All Entry Screens) | 21 |
| 4 | Preferred PM Task List for an Example PM Shop | 38 |
| B1 | Interim General PM Task Preference List | 50 |
| B2 | Interim Assessments of PM Activities | 52 |

PREVENTIVE MAINTENANCE AUTOMATED COST-EFFECTIVENESS REVIEW (PACER) PROGRAM USERS MANUAL: PROTOTYPE VERSION

# 1 INTRODUCTION

The PACER Program is an automated system that provides preventive maintenance (PM) cost-effectiveness comparisons, a prioritized roster of PM tasks, and an upward reporting service for maintenance cost data. It was proposed by earlier research.[1] PACER is an acronym for PM Automated Cost-Effectiveness Review.

PACER is designed to assist Army installation maintenance managers by automating PM cost assessments and analytical reports, the planned application being Army hospitals. PACER can be used either in an interface mode with principal maintenance management software or in a stand-alone environment. It was developed to be compatible with the commercially available MAXIMO Maintenance Management Program (by PSDI), as installed at the Madigan Army Medical Center, Fort Lewis, WA. PACER requires minimal training since it provides ample guidance with a series of menus and prompts.

## 1.1 Computer Hardware and Operations Software Requirements

The PACER Program requires the following:

IBM-AT compatible (80286) computer
20-megabyte hard drive
Color or monochrome monitor
512-kilobyte random access memory (assuming no memory resident programs beyond DOS)
IBM or Epson-compatible printer
MS-DOS or PC-DOS (Version 3.3 or higher)

The PACER Program is written in dBase III+, and the prototype release is in an uncompiled version. (Both the dBase III+ or dBase IV and the PACER diskettes must be installed on your PC to run a PACER Program.) The PACER Program should be installed on a PC as described in Chapter 2.

## 1.2 PACER Services and Products

The PACER Program can:

a. Assist the user in off-line practice or developmental sessions including PM cost estimation/ computation procedures, and PM data collection guidance.

[1] J.H. Johnson, *The Value Assessment for Evaluating Preventive Maintenance Activities*, Technical Report P-91/35/ADA-240109 (U.S. Army Construction Engineering Research Laboratory [USACERL], August 1991).

b. Automate key PM managerial and reporting functions, including:

(1) Development of a formal PM Job Roster (or Catalogue) that is prioritized to reflect Army regulations and estimated cost benefits.

(2) Generation of shop listings of facility and equipment systems ordered according to the computed or estimated cost-effectiveness of the PM activities applied to these assets.

(3) Analysis of PM costs as applied to specific assets (equipment units); estimations of the cost benefit of the shop PM (over operations or no PM) to the installation.

(4) Performance of system summations that allow total PM program cost assessments.

c. Provide facility component or equipment system/unit diagnostics from maintenance cost records. These diagnostics may include:

(1) Projections of optimal replacement times for specific equipment types, based on historical (statistical) records of the rise in maintenance costs with time.

(2) Warning flags when specific equipment units exceed normal projections for that type of unit.

(3) Guidance in determining the cost-justification for replacing the unit.

d. Generate directed studies and special reports for the above.

### 1.3 Needed User Support

The PACER Program is an automated evaluation system for a user involved in maintenance management problems. This program "learns" with the user. Thus, the user should build the quality of PACER by taking the time to interpret the outputs and improve the inputs. The system's usefulness depends on the user's ability and willingness to make reasonable estimates of the parameters that determine PM effectiveness.

The PACER approach is to add new data, improve existing data, and estimate a range of values for unknown data. The first goal of PACER is to determine relative cost-benefit rankings of PM tasks; additional goals are maintenance of equipment histories, identification of inspector/craftsman experience, and expansion of a data collection program to provide the base for more quantitative evaluations. PACER provides the automatic data processing (ADP) incentive and means to upgrade the database as the user gains experience and local PM operations data are collected.

The PACER goal is to provide useful PM information from both approximate (estimated) and empirically derived inputs. Although it is anticipated that PM task information will not be sufficient to develop quantitative cost benefit evaluations in the near-term, it is maintained that estimates, consistently developed, provide relative PM-return information that is needed in good maintenance management.

## 1.4 Mode of Technology Transfer

Questions and comments on the prototype PACER can be referred to the U.S. Army Construction Engineering Research Laboratory (USACERL), Facility System Division, Real Property Maintenance Activity Team at 800-USA-CERL, extension 711.

# 2 INSTALLATION AND STARTUP

If you are installing the PACER Program for the first time, please carefully read and follow the instructions given in this chapter. If your familiarity with personal computers (PCs) is minimal and you do not understand something in this chapter, an inquiry to your local computer support organization may help.

## 2.1 PACER Program Installation and Adjustments

### 2.1.1 Installing System Files on the PC Hard Disk

a. To install the uncompiled prototype PACER Program.

(1) Create a directory called PACER on your hard disk, and make this the default directory for running the program. Choose the particular drive that is convenient for you (here taken as the C: drive). Create the PACER Directory as follows:

From the C:\> prompt, make a PACER directory by typing MD PACER and pressing the Enter key.

Type CD\PACER to change to the PACER directory.

Then press the Enter key; the screen will show:

C:\PACER>

(2) Place the supplied PACER diskette No. 1 in the A: drive of the PC.

From the C:\PACER> prompt, type COPY A:*.* and press the Enter key.

Various monitor responses will appear, ending with:

All Files Copied.

(3) Repeat Step (2) until all PACER Program diskettes are loaded.

(4) After all the diskettes have been loaded, place them in a protected area for safekeeping and possible backup.

b. To verify that recommended operations values are correctly set on the PC.

Access the AUTOEXEC file and set the value for FILES = 30 or more, and the value for BUFFERS = 20 or more.

**Note:** If dBase III+ or dBase IV are already on the machine, adjust the DOS path to permit support to the PACER Program. If this software is not on the PC, but the PC is licensed to use this commercial package, load according to the dBase users manual.

## 2.2 Installing the Prototype PACER Database

The operations database must be developed from installation inventory and maintenance records. During normal operations, facility or equipment (F/E) assets will be identified and unit maintenance information will be entered or modified by keyboard entries while in the PACER Program.

Only single systems/units may be conveniently loaded into the database while the PACER Program is executing. To load more extensive data collections, properly formatted data files may be "imported" by dBase with the PACER Program off. Whenever a large quantity of data is to be entered, the import/dBase data loading mode should be used. Completely read this section and Appendix A before attempting the procedures provided.

### 2.2.1. Preparation of the Data Import Files

Two PACER data files are to be loaded: an operations systems level file (SYSTEMS.DBF) and an F/E unit level file (UNITS.DBF). Note that once these files are loaded, they remain as a source in the database and need never be entered again. Updates, corrections, and additions can be done directly in the executing program. Batch loading of source data for the uncompiled prototype PACER Program uses the dBase data import method as discussed in the following paragraphs.

a. Formatting an import file for the PACER operations SYSTEMS category (file).

Loading PACER under the SYSTEMS category currently requires three fields for each facility component or equipment unit. This information is retrieved from the SYSTEMS file through the "Systems Label" entry which is called from the Add, Change, Delete Source Data entry of the Utilities Menu. For the first field, the CACES number is registered by the first 4 alphanumeric characters; representing the F/E Category (first 2 characters), Class (3rd character), and the type of System (4th character).

Requirements for formatting listed fields for import to PACER are as follows:

(1) The batch file cannot contain blank records (lines), and must be in flat ASCII format.

(2) All fields, except dollar values, must start and finish with percent signs (%); fields must be separated by a comma.

(3) A record (line) must consist of three fields in a prescribed order and field length as follows:

| **Entry Description** | **Necessary Format** |
|---|---|
| CACES Activity Code Number: | %<4 alphanumeric characters>%, |
| Description of System: | %<up to 34 alphanumeric characters>%, |
| Building Identification Code: | %<11 alphanumeric characters (no dashes)>%, |

**Example SYSTEMS Record** (Line of Data):

%0811%,%FIXTURES, SANITARY SYSTEMS,PLUMBING %,%BldgNo.9092%,

**WARNING:** In the previous example, if the system description field contains a percent sign (%) all subsequent data in the input file will be misread, and the data will have to be reloaded.

b. Formatting a PACER import file for the equipment UNITS file.

(1) This batch file cannot contain blank records (lines), and must be in flat ASCII format.

(2) All fields, except dollar values, must start and finish with percent signs (%); fields must be separated by a comma.

(3) A record (line) must consist of seven fields in a prescribed order and field length as follows:

| **Entry Description** | **Necessary Format** |
|---|---|
| F/E Class Code (CACES#): | %<6 alphanumeric characters>%, |
| Component/Unit #: | %<2 alphanumeric characters>%, |
| Location of Asset: | %<11 alphanumeric characters>%, |
| Description of Asset: | %<30 alphanumeric characters>%, |
| Cost of Asset:<br>(exclude % signs for this field) | <7 numbers>, |
| Installation Date: | %<mm/dd/yy>%, |
| Skill or Shop ID: | %<4 letters>%, |

**Example UNITS Record:**

%081110%,%01%,%LOCATION-ID%,%TANKLESS WATER CLOSET,
SAN.SYS%,0000580,%12/12/90%,%PLUM%,

2.2.2 Batch Loading Procedure (uncompiled prototype PACER version)

Standard dBase procedures are used to load systems or F/E units data into the Prototype PACER Program as provided in Appendix A. Two approaches are appropriate for a batch data loading mode. The first is applicable when all data are largely ready for incorporation into the database (total loading); the second is for an incremental loading process as the needed operations PACER data are developed. PACER outputs, as with any software, depend on a properly constructed database; follow the instructions in Appendix A carefully.

## 2.3 Getting Started

Having installed the PACER Program and loaded the basic data, you are now ready to begin your first session on the system. This section will discuss how to start and quit the system, how to start the program, move between the menus, issue passwords, enter information to build up the database files, and derive the fullest use of the prototype PACER Program.

### 2.3.1 Starting the PACER Program

To enter the PACER Program while in the PACER subdirectory, type dBASE (space) MAINMENU or PACER (upper or lower case) at the DOS prompt.

a. From the C:\> prompt:

(1) Type: CD\PACER

(2) Press the Enter key and again type PACER for:

C:\PACER\>PACER

(3) Now press the Enter key to start the program.

(4) The PACER title screen appears as shown in Figure 1.

### 2.3.2 Passwords and Security

A valid password must be entered to access the PACER Program. For the newly installed system, you can enter the PACER Program by typing TEMP and pressing the Enter (Return) key. Chapter 6 discusses how to assign passwords to limit access and protect the database. Once a password has been established, the system allows three attempts at entering the password before it returns to DOS. If you find yourself returned to the DOS prompt, start over by typing PACER again.

a. For the present, proceed as follows:

(1) Type: TEMP

(2) Press the Enter key to access the PACER Program. (The MAIN MENU will then appear.)

### 2.3.3 Menu Structure of PACER

The menu/screen relationships of the PACER Program have a predictable flow. The Main Menu and subordinate menus and screens of the PACER Program allow a continuity as follows:

a. The Main Menu.

The Main Menu, shown in Figure 2, accesses all program performance areas.

The MAIN MENU allows selection of the PACER activity:

(1) The first entry calls the part of the program that creates PM task/asset rankings and generates PM task listings of use to maintenance management evaluation studies and planning.

(2) The next entry permits a cost benefit estimate for each PM task on the basis of a facility component or equipment unit.

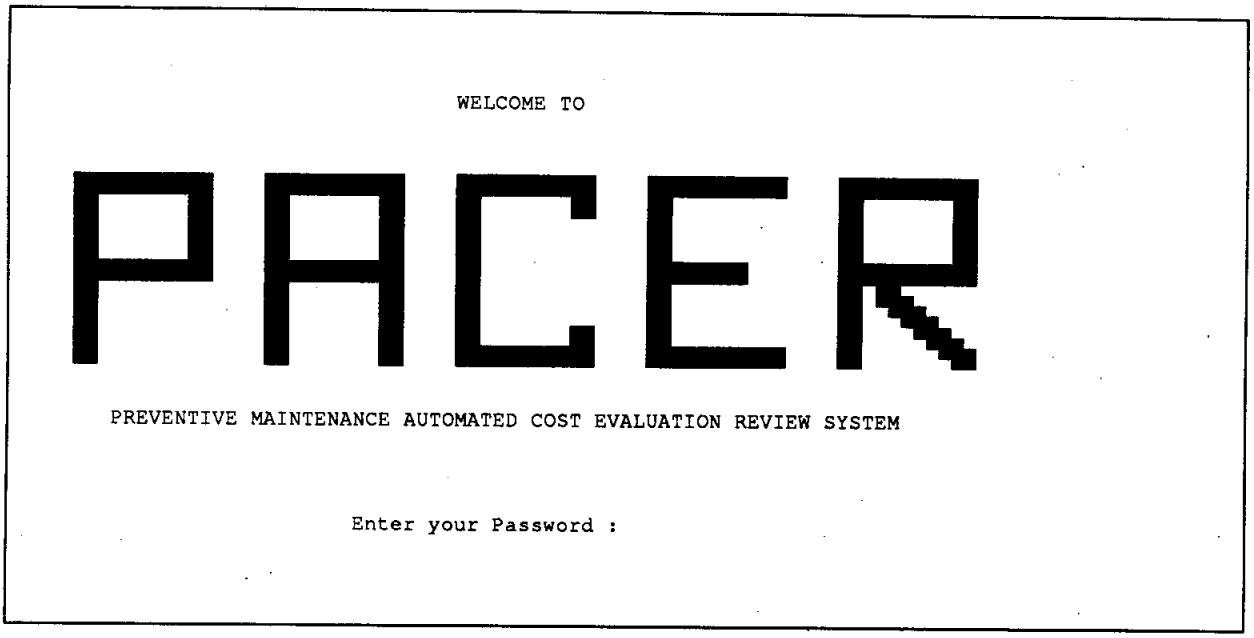



**Figure 1. The Title Screen for the Prototype PACER Program.**

(3) The third entry allows an economic assessment of unit maintenance cost as an indicator for possible replacement.

(4) The fourth entry allows database entry and software management review, addition, and updating.

(5) Striking the ESCape key or selecting the fifth (last) entry causes an immediate exit.

b. Submenus and data input screens.

The content of the submenus or data input screens called from the Main Menu is as follows:

| Submenu Content | Purpose |
|---|---|
| (1) **Ordered PM Task and Equipment Listings** | Menu for PM task ranking/listing functions. |
| Preferred PM Task Listing | PM Roster developments. |
| Pref PM Task/Category List | Shop (skill) ordered listings. |
| General PM List | All PM supportable equipment in the database. |
| Return to Main Menu | As stated. |
| (2) **PM Cost-Effectiveness Studies** | For determining cost/trend assessment functions. |
| Create New PM Study | Facility/equipment cost evaluation computations and summations. (Study may be saved in a file or discarded.) |
| Review/Mod Existing Study | For upgrading previously recorded cost benefit (CB) study files. |

```
05/07/91                          PACER                          F1 for HELP
                                Main Menu

                    ▸ Ordered PM Task & Equipment Listings
                      PM Cost-Effectiveness Studies
                      Maintenance Costing and Equipment Replacement
                      Data Entry and Utilities
                      Exit PACER

=========<MESSAGES>=========================================================
    Use <UPARROW> or <DOWNARROW> and press <ENTER> or press <ESC> to exit
```

**Figure 2. The Main Menu of the Prototype PACER.**

| | |
|---|---|
| Assisted PM Studies | User-guided CB computations for estimating the cost effectiveness of portions of or the total PM program. |
| Return to Main Menu | As stated. |
| **(3) Maintenance Costing and Equipment Replacement** | Cost constraints of facility/equipment maintenance support. |
| **(4) Data Entry and Utilities** | Menu for management of PACER database and operations software. |
| **Add, Change, Delete Source Data** | Calls screen menu for reviewing/editing the inventory of assets that receive PM support. |
| • Equipment | Equipment category and unit identifications. |
| • Facilities | Facility location designators. |
| • CACES Codes | Maintenance job indexing system. |
| • System Labels | Essentiality levels (labels) for classes of facilities or equipment. |
| **Backup PACER data** | Standard or PC DOS backup procedures using 5-1/4" floppy disk. |
| **Print Reference Listings** | Print command for PACER Program. |
| **Restore PACER Data** | Restoration of data from backup disks. |

| | |
|---|---|
| **Password Utilities**<br>• PW Changes<br>• PW Monitoring | Password changes and summary listings. |
| **Rebuild Data Files** | For restarting after a PC hard disk crash; also used for integrating batch data into the database. |
| **(5) Exit PACER** | Return to Main Menu. |

Chapter 4 describes the operations information needed to perform under each of the Main Menu selections. The sections of Chapter 4 are in the same order as the entries of the Main Menu. Throughout the PACER Program, "message" lines on the bottom of the screen prompt the correct next step.

# 3 BASIC PERFORMANCE OPERATIONS

PACER Program operating features are briefly reviewed in this chapter to introduce the functions and operating methods that will be encountered.

## 3.1 Functional Features

The data that must be provided to PACER, and the services and reports you may expect from PACER are summarized below.

### 3.1.1 Data Processed by the PACER Program

The PACER database is built from facility component and equipment unit information collected from maintenance shop and management sources. In addition, the database contains management/PACER-generated estimates needed for listing and cost-effectiveness reporting.

a. Keyboard entry of PACER data.

Manual data entry is permitted by designated users as follows:

(1) Gradings of F/E Systems or Units.

(a) PM Identifiers and Labels - The level of regulatory necessity that must be imposed before economic value of the PM task is considered.

- MUST: Required by statute (EPA/OSHA/etc.).
- REQUIRED: When unit operation affects mission performance.
- NEEDED: Unit operation affects efficient system performance.

(b) PM Cost Data - Total allocated PM costs for the specific system or unit on a dollar/month basis.

(c) Ordered listings (prioritization) of PM tasks according to the cost benefit (nonperformance penalty less PM task cost) of each task.

(2) Vital Statistics (Historical Records) for all F/E Assets.

(a) Original unit acquisition and installation costs.
(b) Maintenance and repair (M&R) dates and cost records.
(c) Equipment nameplate data.

b. PACER-derived entries in the database.

Computation and estimation assistance is provided to facilitate performing PM economic studies. Special guidance is provided in the areas of:

(1) Unit cost benefit estimations - defined as the cost savings in performing shop PM for a given unit over paying the penalty of not performing this service for this unit.

(2) F/E list PM cost-effectiveness values - the sum of all cost benefits for a specified list of facility components or equipment units is defined as the cost-effectiveness for that list.

(3) Generation/modification of PM task cost-effectiveness study files.

3.1.2 Reports Generated by the PACER Program

a. PM activity listings for:

(1) DEH (the Directorate of Engineering and Housing) Managers (Preferred PM Task Roster) - a cost benefit prioritized list of tasks performed under different regulatory labels as part of the PM Program.

(2) Shop Foreman Review (PM Category/Task List) - a prioritized PM list grouped according to shop or skill category.

(3) Operations & Maintenance (O&M) Technical Review (General PM List) - a PM supported list of equipment assets as recorded in the database.

b. Cost effectiveness studies.

The value of PM activities may be evaluated for individual assets, groups of assets, or the entire asset inventory according to the requirements of the study being performed. PACER guided studies include:

(1) System/Unit studies.

(2) F/E Class studies.

(3) PM Program studies.

c. Maintenance costing and equipment replacement sudies.

PACER can generate a report that provides economic arguments for replacing aging equipment and machinery.

3.1.3 Support to Advanced or Major Management Studies

DEH and Army Medical Center maintenance managers may request PACER to generate:

a. PM task justification reports: PACER will provide cost benefit arguments for retaining a particular PM task or a class of task, a performance history for the task/unit, a PM task labeling service, and a cost-effectiveness computation.

b. PM program/category justification reports: To provide a justification report for the entire PM program or a PM category, PACER will sum the cost benefits to determine relative cost-effectiveness levels for all PM categories (from each PM task making up the category), and these category sums can be summed for the total PM Program.

## 3.2 Operating Methods

### 3.2.1 Selection and Movement Controls

a. Menu review and making a selection. The PACER Program uses menu and data entry screens to allow you to move between different parts of the system. When a menu appears, the first option will be highlighted. To select an option other than the one highlighted, use the up or down arrow keys to highlight the desired option. Press Enter to access the highlighted option.

b. Keyboard control methods. All operations are accessed from the Main Menu (Figure 2). For example, (1) if you want assistance in developing a PM Task Roster, adjust the select arrow to highlight the first Main Menu entry, Ordered PM Task Listings, and then press Enter. (2) If you want to edit nontemporary facility/equipment attributes in the database, you could:

(a) Press the down arrow three times to highlight the Data Entry and Utilities option.

(b) Press Enter to select the highlighted option, causing an add/edit submenu to appear.

(c) Press the down arrow to highlight the type of data entry desired, and then press Enter. After each selection from the Main Menu, the screen clears and a submenu appears. It is from the submenus that PACER Program activities are selected for productive work. Table 1 lists the keys used to move inside and between menus.

### 3.2.2 Screens for Data Entry and Editing

The PACER Program uses data screens for entering or revising data. The current field is always highlighted. While entering data, the ESC key aborts the operation and discards all data entered or revised. The Enter or Carriage Return (CR) key enters the data shown on the screen, and, after the last entry, saves the screen data information entered or revised and performs the requested operation. When entering maintenance records/parameters, the Data Entry and Utilities (more simply, the Utilities Menu) should be used.

First on the Utilities Menu is the Add, Change, Delete Source Data entry. This selection provides an edit option for facilities and equipment classes. After selecting the category of systems to be controlled, sequential data can be displayed on the screen and controlled with the function keys as listed in Table 2.

Within the highlighted data fields on the facility/equipment screen displays, data can be modified by using the keys as listed in Table 3.

**Table 1**

**Standard Keys Used to Move Between Menus**

| Key | Function |
|---|---|
| Esc | Return to Previous Menu; or quit program (if at Main Menu). |
| Up Arrow | Move menu highlighter up |
| Down Arrow | Move menu highlighter down |
| Enter | Make menu selection |

**Table 2**

**Sequential Keys Used for Data Entry (Utilities Menu)**

| Key | Function |
|---|---|
| ESCape | Exits from data entry mode, and returns operation to the first entry of the Utilities Menu. |
| Letter A | Creates a new asset screen or pulls up an existing asset screen for the CACES number entered. |
| Enter (A) | After the first field entry, press Enter; this displays the unit ID and equipment number on the screen and highlights the next field. After all fields are entered (or skipped), press Enter to exit the screen. The screen is held in memory until the ESCape key is entered. |
| ESC | ESCape key is used to save all screens after the last field has been entered, returning the operator to the Utilities Menu. |
| Letter C | Allows changes to facility data for a highlighted field on the date entry screen. |
| ENTER(C) | The Enter key stores data from a highlighted field and then moves to the next field. After the last entry, the Enter key moves out of the data entry mode. |
| ESCape | Saves all revised (and added) data screens. |
| Letter D | Calls up Deletion Mode; a repeated D deletes the entire unit data entry shown on the screen. |

Table 3

Keys Used for Data Editing (All Entry Screens)

| Key | Function |
|---|---|
| **Backspace** | Erases the character to the left of the cursor and moves the cursor left one space. |
| **INS** | Inserts characters in data. Press the **Ins** key once to turn on the insert mode, press the **Ins** key again to turn off the insert mode. |
| **Del** | Deletes the cursor designated character. |
| **ENTER/Arrow** | Moves to the next data entry field. |
| **Home** | Moves to first space in data entry field. |
| **End** | Moves to end of data entry field. |
| **ESC** | Aborts screen add/change operation if pressed before entering the last field on the screen; always calls back the screen containing an aborted data field to verify content. |
| **ENTER** | Completes data field change operation, saves data. |
| **Space Bar** | If cursor has moved past last data field, press the Space Bar to move the display to the next facility or equipment date screen. |

# 4 PACER PROGRAM PERFORMANCE AREAS

PACER outputs (ordered listings or PM cost-effectiveness studies) may be generated through the menus mentioned in Chapter 3; the outputs are reviewed below.

## 4.1 Ordered PM Task Listings

When the Ordered PM Task Listings entry is selected from the Main Menu, another menu appears showing three types of PM task listings.

a. A Preferred PM Task List.

PM tasks are ordered by F/E Class Label (from the database) and then by computed cost benefits as assigned to each item or asset listed. An absolute priority ladder can be provided by the Preferred PM Task List for every PM task performed at the installation. PACER generates the Preferred PM Task List by extracting all of the assignable PM tasks from the database, computing a cost benefit for each unit selected, and reordering these tasks according to their labeling and decreasing cost benefit values.

b. A Preferred PM Category and Task List.

This list is ordered by Shop/Category (by ascending CACES number), then by F/E Class Label, and by cost benefit assignments. The Preferred PM Category and Task List is the same as a General PM List except that the PM tasks are grouped under a parent (or shop) category in order of their PM Task List sequence number (i.e., descending cost benefit values). The PM Category and Task List may be considered a version of the General PM List modified for maintenance managers to use for PM shop planning.

c. A General PM Task List.

This list is ordered by O&M Category, System Category, System Class, and Equipment Type. The General PM Task List potentially includes all PM Category systems/units in the database, and by implication, all of their associated PM tasks. Essentially, for each PM Category entry in the database, the associated systems/equipment supported under that category are identified and listed in the order of ascending CACES unit numbers.

Selecting one of these three entries will result in the question "*Do you know the specific CACES numbers for the assets to be included in the proposed list?*" A YES response results in individual entries by the user, which are verified from the database by PACER. A NO response results in a review of the possible categories of assets for each installation class. The selection of the category results in a list of ALL assets contained in the database for that class and category.

Once generation of the listing is initiated, an appropriate processing message from the examples in Figure 3 is provided.

## 4.2 Maintenance Costing of PM for F/E Assets

If the PM Cost-Effectiveness Studies entry is selected from the Main Menu, a submenu appears that permits the generation or review of stored files containing asset (equipment unit) cost benefit studies. Since the computations/estimates made by PACER usually require explanation, guidance in preparing these

```
----> MESSAGES <-------------------------------------------------------

Building Work Files . . .                    nn
Checking System Labels . . .
Checking Cost-Benefit Calculations . . .
Determining PM Priority Labels . . .
Printing the PM Equipment List . . .


Do you want this listing sent to the Printer, the Screen or Both ? ___
```

**Figure 3. Examples of Working Messages When Generating Facility/Equipment Listings.**

(Note: the **nn** on this screen represents the CACES ID# for the category of assets.)

studies is provided by selecting Assisted PM Studies from the PM Cost-Effectiveness submenu. The options are to:

a. Create a new study. For a single unit or a selection of units, a new study may be created as shown in Figure 4, and for a category or class of units as shown in Figure 5.

b. Review/update an existing study. As above.

c. Assist in PM studies. Assisted PM Studies are provided to guide the novice and to permit the use of estimated ranges for Mean Time Between Failure (MTBF) and Loss Of Service (LOS) values. See Figure 6 for an example input screen that is used for developing PM study parameters.

| PM Task Code No. | Description | Accepted ? |
|---|---|---|
| 081110[01] | Water Closet, Industrial, Sanitary Systems | (Y/N). Y |
| 092340[01] | Special Equipment, HVAC Systems | (Y/N). Y |
| 181000[03] | This system/unit is not in the data base. . . | |

**Figure 4. Example of Special Study Entries for Specific PM Task Numbers.**

SUCCESSIVELY APPEARING SCREENS OF CATEGORY SELECTIONS FOR PM COST EVALUATION STUDIES

| Area/Facility-Class Options | PM Craft/Activity Options | HVAC Options | Selections |
|---|---|---|---|
| All Facilities | 03 Roofing | **All Services** | **New MAMC Facilities** |
| A Administration | 04 Exterior Closure | 1 Heating Furnaces, NGS | |
| B Old MAMC Facilities | 05 Interior Construction | 2 Heating Furnaces, Fuel | |
| C Troop Medical Clinic | 06 Interior Finishes | 3 Heating Furnaces, LPG | **HVAC** |
| D Dental Clinic | 07 Specialties | 4 Steam Heat (Cntl Source) | |
| G Grounds, Roads, etc. | 08 Plumbing | 5 Heated Water (Cntl Source) | **All Services** |
| I Clinical Investigation Area | **09 HVAC** | 6 Elec Heating Systems | |
| N New MAMC Facilities | 10 Exterior Electrical | 7 Heat, Solar Systems | (Echo of selections |
| S Warehouse/Storage Facil. | 11 Interior Electrical | 8 Other Heat Gen Sys | from preceding columns) |
| T Training Areas | 12 Computers & Comm | 9 Cooling Gen Systems | |
| | 13 Special Conveyances | A Heat & Cool Gen Sys | |
| | 14 Hosp. Medical Systems | B Ventilation Systems | |
| | 15 Protective Coatings | C Exhaust Systems | |
| | 16 Site Utilities | D Special Systems | |
| | | E Controls and Instr. | |
| | | F Testing, Balance, etc. | |

**Figure 5. Selection Screens for Bringing Classes of Assets into PM Cost Effectiveness Studies.**

**Code:** 081110 **ID:** 01 **Building:** LOCATION **Description:** WATER CLOSET, INDUSTRIAL TYPE.

**Select desired boundary limits and the best estimate characteristics for this PM study**

| | |
|---|---|
| **Period of Study:** | 10 years |
| **Annual PM Cost:** | 100 $/Yr |
| **Estimated LOS Cost:** | 2000 to 4000 $/unit-failure |
| **Estimated MTBF:** | 2 to 5 years |
| **Cost Benefit:** | <CB range computed> |

---

You can enter zero (0) for any one of the four variables OR enter zero for the Cost Benefit and any other variable OR enter a range for LOS and/or MTBF; and the PACER Program will calculate the missing variables for you.

**Figure 6. Example of PM Study Parameter Selection Screen.**

### 4.3 F/E Replacement Studies

When Maintenance Costing and Equipment Replacement is selected from the Main Menu, a screen appears that shows four steps in determining the replacement schedule for a piece of on-line operating equipment or machinery under a reasonably consistent work schedule.

These steps are:

STEP 1: Select equipment unit (i.e., type in equipment ID number).

STEP 2: Verify maintenance costs for average (typical) unit.

STEP 3: Check to see if the unit is substandard by comparing actual maintenance costs to expected costs.

STEP 4: Enter Projected Maintenance Costs to get a replacement recommendation based only on cost.

### 4.4 F/E Recordkeeping

If the Data Entry and Utilities entry is selected from the Main Menu, a submenu appears that permits the review or generation of stored PACER data, and the restoration/rebuilding of the PACER database as needed. Facility/equipment records manipulation requires a user-access classification that permits selection of the Add, Change, Delete Source Data entry. This brings up an insert submenu that permits data entry/reviews of the database under an Equipment/Facilities/CACES Code/System Labels call-up.

#### 4.4.1 Editing Categories

Input screens may be called up for data editing in PACER as discussed below.

a. Equipment.

A Data Entry Screen for entering (reviewing) equipment unit data into (in) the PACER database, as shown in Figure 7. The UNITS file (UNITS.DBF) of the PACER Program stores the equipment data.

b. Facilities - for entering data into the base facility list.

Facilities are identified in the PACER Program by their maintenance identification number, description, and site location (address). Facility status or other information of interest to the maintenance management may be added to this data set.

c. CACES code - for category numbers.

PM support and the corresponding facility/equipment class/systems are coded into the CACES numbering. The implications of the numbering system are indicated by the example in Figure 8.

d. System/location labels - for data entry to the SYSTEMS file.

System labels are applied to classes/categories of equipment by the Systems Data Screen as shown in Figure 9.

| | | |
|---|---|---|
| Selection Code: 081110 | | Unit ID: 01 |
| Building Code: LOCATION 1991-1-011 | | |
| Description: WATER CLOSET, INDUSTRIAL TYPE | | |
| Purchase Price: 560 | | Data Installed: 12/12/89 |
| Estimated LOS: 490 | MTBF: 3 years | Annual PM Cost: 110 $/Yr. |
| Unit Label: E | | System Label: REQUIRED |
| PM Rating: I | | PM Feasibility: E |
| Shop: PLUM | | |

**Figure 7. Key Equipment Information as Stored in the PACER Database (UNITS.DBF).**

| | | | | |
|---|---|---|---|---|
| **CACES Code:** | **08** | **081** | **0811** | **08111** |
| **Description:** | Plumbing | Lavatory Units, Pl | Water Closet, Indus. Type | WC Unit, Indus., LU/Pl |

**Figure 8. Meaning of the Numbering Progression in the CACES Coding System.**

Systems Code: 0811

Description: Water Closet, Industrial Type, San, System

Location: New MAMC area

System Label: (R)EQUIRED

**Figure 9. Input Screen for System Labels.**

# 5 APPLICATIONS FOR THE PRACTICED USER

PACER is a DEH resource that can provide reports for needed PM and documentation on PM cost-effectiveness. This documentation should be readily available for defending a PM Program in times of cost cutting.

The experience of large eastern cities is that continually postponing the maintenance of bridge and other city infrastructure has resulted in structures being degraded to the point that repair is no longer feasible; replacement is needed. The high costs of replacing these structures are causing a rethinking of the political processes that allowed the accumulation of such losses by these cities.

The delayed PM trap can be avoided at U.S. Army installations by developing convincing justifications for the PM activities at each installation. This can be done by adopting meaningful analytical evaluations of performed PM, which can be generated at the field level.

## 5.1 Improving PM Management Effectiveness

Improvements in PM and better PM definitions will upgrade the total maintenance management. If cognizant of PM performance from every source, maintenance managers are in a better position to make the economic decisions that constitute a cost-effective and technically sound PM program.

### 5.1.1 The Maintenance Decision Process

Since PM operations are subject to close scrutiny in any cost-cutting investigation, maintenance managers must be prepared to defend justifiable PM activities. Justifications of scheduled maintenance (including PM) should be included as a part of the general maintenance decision process. To be effective, this maintenance decision process should include:

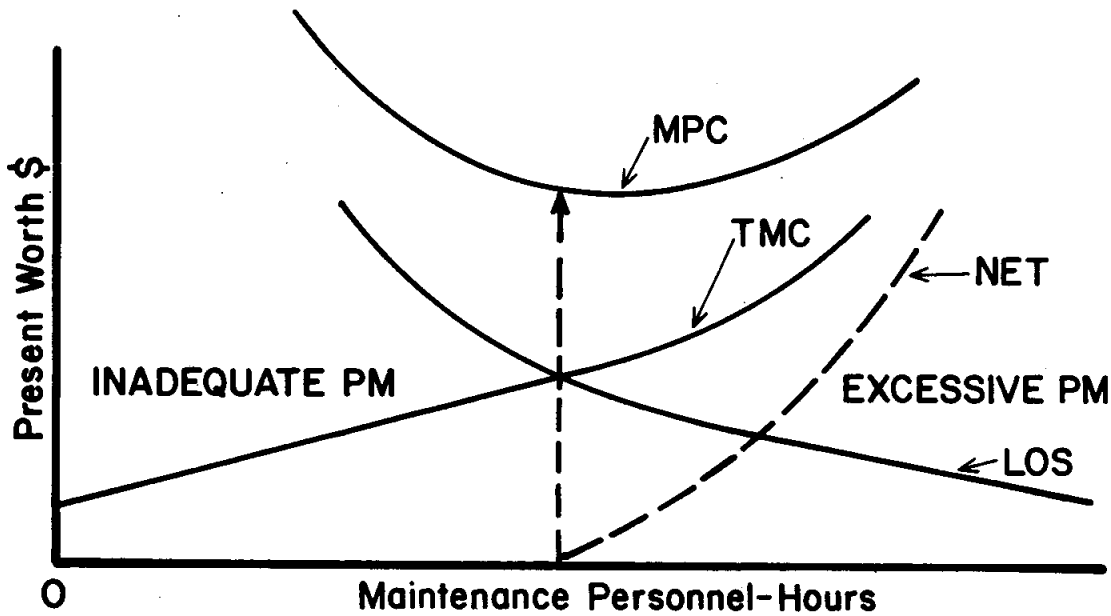
- Applying the RESOURCES of a skilled maintenance organization.
- PLANNING for a fully defined workload.
- SCHEDULING the resources that are optimal for the priority and type of task.
- EXECUTING the maintenance tasks effectively under a comprehensive inspection and recordkeeping program.

The elements of the maintenance decision process are:

a. Maintenance organization. The DEH organization may perform maintenance both with in-house personnel and contract personnel. Whether maintenance management emphasis is placed on in-house performance or on quality assurance of contracted work, the PM prioritization (or justification), selection, and planning processes can be difficult.

b. Planning and scheduling. Planning should consider all required maintenance in a framework of facility/system/equipment priorities, immediacy of need, availability of appropriate resources, and the local characteristics of the units maintained.

This planning should reflect the technical feasibility and cost justification studies for new or proposed maintenance, and the effect of this support on the total organization. Figure 10 shows an "optimum" level of maintenance for an organization or a specific system. Obtaining the quantitative information implied by such a plot is difficult, but decision level approximations usually can be made.




TMC: Total Maintenance Costs (Expenditures).

LOS: Loss Of Service Cost (unit cost of not providing full maintenance + the allocated costs of total system downtime and lowered customer goodwill).

MPC: Total Maintenance Program Cost = TMC + LOS.
(This is the total operations cost that is due to the level of maintenance performed).

**Figure 10. Identifying Optimum Levels of Maintenance Performance.**

It should be noted that Figure 10 assumes a fixed quality of maintenance. If maintenance effectiveness improves, the Loss Of Service (LOS) curve charge per maintenance man-hour (MMHr) would be lowered, reducing the Total Maintenance Cost (TMC) required for optimum cost performance. A manager mindful of maintenance overhead can improve this picture by lowering the TMC plot, moving the optimal operating point to the right. This allows the assignment of more maintenance man-hours because the better return-on-investment results in no net increase in cost.

### 5.2 The Cost Effectiveness of PM Activities

At most DEH centers, the effect of PM on unit failure rates is not known. PM economic studies rely on sketchy historical data, shop expertise, and averaged data from the literature. Even so, an organized cost benefit analysis of PM operations, using available data, will be better reasoned and more accurate than any "eyeballing" of PM advantages.

### 5.2.1 Cost Benefit Relationships

The PM Program analyst should have a good understanding of the short- and long-term justifications for the systems/equipment that are supported. To assist in this responsibility, general cost benefit graphs are needed for PM cost-control and cost-justification purposes.

For the simplified context of either performing PM at a specified level or NOT performing any PM and paying the failure-repair/major-overhaul penalty, a graph may be constructed as shown in Figure 11. When only regions of PM acceptability are sought, this type of correlation can be useful, even when built from very qualitative data.

**Note:** Figure 11 is for PM **OR** Repair/Overhaul. When the situation occurs that PM **AND** a Major Overhaul is being evaluated, find the present worth (PW) of this combination, and use this cost for the PM line to justify not using the Repair/Overhaul approach alone.

a. Use of developed PM correlations.

A quick readout of the approximate cost advantage of performing PM versus not performing PM for a specific unit/system should be useful to PM planning and maintenance managers. The approach of Figure 11 is now developed into an actual PM cost justification graph for any UNIT PM over a 10-year life study in Figure 12. This model is applicable to any PM unit or system cost analysis in which PM expenditures are known and the MTBF and LOS penalty can be estimated. The MTBF is assumed to be essentially the same as Years between Major Expenditures for the x-axis of this graph. Estimating the PM cost benefit for a hypothetical UNIT X is simplified when using the present worth graph of Figure 12. Note that the figure is not restricted to this example, but is applicable to the PM cost evaluation of any unit for which an identifiable (time and materials) PM can be provided and for which some estimate of the penalty for not doing the PM can be made.

**EXAMPLE** (Cost Benefit of a PM Task):

*Problem*

Suppose DEH management has questioned the validity of spending PM funds on UNIT X. After ensuring that the PM applied to UNIT X is technically effective and efficient, PM management wishes to estimate the cost benefit of performing UNIT X PM.

*Assumptions*

(1) UNIT X has PM performed at a net cost of $1000/year.

(2) Statistically, UNIT X can be in service for 10 years without a cost-significant breakdown when provided the above PM.

(3) Historical evidence indicates that without any PM, UNIT X will fail or have a major repair every 3 years.

(4) For every failure of UNIT X, the Loss of Service (LOS) penalty (including repair) is estimated to be $5000.

NET PRESENT WORTH (NPW) -

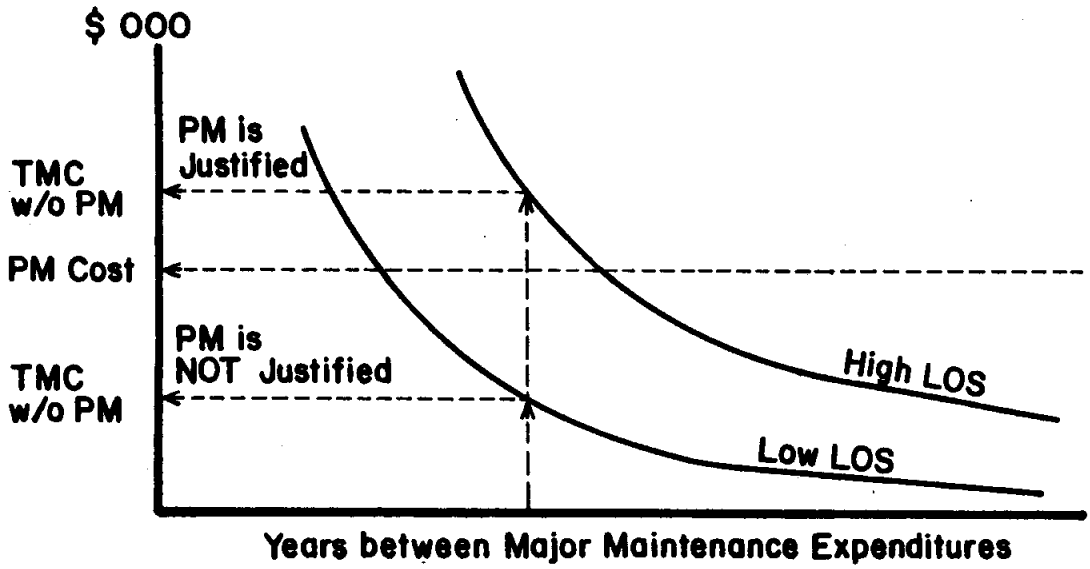



**Figure 11. Graph Showing Regions of PM Cost Justification.**

*Example Manual Solution*

Use Figure 12 as follows:

(1) On the x-axis, find the vertical line for 3 years between major expenditures.

(2) Move up this line to the horizontal line corresponding to a PM of $1000 per year; read the 10-year present worth of this PM on the y-axis which is approximately $6150.

(3) Continue up the 3-year line to the LOS = 5K curve; note the present worth of LOS (for 3+ failures over 10 years) on the y-axis is approximately $8800.

(4) To get an approximate cost benefit for UNIT X PM, subtract PM Present Worth of Item (2) from the LOS present worth of Item (3): $8800 - $6150 = $2650.

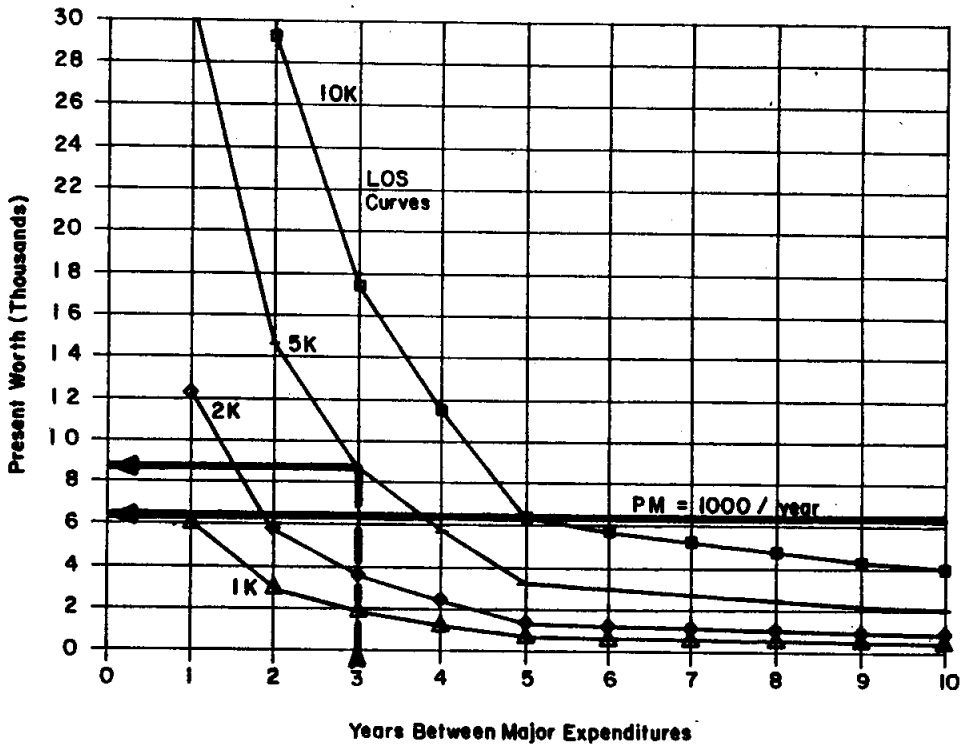
*Example PACER Solution*

By providing the annual PM cost and estimates of the MTBF and LOS, PACER will perform the above four steps and provide the same answer. In addition, if an estimate range is provided, PACER will give a corresponding cost benefit range and graph the area of uncertainty.

b. Developing a detailed cost benefit analysis.

A PM cost benefit analysis is appropriate for the total installation program evaluation, for facility categories, for an operating plant, for a system, and for an individual unit. Previously identified lists of prioritized PM tasks can be used to identify marginal candidates that will benefit most from a detailed cost

NET PRESENT WORTH
TOTAL MAINTENANCE COST (TMC):




| | |
|---|---|
| LOS: | Total Loss Of Service charges including Major Repair/Overhaul + loss of the UNIT's operation + estimated damage to Installation Mission, + etc., for one scheduled downtime. |
| MTBF: | The statistical Mean Time Between Failure for the UNIT under specified operating and service conditions. |
| PM: | Preventive Maintenance at a specified cost level. |
| TMC: | Total Maintenance Cost in Present Worth (PW) dollars at 10% interest for the 10 year period of the graph. |

**Figure 12. General Relationship of Maintenance Cost vs MTBF for a 10-Year Study.**

benefit analysis. A manual cost analysis comparing different PM levels for a hypothetical deep well pump in a water supply system is provided in Appendix C, as a procedural example.

5.2.2 Making a Best Estimate

a. Estimating Mean Time Between Failure (MTBF) from F/E maintenance data.

For each class of equipment, and for each unit in that class, a historical data file should be established in PACER and updated accurately. From such data (often supported by good engineering estimates), the effect of PM on total performance costs of a unit or class of units can be derived. Figure 13 shows the incidence of failure and/or prescribed major overhaul for varying rates of applied PM as recorded for a fictitious UNIT X. The example assumes that data and/or experience are available for any

PRESENT WORTH
of PM COSTS
for UNIT X:

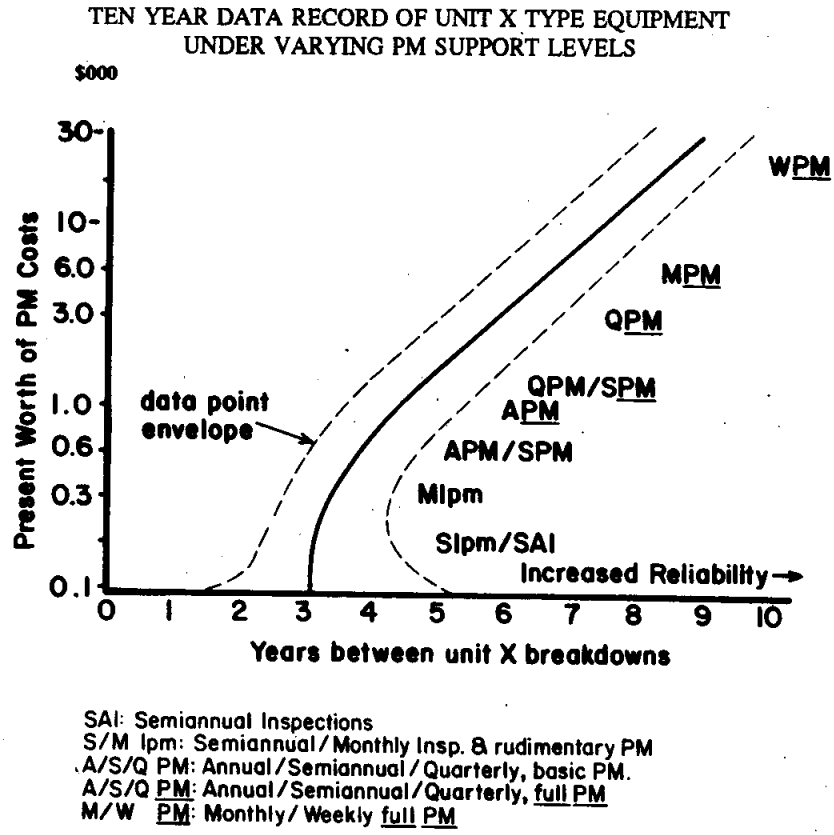



**Figure 13. Example of Correlating Data Points That Represent Failure Rates for a Specific Type of Equipment Under Varying PM Levels.**

particular unit or class of units in the PM support roster of the particular DEH. The different unit environments and the PM practices of different DEHs will affect collected PM correlations. For a quick look at the PM cost-effectiveness for any particular unit, some knowledge of the effect of PM on that unit must be known. Unit history, inspector/craftsman knowledge, and manufacturer's information may provide a usable correlation of PM and MTBF (as diagramed in Figure 13). Ideally, the plot in Figure 13 is developed from reliability histories of units similar to UNIT X in similar environments and work loads. (When lacking this ideal, get an estimate from the shop foreman.) The average (mean) of the data points collected constitutes the desired correlation. Such data point clustering (i.e., correlation) could be automatically processed if minimal unit operations experience can be collected. The MTBF analysis assists PACER in predicting what cost effect will occur for different PM support levels for a given unit. The PACER total PM program assessment will assist DEH maintenance management in estimating what failure-rate effect will occur for any given PM funding constraint.

b. Estimating the loss of service (LOS) penalty.

The estimate of the LOS penalty defines the cost benefit of spending PM resources for maintaining a trouble-free asset over the fix-it-if-it's-broken approach. The LOS penalty is what must be paid for an unexpected breakdown and off-line repair of a particular unit. LOS charges in dollars are the sum of:

(1) Shop/contracted repair (including premium time) and parts replacement of the failed unit.

(2) Removal/reinstallation of the failed unit.

(3) Downtime equipment rentals and contingency actions taken to ameliorate the failure.

(4) Mission-default charges or what the failed unit could cost the Major Command (MACOM) and other customers.

(5) Customer goodwill damage from that type of breakdown. (A locally determined charge that cannot bring the total LOS to exceed the cost of installing a standby unit.)

### 5.2.3 Confidence in the PM Management Estimates

If you can bracket a range for the estimates provided, the PACER Program will display the estimation boundaries that these reasonable limits allow. Figure 14 shows an area of probable values produced by PACER. The area will be reduced (and the confidence level increased) by more definitive input information. This type of estimation by a knowledgeable user can provide important qualitative information about the expected cost-effectiveness of a PM activity, with the output becoming more quantitative as the uncertainty box shrinks.

## 5.3 Methodology Development

The PM assessment method used by PACER is one of logically generated PM activity lists that are an automated development from a current database. The database must be periodically updated by maintenance managers, inspection personnel, and in-house or contracted PM performance personnel.

### 5.3.1 The Value Assessment Method

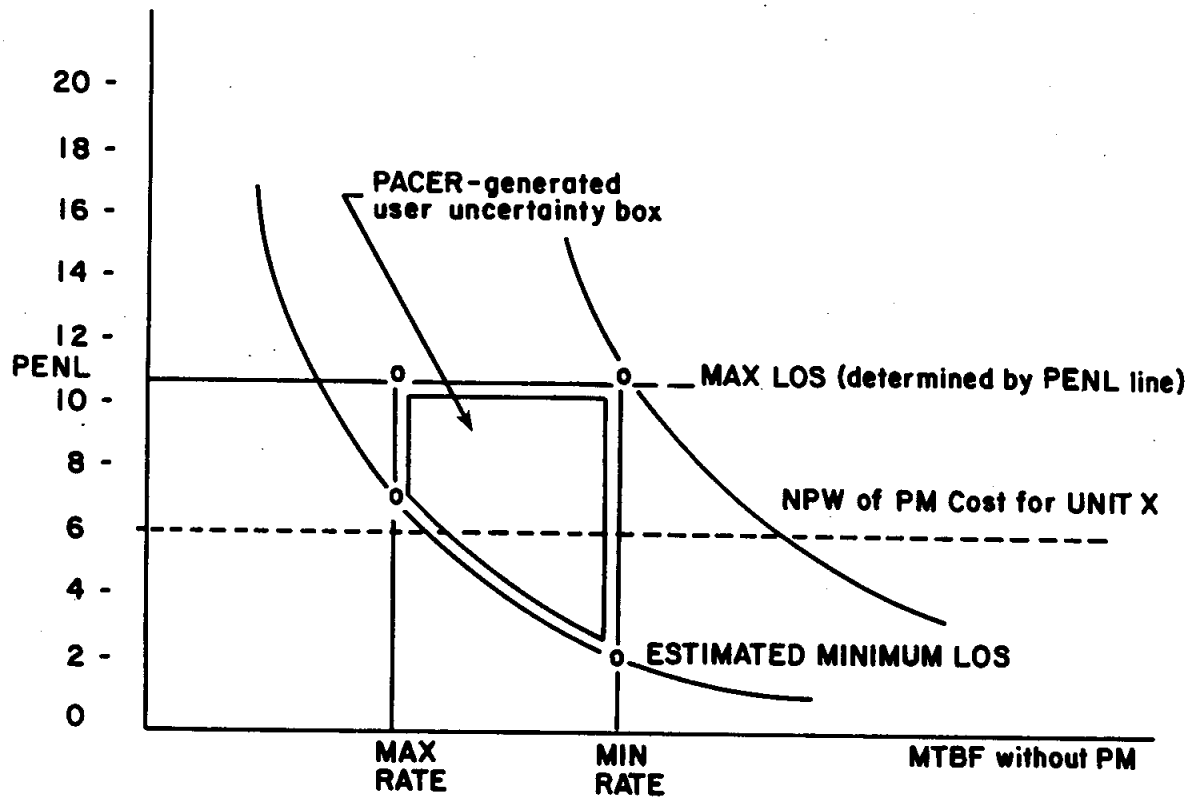
The PM Value Assessment Method[2] used by PACER computes relative dollar weights to the tasks of a PM program. These "values" can be used to justify specific PM activities and/or to determine the least damaging workload deletions under mandated budget cuts. When automated, the method allows a prompt response to general or specific PM inquiries. The relative values of PM activities are not fixed and can change with DEH redirection, with modifications to or the phaseout of supported systems, and with alterations in the needs of the installation. It is only because the same database is used for inspector and PM technician daily reports, that the uniformity and currentness of the technical and PM cost data sources to PM preferential listings can be relied upon.

---

[2] J.H. Johnson.

NET PRESENT WORTH (NPW)

$ 000 VARIATION IN NPW WITH DECLARED UNCERTAINTY RANGES




PENL (Penalty Limit) - Assumed cost to facility of a Backup (Standby) Unit to Unit X.

**Figure 14. Graphical Boundaries Reflecting the Range of User Uncertainty in Estimating the MTBF and LOS Parameters.**

5.3.2 Ordered PM Listings

To be successful, the PM lists must be generated and applied by PACER in accordance with locally determined values and constraints. When the appraisal of the PM workload is handled by maintenance managers at the local level, adjustments can be made for the many influences and factors at play in the particular installation.

a. Developing an Ordered PM-Category List.

The basic list in the Value Assessment Method is the Ordered PM-Category (PMC) List, which groups all admissible PM Categories under four priority classes:

(1) Mission and Safety (M/S) PM Categories are labeled MUST.

(2) Non-M/S categories that are functionally essential to base operations are REQUIRED.

(3) Non-M/S categories that are not essential but contribute to functional and efficient base operations receive the NEEDED label.

(4) Other PM categories are MARGINAL.

b. Developing a General PM List.

As previously noted, the General PM List potentially includes all PM Category systems/units and, by implication, all of their associated PM tasks. This list is grouped in the PM Category order in PACER, and is built as follows:

(1) For each PM Category entry in the PMC List, the associated systems/equipment supported under that category (or support units) are identified and listed.

(2) All PM tasks associated with each supported unit (belonging to a parent system in a specific PM Category) are then included in the General PM List.

(3) If the General PM List development is automated, priority and cost-effectiveness are then included as attributes to each PM task.

c. Preferred PM Listings.

Spin-offs from the General PM List (charted in Figure 15) are most useful, and may be described as follows:

(1) Preferred PM Task List. A relative PM value is provided for every PM task on the Preferred PM Task List. The list is generated by abstracting all of the assignable PM tasks from the General PM Task List for the installation, and reordering these tasks according to their labeling. Where tasks have the same label, their cost benefits and then the level of the parent category will determine the sequence of tasks. In the unlikely event that two tasks have the same label, cost-effectiveness, and parent level, decreasing assignable personnel-hours for the PM task can determine the order. For a completed Preferred PM Task List, every PM task will have a unique position or sequence number, which becomes a part of its label (or PMT attributes).

(2) Preferred PM Category and Task List. The PM Category and Task List is the same as the Preferred PM Task List except that the PM tasks are grouped under a parent (or shop) category in order of their PM Task List sequence number. The PM Category and Task List can be generated as a modification of the General PM List of Table B1 (Appendix B) for the convenience of PM planning or control.

CHART FOR DEVELOPING PM EVALUATION LISTS

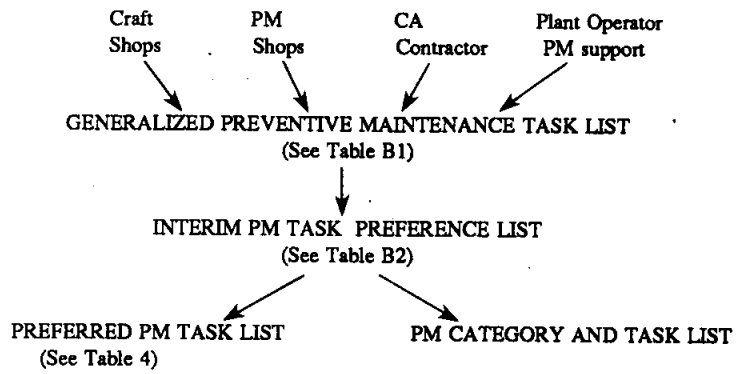



**Figure 15. Development Sequence of PM Listings in the Value Assessment Method.**

5.3.3 Processing The General PM Task List

The continuing development and upgrading of the General PM List is fundamental to the Value Assessment Method. If the report listings to be spunoff from the General PM List are to be accurate, the list should be on-line to an active PM database. Essential elements of the PM database should be the key descriptors (attributes) of the PM tasks, and the log-record dates of the supported units.

a. For each PM task applied to a unit on the General PM List, determine the standard craft-hours, the equipment and material charges involved, and the estimated level of cost-effectiveness. The first two are obtained according to standard DEH practices and the last by procedures of Chapter 4.

b. Develop and record a "priority label" for each PM task (UNIT) as follows:

(1) Determine if the PM task is MUST:
- it is feasible to perform.
- it is essential to maintaining the UNIT.
- the UNIT is essential to a MUST PM Category.

(2) Determine if the PM task is REQUIRED:
- it is feasible to perform.
- it is cost-effective to perform.
- it is essential/important to maintaining the UNIT.
- UNIT is essential/important to a REQUIRED/MUST PM Category.

(3) Determine if the PM task is NEEDED:
- it is as in (2) but is marginally cost-effective.
  (OR)
- it is easily feasible.
- it is cost-effective.
- it is essential/important/helpful in maintaining the UNIT.
- UNIT is essential/important/contributory to a NEEDED/REQUIRED/MUST Category.

(4) Determine if the PM task is MARGINAL:
- it is as in (2), but is difficult to perform.
  (OR)
- UNIT is in a REQUIRED Category; PM Task is feasible, but is marginally cost-effective.
  (OR)
- it is easily feasible.
- it is cost-effective.
- UNIT is important/contributory to a NEEDED/REQUIRED Category.

Although this process is automated, it is still necessary to understand the above logic to have confidence in the labeling of the PM tasks. The use of this development procedure is explained in the following example.

**EXAMPLE** (Value Assessment Methodology)

*Problem* Develop a Preferred PM Task List (like Table 4).

*Assumptions*

Assume that a particular Army installation is supported by a DEH with a PM Shop responsible for air compressors/blowers and air conditioners. (All other PM is performed by other shops or is contracted.) Also assume that the maintenance manager wants to create an ordered list of the PM tasks on the performance roster of this PM Shop, which are taken from the General PM List previously developed for the installation.

*Procedure*

If a PM Task List is created manually, an interim list of applicable PM jobs or tasks would be taken from the General PM List, and left in the same order. Further, if the interim list is annotated to assess each PM task according to the evaluation system previously outlined, a MUST, REQUIRED, NEEDED, or MARGINAL rating for each job/task in the PM Shop can be developed. Table B2 shows some of the steps in this process; Table 4 provides the interim list for the PM Shop.

**CAUTION**: In tracing the procedures of this chapter, remember that:

(1) There are no scheduling inferences to Tables 4, B1, and B2; only the relative value of the PM or task to the maintenance mission.

(2) The process is NOT judging retention of the unit, but rather the value of the PM supporting the unit.

By grouping tasks under their appropriate ratings in the sequence that they are processed, a Preferential PM Task List for the PM Shop will be obtained, as illustrated in Table 4. This process can be repeated to get the PM activities ordered to the subtask level, if needed. Appendix B contains developmemntal listings from which the numerical references in Table 4 were developed.

**Table 4**

**Preferred PM Task List for an Example PM Shop**

| MUST | REQUIRED | NEEDED | MARGINAL |
|---|---|---|---|
| B.3.c:<br>HVAC System<br>C&C Facilities | C.3.f:<br>CAS System<br>Sewage Plant | C.3.c:<br>S/S Blower<br>Sewage Plant | C.3.b:<br>Gr.Blower<br>Sewage Plant |
| C.1.b:<br>FAB Sys.<br>Steam Plant | H.2.a:<br>VEH-air compr.<br>POL Center | G.2.a:<br>Kitchen Eq-ice cream maker<br>Commissary Facilities | G.2.a:<br>Kitchen-vents<br>Commissary |
| G.1.a:<br>Cold Storage<br>CS Plant (Com) | I.3.b:<br>Appl-air cond.<br>Service Bldg. | G.2.b:<br>Kitchen Eq-refrg/freezer<br>Commissary Facilities | I.3.b:<br>Ice Machine<br>Service Bldgs. |
| | J.3.a:<br>Appl-air cond.<br>Buildings | H.1.a:<br>POL-air compr.<br>POL Center | J.3.c:<br>Ice Machine<br>Commissary |
| | J.3.c:<br>Appl-refrig.<br>Buildings | I.2.b:<br>Roof-vents/ducts<br>Service Bldg. | |

## 5.4 Benefits to RPMA Management

An effective PM Program can be a cornerstone to effective maintenance management. The data collection and ordering capabilities of PACER will be considered an indispensable information source once completely integrated into the DEH maintenance management process.

### 5.4.1 Better Insights into PM Management Control

PACER is designed to create a renewed interest in collecting maintenance data for statistical purposes. A broader statistical record will be needed for improved PM management levels. Records of operating levels, maintenance, failure, repair, and analytical studies for any unit or class of units should be readily available. Such records will greatly strengthen the arguments of maintenance managers that all performed PM tasks produce long-term benefits. Maintenance histories of locally supported systems/units can be built from operation records, and also, possibly, from outside sources. Microcomputers are presently available to most PM managers and should be available for recording the maintenance history for every PM supported unit on a base.

a. The information collected for a maintained UNIT should include:

(1) Manufacturer's data and installation date.

(2) An operations history including inspection/maintenance/repair records.

(3) Type/frequency of maintenance required.

(4) Parts replaced and expenditures charged.

(5) Unit's schedule of events:
- next inspection.
- PM frequency and type.
- next overhaul date.
- expected replacement date.

5.4.2 Economic Arguments for Asset Replacement

Projecting the minimum Maintenance Program Cost (MPC) operating point for a particular unit over time can help predict when replacement of the unit will be cost effective. This is shown in Figure 16 for a straight-line Unit Depreciation Cost (UDC). The UDC resembles buying an item on time payments. When the upkeep costs exceed the payments or allocated value of the unit, one should consider buying a replacement. In the diagram, the line indicating total yearly depreciation plus the MPC payments for the new unit should be above MPC upkeep projections for the old unit, if retention of the old unit and its increased maintenance costs are justified.

PACER uses a more classical replacement analysis than the conceptual explanation in Figure 16, considering purchase and installation costs, annual operating cost trends, and maintenance cost trends in a net present worth analysis.

5.4.3 Automated Analytical Support

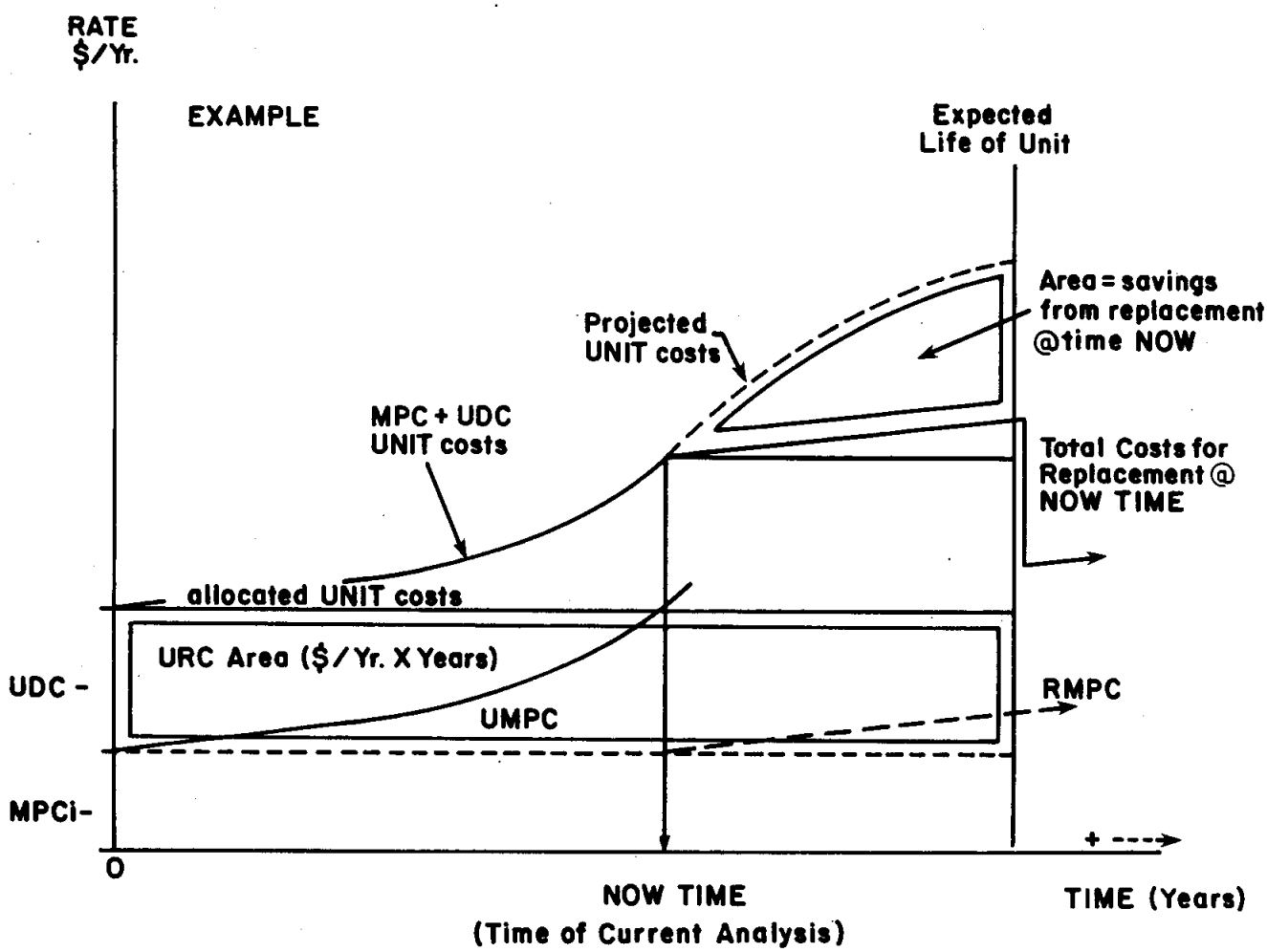
If indicator-type information is available from a maintained database, analytical cost studies can be prepared by PACER in minutes rather than the days/weeks traditionally spent on such tasks. PACER uses the Value Assessment Method for simple manipulations of ordered/prioritized listings. These procedures, and PACER, can be integrated into a total PM Management System. Useful outputs from this system approach would be:

a. Continuous PM costs monitoring.

A dynamic reporting system in which any variations or changes in budgets or PM costing can quickly be related to the effect on the entire program.

b. Budgetary changes.

To identify the PM effect of budgetary reductions, equivalent PM man-hours allowed by the new budget can be determined; the man-hours are then summed (top-to-bottom) in the PM Task List until the materials and personnel charges are exhausted. The "drop line" for the proposed budget is then drawn at that point, and the criticality of the reduction may be assessed.




MPC: Maintenance Program Costs.

MPCi: initial MPC (for a new UNIT).

RMPC: Projected MPC of Replacement of UNIT @ NOW time.

UMPC: Actual MPC of UNIT under analysis.

UDC: UNIT (straight line) Depreciation Cost.

URC: Unit Recovery Cost = UDC X UNIT Exp. Life
(Assumes accumulated interest = inflation.)

**Figure 16. Graphical Representation of Rising Maintenance Cost as an Equipment Replacement Argument.**

c. Determining an optimal cutoff.

Under increased costs for maintenance contracts or materials, the mix of PM support should be reviewed. A cost benefit/customer service model that provides an optimal return seeks the best balance between maintenance resources and installation needs.

# 6 PACER SOFTWARE FUNCTIONAL FEATURES

Software and database control functions are exercised in the PACER Program through the Utilities Menu (Figure 17). The first entry allows source data editing that is essential to PACER operations. The Rebuild Source Data Files entry is essential to restructuring any damaged data files, and to batch loading of the database. The backup, restore, and rebuild capabilities are needed for effective data file management. Print Reference Lists directs printouts of database content for review. Password Utilities permits supervisor management of database security through user access control.

## 6.1 Edit PACER Source Data

Selection of the entry for Add, Change, or Delete Source Data will superimpose a selection choice of Equipment, Facilities, CACES Codes, or System Labels. After high-lighting the data of interest, press Enter to bring up a data screen with the known/entered information for that entry.

## 6.2 Perform PACER Operations Functions

### 6.2.1 Backup PACER Program Data

Simple PC floppy-disk backup procedures are spelled out for the user by this selection.

### 6.2.2 Print Reference Lists

A printout of the study files generated and saved in the program and a complete listing of all categories/systems in the system labels database will be provided.

### 6.2.3 Restore PACER Program Data

Instructions are provided for restoring PACER Program data from a previously made PC floppy backup disk.

## 6.3 Reports Generation

Reports generated on request by PACER include basic PM Listings, PM Cost Studies, Facility or Equipment (F/E) Asset Evaluations, and Life-Cycle/Equipment-Replacement Computations. Eventually, PACER will include a Reports Menu listing all of the readily generated reports of the program. An accounting of generated reports will also be provided. The Reports Menu will include the selections shown in Figure 18.

## 6.4 Perform Password Utilities

The assignment of passwords provides security for PACER's use, but is not essential to its use. Choose the Password Utilities selection from the Utilities Menu, and the Change Password or User Access List choices will appear on the Main Menu screen (Figure 19). First-time password assignments should be performed by the PACER Program software supervisor.

```
05/08/91                    PACER                          F1 for HELP
                         Utilities  Menu
=================================================================================

                    ADD, CHANGE, DELETE SOURCE DATA

                    Back-up PACER Data

                    Print Reference Lists

                    Restore PACER Data

                    Password Utilities

                    Rebuild Source Data Files

                    Return to Main Menu

=========<MESSAGES>=================================================================
```

**Figure 17. The Utilities Menu of the PACER Program.**

### 6.4.1 Password Functions

The password functions allow adding, editing, and deleting passwords, and choosing functions to which each password will have access. These functions can be used when new operators are allowed onto the system, when there are changes in operator information or function access, or when operator passwords are removed from the system.

a. Password assignments.

Choose the Password Utilities selection from the Utilities Menu, and the Change Password or Password Utilities (Figure 20) choices will appear on the screen. First-time password assignments should be performed by the PACER Program software supervisor.

**WARNING:**

(1) The first password created should be a master password with access to all supervisory functions. (Supervisory functions include password monitoring and database read/write privileges.)

(2) Class 1 passwords have READ/WRITE privileges for all data in the PACER database.

(3) Class 2 passwords do not have access to the PACER database (prototype version).

REPORTS MENU
PM Job Roster Report
PM Supported F/E Listings
PM Cost Evaluation Report
F/E Asset Evaluation Report
Asset Cost-Effectiveness Life Studies
Asset/Unit Replacement Study
Record of Reports Generated

**Figure 18. A Reports Menu as Planned for PACER.**

```
05/08/91                    PACER                                F1 for HELP
                          Utilities  Menu
=================================================================================

                    Add, Change, Delete Source Data

                    Back-up PACER Data

                    Print Reference Lists

                    Restore PACER Data

                    PASSWORD UTILITIES

                    Rebuild Source Data Files          CHANGE PASSWORD
                                                       User Access Mgt.
                    Return to Main Menu

=========<MESSAGES>=================================================================
```

**Figure 19. Password Utilities Menu.**

b. Change passwords.

Changing passwords at the user level is guided by the Change Password instructions provided. (The new password will be at the same access level unless a change of status is implemented by the supervisor through the Add/Change Users entry of the Password Utilities Menu.)

Choose Utilities Menu from the Main Menu, and then press Enter.

Choose Password Utilities from the Utilities Menu, and then press Enter.

The Change Password option screen will then appear and prompt for the password to be entered. The ESCape key returns you to the Utilities Menu.

6.4.2 Changing the PACER Program User Roster

Changing the name, job, or access level of an operator is done by choosing the appropriate field and typing over the present entry. Add/change options are listed in the Password Utilities Menu.

## 6.5 Quit System to DOS

This function causes the program to end, and returns the operator to the DOS system. Always end the system by selecting this last option. This ensures that all data files will be updated and closed properly.

To quit to DOS, either:

- Choose Quit System to DOS from the MAIN MENU, and then press Enter.
  or:
  - Press Q.

```
05/16/91                          PACER                          F1 for HELP
                              Password Utilities
=================================================================================

                              ADD/CHANGE USERS

                              Delete Users

                              List Users

                              Return to Utilities Menu
=========<MESSAGES>=============================================================

    Use <UPARROW> or <DOWNARROW> and press <ENTER> or press <ESC> to Exit.
```

**Figure 20. User Access List Control Menu.**

## APPENDIX A: dBASE LOADING PROCEDURES FOR THE PROTOTYPE PACER DATABASE

### 1 INITIAL BATCH LOADING PROCEDURE (Uncompiled Prototype PACER Version)

This section provides procedures for a first time database loading of systems or F/E units data. Two approaches may be processed in a batch data loading mode. The first is applicable when all data is largely ready for incorporation into the database (total loading). The second is for an incremental loading process as the needed operations PACER data is developed.

**Total Loading Procedure**

When a representative amount of data is known in every category and these data have been collected and properly formatted, the following procedure may be applied:

1. Place prepared files in C:\PACER or any convenient directory.

2. Access the dBase Program by typing DBASE and pressing the Enter key; leave the dBase option screen and go to the dot (.) command (via the ESCape key).

3. To load Systems Data, at the dBase dot prompt enter in capital letters the following:

```
. USE INSYS
```

4. Press the Enter key for a new dot prompt, and enter:

```
. APPEND FROM <file-name> TYPE DELIMITED WITH %
```

where < > should be replaced by your data file name. The dBase system will respond by a count of the records added to the INSYS file.

5. For each data file to be entered, repeat Procedure 4 k times (where k = number of formatted data files) as follows:

```
. APPEND FROM <file-name(1)> TYPE DELIMITED WITH %
      n records added
      .
      .
      .
. APPEND FROM <file-name(k)> TYPE DELIMITED WITH %
      n records added
```

6. You are now ready to load these entries from the INSYS.DBF holding file to the SYSTEMS.DBF PACER data file. At the dBase dot prompt enter in capital letters the following:

```
. USE SYSTEMS (CR)
. APPEND FROM INSYS (CR)
      n records added
```

7. Similarly, to load Equipment Units Data, at the dBase dot prompt enter the following:

```
. USE INDATA
. APPEND FROM <eq.file-name(1)> TYPE DELIMITED WITH %
        n records added          (dBase response)
              .
              .
              .
. APPEND FROM <eq.file-name(n)> TYPE DELIMITED WITH %
        n records added
. USE UNITS
. APPEND FROM INDATA
        n records added
. QUIT
```

8. After performing either Procedures 3 or 4, you MUST immediately perform the following:

a. Access the PACER Program by typing DBASE MAIN-MENU; move from the Main Menu to the Utility Menu and highlight the entry Rebuild PACER Files.

b. Select the Rebuild PACER Files entry; the newly entered data will then be reordered into a sequence by CACES numbers.

**Partial Loading Procedure**

For a first partial loading, proceed as in Total Loading Procedure. If other entries have been loaded previously, copy SYSTEMS.DBF and UNITS.DBF to an archive directory (as a backup). You are then ready to prepare the working files for the next entry and verification stage.

1. Preparation of Working Files

a. Place prepared files in C:\PACER or any convenient directory.

b. Access the dBase Program by typing DBASE, leave the DBASE Option Screen and go to the dot (.) command (via the ESCape key).

c. Clear the PACER data files of old data (so it does not generate double entries).

| *Systems Data* | *Equipment Data* |
|---|---|
| . USE SYSTEMS | . USE UNITS |
| . DELETE ALL<br>n records deleted (response) | . DELETE ALL<br>n records deleted |
| . PACK<br>no records copied | . PACK<br>no records copied |
| . QUIT | . QUIT |

2. Loading of Next Systems Data Set

a. For loading Systems Data, go to the dBase dot prompt as described above, and enter the following:

. USE INSYS

b. Press the Enter key for a new dot prompt, and enter:

. APPEND FROM <file-name> TYPE DELIMITED WITH %
where < > should be replaced by your data file name. The dBase System will respond by a count of the number (n) of records added to the INSYS file:

. APPEND FROM <filename> TYPE DELIMITED WITH %
n records added (dBase response)

c. Press the Enter key for a new dot prompt, and enter:
. APPEND FROM INSYS
n records added

d. If the screen appears as shown below, the data has been entered successively, and you are now ready to exit from the DBASE operation by typing "quit" at the dot (.) prompt:

. USE INSYS
. APPEND FROM <filename> TYPE DELIMITED WITH %
. APPEND FROM <filename> TYPE DELIMITED WITH %
n records added (dBase response)
. APPEND FROM INSYS
n records added
.QUIT

3. To load the next F/E Units Data, at the dBase dot prompt enter the following:

. USE INDATA
. APPEND FROM <eq.file-name> TYPE DELIMITED WITH %
n records added (dBase response)
.USE UNITS
. APPEND FROM INDATA
n records added
. QUIT

4. After performing either Procedures 2 or 3 you MUST immediately perform the following:

a. Access PACER Program; go to the Utility Menu and highlight the entry Rebuild PACER FILES.
b. Select the Rebuild PACER Files entry; the newly entered data will then be reordered into a sequence by CACES numbers.

5. Repeat Steps 1 to 4 until all data is developed and loaded. In the Prototype-Version, if an error is made late in the incremental loading and verification procedure and a total reload is necessary, much valuable data or keyboard entry time may be lost.

**WARNING: Always backup the systems and units files before starting the next incremental loading.**

## 2 BATCH RELOADING PROCEDURE

For a database reloading of a formatted data file that was not successfully entered, reload data from the beginning as follows:

1. Place the new/corrected ASCII data file in the appropriate directory.

2. IMPORTANT: Copy the "old" PACER database files to be changed (UNITS.DBF or SYSTEMS.DBF) to a safe archive directory.

3. Access the dBase Program, and go to the dot (.) command (via ESCape key).

4. So as not to duplicate unit/system assets in the database, type the following:
   . USE INSYS/INDATA (one or the other)
   . DELETE ALL
   n records deleted
   . PACK (a MUST step)
   no records copied
   . USE SYSTEMS/UNITS
   [SYSTEMS(or UNITS) consistent with INSYS (INDATA)]
   . DELETE ALL
   n records deleted
   . PACK
   no records copied
5. To load F/E Units data enter the following:
   . USE INDATA
   . APPEND FROM <new/corrected file-name> TYPE DELIMITED WITH %
   n records added
   . USE UNITS
   . APPEND FROM INDATA
   n records added

6. To load Systems data, enter the following:
   . USE INSYS
   . APPEND FROM <new/corrected file-name> TYPE DELIMITED WITH %
   n records processed
   . USE SYSTEMS
   . APPEND FROM INSYS
   n records processed

7. After performing Procedures 3 or 4 you MUST immediately perform the following:

a. Access the PACER Program; go to the Utility Menu and highlight the entry Rebuild PACER Files.

b. Select the Rebuild PACER Files entry; the newly entered data will then be reordered into a sequence by CACES numbers.

## APPENDIX B: DEVELOPMENTAL LISTINGS FOR GENERATING TABLE 4

**Table B1**

**Interim General PM Task Preference List**

| | |
|---|---|
| A. HOSPITALS: NA | |
| B. COMMAND & CONTROL FACILITIES: | |
| 3. ENVIRONMENTAL CONTROL, MISSION AREAS: | |
| b. HUMIDIFIERS. | MUST |
| c. HVAC Systems. | MUST |
| C. G/P PLANTS: | |
| 1. Steam Plant (SP). | |
| b. Forced Air Blowers (FAB): | |
| (for boiler furnace) | |
| - blower unit | MUST |
| - duct/injection system. | MUST |
| 3. Sewage Plant. | |
| b. Blower Sys,Grit Area. | MARGINAL |
| c. Blowers, Sludge & Scum Rooms. | NEEDED |
| f. Compressed Air Supply System (CAS). | |
| - air compressor | REQUIRED |
| - sto.tank & distr. | REQUIRED |
| D. M/D CLINICS: | |
| 1. Emergency/Patient Room Systems. | |
| b. Pressurized Gas Systems. | MUST |
| E. UTILITY DISTRIBUTION SYSTEMS: | |
| none. | |
| F. FIRE & SECURITY PROTECTION: | |
| G. COMMISSARY FACILITIES: | |
| 1. Cold Storage Plant. | |
| a. Room/Locker Refrigeration Systems. | MUST |
| 2. C Equipment & Appliances. | |
| a. Kitchen Equipment: | |
| - heat/smoke vents. | REQUIRED |
| - ice cream makers | NEEDED |
| b. Ice Machines. | NEEDED |

Table B1 (Cont'd)

| | |
|---|---|
| c. Refrigerators/Freezers: | |
| - reach-in. | REQUIRED |
| - walk-in. | REQUIRED |
| d. Air Dryer Equipment. | NEEDED |
| **H. POL/VEHICLE CENTERS:** | |
| 1. POL Center. | |
| a. Air Compressors. | NEEDED |
| 2. Vehicle Center. | |
| a. Air Compressor. | REQUIRED |
| **I. SERVICE BUILDINGS (SBs):** | |
| 2. SB Components: | |
| b. Roof/Ceiling Components: | |
| - ventilators & ducts. | MUST |
| 3. SB Utilities: | |
| b. SB Appliances: | |
| - AC | REQUIRED |
| - Ice Machines. | NEEDED |
| - Refrigeration Equipment | REQUIRED |
| **J. BUILDINGS, QUARTERS & HOUSING:** | |
| 3. Habitability Systems: | |
| a. Air Conditioners: | |
| - AC, package. | NEEDED |
| - AC, window. | NEEDED |
| c. Appliances: | |
| - ice machines. | NEEDED |
| - refrigerators. | REQUIRED |

Table B2

Interim Assessments of PM Activities

| PM TASKS CONSIDERED | EVALUATION OF PM TASK | PRIORITY LABEL |
|---|---|---|
| A. HOSPITALS: To be supplied. | | |
| B. COMMAND & CONTROL (C2) FAC.: | | |
| 1. Environmental Control. | | |
| a. HVAC Systems: | | |
| - air handlers | HVAC essential to C2 Feas. for this PM Shop | MUST |
| - chillers/refrg.unit | Unit essential to HVAC same | MUST |
| - control system. | same | MUST |
| C. G/P PLANTS: | | |
| 1. Steam Plant (SP). | | |
| b. Forced Air Blowers (FAB): (for boiler furnace) | | |
| - blower unit | FAB essential to SP PM is feasible. | MUST |
| - duct/injection system. | Unit essential to FAB same | MUST |
| 3. Sewage Plant (SgP). | | |
| b. Blower Sys.(BS) in Grit Area | BS is important to SgP. Marg.feas.(poor access) Marg. cost-effective. Blower essential to BS. | MARGINAL |
| c. Blowers, Sludge & Scum Rooms. | same - except completely feasible. | NEEDED |
| f. Compressed Air Supply System (CAS). | | |
| - air compressor | CAS is imp.to SgP. Feas.& cost-effect. | REQUIRED |
| - sto. tank & distr. | Essential to CAS same | REQUIRED |

## APPENDIX C: MANUAL COMPUTATION FOR A DETAILED PM COST-EFFECTIVENESS STUDY

**EXAMPLE** (Deep Well Pump):

Problem: Compare three PM scenarios for an accessible deep-well motor driven pump. Basic charges are provided as follows:

a. In each case pump and drive can be bought and installed for approximately $25,000. If the pump should break down, repair charges are estimated to be approximately $5000. A $2000 down-time charge is assessed for any unscheduled repairs. Scheduled repairs and overhauls cost the same as unscheduled repairs, but can be performed on weekends for $1000 (overtime + other expenses).

b. Full PM and associated PM inspections are performed at a rate of $300/year with a $75 increase every 5 years because of system aging. Nominal PM and PM inspections can be performed at $120/year without increase.

Assumptions:

a. System removal and sales cost always equals salvage return, or salvage is not a factor.

b. The cost of money (interest) is constant at 10%; future purchase inflation is balanced by money charges.

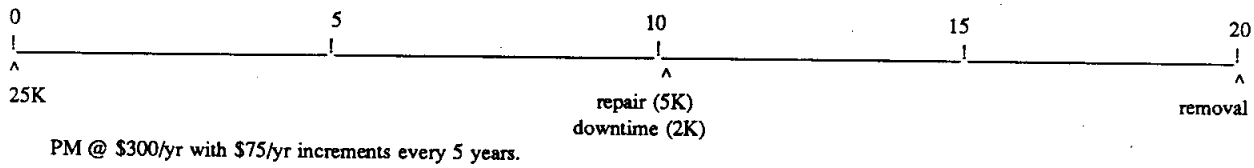
c. The system will last for at least 20 years with full PM services, experiencing only one overhaul in the last 10 years of its projected life.

d. The system will last for at least 15 years with nominal PM (inspections) and one major overhaul.

e. The system will last for at least 10 years with no PM and one breakdown at year 5.

Example Evaluation: Manual computations provide the following results:

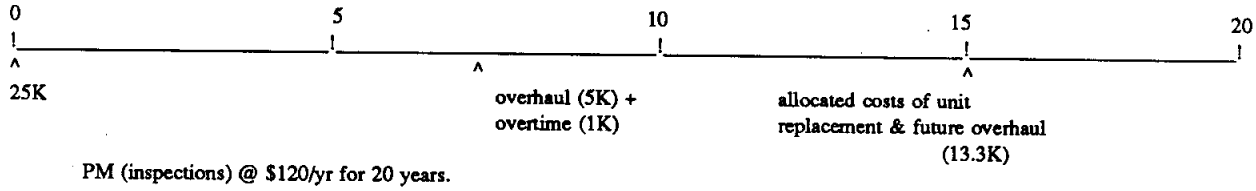
CASE 1: Full PM, 20 year life, a 20 year study period.




PM @ $300/yr with $75/yr increments every 5 years.

| | |
|---|---|
| Initial Outlay: | $25,000 |
| PW(PM): | 3,154 |
| PW(Ovhl) | 1,675 |
| TOTAL | $29,829 |

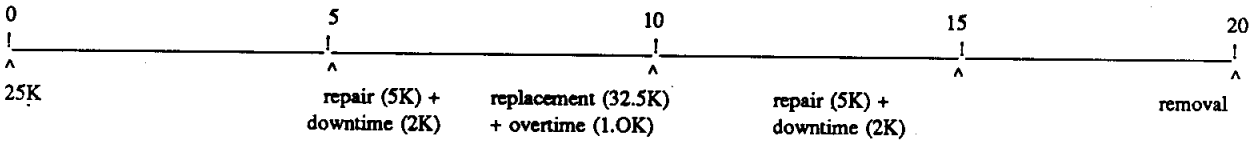
CASE 2: Nominal PM, 15 year life with a 5 year prorated replacement, a 20 year study period.




PM (inspections) @ $120/yr for 20 years.

| | |
|---|---|
| Initial Outlay: | $25,000 |
| PW(PM): | 1,022 |
| PW(Ovhl): | 2,799 |
| PW(13.3K): | 3,172 |
| TOTAL | $31,993 |

CASE 3: No PM, 10 year life with replacement, a 20 year study period.




| | |
|---|---|
| Initial Outlay: | $25,000 |
| PW (Repair 1): | 4,346 |
| PW (Replacement): | 12,916 |
| PW (Repair 2): | 1,675 |
| TOTAL | $43,937 |

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