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16. Abstract

The Texas Department of Transportation (TxDOT) owns and maintains an active fleet inventory of approximately 17,000 units, replacing about ten percent of them annually. Private and public agencies do not routinely use life-cycle cost as a replacement criteria because, until now, the only way to automate the inspection of thousands of life-cycle cost histories was to define an acceptability threshold for annualized costs. Most fleet managers rightfully consider this practice too inaccurate. The most relevant information provided by a life-cycle cost graph is its trend; units whose life cycle costs have been increasing longer and/or at a faster rate should have higher replacement priority. A major contribution of this research project is the development of the life cycle cost trendscore, a method that enables a computer to mimic replacement decisions made by a person visually inspecting a series of life cycle cost histories. Research project 7-4941 developed and tested the Texas Equipment Replacement Model (TERM); a computerized system that uses the trendscore to support equipment replacement decisions with life cycle cost based replacement criteria. TERM is a menu-driven system that can generate data tables and graphs, calculate and compare life cycle cost profiles and trends, prioritize units for replacement based on fleet-wide comparisons of each unit's condition, to the condition of all other units within its class. This report, the third of the 7-4941 series, consists of the TERM software manual.

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TEXAS EQUIPMENT REPLACEMENT MODEL (TERM) SOFTWARE MANUAL

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Research Report 0-4941-3

Research Project 0-4941

"Equipment Replacement Criteria Based On Life Cycle Cost Benefit Analysis (LCCBA) TERM: Transportation Equipment Replacement Methodology"

Conducted for the
TEXAS DEPARTMENT OF TRANSPORTATION

By the
THE UNIVERSITY OF TEXAS AT SAN ANTONIO

July 2003

ABSTRACT

The Texas Department of Transportation (TxDOT) owns and maintains an active fleet inventory of approximately 17,000 units, replacing about ten percent of them annually. Private and public agencies do not routinely use life-cycle cost as a replacement criteria because, until now, the only way to automate the inspection of thousands of life-cycle cost histories was to define an acceptability threshold for annualized costs. Most fleet managers rightfully consider this practice too inaccurate. The most relevant information provided by a life-cycle cost graph is its trend; units whose life cycle costs have been increasing longer and/or at a faster rate should have higher replacement priority. A major contribution of this research project is the development of the life cycle cost trendscore, a method that enables a computer to mimic replacement decisions made by a person visually inspecting a series of life cycle cost histories.

Research project 7-4941 developed and tested the Texas Equipment Replacement Model (TERM); a computerized system that uses the trendscore to support equipment replacement decisions with life cycle cost based replacement criteria. TERM is a menu-driven system that can generate data tables and graphs, calculate and compare life cycle cost profiles and trends, prioritize units for replacement based on fleet-wide comparisons of each unit's condition, to the condition of all other units within its class. This report, the third of the 7-4941 series, consists of the TERM software manual.

DISCLAIMERS

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This research effort was a model of productive teamwork in a cooperative environment.

IMPLEMENTATION RECOMMENDATIONS

This report contains the information needed to install, use, update, and maintain the fist build of the Texas Equipment Replacement Model (TERM) software at TxDOT's General Services Division–Purchase and Equipment Sections. TERM end-users and system managers will also find relevant information in the two previous reports of the 7-4941 series.

The researchers recommend that, in the beginning, fleet managers use Texas Equipment Replacement Model (TERM) capabilities to prepare replacement priority lists based on different combinations of criteria, including automatic qualification based on thresholds. Comparisons among these lists will give managers a good feel for the new method, and will also enable them to devise ways to upgrade and improve TERM's practical features.

TERM should not be regarded as a one-time-only effort. Like all other computer softwares in the market, it should be viewed as an ongoing programming effort, subject to periodic upgrades. In order to accomplish this, TxDOT must assign TERM to a staff member who is proficient in the SAS programming language. This person should be responsible for two tasks: periodic update of the historical data sets used by the program, and ongoing programming of TERM upgrades requested by the users. The first task requires basic knowledge of SAS, enough to run the program in the data update module outside a menu-driven environment, to manipulate and rename the resulting SAS data sets, and to write SAS data step code to implement user-requested data changes, if any. Programming new screens to upgrade the system requires a deep knowledge of SAS, including the more complex SAS/AF, SAS/SCL, and SAS/IML environments. Devising and implementing new modules may require research effort prior to programming.

Prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

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CHAPTER 1
INTRODUCTION

FOREWORD

The primary function of equipment managers is to provide the proper equipment, at the right time and at the lowest overall cost. A major task in accomplishing this function is fleet planning, which involves identifying the requirements of equipment users, developing optimal strategies to meet those needs, and putting the plan into action. Equipment replacement is a complex portion of this process. It requires a methodology to assure that each unit is replaced or remanufactured at its optimal economic life point. This is the main thrust of this research project.

Currently, TxDOT uses a methodology also called TERM, which uses threshold values for age and usage to identify candidates for replacement one year in advance. For example, current replacement threshold values for dump trucks with tandem rear axles (class code 540020) for age and usage, are respectively 10 years and 150,000 miles.

In addition to targeting life and usage, units with exceptionally high repair cost are also targeted, by establishing an exception threshold, so that units that exceed the class average repair costs can be identified. For example, the current system identifies units that exceeded a certain predetermined threshold of the repair costs represented as a percentage of the original purchase cost. Using the dump trucks with tandem rear axles again as an example, the current threshold in TxDOT's TERM system for the repair cost is 100 percent.

SYSTEM OVERVIEW

The computerized system described in this manual was a response to the need for equipment replacement analysis procedures based on engineering economics principles. The new TERM (Texas Equipment Replacement Model) is a SAS/AF Frame entry application created for the TxDOT's General Services Division–Purchase and Equipment Section group at TxDOT.

TERM is composed of two major parts: a database update module, and eight menu-driven modules. These modules query the data base; calculate, report, and plot life-cycle cost histories; tabulate and plot other attributes; perform attribute analysis by make and model; and two modules generate prioritized replacement lists by classcode. One of these modules generates replacement priority lists based on user-selected criteria that can include life cycle cost trends, downtimes, age, mileage, and repair costs, in terms of thresholds and in terms of fleet-level ranking by percentile. There is another ranking module that uses life-cycle costs as the only replacement priority criterion.

MANUAL ORGANIZATION

This report consists of a manual for installing, updating, using and operating the TERM computerized system. Theoretical background for the TERM computerized system can be found in two previous research reports, 4941-1 and 4941-2 (Refs. 1,2).

This software manual is organized into 7 chapters. This first chapter, **Introduction**, presents a general background and describes the manual organization. Chapter 2, **System Framework and**

Overview, discusses TERM's structure, its programming language, and its framework. One-page Chapter 3, **System Installation**, has instructions on how to install TERM in the user's computer, at TxDOT's General Services Division, and at the Districts. Installation is also automated. Chapter 4, **Input Data Sets and Variables**, explains the structure of the SAS data sets used by TERM. It is useful for both the user and the system administrator.

Chapter 5, **Data Update Module**, is also useful for both user and administrator. First, it explains how the system administrator will use the data update program when new a EOS file becomes available. It also explains how the update module detects, flags, and writes reports on equipment units that have changed classcodes and receipt dates (if any). TERM data sets will be updated and ready to use regardless of these changes, which are reported for the fleet managers' benefit. This chapter also conceptually discusses how the units that changed classcodes appear in the replacement priority lists, to assist the managers in making decisions regarding these units.

Chapter 6, **TERM Modules**, thoroughly describes each one of TERM's practical modules to retrieve and plot data, obtain replacement lists, perform life-cycle costs, and perform vendor analysis. The chapter ends with a quick-reference troubleshooting list for the user. Chapter 7, **Summary, Conclusions, and Recommendations**, contains recommendations for TERM implementation, use and future upgrades.

CHAPTER 2
SYSTEM FRAMEWORK AND OVERVIEW

TERM DESIGN

TERM is an automated PC based-system for equipment replacement analysis. The Graphics User Interface (GUI) design of the TERM application provides TxDOT with very good tools to make equipment replacement decisions. This computerized TERM application processes the life cycle cost profiles for different pieces of equipment in the TxDOT inventory, applying the replacement criteria developed by this project to support equipment replacement decisions. The GUI interface integrates all the PC SAS modules developed in a menu-driven software that does not require any training and can be put to immediate use.

The GUI application design objectives are to:

- Eliminate the need to type on keyboard,
- Show all the choices valid for a given situation, and
- Minimize the need for the user to remember data set naming conventions for both input and intermediate and summary files.

The GUI application business objectives are to:

- Eliminate the need to know SAS programming language in order to operate TERM,
- Provide a systematic tool for equipment managers to calculate and effectively utilize equipment life-cycle-costs trends,
- Provide a tool for equipment managers to examine the condition and cost history of each equipment unit, and
- Create equipment replacement priority lists that optimize capital investment, based on a fleet-wide comparison of each unit to the rest of the fleet in its class.

TERM FRAMEWORK

Figure 2.1 depicts TERM's system framework. TERM is divided into four logical sections:

1. A data update module,
2. Two identical copies of an input data set together with an input-output life-cycle cost data set,
3. A research support library, and
4. A series of interconnected menu-driven modules with different reporting and calculating capabilities.

All modules except the data update are menu and button driven and their use is self-explanatory. The data update module, meant to be used periodically by the system administrator, requires only a very basic knowledge of SAS. Programming and implementing system upgrades, such as an additional menu-driven screen or a new graph module, requires advanced knowledge of SAS/AF, SAS/SCL, SAS macros,

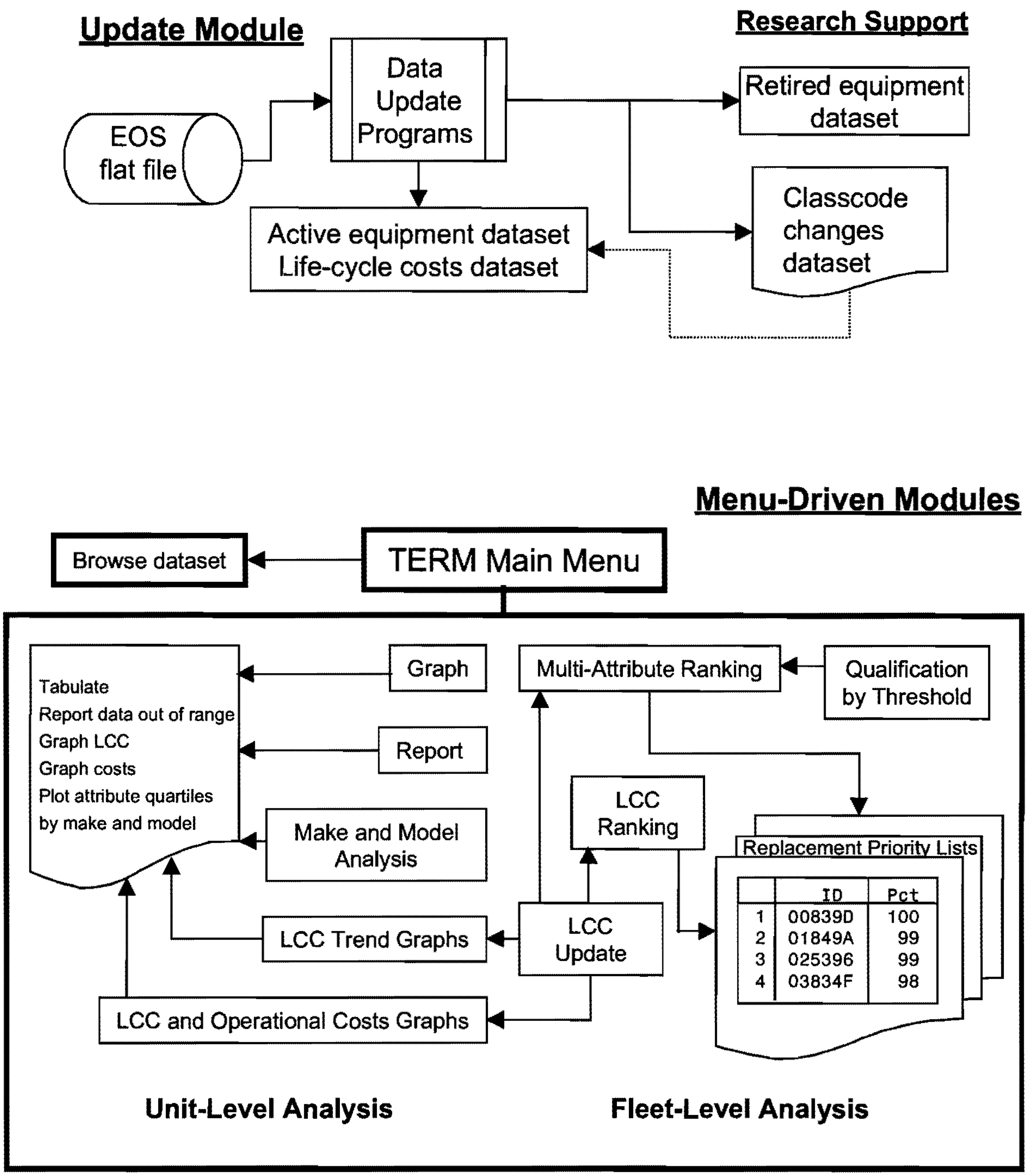


Figure 2.1 TERM Computerized System Framework

and SAS/IML. Developing the underlying concepts and calculations for additional modules and features may require research effort, depending on the complexity of the desired upgrade.

TERM ENVIRONMENT AND LANGUAGE

The TERM system modules and the application's GUI are programmed in SAS language. SAS is an integrated programmable environment providing complete control over data access, management, analysis and presentation. It can perform statistical analysis, reporting, graphics, econometrics and operations research analysis.

SAS has powerful data management, statistical analysis and graphics reporting capabilities. Recently, SAS redesigned its SAS/AF environment, for the development of GUIs. The components of SAS used for GUI development are SAS/AF frames and SCL (Screen Control language) combined with SAS Macros. SAS/AF Frame entries provide a wealth of objects that can be used to control applications and make selections, such as:

- Icons and buttons for function selection,
- Push buttons where selection space is limited,
- Radio boxes for mutually exclusive selections,
- Check boxes for non-exclusive selections,
- List boxes for single dynamic selections,
- Data Tables where multiple columns can be viewed, and
- Text-entry fields.

SAS can handle large databases and analyze and summarize data fairly quickly. Statistical analysis, econometrics, and time series routines are available from the SAS library, which contributed for SAS being selected as the programming environment for this study [Ref. 3].

CHAPTER 3
SYSTEM INSTALLATION

INSTALLING TERM AT TXDOT'S GENERAL SERVICES DIVISION

The installation CD provides the subdirectory Equipment, with all necessary files and the file for the shortcut. They just need to be copied to the appropriate spots in the C: drive. Figure 3.1 shows all the files necessary to run TERM.

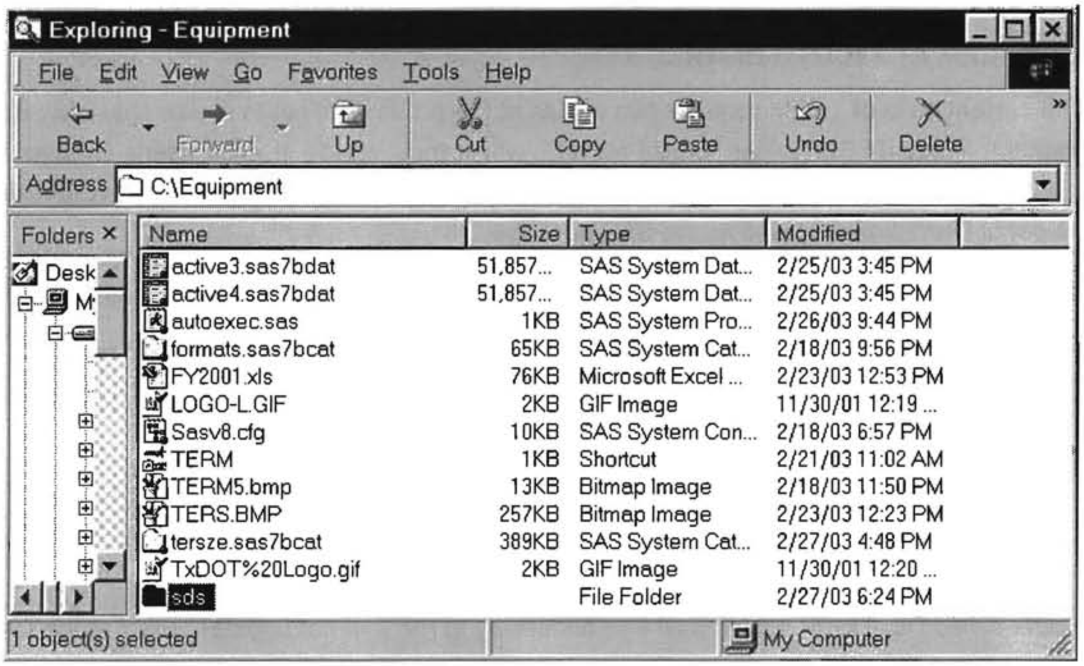


Figure 3.1 Required files to run TERM

Below is a step-by-step procedure for additional clarification.

STEP 1 Make sure the SAS environment is already installed in this computer, including SAS/IML (Interactive **M**atrix **L**anguage). The life cycle cost trends used by TERM modules are programmed in IML. Time-series trend calculations are very time-consuming, and this dynamic programming language is essential because of its efficient memory allocation and dimensioning of matrices.

STEP 2 The installation disk contains a subdirectory named Equipment. This subdirectory needs to be copied to drive C: of the installation computer and should not be nested in another subdirectory. The contents of the subdirectory Equipment, displayed in Figure 3.1, are the required files to run TERM.

STEP 3 Copy the supplied Shortcut file TERM to the desktop of the installation computer.

STEP 4 If this is the system administrator's computer, make sure the subdirectory "SDS" is also copied into directory C:\equipment. This subdirectory does not need to be installed at the user's computer, as it is never used by the menu-driven application. It is used by the data update module. It contains the following files:

- Permanent data sets SDS.RETIRED, SDS.TABLE1, SDS.CLASS_CH AND SDS.RECDT_CH. These files are discussed in chapter 5.
- SAS program "UPDATE.SAS".

STEP 5 Double click the shortcut icon TERM to start the TERM application.

Statewide TERM is now installed in your computer with equipment data up to 2002. The data update module, discussed in Chapter 5, should be used to include the new EOS files, as they become available.

INSTALLING TERM AT TXDOT'S DISTRICTS

The current build of TERM requires two copies of the active data set to reside physically on each user's computer, inside TERM' folder "EQUIPMENT", which must reside in each user's C drive. It also requires SAS to be installed in each user computer. As such, each District user must have his/her own active data set of District data as well as the SAS package.

District-level TERM was **NOT** part of this project's scope. Nevertheless, the researchers delivered a CD with all files and computer programs necessary for:

- Installing TERM in all TxDOT Districts, and
- Periodically updating the District-Level data.

Preparing CDs for District Level Installation

The CD delivered by the research team contains directory DISTRICTS. Inside it, there are the following files:

- Folder called DL_TERM contains all files necessary to run (but not update) TERM at the Districts, **except** the active equipment data. Those are stored in
- 27 SAS data sets named DIST and numbered after the districts. For example, file DIST1.sas7bdat contains the active equipment data set for District 1 (Paris).

The CD to be sent to each District should be prepared as follows:

1. Copy folder DL_TERM into the CD's root and rename it EQUIPMENT;
2. Copy TERM's shortcut into the CD root;
3. Copy the appropriate district data set (DIST*n*.sas7bdat) into the folder you renamed equipment (see step 1);
4. Rename the data set ACTIVE4.sas&bdat (DO NOT RENAME THE FILE TYPE!);
5. Make a copy of ACTIVE4.sas&bdat and rename it ACTIVE3.sas&bdat.

Send the CDs to each District along with a copy of this research report (4941-3, TERM Manual). After installation, the Districts must remember to run TERM's Update LCC module with 0,03 for discount rate and 20 for downtime.

CHAPTER 4
INPUT DATA SETS AND VARIABLES

INPUT DATA SETS USED BY TERM

TERM starts up with three permanent data sets in the EQUIP SAS library: EQUIP.ACTIVE3, EQUIP.ACTIVE4 and EQUIP.LCC. The first two are identical copies; TERM structure sometimes requires two copies of the same data set for efficient operation. Data set EQUIP.LCC contains the results of the life cycle cost calculations, using data from EQUIP.ACTIVE4.

Research report 4941-1 documents in detail the design of TERM's input data set, and the results of a comprehensive data validation. Research report 4941-2 has one chapter with a comprehensive summary of the main findings of this data validation process. It is relevant to note that the validation procedure resulted in a remarkable overall level of accuracy over 99.5%. Nevertheless, TERM contains code to flag data inconsistencies that may be present. The levels of tolerance used for flagging each variable were selected in concert with the project Advisory Committee and are also documented in previous reports for the project (1,2), and summarized in this chapter. TxDOT's file number 29, ADY.DIC.0204 (Ref. 2.1), termed "data dictionary", is a very useful reference for the different variables definitions included in TERM's input data set.

As requested by the Advisory Committee, units not yet received (Status P, Q), retired and slated to be retired (status W, X, Y, Z), classcode 940000 (minor equipment), and undefined classcodes are not part of TERM's data sets. Active data set variables, their meaning, and their characteristics are summarized in tables 4.1 through 4.5. These tables are organized by data type, as follows:

<u>Variables read from the EOS file.</u>

- Unit identification, description and location,
- File dates,
- Yearly usage, cost, and downtime
- Cumulative usage, cost, and downtimes

<u>Variables read from other TxDOT files</u>

- Make description (saved into format "MAKEFM")
- District names (saved into format "DISTFM")
- Classcode description (a data set character variable)

  71-character long SAS variable (CLNAME) records classcode names in the active and retired data sets. This is useful for the system administrator, in case s/he receives a request to retrieve records pertaining to all units in a group of classcodes. For example, SAS command:

  ```
  IF (SUBSTR(CLNAME,1,10)) = ' AUTOMOBILE ';
  ```

  finds all records pertaining to automobiles, without the need to look up classcode numbers, and code one "IF" clause for each relevant classcode.

New variables created by the research team to flag certain issues that affect the analysis interpretation. These variables are explained below, and documented in table 4.6. Both user and system administrator must understand these flags. They are:

- Flag for classcode changes;
- Flag for negative life-cycle cost variables;
- Flag for life-cycle cost variables out of the tolerances assigned by the Project Advisory Committee;
- Two variables to count the number of classcodes per unit: COUNT and NCOUNT. Variable COUNT records the number of classcodes per unit before the research team implemented changes requested by the Advisory Committee (includes data up to 2000). As such, some units have the same classcode throughout their history and variable COUNT>0. Variable NCOUNT records the most recent number of classcodes per unit. The data update module will update this variable automatically. We left variable COUNT in the data set to help the system administrator identify which units were subject to classcode harmonization for replacement decisions implemented by the research team. This variable is missing from 2001 on. The system administrator can decide when to delete it from the active data set.

Table 4.1 Variables for Unit Identification, Capital Cost, and Description

Variable Origin	Variable Name	Type	Length	Meaning	SAS Format
EOS	CLASSCOD	Num.	6	Unit classcode	
EOS	COST-ADJ	Num.		Cost adjustment	
EOS	DISTRICT	Num.	3	TxDOT District	DISTFM
EOS	ID	Char.	6	Unit identification code	
EOS	MAKE	Num.	3	Unit make	MAKEFM
EOS	NETC	Num.	8	Net cost	
EOS	MODEL	Char.	10	Unit model	
EOS	PURCOST	Num.	8	Purchase cost	
EOS	RECDT	Num.	8	Date received	MMDDYY
EOS	SECTION	Num.	3	TxDOT section	
EOS	SIC	Char.	1	Special ID codes	
EOS	STATUS	Char.	1	Status: R, S or V only (see EOS data dictionary, ref. 4)	
EOS	YMADE	Num.	3	Year manufactured	
Other TxDOT	CLNAME	Char.	71	Classcode description	

The active data sets also contain a flag to mark equipment IDs from retired equipment that were reassigned to new units. This flag was useful during the development of this research, since these IDs also appear in the retired data set. The Advisory Committee does not attach any importance to this flag, for TERM users are not concerned with retired equipment. Research report 4941-1 series (ref. 1) discusses the data validation phase in detail, and documents the tolerance ranges established by the project's Advisory Committee. Chapter 2 of research report 4941-2 presents a summary of this documentation, for convenience. Table 4.5 presents a quick-reference summary of these flag variables created by the research team.

Table 4.2 Variables for File Date
Origin: EOS Files

Variable Origin	Variable Name	Type	Length	Meaning	Format
EOS	DBDT	Num.	8	Last database update	MMDDYY
Research team	FLYR	Num.	3	Fiscal year	

Table 4.3 Variables for Yearly Cost and Usage
Origin: EOS Files

Variable Name	Type	Length	Meaning
DIESEL	Num.	8	Diesel expenses in latest fiscal year
DIESELQ	Num.	8	Diesel gallons in latest fiscal year
DOWN	Num.	8	Downtime hrs in FY in latest fiscal year
GAS	Num.	8	Gasoline expenses in latest fiscal year
GASQ	Num.	8	Gasoline gallons in latest fiscal year
HYDFL	Num.	8	Hydraulic fluids expenses in latest fiscal year
HYDFLQ	Num.	8	Hydraulic fluids quarts in latest fiscal year
INDIRECT	Num.	8	Indirect expenses in latest fiscal year
OIL	Num.	8	Oil expenses in latest fiscal year
OILQ	Num.	8	Quarts of oil in latest fiscal year
OTHERFUEL	Num.	8	Other fuel expenses in latest fiscal year
OTHERFUELQ	Num.	8	Other fuel gallons in latest fiscal year
RENTAL	Num.	8	Rental cost
REPAIR	Num.	8	Repair expenses in latest fiscal year
USAGE	Num.	8	Usage in latest fiscal year
USECD	Char.	2	Usage code, "mi" for miles, "hr" for hours.

Table 4.4 Variables for Cumulative Costs
Origin: EOS Files; All Lengths 8 SAS Bytes, Numeric

Variable Name	Meaning
CUM_DIESEL	Cumulative diesel expenses from receipt to latest recorded fiscal year
CUM_DIESELQ	Cumulative diesel quantities from receipt to latest recorded fiscal year
CUM_DOWN	Cumulative downtime hours from receipt to latest recorded fiscal year
CUM_GAS	Cumulative gasoline expenses from receipt to latest recorded fiscal year
CUM_GASQ	Cumulative gasoline quantities from receipt to latest recorded fiscal year
CUM_HYDFL	Cumulative hydraulic fluids expenses from receipt to latest recorded fiscal year
CUM_HYDFLQ	Cumulative hydraulic fluids quantities from receipt to latest recorded fiscal year
CUM_INDIRECT	Cumulative indirect cost
CUM_OIL	Cumulative oil expenses from receipt to latest recorded fiscal year
CUM_OILQ	Cumulative oil quantities from receipt to latest recorded fiscal year
CUM_OTHERFUEL	Cumulative other fuel expenses from receipt to latest recorded fiscal year
CUM_OTHERFUELQ	Cumulative other fuel quantities from receipt to latest recorded fiscal year
CUM_REPAIR	Cumulative repair expenses from receipt to latest recorded fiscal year
CUM_USE	Cumulative usage from receipt to latest recorded fiscal year. Variable USECD indicates miles or hours; see table 4.3.

RETIRED EQUIPMENT DATA SET

The retired equipment data set is a subset of the EOS data files analogous to the active data set. It contains the histories of equipment either already retired, or slated for retirement, starting with the 1990 EOS file. When a new EOS file becomes available, the data update module checks for equipment newly retired or slated to be retired, removes the entire histories of these units from the active data set, and places them in the retired data set. This data set resides in a separate subdirectory from the one used for running TERM, and is assigned to a separate SAS library (named SDS, an acronym for support data sets) during the data update module execution.

The TERM system, of course, does not use information from the retired data set, since it concerns itself with replacement priorities for active equipment. The research team recommends that TxDOT should maintain the retired data set for future research purposes. This data set contains the same variables of the active data sets, plus variables to indicate retirement date, resale costs, etc. It does not have flag variables, since these are useful for replacement decisions based on life cycle costs. Table 4.6 shows these differences in detail.

Table 4.5 Flag Variables
Origin: Research Team

Variable Name	Type	Length	Values	Meaning
COUNT	Num.	3	0 to records per ID-1	Number of classcodes per ID before research team implemented requested changes (2000 and before).
NCOUNT	Num.	3	0 to records per ID	Number of classcodes per ID latest fiscal year
	Char.	7	RECY_ID	Indicates if the equipment ID was reassigned from a retired unit (up to 2000)
FLAG1			blank	ID not in retired data set (up to 2000)
			NOT_UPD	No longer updated (as indicated by Advisory Committee
FLAG2	Num.	3	0	No negative costs
Indicates if			1	Repair or indirect costs are negative
there are			2	Fuel costs and respective quantities are negative
negative values			3	Fuel costs are negative but quantities are positive
for costs, usage, downtime, or			4	Fuel quantities are negative but costs are positive
quantities			5	Fuel (cost and/or quantity) and (repair or indirect) are negative
FLAG3	Char.	5	OK	Classcode is constant throughout the unit (ID) history
Indicates			SIZE	Classcode changed to a different size of equipment
classcode			DESCR	Classcode changed to a different equipment description
changes			OTHER	Other reasons, especially mounting/ dismounting devices
			PEND	Classcode change is awaiting inspection by fleet manager
FLAG4	Num.	3	0	No values out of range
Indicates unit costs, usage, or			1	Mileage>80,000 mi/year or Hours of usage> 8,760 (mileage/40mph)+downtime>8,760 hours
downtime values			2	Downtime>2,080 hours
out of tolerance			3	Gas: unit price outside the $0.5 to $2.00 range
ranges			4	Diesel: unit gallon the $0.5 to $2.00 range
			5	Hydraulic fluids: unit price outside the $0.5 to $2.00 range
			6	Oil: unit price outside the $0.5 to $2.00 range
			7	More than one of the flag4 criteria
			8	Negative value for mileage, downtime, or fuel price/fuel quantity

Table 4.6 Differences Between Contents of the Retired and Active Equipment Data Sets

Variables Added	Type	Length	Meaning
RESALE	Num.	8	Resale Price
RETCD	Num.	2	Retirement codes, 1 through 9, see EOS data dictionary, pg. 13, ref. 4, for meanings.
RETDT	Num.	3	Retirement date.
Variables Removed			FLAG1 through FLAG4, COUNT and NCOUNT

CHAPTER 5
DATA UPDATE MODULE

MODULE OBJECTIVE

The data update module should be used at least once a year, when the end of fiscal year summaries from EOS become available, to include the newest EOS database records in the historical data set, flag out-of-range data, remove retired equipment from it, and generate reports on units that changed classcode and receipt date. This is the only module that does not have a menu-driven interface, since it is meant to be used by the system administrator, who must be proficient in the SAS programming language.

The classcode change issue will require the fleet managers' participation and attention. The receipt date change issue (discussed later in this chapter) may also require the managers' attention. These issues are highlighted in a separate sub-section that should be read by the fleet managers in addition to the system administrator.

UPDATE MODULE COMPONENTS

SAS Program

This program reads the selected records from the EOS file (discussed in Chapter 4 and summarized in Tables 4.1 through 4.5), applies the data validation criteria and creates the flag variables discussed in chapter 4. It also writes units that changed classcodes as well as those that changed receipt date to two permanent SAS data sets for inspection. Details on these flag variables and other data validation criteria are discussed in detail in research report 4941-1 (ref. 1) and summarized in chapter 2 of research report 4941-2 (ref. 2),

Program UPDATE.SAS contains full internal documentation. It starts and ends with explanation of the data update procedure; and each one of its steps is explained. Some samples of documentation are listed below.

Example of file definition documentation

```
libname equip 'c:\equipment'; /*this is TERM*/
```

Example of input variables documentation

```
/****** read data from new EOS file **********
*****************************************************/
 data new; flag='O';
 infile in_new;
 input
 ID $ 1-6  /* equipment unit identification */
Classcod 7-12     /*equipment class code */
```

Example of program section documentation

```
/***************************************************************************
Remove units that are either retired or slated to be retired from the previous
EQUIP.active4 data set and:
    ----1. append them to previous SDS.retired data set.
           PRODUCT: permanent data set SDS.retired2 is updated.
    ----2. remove them from the new data.
           results:  temporary data set ac2001.
                     permanent data set equip.active5=previous EQUIP.active4
                     purged from retired equipment EQUIP.active5 still lacks
                     the new data this program will later append.
***************************************************************************/
proc sort data=new; by id;
data ret2; set new;
if ((status='Z') or (status='W') or (status='Y')or (status='X'));
```

Sample of documentation written in the end of program UPDATE.SAS

```
/**************************************************************************
   PRODUCTS: 1. PERMANENT DATA SETS EQUIP.ACTIVE5.
             2. Permanent data set sds.retired2. Never called by the system,
                kept updated for future research needs only.
             3. Permanent data set SDS.recdt_ch. It has the entire history
                of units that changed receipt date.
             4. Permanent data set SDS.Class_ch. It has the entire history
                of units that changed classcode.
              DATA SETS SDS.RECDT_CH AND SDS.CLASS_CH may be empty!!!!!

RECOMMENDATIONS:
  WE RECOMMEND MAKING SURE THE NEW DATA SETS EQUIP.ACTIVE5 AND SDS.RETIRED2
  ARE CORRECT. (YOU MAY USE PROC COMPARE). The syntax is:
```

Flat Input File (EOS)

Program UPDATE.SAS reads the end of fiscal year summaries for the variables discussed in chapter 4, and summarized in Tables 4.1 through 4.5. The end of fiscal year summaries are downloaded from EOS, which currently resides in the TxDOT mainframe, in text (flat file) format with a certain specification.

The variables relevant for the update program required a logical record length of 1,531 for fiscal year 2001. For fiscal years 2000 and before, the logical record length was 1,509 characters. The system administrator must check with the EOS administrator if the length and format of any EOS variable has changed. If they have, he must edit the input statement in program UPDATE.SAS to reflect these changes. The file definition LRECL specification may also change.

Excel Spreadsheet

In order to facilitate editing the input statement if EOS record formats change again, the research team prepared an Excel spreadsheet that calculates column pointers and minimal logical record length, given the variable lengths and data column pointers in the EOS file formats. This version of the spreadsheet included with TERM system calculates column pointers referring to fiscal year 2001 EOS file format. This spreadsheet is an updated version of the original one, which was compatible with EOS files 2000 and before. Table 5.1 shows a part of this spreadsheet.

Table 5.1 Sample Spreadsheet for UPDATE.SAS Program Input Statement

#O-BASIC-SEGMENT	(A108)	Format	Start Col.	End Col.	
REDEFINE #O-BASIC-SEGMENT					
#O-EQUIP-NO		(A6)	1	6	
#O-CLASS-CODE		(A6)	7	12	
#O-LAST-UPDT-DATE-DT		(N8)	13	20	
#O-LAST-UPDT-TIME		(N8)	21	28	
#O-EQUIP-STATUS		(A1)	29	29	
#O-INVENT-SECT		(N1)	30	30	
#O-DISTRICT		(N2)	31	32	
#O-SECTION-NO		(N2)	33	34	
#O-MAKE-CODE		(N3)	35	37	
#O-MODEL-NAME		(A10)	38	47	
#O-MODEL-YEAR-DT		(N4)	48	51	
#O-RECEIPT-DATE-DT		(N8)	52	59	
#O-EQUIP-SERIAL-NO		(A17)	60	76	
#O-CHAS-SERIAL-NO		(A17)	77	93	
#O-COUNTY-NO		(N3)	94	96	
#O-TRANSFER-DATE-DT		(N8)	97	104	
#O-TRANS-DIST-FROM		(N2)	105	106	
#O-TRANS-SECT-FROM		(N2)	107	108	
#O-UTILIZATION-SEGMENT	(A8)				
REDEFINE #O-UTILIZATION-SEGMENT					
#O-USE-UNIT-CODE		(N2)	109	110	
#O-RENT-RATE		(A6)	111	116	/* SIGN,31NTEGERS,2DEC
#O-CAPITAL-ASSET-SEGMNT	(A36)				
REDEFINE #O-CAPITAL-ASSET-SEGMNT					
#O-PURCHASE-COST		(A10)	117	126	/* SIGN,7INTEGERS,2DEC
#O-NET-ADJ-CAPITAL		(A10)	127	136	/* SIGN,7INTECERS,2DEC
#O-SALVAGE-PERCENTAGE		(A4)	137	140	/* SIGN, 3DECIMALS

Support Data Sets (SDS)

Program UPDATE.SAS will read classcode names from support SAS data set "TABLE1", and will append the retired equipment records into SAS data set SDS.RETIRED, creating an updated version named SDS.RETIRED2. The program will also create two other data sets (SDS.CLASS_CH and

SDS.RECDT_CH) if it finds instances of classcode changes or receipt date changes. This issue is discussed in the next section.

SDS files reside in separate folder (C:\EQUIPMENT\SDS). The update program loads them into a SAS library also named SDS. Both active and retired data sets call SAS format catalog stored in SAS catalog "FORMATS" residing in TERM's SAS library and in the research SAS support library SDS. This catalog defines internal formats for numeric variables MAKE and DIST (District), automatically reported respectively by description and name (see SAS PROC FORMAT for details).

THE DATA UPDATE PROCEDURE

Updating for the System Administrator

STEP 1 Obtain the new EOS files, and check to see if its format changed. If so, edit the input statement in program UPDATE.SAS to make sure the data are being read correctly. Use the spreadsheet provided with TERM for convenience, to calculate column pointers for EOS changes in variable lengths.

STEP 2 In the data update program delivered by the researchers, the EOS file appears defined as:

```
filename in_new 'c:\3equipment\databases\Heqp2001' lrecl=1531;
```

Edit this statement to reflect the file name and location you selected. If EOS variables have changed length, make sure the logical record length 1531 is enough to reach the last EOS variable read by the input statement, which is:

```
cum_down 1309-1318 /* total downtime from recdt to date */
```

STEP 3 Run UPDATE.SAS program. Program UPDATE.SAS will output the following permanent SAS data sets:

(1) **EQUIP.ACTIVE5**, which is the updated version of the old active equipment data sets, at this point still in your equipment folder and SAS library EQUIP with original names EQUIP.ACTIVE4 and EQUIP.ACTIVE3 (TERM requires two copies to run).

(2) **SDS.RETIRED2**, which is the updated version of the old retired data set SDS.RETIRED, at this point also still in your SDS library. This data set is never by TERM, but the researchers strongly recommend keeping it updated for future research needs.

(3) **SDS.CLASS_CH** has the entire history of units that changed classcode. It will **replace** the previous year's class code changes report.

(4) **SDS.RECDT_CH** has the entire history of units that changed receipt date. It will **replace** the previous year's receipt date changes report.

STEP 4 If data set SDS.RECDT_CH is not empty, the system administrator should study it and see if these changes were obvious typos in the new EOS version. S/he should then write SAS code to ensure that the receipt date is consistent throughout the unit's history. This is a negligible amount of work. The research team found and corrected only 23 instances of such typos in 11 years of history. The 2001 EOS, for example, had only one of these cases. This issue is best checked by hand, because some receipt date changes are due to classcode changes. For example, when a new device is bought and mounted on a truck already in the EOS database, the receipt date will indicate the device's rather than the truck's receipt date. These instances will be reported in data set SDS.CLASS_CH.

STEP 5 Check and then rename and copy the updated data sets. Program UPDATE.SAS will not replace old data sets EQUIP.ACTIVE4, EQUIP.ACTIVE3, and SDS.RETIRED. This is a safety precaution. We recommend you make sure the new data sets are correct before renaming them and creating a copy. PROC COMPARE can pick al variable additions and changes; sorting both data sets by file year (regardless of equipment ID) will place all new data at the end of EQUIP.ACTIVE5, and facilitate the checking process. When you are satisfied that EQUIP.ACTIVE5, and SDS.RETIRED2 are correct:

Erase EQUIP.ACTIVE4, rename EQUIP.ACTIVE5 as EQUIP.ACTIVE4, create a copy, and rename it EQUIP.ACTIVE3. TERM requires two copies of the active data set with these names.

Erase SDS.RETIRED, rename SDS.RETIRED2 as SDS.RETIRED. TERM never uses this data set, but the data update module does, and won't run properly if SDS.RETIRED is not available or if it is named differently.

STEP 6 To finalize updating TERM, run TERM's "Update LCC" module with default values downtime = $20 and discount rate=0.03. This will create permanent data set LCC which is necessary to run TERM. The Update LCC module is available from within the Retrieve Data, Ranking and LCC Ranking modules discussed later in this report.

TERM IS NOW UPDATED.

The system administrator can now distribute copies of the updated data sets: EQUIP.ACTIVE3, EQUIP.ACTIVE4, and EQUIP.LCC, the only ones used by TERM. If data set SDS.CLASS_CH is not empty, give a printout to the fleet managers, and implement their recommendations (if any). This issue is discussed in the next section. There is no need to wait for the fleet managers to decide about the classcode changes in order to start using TERM.

Classcode Changes

TERM ranks replacement priorities by classcode, using data from the latest fiscal year. If units changed classcode, the program writes them into data set SDS.CLASS_CH, which resides in the support library. Table 5.2 shows a partial printout of this data set. File CLASSCH.XLS is an excel spreadsheet with complete list of changes detected by the research team, but not checked by the project's Advisory Committee. Classcode changes occurred 2000 and before have already been inspected by the Advisory Committee; in some cases, the Committee decided to assign the previous classcode for the unit, so it could be prioritized for replacement together with units from its previous classcode. These decisions are already implemented. This matter is documented in research report 4941-1 (ref. 1).

Data set SDS.CLASS_CH may be empty. If not, the equipment managers should study it and decide if they want to include these units in its previous classcode for the purposes of replacement priority. These decisions cannot be automated at this point; the fleet manager must study the unit's history to decide what to do.

The researchers reiterate to the fleet managers that TERM can run perfectly well **without** the need to harmonize classcodes throughout the units' history. It can also run with the new data **while** fleet managers are inspecting file SDS.CLASS_CH. This file is generated for convenience, in case the manager desires to rank the unit in the replacement list of a classcode other than its latest.

If the fleet managers request changes in the database, the system administrator will write SAS code to perform these customized requests. Character variable FLAG3 values should reflect the type of change requested by the fleet manager, as shown in table 4.5.

Table 5.2 Classcode Changes from 2000 to 2001 (Sample of SDS.CLASS_CH Data Set)

ID	NEW CLASS	OLD CLASS	OLD NAME	NEW NAME
01444	90030	90040	GRADER, MOTOR, CLASS IV, 150 H.P. AND GREATER	GRADER, MOTOR, CLASS III, 125 TO 149 H.P.
02076C	178020	176010	ROLLER, TAMPING, SELF PROPELLED	ROLLER, VIBRATING, SELF PROPELLED W/PNEUMATIC TIRES
02120C	178020	176010	ROLLER, TAMPING, SELF PROPELLED	ROLLER, VIBRATING, SELF PROPELLED W/PNEUMATIC TIRES
02284D	115030	115020	LOADER, PNEUMATIC TIRED, INTEGRAL UNIT, 5200 TO 6699 LB OPSCAPACITY	LOADER, PNEUMATIC TIRED, INTEGRAL UNIT, 6700 TO 8000 LBS. OPS. CAP.
02285D	115030	115020	LOADER, PNEUMATIC TIRED, INTEGRAL UNIT, 5200 TO 6699 LB OPSCAPACITY	LOADER, PNEUMATIC TIRED, INTEGRAL UNIT, 6700 TO 8000 LBS. OPS. CAP.
02448D	115030	115020	LOADER, PNEUMATIC TIRED, INTEGRAL UNIT, 5200 TO 6699 LB OPSCAPACITY	LOADER, PNEUMATIC TIRED, INTEGRAL UNIT, 6700 TO 8000 LBS. OPS. CAP.
02451	230030	192020	SPRAYER, HERBICIDE/INSECTICIDE TRAILER MOUNTED, SELF POWERED	TRACTOR, PNEUMATIC TIRED, 65 H.P. AND ABOVE (TRACTOR ONLY)
02538D	115030	115020	LOADER, PNEUMATIC TIRED, INTEGRAL UNIT, 5200 TO 6699 LB OPSCAPACITY	LOADER, PNEUMATIC TIRED, INTEGRAL UNIT, 6700 TO 8000 LBS. OPS. CAP.
02794D	115030	115020	LOADER, PNEUMATIC TIRED, INTEGRAL UNIT, 5200 TO 6699 LB OPSCAPACITY	LOADER, PNEUMATIC TIRED, INTEGRAL UNIT, 6700 TO 8000 LBS. OPS. CAP.
02804	230030	136010	MOWER, SLOPE,SIDE BOOM, ROTARY OR FLAIL, TRACTOR MOUNTED(INC.TRACTOR)	TRACTOR, PNEUMATIC TIRED, 65 H.P. AND ABOVE (TRACTOR ONLY)

The research team recommends saving these changes in a different data set, and running a PROC.COMPARE to make sure the only changes were those requested by the managers. Make sure both data sets are sorted by the same variables before comparing. After implementing these changes, and before distributing copies of the newly corrected active data sets, the system administrator should **remember to**:

- Update ACTIVE3; it should be a copy of ACTIVE4.
- The system administrator needs to run TERM's "Update LCC" module again ONLY if any of the requested changes included deleting or adding observations to the active data sets, or if they asked to change any cost variable. If in doubt, run it again and either distribute to users, or remind them to run their own update LCC module immediately.

Data Update Troubleshooting

Question I think program UPDATE.SAS has a reading format error. I get lots of "invalid data" messages in the log.

Answer The program reads date variables in SAS date format. When a date is missing in the EOS file, it is coded as string of zeroes, which is an invalid SAS date format. When SAS reads an invalid format it sets the value to missing, which is the intended match to the EOS file. This happens often because the retirement date it is missing for all active units.

Question Regarding the classcode changes, data set ACTIVE4 has several instances of equipment history that have FLAG3 values indicating a classcode change, variable COUNT values greater than one, but the same classcode throughout the unit history. Is this a data set error?

Answer No. The Advisory Committee requested classcode harmonization in many cases, and these were implemented. Variable COUNT was left there to assist you in finding these units, should the need arise.

Question I ran a PROC COMPARE to make sure the updated data sets are correct and almost all variables are different.

Answer Try running PROC COMPARE again after making sure both data sets are sorted exactly the same way.

Question Data set SDS.CLASS_CH is empty.

Answer There were no classcode changes.

Question Data set SDS.RECDT_CH is empty.

Answer There were no changes in receipt date.

Updating TERM at District Level

The process of creating District-Level data sets for TERM has already been automated by the research team. TERM's installation CD contains file DISTRICT.SAS in the directory "Districts". Once the data update process is completed according to the steps described above, the system administrator should run program DISTRICT.SAS. It creates each District's active data set, named and stored as described in the installation section. The system administrator will then send the updated active data sets to each District. The District person should rename this file ACTIVE4.sas&bdat, create a copy, and rename it ACTIVE3.sas&bdat. These new versions should replace the old copies in each user's own C:\EQUIPMENT folder. Updating District Level TERM

RECOMMENDATION

Updating the data sets at District level would become unnecessary after reprogramming TERM as a Web-enabled application. Web-based TERM could provide remote access to the data and bring the TERM application to any desktop, regardless of whether or not SAS software is installed in that specific computer. Once the statewide active equipment data sets are modified or updated, all users would have immediate access to it. The system administrator's workload would be greatly reduced, and District level personnel would not have to worry about checking the status of their data and/or TERM upgrades. A web-based application would make TERM maintenance extremely efficient.

CHAPTER 6
TERM MODULES

This chapter explains the user-friendly TERM modules designed for use by fleet managers. This manual concentrates on practical issues: navigating TERM, understanding the outputs, and user troubleshooting. TERM relies on three innovative concepts developed by this project: the life cycle cost trendscore, the fleet-level priority rank methodology, and automatic qualification combined with ranking. They are TERM's analytical foundation. Research report 4941-2 documents the development of these concepts. It also presents a discussion of the life cycle cost concept and calculation (Ref. 2).

MAIN MENU SCREEN

The main menu allows the user to access TERM's other modules. Figure 6.1 depicts a screen capture of the main menu module. It provides the user with eight navigation buttons named as follows:

1. Retrieve Data,
2. Rank,
3. LCC rank,
4. LCC and Trend,
5. Analysis Make/Model,
6. Plot Graph,
7. Exit, and
8. About TERM.

All buttons except the "exit" access additional screens that perform TERM functions and calculations. TERM runs within the SAS environment. The exit button exits both TERM and SAS.

The screens accessed by the first four buttons of the list above provide access to another supporting screen to recalculate the life-cycle costs with different values for cost of downtime and discount rate. All screens are discussed in this chapter.

The main menu screen allows the user to scroll through the active equipment data set used in the analysis. The five lines and columns shown in Figure 6.1 represent the historical data for equipment ID 00001D for fiscal years 1995 through 1999. By using the horizontal scroll bar, the user is able to see the remainder of the historical variables for this specific unit. By using the vertical scroll bars, the user is able to see the rest of this unit's history, and other records in the active equipment database.

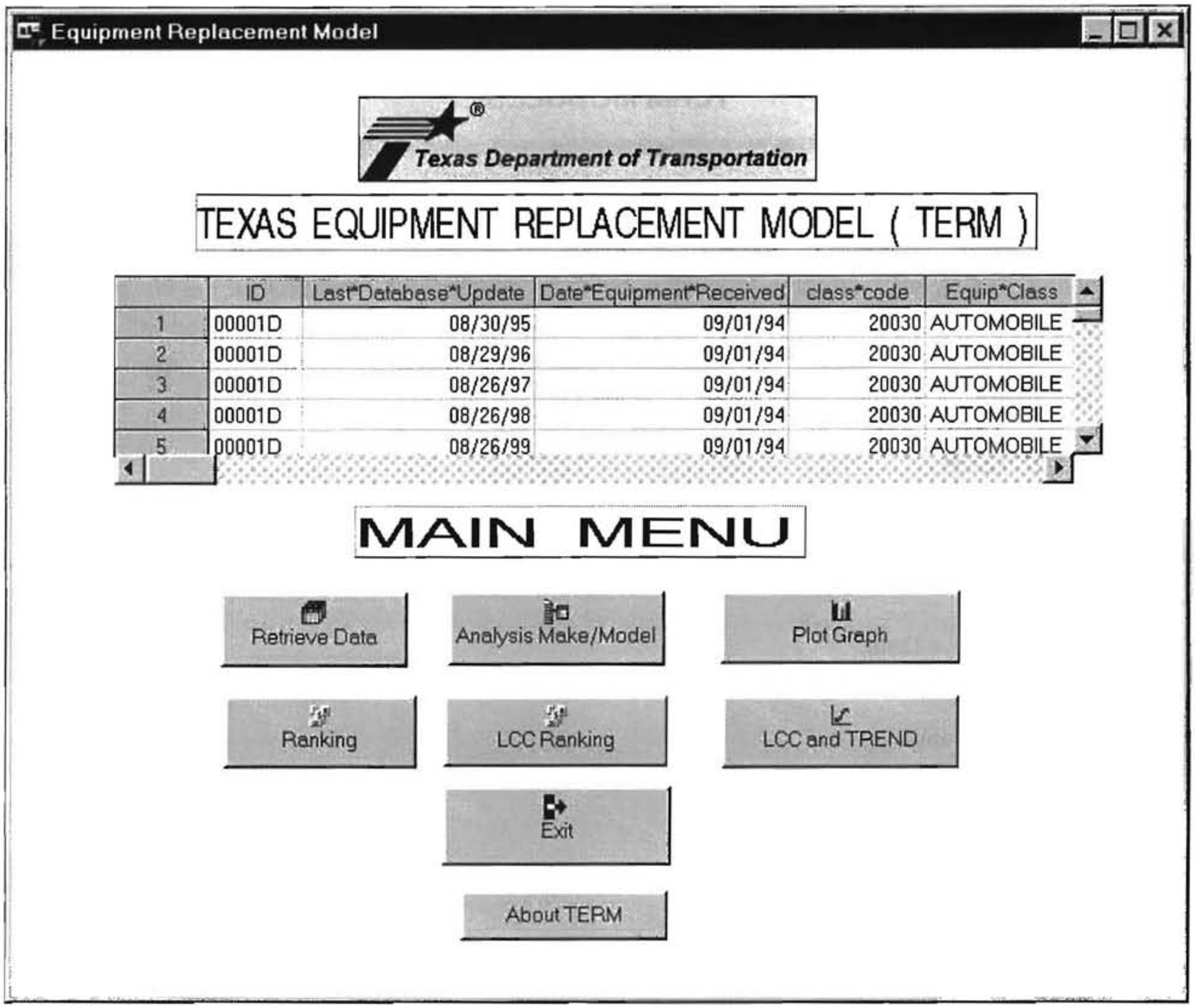


Figure 6.1 TERM Application Main Menu

ABOUT TERM SCREEN

The "about" button in the main menu screen is an operational module of the TERM system. It displays a list of the different modules that compose TERM, with their respective build dates. It also displays the credits for the program development. Figure 6.2 shows a screen capture of the "About Screen". The OK button returns the user to the Main Menu screen.

Each of the components listed in this screen is a component of SAS catalog TERZE, which is a file that contains all the SAS AF/SCL code needed to run TERM. TERZE is one of the files listed in the installation directory C:/Equipment (see figure 3.1 in chapter 3). For example, figure 6.2 indicates that the SAS AF/SCL code for the about screen was last updated 02/25/2003 at 6:38 PM.

This feature was included to allow the user to check if his/her TERM build is the latest, and ask for new features that the system administrator may have added.

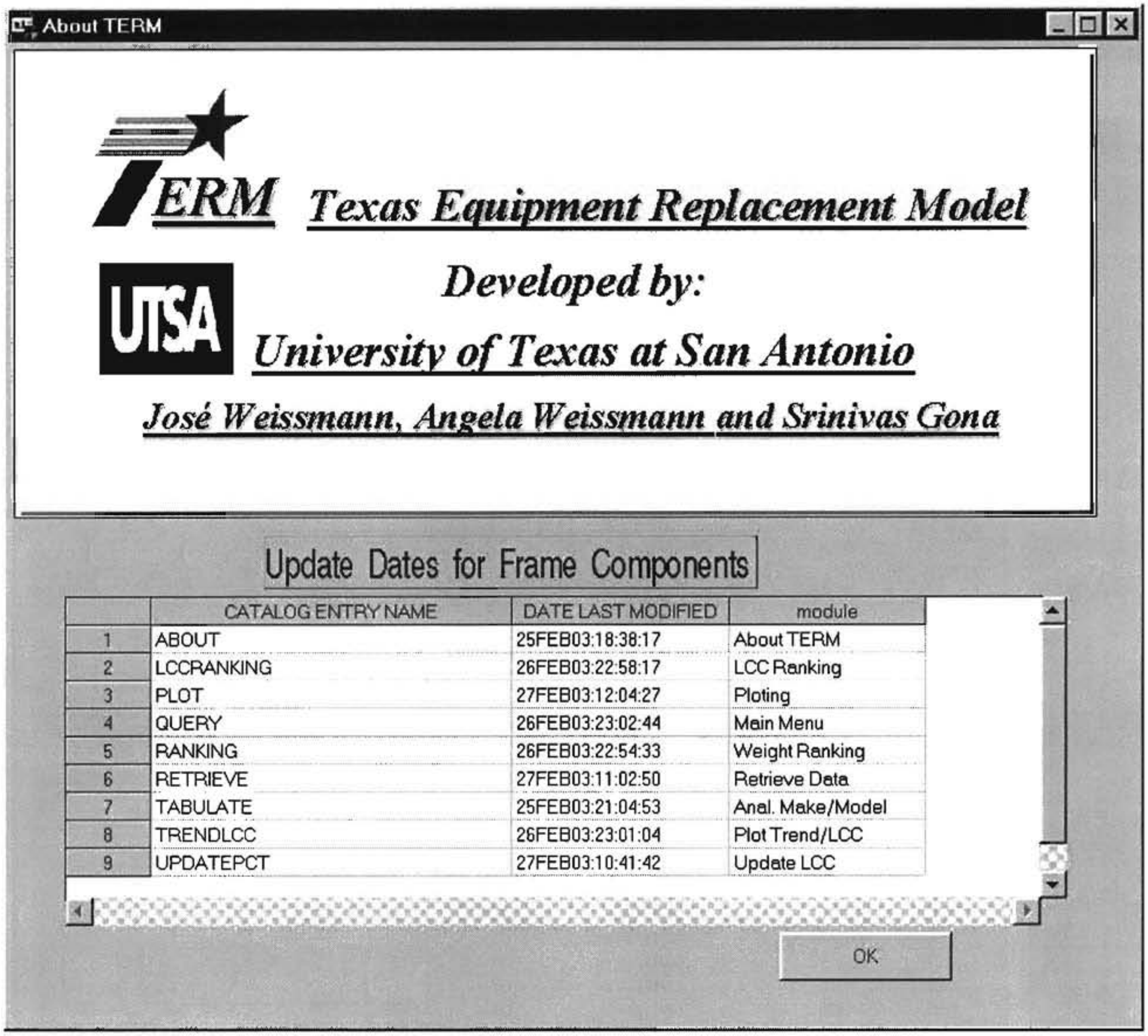
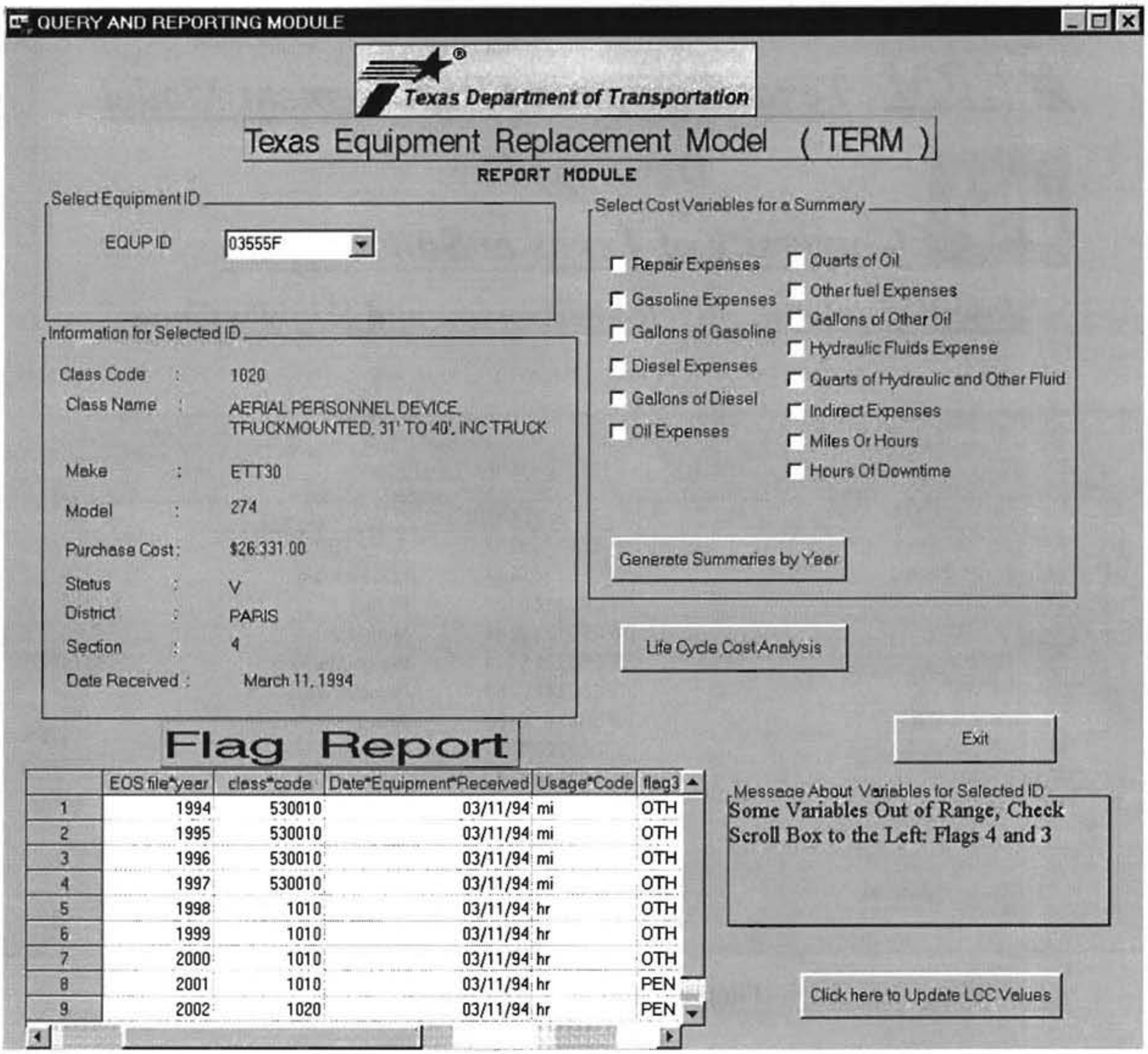


Figure 6.2 About TERM screen

RETRIEVE DATA SCREEN

The Retrieve Data button accesses the Report Module screen, depicted in Figure 6.3 below. This module allows the user to retrieve specific data for an equipment ID selected from the drop down box at the top of the screen. TERM outputs the "information for the selected ID" in the appropriate box. During the data retrieval process, TERM checks for out-of-range data and classcode changes, using the flag variables discussed in chapter 4. In case there is a flagged value for this unit, the "Flag Report" window pops at the bottom, allowing the user to inspect the flag variables.

In order to explain this feature, we intentionally selected a unit that had a classcode change (FLAG3='OTHER'), and an out-of-range value (FLAG4=1). Table 4.6 indicates that a value 1 for FLAG4 means that either usage or usage plus downtime are out-of-range. The TERM user can now inspect these variables in two ways: by returning to the main menu screen (figure 6.1) and using the scroll box or, more conveniently, by selecting the desired variables in this screen (see figure 6.3 below). Clicking the "generate summaries by year" button generates the report displayed in figure 6.4.



	EOS file*year	class*code	Date*Equipment*Received	Usage*Code	flag3
1	1994	530010	03/11/94	mi	OTH
2	1995	530010	03/11/94	mi	OTH
3	1996	530010	03/11/94	mi	OTH
4	1997	530010	03/11/94	mi	OTH
5	1998	1010	03/11/94	hr	OTH
6	1999	1010	03/11/94	hr	OTH
7	2000	1010	03/11/94	hr	OTH
8	2001	1010	03/11/94	hr	PEN
9	2002	1020	03/11/94	hr	PEN

Figure 6.3 Data Report Module Screen

The user can then understand this unit's history. In 1997, an aerial device (classcode 1010, usage in hours) was mounted on this truck (classcode 530010, usage in miles). The project Advisory Committee decided to leave both classcodes in TERM active's data set. This is why FLAG3='OTHER'. In 1998, the downtime values are within range, but usage (9,497 hours) was greater than the maximum number of hours per year (FLAG4=1).

If the output screen shown in figure 6.4 does not appear after clicking the "generate summaries by year" button, open the output window by selecting View-Output from the menu bar above TERM's screen (not shown in this chapter's figures). The output can be saved to a file, sent to a printer, and copied or exported into another application such as Microsoft Word for further reporting and formatting.

Clicking on the exit button returns to the main menu screen. Results can also be generated in HTML format. To do this, select Tools→options→preferences, then go to results tab and check Create HTML. Check box and click OK.

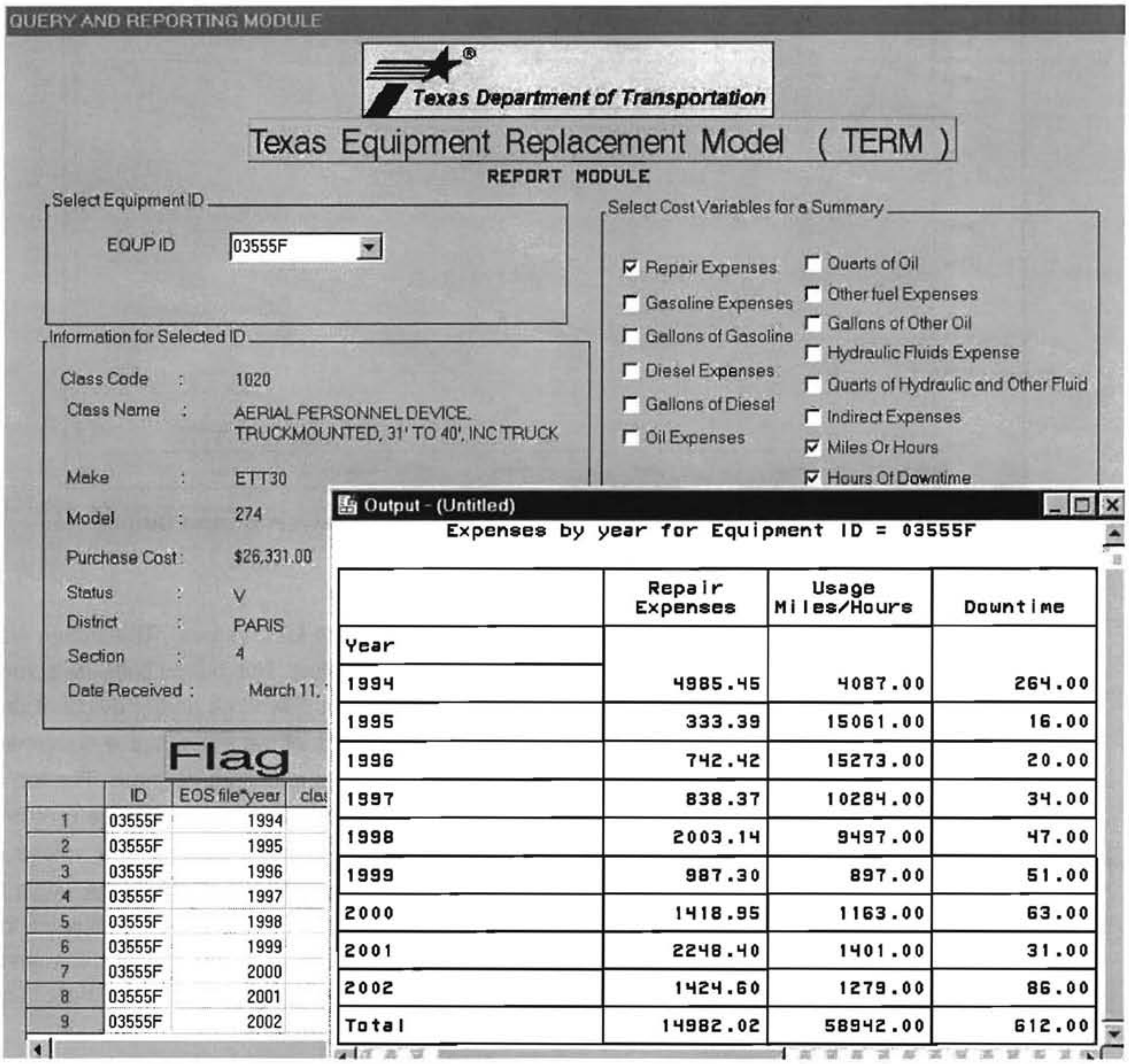


Figure 6.4 Data Report Module Screen: Generate Summaries by Year Output

The user can also click on "life-cycle cost analysis" to generate the output depicted in figure 6.5. The cost of mounting the aerial device is evident in the equivalent uniform annualized costs (LCC or EUALCC) graph: there is a peak in 1998.

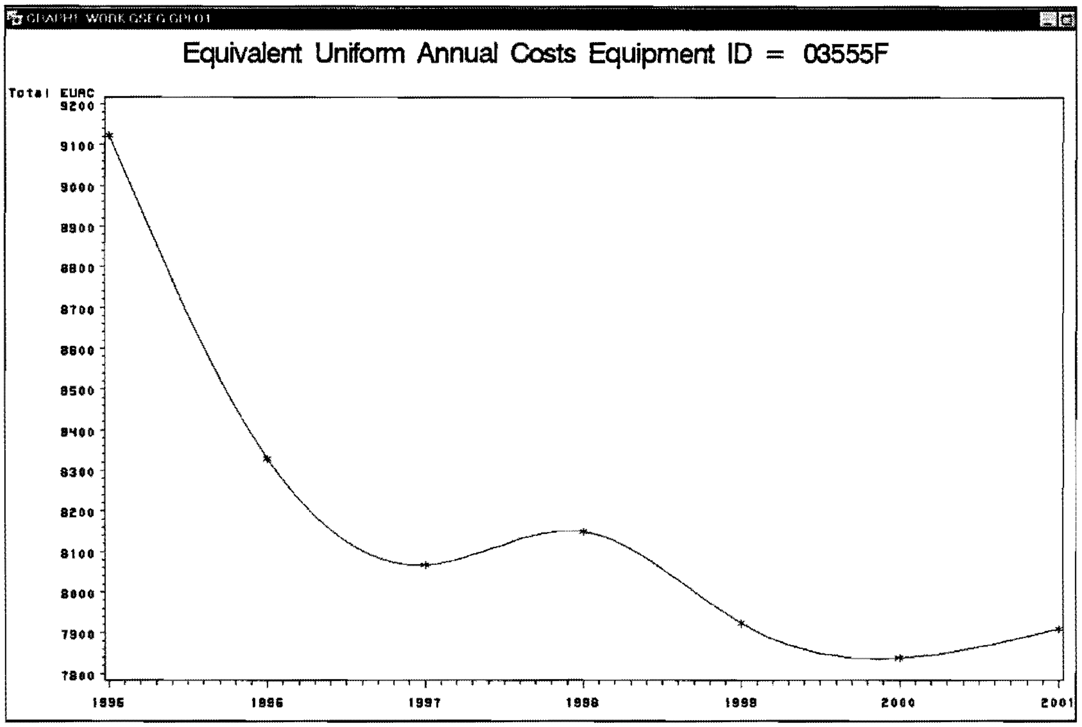


Figure 6.5 Data Report Module Screen: Life Cycle Cost Analysis Button Output

UPDATE LCC SCREEN

In figure 6.3, the user can see a button titled "click here to update LCC values". This button also appears in other TERM screens that handle LCC values (all discussed later). This button calls the screen depicted in figure 6.6. This screen allows the user to change the current downtime and/or discount rate values in permanent data set EQUIP.LCC, and update the life cycle costs of the entire active equipment data set. The discount rate is in decimal format, and the downtime rate is in dollars per hour. The top of the screen shows values that are currently embedded in the EQUIP.LCC SAS data set, and the date and time when data set EQUIP.LCC was last updated. If the user wants to change the current values of discount and downtime rates, the user has to enter **both** numbers in **both** boxes, even if s/he wants to change only **one** value. By clicking the button "Update", the module calls the program that calculates the life cycle cost values using the new values of discount and down time rates, and replaces permanent SAS data set EQUIP.LCC, which resides in the SAS permanent data set library in C:\Equipment. This process takes a few minutes, given the massive amount of active equipment data.

The theoretical background of equivalent uniform annualized LCC calculations is thoroughly discussed in research report 4941-2 (ref. 2). This report also discusses how this concept was implemented into TERM. One issue deserves to be repeated here. The active equipment data set has units that were received before 1990, the oldest record in the data set. In order to maintain consistency, TERM's LCC program estimates the annual cost history before 1990, based on the cumulative 1990 cost data, and calculates the LCC for the entire equipment life. An example is shown in figure 6.9.

The process of calculating LCC and replacing data set EQUIP.LCC does not need to be repeated every time the TERM application is started. The only times the user will need to use the Update LCC button are:

(1) The first time TERM is run in his/her computer, if this was not yet done by the system administrator; and

(2) When the user needs to change the values for the discount rate and downtime costs; and

The system administrator should run this module with default values to finalize the data update procedure, as discussed in chapter 5.

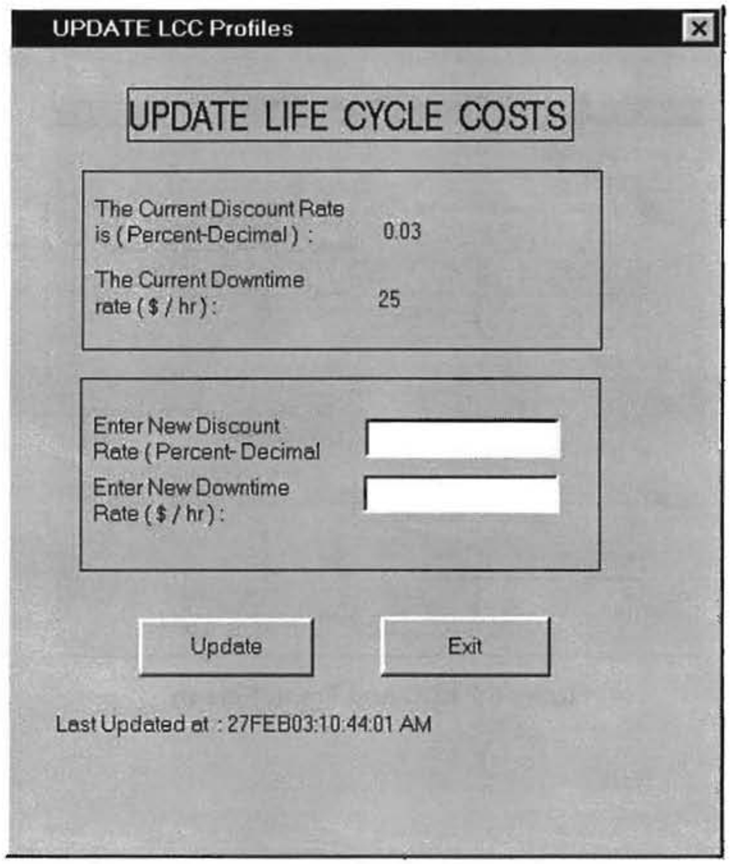


Figure 6.6 Update Life Cycle Costs Screen

LCC AND TREND SCREEN

This screen accesses the programs that calculate the life cycle cost trends, and plots the results for selected units. Figure 6.7 depicts the screen. Figures 6.8 and 6.9 respectively depict the text and graphic outputs for the selected unit. For the illustrative purposes of this manual, we selected an old unit with a long life-cycle history, to emphasize how the calculated trend mimics as closely as possible the human interpretation of the randomness in the life cycle cost history. The user will also notice that the trend is missing for the first two years. This is necessary because these two years' sharp depreciation may bias the trend estimates for later years.

The theory underlying the LCC trend calculations is discussed in research report 4941-2 (Ref. 2). One issue deserves to be repeated here. The LCC trends are not adjusted using least squares regression, an easy to program and computationally fast technique to adjust functions to data. As explained in Ref. 2, least squares is not appropriate for autocorrelated data, such as life cycle costs histories (time series). To calculate trends, TERM calls a SAS/IML subroutine that performs Bayesian time series adjustments. TERM will decompose the unit's life cycle cost time series into a trend component and a random component. The trend component is calculated by minimizing a matrix function of differential operators of trend smoothness. Minimizing these functions takes more processing time than procedures commonly used for statistical analysis. The user will notice this extra time for classcodes with several thousands of units, such as 430010 or 540010 (trucks). The additional processing time for these type of classcodes does not mean that TERM crashed.

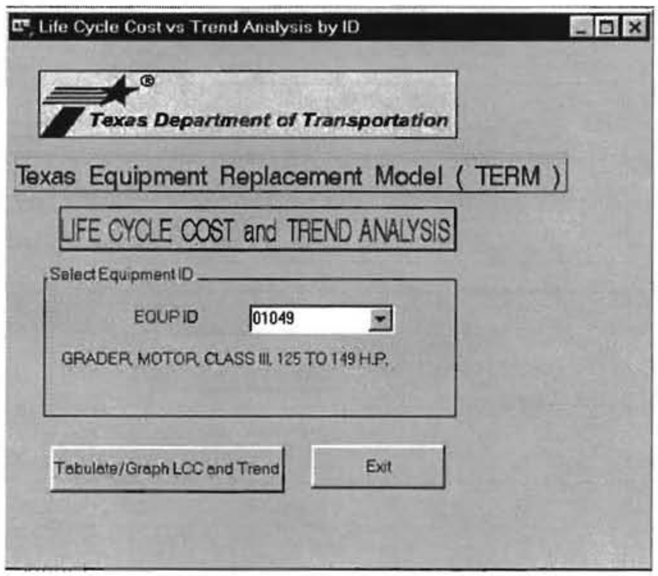


Figure 6.7 LCC and Trend Screen

Output - (Untitled)

Equivalent Uniform Annual Costs and Trends Equipment ID = 01049

Obs	ID	FLYR	LCC	TREND	dbdt	age
1	01049	1983	20632.67	.	09/09/83	1
2	01049	1984	15047.73	.	09/08/84	2
3	01049	1985	12999.97	12967.89	09/08/85	3
4	01049	1986	11868.93	11861.54	09/08/86	4
5	01049	1987	11078.57	10754.99	09/08/87	5
6	01049	1988	9931.42	9648.14	09/07/88	6
7	01049	1989	9068.52	8541.40	09/07/89	7
8	01049	1990	6595.63	7519.49	08/31/90	8
9	01049	1991	6358.88	6637.06	08/30/91	9
10	01049	1992	6277.30	5932.77	08/28/92	10
11	01049	1993	6988.92	5463.06	08/26/93	11
12	01049	1994	6747.53	5240.46	08/10/94	12
13	01049	1995	6903.32	5264.25	08/30/95	13
14	01049	1996	8533.22	5496.83	08/13/96	14
15	01049	1997	8338.35	5885.93	08/22/97	15
16	01049	1998	8842.02	6371.35	08/20/98	16
17	01049	1999	8504.47	6902.30	08/12/99	17
18	01049	2000	8642.63	7450.33	08/08/00	18
19	01049	2001	8349.20	8001.51	08/10/01	19

Figure 6.8 LCC and Trend Module Text Output

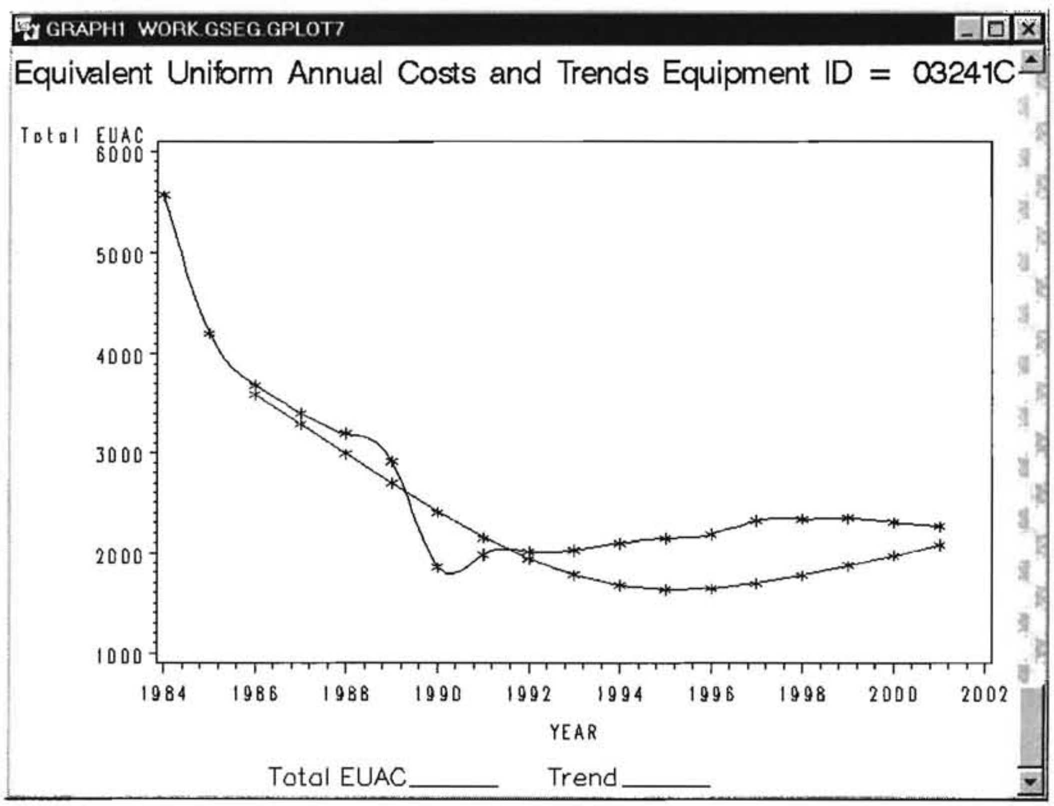


Figure 6.9 LCC and Trend Module Graphic Output

TERM'S REPLACEMENT PRIORITY LISTS

TERM's main feature and objective is to generate equipment replacement priority lists by classcode. There are two modules to do this: the LCC Ranking Module and the Multi-Attribute Ranking Module. They have similar use and interpretation.

Fundamental Concepts

The Ranking Module relies on three concepts developed by the research team: trendscores, multi-attribute priority ranking and automatic qualification. The theoretical development of these concepts is thoroughly discussed in research report 4941-2 (Ref. 2). The brief background below is a quick reference to help the fleet manager select appropriate inputs, and use the output effectively.

Trendscore is a new concept developed in this project to enable a computer to mimic replacement decisions made be a person inspecting life-cycle cost graphs such as those depicted in figure 6.9. A person comparing life cycle cost histories in order to pick units for replacement would prioritize the unit whose life-cycle cost has been increasing for the longest time, and at the steepest rate. The trendscore captures exactly these attributes in a way that can be handled by computer logic.

Multi-attribute priority ranking is another concept developed in this project, to compare the challenged unit to all other active units within a desired class. This was based on the conceptual approach developed by Weissmann in 1990 for TxDOT's Bridge Division (Ref. 5). Weissmann's method for prioritizing bridges for maintenance and replacement has been successfully used for over 10 years by TxDOT, giving the researchers confidence that a similar approach will also be useful for equipment management.

The attributes selected for comparison are trendscore (life cycle cost trends), repair costs, cumulative usage, and cumulative downtime. Each unit's replacement priority rank is calculated for the combination of attributes and relative weighs selected by the manager. A unit has replacement priority over all units that have a better combination of attributes, in terms of cumulative percentiles. The percentiles ("P") are dynamically calculated, and represent the percent of equipment units that have worse attribute values than the specific unit being ranked (within a classcode). In other words, the percentile represents the relative position of a piece of equipment with respect to the rest of the fleet in its classcode. Dynamically calculated means that the percentiles are always calculated as of the latest active data base update.

To generate replacement lists, the user inputs each attribute's weights, which represent their relative importance. For example, if the user feels that downtime and repair costs should be twice as important as the trendscore and the usage, the weights of these attributes could be respectively 0.335, 0.335, 0.165 and 0.165. We recommend that the sum of the weights be one, so that the highest priority for replacement will have a maximum score of one hundred.

Automatic qualification. The system allows the user to input thresholds for automatic replacement qualification, if desired. When an automatic qualification threshold is selected for an attribute, the system uses a two-level ranking procedure. Units above that threshold go to the top of the list, ranked by the multi-attribute method. Then come units below the threshold, also ranked by the multi-attribute method. This is a very important feature, for it allows the manager to enforce current TxDOT policies while at the same time raking units. It also helps the user make a smooth transition between the old threshold method and the new fleet-level ranking method.

Ranking Module Screen: Obtaining a Priority List

Figure 6.10 shows the multi-attribute ranking module screen. The user selects or enters the desired classcode in the drop down list, enters the weights (mandatory) and the automatic qualification (if desired) in the top box. Weights MUST be provided. The user can eliminate an attribute by assigning zero weight to it. The entry for the Automatic Qualifier thresholds is optional. For any change in weights, predefined threshold values for automatic qualification, or class code, the list will be recomputed when the "Generate Replacement Priority List" button is clicked.

Replacement Lists: Interpretation

Clicking the button "Generate Replacement Priority List" generates the replacement priority list displayed in the scroll box in figure 6.10. The first column (blue numbers) is the replacement priority; first priority is unit 10745H, and so on. Scrolling the box to the right will show the ranking score and the weighted average. This list was generated with weights of 0.2 each for trendscore and downtime, and 0.3 each for repair cost and usage.

This list is also sent to an output file that can be printed or exported as RTF or text format, and pasted in a word file. Table 6.1 shows an RTF file pasted directly as saved. It is the list generated when the user enters 5,000 hours as an automatic qualification threshold for downtime in the appropriate box. The list will also appear in the scroll box. Table 6.1 shows a text file reformatted as word table, that corresponds to the list displayed in figure 6.10.

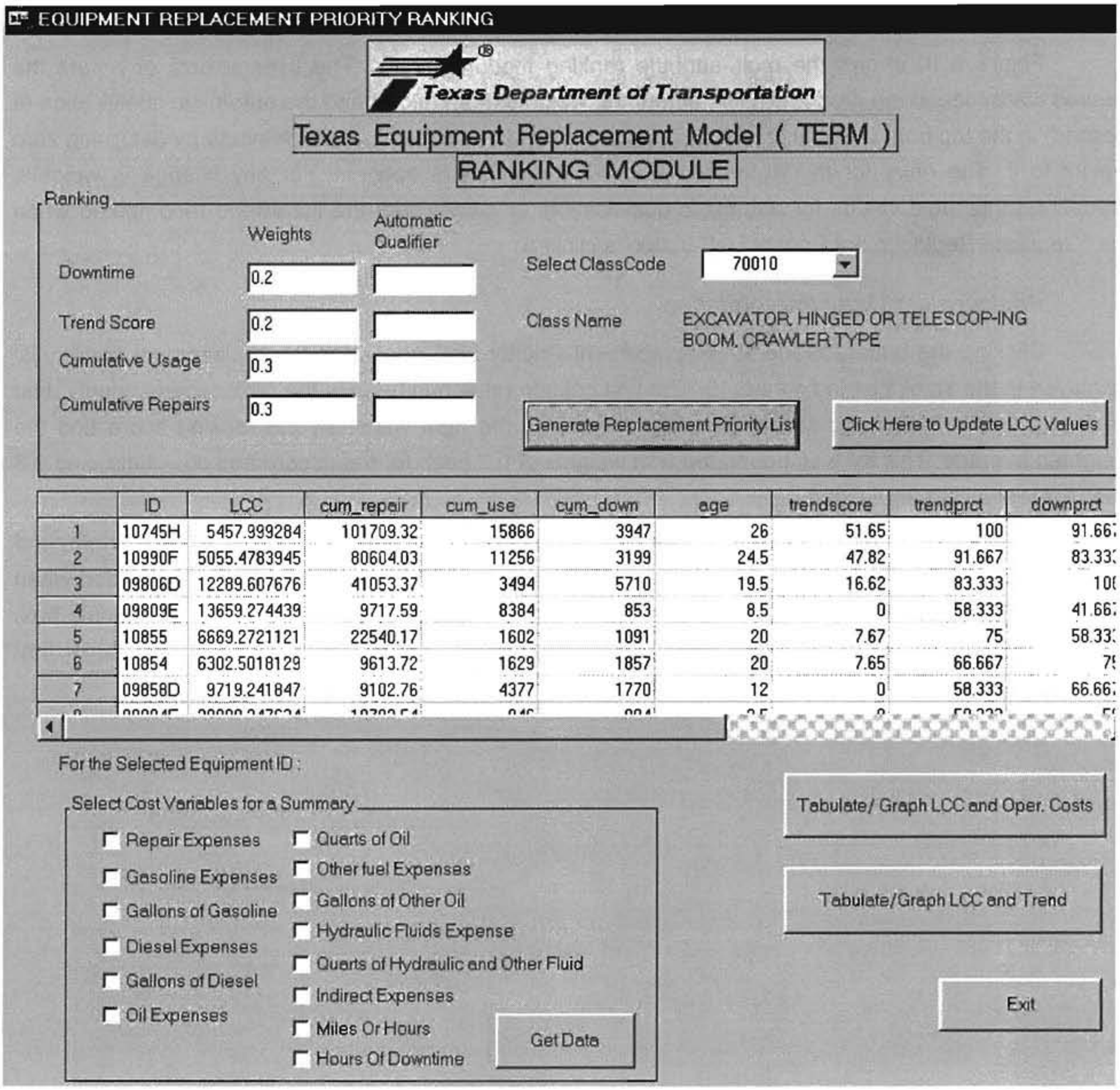


Figure 6.10 Ranking Module Screen and Output

The columns are the same in both tables 6.1 and 6.2. The first column (obs) is the row number and also the replacement priority, since the list is sorted by descending order of scores and thus replacement priority. It corresponds to the blue numbers in the screen output scroll box. The second column is the equipment ID. The third is the weighted ranking score, and the fourth indicates which automatic qualification attribute placed the unit in that specific replacement priority. The other columns have the attribute values and their percentiles (prct).

Without automatic qualification, unit 10745H has the top replacement priority for the weight combination shown in figure 6.10. Its percentiles for the down time, trendscore, use and repair were respectively 91.667, 100, 100 and 100, combining into a the highest weighted average of 98.3334 (column score). Unit 09806D, which had the third priority in table 6.2, goes to the top of the list on table

6.1. Its cumulative downtime is 5,000 hours, and the automatic qualification threshold entered was 5,000 for downtime.

These replacement lists are prepared by classcode, as of the latest data base update. The data update module generates a data set listing units that changed classcode in the latest EOS file, as shown in spreadsheet classch.xls. Unless the fleet managers inspecting the list decide otherwise, units that changed classcodes will appear on the list of their latest classcode in the database. Classcodes with several thousands of units will be somewhat time-consuming to rank. The user should not think that TERM crashed.

Table 6.2 Replacement Priority List With Automatic Qualification

Replacement Priority List for class code 70010

Obs	ID	score	qualified	cum_down	trendscore	cum_use
1	09806D	76.6665	Downtime	5710	16.62	3494
2	10745H	98.3334		3947	51.65	15866
3	10990F	90.0002		3199	47.82	11256
4	09809E	62.4998		853	0.00	8384
5	10855	59.1665		1091	7.67	1602
6	10854	55.8335		1857	7.65	1629
7	09858D	55.0000		1770	0.00	4377
8	09884E	49.1667		884	0.00	946
9	09800E	49.1665		617	0.00	7336
10	09899D	45.8333		709	0.00	5798
11	09804F	23.3334		60	0.00	463
12	09811G	19.9998		78	0.00	45

Obs	cum_ repair	downprct	trendprct	useprct	repairprct	age
1	41053.37	100.000	83.333	50.000	83.333	19.5
2	101709.32	91.667	100.000	100.000	100.000	26.0
3	80604.03	83.333	91.667	91.667	91.667	24.5
4	9717.59	41.667	58.333	83.333	58.333	8.5
5	22540.17	58.333	75.000	33.333	75.000	20.0
6	9613.72	75.000	66.667	41.667	50.000	20.0
7	9102.76	66.667	58.333	58.333	41.667	12.0
8	10782.54	50.000	58.333	25.000	66.667	2.5
9	6775.81	25.000	58.333	75.000	33.333	8.5
10	6205.83	33.333	58.333	66.667	25.000	8.5
11	565.64	8.333	58.333	16.667	16.667	1.5
12	544.74	16.667	58.333	8.333	8.333	40.0

Table 6.1 Replacement Priority List Without Automatic Qualification

Replacement Priority List for class code 70010

OBS	ID	Score	Qualified	Cum_ down	Trend score	Cum_ use	Cum_ repair	Down prct	Trend prct	Use prct	Repair prct	Age
1	**10745H**	98.3334		3947	51.65	15866	101709.32	91.667	100.000	100.000	100.000	26.0
2	10990F	90.0002		3199	47.82	11256	80604.03	83.333	91.667	91.667	91.667	24.5
3	09806D	76.6665		5710	16.62	3494	41053.37	100.000	83.333	50.000	83.333	19.5
4	09809E	62.4998		853	0.00	8384	9717.59	41.667	58.333	83.333	58.333	8.5
5	10855	59.1665		1091	7.67	1602	22540.17	58.333	75.000	33.333	75.000	20.0
6	10854	55.8335		1857	7.65	1629	9613.72	75.000	66.667	41.667	50.000	20.0
7	09858D	55.0000		1770	0.00	4377	9102.76	66.667	58.333	58.333	41.667	12.0
8	09884E	49.1667		884	0.00	946	10782.54	50.000	58.333	25.000	66.667	2.5
9	09800E	49.1665		617	0.00	7336	6775.81	25.000	58.333	75.000	33.333	8.5
10	09899D	45.8333		709	0.00	5798	6205.83	33.333	58.333	66.667	25.000	8.5
11	09804F	23.3334		60	0.00	463	565.64	8.333	58.333	16.667	16.667	1.5
12	09811G	19.9998		78	0.00	45	544.74	16.667	58.333	8.333	8.333	40.0

Ranking Module Screen: Tabulate/Graph Buttons

As shown in figure 6.10, the multi-attribute-ranking module has two tabulate/graph buttons. The user can plot the life-cycle history of any selected unit in two ways: total life cycle with its trend component, and total life cycle with its capital and operational cost components. Select the unit ID for which the Tabulate/Graph is desired by clicking on it in the scroll-down table showing the prioritized units. "Tabulate/graph LCC and trend" button generates the type of output already depicted in figures 6.8 and 6.9. "Tabulate/graph LCC oper. costs" button generates the outputs shown in figure 6.11.

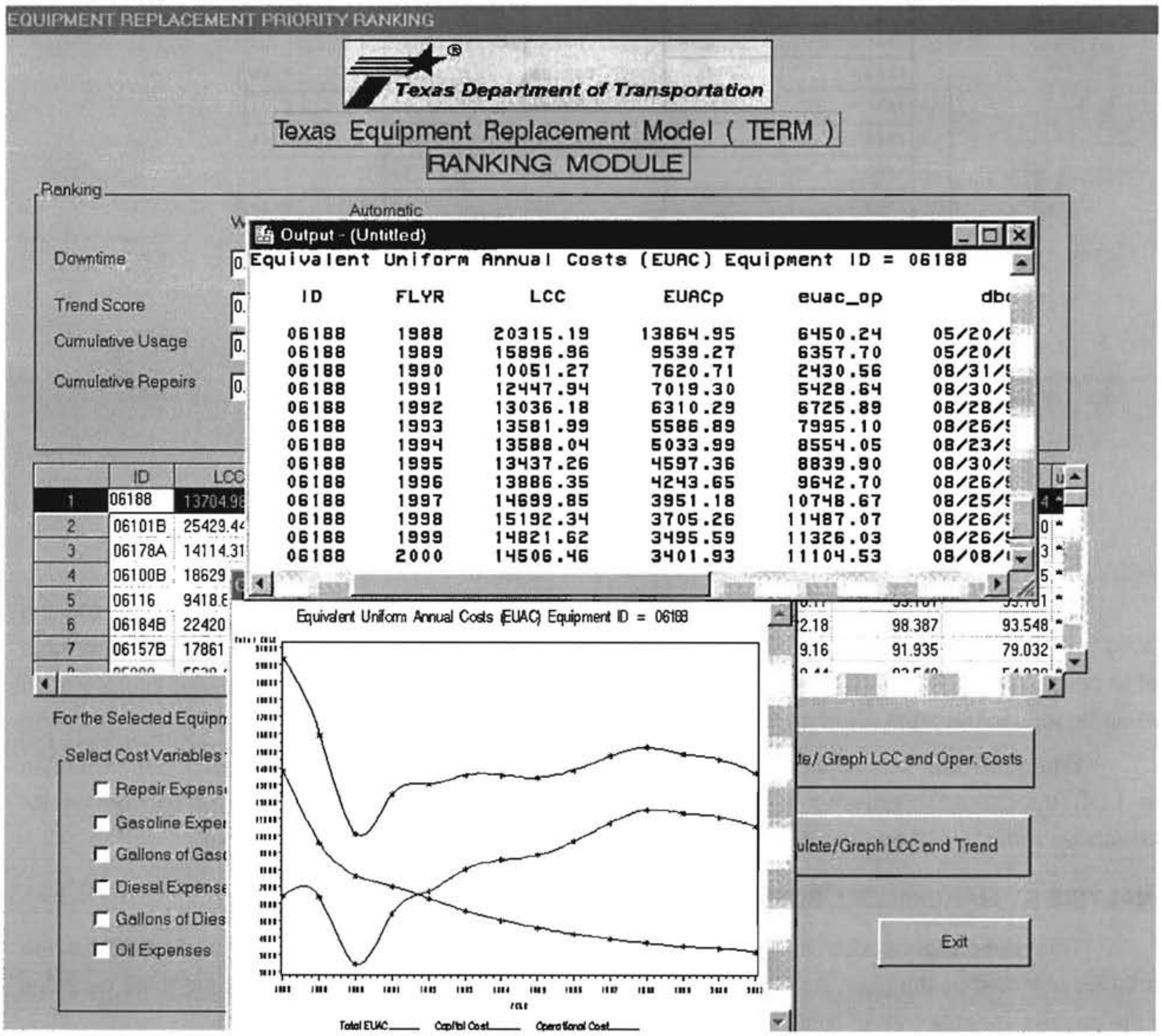


Figure 6.11 Ranking Module Output: Tabulate/Graph LCC and Oper Cost Button

Ranking Module Screen: Get Data Button

The "get data" button allows the user to retrieve specific information about the equipment ID selected in the ranked list scroll window. In the specific example depicted in Figure 6.11, the user selected equipment ID 02830A and checked repair expenses, usage and downtime for reporting. The Get Data button generates the report depicted in Figure 6.12 available in the SAS Output window.

Output - (Untitled)

Equipment Data for Equipment 02830A

	Repair Expenses	Usage Miles/Hours	Downtime
Year			
1990	202.59	17.00	7.00
1991	37.42	31.00	2.00
1992	2225.72	7.00	390.00
1993	60.63	26.00	1.00
1994	71.32	64.00	4.00
1995	79.91	5.00	2.00
1996	0.00	0.00	0.00
1997	0.00	0.00	0.00
1998	293.52	16.00	7.00
1999	4873.36	64.00	512.00
2000	234.22	51.00	19.00
Total	8078.69	281.00	944.00

Figure 6.12 Ranking Module Output: Get Data Button

LCC Ranking Module

This module is a simplification of the Multi-Attribute Ranking Module, performing the ranking based solely on the Trendscore attribute. It is equivalent to running the Ranking Module with all weights set to zero except the Trendscore, which would be set to one. The screen use and output interpretation are analogous to the Multi-Attribute Ranking Module previously discussed.

When the user selects a classcode for ranking, TERM accesses the SAS program that calculates the LCC trends. As discussed in the previous section, these calculations are time-consuming for classcodes with several thousands of units. The user should not think that TERM crashed.

ANALYSIS BY MAKE/MODEL SCREEN

This button generates a bar graph comparing different makes within a classcode, for the variables selected by the user. An example is shown in figure 6.13. The graph displays the three quartiles of the desired variable (repair costs in this case), labeling them Q25, Q50, and Q75.

Quartiles are statistics that capture the 25th percentile, the median (50th percentile), and the 75th percentile. The median, or second quartile, divides the data exactly in two halves. One quarter of the data is less than the first quartile and the other quarter is greater than the 3rd quartile. Half the data are inside the interquartile range (difference between 3rd and 1st quartiles). Quartiles are a useful way to compare data when it is not desirable to include unusual extremes in the analysis.

TERM calculates the percentiles over the entire history of every unit within each make for the selected classcode. Figure 6.14 indicates that half of all observed yearly repair expenses for DUR-A-LIFT were less than $1,900 per year (Q50), while the other half were greater than this value. VERSALIFT had the highest value for the third quartile, which means that one-quarter of the observed VERSALIFT yearly repair expenses were higher than all other makes for this aerial device.

The fleet manager must be careful when interpreting this type of analysis. While it provides very useful insights for comparing vendors, there is a catch. In general, the more units a vendor has, the greater the chance for anything undesirable to occur (such as repair or a downtime), so taller bars in the graph may not necessarily indicate a worse product. The fleet manager should graphic output of the type shown in figure 6.3 in conjunction with other information before deriving conclusions about a vendor.

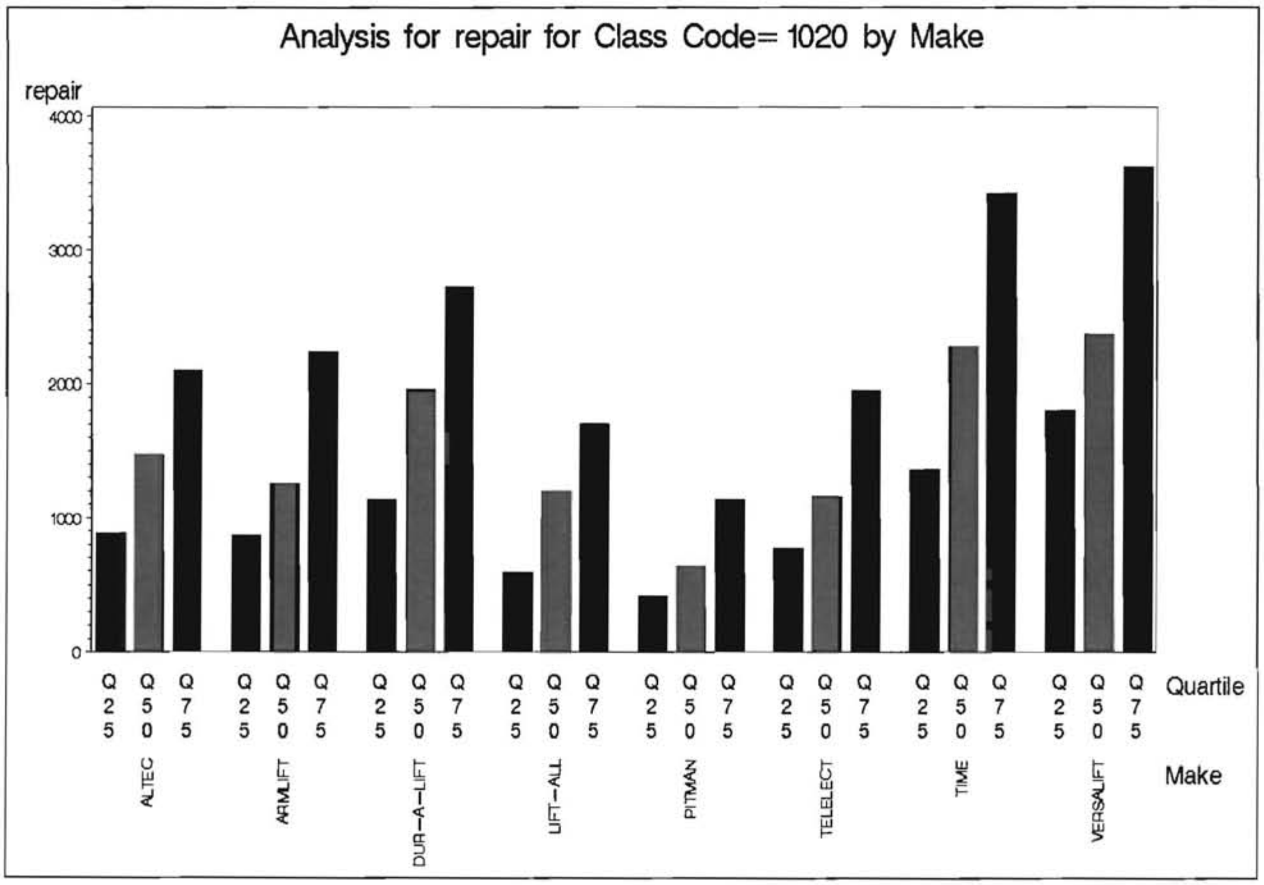


Figure 6.13 Analysis by Make and Model Output

PLOT GRAPH SCREEN

The plot graph screen allows TERM user to select a Y variable to plot against time, for a specified equipment ID. Figure 6.14 depicts the screen for the Plot Graph module, with a request for a graph of the repair expenses by year for equipment ID 00004D. By clicking on the Plot Graph button, the graph depicted in Figure 6.15 is displayed on the SAS Graph output window.

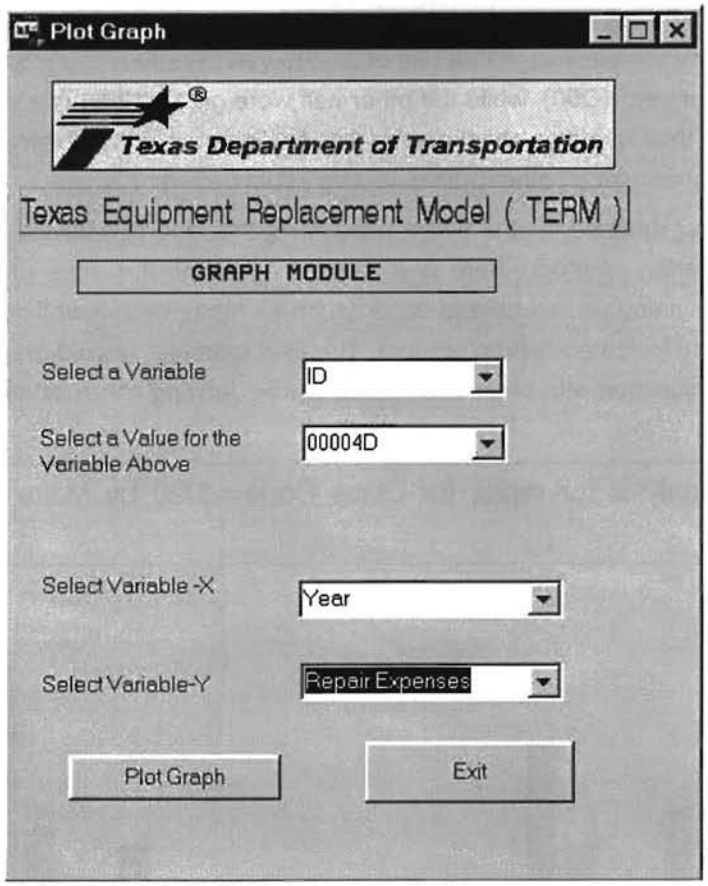


Figure 6.14 Graph module menu screen

TERM USER TROUBLESHOOTING

Saving TERM's Output into Other Files

The user may need to save TERM's graphs into files that can be pasted in microsoft word, for reporting (like this manual).

GRAPHS While the graph screen is open, go to the file menu, select "save". We recommend JPEG format. In order to paste it in a word file, use the "insert picture" feature in microsoft word.

TEXT While the printed output screen is open, go to the file menu, and select "save". We recommend rich text format (RTF). You can use microsoft word's insert file feature to add this text to your report. The tables will keep their RTF format. but can be reformatted in microsoft word.

Other Troubleshooting

Question I requested tables from TERM's query module, but there is no output on the screen.

Solution The output window is off. To turn it on, pull down the view menu on top of the screen, select output. If you want to erase the output, don't close the window again; instead, right-click anywhere on it, click on edit from the menu that will appear, and select clear. To return to TERM, click on its icon and name on the bottom of the screen.

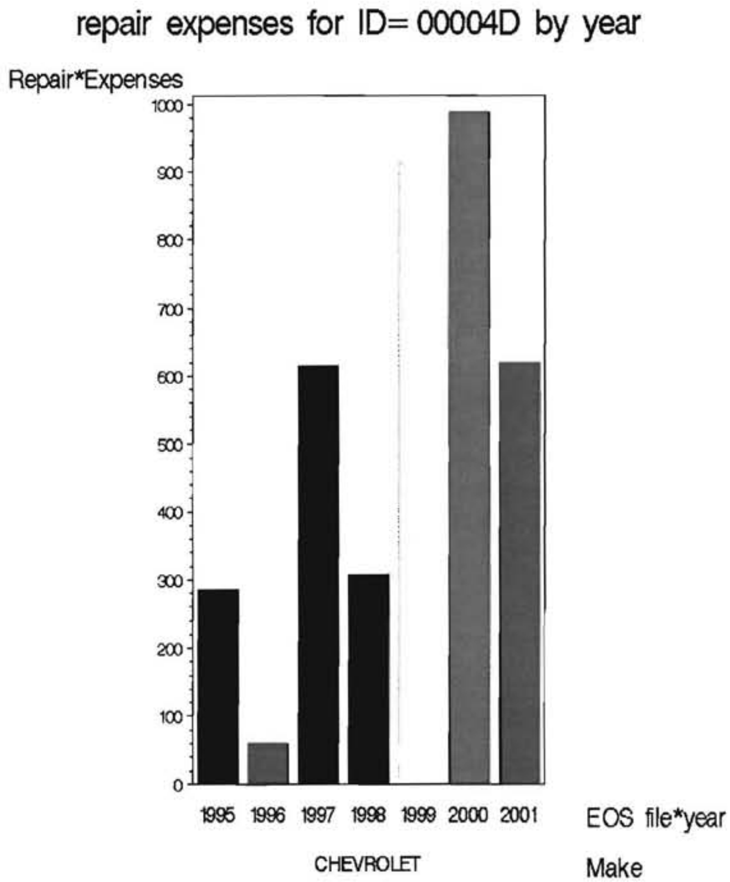


Figure 6.15 Example of Output of the Plot Graph Screen

Question I have been running term for a while without problems, and suddenly it won't work anymore.

Answer The SAS log may be full. To erase it, pull down the view menu on top of the screen, select log. Then, right click anywhere on it, click on edit from the menu that will appear, and select clear. Then you can close the log window and try to run TERM again. If this fails, exit TERM and restart it.

Question TERM takes too long to update the life cycle cost values.

Answer This analysis does take a long time, especially for classcodes with several thousand units. See "LCC and TREND SCREEN" section of chapter 6 for more details.

Question Data columns in data set viewer are too wide.

Answer Use the mouse to decrease their width.

Question I requested a new graph but the graph window will show the old one.

Answer TERM appends graph requests to one another. Use the scroll button on the right side of the screen. .

Question The rank module won't run.

Answer Make sure you entered weight values for all four attributes. If you don't want to consider an attribute, set its weight to zero.

Question I tried to exit term using its exit button, but the output screens won't close. Is TERM stuck?

Answer No. This feature was programmed on purpose, in case you forgot to save or print the outputs. To save, use the "save" feature under the file menu. To exit TERM, either close the output window, or select "exit" under the file menu.

Question I am trying to a plot life cycle cost graph but TERM returns an empty graph.

Answer There are two possibilities: either data set EQUIP.LCC is empty, or this specific unit does not have a life-cycle cost history either because it is too new, or because some of its life-cycle parameters (such as purchase cost) are missing. You can check on the unit's history and data using another TERM module.

To check if data set EQUIP.LCC is empty, try to plot another unit you already know has LCC history. If this also fails, you must build the LCC data set. To build it, go to the Report Module (retrieve data button), Ranking Module (rank button) or LCC Ranking Module (LCC ranking button), click on *Update LCC* button, and follow the instructions in section titled " Update LCC Screen". Make <u>sure</u> you enter both downtime costs AND discount rate values, even if their values already show in the top box. If the problem persists, contact the system administrator.

CHAPTER 7
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The Texas Department of Transportation (TxDOT) owns and maintains an active fleet of approximately 17,000 units, replacing about ten percent of them annually. TxDOT's General Services Division–Purchase and Equipment also maintains a very comprehensive database containing all information about the fleet, including data relevant to life cycle cost analysis.

The most relevant information provided by a life-cycle cost graph is its trend. Equipment units whose life cycle costs have been increasing longer and/or at a faster rate should have higher replacement priority than those still amortizing. Private and public agencies do not routinely use life-cycle cost as a replacement criteria because until now the only way to automate the inspection of thousands of life-cycle cost histories was to define a cost threshold for acceptability. Most fleet managers rightfully consider this practice too inaccurate. What they really needed was to visually compare these life cycle cost graphs to one another. For 17,000 units, this is impossible.

Researchers from the University of Texas at San Antonio (UTSA) developed and tested the Texas Equipment Replacement Model (TERM), an automated, menu-driven, PC based-system that can generate data tables and graphs, calculate and compare the life cycle cost profiles and trends, and prioritize units for replacement based on life cycles cost trends and/or other performance measures.

This project made three major innovative contributions:

1. Life cycle cost trendscore, a method that enables a computer to mimic replacement decisions made by a person inspecting a series of life cycle cost history graphs.
2. Multi-attribute priority ranking, which automatically ranks replacement priorities based on comparisons of the challenged unit to the entire fleet within its class or group, instead of one-on-one comparisons to threshold or minimum values still in use by private and public agencies world-wide. The replacement budget can be matched to the units on top of the replacement priority list, making a budget shortfall more visible.
3. Automatic Qualification. TERM allows the user to input thresholds for automatic replacement qualification, which supersede the ranking criteria. This allows the fleet manager a smooth transition between the old and new systems. It also allows TxDOT threshold policies to be implemented together with ranking method.

This report contains the information needed to install, use, update, and maintain TERM software's first build at TxDOT's General Services Division–Purchase and Equipment Sections. TERM end-users and system administrators will also find relevant information in the two previous reports of the 7-4941 series (refs. 1 and 2).

CONCLUSION

TERM should not be regarded as a one-time-only effort, or, to use fleet management jargon, a capital acquisition subject only to routine maintenance. Like all other computer softwares in the market, TERM should be viewed as an ongoing programming effort, with periodic upgrades. In order to accomplish this, TxDOT must assign TERM to a staff member who is very proficient in the SAS programming language. This person should be responsible for two tasks: periodic update of the historical data sets used by the program, and ongoing programming of the software upgrades requested by the users.

The first task requires only a basic knowledge of SAS, enough to run the program in the data update module outside a menu-driven environment, to manipulate and rename the resulting SAS data sets, and to edit the active data sets if requested by the fleet managers.

The second task has several levels of complexity. The least complex is upgrading TERM (for example) to add screens that tabulate or plot additional data. This requires a very deep knowledge of SAS, including the more complex SAS/AF, SAS/SCL, and SAS/IML environments, but no additional research. Designing and programming new conceptual modules (such as budget allocation) will require additional research effort prior to programming.

RECOMMENDATIONS FOR TERM USERS

In the beginning, we recommend that fleet managers use TERM capabilities to prepare replacement priority lists based on different combinations of criteria, with and without automatic qualification based on thresholds. Comparisons among these lists will give managers a good feel for the new method, and will also enable them to devise ways to upgrade and improve the TERM's practical features.

Fleet managers should keep in mind that TERM ranks units for replacement based on the latest data set update. Units that changed classcodes will be considered for replacement as belonging to their newest classcode. If this is not desirable, the fleet manager should ask the system administrator to edit the active equipment data sets to show another classcode. Editing the active data sets requires minimal programming effort.

Classcode changes are flagged as described in chapter 6, "Retrieve Data Screen" section, according to flag values and tolerances described in chapter 4 of this manual. For more details, see chapter 2 of research report 4941-2 (ref. 2). For maximum detail, see research report 4941-1 (ref. 1).

The data update program also writes classcode changes to permanent data set SDS.CLASS_CH, discussed in chapter 6, "Classcode Changes" sub-section. Classcode changes are not common, but happen primarily for two reasons: unit changed size (probably a new engine), and devices were mounted or dismounted. We strongly recommend reviewing these changes every time the data set is updated.

UPGRADE RECOMMENDATION 1: BUDGET ALLOCATION MODULE

The primary function of equipment managers is to provide the proper equipment, at the right time and at the lowest overall cost. A comprehensive equipment replacement method should ideally include the following steps:

(1) Identify units targeted for replacement,
(2) Obtain replacement requests from users,
(3) Apply an economic analysis model,
(4) Prioritize replacement units,
(5) Allocate budget to the prioritized units, and make purchasing decisions,
(6) Acquire new equipment, and
(7) Dispose of old equipment.

This first build of TERM provides TxDOT with a very good tool to automate steps 1 through 4 The last two steps are practical in nature, and as such not amenable to automation tools. TERM would help fleet managers even more if it included additional modules to perform budget allocations.

Fleet managers should devise these modules' capabilities after some experience with the current build of TERM. After that, they can write a problem statement for a new methodology to assure effective budget allocation and deal with shortfalls.

UPGRADE RECOMMENDATION 2: WEB-BASED TERM

Fleet managers are the ideal persons to evaluate TERM. After using it for a while, they will certainly have ideas for future upgrades. Although not part of this project's scope, the research team delivered a pilot District-Level TERM, for evaluation by the Districts.

The current version of TERM requires two copies of the active data set to reside physically on each user's computer. It also requires SAS to be installed in each user computer. The researchers recommend making TERM a Web-enabled application. A web-based TERM can provide remote access to the data and bring the TERM application to any desktop, regardless of whether SAS software is installed in that specific computer. A web-based TERM also has another important advantage: it is easier to maintain data consistency. The active equipment data sets can be modified or updated only by those who have appropriate privileges to do so. All users have immediate access to any modifications. The system administrator would no longer have to provide data set updates to every user. This would result in extremely efficient District-Level implementation and update.

UPGRADE RECOMMENDATION 3: CHANGE THE FRAMEWORK FOR TRENDSCORE CALCULATION

The LCC calculations, and consequently the trendscores, depend on two default parameters that can be overridden by the user: hourly cost of downtime of $20.00 and 3% yearly discount rate. The first version of TERM is structured such that the life-cycle cost and trendscores are freshly calculated every time the user selects a classcode to analyze, regardless of whether or not s/he overrides the default values. This structure is convenient for the first build, when the user is expected to change the values of these parameters often. Trendscore calculations are very time-consuming, as explained in chapter 6. The modification suggested below will eliminate the need to wait for these time consuming calculations if users reach a point where they are not needed as often as they will in the beginning.

After using the system for some time, however, the fleet managers will develop experience with downtime costs for each classcode, eliminating the need to run these calculations every time the ranking modules are accessed. When this experience develops, the system should be upgraded as follows:

- Add the new default values for interest rate and downtime cost (by classcode if needed) to the program that calculates the trendscores;
- Add this program to the data update module, and make the trendscores calculated with the recommended default values an integral part of the EQUIP.LCC data set;
- In all modules accessing the LCC trends, add instructions for the program to access the trendscore values in the EQUIP.LCC data set unless the user overrides the downtime cost, the discount rate, or both. In this case, and only in this case, TERM will calculate the life-cycle cost and the trendscores again for the desired classcode.

UPGRADE RECOMMENDATION 4: CLASSCODE CHANGES AND EOS DATA

Classcode changes are not a considerable problem; as of 2002, there were 272 units that changed classcodes. This is less than 0.02 percent of the fleet. Some cases are obvious corrections, such as an automobile that changed wheel base size. Classcode changes should be looked at by the fleet manager and the system administrator, and when possible harmonized throughout the unit's history, every year, as part of the data update procedure.

Truck mounted devices present a different situation. The program will calculate the life-cycle cost for the entire unit history, regardless of classcode changes. At this point, the cost of mountig

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