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NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

H3446

DESIGN AND DEVELOPMENT OF A USER INTERFACE
FOR THE DYNAMICA MODEL OF SOFTWARE
PROJECT MANAGEMENT

by

Carson E. Haury

March 1988

Thesis Advisor:

Tarek K. Abdel-Hamid

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T238967

REPORT DOCUMENTATION PAGE

REPORT SECURITY CLASSIFICATION UNCLASSIFIED		1b RESTRICTIVE MARKINGS	
SECURITY CLASSIFICATION AUTHORITY		3 DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.	
DECLASSIFICATION / DOWNGRADING SCHEDULE			
PERFORMING ORGANIZATION REPORT NUMBER(S)		5. MONITORING ORGANIZATION REPORT NUMBER(S)	
NAME OF PERFORMING ORGANIZATION Naval Postgraduate School	6b. OFFICE SYMBOL (If applicable) 54	7a NAME OF MONITORING ORGANIZATION Naval Postgraduate School	
ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000		7b. ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000	
NAME OF FUNDING / SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
ADDRESS (City, State, and ZIP Code)		10. SOURCE OF FUNDING NUMBERS	
		PROGRAM ELEMENT NO.	PROJECT NO.
		TASK NO.	WORK UNIT ACCESSION NO.
TITLE (Include Security Classification) DESIGN AND DEVELOPMENT OF A USER INTERFACE FOR THE DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT			
PERSONAL AUTHOR(S) Haury, Carson E.			
TYPE OF REPORT Master's Thesis	13b TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Year, Month, Day) 1988 March	15 PAGE COUNT 116
SUPPLEMENTARY NOTATION The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	software project management, system dynamics, user interfaces, simulation, software estimating	
ABSTRACT (Continue on reverse if necessary and identify by block number)			
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DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
NAME OF RESPONSIBLE INDIVIDUAL Arek K. Abdel-Hamid		22b. TELEPHONE (Include Area Code) (408) 646-2686	22c. OFFICE SYMBOL 54Ah

Block 19 (continued)

model and the creation of a Dynex model interface to aid in variable manipulation.

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Design and Development of a User Interface
for the Dynamica Model of Software
Project Management

by

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Submitted in partial fulfillment of the
requirements for the degree of

MASTERS OF SCIENCE IN INFORMATION SYSTEMS

from the

NAVAL POSTGRADUATE SCHOOL
March 1988

ABSTRACT

Managing large software development projects and delivering them on time and within budget has proven to be a difficult task. The Dynamica Model of Software Project Management, has been designed to support the management of the software development process. The current interface to the model, however, is not suited to the inexperienced user.

The objective of this thesis is to enhance the usability and acceptance of the Dynamica Model of Software Project Management. The design of the user interface accomplished in this thesis is an attempt to provide the maximum benefit of the model to the user by simplifying the process of using, viewing, and storing results from the model. This allows the user to focus his or her attention on design considerations and interpreting model experiments.

Specifically the accomplishments of this thesis include the development of a menu system which provides a logical format for accessing the Dynamica model and the creation of a Dynex model interface to aid in variable manipulation.

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I. INTRODUCTION

A. BACKGROUND

In recent years, rapid technological advancements in computer hardware, and the ensuing cost reduction of equipment, has increased the demand for hardware and consequently the demand on software. A tenfold increase in software demand is expected over the next 10 years [Ref. 1:pp. 55-62].

However, the growth in the software industry has not been painless. There are currently numerous problems facing software project managers. Software development projects have been marked by cost overruns, late deliveries, poor reliability and user dissatisfaction [Ref. 2:pp. 36-41] and [Ref. 3:pp. 132-142]. Only recently has the software project manager seen the development of an assortment of "tools" to aid him in estimating, tracking and forecasting costs, scheduling completion dates, and in the myriad of other tasks which are integral parts of the software development process.

The Dynamica Model of Software Project Management, created by Tarek K. Abdel-Hamid while at the Massachusetts Institute of Technology, is one of the exciting new "tools" recently developed. It is a comprehensive model of the software development process. Written in Professional Dynamo, the model integrates both the management-type

functions (e.g., planning control, and staffing) with the software production-type activities (e.g., design, coding, reviewing and testing).

The Dynamica Model of Software Management can perform several important roles. Its main goal is to aid the software project manager in understanding the software development process. The manager can conduct "what if" experiments with the model to develop a more comprehensive understanding of the interrelationships of software development variables. For example, what is the impact on project cost of an increase in quality assurance effort. The model allows the user to track, store, graph and plot large amounts of project data, quickly and efficiently. In so doing, the user can improve and fine tune his fundamental understanding of the software development process through the advantages gained by using a computer simulation model.

Secondly, the Dynamica model can be used to aid the software project manager in the actual management process. For example, the model can be utilized to estimate project cost, schedule completion time, and numerous other variables. Variables in a software development project can be changed and simulations can be run in a matter of minutes. This allows the manager to evaluate different management strategies.

Currently the Dynamica model interface is limited to simulations performed by the experienced model user. The model does not provide the new user with any assistance or guidance. For example, the model does not define the variables in the model or explain what options are available to the user.

To provide the maximum benefits from any computer based system, great care must be taken in the design of the human interface. User friendly systems are much more likely to gain wide spread acceptance. Learning to use and operate a computer based system must be easy enough for the beginner yet flexible enough not to constrain more experienced users. The interface of the system, must stress simplicity and efficiency without limiting the users creativity. The interface should be designed to focus the users attention on important information and not clutter the screen with inconsequential data. Feedback should be provided in a timely manner to keep the users attention.

B. PURPOSE OF RESEARCH

The objective of this thesis is to enhance the effectiveness of the Dynamica Model of Software Management by providing an improved user interface which enhances the usefulness of the model for a wide range of users.

This is accomplished by determining the most commonly used functions of the Dynamica model and designing a system to allow the user a simple method of access to them. The

design of the model interface should build upon and complement the menu interface available in Professional Dynamo. The interface should be self documenting and lead the user through the process of selecting variables, running simulations and storing results. It should also allow the user to avoid the documentation as his/her experience level grows. Since a major purpose of the Dynamica model is to enhance the user's understanding of the software development process, the interface should provide the tools the user needs for accessing, and analyzing all critical data created by the model.

C. SCOPE OF RESEARCH

The scope of this research will include the design and development of a user interface for the Dynamica model utilizing the executive level interface of Professional Dynamo - Dynex, DOS batch files, and the Extended Batch Language (EBL) menu facility EXECMAKE. The model documentation included in this thesis will in addition comprise a user's manual for the system.

D. THESIS ORGANIZATION

Chapter II will briefly discuss problem areas in the current methods of software project management and the role of the Dynamica Model of Software Project Management to solve those problems. The user interface developed in this thesis will be thoroughly demonstrated in Chapter III. In Chapter

IV we discuss the system architecture for the user interface developed in this thesis, and discuss the interrelationships of the sub components of the interface.

II. RESEARCH BACKGROUND AND OBJECTIVES

A. CURRENT PROBLEMS IN SOFTWARE PROJECT MANAGEMENT

There has been tremendous growth in the demand for software systems over the past 20 years. The software development process unfortunately, has earned an "infamous" reputation for cost overruns, late deliveries, poor reliability and users' dissatisfaction [Ref. 2:pp. 36-41] and [Ref. 3:pp. 132-142].

While significant progress has been made over the past 20 years in improving the technology of software development, little research effort has been devoted to the managerial issues.

Software Engineering Project Management (SEPM) has not enjoyed the same progress (as the technology of software development). While it might be argued that SEPM has been defined, it is far from a recognized discipline.... The major issues and problems of SEPM have not been agreed on by the computing community as a whole, and consequently, priorities for addressing them have not been widely established. Furthermore, research in this area has been scant. [Ref. 4:p. 333]

B. THE DYNAMICA MODEL

The goal of the Dynamica model is to provide an understanding of the dynamic behavior of software projects and support the management of the software development process [Ref. 5:pp. 8-10].

The Dynamica model is a comprehensive system dynamics model of the software development process. The model integrates the multiple functions of the software development process, including both the management-type functions (e.g., planning, control, staffing) as well as the software production-type activities (e.g., design, coding, reviewing, testing) [Ref. 6:pp. 6-11]. Such an integrative approach is useful since it would prompt and facilitate a search for the multiple, and potentially diffuse set of factors that are interacting to cause some software project problem(s) [Ref. 6:p. 14].

Another distinctive aspect of the Dynamica model is its use of computer simulation techniques to handle the high complexity of the integrative feedback model.

The behavior of systems of interconnected feedback loops often confounds common intuition and analysis, even though the dynamic implications of isolated loops may be reasonably obvious. The feedback structures of real problems are often so complex that the behavior they generate over time can usually be traced only by simulation. [Ref. 7:pp. 6-7]

The Dynamica model consists of the four subsystems shown in Figure 2-1 [Ref. 5:p. 12]. The Human Resource Management Subsystem captures the hiring, training, assimilation and transfer of the project's human resources. The Software Production Subsystem captures the design, coding, quality assurance, rework, and testing activities [Ref. 6:pp. 11-25]. The Planning Subsystem models the scheduling activities that

take place throughout the project's life cycle. The Control Subsystem captures the measurement of progress on the project.

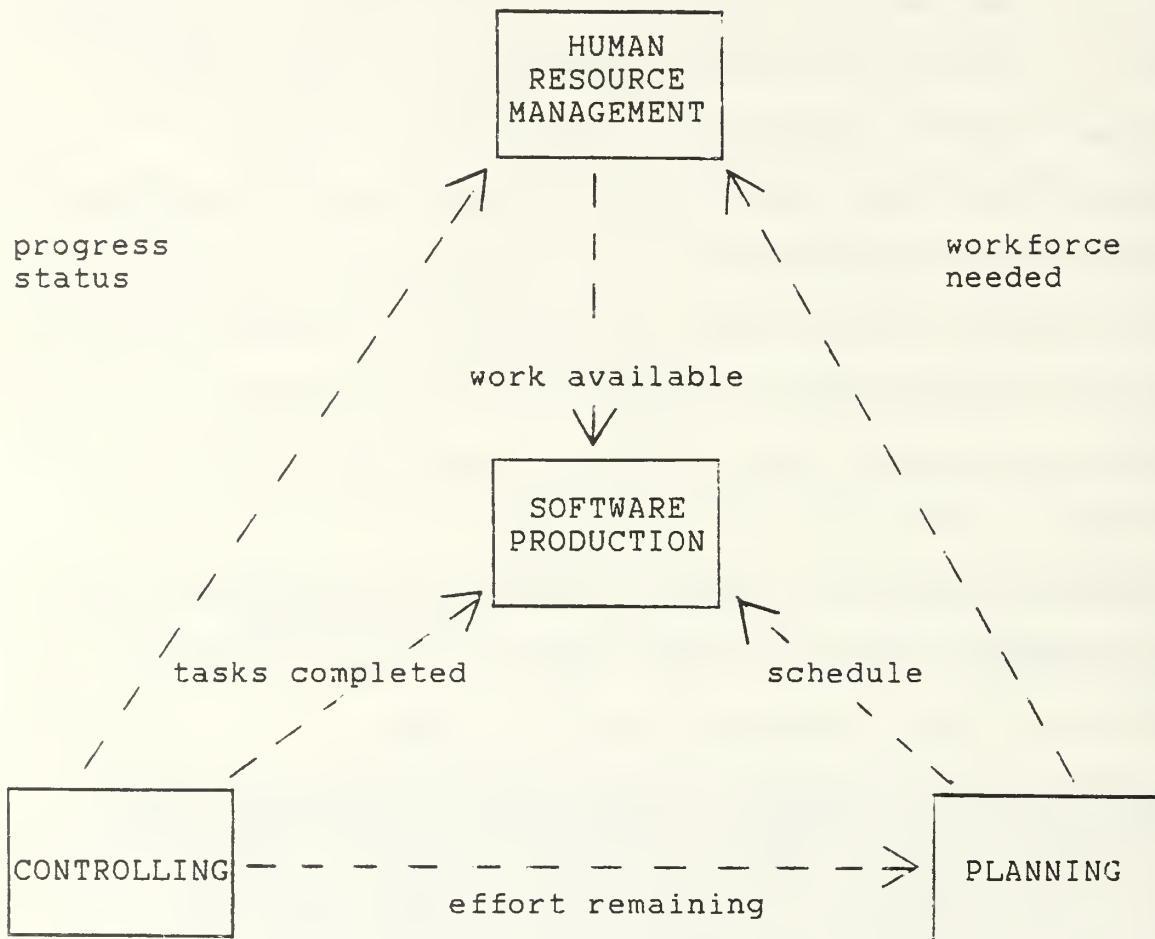


Figure 2-1. Four Subsystems of The Dynamica Model

C. RESEARCH OBJECTIVES

The goal of this thesis is to design and develop a user interface for the Dynamica model which would improve the Dynamica model's utility as both a learning tool and a management support system. Three areas of the model interface are targeted for improvement: (1) ease of

operation, (2) improved facilities for accessing, storing and reviewing simulation results and (3) improved method of variable manipulation.

The Dynamica model currently is extremely difficult for the new user to operate. For example, the model does not provide the user with a clear guide for operation and there is no online help or documentation available. These problem areas will be addressed through the design of a new menu type interface. The menu system will outline the functions available within the Dynamica model, explaining these functions, and make them easy to access and invoke.

One of the major advantages of the Dynamica simulation model is its capability to provide the user with a dynamic and detailed picture of how model variables change throughout the project's life cycle. One of the goals of this thesis is to provide the user a easy method for data storage as well as plotting, graphing and printing the simulation results. A standardized report format and plot functions will be made available to the user via the menu system.

Finally, the Dynamica model needs to provide the user with a framework for manipulating variables and controlling the model. Professional Dynamo provides the experienced model builder an executive interface language, Dynex, for creating an easily understood format for model manipulation. A goal of this thesis is the design and coding of a dynex

interface for the model. This interface will contain the definitions of 18 selected variables and allow their manipulation within the model.

III. INTERFACE DESIGN

A. INTRODUCTION

This chapter provides a detailed description of the user interface. It provides explanatory information on the portions of the interface visible to the user. In effect, it is a manual for the system, providing guidance on operating the system and explaining its characteristics.

The user interface for the DYNAMICA MODEL OF SOFTWARE MANAGEMENT consists of three main parts: (1) the Model Menu and its Submenus, (2) 24 batch files called by the Model Menu and (3) the Model interface written in DYNEX (the executive interface language of Professional Dynamo).

To operate the Dynamica model requires an IBM or IBM compatible XT/AT microcomputer, with 640 K of RAM and either a hard disk or 1.2 meg floppy disk. Microsoft (MS) or Personal Computer (PC) DOS 2.xx or greater is also required.

Section B of this chapter contains a complete tour of the user interface.

B. THE MAIN MODEL MENU AND ITS SUBMENUS

To initiate the main Model Menu type (menu) followed by enter/return at the DOS prompt of the directory containing the files of the system disk. Figure 3-1 will appear on the display. (For uniformity and clarity when reading interface documentation or prompts, the keystrokes required as input

will be placed in parenthesis. Unless otherwise stated, input may be lower or upper case.)

```
*****
                                MODEL MENU
    FOR THE DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT
*****

    1. INTRODUCTION TO THE MODEL MENU
    2. HELP FACILITIES
    3. VARIABLE MANIPULATION
    4. RUN SIMULATIONS
    5. TO STORE AND PRINT RESULTS
    6. VIEW RESULTS AND PRINT GRAPHS
    7. EXIT TO DOS

Choose an option: (ESC exits menu)
```

Figure 3-1. The Model Menu

The user needs only to type the number of his/her selection and follow the prompts to move through any of the menu items selected. Pressing the escape key at any submenu will return the user to the next higher level menu until reaching the Model Menu's main screen Figure 3-1.

The Model Menu provides the user six topic areas to choose from. Menu options are explained below in the order listed in the Model Menu of Figure 3-1. All submenus of an option (e.g., selecting option 1 provides the user a submenu of the same title with three additional selections) will be discussed before proceeding to the next menu selection.

The first option on the main menu is INTRODUCTION TO THE MODEL MENU. If selected, the user is presented the submenu shown in Figure 3-2.

```
*****
      INTRODUCTION TO THE MODEL MENU
THE FOLLOWING MENU PROVIDES INTRODUCTORY INFORMATION TO
      NEW USERS
*****

      1.  PURPOSE OF THE MODEL MENU
      2.  HARDWARE/SOFTWARE REQUIREMENTS
      3.  SUGGESTIONS FOR USING THE MENU

Choose an option:  (ESC exits menu)
```

Figure 3-2. Introduction to the Model Menu

The three user selections available in Figure 3-2, provide introductory information on the operation of the model menu. The three selections are (1) Purpose of the Model Menu, (2) Hardware/Software Requirements, and (3) Suggestions for Using the Menu, Figures 3-3, 3-4 and 3-5.

After returning to the main Model Menu, selection of option # 2, Help Facilities, provides the user access to the submenu shown in Figure 3-6.

WELCOME

WELCOME TO THE MODEL MENU ! JUST BRIEFLY,
LETS DISCUSS WHAT THE MODEL MENU IS AND WHAT
IT ISN'T, TO HOPEFULLY AVOID ANY CONFUSION AS YOU
BEGIN TO FAMILIARIZE YOURSELF WITH THE DYNAMICA
MODEL OF SOFTWARE PROJECT MANAGEMENT.

I. COMPONENTS OF THE MODEL MENU

THE DYNAMICA MODEL OF SOFTWARE PROJECT
MANAGEMENT IS A SOPHISTICATED SIMULATION MODEL
WRITTEN BY DR. TAREK K.ABDEL-HAMID, IN PROFESSIONAL
DYNAMO. PROFESSIONAL DYNAMO (ABBREVIATED PD) IS
A HIGH LEVEL SIMULATION LANGUAGE CREATED BY PUGH -
ROBERTS ASSOCIATES, INC.

ACCESS TO THE SYSTEM DYNAMICS MODEL OF
SOFTWARE MANAGEMENT IS PROVIDED BY THE MODEL MENU.
THE MODEL MENU, WRITTEN USING EXTENDED BATCH LANGUAGE,
DOS COMMANDS, SEVERAL PUBLIC DOMAIN BATCH FILE
UTILITIES AND THE PD INTERFACE LANGUAGE DYNEX, HAS
BEEN DESIGNED TO EASE AND SPEED USER ACCESS TO THE
MODEL AND AID IN THE MANIPULATION OF SIMULATION
RESULTS.

HIT ANY KEY TO CONTINUE.

Figure 3-3. Purpose of the Model Menu

HARDWARE AND SOFTWARE REQUIREMENTS

HARDWARE:

THE MODEL REQUIRES AN IBM OR IBM COMPATIBLE XT/AT MICROCOMPUTER, WITH 640 K OF RAM AND A HARD DISK OR 1.2 MEG FLOPPY.

EXECUTION OF MODEL SIMULATIONS IS A VERY NUMERICALLY INTENSIVE OPERATION. THE EXECUTION SPEED INCREASES TREMENDOUSLY WITH THE USE OF A MATH CO-PROCESSOR CHIP.

THE MODEL PROVIDES SUPPORT FOR THE MOST COMMON GRAPHIC DISPLAY MODES, MDA, CGA AND EGA. THE MODEL'S USE OF COLOR IS DESIGNED TO ENHANCE USABILITY BUT IS NOT A REQUIREMENT.

SOFTWARE:

THE MODEL REQUIRES MS OR PC DOS 2.xx OR GREATER. CHECK TO MAKE SURE ALL THE FILES LISTED ON THE SYSTEM DISK ARE PRESENT IF ANY PROBLEMS ARISE.

HIT ANY KEY TO CONTINUE

Figure 3-4. Hardware and Software Requirements

SUGGESTIONS

THE FIRST RECOMMENDED ORDER OF BUSINESS FOR ALL NEW USERS IS TO FAMILIARIZE YOURSELVES WITH THE MODEL MENU. TAKE A FEW MOMENTS AND EXPLORE ALL THE MENU SELECTIONS. THERE IS NO NEED TO ENTER DATA OR RESPOND TO ANY OF THE QUERIES, JUST SCAN THE SCREENS AND HIT ENTER OR ANY KEY AS PROMPTED TO CONTINUE. THIS WHOLE PROCESS SHOULD ONLY TAKE YOU 10 MINUTES OR SO.

HIT ANY KEY TO CONTINUE

Figure 3-5.1. Suggestions for Using the Model

REVIEW THE MODEL VARIABLES

IF YOU PLAN TO USE THE MODEL TO SIMULATE A PARTICULAR SOFTWARE PROJECT THAT YOU HAVE DATA ON, THE MODEL SHOULD BE CUSTOMIZED TO REFLECT THAT PROJECT. YOUR FIRST STEP TOWARDS THAT GOAL OF MODEL PARAMETERIZATION IS TO REVIEW THE DEFINITIONS OF THE ADJUSTABLE VARIABLES WITHIN THE MODEL. THESE DEFINITIONS ARE AVAILABLE BY SELECTING # 3, VARIABLE MANIPULATION FROM THE MODEL MENU.

HIT ANY KEY TO CONTINUE

Figure 3-5.2. Suggestions for Using the Menu

HELP FACILITIES
INTRODUCTION TO DYNAMICA AND PROFESSIONAL
DYNAMO HELP FACILITIES

1. OVERVIEW OF HELP FACILITIES
2. ONLINE MODEL HELP INFORMATION
3. PROFESSIONAL DYNAMO HELP

Choose an option: (ESC exits menu)

Figure 3-6. Help Facilities

Selection # 1, Overview of Help Facilities, provides the user with an explanation of the two types of help facilities available in the model Figure 3-7.

OVERVIEW OF AVAILABLE HELP FACILITIES

THERE ARE TWO TYPES OF HELP AVAILABLE TO THE USER:
(1) ONLINE MODEL HELP
(2) PROFESSIONAL DYNAMO HELP

(1) ONLINE MODEL HELP IS AVAILABLE TO THE USER WHEN UTILIZING SELECTION # 3 OF THE MAIN MENU - VARIABLE MANIPULATION. AT ANY PROMPT, THE USER NEED ONLY TO TYPE (H)ELP (H)ELP TO GET A LIST OF AVAILABLE HELP CATEGORIES.

(2) PROFESSIONAL DYNAMO HELP PROVIDES THE MORE EXPERIENCED MODEL USER ACCESS TO 8 PD HELP TOPICS.

HIT ANY KEY TO CONTINUE

Figure 3-7. Overview of Help Facilities

Selection # 2, Online Model Help Information, explains the operation and capabilities of online model help Figure 3-8.

Selection # 3 , Professional Dynamo Help, presents the user a submenu containing a list of the PD Help Facilities available Figure 3-9. Professional Dynamo Help is listed in Appendix C.

ONLINE MODEL HELP INFORMATION

THE DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT HAS THE CAPABILITY FOR EXTENSIVE, USER DEFINED, EASILY MODIFIABLE HELP. ACCESS TO THIS HELP IS AVAILABLE WHILE UTILIZING MAIN MENU SELECTION # 3, MODEL & VARIABLE MANIPULATION. THIS HELP CAPABILITY IS A FEATURE OF PROFESSIONAL DYNAMO, DESIGNED BY PUGH-ROBERTS ASSOCIATES, INC.

TO ACCESS AN EXAMPLE OF THIS HELP, THE USER SIMPLY TYPES (H)ELP (H)ELP FOLLOWED BY ENTER.

HIT ANY KEY TO CONTINUE

Figure 3-8. Online Model Help Information

```
*****
PROFESSIONAL DYNAMO HELP
THE FOLLOWING MENU PROVIDES ACCESS TO
PD HELP FACILITIES
*****
```

1. OVERVIEW OF PD HELP
2. DYNEX HELP
3. EDITOR HELP
4. SIMULATION HELP
5. TOOLS HELP
6. TRANSLATOR HELP
7. UTILITIES HELP
8. VIEW HELP

Choose an option: (ESC exits menu)

Figure 3-9. Professional Dynamo Help

Returning to the main menu, we now discuss Model Menu option # 3, Variable Manipulation. The objective of this selection is define the variables for the new user and allow manipulation of these variables in the Dynamica model. This is accomplished via the Dynex Model Interface, written for this thesis in Professional Dynamo's executive level programming language Dynex.

The Dynex interface allows the user to view and manipulate variable values within the model. After selecting Variable Manipulation the user is presented Figure 3-10. The purpose of Figure 3-10 is simply to acknowledge to the user

that the selection has been activated and to prevent him from having to stare at a blank screen for the four to five seconds required to load the Dynex Interface. The local time and date will be displayed if the computer in use has a battery powered clock/calendar.

THE MODEL IS BEING LOADED !

Local Time
Local Date

Figure 3-10. Variable Manipulation

After the Dynex Model Interface is loaded the user will be presented Figure 3-11.

```
*****  
THE DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT  
March 1988  
*****
```

Press ENTER for a brief introduction to Model and Variable Manipulation. It is suggested reading for all new users of Dynamica.

Experienced users will most likely want to skip directly to Model and Variable Manipulation. To do so type (n)o followed by Enter.

Press Enter or (n)o followed by Enter to Continue

Figure 3-11. Dynex Interface Introduction

The introduction, shown in full in Figures 3-12, 3-13, 3-14 and 3-15, is appropriate for new users of the Dynamica model, but may be skipped if desired by the experienced user.

The Dynex Model Interface then identifies, and defines the 18 model variables in Figures 3-16 and 3-17 which are available to the user to manipulate. The variables are divided into four categories: (1) Estimated Actual Project Size, (2) Variables Characteristic of the Organizational Environment, (3) Policy Variables, and (4) Model Control Variables.

```
*****
WELCOME TO PROFESSIONAL DYNAMO AND THE DYNAMICA MODEL
      OF SOFTWARE PROJECT MANAGEMENT           page 1
*****
```

INTRODUCTION

Professional Dynamo is a high level model simulation language that has been used to create THE DYNAMICA MODEL OF SOFTWARE MANAGEMENT. You need to have no knowledge of how Professional Dynamo works to use the model.

THE DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT, here after simply referred to as DYNAMICA, is a sophisticated simulation model designed to provide assistance in understanding and estimating the numerous and complex variables dynamically involved in a large software development project.

Press Enter to Continue

Figure 3-12. Dynex Interface page 1

Introduction

page 2

To speed you on your way, a menu system has been developed to help you access the model which is written in PROFESSIONAL DYNAMO. This menu allows the user to customize the model to fit a specific software project and conduct "what if" type experimentation. The user may access any of 18 variables or table values, from four categories.

Press Enter to Continue

Figure 3-13. Dynex Interface page 2

Introduction

page 3

When addressing a particular variable, the user may chose any value or use a previously defined value. Changes to variables from your last simulation are automatically stored with your simulation results if you chose to store your results.

Your first step after you become familiar with the mechanics of the model will be to adjust all the pertinent variables to customize the model to represent any specific software project you might have in mind. Otherwise, you may use the model "as is", to conduct your experimentation in the relationships of the variables.

Press Enter to Continue

Figure 3-14. Dynex Interface page 3

Introduction page 4

The DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT has the potential for extensive online help facilities. Currently, only one aspect of the online help facility is employed, that being HELP on HELP. This has been done to demonstrate the available capability. To view the HELP on HELP, type (h)elp followed by a space and (h)elp again followed by striking the enter/return key.

Press Enter to Continue

Figure 3-15. Dynex Interface page 4

VARIABLE MANIPULATION

page 5

The following 18 model variables of Dynamica are adjustable via the menu
They are grouped in 4 categories for easy access.

- I. ESTIMATED ACTUAL PROJECT SIZE
 - 1. RJBDSIReal Job Size in DSI
- II. VARIABLES CHARACTERISTIC OF THE ORGANIZATIONAL ENVIRONMENT
 - A. Productivity
 - 2. DSIPTK.....Delivered Source Instruction Per Task
 - B. Quality
 - 3. TNERPK.....Error Rate Per 1000 Delivered Source Instruction
 - C. Staffing Variables
 - 4. HIREDY.....Hiring Delay
 - 5. ASIMDY.....Assimilation Delay
 - 6. AVEMPT.....Average Employment
- III. POLICY VARIABLES
 - A. Estimation
 - 7. UNDEST.....Task Underestimation Factor
 - 8. TOTMD1.....Total Mandays
 - 9. TDEV1.....Time to Develop

Press Enter To See the Remaining Variables

Figure 3-16. Dynex Interface page 5

MODEL AND VARIABLE MANIPULATION

page 6

- B. Resource Allocation
 - 10. DEVPRT% of Effort Assumed Needed for Development
 - 11. TPRMQA....Fraction of Manpower Devoted to Quality Assurance
 - 12. INDUST.....Initial Understaffing Factor
 - 13. WCWF1.....Willingness to Change the Workforce
- C. Staffing
 - 14. TRPHNR.....% of Experienced Employee Effort to Train a New Employee
 - 15. AMPPS.....Average Daily Manpower/Staff Expended on Project

IV. MODEL CONTROL

- 16. MAXLEN.....Max Length of Project
- 17. SAVPER.....Save Period for Data

Press Enter to See Variable Definitions
or to Manipulate Variable Values.

Figure 3-17. Dynex Interface page 6

The user may select to first look at a brief explanation of the variables, or go directly to variable manipulation as shown in Figure 3-18. To make a selection, type the number of the choice or choices, separating each number by a space or a comma. If no choice or an illegal choice is made, Dynex will prompt the user to reenter all of his choices again.

MODEL AND VARIABLE DEFINITION AND MANIPULATION page 7

Select one or more of the following eight topic areas. You may chose to first look at a brief explanation of the variables or go directly to variable manipulation.

- I. MODEL VARIABLE DEFINITIONS
 - 1. ESTIMATED ACTUAL PROJECT SIZE DEFINITION
 - 2. VARIABLES CHARACTERISTIC OF THE ORGANIZATIONAL ENVIRONMENT DEFINED
 - 3. POLICY VARIABLES DEFINED
 - 4. MODEL CONTROL VARIABLES DEFINED

- II. MANIPULATION OF MODEL VARIABLES
 - 5. ESTIMATED ACTUAL PROJECT SIZE
 - 6. VARIABLES CHARACTERISTIC OF THE ORGANIZATIONAL ENVIRONMENT
 - 7. POLICY VARIABLES
 - 8. MODEL CONTROL VARIABLES

Enter the number(s) of your selected choices.
Separate each choice by a space or a comma.

Figure 3-18. Dynex Interface page 7

Selection of choice # 1 from Figure 3-18, provides the user the definition of Estimated Actual Project Size Figure 3-19. The user is automatically returned to the main Model

Menu after reviewing the last choice selected. Let us assume for the sake of this tour that the user has selected all eight choices.

ESTIMATED ACTUAL PROJECT SIZE DEFINITION page 8

REAL JOB SIZE IN DSI.....RJBDSI

The real size of the software project in delivered source instructions (DSI) with comments. The following definitions are from Boehm, 1981.

Delivered. This term is generally meant to exclude nondelivered support software such as test drivers. However, if these are developed with the same care as delivered software, with their own reviews, test plans, documentation, etc., then they should be counted.

Source Instructions. This term includes all program instructions created by project personnel and processed into machine code by some combination of preprocessors, compilers, and assemblers. It excludes comment cards and unmodified utility software. It includes job control language, format statements and data declarations. Instructions are defined as lines of code or card images. Thus, a line containing two or more source statements counts as one instruction; a five-line data declaration counts as five instructions.

Press Enter to Continue

Figure 3-19. Dynex Interface page 8

Selection # 2, Variables Characteristic of the Organizational Environment, presents the user the five variables definitions shown in Figures 3-20, 3-21, and 3-22.

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL
ENVIRONMENT DEFINITION page 9

DELIVERED SOURCE INSTRUCTION PER TASK.....DSIPTK

This parameter is set to the value of the nominal potential productivity in the organizational environment being modeled. For example, if the nominal potential productivity is 50 DSI/Man-Day then DSIPTK would be set to 50.

ERROR RATE PER 1000 DELIVERED SOURCE
INSTRUCTIONS (KDSI)TNERPK

TNERPK is the number of errors committed on the average, per 1000 DSI, as the software project is being developed. It is not a single number but rather a table function. This allows the user to set different error rates at different stages of the project's lifecycle.

Press Enter to Continue

Figure 3-20. Dynex Interface page 9

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL
ENVIRONMENT DEFINITION page 10

HIRING DELAYHIREDY

HIREDY is the average delay time, in work days, incurred in adding new staff members to the project.

ASSIMILATION DELAYASIMDY

ASIMDY is the average time needed to assimilate newly hired personnel into the project, measured in workdays. It is the time required for orientation, institutionalization and training.

Press Enter to Continue

Figure 3-21. Dynex Interface page 10

AVERAGE EMPLOYMENTAVEMPT
AVEMPT is the average employment time of project team members, measured in working days. It is indirectly proportional with TURNOVER. For example, the smaller the AVEMPT the larger the turnover rate, and conversely, the smaller the turnover rate the higher the AVEMPT.

Press Enter to Continue

Figure 3-22. Dynex Interface page 11

Selection # 3, Policy Variables, presents the user the definitions of the seven policy variables shown in Figures 3-23, 3-24, 3-25, 3-26, and 3-27.

Selection of # 4, Model Control Variables, presents the user the definitions shown in Figure 3-28. The Dynex interface allows the user to adjust two model control variables. These variables provide the user control over two aspects of model operation.

POLICY VARIABLES DEFINITIONS

page 12

TASK UNDER ESTIMATION FACTORUNDEST

Undersizing is a large problem in project management. This variable allows the to experiment with different values of underestimates. Thus to simulate a situation where the project size is initially underestimated by 25%, this variable would be set to 0.25.

TOTAL MAN DAYSTOTMD1

TOTMD1 is the man-day estimate produced at the start of the project, for design, coding and system testing of the project.

TIME TO DEVELOPTDEV1

TDEV1 represents the estimated time, measured in work days, for the design, coding and testing stages of the project, produced at the start of the project. For example, if the initial project duration estimate was 16 months, TDEV1 would be equal to (16 x 20) or 320 working days.

Press Enter to Continue

Figure 3-23. Dynex Interface page 12

POLICY VARIABLES DEFINITIONS

page 13

% OF EFFORT ASSUMED NEEDED FOR DEVELOPMENTDEVPR

This variable is used to allocate the projected total budget, measured in Man-Days, for the development (which includes design and coding) and testing phases. For example, if it is decided that 80% of the total Man-Days would be allocated to development and 20% to testing, then DEVPR would be set to 0.80.

FRACTION OF MANPOWER DEVOTED TO QUALITY ASSURANCE ...TPFMQA

TPFMQA is the percent of development effort allocated in the project's plan for QA activities during the design and coding stages. It is not a single number but rather a table function that allows the user to change the number of Man-Days allocated to QA at different stages in the project lifecycle. A value of 0.20 at some point in the project would indicate that at this point, 20% of the Man-Day budget is allocated to QA.

Press Enter to Continue

Figure 3-24. Dynex Interface page 13

POLICY VARIABLES DEFINITIONS

page 14

INITIAL UNDERSTAFFING FACTORINDUST

The project's average staffing level is equal to the project's total number of Man-Days divided by the project's scheduled duration. Typically, the project will start with a small core team which grows in size. This variable specifies the size of the starting group. Thus a value of 0.5 indicates that the startup team is half the size of the average staff size.

Press Enter To Continue

Figure 3-25. Dynex Interface page 14

POLICY VARIABLES DEFINITIONS

page 15

WILLINGNESS TO CHANGE THE WORKFORCEWCWF1

On deciding upon a "Workforce" level desired, project managers typically consider a number of factors. One important factor is the project's scheduled completion date. As part of the planning function, management determines the workforce level that it believes is necessary to complete the project on schedule. In addition to this factor, consideration is also given to the stability of the workforce. Thus, before adding new project members, management tries to contemplate the project employment for new members. Different organizations weigh this factor differently. In general, the relative weighing between the desire for workforce stability on one hand and the desire to complete the project on time, on the other, is not static, but changes dynamically throughout the lifecycle of the project. For example, toward the end of the project there is typically considerable reluctance to bring in new people, even if the project is behind schedule. It would take too much time and effort (relative to the time and effort that are remaining) to acquaint new people with the mechanics of the project, integrate them into the project team and train them in the necessary technical areas.

Press Enter for More Information of WCWF1

WCWF1 DEFINITION CONTINUE

page 16

These managerial considerations are operational in the model as follows: $WORKFORCE\ LEVEL\ NEEDED = (INDICATED\ WORKFORCE\ LEVEL) * (WCWF) + (CURRENT\ WORKFORCE) * (1-WCWF)$

The Weighting Factor (WCWF) is termed Willingness to Change the Workforce.

In the early stages of the project when "Time Remaining" is generally much larger than the sum of "Hiring Delay" and the "Average Assimilation Delay" WCWF would be equal to 1. When WCWF is = 1, the "Workforce Level Needed" in the above equation would simply be equal to the "Indicated Workforce Level," i.e., management would be adjusting its workforce size to the level it feels is needed to finish on schedule. The "Indicated Workforce Level" can be determined by dividing the amount of effort that management perceives is still remaining (in Man-Days) by the time remaining to complete the project in days.

When the "Time Remaining" decreases, ASSIMILATION DELAY (ASIMDY) could be set to equal exactly 0. The "Workforce Level Needed" in the equation would thus be equal to the "Current Workforce" i.e., management attempts to maintain the projects workforce at its current level, and make adjustments to the schedule instead.

Press Enter to Continue

Figure 3-26. Dynex Interface page 16

POLICY VARIABLE DEFINITIONS

page 17

TRAINERS PER NEW EMPLOYEETRPHNR

In most organizations, training of new employees is carried out by the more experienced employees. This variable defines the fraction of an experienced staff member's time that is devoted to train new hirees. For example, a value of 0.2 indicates that on the average each new employee consumes 20% of an experienced employee's time for the duration of the assimilation delay.

AVERAGE DAILY MANPOWER PER STAFF EXPENDED
ON PROJECTADMPPS

Project members are often only assigned part-time to a project. ADMPPS defines the % of time that the team members devote, on an average to the particular project being simulated. For example, if staff members tend to divide their time equally between two projects, i.e., half of their time is spent on project A and the other half is spent on project B, then ADMPPS would be = 0.5.

Press Enter to Continue

Figure 3-27. Dynex Interface page 17

MODEL CONTROL VARIABLE DEFINITIONS page 18

MAX LENGTH OF PROJECTMAXLEN

This model control variable is useful in controlling the simulations. It precludes the model from continuing a simulation beyond a predetermined length, e.g., 1000 days.

SAVE PERIOD FOR DATASAVPER

This model control variable allows the user to adjust the models save period for data for later viewing. For example, if the user sets the SAVPER = 1, the model will save all variable values on a daily basis, this data would be available for the user to examine and plot at the end of a simulation. A SAVPER of 10, saves values every 10 days. This provides the user with a trade off between the time required for a simulation and the level of detail of the results.

Press Enter to Continue

Figure 3-28. Dynex Interface page 18

Selections # 4-8 provide the user the opportunity to manipulate the variables defined by the first four selections. When the user selects any category of model manipulation, the current value of each variable is displayed as shown in Figures 3-29 - 3-43. To change a variable enter the value desired and depress enter/return. If the user wishes to use the current value simply press enter/return. In either case the next variable to be manipulated will be displayed or the user will be automatically returned to the Model Menu if no other variables have been selected.

```
*****
ESTIMATED ACTUAL PROJECT SIZE VARIABLE MANIPULATION page 19
```

```
*****
REAL JOB SIZE IN DELIVERED SOURCE INSTRUCTIONS .....RJBDSEI
Enter a new value for REAL JOB SIZE IN DELIVERED SOURCE
INSTRUCTIONS or press enter to use the preset value. The
preset value is written using a form of scientific notation
where e3 represents x 10 to the third power. You do not have
to enter a value in that format but be aware that the model
will represent numbers in that format.
24.4e3
```

Figure 3-29. Dynex Interface page 19

```
*****
VARIABLES CHARACTERISTIC OF ORGANIZATIONAL
ENVIRONMENT MANIPULATION page 20
*****
```

```
Enter a new value for DELIVERED SOURCE INSTRUCTIONS PER
TASK or press enter to use the preset value.
40.0
```

Figure 3-30. Dynex Interface page 20

Although most variables are a single value, some of the variables have more than one value and are referred to as table values. Examples of table values are shown in Figures 3-31, 3-31.1, 3-36, 3-38 and 3-40. Figures 3-31, and 3-31.1 show that the user enters all six table values, separating each value by either a space or comma, before depressing enter/return. Table values generally represent variables whose values change over time. Dynex will prompt the user to

respond again if an incorrect number of variables are entered. The method of entering multiple variables is the same as selecting multiple choices from a Dynex Menu, each choice must be separated by a space or a comma.

```
*****
      VARIABLES CHARACTERISTIC OF ORGANIZATIONAL
      ENVIRONMENT MANIPULATION                      page 21
*****
```

Enter a new value for ERROR RATE PER 1000 DELIVERED SOURCE INSTRUCTIONS or press enter to use the preset table values.

1 2 3 4 5 6

Figure 3-31. Dynex Interface page 21

```
*****
      VARIABLES CHARACTERISTIC OF ORGANIZATIONAL
      ENVIRONMENT MANIPULATION                      page 21
*****
```

Enter a new value for ERROR RATE PER 1000 DELIVERED SOURCE INSTRUCTIONS or press enter to use the preset table values.

1	2	3	4	5	6
24.0	22.9	20.75	15.25	13.1	12.0

Figure 3-31.1. Dynex Interface page 21

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL
ENVIRONMENT MANIPULATION page 22

Enter a new value for HIRING DELAY or press enter to use
the preset value.
30.0

Figure 3-32. Dynex Interface page 22

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL
ENVIRONMENT MANIPULATION page 23

Enter a new value for ASSIMILATION DELAY or press enter
to use the preset value.
20.0

Figure 3-33. Dynex Interface page 23

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL
ENVIRONMENT MANIPULATION page 24

Enter a new value for AVERAGE EMPLOYMENT or press enter
to use the preset value.
1000

Figure 3-34. Dynex Interface page 24

The user is provided two methods of entering values for the variables Total Man-Days and Time to Develop as shown in Figure 3-35. The values may be entered directly, similar to the other variables or the user may elect to have the model compute both values using COCOMO.

POLICY VARIABLE MANIPULATION page 25

For assigning values to TOTAL MANDAYS and TIME TO DEVELOP the user may either:

1. Calculate the two values external to the model and input them directly at the prompt below.

OR

2. Allow the model to calculate the two values internally utilizing COCOMO by imputing 0 for each of the 2 variables at the COCOMO PROMPT.

TOTMD1 1111
TDEV1 320.0

COCOMO PROMPT:

Enter 1 at the next two prompts to allow COCOMO to compute TOTMD1 AND TDEV1. OR enter 0 to use your own values input above.

Press Enter to Continue

Figure 3-35. Dynex Interface page 25

POLICY VARIABLES MANIPULATION page 26

Enter a new set of table values for the TASK UNDER ESTIMATION FACTOR or press enter to use the preset value.

1 2 3 4 5 6 7 8 9 10 11

Figure 3-36. Dynex Interface page 26

POLICY VARIABLES MANIPULATION page 27

Enter a new value for % OF EFFORT ASSUMED NEEDED FOR DEVELOPMENT or press enter to use the preset value.

.5

Figure 3-37. Dynex Interface page 27

POLICY VARIABLES MANIPULATION page 28

Enter a new value for FRACTION OF MANPOWER DEVOTED TO QUALITY ASSURANCE or press enter to use the preset value.

1 2 3 4 5 6 7 8 9 10 11

Figure 3-38. Dynex Interface page 28

POLICY VARIABLES MANIPULATION page 29

Enter a new value for INITIAL UNDERSTAFFING FACTOR or press enter to use the preset value.

.4

Figure 3-39. Dynex Interface page 29

POLICY VARIABLES MANIPULATION page 30

Enter a new value for WILLINGNESS TO CHANGE THE WORKFORCE or press enter to use the preset table values.

1 2 3 4 5 6 7 8 9 10 11 12 13 14

Figure 3-40. Dynex Interface page 30

POLICY VARIABLES MANIPULATION page 31

Enter a new value for PERCENT OF EXPERIENCED EMPLOYEE EFFORT TO TRAIN A NEW EMPLOYEE or press enter to use the preset value.

.25

Figure 3-41. Dynex Interface page 31

POLICY VARIABLES MANIPULATION page 32

Enter a new value for AVERAGE DAILY MANPOWER PER STAFF EXPENDED ON PROJECT TO TRAIN A NEW EMPLOYEE or press enter to use the preset value.

.5

Figure 3-42. Dynex Interface page 32

MODEL CONTROL VARIABLE MANIPULATIONS page 33

Enter a new value for MAX LENGTH OF PROJECT or press enter to use the preset value.

1000

Figure 3-43. Dynex Interface page 33

MODEL CONTROL VARIABLE MANIPULATIONS page 34

Enter a new value for SAVE PERIOD FOR DATA or press enter to use the preset value.

10

Figure 3-44. Dynex Interface page 34

Figure 3-44 is the last screen in the Dynex Model Interface. The user is automatically returned to the main Model Menu.

After returning to the main Model Menu, selection # 4, Run Simulation, allows the user to run a model simulation with the variable values selected via main Model Menu selection # 3. After selecting Run Simulation the user views Figure 3-45 while the Dynamica model is prepared for simulation.

THE MODEL IS BEING PREPARED FOR A SIMULATION !

Local Time
Local Date

Figure 3-45. Run Simulation

After loading the Dynamica model automatically runs the simulation. Upon conclusion of the simulation run, the user is automatically returned to the main Model Menu.

Selection of Model Menu # 5, To Store and Print Results, provides the user access to the submenu shown in Figure 3-46.

```
*****
      TO STORE AND PRINT RESULTS
    THIS MENU ALLOWS THE USER TO STORE AND PRINT
      SIMULATION RESULTS
*****

      1.  STORING STATISTICS

      2.  PLOTTING RESULTS

      3.  PRINTING YOUR RESULTS

Choose an option:  (ESC exits menu)
```

Figure 3-46. To Store and Print Results

The user is provided three submenu selections in Figure 3-46: (1) Storing Statistics, (2) Plotting Results and (3) Printing Your Results.

If # 1, Storing Statistics is selected, the model collects statistics from the previous simulation and places them in a predefined report format. This report format may be adjusted utilizing Professional Dynamo, to suit the user's needs. This report may then be stored under a file and in a directory of the user's choice for future reference Figure 3-47. Any changes to variables from the previous simulation run will be appended and stored at the bottom of the report.

YOUR RESULTS ARE BEING STORED IN THE PROPER FORMAT !

Local Time
Local Date

PLEASE ENTER THE FILE NAME YOU DESIRE FOR THIS REPORT.
IT IS SUGGESTED THAT YOU NAME YOUR FILES IN A MANNER
WHICH WILL ALLOW THE MAXIMUM BENEFITS OF THE DOS
WILDCARD (*) FEATURE WHEN MANIPULATING YOUR FILES.

EXAMPLE: (PROJECT.*)

NOTE: CHANGES MADE TO VARIABLES ARE APPENDED TO THIS
FILE. FOR EXAMPLE IF HIRING DELAY WAS CHANGED
FROM 30 TO 40, THAT INFORMATION WOULD BE STORED
AT THE END OF THE REPORT.

ENTER THE FULL PATH NAME OF THE DIRECTORY WHERE
YOU WOULD LIKE THE RESULTS STORED.

Figure 3-47. Storing Statistics

At the conclusion of Storing Statistics, the user is
automatically returned to Figure 3-46.

Selecting # 2, Plotting Results, provides the user access
to the submenu shown in Figure 3-48.

```
*****  
                                PLOTTING RESULTS  
THE FOLLOWING MENU ALLOWS THE USER TO VIEW AND  
                                SAVE 4 PREDEFINED PLOTS  
*****
```

1. OVERVIEW PLOTTING FUNCTIONS
2. PLOT 1
3. PLOT 2
4. PLOT 3
5. PLOT 4

Choose an option: (ESC exits menu)

Figure 3-48. Plotting Results

There are five selections available in Figure 3-48. Selection # 1, Overview of the Plotting Functions, provides the user an introduction to the origin and purpose of a set of four predefined plots, selections # 2-5 Figure 3-49. Selecting any of the predefined plots presents the user a list of the variables plotted by that selection Figures 3-50, 3-51, 3-52 and 3-53. The variables are then plotted and the user is given the option of printing the plot if so desired.

OVERVIEW OF PLOTTING FUNCTIONS

The Dynamica model can create plots of preselected variables. Each Plotting function, contains a list of the variables plotted by that menu selection. Viewing a plot is simply a matter of selecting the number of the plot desired. These plots may be printed using the print function of the included menu.

HIT ANY KEY TO CONTINUE !

Figure 3-49. Overview of Plotting Functions

PLOT 1

PLOT 1 GRAPHS THE FOLLOWING VARIABLES:

SCHCDT ESTIMATED SCHEDULE IN DAYS

PJBSZ PERCEIVED PROJECT SIZE IN TASKS

JBSZMD ESTIMATED PROJECT COST IN MAN-DAYS

TOTWF TOTAL WORKFORCE PEOPLE

CUMMD CUMULATIVE MAN-DAYS EXPENDED

IF YOU HAVE AN EGA CARD TYPE (Y)ES IF NOT TYPE (N)O.

Figure 3-50. Plot 1

PLOT 2

FIRST, A QUICK REVIEW OF THE VARIABLES BEING PLOTTED:

CMTKDV CUMULATIVE TASKS DEVELOPED

CUMTKTCUMULATIVE TASKS TESTED

CUMMD CUMULATIVE MAN-DAYS EXPENDED

PJBSZ PERCEIVED PROJECT SIZE IN TASKS

PDEVRC ESTIMATED % DEVELOPMENT COMPLETE

IF YOU HAVE AN EGA CARD TYPE (Y)ES IF NOT TYPE (N)O.

Figure 3-51. Plot 2

PLOT 3

FIRST, A QUICK REVIEW OF THE VARIABLES BEING PLOTTED:

TOTWF TOTAL WORKFORCE

FRWFEX FRACTION OF WORKFORCE THAT IS
EXPERIENCED

SDVPRD PRODUCTIVITY

COMMOH COMMUNICATION OVERHEAD

IF YOU HAVE AN EGA CARD TYPE (Y)ES IF NOT TYPE (N)O.

Figure 3-52. Plot 3

PLOT 4

FIRST, A QUICK REVIEW OF THE VARIABLES BEING PLOTTED:

AFMPDJ ACTUAL FRACTION OF A MAN-DAY ON
PROJECT

JBSZMD PERCEIVED TOTAL JOB SIZE IN
MAN-DAYS

PJBSZ PERCEIVED JOB SIZE IN TASKS

PMDSHR PERCEIVED SHORTAGE IN MAN-DAYS

IF YOU HAVE AN EGA CARD TYPE (Y)ES IF NOT TYPE (N)O.

Figure 3-53. Plot 4

When the user is finished with the plotting functions, pressing the escape key returns Figure 3-46 to the screen.

The last option available to the user in Figure 3-46 is selection # 3, Printing Your Results. Selection of choice # 3, Printing Your Results, allows the user to print any files to an attached printer. The user is asked to type only the name of the file to be printed. The use of DOS wildcard symbols is suggested to aid in printing large numbers of files at a time Figure 3-54. The DOS command graphics has been entered for the user, to allow the use of bit mapped graphics for suitably configured printers.

```
PLEASE ENTER THE FULL NAME OF THE FILE YOU WOULD LIKE  
PRINTED. YOU MAY USE DOS WILDCARD ( * ) SYMBOLS FOR  
PRINTING MORE THEN ONE FILE AT A TIME.
```

```
OTHERWISE, PLEASE TYPE (Q) TO QUIT.  
EXAMPLE: (MONDAY.*)
```

Figure 3-54. Printing Your Results

Typing (Q)uit returns the user to Figure 3-46. To return to the main Model Menu press escape.

Selection of # 6, from the Model Menu, View Results and Print Graphs, allows the user to view statistical results on any or all of 46 performance parameters measured for each simulation or create graphs for any of 30 variables. After selecting # 6, the user is queried as to the graphics card

capability of the computer in use Figure 3-55. This allows graphs to be displayed and printed at the maximum resolution for the equipment in use.

YOUR RESULTS ARE BEING PREPARED FOR VIEWING !

IF YOU HAVE AN EGA GRAPHICS CARD TYPE (y)
FOLLOWED BY ENTER.

IF YOU DO NOT HAVE AN EGA CARD TYPE (n)
FOLLOWED BY ENTER.

Figure 3-55. View Results and Print Graphs

The user may return to the main Model Menu by pressing escape or quit at the prompt after making any number of graphs desired.

The final selection of the main Model Menu is # 7, Exit To Dos. This selection simply returns the user to the DOS prompt in the directory where the user interface is stored. To return to the Model Menu, type (menu) and depress enter/return.

IV. SYSTEM ARCHITECTURE

A. OVERVIEW OF THE SYSTEM ARCHITECTURE

A system architecture overview of the user interface created in this thesis is depicted in Figure 4-1. There are three interrelated subsystems represented at this level, the Model Menu, the Dynamica model and the Dynex Model Interface.

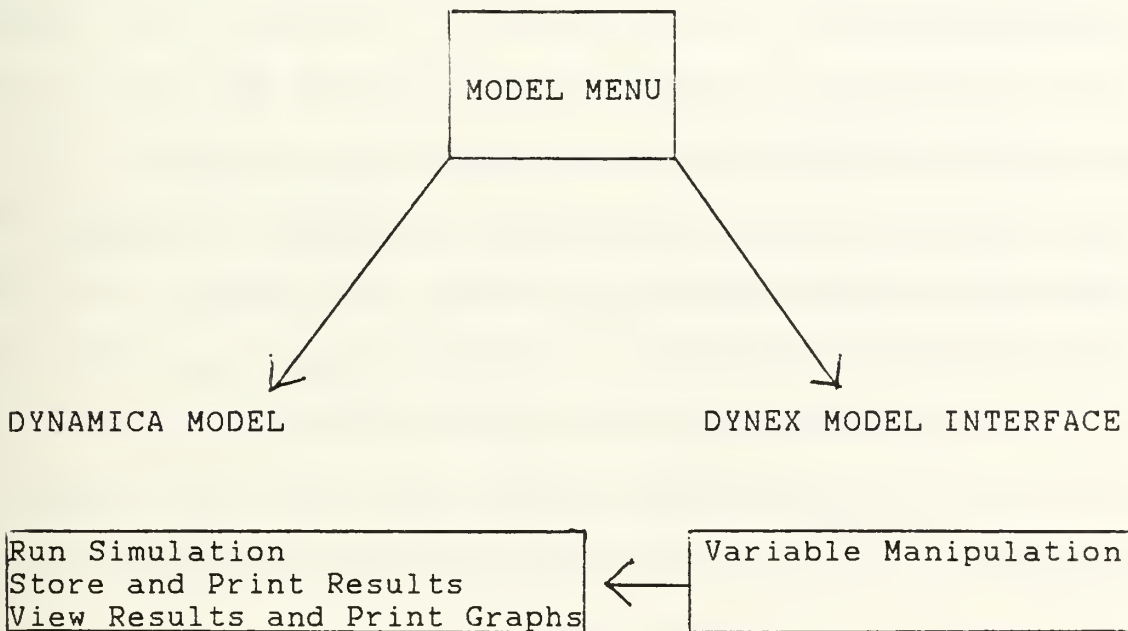


Figure 4-1. Overview of System Architecture

The heart of the system is the Dynamica model. The Dynamica model, written in Professional Dynamo, allows the dynamic processing of variables from management-type functions and software production type activities. The Model menu allows the inexperienced modeler, access to the Dynamica

model directly to perform the numerous model functions available through Professional Dynamo (e.g., run simulations, store and plot statistics and to view simulation results). The Dynex Model Interface is unique in that it allows the user to interact with the Dynamica model (e.g., changing the values of variables and constants). The Model Menu accesses the Dynamica model via the Dynex Model Interface to allow the user to manipulate variable values within the Dynamica model.

B. MODEL MENU

The Model Menu is a shell which allows the logical organization by function, of 24 separate batch files. The Model Menu utilizes the nesting of submenus to enhance the functional organization of the menu. For example, if # 2 Help Facilities is selected from the main Model Menu, the user is presented a submenu of three help related topics. Selection of # 3, Professional Dynamo Help, from this second menu presents the user with a submenu of eight Professional Dynamo Help topics to choose from.

The Model Menu has five functionally related submenus, Introduction to the Model Menu, Help Facilities, Professional Dynamo Help, To Store and Print Results, and Plotting Results. Typing the number of any menu selection initiates a batch file which either performs a function (e.g., selection of # 2, Run Simulation, runs a model simulation) or produces a submenu with additional choices. The 24 batch files are separate from the menu shell and are easily modified. The

submenus are part of the shell structure as listed in Appendix B and require the use of the EXECMAKE function of EBL to be modified.

The name of the batch file which initiates the menu program is menu.bat. It performs the following functions: (1) turn echo off, (2) enters the DOS command graphics, (3) loads the BATALLF command file from EBL and (4) brings the main menu, titled MODEL MENU to the display. The BATALLF command file contains the Extended Batch Language program and all external EBL function commands [Ref. 8:pp. 2-5].

The Model Menu was written using the EXECMAKE function of Extended Batch Language, Version 3 [Ref. 8:p. 10]. EBL is a high level, command programming language which can be used in replacement of, or in conjunction with DOS batch files [Ref. 9:p. 2]. EBL provides enhanced string handling characteristics, superior control structures and screen control relative to standard DOS batch files [Ref. 9:pp. 2-3].

The 24 batch files have been divided into three categories based on their functions in the Model Menu. They are discussed separately in the following three sections. A program listing of the batch files has been provided in Appendix C.

1. Batch File Explanations of Model Functions

Fourteen of the twenty-four batch files called by the Model Menu are script files which provide the user

instructions or background information on the use of the Dynamica model and the user interface Figure 4-2. All of these script files, except for Professional Dynamo Help were created for this thesis using the advanced string handling characteristics of EBL.

Figure 4-2 depicts the batch files that provide the explanation screens of menu options discussed in Chapter III.

<u>MODEL MENU</u>	<u>BATCH FILES</u>
Introduction to the Model Menu	
Purpose of the Model Menu	Purpose.bat
Hardware/Software Requirements	Hardwar.bat
Suggestions for Using the Menu	Suggest.bat

Figure 4-2. Batch File Explanations of Model Menu Functions

2. Help Batch Files

Professional Dynamo Help provides the user access to the help facilities provided within Professional Dynamo [Ref. 10]. These help facilities provide valuable information to the experienced model builder on the operation of the model. The batch files which access the eight separate Professional Dynamo help files are listed in Figure 4-3. Users view these eight separate help files via the public domain software program, List.com. List.com allows

the user to page or scroll through the files, forwards or backwards, after they have been accessed from the Model Menu [Ref. 11].

<u>MODEL MENU</u>	<u>BATCH FILES</u>
Professional Dynamo Help	
Overview of PD Help	PD.bat
Dynex Help	Dynex.bat
Editor Help	Editor.bat
Simulation Help	Simhelp.bat
Tools Help	Tools.bat
Translator Help	Transhel.bat
Utilities Help	Utilhel.bat
View Help	Viewhel.bat
To Store and Print Results	
Plotting Results	
Over of Plotting	
Funcitons	Overview.bat
Help Facilities	
Over of Help	
Facilities	Over.bat
Online Model Help	
Information	Help.bat

Figure 4-3. Help Batch File

3. Batch Files for Printing Simulation Results

As a convenience to the user, a file printing facility was created and included in the menu system to allow the user to produce hard copies of simulation results with an attached printer. The print.bat file see Figure 4-4 was

written using DOS and EBL commands. A public domain software program, SDIR26.com, is utilized in the batch file to produce the directory display the user views [Ref. 12].

<u>MODEL MENU</u>		<u>PRINTING FILES</u>
Printing Your Results	Print.bat	prints files using DOS commands

Figure 4-4. Model Menu - Printing Files

C. THE DYNAMICA MODEL

The Dynamica model, was originally written by Dr. Tarek K. Abdel-Hamid, while at the Massachusetts Institute of Technology [Ref. 13]. The Model Menu accesses the Dynamica model directly via the seven separate batch files listed in Figure 4-5, or indirectly via the Dynex Model Interface. The seven batch files shown in Figure 4-5, call commands within the Dynamica model. The Dynex Model Interface is explained in part D. of this chapter.

Explanations of the Dynamica model commands shown in Figure 4-5, which would be useful to the experienced model builder, can be found in the Professional Dynamo Help screens.

<u>MODEL MENU</u>		<u>PROFESSIONAL DYNAMO</u> <u>COMMANDS</u>
Run Simulations	Runsim.bat	smlt project -go =
Store and Print Results		
Storing Statistics	Simulat.bat	project stats
Plotting Results Functions		
Plot 1	Plot1.bat	rep project plot1
Plot 2	Plot2.bat	rep project plot2
Plot 3	Plot3.bat	rep project plot3
Plot 4	Plot4.bat	rep project plot4
View Results and Print Graphs	Viewsim.bat	view project.rsl

Figure 4-5. Model Menu - Dynamica Model

D. THE DYNEX MODEL INTERFACE

The Dynex Model Interface, was written for this thesis in Dynex, the high level model interface language of Professional Dynamo. Dynex was specifically designed to allow the experienced model builder to create an environment for model operation specifically suited for a certain skill level of user. Most often, the model builder creates a "game" type of format, which allows the model to be used by inexperienced modelers. Dynex allows the model builder to set up files which execute Professional Dynamo commands, transparently to the user [Ref. 10:p. 181].

When Dynex files are invoked, model functions are performed automatically for the user. The experienced model builder can use Dynex to make a model available for users in

a structured and easily understandable framework [Ref. 10:p. 181]. He can provide information on model operation to a user, at a level commensurate with the user's abilities and experience level.

Dynex is unique in that it allows the user to access the variables within a simulation model written in Professional Dynamo. In contrast, the batch files written for the user interface, perform "house-keeping details", and execute numerous commands for the convenience of the user.

The Model Menu system accesses Dynex Model Interface via the single batch file shown in Figure 4-6.

MODEL MENU

DYNEX MODEL INTERFACE

Variable
Manipulation

Variabl.bat

project dynex

Figure 4-6. Model Menu - Dynex Model Interface

After the user has completed using the Dynex Model Interface, he/she will be returned automatically to the main Model Menu.

V. CONCLUSIONS

A. ACCOMPLISHMENTS

The primary objective of this thesis was the development of a user interface for the Dynamica Model of Software Project Management which would: (1) make the Dynamica model easier to use, (2) improve the model's facilities for accessing, storing and reviewing simulation results and (3) improve the current method of variable manipulation.

A menu system was created to outline and provide easy access to the major functions of the Dynamica model. A help system was provided along with numerous script files explaining model functions. Facilities were provided to allow the user to store, plot or print simulation results. Viewing simulation results was also made easier. Most of these improvements were done with the use of DOS and EBL batch files in conjunction with the model menu. The user is able to select a desired function using the Model Menu system and have the batch files perform the low level work.

A model interface was programmed in Dynex to control and improve the access and manipulation of variables in the Dynamica model.

B. LESSONS LEARNED

The user interface for the Dynamica model was designed by an iterative process of prototyping and testing. This

method of design was successful but time consuming. The testing of the prototype systems often revealed flaws that otherwise were not readily apparent. For example, early prototypes did not provide the user with an adequate amount of feedback after menu selections. It was recognized that periods of "dead time" on the users display, while files were loaded or DOS commands were being executed, gave the impression to the user that the interface was not functioning properly. Since these commands and DOS functions could not be sped up, the dead periods were replaced with screens which provided the user assurances that the model was functioning normally.

Secondly, to offset the time consuming process of prototyping a system design of this nature, the designer is best served by creating and experimenting with only the shell of the proposed system. Only after the design of the shell has met with approval via testing should the designer begin writing the modules called by the shell.

Originally, the 24 batch files were part of the Model Menu shell created with the EXECMAKE facility of EBL. Editing of any batch file required that the Model Menu shell be similarly adjusted, a time consuming process. This editing problem was resolved by having the Model Menu contain only calls to the batch files. The 24 separate batch files can now be edited individually.

Lastly, early prototypes of the Dynex Model Interface were found to include more information for the user than was suitable for that format. Much of this information, belonged more appropriately in a user or reference manual format.

C. FUTURE DIRECTION

There are many areas available for future research. These areas fall under two general categories, the refining of the current interface, and expanding the capabilities of the interface.

There are many areas in the current interface that need refinement or expanding. Keeping in mind that the major goal of the Dynamica model is for users to develop a better understanding of the dynamic behavior of software project variables, improved methods of storing and analyzing the results of numerous simulations are needed. One suggestion is to use the Professional Dynamo, Report Generator facilities to plot the results of variables from multiple simulations. Another is to provide the user the capability to save plots or graphs in files of the user's choosing.

The current system also needs the development of a more complete user's manual. This user's manual should provide detailed information on the Dynamica model as well as the design of the user interface. Its goal should be to help users learn how to manipulate the Dynamica model to best suit their own needs. To do this would require an extensive,

detailed manual with numerous examples. It would require the compilation of reference information from Professional Dynamo, EBL, and the Dynamica model.

User comments should also be collected and studied to determine problem areas of the interface in its current form. Users should be queried as to what other variables or capabilities they would like made available.

Dynex also has the capability for the creation of extensive online help facilities. These help facilities are available when the user is operating within the Dynex model interface. Suggested topic areas for this help would include inputting variable values (for both single value variables and table variables), saving and printing simulation results (plotting, graphs and report generation) and the explanation of Dynex error codes.

Finally, a more ambitious suggestion would be to include the Intermediate Constructive Cost Model (COCOMO) in the user interface [Ref. 14:p. 58]. COCOMO is a generic name for a hierarchy of software cost-estimation models. The intermediate level of COCOMO uses 15 cost drivers or predictors to estimate software development effort. Research for this thesis, would suggest two possible implementation schemes. First and most preferable, would be to incorporate the COCOMO variables and their equations into the Dynamica model using Professional Dynamo. These variables could then be accessed via the Dynex Model Interface. A second option would be to

write a C or BASIC program which would accept variable values and perform the required COCOMO calculations. This program would be called by the Model Menu, via a DOS batch file. This DOS batch file would also return the variables calculated by COCOMO to the Dynamica model. The first option would be preferred for its speed, ease of operation, and the increased flexibility provided the system designer and the user. Using either option mentioned, would allow the user to refine a basic COCOMO development effort estimate.

Dynex allows the use of arithmetic expressions of parameter names and numbers within the display of text. An experienced model builder could therefore create a "learning game" where user predictions could be matched against the quantitatively produced COCOMO estimations. The user could then select the values of his choice for use in the Dynamica model, and be provided rapid feedback on the consequences by running a model simulation.

APPENDIX A
BATCH FILES PROGRAM LISTING

```
BAT CLS  
ECHO OFF  
BAT REM FILE NAME:          VARIABL.BAT  
BAT BEGTYPE  
\0A
```

THE MODEL IS BEING LOADED !

```
END  
BAT TYPE TIME( C )  
BAT TYPE DATE()  
DYNEX PROJECT
```

```
BAT CLS  
ECHO OFF  
BAT REM FILE NAME:          RUNSIM.BAT  
BAT CLS  
BAT BEGTYPE  
\0A
```

THE MODEL IS BEING PREPARED FOR A SIMULATION !

```
END  
BAT TYPE TIME( C )  
BAT TYPE DATE()  
SMLT PROJECT -GO =
```

```
BAT CLS
ECHO OFF
BAT REM FILE NAME:          VIEWSIM.BAT
BAT CLS
BAT BEGTYPE
\0A
```

YOUR RESULTS ARE BEING PREPARED FOR VIEWING !

IF YOU HAVE AN EGA GRAPHICS CARD TYPE (y)
FOLLOWED BY ENTER.

IF YOU DO NOT HAVE AN EGA CARD TYPE (n)
FOLLOWED BY ENTER.

```
END
BAT INKEY %0
BAT IF Y = %0 THEN GOTO EGA
BAT ELSE GOTO OTHER
```

```
:EGA
VIEW PROJECT.RSL -PLM 6
BAT CLS
BAT EXIT
```

```
:OTHER
VIEW PROJECT.RSL
BAT EXIT
ECHO OFF
```

```
BAT REM FILE NAME:          PURPOSE.BAT
```

```
*****
```

WELCOME

```
*****
```

WELCOME TO THE MODEL MENU ! JUST BRIEFLY, LETS
DISCUSS WHAT THE MODEL MENU IS AND WHAT IT ISN'T, TO
HOPEFULLY AVOID ANY CONFUSION AS YOU BEGIN TO FAMILAIARIZE
YOURSELF WITH THE DYNAMICA MODEL OF SOFTWARE PROJECT
MANAGEMENT.

I. COMPONENTS OF THE MODEL MENU

THE DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT
IS A SOPHISTICATED SIMULATION MODEL WRITTEN BY DR. TAREK
K.ABDEL-HAMID, IN PROFESSIONAL DYNAMO. PROFESSIONAL
DYNAMO (ABBREVIATED PD) IS A HIGH LEVEL SIMULATION
LANGUAGE CREATED BY PUGH - ROBERTS ASSOCIATES, INC.

ACCESS TO THE SYSTEM DYNAMICS MODEL OF SOFTWARE
MANAGEMENT IS PROVIDED BY THE MODEL MENU. THE MODEL
MENU , WRITTEN USING EXTENDED BATCH LANGUAGE, DOS

COMMANDS, SEVERAL PUBLIC DOMAIN BATCH FILE UTILITIES AND THE PD INTERFACE LANGUAGE DYNEX, HAS BEEN DESIGNED TO EASE AND SPEED USER ACCESS TO THE MODEL AND AID IN THE MANIPULATION OF SIMULATION RESULTS.

HIT ANY KEY TO CONTINUE.

END
BAT INKEY
BAT CLS
ECHO OFF
BAT REM FILE NAME:
BAT CLS
BAT BEGTYPE

HARDWAR.BAT

\OA*****
HARDWARE AND SOFTWARE REQUIREMENTS.

HARDWARE:

THE MODEL REQUIRES AN IBM OR IBM COMPATIBLE XT/AT MICROCOMPUTER, WITH 640 K OF RAM AND A HARD DISK OR 1.2 MEG FLOPPY.

EXECUTION OF MODEL SIMULATIONS IS A VERY NUMERICALLY INTENSIVE OPERATION. THE EXECUTION SPEED INCREASES TREMENDOUSLY WITH THE USE OF A MATH CO-PROCESSOR CHIP.

THE MODEL PROVIDES SUPPORT FOR THE MOST COMMON GRAPHIC DISPLAY MODES, MDA, CGA AND EGA. THE MODEL'S USE OF COLOR IS DESIGNED TO ENHANCE USABILITY BUT IS NOT A REQUIREMENT.

SOFTWARE:

THE MODEL REQUIRES MS OR PC DOS 2.xx OR GREATER. CHECK TO MAKE SURE ALL THE FILES LISTED ON THE SYSTEM DISK ARE PRESENT IF ANY PROBLEMS ARISE.

HIT ANY KEY TO CONTINUE

END
BAT INKEY
BAT CLS
ECHO OFF
BAT REM FILE NAME:
BAT CLS
BAT BEGTYPE

SUGGEST.BAT

\0A*****
SUGGESTIONS ?

THE FIRST RECCOMENDED ORDER OF BUSINESS FOR ALL NEW USERS IS TO FAMILIARIZE YOUR SELF WITH THE MODEL MENU. TAKE A FEW MOMENTS AND EXPLORE ALL THE MENU SELECTIONS. THERE IS NO NEED TO ENTER DATA OR RESPOND TO ANY OF THE QUERIES, JUST SCAN THE SCREENS AND HIT ENTER OR ANY KEY AS PROMPTED TO CONTINUE. THIS WHOLE PROCESS SHOULD ONLY TAKE YOU 10 MINUTES OR SO. WRITE DOWN ANY QUESTIONS THAT COME TO MIND AS YOU SCAN.

IF YOUR QUESTIONS ARE BEGINING TO DEAL MORE WITH HOW AM I GOING TO USE DYNAMICA TO BETTER UNDERSTAND SOFTWARE PROJECT MANGEMENT AND HOW CAN I CUSTOMIZE IT, IT IS TIME FOR YOU TO GO TO THE NEXT STEP.

HIT ANY KEY TO CONTINUE

END
BAT INKEY
BAT CLS
BAT BEGTYPE

REVIEW THE MODEL VARIABLE
DEFINITIONS

IF YOU PLAN TO USE THE MODEL TO SIMULATE A PARTICULAR SOFTWARE PROJECT THAT YOU HAVE DATA ON, THE MODEL SHOULD BE CUSTOMIZED TO REFLECT THAT PROJECT. YOUR FIRST STEP TOWARDS THAT GOAL IS TO DISCOVER WHAT VARIABLES ARE AVAILABLE IN DYNAMICA AND WHAT THEY REPRESENT IN THE MODEL. YOU AND THE MODEL HAVE TO UNDERSTAND ONE ANOTHER. FOR EXAMPLE, IF HIRING DELAY IS A VARIABLE YOU WISH TO ADJUST, YOU MUST UNDERSTAND HOW IT IS DEFINED BY THE MODEL.

HIT ANY KEY TO CONTINUE

END
BAT INKEY
BAT CLS
BAT BEGTYPE

NOTE:

THE QUANTITATIVE TYPES READING THIS ARE ALREADY SAYING TO THEMSELVES, WHY DON'T THEY GIVE US THE EQUATIONS THE MODEL USES, THEN I CAN REALLY FIGURE OUT WHAT'S GOING ON. UNFORTUNATELY, TO DO THAT WOULD REQUIRE THAT YOU BECOME FAMILIAR WITH FAR MORE VARIABLES THEN THE 20 PRIMARY

VARIABLES ADJUSTABLE VIA THE MENU, LIKE ROUGHLY 150 MORE, AND BECAUSE THIS IS A DYNAMIC MODEL THE RELATIONSHIPS VARY THROUGHOUT THE LIFE OF THE SOFTWARE PROJECT. THATS WHY COMPUTER MODELS ARE SO VALUABLE. IN A FEW MINUTES TIME, THE MODEL VARIABLES CAN BE ADJUSTED AS YOU SEE FIT, A SIMULATION CAN BE RUN WITH THOSE VARIABLES AND RESULTS STORED ON OVER _____QUANTITATIVE MEASURES OF PROJECT PERFORMANCE.

HIT ANY KEY TO CONTINUE

```
END
BAT INKEY
BAT CLS
ECHO OFF
BAT REM FILE NAME:          OVER.BAT
BAT CLS
BAT BEGTYPE
```

```
\OA*****
                OVERVIEW OF AVAILABLE HELP FACILITIES
*****
```

THERE ARE TWO TYPES OF HELP AVAILABLE TO THE USER: (1) ONLINE MODEL HELP AND (2) PROFESSIONAL DYNAMO HELP.

ONLINE MODEL HELP IS AVAILABLE TO THE USER WHEN UTILIZING SELECTION # 3 OF THE MAIN MENU - VARIABLE MANIPULATION. AT ANY PROMPT, THE USER NEED ONLY TO TYPE (H)ELP (H)ELP TO GET A LIST OF AVAILABLE HELP CATEGORIES.

PROFESSIONAL DYNAMO HELP PROVIDES THE MORE EXPERIENCED MODEL USER ACCESS TO 8 PD HELP TOPICS.

HIT ANY KEY TO CONTINUE !

```
END
BAT INKEY
BAT CLS

ECHO OFF
BAT REM FILE NAME:          HELP.BAT
BAT CLS
BAT BEGTYPE
```

```
\OA*****
                ONLINE MODEL HELP INFORMATION
*****
```

THE DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT HAS THE CAPABILITY FOR EXTENSIVE, USER DEFINED, EASILY MODIFIABLE HELP. ACCESS TO THIS HELP IS AVAILABLE WHILE UTILIZING MAIN MENU SELECTION # 3, MODEL & VARIABLE MANIPULATION. THIS HELP CAPABILITY IS A FEATURE OF PROFESSIONAL DYNAMO, DESIGNED BY PUGH-ROBERTS ASSOCIATES, INC.

TO ACCESS AN EXAMPLE OF THIS HELP, THE USER SIMPLY TYPES (H)ELP (H)ELP FOLLOWED BY ENTER.

HIT ANY KEY TO CONTINUE

END
BAT INKEY

BAT CLS

ECHO OFF
BAT REM FILE NAME: SIMULAT.BAT
BAT CLS
BAT BEGTYPE
\0A

YOUR RESULTS ARE BEING STORED IN THE PROPER FORMAT !

END

BAT TYPE TIME(C)
BAT TYPE DATE()

REP PROJECT STATS

BAT CLS
BAT BEGTYPE
\0A

PLEASE ENTER THE FILE NAME YOU DESIRE FOR THIS REPORT. IT IS SUGGESTED THAT YOU NAME YOUR FILES IN A MANNER WHICH WILL ALLOW THE MAXIMUM BENEFITS OF THE DOS WILDCARD (*) FEATURE WHEN MANIPULATING YOUR FILES.

EXAMPLE: (PROJECT.*)

NOTE:

CHANGES MADE TO VARIABLES ARE STORED IN THE FILE. FOR EXAMPLE IF HIRING DELAY WAS CHANGED FROM 30 TO 40, THAT INFORMATION WOULD BE STORED AT THE END OF THE REPORT.

END

BAT READ %0
BAT CLS
BAT BEGTYPE
 \0A

ENTER THE FULL PATH NAME OF THE DIRECTORY WHERE YOU WOULD LIKE THE RESULTS STORED.

END

BAT READ %1
REN PROJECT.OUT %0
COPY %0 + PROJECT.WAS
COPY %0 %1
ECHO OFF
BAT REM FILE NAME: PRINT.BAT
BAT CLS

D /6

BAT TYPE HIT ANY KEY TO CONTINUE !
BAT INKEY
:AGAIN
BAT CLS
BAT BEGTYPE

\0A

PLEASE ENTER THE FULL NAME OF THE FILE YOU WOULD LIKE PRINTED. YOU MAY USE DOS WILDCARD (*) SYMBOLS FOR PRINTING MORE THEN ONE FILE AT A TIME.

OTHERWISE, PLEASE TYPE (Q) TO QUIT.
EXAMPLE: (MONDAY.*)

END

BAT read %2
BAT IF %2 = Q THEN EXIT
BAT ELSE

COPY %2 PRN
BAT GOTO :AGAIN

```
ECHO OFF
BAT CLS
BAT REM FILE NAME:          OVERVIE.BAT
BAT BEGTYPE
```

```
ECHO OFF
BAT REM FILE NAME:          PLOT1.BAT
BAT CLS
BAT BEGTYPE
```

```
\0A*****
                                  PLOT 1
*****
```

PLOT 1 GRAPHS THE FOLLOWING VARIABLES:

```
SCHCDT . . . . . ESTIMATED SCHEDULE IN DAYS
PJBSZ . . . . . PERCEIVED PROJECT SIZE IN TASKS
JBSZMD . . . . . ESTIMATED PROJECT COST IN MAN-DAYS
TOTWF . . . . . TOTAL WORKFORCE PEOPLE
CUMMD . . . . . CUMULATIVE MAN-DAYS EXPENDED
```

IF YOU HAVE AN EGA CARD TYPE (Y)ES IF NOT TYPE (N)O.

END

```
BAT INKEY %0
```

```
BAT CLS
BAT IF Y = %0 THEN GOTO EGA
BAT ELSE GOTO OTHER
```

```
:EGA
REP PROJECT PLOT1 -PLM 6
BAT GOTO -NEXT
:OTHER
REP PROJECT PLOT1
```

```
BAT -NEXT
BAT CLS
BAT BEGTYPE
\0A
```

IF YOU WOULD LIKE TO SAVE THE PLOT PLEASE ENTER A DOS LEGAL FILE NAME, OTHERWISE TYPE (Q)UIT TO RETURN TO THE MENU.

```
END
BAT READ %1
BAT IF Q = %1 THEN GOTO LEAVE
BAT ELSE GOTO NAME
:NAME
REN PLOT 1.OUT %1
```

```
:LEAVE
BAT EXIT
ECHO OFF
BAT REM FILE NAME: PLOT2.BAT
BAT CLS
```

```
BAT BEGTYPE
\0A*****
```

PLOT 2

```
*****
```

FIRST, A QUICK REVIEW OF THE VARIABLES BEING PLOTTED:

```
CMTKDV . . . . . CUMULATIVE TASKS DEVELOPED
CUMTKT . . . . . CUMULATIVE TASKS TESTED
CUMMD . . . . . CUMULATIVE MAN-DAYS EXPENDED
PJBSZ . . . . . PERCEIVED PROJECT SIZE IN TASKS
PDEVRC . . . . . ESTIMATED % DEVELOPMENT COMPLETE
```

IF YOU HAVE AN EGA CARD TYPE (Y)ES IF NOT TYPE (N)O.

```
END
BAT INKEY %0

BAT CLS
BAT IF Y = %0 THEN GOTO EGA
BAT ELSE GOTO OTHER
```

```
:EGA
REP PROJECT PLOT2 -PLM 6
BAT GOTO -NEXT
:OTHER
REP PROJECT PLOT2
```

```
BAT -NEXT
BAT CLS
BAT BEGTYPE
\0A
```

IF YOU WOULD LIKE TO SAVE THE PLOT PLEASE ENTER A DOS LEGAL FILE NAME, OTHER WISE TYPE (Q) TO RETURN TO THE MENU.

```
END
BAT READ %1
BAT IF Q = %1 THEN GOTO LEAVE
BAT ELSE GOTO NAME
:NAME
REN PLOT2.OUT %1
```

```
:LEAVE
BAT EXIT
ECHO OFF
BAT REM FILE NAME: PLOT3.BAT
BAT CLS
```

```
BAT BEGTYPE
\0A*****
```

PLOT 3

```
*****
FIRST, A QUICK REVIEW OF THE VARIABLES BEING
PLOTTED:
```

```
TOTWF . . . . . TOTAL WORKFORCE
FRWFEX . . . . . FRACTION OF WORKFORCE THAT IS EXPERIENCED
SDVPRD . . . . . PRODUCTIVITY
COMM OH . . . . . COMMUNICATION OVERHEAD
```

IF YOU HAVE AN EGA CARD TYPE (Y)ES IF NOT TYPE (N)O.

```
END
BAT INKEY %0

BAT CLS
BAT IF Y = %0 THEN GOTO EGA
BAT ELSE GOTO OTHER
```

```
:EGA
REP PROJECT PLOT3 -PLM 6
BAT GOTO -NEXT
```



```
:OTHER
REP PROJECT PLOT3
```

```
BAT -NEXT
BAT CLS
BAT BEGTYPE
\OA
```

IF YOU WOULD LIKE TO SAVE THE PLOT PLEASE ENTER A DOS LEGAL FILE NAME, OTHER WISE TYPE (Q) TO RETURN TO THE MENU.

```
END
BAT READ %1
BAT IF Q = %1 THEN GOTO LEAVE
BAT ELSE GOTO NAME
:NAME
REN PLOT3.OUT %1
```

```
:LEAVE
BAT EXIT
ECHO OFF
BAT REM FILE NAME: PLOT4.BAT
BAT CLS
```

```
BAT BEGTYPE
\OA*****
```

PLOT 4

```
*****
```

FIRST, A QUICK REVIEW OF THE VARIABLES BEING PLOTTED:

```
AFMPDJ . . . . . ACTUAL FRACTION OF A MAN-DAY ON PROJECT
JBSZMD . . . . . PERCEIVED TOTAL JOB SIZE IN MAN-DAYS
PJBSZ . . . . . PERCEIVED JOB SIZE IN TASKS
PMDSHR . . . . . PERCEIVED SHORTAGE IN MAN-DAYS
```

IF YOU HAVE AN EGA CARD TYPE (Y)ES IF NOT TYPE (N)O.

```
END
BAT INKEY %0

BAT CLS
BAT IF Y = %0 THEN GOTO EGA
BAT ELSE GOTO OTHER
```

```
:EGA
REP PROJECT PLOT4 -PLM 6
BAT GOTO -NEXT
```

```
:OTHER
REP PROJECT PLOT4
```

```
BAT -NEXT
BAT CLS
BAT BEGTYPE
\0A
```

IF YOU WOULD LIKE TO SAVE THE PLOT PLEASE ENTER A
DOS LEGAL FILE NAME, OTHER WISE TYPE (Q) TO RETURN
TO THE MENU.

```
END
BAT READ %1
BAT IF Q = %1 THEN GOTO LEAVE
BAT ELSE GOTO NAME
:NAME
REN PLOT4.OUT %1
```

```
:LEAVE
BAT EXIT
```

APPENDIX B

MODEL MENU SHELL PROGRAM LISTING

```
ECHO OFF
BATALLF.COM
GRAPHICS
bat /N /p /s * ... Loading ... MODEL MENU
    Call -top1
    Exit
-top    goto -top%A
*****
* Remove the following data ONLY if further changes will not*
*                               be made                               *
*****

~~EMS~~ 1.40
EBL Extended Variables - Version 1.03
Current variable contents is:

&C5      = 17
&DESCRIP81  =
&K81      = H
&DESCRIP91  =
&K91      = I
&DESCRIP101 =
&K101     = J
&DESCRIP111 =
&K111     = K
&DESCRIP121 =
&K121     = L
&DESCRIP131 =
&K131     = M
&DESCRIP141 =
&K141     = N
&DESCRIP151 =
&K151     = O
&DESCRIP161 =
&K161     = P
&DESCRIP171 =
&K171     = Q
&DESCRIP181 =
&K181     = R
&DESCRIP191 =
&K191     = S
&DESCRIP201 =
&K201     = T
&C1       = 1F
&C2       = 1A
```

```

&C3      = 1A
&C4      = 1D
&NAME1   = MODEL MENU
&TITLE1  = FOR THE DYNAMICA MODEL OF SOFTWARE PROJECT
MANAGEMENT.
&K11     = 1
&DESCRIP11      = INTRODUCTION TO THE MODEL MENU
&CMD11  = ~SUB-MENU-2
&NAME2   = INTRODUCTION TO THE MODEL MENU
&DESCRIP42      =
&K42     = D
&DESCRIP52      =
&K52     = E
&DESCRIP62      =
&K62     = F
&DESCRIP72      =
&K72     = G
&DESCRIP82      =
&K82     = H
&DESCRIP92      =
&K92     = I
&DESCRIP102     =
&K102    = J
&DESCRIP112    =
&K112    = K
&DESCRIP122    =
&K122    = L
&DESCRIP132    =
&K132    = M
&DESCRIP142    =
&K142    = N
&DESCRIP152    =
&K152    = O
&DESCRIP162    =
&K162    = P
&DESCRIP172    =
&K172    = Q
&DESCRIP182    =
&K182    = R
&DESCRIP192    =
&K192    = S
&DESCRIP202    =
&K202    = T
&K12     = 1
&DESCRIP12     = PURPOSE OF THE MODEL MENU
&CMD12  = 22187 2
&K22     = 2
&DESCRIP22     = HARDWARE/SOFTWARE REQUIREMENTS
&CMD22  = 22226 2
&KSUM2  = 1 2 3 D E F G H I J K L M N O P Q R S T
&K32     = 3
&DESCRIP32     = SUGGESTIONS FOR USING THE MENU

```

```

&TITLE2 = THE FOLLOWING MENU PROVIDES INRTODUCTORY
INFORMATION TO NEW USERS.
&K21     = 2
&DESCRIP21     = HELP FACILITIES
&CMD21  = ~SUB-MENU-3
&NAME3   = HELP FACILITIES
&DESCRIP43     =
&K43     = D
&DESCRIP53     =
&K53     = E
&DESCRIP63     =
&K63     = F
&DESCRIP73     =
&K73     = G
&DESCRIP83     =
&K83     = H
&DESCRIP93     =
&K93     = I
&DESCRIP103    =
&K103    = J
&DESCRIP113   =
&K113    = K
&DESCRIP123   =
&K123    = L
&DESCRIP133   =
&K133    = M
&DESCRIP143   =
&K143    = N
&DESCRIP153   =
&K153    = O
&DESCRIP163   =
&K163    = P
&DESCRIP173   =
&K173    = Q
&DESCRIP183   =
&K183    = R
&DESCRIP193   =
&K193    = S
&DESCRIP203   =
&K203    = T
&K13     = 1
&DESCRIP13     = OVERVIEW OF HELP FACILITIES
&CMD13  = 22287 2
&TITLE3 = INTRODUCTION TO DYNAMICA AND PROFESSIONAL DYNAMO
HELP FACILITIES.
&K23     = 2
&DESCRIP23     = ONLINE MODEL HELP INFORMATION
&CMD23  = 22323 2
&KSUM3   = 1 2 3 D E F G H I J K L M N O P Q R S T
&K33     = 3
&DESCRIP33     = PROFESSIONAL DYNAMO HELP
&CMD33  = ~SUB-MENU-4

```

```

&NAME4 = PROFESSIONAL DYNAMO HELP
&DESCRIP94 =
&K94 = I
&DESCRIP104 =
&K104 = J
&DESCRIP114 =
&K114 = K
&DESCRIP124 =
&K124 = L
&DESCRIP134 =
&K134 = M
&DESCRIP144 =
&K144 = N
&DESCRIP154 =
&K154 = O
&DESCRIP164 =
&K164 = P
&DESCRIP174 =
&K174 = Q
&DESCRIP184 =
&K184 = R
&DESCRIP194 =
&K194 = S
&DESCRIP204 =
&K204 = T
&TITLE4 = THE FOLLOWING MENU PROVIDES ACCESS TO PD HELP
FACILITIES.
&K14 = 1
&DESCRIP14 = OVERVIEW OF PD HELP
&CMD14 = 22359 2
&K24 = 2
&DESCRIP24 = DYNEX HELP
&CMD24 = 22377 2
&K34 = 3
&DESCRIP34 = EDITOR HELP
&CMD34 = 22398 2
&K44 = 4
&DESCRIP44 = SIMULATION HELP
&CMD44 = 22418 2
&K54 = 5
&DESCRIP54 = TOOLS HELP
&CMD54 = 22438 2
&K64 = 6
&DESCRIP64 = TRANSLATOR HELP
&CMD64 = 22459 2
&K74 = 7
&DESCRIP74 = UTILITIES HELP
&CMD74 = 22479 2
&KSUM4 = 1 2 3 4 5 6 7 8 I J K L M N O P Q R S T
&K84 = 8
&DESCRIP84 = VIEW HELP
&CMD84 = 22500 2

```

```

&K31      = 3
&DESCRIP31      = VARIABLE MANIPULATION
&CMD31      = 22520 2
&K41      = 4
&DESCRIP41      = RUN SIMULATIONS
&CMD41      = 22559 2
&K61      = 6
&DESCRIP61      = VIEW RESULTS AND PRINT GRAPHS
&CMD61      = 22597 2
&K71      = 7
&DESCRIP71      = EXIT TO DOS
&CMD71      = 22636 2
&KSUM1      = 1 2 3 4 5 6 7 H I J K L M N O P Q R S T
&K51      = 5
&DESCRIP51      = TO STORE AND PRINT RESULTS
&CMD51      = ~SUB-MENU-5
&NAME5      = TO STORE AND PRINT RESULTS
&DESCRIP45      =
&K45      = D
&DESCRIP55      =
&K55      = E
&DESCRIP65      =
&K65      = F
&DESCRIP75      =
&K75      = G
&DESCRIP85      =
&K85      = H
&DESCRIP95      =
&K95      = I
&DESCRIP105     =
&K105     = J
&DESCRIP115    =
&K115     = K
&DESCRIP125    =
&K125     = L
&DESCRIP135    =
&K135     = M
&DESCRIP145    =
&K145     = N
&DESCRIP155    =
&K155     = O
&DESCRIP165    =
&K165     = P
&DESCRIP175    =
&K175     = Q
&DESCRIP185    =
&K185     = R
&DESCRIP195    =
&K195     = S
&DESCRIP205    =
&K205     = T
&TITLE5      = THIS MENU ALLOWS THE USER TO STORE AND PRINT

```

SIMULATION RESULTS.

&K15 = 1
&DESCRIP15 = STORING STATISTICS
&CMD15 = 22655 2
&K25 = 2
&DESCRIP25 = PLOTTING RESULTS
&KSUM5 = 1 2 3 D E F G H I J K L M N O P Q R S T
&K35 = 3
&DESCRIP35 = PRINTING YOUR RESULTS
&CMD35 = 22730 2
&CMD32 = 22767 2
&CMD25 = ~SUB-MENU-6
&NAME6 = PLOTTING RESULTS
&DESCRIP66 =
&K66 = F
&DESCRIP76 =
&K76 = G
&DESCRIP86 =
&K86 = H
&DESCRIP96 =
&K96 = I
&DESCRIP106 =
&K106 = J
&DESCRIP116 =
&K116 = K
&DESCRIP126 =
&K126 = L
&DESCRIP136 =
&K136 = M
&DESCRIP146 =
&K146 = N
&DESCRIP156 =
&K156 = O
&DESCRIP166 =
&K166 = P
&DESCRIP176 =
&K176 = Q
&DESCRIP186 =
&K186 = R
&DESCRIP196 =
&K196 = S
&DESCRIP206 =
&K206 = T
&K16 = 1
&DESCRIP16 = OVERVIEW PLOTTING FUNCTIONS
&CMD16 = 22806 2
&K26 = 2
&DESCRIP26 = PLOT 1
&CMD26 = 22845 2
&K36 = 3
&DESCRIP36 = PLOT 2
&CMD36 = 22882 2


```

&K46      = 4
&DESCRIP46 = PLOT 3
&CMD46    = 22919 2
&KSUM6    = 1 2 3 4 5 F G H I J K L M N O P Q R S T
&K56      = 5
&DESCRIP56 = PLOT 4
&CMD56    = 22956 2
&I        = title
&TITLE6   = THE FOLLOWING MENU ALLOWS THE USER TO VIEW AND SAVE
4 PREDEFINED PLOTS.
&LVL      = 1
&PAGE     = 1

```

```

10000 bytes allocated   2641 bytes free
*****
* Remove the previous data ONLY if further changes will*
*                               not be made                *
*****

```

```

-top1 %A = 1
        color \1F
        ram
        cls
        begtype

```

```

L MENU                                \1F
  \1A      FOR THE DYNAMICA MODEL OF SOFTWARE PROJECT
MANAGEMENT.                            \1F

```

```

MENU                                \1D 1   \1F INTRODUCTION TO THE MODEL

```

```

                                \1D 2   \1F HELP FACILITIES

```

```

                                \1D 3   \1F VARIABLE MANIPULATION

```

```

                                \1D 4   \1F RUN SIMULATIONS

```

```

RESULTS                                \1D 5   \1F TO STORE AND PRINT

```

```

GRAPHS                                \1D 6   \1F VIEW RESULTS AND PRINT

```

```

Choose an option: (ESC exits menu):;
end
-1stkey1 inkey %0 | if %0 # = 1 type %0;
    if %0 = key01b return
    goto -%0~1
-2ndkey1 inkey %1 | if %1 # = 1 type %1;
    if %1 = key01b return
    if %1 = key020 goto -$$0$1
    if %1 = key00d goto -$$0$1
    if %1 = key008 goto -top1
    if %1 = key14b goto -top1
    goto -%0%11

-1~1 **** INTRODUCTION TO THE MODEL MENU ****
    call -top2
    bat /p /s goto -top1

-2~1 **** HELP FACILITIES ****
    call -top3
    bat /p /s goto -top1

-3~1 **** VARIABLE MANIPULATION ****
    BAT CLS
    BAT SHELL BAT /R VARIABL.BAT
    bat /p /s goto -top1

-4~1 **** RUN SIMULATIONS ****
    BAT CLS
    BAT SHELL BAT /R RUNSIM.BAT
    bat /p /s goto -top1

-5~1 **** TO STORE AND PRINT RESULTS ****
    call -top5
    bat /p /s goto -top1

-6~1 **** VIEW RESULTS AND PRINT GRAPHS ****
    BAT CLS
    BAT SHELL BAT /R VIEWSIM.BAT
    bat /p /s goto -top1

-7~1 **** EXIT TO DOS ****
    BAT CLS
    BAT EXIT
    bat /p /s goto -top1

-%0~1
-$$0$1
-%0%11 beep goto -top1
-top2 %A = 2

```

```
color \1F
ram
cls
begtype
```

```
O THE MODEL MENU          \1F
  \1A THE FOLLOWING MENU PROVIDES INRTODUCTORY INFORMATION
TO NEW USERS.          \1F
```

```
\1D 1  \1F PURPOSE OF THE MODEL MENU
```

```
\1D 2  \1F HARDWARE/SOFTWARE
REQUIREMENTS
```

```
\1D 3  \1F SUGGESTIONS FOR USING THE
MENU
```

```
Choose an option:  (ESC exits menu):;
end
```

```
-1stkey2 inkey %0 | if %0 # = 1 type %0;
  if %0 = key01b return
  goto -%0~2
```

```
-2ndkey2 inkey %1 | if %1 # = 1 type %1;
  if %1 = key01b return
  if %1 = key020 goto -$$0$2
  if %1 = key00d goto -$$0$2
  if %1 = key008 goto -top2
  if %1 = key14b goto -top2
  goto -%0%12
```

```
-1~2 **** PURPOSE OF THE MODEL MENU ****
  BAT CLS
  BAT SHELL BAT /R PURPOSE.BAT
  bat /p /s goto -top2
```

```
-2~2 **** HARDWARE/SOFTWARE REQUIREMENTS ****
  BAT CLS
  BAT SHELL BAT /R HARDWAR.BAT
  bat /p /s goto -top2
```

```
-3~2 **** SUGGESTIONS FOR USING THE MENU ****
  BAT CLS
  BAT SHELL BAT /R SUGGEST.BAT
  bat /p /s goto -top2
```

```
-%0~2
-$$0$2
-%0%12 beep goto -top2
-top3 %A = 3
```

```
color \1F
ram
cls
begtype
```

```
CILITIES \1F
\1A INTRODUCTION TO DYNAMICA AND PROFESSIONAL DYNAMO
HELP FACILITIES. \1F
```

```
\1D 1 \1F OVERVIEW OF HELP
FACILITIES
```

```
\1D 2 \1F ONLINE MODEL HELP
INFORMATION
```

```
\1D 3 \1F PROFESSIONAL DYNAMO HELP
```

```
Choose an option: (ESC exits menu):;
end
```

```
-1stkey3 inkey %0 | if %0 # = 1 type %0;
    if %0 = key01b return
    goto -%0~3
-2ndkey3 inkey %1 | if %1 # = 1 type %1;
    if %1 = key01b return
    if %1 = key020 goto -$$%0$3
    if %1 = key00d goto -$$%0$3
    if %1 = key008 goto -top3
    if %1 = key14b goto -top3
    goto -%0%13
```

```
-1~3 **** OVERVIEW OF HELP FACILITIES ****
    BAT CLS
    BAT SHELL BAT /R OVER.BAT
    bat /p /s goto -top3
```

```
-2~3 **** ONLINE MODEL HELP INFORMATION ****
    BAT CLS
    BAT SHELL BAT /R HELP.BAT
    bat /p /s goto -top3
```

```
-3~3 **** PROFESSIONAL DYNAMO HELP ****
    call -top4
    bat /p /s goto -top3
```

```
-%0~3
-$$%0$3
-%0%13 beep goto -top3
-top4 %A = 4
    color \1F
```

```
ram
cls
begtype
```

```
L DYNAMO HELP          \1F
  \1A      THE FOLLOWING MENU PROVIDES ACCESS TO PD HELP
FACILITIES.          \1F
```

```
      \1D 1    \1F OVERVIEW OF PD HELP
```

```
      \1D 2    \1F DYNEX HELP
```

```
      \1D 3    \1F EDITOR HELP
```

```
      \1D 4    \1F SIMULATION HELP
```

```
      \1D 5    \1F TOOLS HELP
```

```
      \1D 6    \1F TRANSLATOR HELP
```

```
      \1D 7    \1F UTILITIES HELP
```

```
      \1D 8    \1F VIEW HELP
```

```
Choose an option:   (ESC exits menu)::
end
-1stkey4 inkey %0 | if %0 # = 1 type %0;
  if %0 = key01b return
  goto -%0~4
-2ndkey4 inkey %1 | if %1 # = 1 type %1;
  if %1 = key01b return
  if %1 = key020 goto -%0$4
  if %1 = key00d goto -%0$4
  if %1 = key008 goto -top4
  if %1 = key14b goto -top4
  goto -%0%14
```

-1~4 **** OVERVIEW OF PD HELP ****

BAT CLS
L PD.HP
bat /p /s goto -top4

-2~4 **** DYNEX HELP ****

BAT CLS
L DYNEX.HP
bat /p /s goto -top4

-3~4 **** EDITOR HELP ****

BAT CLS
L EDTR.HP
bat /p /s goto -top4

-4~4 **** SIMULATION HELP ****

BAT CLS
L SMLT.HP
bat /p /s goto -top4

-5~4 **** TOOLS HELP ****

BAT CLS
L TOOLS.HP
bat /p /s goto -top4

-6~4 **** TRANSLATOR HELP ****

BAT CLS
L TRNS.HP
bat /p /s goto -top4

-7~4 **** UTILITIES HELP ****

BAT CLS
L UTILS.HP
bat /p /s goto -top4

-8~4 **** VIEW HELP ****

BAT CLS
L VIEW.HP
bat /p /s goto -top4

-%0~4

-\$%0\$4

-%0%14 beep goto -top4

-top5 %A = 5

color \1F
ram
cls
begtype

PRINT RESULTS \1F
\1A THIS MENU ALLOWS THE USER TO STORE AND PRINT
SIMULATION RESULTS. \1F

\1D 1 \1F STORING STATISTICS

\1D 2 \1F PLOTTING RESULTS

\1D 3 \1F PRINTING YOUR RESULTS

Choose an option: (ESC exits menu):;

end

-1stkey5 inkey %0 | if %0 # = 1 type %0;

if %0 = key01b return

goto -%0~5

-2ndkey5 inkey %1 | if %1 # = 1 type %1;

if %1 = key01b return

if %1 = key020 goto -%0\$5

if %1 = key00d goto -%0\$5

if %1 = key008 goto -top5

if %1 = key14b goto -top5

goto -%0%15

-1~5 **** STORING STATISTICS ****

BAT CLS

BAT SHELL BAT /R SIMULAT.BAT

bat /p /s goto -top5

-2~5 **** PLOTTING RESULTS ****

call -top6

bat /p /s goto -top5

-3~5 **** PRINTING YOUR RESULTS ****

BAT CLS

BAT SHELL BAT /R PRINT.BAT

bat /p /s goto -top5

-%0~5

-\$%0\$5

-%0%15 beep goto -top5

-top6 %A = 6

color \1F

ram

cls

begtype

G RESULTS

\1F

\1A THE FOLLOWING MENU ALLOWS THE USER TO VIEW AND SAVE 4
PREDEFINED PLOTS. \1F

```

FUNCTIONS                                \1D 1   \1F OVERVIEW PLOTTING

                                           \1D 2   \1F PLOT 1

                                           \1D 3   \1F PLOT 2

                                           \1D 4   \1F PLOT 3

                                           \1D 5   \1F PLOT 4

```

```

Choose an option:   (ESC exits menu):;
end
-1stkey6 inkey %0 | if %0 # = 1 type %0;
            if %0 = key01b return
            goto -%0~6
-2ndkey6 inkey %1 | if %1 # = 1 type %1;
            if %1 = key01b return
            if %1 = key020 goto -%0$6
            if %1 = key00d goto -%0$6
            if %1 = key008 goto -top6
            if %1 = key14b goto -top6
            goto -%0%16

-1~6 **** OVERVIEW PLOTTING FUNCTIONS ****
      BAT CLS
      BAT SHELL BAT /R OVERVIE.BAT
      bat /p /s goto -top6

-2~6 **** PLOT 1 ****
      BAT CLS
      BAT SHELL BAT /R PLOT1.BAT
      bat /p /s goto -top6

-3~6 **** PLOT 2 ****
      BAT CLS
      BAT SHELL BAT /R PLOT2.BAT
      bat /p /s goto -top6

-4~6 **** PLOT 3 ****
      BAT CLS
      BAT SHELL BAT /R PLOT3.BAT
      bat /p /s goto -top6

```


APPENDIX C

DYNEX MODEL INTERFACE PROGRAM LISTING

display clear

```
*****
THE DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT
                                   March 1988
*****
```

Press ENTER for a brief introduction to Model and Variable Manipulation.

It is suggested reading for all new users of Dynamica.

Experienced users will most likely want to skip directly to Model and Variable Manipulation. To do so type (n)o followed by enter.

Press Enter or (n)o followed by Enter to Continue

dendq
choice 1

display clear

```
*****
WELCOME TO PROFESSIONAL DYNAMO AND THE DYNAMICA MODEL OF
SOFTWARE PROJECT MANAGEMENT           page 1
*****
INTRODUCTION
```

Professional Dynamo is a high level model simulation language that has been used to create THE DYNAMICA MODEL OF SOFTWARE MANAGEMENT. You need to have no knowledge of how Professional Dynamo works to use the model.

THE DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT, here after simply Referred to as DYNAMICA, is a sophisticated simulation model designed to provide assistance in understanding and estimating the numerous and complex variables involved in a large software development project.

Press Enter to Continue

dendq
choice 1
cend 1/1

display clear

Introduction page 2 *

To speed you on your way, a menu system has been developed to interface with the model which is written in PROFESSIONAL DYNAMO. This menu allows the the user to customize the model to fit a particular software project by providing access to 18 different variables or table values, from three major areas of interest to the software project manager: Estimated Project Size, Organizational Environment and Policy Variables. A fourth area provides the user access to important model controls, the maxlength of project and the save period for data.

Press Enter to Continue

dendq
choice 1
cend 1/1

display clear

Introduction
page 3

When addressing a particular variable, the user may chose any value or use a previously defined value. Changes to variables from your last simulation are automatically stored with your simulation results if you chose to store your results.

Your first step after you become familiar with the mechanics of the model will be to adjust all the pertinent variables to customize the model to represent any specific software project you might have in mind. Otherwise, you may use the model " as is ", to conduct your experimentation in the relationships of the variables.

Press any Key to Continue

dendq
choice 1
cend 1/1

display clear

The DYNAMICA MODEL OF SOFTWARE PROJECT MANAGEMENT has the potential for extensive online help facilities. Currently, only one aspect of the online help facility is employed, that being HELP on HELP. This has been done to demonstrate the available capability. To view the HELP on HELP, type (h)elp followed by a space and (h)elp again followed by striking the enter/return key.

Press Enter to Continue

dendq
choice 1

cend 1/1
cend 1/1

display clear

The following 18 model variables of Dynamica are adjustable via the menu.

They are grouped in 4 categories for easy access.

- I. ESTIMATED ACTUAL PROJECT SIZE
 - 1. RJBDSI Real Job Size in DSI
- II. VARIABLES CHARACTERISTIC OF THE ORGANIZATIONAL ENVIRONMENT
 - A. Productivity
 - 2. DSIPTK Delivered Source Instruction Per Task
 - B. Quality
 - 3. TNERPK . . Error Rate Per 1000 Delivered Source Instruction
 - C. Staffing Variables
 - 4. HIREDY Hiring Delay
 - 5. ASIMDY Assimilation Delay
 - 6. AVEMPT Average Employment
- III. POLICY VARIABLES
 - A. Estimation
 - 7. UNDEST Task Underestimation Factor
 - 8. TOTMD1 Total Mandays
 - 9. TDEV1 Time to Develop

Press Enter To See the Remaining Variables

dendq
choice 1
cend 1/1

display clear

MODEL AND VARIABLE MANIPULATION page 6

B. Resource Allocation

- 10. DEVPRT % of Effort Assumed Needed For Development
- 11. TPFMQA . Fraction of Manpower Devoted to Quality Assurance
- 12. INDUST Initial Understaffing Factor
- 13. WCWF1 Willingness to Change the Workforce

C. Staffing

- 14. TRPHNR . . . % of Experienced Employee Effort to Train a New Employee
- 15. AMPPS . Average Daily Manpower / Staff Expended On Project

IV. MODEL CONTROL

- 16. MAXLEN Max Length Of Project
- 17. SAVPER Save Period For Data

Press Enter to See Variable Definitions or to Manipulate Variable Values.

dendq
choice 1
cend 1/1

display clear

MODEL AND VARIABLE DEFINITION AND MANIPULATION page 7

Select one or more of the following eight topic areas. You may chose to first look at a brief explanation of the variables or go directly to variable manipulation.

I. MODEL VARIABLE DEFINITIONS

- 1. ESTIMATED ACTUAL PROJECT SIZE DEFINITION
- 2. VARIABLES CHARACTERISTIC OF THE ORGANIZATIONAL ENVIRONMENT DEFINED
- 3. POLICY VARIABLES DEFINED

4. MODEL CONTROL VARIABLES DEFINED

II. MANIPULATION OF MODEL VARIABLES

- 5. ESTIMATED ACTUAL PROJECT SIZE
- 6. VARIABLES CHARACTERISTIC OF THE ORGANIZATIONAL ENVIRONMENT
- 7. POLICY VARIABLES
- 8. MODEL CONTROL VARIABLES

Enter the number(s) of your selected choices.

Seperate each choice by a space or a comma.

dendq
choices 8

display clear

```
*****
ESTIMATED ACTUAL PROJECT SIZE DEFINITION           page 8
*****
```

REAL JOB SIZE IN DSI RJBDSI

The real size of the software project in delivered source instructions (DSI) with comments. The following definitions are from Boehm, 1981.

Delivered. This term is generally meant to exclude nondelivered support software such as test drivers. However, if these are developed with the same care as delivered software, with their own reviews, test plans, documentation, etc., then they should be counted.

Source Instructions. This term includes all program instructions created by project personnel and processed into machine code by some combination of preprocessors, compilers, and assemblers. It excludes comment cards and unmodified utility software. It includes job control language, format statements and data declarations. Instructions are defined as lines of code or card images. Thus, a line containing two or more source statements counts as one instruction; a five-line data declaration counts as five instructions.

Press Enter to Continue

dendq
choice 1
cend 1/1
cend 1/8

display clear

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL ENVIRONMENT
DEFINITION page 9

DELIVERED SOURCE INSTRUCTION PER TASK DSIPTK

This parameter is set to the value of the nominal potential productivity in the organizational environment being modeled. For example, if the nominal potential productivity is 50 DSI/Man-Day then DSIPTK would be set to 50.

ERROR RATE PER 1000 DELIVERED SOURCE
INSTRUCTIONS (KDSI) TNERPK

TNERPK is the number of errors committed on the average, per 1000 DSI, as the software project is being developed. It is not a single number but rather a table function. This allows the user to set different error rates at different stages of the project's lifecycle.

Press Enter to Continue

dendq

choice 1
cend 1/1

display clear

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL ENVIRONMENT
DEFINITION page 10

HIRING DELAY HIREDY

HIREDY is the average delay time, in work days, incurred in adding new staff members to the project.

ASSIMILATION DELAY ASIMDY

ASIMDY is the average time needed to assimilate new hires into the project, measured in workdays. It is the time required for orientation, institutionalization and training.

Press Enter to Continue

dendq

choice 1
cend 1/1

display clear

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL ENVIRONMENT
DEFINITION page 11

AVERAGE EMPLOYMENT AVEMPT

AVEMPT is the average employment time of project team members, measured in working days. It is indirectly proportional with TURNOVER. For example, the smaller the AVEMPT the larger the turnover rate, and conversely, the smaller the turnover rate the higher the AVEMPT.

Press Enter to Continue

dendq
choice 1
cend 1/1

cend 2/8

display clear

POLICY VARIABLES DEFINITIONS page 12

TASK UNDER ESTIMATION FACTOR UNDEST

Undersizing is a large problem in project management. This variable allows the to experiment with different values of underestimates. Thus to simulate a situation where the project size is initially underestimated by 25 %, this variable would be set to 0.25.

TOTAL MAN DAYS TOTMD1

TOTMD1 is the man-day estimate produced at the start of the project, for design, coding and system testing of the project.

TIME TO DEVELOP TDEV1

TDEV1 represents the estimated time, measured in work days, for the design, coding and testing stages of the project, produced at the start of the project. For example, if the initial project duration estimate was 16 months, TDEV1 would be equal to (16 x 20) or 320 working days.

Press Enter to Continue

dendq
choice 1

cend 1/1

display clear

POLICY VARIABLES DEFINITIONS page 13

% OF EFFORT ASSUMED NEEDED FOR DEVELOPMENT . . . DEVPRT

This variable is used to allocate the projected total budget, measured in Man-Days, for the development (which includes design and coding) and testing phases. For example, if it is decided that 80 % of the total Man-Days would be allocated to development and 20 % to testing, then DEVPRT would be set to 0.80.

FRACTION OF MANPOWER DEVOTED TO QUALITY

ASSURANCE TPFMQA

TPFMQA is the percent of development effort allocated in the project's plan for QA activities during the design and coding stages. It is not a single number but rather a table function that allows the user to change the number of Man-Days allocated to QA at different stages in the project lifecycle. A value of 0.20 at some point in the project would indicate that at this point, 20 % of the Man-Day budget is allocated to QA.

Press Enter to Continue

dendq

choice 1

cend 1/1

display clear

POLICY VARIABLE DEFINITIONS page 14

INITIAL UNDERSTAFFING FACTOR INDUST

The project's average staffing level is equal to the project's total number of Man-Days divided by the project's scheduled duration. Typically, the project will start with a small core team which grows in size. This variable specifies the size of the starting group. Thus a value of 0.5 indicates that the startup team is half the size of the average staff size.

Press Enter To Continue

dendq

choice 1

cend 1/1

display clear

WILLINGNESS TO CHANGE THE WORKFORCEWCWF1

On deciding upon a "Workforce" level desired, project managers typically consider a number of factors. One important factor is the project's scheduled completion date. As part of the planning function, management determines the workforce level that it believes is necessary to complete the project on schedule. In addition to this factor, consideration is also given to the stability of the workforce. Thus, before adding new project members, management tries to contemplate the project employment for new members. Different organizations weigh this factor differently. In general, the relative weighing between the desire for workforce stability on one hand and the desire to complete the project on time, on the other, is not static, but changes dynamically throughout the lifecycle of the project. For example, toward the end of the project there is typically considerable reluctance to bring in new people, even if the project is behind schedule. It would take too much time and effort (relative to the time and effort that are remaining) to acquaint new people with the mechanics of the project, integrate them into the project team and train them in the necessary technical areas.

Press Enter for More Information of WCWF1

dendq
choice 1
cend 1/1

display clear

These managerial considerations are operational in the model as follows:
 $WORKFORCE\ LEVEL\ NEEDED = (INDICATED\ WORKFORCE\ LEVEL) * (WCWF) + (CURRENT\ WORKFORCE) * (1 - WCWF)$
The Weighting Factor (WCWF) is termed Willingness to Change the Workforce.

In the early stages of the project when "Time Remaining" is generally much larger than the sum of "Hiring Delay" and the "Average Assimilation Delay" WCWF would be equal to 1. When WCWF is = 1, the "Workforce Level Needed" in the above equation would simply be equal to the "Indicated Workforce Level," i.e., management would be adjusting its workforce size to the level it feels is needed to finish on schedule. The "Indicated Workforce Level" can be determined by dividing the amount of effort that management perceives is still

remaining (in Man-Days) by the time remaining to complete the project in days.

When the "Time Remaining" decreases, ASSIMILATION DELAY (ASIMDY) could be set to equal exactly 0. The "Workforce Level Needed" in the equation would thus be equal to the "Current Workforce" i.e., management attempts to maintain the projects workforce at its current level, and make adjustments to the schedule instead.

Press Enter to Continue

dendq
choice 1
cend 1/1

display clear

```
*****  
POLICY VARIABLE DEFINITIONS page 17  
*****
```

TRAINERS PER NEW EMPLOYEE TRPHNR

In most organizations, training of new employees is carried out by the more experienced employees. This variable defines the fraction of an experienced staff member's time that is devoted to train new hires. For example, a value of 0.2 indicates that on the average each new employee consumes 20 % of an experienced employee's time for the duration of the assimilation delay.

AVERAGE DAILY MANPOWER PER STAFF EXPENDED ON PROJECT ADMPPS

Project members are often only assigned part-time to a project. ADMPPS defines the % of time that the team members devote, on an average to the particular project being simulated. For example, if staff members tend to divide their time equally between two projects, i.e., half of their time is spent on project A and the other half is spent on project B, then ADMPPS would be = 0.5.

Press Enter to Continue

dendq
choice 1
cend 1/1
cend 3/5

display clear

```
*****  
MODEL CONTROL VARIABLE DEFINITIONS page 18  
*****
```

MAX LENGTH OF PROJECT MAXLEN

This model control variable is useful in controlling the simulations. It precludes the model from continuing a simulation beyond a predetermined length, e.g., 1000 days.

SAVE PERIOD FOR DATA SAVPER

This model control variable allows the user to adjust the models save period for data for later viewing. For example, if the user sets the SAVPER = 1, the model will save all variable values on a daily basis, this data would be available for the user to examine and plot at the end of a simulation. A SAVPER of 10, saves values every 10 days. This provides the user with a trade off between the time required for a simulation and the level of detail of the results.

Press Enter to Continue

dendq
choice 1
cend 1/1
cend 4/8

display clear

```
*****  
ESTIMATED ACTUAL PROJECT SIZE VARIABLE  MANIPULATION  
                                           page 19 *  
*****  
REAL JOB SIZE IN DELIVERED SOURCE  
INSTRUCTIONS . . . . . RJBDSI
```

Enter a new value for REAL JOB SIZE IN DELIVERED SOURCE INSTRUCTIONS or press enter to use the preset value. The preset value is written using a form of scientific notation where e3 represents x 10 to the third power. You do not have to enter a value in that format but be aware that the model will represent numbers in that format.

dendq
cq rjbdsi=24.4e3

cend 5/8

display clear

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL ENVIRONMENT
MANIPULATION page 20

Enter a new value for DELIVERED SOURCE INSTRUCTIONS PER
TASK or press enter to use the preset value.
dendq
cq dsiptk=40.0

display clear

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL ENVIRONMENT
MANIPULATION page 21

Enter a new value for ERROR RATE PER 1000 DELIVERED
SOURCE INSTRUCTIONS or press enter to use the preset value.
1 2 3 4 5 6
dendq
cq tnerpk=24,22.9,20.75,15.25,13.1,12

display clear

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL ENVIRONMENT
MANIPULATION page 22

Enter a new value for HIRING DELAY or press enter to use
the preset value.
dendq
cq hiredy=30.

display clear

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL ENVIRONMENT
MANIPULATION page 23

Enter a new value for ASSIMILATION DELAY or press enter to use the preset value.
dendq
cq asimdy=21.0

display clear

VARIABLES CHARACTERISTIC OF ORGANIZATIONAL ENVIRONMENT
MANIPULATION page 24

Enter a new value for AVERAGE EMPLOYMENT or press enter to use the preset value.
dendq
cq avempt=1000

cend 6/8

display clear

POLICY VARIABLE MANIPULATION page 25

For assigning values to TOTAL MANDAYS and TIME TO DEVELOPE the user may either:
1. Calculate the two values external to the model and input them directly at the prompt below.

OR

2. Allow the model to calculate the two values internally utilizing COCMOC by inputting 0 for each of the 2 variables at the COCMO prompt.

TOTMD1
TDEV1
dend
cq totmd1=1111
cq tdev1=320
display
COCOMO PROMPT:

Enter 1 at the next two prompts to allow COCOMO to compute TOTMD1 AND TDEV1.
OR enter 0 to use your own values input above.

```
dend
cq scswch=0
cq mdswh=0
pjbdsi=rjbdsi*(1-undest)
```

```
display
TOTMD1=((2.4*EXP(1.05*LOGN(pjbdsi/1000)))*19.
dendq
```

```
display
TDEV1=((19*2.5*EXP(0.38*LOGN(totmd/19))).
dendq
```

```
display
#TDEV1
```

Press Enter to Continue

```
dendq
```

```
choice 1
cend 1/1
```

```
display clear
*****
POLICY VARIABLES MANIPULATION page 26
*****
```

Enter a new value for TASK UNDER ESTIMATION FACTOR or press enter to use the preset value.

```
dendq
cq undest=.35
```

```
display clear
*****
POLICY VARIABLES MANIPULATION page 27
*****
```

Enter a new value for % OF EFFORT ASSUMED NEEDED FOR DEVELOPMENT or press enter to use the preset value.

```
dendq
cq devprt=.5
```

display clear

POLICY VARIABLES MANIPULATION page 28

Enter a new value for FRACTION OF MANPOWER DEVOTED TO
QUALITY ASSURANCE or press enter to use the preset value.

1 2 3 4 5 6 7 8 9 10 11

dendq

dq tpfmq=.325,.29,.275,.255,.25,.275,.325,.375,.4,.4,0.0

display clear

POLICY VARIABLES MANIPULATION page 29

Enter a new value for INITIAL UNDERSTAFFING FACTOR or
press enter to use the preset value.

dendq

cq inudst=.4

display clear

POLICY VARIABLES MANIPULATION page 30

Enter a new value for WILLINGNESS TO CHANGE THE WORKFORCE
or press enter to use the preset value.

1 2 3 4 5 6 7 8 9 10 11 12 13 14

dendq

dq

twcwfl=0.0,0.0,.1,.4,.85,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0

display clear

POLICY VARIABLES MANIPULATION page 31

Enter a new value for % OF EXPERIENCED EMPLOYEE EFFORT TO TRAIN A NEW EMPLOYEE or press enter to use the preset value.

dendq
cq trpnhr=.25

display clear

POLICY VARIABLES MANIPULATION page 32

Enter a new value for AVERAGE DAILY MANPOWER PER STAFF EXPENDED ON PROJECT TO TRAIN A NEW EMPLOYEE or press enter to use the preset value.

dendq
cq admpps=.5

cend 7/8

display clear

MODEL CONTROL VARIABLE MANIPULATIONS page 33

Enter a new value for MAX LENGTH OF PROJECT or press enter to use the preset value.

dendq
cq maxlen=1000

display clear

MODEL CONTROL VARIABLE MANIPULATIONS page 34

Enter a new value for SAVE PERIOD FOR DATA or press
enter to use the preset value.

dendq
cq savper=10

cend 8/8

quit

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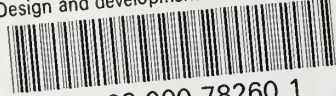
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c.1 Design and development
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