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# REUSE ECONOMICS SPREADSHEET MODEL USER MANUAL

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VERSION 01.00.00

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# CONTENTS


**PREFACE** ..... **ix**

**ACKNOWLEDGEMENTS** ..... **xi**

**1. INTRODUCTION** ..... **1-1**

1.1 Overview ..... 1-1

1.2 Background ..... 1-1

1.3 Audience and Purpose ..... 1-2

1.4 Manual Organization ..... 1-2

1.5 Typographic Conventions ..... 1-2

**2. REUSE ECONOMICS MATHEMATICAL MODELS** ..... **2-1**

2.1 Section Overview ..... 2-1

2.2 Basic Economics Model ..... 2-1

2.2.1 Basic Unit Cost Equation ..... 2-1

2.2.2 Efficiency of the Library Infrastructure ..... 2-2

2.3 Mode 1 - Reuse With Up-Front Reuse Program Investment ..... 2-3

2.3.1 Break-Even Number of Systems ..... 2-3

2.3.2 Return and Return on Investment ..... 2-3

2.4 Mode 2 - Reuse With Incremental Reuse Program Investment ..... 2-4

2.4.1 Cost Models for Incremental Reuse Program Investment ..... 2-4

2.4.2 Break-Even Number of Systems ..... 2-5

2.4.3 Return on Investment ..... 2-6

**3. INVOKING THE TOOL** ..... **3-1**

3.1 Invoking the Tool From the Diskette ..... 3-1

3.1.1 Using Microsoft Excel Version 3.0a ..... 3-1

3.1.2 Using Microsoft Excel Version 3.0 ..... 3-1

3.2 Copying the Diskette to the Hard Drive ..... 3-2

3.3 Invoking the Tool From the Hard Drive ..... 3-2

3.3.1 Using Microsoft Excel Version 3.0a ..... 3-2

3.3.2 Using Microsoft Excel Version 3.0 ..... 3-3

**4. OPERATING THE TOOL ..... 4-1**

4.1 User Interface Conventions ..... 4-1

4.1.1 Selecting From Menus ..... 4-1

4.1.2 Selecting From a Worksheet ..... 4-1

4.1.3 Editing a Worksheet ..... 4-1

4.1.4 Activating a Window ..... 4-1

4.1.5 Menu Bars and Active Windows ..... 4-1

4.1.6 Closing the Active Window ..... 4-2

4.1.7 Sizing the Active Window ..... 4-2

4.1.8 Scrolling the Active Window ..... 4-2

4.2 The Main Window ..... 4-3

4.2.1 The File Menu ..... 4-3

4.2.2 The Modes Menu ..... 4-3

4.3 The Mode 1 Window ..... 4-3

4.3.1 The File Menu ..... 4-6

4.3.2 The Edit Menu ..... 4-6

4.3.3 The Data Menu ..... 4-7

4.3.4 The Graphs Menu ..... 4-9

4.3.5 The Window Menu ..... 4-9

4.3.6 Graphs ..... 4-10

4.3.6.1 Relative Productivity Versus Proportion of Code Reuse Graph ..... 4-10

4.3.6.2 Relative Productivity Versus Relative Reuse Cost Graph ..... 4-12

4.3.6.3 Product Productivity Versus Number of Application Systems Graph .. 4-15

4.3.6.4 Return on Investment Versus Number of Application Systems Graph . 4-17

4.4 The Mode 2 Window ..... 4-19

4.4.1 Editing The Worksheet ..... 4-21

4.4.2 The File Menu ..... 4-21

4.4.3 The Data Menu ..... 4-22

4.4.4 The Graphs Menu ..... 4-23

4.4.5 The Window Menu ..... 4-23

4.4.6 Graphs ..... 4-23

4.4.6.1 Labor Months Versus Number of Application Systems Graph ..... 4-23

4.5 The Graph Window ..... 4-25

**APPENDIX. USING THE PC VERSION OF THE REUSE ECONOMICS SPREADSHEET MODEL TOOL ..... A-1**

A.1 Recommended Configuration ..... A-1

A.2 Installing the Software on a Hard Disk ..... A-1

A.3 Running the Reuse Economics Spreadsheet Model Tool ..... A-2

A.3.1 Invoking the Reuse Economics Spreadsheet Model Tool From a Floppy Disk ..... A-2

A.3.2 Invoking the Reuse Economics Spreadsheet Model Tool From a Hard Disk ..... A-2

**GLOSSARY ..... Glo-1**

**REFERENCES ..... Ref-1**

**INDEX ..... Ind-1**

# FIGURES

Figure 4-1. Reuse Economics Spreadsheet Model Menu Hierarchy ..... 4-2

Figure 4-2. The Main Window ..... 4-3

Figure 4-3. The Mode 1 Window (Part 1) ..... 4-4

Figure 4-4. The Mode 1 Window (Part 2) ..... 4-4

Figure 4-5. The Mode 1 Window (Part 3) ..... 4-5

Figure 4-6. The Mode 1 Data Form ..... 4-7

Figure 4-7. Graph Input Dialog Box ..... 4-9

Figure 4-8. Arrange All Display ..... 4-10

Figure 4-9. Mode 1 Graph1 Input Dialog Box ..... 4-11

Figure 4-10. Relative Product Productivity Versus Proportion of Code Reuse Graph Window ..... 4-11

Figure 4-11. Mode 1 Graph2A Input Dialog Box ..... 4-13

Figure 4-12. Mode 1 Graph2B Input Dialog Box ..... 4-13

Figure 4-13. Relative Product Productivity Versus Relative Reuse Cost Graph Window ... 4-14

Figure 4-14. Mode 1 Graph3 Input Dialog Box ..... 4-15

Figure 4-15. Product Productivity Versus Number of Application Systems Graph Window ..... 4-16

Figure 4-16. Mode 1 Graph4 Input Dialog Box ..... 4-17

Figure 4-17. Return on Investment Versus Number of Application Systems Graph Window ..... 4-18

Figure 4-18. Mode 2 Window (Part 1) ..... 4-19

Figure 4-19. Mode 2 Window (Part 2) ..... 4-19

Figure 4-20. Mode 2 Window (Part 3) ..... 4-20

Figure 4-21. Mode 2 Data Add Dialog Box ..... 4-22

Figure 4-22. Mode 2 Data Delete Dialog Box ..... 4-23

Figure 4-23. Mode 2 Graph1 Dialog Box ..... 4-24

Figure 4-24. Labor Months Versus Number of Application Systems Graph Window ..... 4-24

Figure 4-25. Sample Graph Window ..... 4-25

Figure 4-26. Graph Save Dialog Box ..... 4-26

# TABLES

Table 2-1. Costs for Four Alternative Reuse Program Investment Regimes ..... 2-5

Table 4-1. Mapping of Worksheet Column Names to Reuse Economic Model Variable Names ..... 4-5

Table 4-2. Input Data Values for Relative Product Productivity Versus Proportion of Code Reuse Graph Window ..... 4-12

Table 4-3. Input Data Values for Relative Product Productivity Versus Relative Reuse Cost Graph Window ..... 4-14

Table 4-4. Input Data Values for Product Productivity Versus Number of Application Systems Graph Window ..... 4-16

Table 4-5. Input Data Values for Return on Investment Versus Number of Applications Graph Window ..... 4-18

Table 4-6. Mapping of Worksheet Column Names to Reuse Economic Model Variable Names ..... 4-20

Table 4-7. Input Data Values for Labor Months Versus Number of Application Systems Graph Window ..... 4-24

# PREFACE

The Reuse Economics Spreadsheet Model tool implements various portions of the software reuse economics model described in (Cruickshank and Gaffney 1991). The model described in the report demonstrates the economic benefits of software reuse. You should be thoroughly familiar with this report to effectively use the tool.

The Spreadsheet Model tool was designed to aid you in evaluating the impact of various reuse strategies on the costs of software products. The tool provides both spreadsheet and graphics capabilities. It requires the use of Microsoft Excel, version 3.0, and can operate on either a Macintosh or an IBM-compatible PC.

The tool can operate in any one of four modes. However, the **version** of the tool documented in this user manual operates **only in mode 1 and mode 2**. The modes are:

- Mode 1: Basic Model—Reuse With Up-front Reuse Program Investment.
- Mode 2: Incremental Reuse Program Investment Without Cost of Money.
- Mode 3: Incremental Reuse Program Investment With Cost of Money.
- Mode 4: Basic Model Plus Reuse of Requirements and/or Design.

The estimates of reuse costs, productivity, return on investment, and number of break-even systems implemented in the Reuse Economics Spreadsheet Model tool are just that—estimates. Mathematics cannot make estimates into certainties. It is very important for you, as the user of this tool, to note that the results of its application can be no better than the data it employs. If you do not have an accurate idea of how much it costs to create new code, how much it costs to reuse code, and how much it costs to invest in a reuse program, then the numbers that the tool generates will be correspondingly inaccurate.

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# 1. INTRODUCTION

## 1.1 OVERVIEW

The Consortium's Reuse Economics Spreadsheet Model, version 2.0, tool provides automated support for performing economic analyses of various software reuse strategies. The tool is implemented on the Microsoft Excel, version 3.0, spreadsheet. You can operate it using either a Macintosh or an IBM-compatible PC. It provides both a spreadsheet and graphics capability.

Section 2 summarizes the detailed model presented in (Cruickshank and Gaffney 1991). You should become familiar with this report before using the Reuse Economics Spreadsheet Model tool so that you can use it with maximum effectiveness.

## 1.2 BACKGROUND

"Reuse may be defined as developing a new software system using existing software components, probably with some new components as well" (Gaffney and Durek 1991). The object of reuse is to avoid building a new software product from scratch. The major benefits that can be realized from reuse include:

- Reducing development and overall life cycle costs (thus saving money and enhancing productivity).
- Enhancing software product quality.
- Reducing the amount of time required for development.
- Enabling more software to be developed and reducing software applications backlog.

Investment is required in order for an organization to realize the benefits of a reuse program. Investment may be in such items as:

- Program planning and the initial stages of implementation.
- The characterization of application systems that will benefit from reuse.
- The location and collection of reusable software.
- The definition of domains.
- The establishment of reuse libraries or repositories.
- The development of systems to aid in the instantiation of reused software into application systems.

All of these are important components in a reuse program. A given reuse program may not include all of these components, but it will include some of them. Therefore, an investment will be required. It is necessary to plan both the amount of investment and the pattern of investment, and the spreadsheet tool offers help in performing "what if" analyses to aid in this planning.

## 1.3 AUDIENCE AND PURPOSE

The intended audience of the Reuse Economics Spreadsheet Model tool includes senior-level line engineers, project managers, and operational area managers interested in exploring economic trade-offs involved in software reuse. This tool analyzes the potential impact of adopting various reuse strategies on the overall cost of software development. It enables you to examine the effects of varying certain parameters (such as the *proportion of code reused*, the unit cost of development for new code, and the unit cost of reusing code) on the software development cost.

## 1.4 MANUAL ORGANIZATION

This manual describes how to use the Reuse Economics Spreadsheet Model tool. It illustrates some of the ways in which you can analyze the potential impact of adopting various reuse strategies on the overall cost of software development. The main body of the manual is organized as follows:

- Section 2, Reuse Economics Mathematical Models, summarizes the reuse economics models implemented in the tool.
- Section 3, Invoking the Tool, describes how to invoke the Reuse Economics Spreadsheet Model tool.
- Section 4, Operating the Tool, describes the operation of the tool. The description covers the menu bar selections and windows presented during tool operation.

The Appendix describes how to use the tool on an IBM-compatible PC. The References section identifies sources of additional information.

## 1.5 TYPOGRAPHIC CONVENTIONS

This manual uses the following typographic conventions:

Serif font ..... General presentation of information.

*Italicized serif* font ..... Publication titles.

**Boldfaced serif** font ..... Section headings and emphasis.

[ ] ..... Screen buttons.

< > ..... Workstation keyboard key names, such as <RETURN> for the Return key.

# 2. REUSE ECONOMICS MATHEMATICAL MODELS

## 2.1 SECTION OVERVIEW

This section describes the reuse economics models implemented by modes 1 and 2 of the Reuse Economics Spreadsheet Model tool. Mode 1 provides the calculations for up-front *reuse program investment*. Mode 2 provides the calculations for incremental reuse program investment. (Cruickshank and Gaffney 1991) provides a more comprehensive description of these models.

## 2.2 BASIC ECONOMICS MODEL

### 2.2.1 Basic Unit Cost Equation

An application system of $S_S$ KSLOC (thousands of source lines of code) is composed of $S_N$ KSLOC of new code and $S_R$ KSLOC of reused code. Thus:

$$S_S = S_N + S_R$$

where:

- $S_N$ = Amount of new code in thousands of source statements developed for this application system.
- $S_R$ = Amount of reused code (from the reuse library). in thousands of source statements, incorporated into this application system.
- $S_S$ = Total size of the application system in thousands of source statements.

The proportion of code reuse, R, is given by the relationship:

$$R = S_R/S_S \text{ and thus } (1-R) = S_N/S_S$$

The mode 1 and mode 2 models assume that there is code reuse as well as reuse of the corresponding design and requirements. Other reuse regimes are possible, such as where there is no code reuse, but there is reuse of design and requirements. The modes 1 and 2 models, implemented in this version of the Model tool, do not represent such situations and are therefore not covered here. They may be covered in future versions of the Model tool.

The reuse economics model reflects the total costs of applying a reuse scheme. The models implemented in modes 1 and 2 of the tool treat the cost of an application system as the sum of the

cost of the capital investment in a reuse program apportioned over an expected N application systems and the cost of application engineering (the cost of creating that particular system). The cost of an application system equals the prorated cost of reuse program investment plus the cost of application engineering. Further, the cost of application engineering is the cost of the new code plus the cost of the reused code in the new application system. R is the proportion of code that is reused code.

The mode 1 operation represents the case in which reuse program investment occurs entirely "up front" before you construct any application systems. The mode 2 operation considers the more general case of funding the reuse program investment incrementally over the N application systems.

The basic unit cost equation ( with "up front" reuse program investment) is:

$$C_{US} = \frac{C_{DE}}{N} \cdot K + C_{VN} - (C_{VN} - C_{VR}) \cdot R$$

where:

$C_{US}$ = Unit cost of the application system.

$C_{DE}$ = *Unit cost of reuse program investment.*

$C_{VN}$ = *Unit cost of new code* developed for this application system.

$C_{VR}$ = Unit cost of reusing code from the reuse library in this application system.

R = Proportion of code reuse.

N = The number of systems over which the cost of reuse program investment is spread.

K = The library relative capacity ( $= S_T/S_S$). This is the average proportion of the function of each of the N applications that the library covers.

Note that R is upper-bounded by K, or:

$$0 \leq R \leq K$$

The symbols for the costs of the various types of code in an application system as well as for the overall application system itself are:

$C_S$ = The total cost of an application system, $C_{US} \cdot S_S$.

$C_D$ = The total cost of reuse program investment, $C_{DE} \cdot S_T$.

$C_N$ = The cost of the new code in the application system, $C_{VN} \cdot S_N$.

$C_R$ = The cost of the reused code in the application system, $C_{VR} \cdot S_R$.

$S_T$ is the expected value of the unduplicated size of the reuse library, i.e., the available, reusable functionality (software code objects measured in thousands of source statements) in the library.

### 2.2.2 Efficiency of the Library Infrastructure

The efficiency of the library infrastructure, E, is the ratio of the amount of reused code in the application system to the reusable code available from the library, or:

$$E = \frac{R}{K} = \frac{S_R \ / \ S_S}{S_T \ / \ S_S} = \frac{S_R}{S_T}$$

where $0 \leq E \leq 1$. The factor E indicates the extent to which the developer of a new application system has been able to make use of the library of reusable components in creating the new application system. E is a measure of the systematic reuse application process efficiency. Normally, E is equal to or slightly less than 1.0, since a development organization would be expected, on average, to reuse as much code as possible when composing an application system.

Under the assumption that $S_R = S_T$ (which means K = R and E = 1), you can rewrite the basic reuse unit cost equation as:

$$C_{US} = \frac{C_{DE}}{N} \cdot R + C_{VN} - (C_{VN} - C_{VR}) \cdot R$$

Consolidating terms gives you:

$$C_{US} = C_{VN} - \left( C_{VN} - C_{VR} - \frac{C_{DE}}{N} \right) R$$

This equation is a form of the basic reuse unit cost equation with K = R.

## 2.3 MODE 1 - REUSE WITH UP-FRONT REUSE PROGRAM INVESTMENT

### 2.3.1 Break-Even Number of Systems

The break-even number of systems is:

$$N_0 = \frac{C_{DE}}{(C_{VN} - C_{VR})E}$$

If the number, N, of application systems over which you apportion the costs of reuse program investment is greater than $N_0$, reuse pays off. If N is less than $N_0$, however, reuse does not pay off. In this case, the greater the amount of reuse (the larger the value of R), the greater would be $C_{US}$, the unit cost of an application system.

### 2.3.2 Return and Return on Investment

The *return* is the difference ( in labor months) between developing N application systems composed of all new code and N application systems composed, in part, with reused code. It takes into account the cost of reuse program investment.The *percent return on investment*, ROI, is equal to the return divided by the cost of reuse program investment times one hundred. It can be shown by the expression:

$$ROI = \left[ \frac{N \cdot E \cdot (C_{VN} - C_{VR})}{C_{DE}} - 1 \right] \cdot 100 = \left[ \frac{N}{N_0} - 1 \right] \cdot 100$$

## 2.4 MODE 2 - REUSE WITH INCREMENTAL REUSE PROGRAM INVESTMENT

### 2.4.1 Cost Models for Incremental Reuse Program Investment

This section generalizes the basic reuse economics model presented earlier. It covers the case in which the reuse program investment is done incrementally, i.e., not done entirely up front.

The basic reuse economics model implies that all of the reuse program investment is complete before the first application system is produced. In some cases, reuse program investment is done incrementally (i.e., piecewise) with some reuse program investment being done in conjunction with one or several of the N application systems produced from the domain.

Consider the $S_T$ KSLOC of unduplicated code in the reuse library that is to be instantiated into one or more of the N application systems produced from the domain. Suppose that $S_{T1}$ KSLOC is developed in association with the development of system number 1, $S_{T2}$ KSLOC is developed in association with the development of system number 2, and so on. In general, $S_{Ti}$ will be developed in association with the development of system number i. Thus $0 \leq S_{Ti} \leq S_T$ for $i = 1,...,N$ so that:

$$S_T = \sum_{i=1}^{N} S_{Ti}$$

Thus, $S_{T1}$ is amortized over N application systems; $S_{T2}$ is amortized over N-1 systems; and, in general, $S_{Ti}$ is amortized over N-(i-1) systems.

Now assume that the efficiency of the library infrastructure is 100 percent ( $E = 1$). In that case, $S_R = S_T$. We can write the equation for the unit cost of the *i*th system out of N application systems:

$$C_{USi} = \left(\frac{C_{DE}}{S_S}\right) \sum_{m=1}^{i} \left(\frac{S_{Tm}}{(N-(m-1))}\right) + C_{VN} - (C_{VN} - C_{VR}) \sum_{m=1}^{i} \left(\frac{S_{Tm}}{S_S}\right)$$

where the first term is the prorata cost of reuse program investment for the i-th application system and the total of the second and third terms is the cost of application engineering for the i-th system.

This is **the basic unit cost equation with incremental reuse program investment** for reuse program investment occurring in more than one period of time. Recall that E is assumed to be equal to 1.0. Also note that if $S_{T1} = S_T$, then the break-even number of systems is $N_0$.

The total cost of application system i in labor months (LM) is:

$$C_{Si} = C_{USi} \cdot S_S = C_{DE} \sum_{m=1}^{i} \left(\frac{S_{Tm}}{(N-(m-1))}\right) + C_{VN}S_S - (C_{VN} - C_{VR}) \sum_{m=1}^{i} S_{Tm}$$

This equation gives the cost per system as illustrated in Table 2-1.

Table 2-1. Costs for Four Alternative Reuse Program Investment Regimes

| | | Case 1 | | Case 2 | | Case 3 | | Case 4 | |
|---|---|---|---|---|---|---|---|---|---|
| System | Cost Per System Without Reuse & Reuse Program Investment | Reuse Program Investment (LM) | Cost Per System (LM) | Reuse Program Investment (LM) | Cost Per System (LM) | Reuse Program Investment (LM) | Cost Per System (LM) | Reuse Program Investment (LM) | Cost Per System (LM) |
| 1 | 2,500 | 3,375 | 1,150 | 1,687.5 | 1,825.0 | 843.75 | 2,162.5 | 1,125 | 2,050 |
| 2 | 2,500 | — | 1,150 | 1,687.5 | 1,234.4 | 843.75 | 1,867.2 | 900 | 1,735 |
| 3 | 2,500 | — | 1,150 | — | 1,234.4 | 843.75 | 1,642.2 | 675 | 1,555 |
| 4 | 2,500 | — | 1,150 | — | 1,234.4 | 843.75 | 1,557.8 | 450 | 1,510 |
| 5 | 2,500 | — | 1,150 | — | 1,234.4 | — | 1,557.8 | 225 | 1,600 |
| Totals | 12,500 | 3,375 | 5,750 | 3,375 | 6,762.6 | 3,375 | 8,787.5 | 3,375 | 8,450 |
| Savings | | 6,750 (= 12,500 - 5,750) | | 5,737.4 (= 12,500 - 6,762.6) | | 3,718.5 (= 12,500 - 8,787.5) | | 3,960 (= 12,500 - 8,450) | |
| Percent Return on Investment = Savings/3,375 | | 200 | | 170 | | 110 | | 120 | |

### 2.4.2 Break-Even Number of Systems

The expression for calculating the break-even number of systems, $N_0$, for the more general case in which at least one of the $S_{Ti} > 0$, $i = 2,3,...,N$, *is found from the relationship* with $N = N_0$ :

$$C_{DE} \sum_{i=1}^{N} \sum_{m=1}^{i} \left( \frac{S_{Tm}}{(N-(m-1))} \right) - (C_{VN} - C_{VR}) \sum_{i=1}^{N} \sum_{m=1}^{i} S_{Tm} = 0$$

Since:

$$\sum_{i=1}^{N} \sum_{m=1}^{i} \frac{S_{Tm}}{(N-(m-1))} = S_{T1} + \ldots + S_{TN} = S_T$$

$$\sum_{I=1}^{N} \sum_{m=1}^{i} S_{Tm} = NS_{T1} + (N-1)S_{T2} + (N-2)S_{T3} + \ldots + S_{TN}$$

The expression for calculating the break-even number of systems, $N_0$, for the more general case in which at least one of the $S_{Ti} > 0$, $i = 2,3,...,N$, is given by:

$$N_0 = \frac{C_{DE}}{C_{VN} - C_{VR}} + P$$

where:

$$P = \sum_{i=1}^{N} (i-1) \cdot a_i = \sum_{i=1}^{N} i \cdot a_i - 1$$

and:

$$S_{Ti} = a_i S_T, \qquad \sum_{i=1}^{N} a_i = 1$$

P is the *incremental spending penalty*, i.e., the extra number of application systems required to break even due to incremental reuse program investment beyond the number of the reuse program investment done up-front. It should be clear that doing reuse program investment incrementally increases the number of systems required to break even relative to doing reuse program investment all at once.

### 2.4.3 Return on Investment

Table 2-1 shows four cases of return on investment with incremental funding of reuse program investment. Each of the four values of P (the additional number of application systems for break even to occur) is calculated using the formula provided above.

Case 1: $S_{T1} = S_T$

$$\frac{(NS_{T1})}{S_T} = N - 0, \quad \text{or} \quad P = 0$$

Case 2: $S_{T1} = S_{T2} = \frac{S_T}{2}$

$$\frac{(NS_{T1} + (N-1)S_{T2})}{S_T} = N - \frac{1}{2}, \quad \text{or} \quad P = 0.5$$

Case 3: $S_{T1} = S_{T2} = S_{T3} = S_{T4} = \frac{S_T}{4}$

$$\frac{(NS_{T1} + (N-1)S_{T2} + (N-2)S_{T3} + (N-3)S_{T4})}{S_T} = \frac{4N - (1+2+3)}{4} = N - \frac{3}{2}, \text{or} \quad P = 1.5$$

Case 4: $S_{T1} = \left(\frac{5}{15}\right)S_T, \quad S_{T2} = \left(\frac{4}{15}\right)S_T, \quad S_{T3} = \left(\frac{3}{15}\right)S_T, \quad S_{T4} = \left(\frac{2}{15}\right)S_T, \quad S_{T5} = \left(\frac{1}{15}\right)S_T$

$$\frac{(N_{ST1} + (N-1)S_{T2} + (N-2)S_{T3} + (N-3)S_{T4} + (N-4)S_{T5})}{S_T} = N - \frac{4}{3}, \quad \text{or} \quad P = 1.33$$

Using these formulas, the cost per application system for each of a family of five systems was computed in the four cases (regimes). The common parametric values used in the four regimes are:

- $S_S = 500$ KSLOC
- $S_T = 450$ KSLOC

- $C_{VN} = 5.000$ LM/KSLOC
- $C_{VR} = 0.5$ LM/KSLOC
- $C_{DE} = 7.5$ LM/KSLOC
- $E = 1.0$

All calculations are in LM.

In Table 2-1, $C_{VN} \bullet S_S = 5.000 \bullet 500 = 12{,}500$ LM is the total cost of developing five new application systems (without reuse). $C_{DE} \bullet S_T = 7.500 \bullet 450 = 3{,}375$ LM is the total investment in a reuse program spread over $N = 5$ application systems. The cost of an application system is given by:

$$C_{Si} = C_{DE} \sum_{m=1}^{i} \left( \frac{S_{Tm}}{(N-(m-1))} \right) + C_{VN} S_S - (C_{VN} - C_{VR}) \sum_{m=1}^{i} S_{Tm}$$

An example of the application of the above equation would be case 1 in which $S_{T1} = S_T$. This is the case in which all of the reuse program investment is done up front.

$$C_{S1} = 7.5\left(\frac{450}{5}\right) + 5.000(500) - 4.5(450) = 675 + 2500 - 2025 = 1150 \text{ LM}$$

In this case, the investment in a reuse program is apportioned uniformly over the five application systems; therefore, each of the five systems costs 1150 LM.

Now consider case 2 where $S_{Ti} = S_T/2$. The first system, $m = 1$, will cost:

$$C_{S1} = 7.5\left(\frac{450/2}{5}\right) + 5.000(500) + 4.5\left(\frac{450}{2}\right) = 337.5 + 2500 + 1012.5 = 1825.0 \text{ LM}$$

The second through the fifth systems, $m = 2$, will cost:

$$C_{S2} = 7.5\left(\frac{450/2}{5} + \frac{450/2}{4}\right) + 5.000(500) + 4.5\left(\frac{450}{2} + \frac{450}{2}\right)$$

$$C_{S2} = 337.5 + 421.875 + 2500 - 2025 = 1234.4 \text{ LM}$$

In each of these cases, the savings resulting from the reuse of code instead of all new development is given by:

$$\text{SAVINGS} = C_{VN} \cdot S_S \cdot N - \sum_{i=1}^{N} C_{Si}$$

Therefore, the percent return on investment is:

$$ROI = \left( \frac{SAVINGS}{C_{DE} \cdot S_T} \right) \cdot 100 \quad .$$

This analysis demonstrates that investing the full cost of a reuse program at the initiation of the domain building effort (case 1) is the least costly course of action with the greatest return on investment. The incremental spending penalty increases as the investment is spread over more application systems.

# 3. INVOKING THE TOOL

The Consortium provides the Reuse Economics Spreadsheet Model tool as a set of Microsoft Excel files on a diskette. The distribution diskette contains files that have a total space consumption of 275 kilobytes. The files named Mode1DB.xls and Mode2DB.xls are likely to change in size over time. They grow or shrink in proportion to the number of worksheet rows. The tool will operate on either a Macintosh or an IBM-compatible PC. You must install Microsoft Excel, version 3.0, on your machine as a prerequisite for operating the tool.

Microsoft Excel retains a list of recently opened files that display in the File Menu. **Do not try to open the Reuse Economics Spreadsheet Model tool from this list.** Attempting to open the tool from the recently opened list may result in the error message, "cannot find MenuBars.xlm." To recover from this error, click the [OK] button. A macro error dialog box appears. Click the [Halt] button. Then select Quit from the File Menu. This problem is due to a bug in Microsoft Excel that is expected to be resolved with version 3.0a.

## 3.1 INVOKING THE TOOL FROM THE DISKETTE

If you are using a PC (or an IBM-compatible PC), go to the Appendix which describes the steps to invoke the Reuse Economics Spreadsheet Model tool from the diskette. If you are using a Macintosh, perform the following steps to invoke the Reuse Economics Spreadsheet Model tool from the diskette:

*NOTE*: If the diskette is write protected, data cannot be saved or modified.

### 3.1.1 USING MICROSOFT EXCEL VERSION 3.0a

- Place the diskette containing the Reuse Economics Spreadsheet Model tool in the disk drive.
- Open the diskette by double-clicking on the Diskette icon. A window displaying the diskette contents appears.
- Open the RESSM folder by double-clicking on the Folder icon. A window displaying the folder contents appears.
- Start the RESSM application by double-clicking on the file RESSMBgn.xlm. The Reuse Economics Spreadsheet Model tool Main window appears.

### 3.1.2 USING MICROSOFT EXCEL VERSION 3.0

- Place the diskette containing the Reuse Economics Spreadsheet Model tool in the disk drive.

- Open the Microsoft Excel application by double-clicking on the Microsoft Excel icon. A default Microsoft Excel menu bar appears.
- Close the default worksheet by holding down the mouse button and dragging the mouse until you highlight Close under the File menu.
- Select File Open from the menu bar by holding down the mouse button and dragging the mouse until you highlight Open under the File menu. A dialog box appears.
- Click the mouse on the [Drive] or [Desktop] button. The dialog box now lists the name of the diskette currently in the disk drive along with the names of the hard drive and any files on the desktop.
- Select the name of the diskette by clicking the mouse button to highlight it.
- Click the mouse on the [Open] button. The dialog box now lists the names of the files on the diskette currently in the disk drive.
- Select RESSM from the list of file names by clicking the mouse button to highlight it.
- Click the mouse on the [Open] button. The dialog box now lists the names of the files in the RESSM folder.
- Select RESSMBgn.xlm from the list of file names by clicking the mouse button to highlight it.
- Click the mouse on the [Open] button. The Reuse Economics Spreadsheet Model tool Main window appears.

## 3.2 COPYING THE DISKETTE TO THE HARD DRIVE

Take the following steps to copy the contents of the diskette to your hard drive:

- Open the hard drive by double-clicking on the Hard Drive icon. A window displaying the hard drive contents appears.
- Place the diskette containing the Reuse Economics Spreadsheet Model tool in the disk drive.
- Open the diskette by double-clicking on the Diskette icon.
- Copy the RESSM folder by clicking on the icon and dragging it to the hard drive window. Release the mouse button to start the copy procedure. The contents of the folder are placed in a folder named RESSM.

## 3.3 INVOKING THE TOOL FROM THE HARD DRIVE

Take the following steps to invoke the Reuse Economics Spreadsheet Model tool from the hard drive:

### 3.3.1 Using Microsoft Excel Version 3.0a

- Open the hard drive by double-clicking on the Hard Drive icon. A window displaying the hard drive contents appears.

- Open the RESSM folder by double-clicking on the Folder icon. A window displaying the folder contents appears.
- Start the RESSM application by double-clicking on the file RESSMBgn.xlm. The Reuse Economics Spreadsheet Model tool Main window appears.

### 3.3.2 Using Microsoft Excel Version 3.0

- Open the Microsoft Excel application by double-clicking on the Microsoft Excel icon. A default Microsoft Excel menu bar appears.
- Close the default worksheet by holding down the mouse button and dragging the mouse until you highlight Close under the File menu.
- Select File Open from the menu bar by holding down the mouse button and dragging the mouse until you highlight Open under the File menu. A dialog box appears.
- Click the mouse on the [Drive] or [Desktop] button. The dialog box now lists the name of the diskette currently in the disk drive along with the names of hard drive and any files on the desktop.
- Select the name of the hard drive by clicking the mouse button to highlight it.
- Click the mouse on the [Open] button. The dialog box now lists the names of the files on the hard drive.
- Select RESSM from the list of file names by clicking the mouse button to highlight it.
- Click the mouse on the [Open] button. The dialog box now lists the names of the files in the RESSM folder.
- Select RESSMBgn.xlm from the list of file names by clicking the mouse button to highlight it.
- Click the mouse on the [Open] button. The Reuse Economics Spreadsheet Model tool Main window appears.

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# 4. OPERATING THE TOOL

## 4.1 USER INTERFACE CONVENTIONS

The Reuse Economics Spreadsheet Model tool uses standard Microsoft Excel interface conventions whenever possible. The tool provides custom menus to protect you from inadvertently modifying the application. It also provides a user-friendly interface to those not well-versed in using Microsoft Excel.

This section provides a brief description of the user interface conventions that the tool uses. It also provides examples of using the tool, including creating graphs of data that you provide and that the tool calculates. For more detailed information about standard Microsoft Excel interface conventions, refer to the *Microsoft Excel User's Guide* (Microsoft 1991).

Figure 4-1 provides a menu hierarchy for the Reuse Economics Spreadsheet Model tool's available functionality.

### 4.1.1 Selecting From Menus

Select an item from the menu by holding down the mouse button and dragging the mouse over the menu selections until you highlight your desired choice. Release the mouse button on the selected option to execute your choice.

### 4.1.2 Selecting From a Worksheet

Make a selection from a worksheet cell by moving the mouse to the desired cell and clicking the mouse button to highlight that cell.

### 4.1.3 Editing a Worksheet

To edit a worksheet, select the cell to be edited and either choose an operation from the Edit menu or type values directly into the cell. In mode 1, you may also use a data form which you access by choosing the Form option from the Data menu (see Section 4.3.3).

### 4.1.4 Activating a Window

Activate a window by clicking the mouse anywhere in the window. The title bar of a window contains stripes when that window is active.

### 4.1.5 Menu Bars and Active Windows

The displayed menu bar corresponds to the appropriate type of menu bar for the active window. The striped title bar indicates the active window.

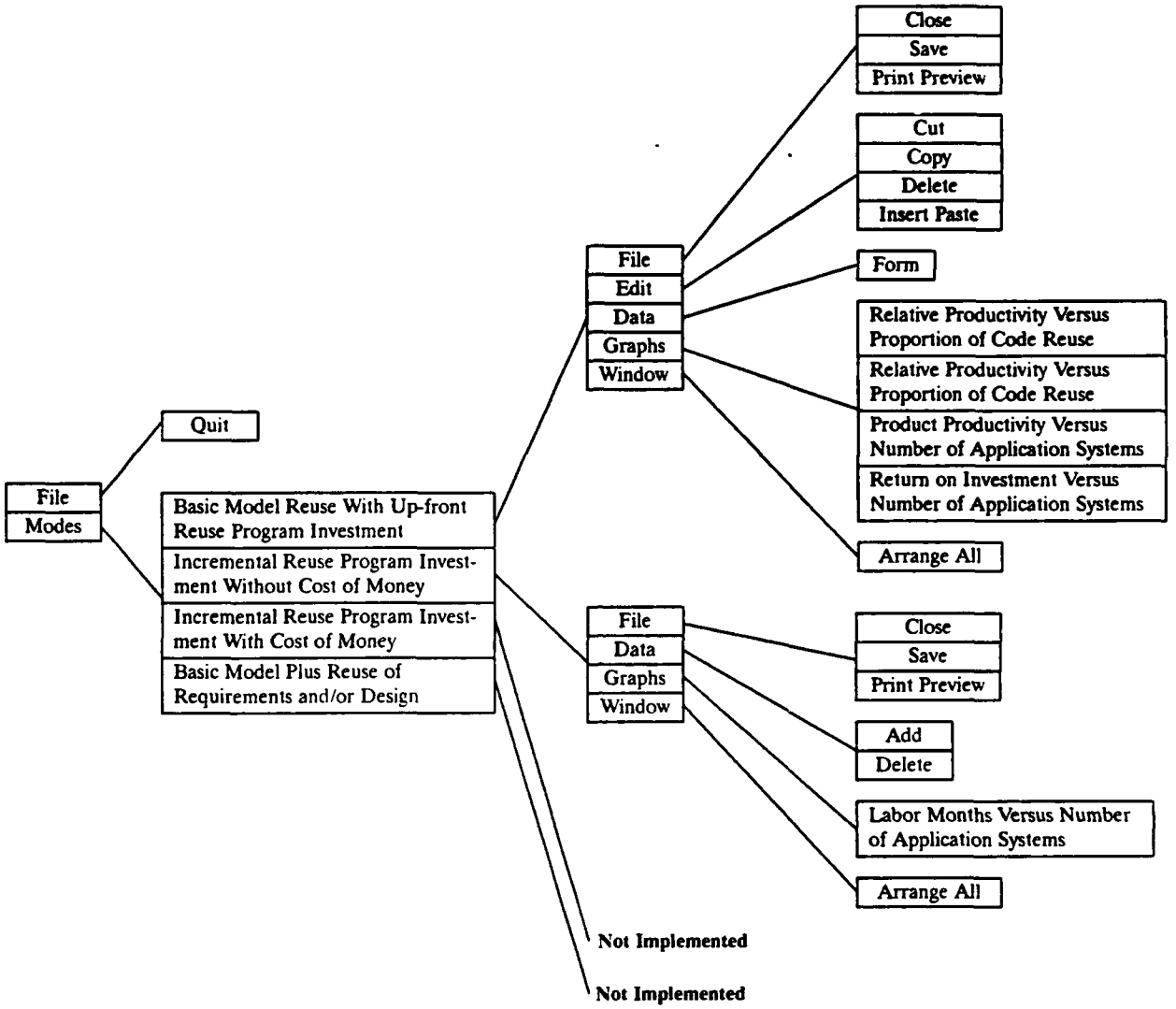


Figure 4-1. Reuse Economics Spreadsheet Model Menu Hierarchy

### 4.1.6 Closing the Active Window

Close the active window by clicking the mouse button on the [Close] box in the upper left corner of the window or by choosing Close from the File menu (see Sections 4.2.1 and 4.3.1).

### 4.1.7 Sizing the Active Window

Use standard mouse techniques to size and move windows. To change the size of a window, select a corner edge and drag the mouse to the desired location. To move a window, select a noncorner portion of a window and drag the mouse to the desired location.

### 4.1.8 Scrolling the Active Window

The tool provides both horizontal and vertical scroll bars to scroll windows.

## 4.2 THE MAIN WINDOW

The Main window appears when you start the system (see Figure 4-2). It provides access to all system functions.

Figure 4-2. The Main Window

The Main window consists of two parts: a static text area and a custom Microsoft Excel menu bar. The static text area momentarily displays the Consortium logo and the tool name. The menu bar contains two menus: File and Modes.

### 4.2.1 The File Menu

The File menu allows you to exit the system. To exit the system, select Quit from the File menu. Quit exits both the application and Microsoft Excel.

### 4.2.2 The Modes Menu

The Modes menu allows you to choose one of the following modes of operation defined for the tool:

- Mode 1: Basic Model—Reuse With Up-front Reuse Program Investment.
- Mode 2: Incremental Reuse Program Investment Without Cost of Money.
- Mode 3: Incremental Reuse Program Investment With Cost of Money.
- Mode 4: Basic Model Plus Reuse of Requirements and/or Design.

To choose the mode of reuse model to use, select one of the modes listed in the Modes menu. This version of the tool supports only modes 1 and 2. Selecting Basic Model-Reuse With Up-Front Reuse Program Investment results in the presentation of the Mode 1 window. Selecting Incremental Reuse Program Investment Without Cost Of Money results in the presentation of the Mode 2 window. The names of the two other modes appear in dimmed video, and you cannot select them.

## 4.3 THE MODE 1 WINDOW

The Mode 1 window appears when you select Basic Model-Reuse With Up-Front Reuse Program Investment from the Modes menu of the Main window. It provides access to all other system functions for mode 1 operation. The window consists of a custom menu bar and an Microsoft Excel worksheet (see Figures 4-3, 4-4, and 4-5). The menu bar contains the File, Edit, Data, Graphs, and Window menus.

The worksheet contains the rows of data that were either entered by you or computed from the values you entered. Each column of data corresponds to a variable described in the reuse economics model detailed in (Cruickshank and Gaffney 1991) and summarized in Section 2. Table 4-1 shows the mapping of column names to variable names.

File Edit Data Graphs Window

R1 | R01

Mode1DB.wls

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | INPUT | N | R | CDE | CVN | CVR | ST | SS | K entered | OUTPUT | K comp |
| 2 | | Number of Application Systems | Proportion of Code Reuse | Unit Cost of Reuse Program Investment | Unit Cost of New Code | Unit Cost of Reused Code | Size of Reuse Library | Average Size of Application System | K entered | | Relatt Libra Capac |
| 3 | | 1 | 0.20 | 15.00 | 10.00 | 1.00 | | | 1.00 | | |
| 4 | | 1 | 0.40 | 15.00 | 10.00 | 1.00 | | | 1.00 | | |
| 5 | | 1 | 0.80 | 15.00 | 10.00 | 1.00 | | | 1.00 | | |
| 6 | | 4 | 0.30 | 15.00 | 10.00 | 1.00 | | | 0.30 | | |
| 7 | | 4 | 0.70 | 15.00 | 10.00 | 1.00 | | | 0.70 | | |
| 8 | | 4 | 0.90 | 15.00 | 10.00 | 1.00 | | | 0.90 | | |
| 9 | | 4 | 0.30 | 15.00 | 10.00 | 2.00 | | | 0.30 | | |
| 10 | | 4 | 0.70 | 15.00 | 10.00 | 2.00 | | | 0.70 | | |
| 11 | | 4 | 0.90 | 15.00 | 10.00 | 2.00 | | | 0.90 | | |
| 12 | | 4 | 0.30 | 15.00 | 10.00 | 3.00 | | | 0.30 | | |
| 13 | | 4 | 0.70 | 15.00 | 10.00 | 3.00 | | | 0.70 | | |
| 14 | | 4 | 0.90 | 15.00 | 10.00 | 3.00 | | | 0.90 | | |
| 15 | | 4 | 0.30 | 15.00 | 10.00 | 4.00 | | | 0.30 | | |
| 16 | | 4 | 0.70 | 15.00 | 10.00 | 4.00 | | | 0.70 | | |
| 17 | | 4 | 0.90 | 15.00 | 10.00 | 4.00 | | | 0.90 | | |
| 18 | | 4 | 0.30 | 15.00 | 10.00 | 5.00 | | | 0.30 | | |
| 19 | | 4 | 0.70 | 15.00 | 10.00 | 5.00 | | | 0.70 | | |
| 20 | | 4 | 0.90 | 15.00 | 10.00 | 5.00 | | | 0.90 | | |
| 21 | | 5 | 0.20 | 15.00 | 10.00 | 1.00 | | | 1.00 | | |
| 22 | | 5 | 0.40 | 15.00 | 10.00 | 1.00 | | | 1.00 | | |
| 23 | | 5 | 0.80 | 15.00 | 10.00 | 1.00 | | | 1.00 | | |
| 24 | | 7 | 0.20 | 15.00 | 10.00 | 1.00 | | | 1.00 | | |

Figure 4-3. The Mode 1 Window (Part 1)

File Edit Data Graphs Window

R1 | R01

Mode1DB.wls

| | L | M | N | O | P | Q | R | S | T |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CUS | PU | P | C | CVRR | NO | ROI | E | |
| 2 | Unit Cost of Product | Product Productivity | Relative Product Productivity | Relative Product Cost | Relative Reuse Cost | Breakeven Number of Systems | Return on Investment | Library Efficiency | |
| 3 | 23.20 | 43.10 | 0.43 | 2.33 | 0.10 | 8.33 | -88.00 | 0.20 | |
| 4 | 21.40 | 46.73 | 0.47 | 2.13 | 0.10 | 4.17 | -76.02 | 0.40 | |
| 5 | 17.80 | 56.18 | 0.56 | 1.79 | 0.10 | 2.08 | -51.92 | 0.80 | |
| 6 | 8.43 | 118.62 | 1.19 | 0.84 | 0.10 | 1.67 | 139.52 | 1.00 | |
| 7 | 6.33 | 157.98 | 1.58 | 0.63 | 0.10 | 1.67 | 139.52 | 1.00 | |
| 8 | 5.28 | 189.39 | 1.89 | 0.53 | 0.10 | 1.67 | 139.52 | 1.00 | |
| 9 | 8.73 | 114.55 | 1.15 | 0.87 | 0.20 | 1.88 | 112.77 | 1.00 | |
| 10 | 7.03 | 142.25 | 1.42 | 0.70 | 0.20 | 1.88 | 112.77 | 1.00 | |
| 11 | 6.18 | 161.81 | 1.62 | 0.62 | 0.20 | 1.88 | 112.77 | 1.00 | |
| 12 | 9.03 | 110.74 | 1.11 | 0.90 | 0.30 | 2.14 | 86.92 | 1.00 | |
| 13 | 7.73 | 129.37 | 1.29 | 0.78 | 0.30 | 2.14 | 86.92 | 1.00 | |
| 14 | 7.08 | 141.24 | 1.41 | 0.71 | 0.30 | 2.14 | 86.92 | 1.00 | |
| 15 | 9.33 | 107.18 | 1.07 | 0.93 | 0.40 | 2.50 | 60.00 | 1.00 | |
| 16 | 8.43 | 118.62 | 1.19 | 0.84 | 0.40 | 2.50 | 60.00 | 1.00 | |
| 17 | 7.98 | 125.31 | 1.25 | 0.80 | 0.40 | 2.50 | 60.00 | 1.00 | |
| 18 | 9.63 | 103.84 | 1.04 | 0.96 | 0.50 | 3.00 | 33.33 | 1.00 | |
| 19 | 9.13 | 109.53 | 1.10 | 0.91 | 0.50 | 3.00 | 33.33 | 1.00 | |
| 20 | 8.88 | 112.61 | 1.13 | 0.88 | 0.50 | 3.00 | 33.33 | 1.00 | |
| 21 | 11.20 | 89.29 | 0.89 | 1.12 | 0.10 | 8.33 | -39.98 | 0.20 | |
| 22 | 9.40 | 106.38 | 1.06 | 0.94 | 0.10 | 4.17 | 19.90 | 0.40 | |
| 23 | 5.80 | 172.41 | 1.72 | 0.58 | 0.10 | 2.08 | 140.38 | 0.80 | |
| 24 | 10.34 | 96.71 | 0.97 | 1.03 | 0.10 | 8.33 | -15.97 | 0.20 | |

Figure 4-4. The Mode 1 Window (Part 2)

File Data Graphs Window

A2 | Case Number

Mode2DB.wls

| | Q | R | S | T | U | V | W |
|---|---|---|---|---|---|---|---|
| 1 | PU | P | C | CVRR | NO | ROI | E |
| 2 | Product Productivity | Relative Product Productivity | Relative Product Cost | Relative Reuse Cost | Breakeven Number of Systems | Return on Investment | Library Efficiency |
| 4 | 434.78 | 2.17 | 0.46 | 0.10 | 1.67 | 200.00 | 1.00 |
| 5 | 434.78 | 2.17 | 0.46 | 0.10 | 1.67 | 200.00 | 1.00 |
| 6 | 434.78 | 2.17 | 0.46 | 0.10 | 1.67 | 200.00 | 1.00 |
| 7 | 434.78 | 2.17 | 0.46 | 0.10 | 1.67 | 200.00 | 1.00 |
| 8 | 434.78 | 2.17 | 0.46 | 0.10 | 1.67 | 200.00 | 1.00 |
| 9 | 273.97 | 1.37 | 0.73 | 0.10 | 2.17 | 130.77 | 1.00 |
| 10 | 405.06 | 2.03 | 0.49 | 0.10 | 2.17 | 130.77 | 1.00 |
| 11 | 405.06 | 2.03 | 0.49 | 0.10 | 2.17 | 130.77 | 1.00 |
| 12 | 405.06 | 2.03 | 0.49 | 0.10 | 2.17 | 130.77 | 1.00 |
| 13 | 405.06 | 2.03 | 0.49 | 0.10 | 2.17 | 130.77 | 1.00 |
| 14 | 231.21 | 1.16 | 0.87 | 0.10 | 3.17 | 57.89 | 1.00 |
| 15 | 267.78 | 1.34 | 0.75 | 0.10 | 3.17 | 57.89 | 1.00 |
| 16 | 304.47 | 1.52 | 0.66 | 0.10 | 3.17 | 57.89 | 1.00 |
| 17 | 320.96 | 1.60 | 0.62 | 0.10 | 3.17 | 57.89 | 1.00 |
| 18 | 320.96 | 1.60 | 0.62 | 0.10 | 3.17 | 57.89 | 1.00 |
| 19 | 243.90 | 1.22 | 0.82 | 0.10 | 3.00 | 66.67 | 1.00 |
| 20 | 288.18 | 1.44 | 0.69 | 0.10 | 3.00 | 66.67 | 1.00 |
| 21 | 321.54 | 1.61 | 0.62 | 0.10 | 3.00 | 66.67 | 1.00 |
| 22 | 331.13 | 1.66 | 0.60 | 0.10 | 3.00 | 66.67 | 1.00 |
| 23 | 312.50 | 1.56 | 0.64 | 0.10 | 3.00 | 66.67 | 1.00 |
| 24 | 471.92 | 0.98 | 1.02 | 0.25 | 4.40 | -31.88 | 1.00 |

Ready NUM

Figure 4-5. The Mode 1 Window (Part 3)

Table 4-1. Mapping of Worksheet Column Names to Reuse Economic Model Variable Names

| Worksheet Column Label | Worksheet Column Name | Variable Name* | Constraints |
|---|---|---|---|
| A | **INPUT** | | |
| B | Number of Application Systems | N | $0 < N$ |
| C | Proportion of Code Reuse | R | $R \leq K_{computed} \leq 1$ |
| D | Unit Cost of Reuse Program Investment | $C_{DE}$ | $0 < C_{DE}$ |
| E | Unit Cost of New Code | $C_{VN}$ | $0 < C_{VN}$ |
| F | *Unit Cost of Reused Code* | $C_{VR}$ | $0 < C_{VR}$ |
| G | *Size of Reuse Library* | ST | $0 \leq ST \leq SS$ |
| H | *Average Size of Application System* | SS | $0 \leq SS$ |
| I | $K_{entered}$ | $K_{entered}$ | $0 \leq K_{entered} \leq 1$ |
| J | **OUTPUT** | | |
| K | *Relative Library Capacity* (calculated by the program, $K_{computed}$: = $K_{entered}$ or ST/SS) | $K_{computed}$ | $0 \leq K_{computed} \leq 1$ |
| L | *Unit Cost of Product* | $C_{US}$ | $C_{US} = (C_{DE}/N) * K_{computed} + C_{VN} - (C_{VN} - C_{VR}) * R$ |
| M | *Product Productivity* | PU | $PU = 1000/C_{US}$ |
| N | *Relative Product Productivity* | P | $P = C_{VN}/C_{US}$ |

Table 4-1, continued

| Worksheet Column Label | Worksheet Column Name | Variable Name* | Constraints |
|---|---|---|---|
| O | *Relative Product Cost* | C | $C = 1/P$ |
| P | *Relative Reuse Cost* | $C_{VRR}$ | $C_{VRR} = C_{VR}/C_{VN}$ |
| Q | *Breakeven Number of Systems* | $N_0$ | $N_0 = C_{DE}/((C_{VN} - C_{VR}) * E)$ |
| R | Return on Investment | ROI | $ROI = ((N/N_0) - 1) * 100$ |
| S | *Library Efficiency* | E | $E = R/K_{computed}$ |

* Section 2 and (Cruickshank and Gaffney 1991) use subscripts on some of these variables such as $C_{DE}$ instead of CDE and $C_{US}$ instead of CUS.

### 4.3.1 The File Menu

The File menu provides the following options:

- ***Print Preview.*** To print the worksheet, select Print Preview from the File menu. The standard Microsoft Excel Print Preview window then appears.

*Note*: Attempting to print when there is no printer connected may result in a macro error. Should this happen, click the mouse on the [Halt] button to return to normal operation.

- ***Save.*** To save changes made to the worksheet, select Save from the File menu. The tool saves the data and returns you to the Mode 1 window. Saving a worksheet overwrites the previous data with the current data. The tool maintains only one version of the worksheet and makes it accessible through the application. To retain old data indefinitely, you should make a copy of the file Mode1DB.xls under a new name. Do this outside of the Reuse Economics Spreadsheet Model tool. To restore old data, rename a saved file to Mode1DB.xls. You should be able to print a saved worksheet from Microsoft Excel. Saving old data under different file names is a way to preserve historical data associated with a particular graph or set of graphs.

- ***Close.*** To exit the Mode 1 window, select Close from the File menu. A dialog box appears warning you if you have any unsaved changes. Click the [Yes] or [No] button, as appropriate, to continue the Close process. When the Close process is completed, the Main window appears.

### 4.3.2 The Edit Menu

The Edit menu provides the following options for you to perform on entire worksheet rows containing the selected cells:

- ***Cut.*** Choose the Cut option from the Edit menu to cut the worksheet row containing the selected cell.

- ***Copy.*** Choose the Copy option from the Edit menu to copy the worksheet row containing the selected cell.

- ***Delete.*** Choose the Delete option from the Edit menu to delete the worksheet row containing the selected cell.

- ***Insert Paste.*** Choose the Insert Paste option from the Edit menu to insert the previously cut or copied worksheet row in front of the worksheet row containing the selected cell.

To edit the worksheet, select the desired option from the Edit menu. These options are custom edit operations that work on entire rows of the worksheet data at a time. To create new rows, use the Copy and Insert Paste options to copy the embedded formulas to them. Specify input values for the worksheet columns between the labels INPUT and OUTPUT. To supply a value for Relative Library Capacity, either enter a value directly into $K_{entered}$ column or enter values for both the Size of Reuse Library ($S_T$) and Average Size of Application System ($S_S$) columns, and the tool computes $K_{computed}$ ( $= S_T/S_S$) for you.

*NOTE*: Incomplete inputs or constraint violations on input values may result in the appearance of standard Microsoft Excel error values in the output fields. Typical error values are #DIV/O!, #VALUE!, and #NUM!. You can correct these errors by typing the appropriate values for the input fields in the same row.

*NOTE*: The message "Please Do Not Type Below This Line" indicates to the user the boundary for input. The worksheet is implemented as a Microsoft Excel database. Microsoft Excel databases do not allow for expansion if the area below the last row is not clear. The message "Database Range Cannot Be Extended" will be displayed if you try to use the Data Form to create a new row when there is data below the boundary line.

### 4.3.3 The Data Menu

The Data menu provides the Form option which allows you to use a custom data form to manipulate data (see Figure 4-6).

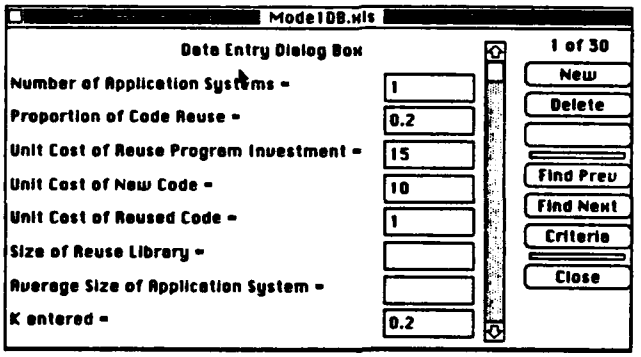


Figure 4-6. The Mode 1 Data Form

To use the custom data form, select Form from the Data menu. You can view and modify the input fields of each row of the worksheet. You can also create new rows and delete existing rows. The form provides scroll bars and buttons to allow easy navigation of the worksheet rows.

This form has a label and value for each input column in the worksheet as well as buttons for the various operations that you may perform. You can modify values enclosed in text boxes.

*NOTE*: Incomplete inputs or constraint violations on input values may result in the appearance of standard Microsoft Excel error values in the output fields. Typical error values are #DIV/O!, #VALUE!, and #NUM!. You can correct these errors by typing the appropriate values for the input fields in the same row.

You can perform the following operations in the data form:

- ***Create a New Row in the Worksheet.*** The [New] button allows you to add new rows to the worksheet. To create a new row in the worksheet, click the [New] button. All of the fields clear, and you can now enter values in the text boxes for the new row. You may move the cursor to the next text box by using either the <TAB> key or by clicking the mouse button on the desired text box.

  *NOTE*: A carriage return creates a new row and causes the data form to display the next row in the worksheet.

  You may enter the value for Library Relative Capacity, $K_{computed}$, in two ways:

  - By entering a value in the $K_{entered}$ text box.
  - By entering values in both the Size of Reuse Library and Average Size of Application System text boxes.

  If you enter both $K_{entered}$ and values for the Size of Reuse Library and Average Size of Application System, then $K_{computed}$ will be determined by the Size of Reuse Library and Average Size of Application System.

- ***Find a Row in the Worksheet.*** You may use one of several methods to locate a particular row:

  - Use the scroll bar to display the desired row.
  - Use the [Find Next] and [Find Prev] buttons. The [Find Next] button allows you to step through the worksheet one row at a time from top to bottom. It initiates a search for the next row (from the current row) that matches the search criteria you specify. If you do not specify search criteria, the search stops at the next row, if one exists.

    The [Find Prev] button allows you to step through the worksheet one row at a time from bottom to top. It initiates a search for the previous row (from the current row) that matches the search criteria you specify. If you do not specify search criteria, the search stops at the previous row, if one exists.

  - Use the [Criteria] button, which allows you to search the worksheet with the [Find Prev] and [Find Next] buttons based on key values. It presents you with a cleared form to enter search criteria. You then use the criteria you specified in subsequent [Find Next] and [Find Prev] operations. For additional searches use the [Clear] button to clear the search criteria and the [Restore] button to restore the search criteria. Use the [Form] button to return to the data form without searching the database.

- ***Modify a Row in the Worksheet.*** To modify an existing row in the worksheet, locate the desired row. Click on the input box you wish to modify and change the existing values.

- ***Delete a Row in the Worksheet.*** The [Delete] button allows you to delete existing rows from the worksheet. To do so, locate the desired row, then click the [Delete] button. A delete confirmation dialog box appears. Click on the [OK] button to confirm the delete operation, or click on the [Cancel] button to prevent the deletion from occurring.

- ***Exit the Data Form.*** The [Close] button allows you to exit the form. To do so, click the [Close] button. The Mode 1 window then appears.

### 4.3.4 The Graphs Menu

The Graphs menu generates built-in graphs for mode 1 calculations. A series of dialog boxes appear when you select a graph from the Graphs menu. These input dialog boxes allow you to specify the options to be applied to the selected graph. They are specific to each graph selection. The dialog boxes request input, such as the number of curves to plot and values to use, as selection criteria when extracting the data to plot.

Each dialog box has option buttons and/or list boxes from which you make selections of input data values. Each box also has an [OK] button and a [Cancel] button. Click on the [OK] button to transmit the input values to the application and continue building the graph. (*Note:* Pressing <RETURN> in response to a dialog box is the same as clicking on the [OK] button.) Click the [Cancel] button to terminate the graph build operation. See Section 4.3.6 for more details about the mode 1 graphs.

*Warning:* If you attempt to save a graph, it must be saved in the current working directory.

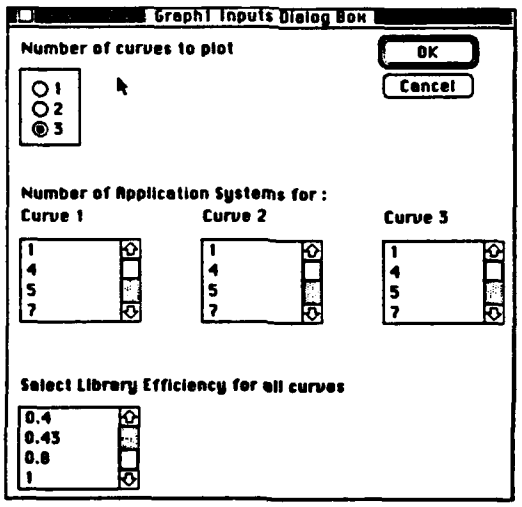


Figure 4-7. Graph Input Dialog Box

### 4.3.5 The Window Menu

The Window menu provides the Arrange All option which allows you to simultaneously display all open windows. This is useful for viewing multiple graphs at the same time. A sample display resulting from invocation of the Arrange All menu selection is shown in Figure 4-8.

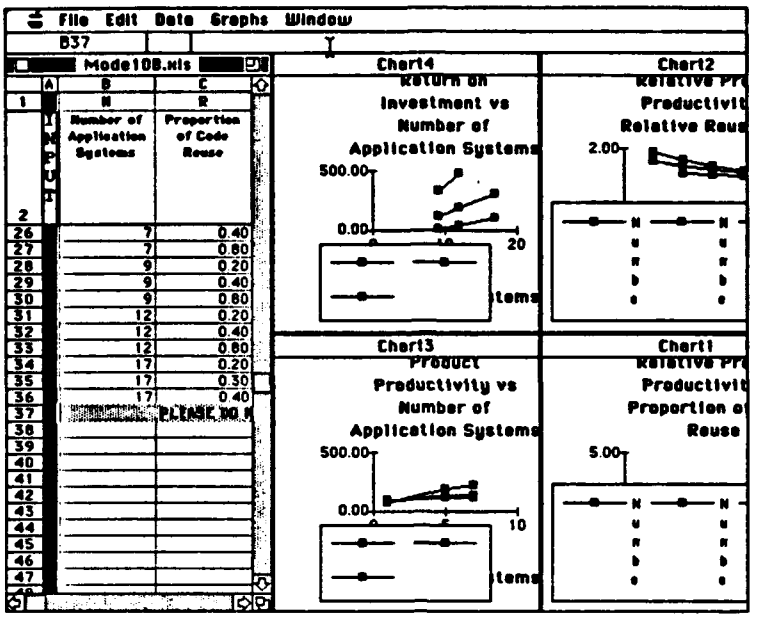


Figure 4-8. Arrange All Display

### 4.3.6 Graphs

To produce a graph from the worksheet data, select the desired graph from the Graphs menu. There are four built-in graphs that you can produce in mode 1:

- Relative Productivity Versus Proportion of Code Reuse
- Relative Productivity Versus Relative Reuse Cost
- Product Productivity Versus Number of Application Systems
- Return on Investment Versus Number Of Application Systems

*Warning*: A macro error occurs when a graph is created from data containing Excel error indicators.

#### 4.3.6.1 Relative Productivity Versus Proportion of Code Reuse Graph

The Relative Productivity Versus Proportion of Code Reuse graph provides up to three graphs of relative productivity (productivity using reused code relative to productivity using only new code) as a function of the proportion of code reused. The three graphs differ with respect to the number of uses (N) employed.

*Note*: You should ensure that all of the points plotted use the same values for the unit costs of reuse program investment ($C_{DE}$), new code ($C_{VN}$), and reusing code ($C_{VR}$).

The Graph1 Inputs Dialog Box (Figure 4-9) appears when you enter your data. It requests a value for the number of curves to plot, the number of application systems for each of the curves, and the library efficiency to use in all plots.

- Select one of the option buttons to specify a value for the number of curves to plot.
- Select a value from the list box corresponding to each desired curve to specify the values for the number of application systems for each curve.
- Select a value from the corresponding list box to specify a value for the library efficiency.

- Click the [OK] button to have the selected inputs accepted by the application and the graph build operation will continue.

- Click the [Cancel] button to terminate the graph build operation and the Mode 1 window will be displayed.

*NOTE*: List boxes display only those values that exist for the appropriate fields in the Mode1DB.xls worksheet.

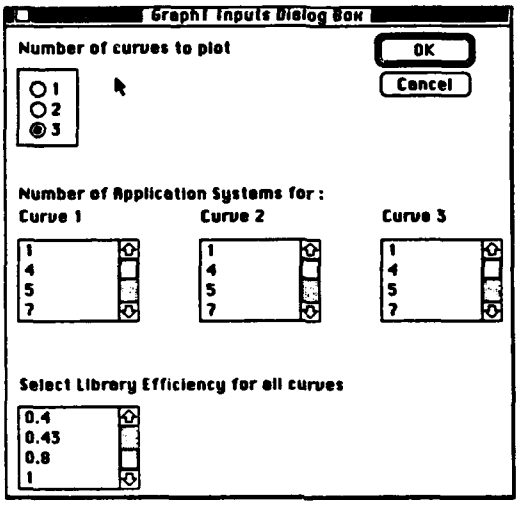


Figure 4-9. Mode 1 Graph1 Input Dialog Box

Once you complete your entries, the graph window displays the resultant graph (see Figure 4-10).

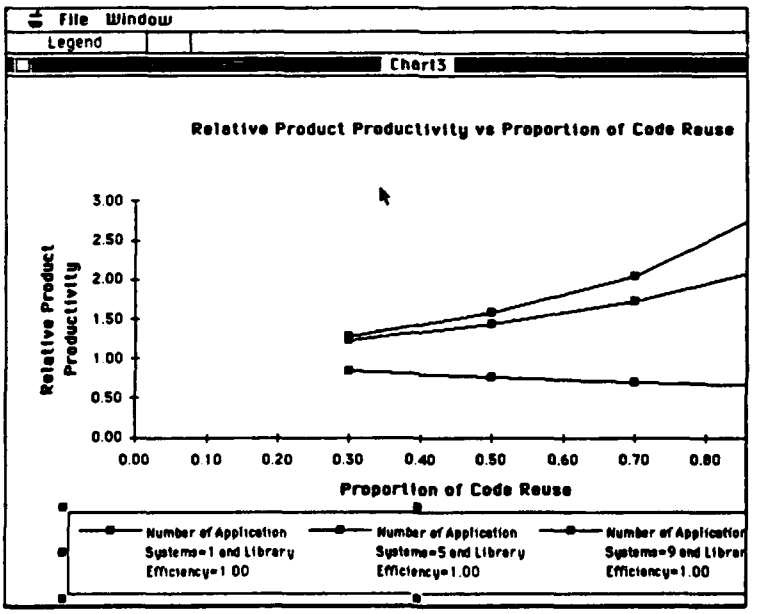


Figure 4-10. Relative Product Productivity Versus Proportion of Code Reuse Graph Window

Table 4-2 shows the input data values that produced this graph.

Table 4-2. Input Data Values for Relative Product Productivity Versus Proportion of Code Reuse Graph Window

| Number of Application Systems (N) | Proportion of Code Reuse (R) | Unit Cost of Reuse Program Investment ($C_{DE}$) | Unit Cost of New Code ($C_{VN}$) | Unit Cost of Reused Code ($C_{VR}$) | $K_{entered}$ (K) |
|---|---|---|---|---|---|
| 1 | 0.3 | 15 | 10 | 1 | 0.3 |
| 1 | 0.5 | 15 | 10 | 1 | 0.5 |
| 1 | 0.7 | 15 | 10 | 1 | 0.7 |
| 1 | 0.9 | 15 | 10 | 1 | 0.9 |
| 5 | 0.3 | 15 | 10 | 1 | 0.3 |
| 5 | 0.5 | 15 | 10 | 1 | 0.5 |
| 5 | 0.7 | 15 | 10 | 1 | 0.7 |
| 5 | 0.9 | 15 | 10 | 1 | 0.9 |
| 9 | 0.3 | 15 | 10 | 1 | 0.3 |
| 9 | 0.5 | 15 | 10 | 1 | 0.5 |
| 9 | 0.7 | 15 | 10 | 1 | 0.7 |
| 9 | 0.9 | 15 | 10 | 1 | 0.9 |

#### 4.3.6.2 Relative Productivity Versus Relative Reuse Cost Graph

The Relative Productivity Versus Relative Reuse Cost graph provides up to three graphs of relative productivity (as defined earlier) as a function of the unit cost of reusing code ($C_{VR}$) relative to the unit cost of creating new code ($C_{VN}$). This relative cost, $C_{VRR}$, is illustrated by the formula, $C_{VRR} = C_{VR}/C_{VN}$. The three graphs differ with respect to the values of the proportion of code reuse (R) that you select.

*NOTE*: You should ensure that all of the points plotted use the same values for the unit costs of reuse program investment ($C_{DE}$) and new code ($C_{VN}$).

Two dialog boxes appear when you enter your data.

- The Graph2A Inputs Dialog Box (Figure 4-11) requests values for the number of curves to plot and the proportion of code reuse for each curve.
  - Select one of the option buttons to specify a value for the number of curves to plot.
  - Select a value from the list box corresponding to each desired curve to specify the values for the proportion of code reuse for each curve.
  - Click the [OK] button to have the selected inputs accepted by the application and the Graph2B Inputs Dialog Box is displayed.
  - Click the [Cancel] button to terminate the graph build operation and the Mode 1 window is displayed.

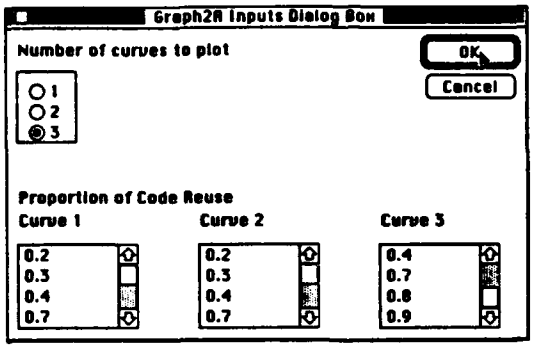


Figure 4-11. Mode 1 Graph2A Input Dialog Box

- The Graph2B Inputs Dialog Box (Figure 4-12) displays the selected values from the Graph2A Inputs Dialog Box and requests values for the number of application systems for all curves and the library efficiency to use in all plots.

  - Select a value from the corresponding list box to specify a value for the number of application systems.

  - Select a value from the corresponding list box to specify a value for the library efficiency.

  - Click the [OK] button to have the selected inputs accepted by the application and the graph build operation continues.

  - Click the [Cancel] button to terminate the graph build operation and the Mode 1 window is displayed.

*NOTE*: List boxes display only values that exist for the appropriate fields in the Mode1DB.xls worksheet.

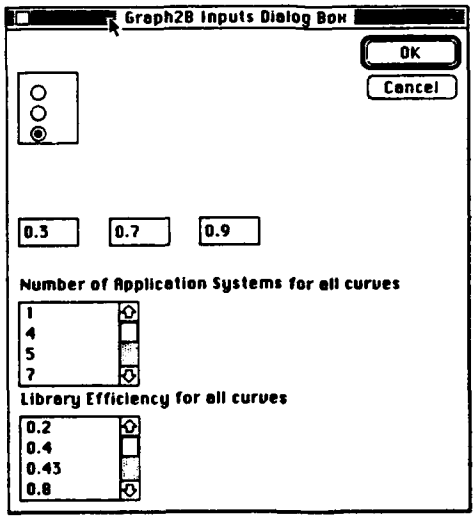


Figure 4-12. Mode 1 Graph2B Input Dialog Box

Once you complete your entries, the graph window displays the resultant graph (see Figure 4-13).

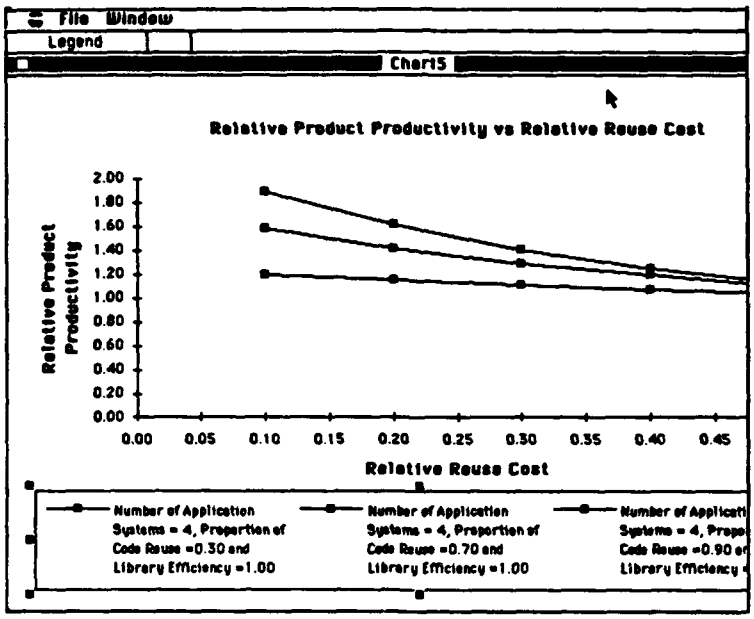


Figure 4-13. Relative Product Productivity Versus Relative Reuse Cost Graph Window

Table 4-3 shows the input data values that produced this graph.

Table 4-3. Input Data Values for Relative Product Productivity Versus Relative Reuse Cost Graph Window

| Number of Application Systems (N) | Proportion of Code Reuse (R) | Unit Cost of Reuse Program Investment ($C_{DE}$) | Unit Cost of New Code ($C_{VN}$) | Unit Cost of Reused Code ($C_{VR}$) | $K_{entered}$ (K) |
|---|---|---|---|---|---|
| 4 | 0.3 | 15 | 10 | 1 | 0.3 |
| 4 | 0.7 | 15 | 10 | 1 | 0.7 |
| 4 | 0.9 | 15 | 10 | 1 | 0.9 |
| 4 | 0.3 | 15 | 10 | 2 | 0.3 |
| 4 | 0.7 | 15 | 10 | 2 | 0.7 |
| 4 | 0.9 | 15 | 10 | 2 | 0.9 |
| 4 | 0.3 | 15 | 10 | 3 | 0.3 |
| 4 | 0.7 | 15 | 10 | 3 | 0.7 |
| 4 | 0.9 | 15 | 10 | 3 | 0.9 |
| 4 | 0.3 | 15 | 10 | 4 | 0.3 |
| 4 | 0.7 | 15 | 10 | 4 | 0.7 |
| 4 | 0.9 | 15 | 10 | 4 | 0.9 |
| 4 | 0.3 | 15 | 10 | 5 | 0.3 |
| 4 | 0.7 | 15 | 10 | 5 | 0.7 |
| 4 | 0.9 | 15 | 10 | 5 | 0.9 |

#### 4.3.6.3 Product Productivity Versus Number of Application Systems Graph

The Product Productivity Versus Number of Application Systems graph format provides up to three graphs of product productivity, $P_U$ ($P_U = 1{,}000/C_{US}$), versus the number of application systems, N. The three graphs differ with respect to the values of R, the proportion of code reuse, that you select.

*NOTE*: You should ensure that all of the points plotted use the same values for the unit costs of reuse program investment ($C_{DE}$), new code ($C_{VN}$), and reusing code ($C_{VR}$).

The Graph3 Inputs Dialog Box (Figure 4-14) appears when you enter your data. It requests values for the number of curves to plot, the proportion of code reuse for each curve, and the library efficiency to use in all plots.

- Select one of the option buttons to specify a value for the number of curves to plot.
- Select a value from the list box corresponding to each desired curve to specify the values for the proportion of code reuse for each curve.
- Select a value from the corresponding list box to specify a value for the library efficiency.
- Click the [OK] button to have the selected inputs accepted by the application and the graph build operation continues.
- Click the [Cancel] button to terminate the graph build operation and the Mode 1 window is displayed.

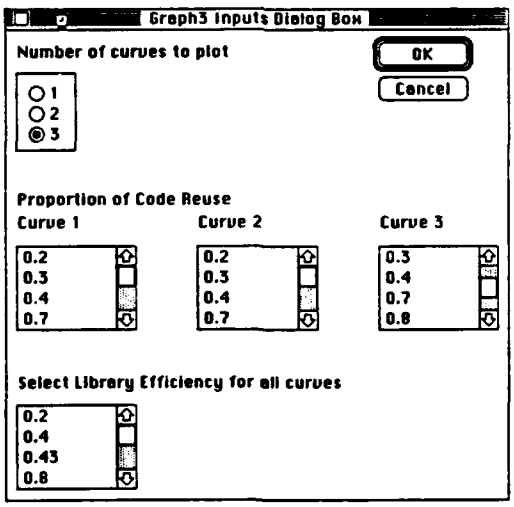


Figure 4-14. Mode 1 Graph3 Input Dialog Box

Once you complete your entries, the graph window displays the resultant graph (see Figure 4-15). Note that the "cross-over" in the plots at a value of N, the number of application systems, is slightly less than 2. The cross-over occurs at a value of $N = N_0$, the break-even number of systems. For N less than $N_0$, higher values of R (the proportion of reuse) make the unit cost of an application system more expensive.

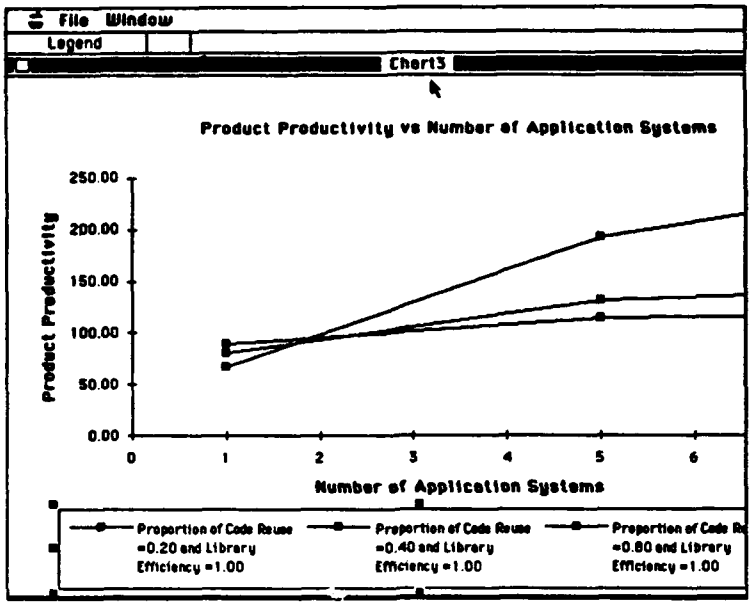


Figure 4-15. Product Productivity Versus Number of Application Systems Graph Window

Table 4-4 shows the input data values that produced this graph.

Table 4-4. Input Data Values for Product Productivity Versus Number of Application Systems Graph Window

| Number of Application Systems (N) | Proportion of Code Reuse (R) | Unit Cost of Reuse Program Investment ($C_{DE}$) | Unit Cost of New Code ($C_{VN}$) | Unit Cost of Reused Code ($C_{VR}$) | $K_{entered}$ (K) |
|---|---|---|---|---|---|
| 1 | 0.2 | 15 | 10 | 1 | 0.2 |
| 1 | 0.4 | 15 | 10 | 1 | 0.4 |
| 1 | 0.8 | 15 | 10 | 1 | 0.8 |
| 5 | 0.2 | 15 | 10 | 1 | 0.2 |
| 5 | 0.4 | 15 | 10 | 1 | 0.4 |
| 5 | 0.8 | 15 | 10 | 1 | 0.8 |
| 7 | 0.2 | 15 | 10 | 1 | 0.2 |
| 7 | 0.4 | 15 | 10 | 1 | 0.4 |
| 7 | 0.8 | 15 | 10 | 1 | 0.8 |
| 9 | 0.2 | 15 | 10 | 1 | 0.2 |
| 9 | 0.4 | 15 | 10 | 1 | 0.4 |
| 9 | 0.8 | 15 | 10 | 1 | 0.8 |
| 12 | 0.2 | 15 | 10 | 1 | 0.2 |
| 12 | 0.4 | 15 | 10 | 1 | 0.4 |
| 12 | 0.8 | 15 | 10 | 1 | 0.8 |

#### 4.3.6.4 Return on Investment Versus Number of Application Systems Graph

The Return on Investment Versus Number of Application Systems graph format provides up to three graphs of ROI versus the number of application systems, N. The three graphs differ with respect to the value of E, the library efficiency, that you use.

*NOTE*: You should ensure that all of the points plotted use the same values for the unit costs of reuse program investment ($C_{DE}$), new code ($C_{VN}$), and reusing code ($C_{VR}$).

The Graph4 Inputs Dialog Box (Figure 4-16) appears when you enter your data. It requests values for the number of curves to plot and the library efficiency for each curve.

- Select one of the option buttons to specify a value for the number of curves to plot.
- Select a value from the list box corresponding to each desired curve to specify the values for the library efficiency for each curve.
- Click the [OK] button to have the selected inputs accepted by the application and the graph build operation continues.
- Click the [Cancel] button to terminate the graph build operation and the Mode 1 window is displayed.

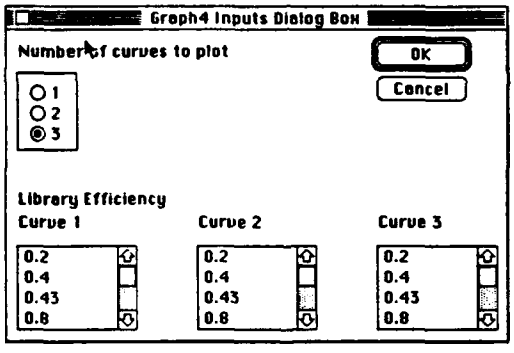


Figure 4-16. Mode 1 Graph4 Input Dialog Box

Once you complete your entries, the graph window displays the resultant graph (see Figure 4-17). Note that the return on investment is negative when N, the number of application systems, is less than $N_0$, the break-even number of systems.

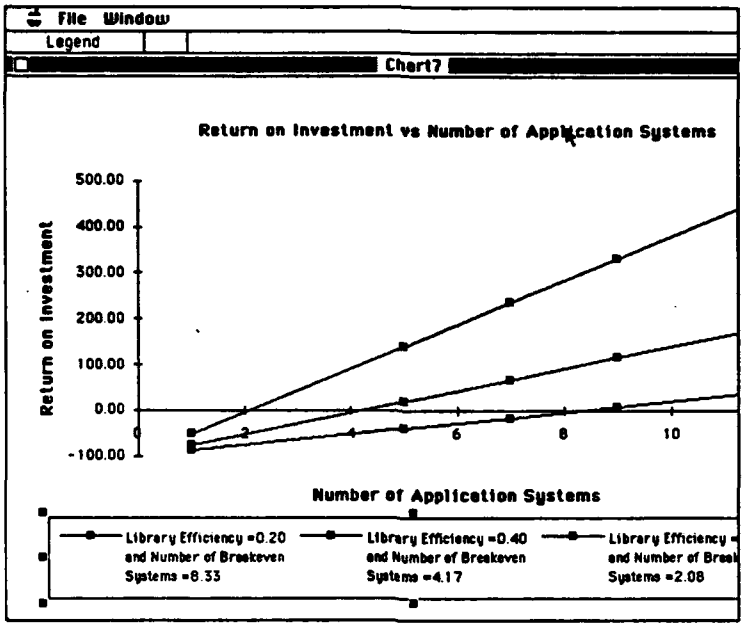


Figure 4-17. Return on Investment Versus Number of Application Systems Graph Window

Table 4-5 shows the input data values that produced this graph.

Table 4-5. Input Data Values for Return on Investment Versus Number of Applications Graph Window

| Number of Application Systems (N) | Proportion of Code Reuse (R) | Unit Cost of Reuse Program Investment ($C_{DE}$) | Unit Cost of New Code ($C_{VN}$) | Unit Cost of Reused Code ($C_{VR}$) | $K_{entered}$ (K) |
|---|---|---|---|---|---|
| 1 | 0.2 | 15 | 10 | 1 | 1.0 |
| 1 | 0.4 | 15 | 10 | 1 | 1.0 |
| 1 | 0.8 | 15 | 10 | 1 | 1.0 |
| 5 | 0.2 | 15 | 10 | 1 | 1.0 |
| 5 | 0.4 | 15 | 10 | 1 | 1.0 |
| 5 | 0.8 | 15 | 10 | 1 | 1.0 |
| 7 | 0.2 | 15 | 10 | 1 | 1.0 |
| 7 | 0.4 | 15 | 10 | 1 | 1.0 |
| 7 | 0.8 | 15 | 10 | 1 | 1.0 |
| 9 | 0.2 | 15 | 10 | 1 | 1.0 |
| 9 | 0.4 | 15 | 10 | 1 | 1.0 |
| 9 | 0.8 | 15 | 10 | 1 | 1.0 |
| 12 | 0.2 | 15 | 10 | 1 | 1.0 |
| 12 | 0.4 | 15 | 10 | 1 | 1.0 |
| 12 | 0.8 | 15 | 10 | 1 | 1.0 |

## 4.4 THE MODE 2 WINDOW

When you select Incremental Reuse Program Investment Without Cost Of Money from the Modes menu of the Main window the Mode 2 window appears. It provides access to all other system functions for mode 2 operation. The window consists of a Custom menu bar and an Microsoft Excel worksheet (see Figures 4-18, 4-19, and 4-20). The menu bar contains the File, Data, Graphs, and Window menus.

File Data Graphs Window

A2 | Case Number

Mode2DB.xls

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | CaseNo | I | N | R | CDE | CVN | CVR |
| 2 | Case Number | Application Number | Number of Application Systems | Proportion of Code Reuse | Unit Cost of Reuse Program Investment | Unit Cost of New Code | Unit Cost of Reused Code |
| 4 | 1 | 1 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 5 | 1 | 2 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 6 | 1 | 3 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 7 | 1 | 4 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 8 | 1 | 5 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 9 | 2 | 1 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 10 | 2 | 2 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 11 | 2 | 3 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 12 | 2 | 4 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 13 | 2 | 5 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 14 | 3 | 1 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 15 | 3 | 2 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 16 | 3 | 3 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 17 | 3 | 4 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 18 | 3 | 5 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 19 | 4 | 1 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 20 | 4 | 2 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 21 | 4 | 3 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 22 | 4 | 4 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 23 | 4 | 5 | 5 | 0.90 | 7.50 | 5.00 | 0.50 |
| 24 | 5 | 1 | 3 | 0.70 | 5.31 | 2.07 | 0.51 |

Ready NUM

Figure 4-18. Mode 2 Window (Part 1)

File Data Graphs Window

A2 | Case Number

Mode2DB.xls

| | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|
| 1 | ST | SS | K | CUSi | CAi | CDEi | CDESTi |
| 2 | Size of Reuse Library | Average Size of Application System | Relative Library Capacity | Unit Cost of ith Application System | Application Engineering Cost Per System | Reuse Program Investment Cost Per System | Reuse Program Investment |
| 4 | 450.00 | 500.00 | 0.90 | 2.30 | 475.00 | 675.00 | 3375.00 |
| 5 | 450.00 | 500.00 | 0.90 | 2.30 | 475.00 | 675.00 | 0.00 |
| 6 | 450.00 | 500.00 | 0.90 | 2.30 | 475.00 | 675.00 | 0.00 |
| 7 | 450.00 | 500.00 | 0.90 | 2.30 | 475.00 | 675.00 | 0.00 |
| 8 | 450.00 | 500.00 | 0.90 | 2.30 | 475.00 | 675.00 | 0.00 |
| 9 | 450.00 | 500.00 | 0.90 | 3.65 | 1487.50 | 337.50 | 1687.50 |
| 10 | 450.00 | 500.00 | 0.90 | 2.47 | 475.00 | 759.38 | 1687.50 |
| 11 | 450.00 | 500.00 | 0.90 | 2.47 | 475.00 | 759.38 | 0.00 |
| 12 | 450.00 | 500.00 | 0.90 | 2.47 | 475.00 | 759.38 | 0.00 |
| 13 | 450.00 | 500.00 | 0.90 | 2.47 | 475.00 | 759.38 | 0.00 |
| 14 | 450.00 | 500.00 | 0.90 | 4.33 | 1993.75 | 168.75 | 843.75 |
| 15 | 450.00 | 500.00 | 0.90 | 3.73 | 1487.50 | 379.69 | 843.75 |
| 16 | 450.00 | 500.00 | 0.90 | 3.28 | 981.25 | 660.94 | 843.75 |
| 17 | 450.00 | 500.00 | 0.90 | 3.12 | 475.00 | 1082.81 | 843.75 |
| 18 | 450.00 | 500.00 | 0.90 | 3.12 | 475.00 | 1082.81 | 0.00 |
| 19 | 450.00 | 500.00 | 0.90 | 4.10 | 1825.00 | 225.00 | 1125.00 |
| 20 | 450.00 | 500.00 | 0.90 | 3.47 | 1285.00 | 450.00 | 900.00 |
| 21 | 450.00 | 500.00 | 0.90 | 3.11 | 880.00 | 675.00 | 675.00 |
| 22 | 450.00 | 500.00 | 0.90 | 3.02 | 610.00 | 900.00 | 450.00 |
| 23 | 450.00 | 500.00 | 0.90 | 3.20 | 475.00 | 1125.00 | 225.00 |
| 24 | 450.00 | 642.86 | 0.70 | 2.12 | 1096.71 | 265.50 | 796.50 |

Ready NUM

Figure 4-19. Mode 2 Window (Part 2)

File Data Graphs Window

A2 | Case Number

Mode2DB.xls

| | Y | Z | AA | AB | AC | AD | AE |
|---|---|---|---|---|---|---|---|
| 1 | S1T | SumTerms1 | S2T | SumTerms2 | AI | S3T | |
| | S1Term | SumTerms1 | S2Term | SumTerms2 | AI | S3Term | |
| 2 | | | | | | | |
| 4 | 90.00 | 90.00 | 450.00 | 450.00 | 1.00 | 0.00 | |
| 5 | 0.00 | 90.00 | 0.00 | 450.00 | 0.00 | 0.00 | |
| 6 | 0.00 | 90.00 | 0.00 | 450.00 | 0.00 | 0.00 | |
| 7 | 0.00 | 90.00 | 0.00 | 450.00 | 0.00 | 0.00 | |
| 8 | 0.00 | 90.00 | 0.00 | 450.00 | 0.00 | 0.00 | |
| 9 | 45.00 | 45.00 | 225.00 | 225.00 | 0.50 | 0.00 | |
| 10 | 56.25 | 101.25 | 225.00 | 450.00 | 0.50 | 0.50 | |
| 11 | 0.00 | 101.25 | 0.00 | 450.00 | 0.00 | 0.00 | |
| 12 | 0.00 | 101.25 | 0.00 | 450.00 | 0.00 | 0.00 | |
| 13 | 0.00 | 101.25 | 0.00 | 450.00 | 0.00 | 0.00 | |
| 14 | 22.50 | 22.50 | 112.50 | 112.50 | 0.25 | 0.00 | |
| 15 | 28.13 | 50.63 | 112.50 | 225.00 | 0.25 | 0.25 | |
| 16 | 37.50 | 88.13 | 112.50 | 337.50 | 0.25 | 0.50 | |
| 17 | 56.25 | 144.38 | 112.50 | 450.00 | 0.25 | 0.75 | |
| 18 | 0.00 | 144.38 | 0.00 | 450.00 | 0.00 | 0.00 | |
| 19 | 30.00 | 30.00 | 150.00 | 150.00 | 0.33 | 0.00 | |
| 20 | 30.00 | 60.00 | 120.00 | 270.00 | 0.27 | 0.27 | |
| 21 | 30.00 | 90.00 | 90.00 | 360.00 | 0.20 | 0.40 | |
| 22 | 30.00 | 120.00 | 60.00 | 420.00 | 0.13 | 0.40 | |
| 23 | 30.00 | 150.00 | 30.00 | 450.00 | 0.07 | 0.27 | |
| 24 | 50.00 | 50.00 | 150.00 | 150.00 | 0.33 | 0.00 | |

Ready NUM

Figure 4-20. Mode 2 Window (Part 3)

The worksheet contains the rows of data that were either entered by you or computed from the values you entered. Each column of data corresponds to a variable described in the reuse economics model detailed in (Cruickshank and Gaffney 1991) and summarized in Section 2. Table 4-6 shows the mapping of column names to variable names.

Table 4-6. Mapping of Worksheet Column Names to Reuse Economic Model Variable Names

| Worksheet Column Label | Worksheet Column Name | Variable Name* | Constraints |
|---|---|---|---|
| A | Application Number | I | $0 < I$ |
| B | Number of Application Systems | N | $0 < N$ |
| C | Proportion of Code Reuse | R | $R \leq K \leq 1$ |
| D | Unit Cost of Reuse Program Investment | $C_{DE}$ | $0 < C_{DE}$ |
| E | Unit Cost of New Code | $C_{VN}$ | $0 < C_{VN}$ |
| F | Unit Cost of Reused Code | $C_{VR}$ | $0 < C_{VR}$ |
| G | Amount of Reuse Library Associated with the ith Application System | $ST_i$ | $0 \leq ST_i \leq SS$ |
| H | Size of Reuse Library | ST | $ST = \sum_{i=1}^{N} ST_i \leq SS$ |
| I | Average Size of Application System | SS | $0 \leq SS$ |
| J | Relative Library Capacity | K | $K = ST/SS$ |

Table 4-6, continued

| Worksheet Column Label | Worksheet Column Name | Variable Name* | Constraints |
|---|---|---|---|
| K | *Unit Cost of ith Application System* | $C_{USi}$ | $C_{US_i} = C_{DE} * \sum_{m=1}^{i}(ST_m/(N-(m-1))) + C_{VN} * SS - (C_{VN} - C_{VR}) * \sum_{m=1}^{i} ST_m$ |
| L | *Application Engineering Cost Per System* | $C_{Ai}$ | $C_{A_i} = C_{VN} * SS - (C_{VN} - C_{VR}) * \sum_{m=1}^{i} ST_m$ |
| M | *Reuse Program Investment Cost Per System* | $C_{DEi}$ | $C_{DE_i} = C_{US_i} - C_{A_i}$ |
| N | Reuse Program Investment | $C_{DESTi}$ | $C_{DEST_i} = C_{DE} * ST_i$ |
| O | *Cost Per System with All New Code* | CT | $CT = C_{VN} * SS$ |
| P | Product Productivity | PU | $PU = 1000/C_{US_i}$ |
| Q | Relative Product Productivity | P | $P = C_{VN}/C_{US_i}$ |
| R | Relative Product Cost | C | $C = 1/P$ |
| S | Relative Reuse Cost | $C_{VRR}$ | $C_{VRR} = C_{VR}/C_{VN}$ |
| T | Breakeven Number of Systems | $N_0$ | $N_0 = (C_{DE}/(C_{VN} - C_{VR})) + ISP$ |
| U | Return on Investment | ROI | $ROI = ((N/N_0) - 1) * 100$ |
| V | Library Efficiency | E | $E = R/K$ |
| W | Incremental Spending Penalty | ISP | $ISP = \sum_{i=1}^{N}(i-1) * a_i$ |
| AC | Ai | $a_i$ | $a_i = ST_i/ST$ |

* Section 2 and (Cruickshank and Gaffney 1991) use subscripts on some of these variables such as $C_{DE}$ instead of CDE and $C_{US}$ instead of CUS.

### 4.4.1 Editing The Worksheet

The values for $ST_i$ may be modified by selecting the worksheet cell to be modified and keying in the new value followed by a carriage return. Modifications to the $ST_i$ values are constantly reflected in the value of ST in such a way as to maintain the constraint that ST is the sum of the $ST_i$ values.

### 4.4.2 The File Menu

The File menu provides the following options:

- ***Print Preview.*** To print the worksheet, select Print Preview from the File menu. The standard Microsoft Excel Print Preview window appears.

*NOTE*: Attempting to print when there is no printer connected may result in a macro error. Should this happen, click the mouse on the [Halt] button to return to normal operation.

- *Save.* To save changes made to the worksheet, select Save from the File menu. The tool saves the data and returns you to the Mode 2 window. Saving a worksheet overwrites the previous data with the current data. The tool maintains only one version of the worksheet and makes it accessible through the application. To retain old data indefinitely, you should make a copy of the file Mode2DB.xls under a new name. Do this outside of the Reuse Economics Spreadsheet Model tool. To restore old data, rename a saved file to Mode2DB.xls. You should be able to print a saved worksheet from Microsoft Excel. Saving old data under different file names is a way to preserve historical data associated with a particular graph or set of graphs.

- *Close.* To exit the Mode 2 window, select Close from the File menu. A dialog box appears warning you if you have any unsaved changes. Click the [Yes] or [No] button, as appropriate, to continue the Close process. When the Close process is completed, the Main window appears.

### 4.4.3 THE DATA MENU

The Data menu provides the following options:

- *Add.* To add data to the Mode2DB.xls worksheet, select Add from the Data menu. The Mode 2 Add Dialog Box appears, as shown in Figure 4-21. To add a group of rows representing a reuse scenario enter values in the fields provided and click the [OK] button. The new rows will be added to the end of the existing worksheet data. All of the rows will be identified by the same Case Number and the default value for $ST_i$ will be ST/N for each of the N rows in the scenario (where N is the Number of Application Systems). Clicking the [Cancel] button terminates the Add operation without adding any data and displays the Mode 2 window.

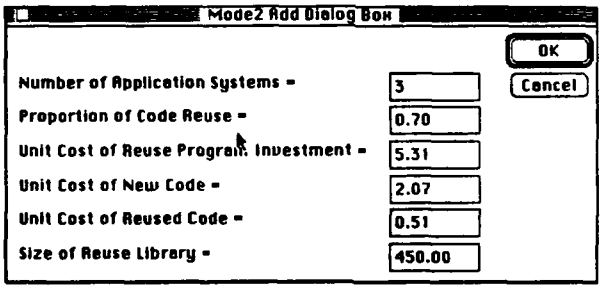


Figure 4-21. Mode 2 Data Add Dialog Box

- *Delete.* To delete data from the Mode2DB.xls worksheet, select Delete from the Data menu. The Mode 2 Delete Dialog Box appears, as shown in Figure 4-22. To delete a group of rows representing a reuse scenario select the corresponding Case Number by clicking the mouse button to highlight the number. Then click the [OK] button. The selected rows are deleted and the remaining worksheet data is renumbered to reflect the different scenarios represented in the worksheet. Clicking the [Cancel] button terminates the Delete operation without deleting any data and displays the Mode 2 window.

  *NOTE*: A carriage return is the same as clicking the [OK] button.

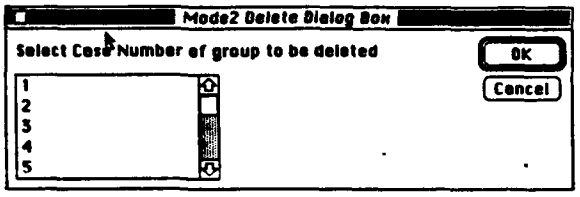


Figure 4-22. Mode 2 Data Delete Dialog Box

### 4.4.4 The Graphs Menu

The Graphs menu generates the built-in graph for mode 2 calculations. A dialog box appears when you select a graph from the Graphs menu. The input dialog box allows you to specify the reuse scenario case number to be used in the graph.

### 4.4.5 The Window Menu

The Window menu provides the Arrange All option which allows you to simultaneously display all open windows. This is useful for viewing multiple graphs at the same time.

### 4.4.6 Graphs

To produce a graph from the worksheet data, select the desired graph from the Graphs menu. There is one built-in graph that you can produce in mode 2: Labor Months Versus Number of Application Systems.

#### 4.4.6.1 Labor Months Versus Number of Application Systems Graph

The Labor Months Versus Number of Application Systems graph provides a bar chart measuring Reuse Program Investment, Cost Per System with All New Code, Application Engineering Cost Per System, and Reuse Program Investment Cost Per System for each of the N applications in the selected reuse scenario.

The Graph1 Inputs Dialog Box (Figure 4-23) appears when you enter your data. It requests a value for the case number of the reuse scenario to plot.

- Select a value from the corresponding list box to specify a value for the case number.
- Click on the [OK] button to transmit the selected value to the application and continue building the graph. (*Note:* Pressing <RETURN> in response to a dialog box is the same as clicking on the [OK] button.)
- Click on the [Cancel] button to terminate the graph build operation and display the Mode 2 window.

Once you complete your entries, the graph window displays the resultant graph (see Figure 4-24).

*Warning:* If you attempt to save a graph, it must be saved in the current working directory.

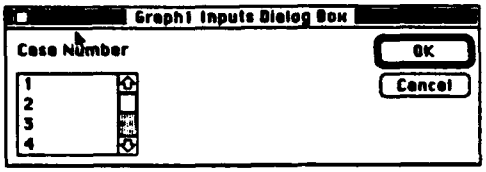


Figure 4-23. Mode 2 Graph1 Dialog Box

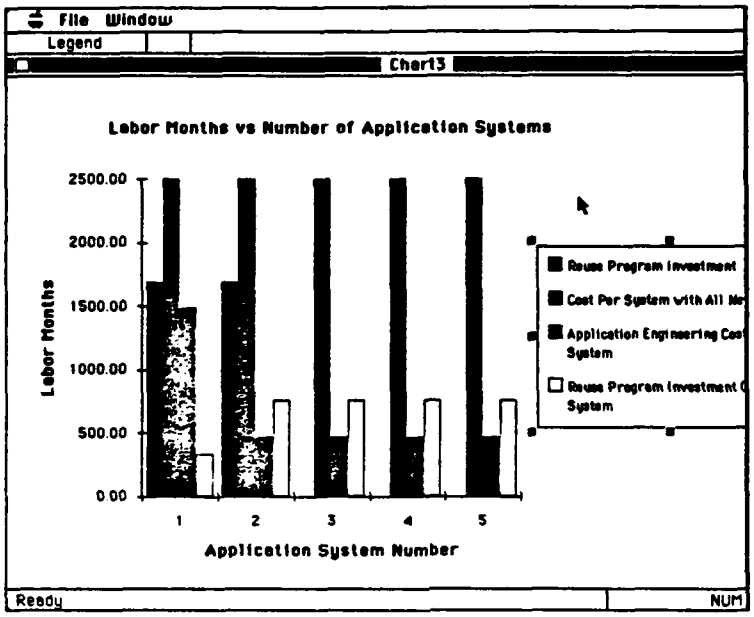


Figure 4-24. Labor Months Versus Number of Application Systems Graph Window

Table 4-7 shows the input data values that produced this graph.

Table 4-7. Input Data Values for Labor Months Versus Number of Application Systems Graph Window

| Application Number (i) | Number of Application Systems (N) | Proportion of Code Reuse (R) | Unit Cost of Reuse Program Investment ($C_{DE}$) | Unit Cost of New Code ($C_{VN}$) | Unit Cost of Reused Code ($C_{VR}$) | Size of Reuse Library (ST) | Amount of Reuse Library Associated with ith Application System ($ST_i$) |
|---|---|---|---|---|---|---|---|
| 1 | 5 | 0.9 | 7.5 | 5 | 0.5 | 450 | 450 |
| 2 | 5 | 0.9 | 7.5 | 5 | 0.5 | 450 | 0 |
| 3 | 5 | 0.9 | 7.5 | 5 | 0.5 | 450 | 0 |
| 4 | 5 | 0.9 | 7.5 | 5 | 0.5 | 450 | 0 |
| 5 | 5 | 0.9 | 7.5 | 5 | 0.5 | 450 | 0 |

## 4.5 THE GRAPH WINDOW

The window for mode 2 graphs appears when you select a graph from the Graphs menu. It provides access to all other system functions allowed for graphs.

The Graph window consists of a custom Microsoft Excel menu and an Microsoft Excel chart containing the specified graph (see Figure 4-25). The menu bar contains the File menu and the Window menu. The File menu allows you to print the chart, save the chart, and return to the window from which you invoked the Graph menu option. The Window menu allows you to arrange multiple windows so that all are displayed simultaneously. The chart plots the selected worksheet data in accordance with the parameters you specify in the Graph Input Dialog Boxes.

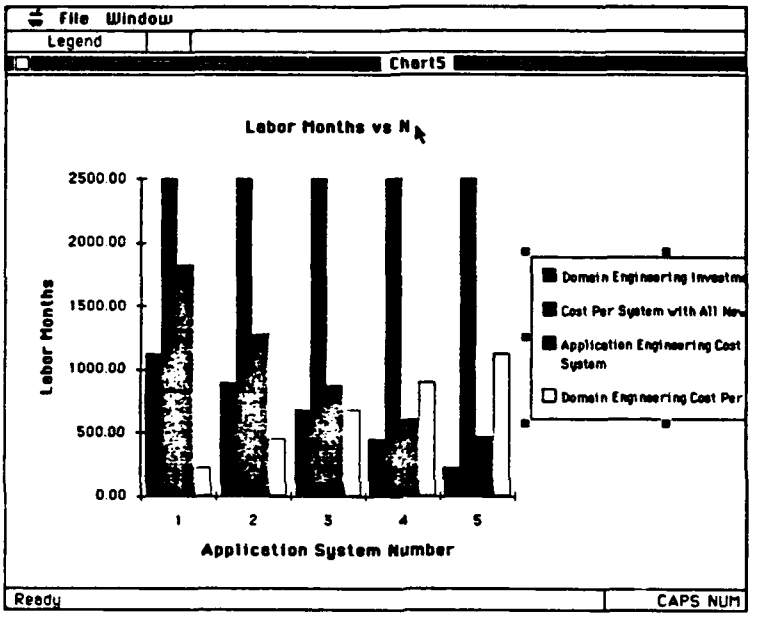


Figure 4-25. Sample Graph Window

The default naming convention followed for graphs is Chart? where the question mark is replaced by a digit (starting at 1) that is incremented for each graph created during a single session. Select the Save option from the File menu to bring up the Graph Save Dialog Box (see Figure 4-26). You may save graphs to the default file name or to a user specified name. You may also print a saved graph using the Print or Print Preview options of the standard Microsoft Excel File menu. When opening a saved graph under standard Excel, you are presented with a dialog box requesting whether to "update references to unopened documents." You must click the [No] button to display the graph as it was saved. *NOTE:* Do not click the [Yes] button to recompute the screen using default data that does not correspond to the saved graph. Rename saved graphs to avoid conflicts that occur when saving subsequent graphs. Should you encounter a naming conflict, a dialog box appears requesting confirmation to overwrite the existing graph. Click the [OK] button to overwrite the existing graph. Clicking the [Cancel] button causes a macro error dialog box to appear. To recover from this error, click the [Halt] button to restore normal operation.

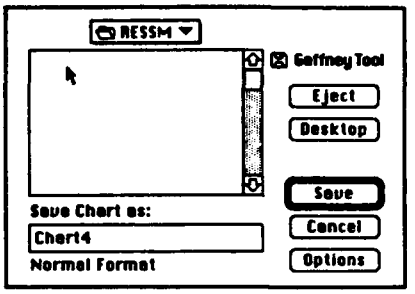


Figure 4-26. Graph Save Dialog Box

# APPENDIX. USING THE PC VERSION OF THE REUSE ECONOMICS SPREADSHEET MODEL TOOL

## A.1 RECOMMENDED CONFIGURATION

The recommended configuration for running the PC version of Reuse Economics Spreadsheet Model tool is:

- A 386 IBM compatible PC.
- 4 megabytes of RAM.
- A 20 megabyte hard disk.
- Microsoft Excel, version 3.0.
- Microsoft Windows, version 3.0 or greater.
- MS-DOS, version 3.3 or greater.

## A.2 INSTALLING THE SOFTWARE ON A HARD DISK

To install the software on a hard disk, perform the following steps:

- Create a subdirectory under the excel directory (i.e., C > mkdir \excel\ressm).
- Copy all files from the floppy disk to the directory you created above. (*NOTE:* You should not place the files in a separate subdirectory from the Microsoft Excel files.)
- Select the File and New options from the Program Manager Menu. A property sheet appears.
- Verify that you have selected the program item and then click on [OK]. The Program Item Properties dialog box appears.
- Type RESSM in the Description field, then press the <TAB> key or move the mouse to the command line field.
- Type C:\excel\ressm\ressmbgn.xlm in the Command line field, and press <RETURN> or click on [OK].

- If you want to replace the icon, select the [Change Icon] button before you click on [OK] or press <RETURN> and enter the full path name containing the icon file. If you do not want to change your icon and accept the default icon, click on [OK].

Installation of RESSM on your hard disk is now complete.

## A.3 RUNNING THE REUSE ECONOMICS SPREADSHEET MODEL TOOL

### A.3.1 Invoking the Reuse Economics Spreadsheet Model Tool From a Floppy Disk

To invoke the Reuse Economics Spreadsheet Model tool from a floppy disk, perform the following steps:

- Double-click on the Microsoft Excel icon to start Microsoft Excel.
- Select the File and Open options.
- Select the drive in the directories list box, where you have inserted the floppy, and click on [OK]. The files contained on the floppy now display in the files list box.
- Select RESSMBGN.XLM, and click on [OK]. The software loads and the opening screen displays with the File and Modes pull-down menus.

Operation of the tool is described in Section 4.

*Note*: If the diskette is write protected, data cannot be saved or modified.

### A.3.2 Invoking the Reuse Economics Spreadsheet Model Tool From a Hard Disk

To invoke the Reuse Economics Spreadsheet Model tool from a hard disk, double-click the RESSM icon. The software loads and the opening screen displays with the File and Modes pull-down menus.

Operation of the tool is described in Section 4.

# GLOSSARY

| | |
|---|---|
| Application Engineering Cost Per System | The unit cost of building the $i^{th}$ application system in a family of application systems which comprise a reuse scenario. This figure excludes the cost of reuse program investment. |
| Average Size of Application System | The size of the average application system in total lines of code. |
| Breakeven Number of Systems | The minimum number of application systems in a family of systems required for the return on reuse program investment to be positive. |
| Cost Per System with All New Code | The unit cost of building an application system in which there is no reuse. |
| Incremental Spending Penalty | The extra number of application systems required to break even because of incremental reuse program investment. |
| Library Efficiency | The ratio of the average amount of functionality reused in each application system of a family to the reusable functionality available in the library. |
| Percent Return on Investment | The return divided by the cost of reuse program investment times one hundred. |
| Product Productivity | The ratio of 1,000 to the unit cost of a product. |
| Proportion of Code Reuse | The ratio of the amount of reused code to the total amount of code in an application system. |
| Relative Library Capacity | The ratio of the size of the reuse library to the average size of an application system. |
| Relative Product Cost | The ratio of the unit cost of a product to the unit cost of its new code component. |
| Relative Product Productivity | The ratio of the unit cost of the new code component of a product to its overall unit cost. This is the inverse of Relative Product Cost. |

| | |
|---|---|
| Relative Reuse Cost | The ratio of the unit cost of reused code to the unit cost of new code. |
| Return | The difference in cost between producing N application systems with no reuse and producing N application systems with reuse, including the cost of reuse program investment. |
| Reuse Program Investment | The amount of capital investment in the reusable software associated with building a family of application software systems. |
| Reuse Program Investment Cost Per System | The pro rata portion of reuse program investment cost borne by a given application system. |
| Size of Reuse Library | The unduplicated code size of the library in total lines of code. |
| Unit Cost of Reuse Program Investment | The unit cost of the capital investment to create reusable software objects. |
| Unit Cost of ith Application System | The unit cost of building the ith application system of a family of application systems, taking into account the costs of new code and reusing code, and the pro rata cost of reuse program investment for the set of application systems in the family. |
| Unit Cost of New Code | The unit cost of new code developed for this application system. |
| Unit Cost of Reused Code | The unit cost of reusing code from the reuse library in this application system. |
| Unit Cost of Product | The unit cost of building an application system, taking into account the costs of reuse program investment and code reuse. |

# REFERENCES


Cruickshank, R.D., and J.E. Gaffney Jr. 1991 — *The Economics of Software Reuse*, REUSE_ECON_MODEL-91128-MC. Herndon, Virginia: Software Productivity Consortium.

Gaffney. J.E. Jr., and T.A. Durek 1991 — Chapter 14, Software Reuse-Key to Enhanced Productivity: Some Quantitative Models, in *The Economics of Information Systems and Software*, Richard Veryard, editor, Butterworth-Heineman Ltd.

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# INDEX


## B

Basic unit cost equation, 2-1, 2-2
Basic unit cost equation with incremental reuse program investment, 2-4
Break-even number of systems
  as computed in mode 1, 2-3
  as computed in mode 2, 2-5

## D

Data form, 4-7

## G

Graphs
  generating, 4-9, 4-23
  input dialog boxes, 4-9, 4-23
  inputs, 4-25
  types
    Labor Months Versus Number of Application Systems Graph, 4-23
    Product Productivity Versus Number of Application Systems, 4-15
    Relative Productivity Versus Number of Application Systems, 4-10
    Relative Productivity Versus Proportion of Code Reuse, 4-10, 4-23
    Relative Productivity Versus Relative Reuse Cost, 4-10
    Relative Productivity Versus Reuse Cost, 4-12
    Return on Investment Versus Number of Application Systems, 4-10, 4-17

## I

Installation
  on IBM-compatible PC, A-1
    from the diskette, 3-1
  on Macintosh, 3-2
    from the diskette, 3-1
Invoking the tool
  on IBM-compatible PC, 3-2
    from a floppy disk, A-2
    from a hard disk, A-2
  on Macintosh
    from a diskette, 3-1
    from the hard drive, 3-2

## M

Menu operations, selecting from menus, 4-1
Mode 1 worksheet, column
  Average Size of Application System, 4-5
  Breakeven Number of Systems, 4-6
  $K_{entered}$, 4-5
  Library Efficiency, 4-6
  Number of Application Systems, 4-5
  Product Productivity, 4-5
  Proportion of Code Reuse, 4-5
  Relative Library Capacity, 4-5
  Relative Product Cost, 4-6
  Relative Product Productivity, 4-5
  Relative Reuse Cost, 4-6
  Return on Investment, 4-6
  Size of Reuse Library, 4-5
  Unit Cost of New Code, 4-5
  Unit Cost of Product, 4-5
  Unit Cost of Reuse Code, 4-5
  Unit Cost of Reuse Program Investment, 4-5
Mode 2 worksheet, column
  Ai, 4-21
  Amount of Reuse Library Associated with the ith Application System, 4-20
  Application Engineering Cost Per System, 4-21
  Application Number, 4-20
  Average Size of Application System, 4-20
  Breakeven Number of Systems, 4-21
  Cost Per System with All New Code, 4-21
  Incremental Spending Penalty, 4-21
  Library Efficiency, 4-21

Number of Application Systems, 4-20
Product Productivity, 4-21
Proportion of Code Reuse, 4-20
Relative Library Capacity, 4-20
Relative Product Cost, 4-21
Relative Product Productivity, 4-21
Relative Reuse Cost, 4-21
Return on Investment, 4-21
Reuse Program Investment, 4-21
Reuse Program Investment Cost Per System, 4-21
Size of Reuse Library, 4-20
Unit Cost of ith Application System, 4-21
Unit Cost of New Code, 4-20
Unit Cost of Reuse Code, 4-20
Unit Cost of Reuse Program Investment, 4-20
Model parameters
$C_{DE}$, 2-2
$C_{US}$, 2-2
$C_{USi}$, 2-4
$C_{VN}$, 2-2
$C_{VR}$, 2-2
E, 2-2
K, 2-2
N, 2-2
$N_0$, 2-3
R, 2-2
ROI, 2-3
$S_S$, 2-1
$S_T$, 2-2
$S_{Ti}$, 2-4
Modes
choosing a mode, 4-3
mode 1, 4-3
mode 2, 4-3
mode 3, 4-3
mode 4, 4-3

## R

Reuse, 1-1
Reuse economics model, 2-1
Reuse investment, 1-1

## W

Window, graph window
File menu, 4-25
Window menu, 4-25
Window operations
activating a window, 4-1
closing the active window, 4-2
interaction between menu bars and active windows, 4-1
scrolling the active window, 4-2
selecting from menus, 4-1
sizing the active window, 4-2
Windows
graph window, 4-25
main window, 4-3
file menu, 4-3
modes menu, 4-3
Model window, 4-3
data menu, 4-7
edit menu, 4-6
file menu, 4-6
graphs menu, 4-9
window menu, 4-9
Mode2 window, 4-19
data menu, 4-22
file menu, 4-21
graphs menu, 4-23
window menu, 4-23
Worksheet, rows, 4-3, 4-20
Worksheet operations
editing a worksheet, 4-1
copy, 4-6
create, 4-8
cut, 4-6
delete, 4-7, 4-9
exit, 4-9
find, 4-8
insert paste, 4-7
modify, 4-8
mode 2, editing the worksheet, 4-21
selecting from a worksheet, 4-1

# REUSE ECONOMICS SPREADSHEET MODEL USAGE SURVEY

**After applying the Reuse Economics Spreadsheet Model, please tell us how well we did by completing this short survey form.**

**Rate the Reuse Economics Spreadsheet Model guidance for:**

| | Adequate | | | | Inadequate | | |
|---|---|---|---|---|---|---|---|
| | Totally | Very | Barely | Borderline | Somewhat | Mostly | Totally |
| Quantitative investigation of reuse economics involving code reuse with up-front reuse program investment | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Quantitative investigation of reuse economics involving code reuse with incremental reuse program investment | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Tool installation | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Tool usage | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**To what kind of project was the Reuse Economics Spreadsheet Model applied?**

| IR&D | Proposal | Contract | Adopted as division standard |
|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ |

**Estimated number of people who used the Reuse Economics Spreadsheet Model on this project:**

| 5 to 20 | 20 to 50 | 50 to 100 | 100 to 200 | More than 250 |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**System requirements include the following types (mark all that apply):**

- ☐ Concurrency
- ☐ Distribution across multiple nodes
- ☐ Above average memory space constraints
- ☐ Above average timing constraints

**What are, in your opinion, the two most important improvements we should make to the Reuse Economics Spreadsheet Model?**

_____

_____

**My primary responsibility on this project has been:**

- ☐ Project management
- ☐ Systems requirements analysis
- ☐ Systems design
- ☐ Software requirements analysis
- ☐ Software design
- ☐ Testing
- ☐ Other _____

SOFTWARE PRODUCTIVITY CONSORTIUM

version 01.00.00

# REUSE ECONOMICS SPREADSHEET MODEL SURVEY

NAME _____ PHONE _____

P.O. BOX _____ MAIL STOP _____

ADDRESS _____

CITY _____ STATE _____ ZIP CODE _____

*COMPANY _____

*ORGANIZATION _____

*Company and organization fields are optional for survey but must be completed to receive information on updates.

FOLD HERE

**GIVE US YOUR OPINION AFTER USING THE REUSE ECONOMICS SPREADSHEET MODEL.**

**ALSO, IF YOU ARE NOT REGISTERED TO RECEIVE UPDATE INFORMATION, PLEASE COMPLETE THE FORM ABOVE**

**FOLD, TAPE, AND MAIL.**

We are working continually to improve the Reuse Economics Spreadsheet Model. After you have actually begun using it on a project, give us your opinion by completing the short survey on the reverse side. It should only take a couple of minutes. We will send you the new Software Productivity Consortium poster in return.

Thank you,

THE REUSE ECONOMICS SPREADSHEET MODEL TEAM

FOLD HERE

TECHNOLOGY TRANSFER CLEARINGHOUSE
SOFTWARE PRODUCTIVITY CONSORTIUM, INC.
**SPC BUILDING**
**2214 ROCK HILL RD**
**HERNDON VA 22070-9858**