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Date August 11, 1987

A JUSTIFICATION METHODOLOGY FOR THE EVALUATION OF LOCAL AREA NETWORK ALTERNATIVES

A Thesis

Presented for the

Master of Science

Degree

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Hampton R. Liggett

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ABSTRACT

The subject of this thesis is the development of a methodology for the justification of communication networks, including local area networks (LANs), which are the backbone of the integrated factory of the future. Alternatives to be investigated include baseband and broadband proprietary networks, as well as non-proprietary broadband networks, which support the Manufacturing Automation Protocol (MAP). Such a methodology will assist with the evaluation of new technologies, a primary stumbling block to the implementation of automated manufacturing systems. Leading economists recognize the fact that traditional justification procedures alone are incapable of providing adequate measures of merit for high technology investments.

New justification models, such as the one presented in this thesis, must be developed to allow the implementation of new technology in American industries. These models should include an analysis of the easily quantifiable financial impact, as well as an analysis of the long-term non-monetary benefits of the projects under consideration. The methodologies should be based on proven, widely accepted procedures, and must be relatively easy to implement.

This thesis proposes the use of a widely accepted form of a multiple attribute decision analysis in conjunction with traditional economic justification techniques to develop a means of assessing the desirabilities of each of a set of mutually exclusive LAN alternatives. Specifically, an additive weighted ranking and rating model is implemented through a series of interconnected computer programs in a manner that allows traditional economic measures to be an integral part of the analysis of difficult-to-quantify strategic measures of the technologies long-term benefits.

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CHAPTER I

INTRODUCTION

1. OBJECTIVE

In today's world of rapidly improving technology, many American manufacturers are being faced with two alternatives--automation or extinction. The huge influx of high quality, low cost products from their foreign competitors has devastated corporations which were world leaders in their industries twenty years ago. The key to both the survival and the prosperity of American manufacturing is computer integrated manufacturing (CIM).

Dan Appleton defines CIM as "a new enterprise-wide management process for industrial automation. It appears as a special program under which industrial automation projects are planned, executed, and integrated." (2, p. 6) The level of integration necessary for a high degree of industrial automation requires that some sort of communication between devices (computers, robots, programmable controllers, etc.) throughout a manufacturing facility be established. This can only be accomplished through some method of interconnecting all of the equipment. A broadband local area network which supports the Manufacturing Automation Protocol (see Appendix I) provides an excellent means of linking heterogeneous devices together.

Before any large automation project can be undertaken, some type of economic assessment of the "value" of the project must be made. Traditional methods of economic justification, however, are the major barrier to the implementation of new manufacturing technologies in American industry (30, p. 46).

This thesis proposes a methodology which allows the inclusion of the many non-monetary benefits of automated manufacturing in the justification equation. The seven-step procedure developed in Chapter III can be applied to help overcome the barrier of economic justification.

2. PROBLEM DEFINITION

A protocol is a rule or regulation defining an acceptable means of behavior. To the plant engineer, a protocol is a rule by which information is exchanged between computer-driven plant systems and processes (46, p. 60). General Motors Corporation began the development of such a set of "rules" in the early 1980's. After finding itself spending 30 to 50% of its automation budget for building custom interfaces between individual pieces of equipment, GM began the development of the Manufacturing Automation Protocol (34, p. IM 30). Since its conception, MAP is quickly becoming a set of international standards for the networking of factory equipment. Seeing the potential for a significant cost reduction made possible through this standardization, other major users of automation equipment have joined with GM and the Society of Manufacturing Engineers to form the MAP Users Group. This group is working closely with both equipment vendors and standards organizations with a common goal of developing a non-proprietary set of standards to allow total integration of all manufacturing functions.

MAP-compatible equipment will soon be available to all manufacturers. The remaining obstacle to total integration will be the significant cost of installing and implementing such a system. This problem can only be overcome by a change in management attitudes and by revising the traditional justification equation. Those companies that wait for new technology to become proven

technology will lose a portion of their market share at best. Many will find themselves so far behind their more progressive competitors that survival becomes an uphill battle and regaining a favorable position in the market becomes an impossibility. According to Henry Ford, one of the most noted pioneers in the field of manufacturing, "If you need a new machine and don't buy it, you pay for it without getting it." (32, p.88).

MAP is recognized by many experts as the primary vehicle for achieving CIM. The broadband backbone of a MAP network can therefore be viewed as a utility by which information is transferred between devices. The total strategic value of such an asset will probably not be realized for many years, as new applications of the technology are discovered.

Without some type of networking, total automation cannot possibly be accomplished. One of the major advantages of MAP is that it provides a relatively inexpensive, much more flexible, alternative when compared to the cost and rigidity of custom-built interfaces (point to point connections). If MAP is to be the utility by which automation is achieved, then it becomes a component of the overall CIM effort. Benefits including reduced lead times, improved product quality, lower inventory levels, greater flexibility, and improved market position can therefore be indirectly attributed to MAP. Time may prove that these represent only a fraction of the value of a MAP-based network. If the network can be justified by the benefits of CIM alone, however, any downstream benefits from new applications are "icing on the cake."

To avoid the consequences of losing the technological battle, American manufacturers must begin to develop long-term objectives. Rather than investing in short-term projects with rapid paybacks and assuming that business as usual continues, managers must realize that the status quo will not remain

unchanged. The realistic alternative to investment in new technology must assume declining cash flows, market share, and profit margins (32, p. 88).

This paper is not intended to imply that traditional economic justification techniques be discarded. The corporation that blindly invests in new projects for strategic reasons alone may find itself in a worse position than the company that does not invest at all. Measures of economic feasibility, such as net present worth, must still be considered. However, it is becoming increasingly apparent that traditional measures of project worth will have to be supplemented by new measures which allow the consideration of the many non-monetary benefits available to those who invest in new technology.

3. CONSIDERATIONS FOR THE JUSTIFICATION OF MAP

For corporations producing programmable controllers, robots, computers, etc., the effort required to make their products MAP-compatible does not involve a complicated justification question. The market for automation equipment is expected to soon reach forty billion dollars per year. Vendors are already seeing that their ability to compete in this market may very well depend on their products' compliance with MAP standards (13, p. 23).

Users of MAP, however, must face the issue of justification. Any company that wishes to remain in business must look carefully at the economic side of implementing new technology. Investments in unproven technology always involve higher risks, but the potential rewards are much more substantial than those to be gained from "low-risk" investments. The complexity of the justification question for "high risk" investments requires consideration of much more than discounted cash flows (32, p. 87). Managers must realize that choosing not to invest may be a much greater risk than the investment. The company that

does not choose to take advantage of new manufacturing technology will most likely discover that some of its competitors have accepted the risk. Deferred investment often leads to reduced profitability, thereby further reducing the incentive to invest. The loss in profits may prove to be irreversible (28, p. 71).

The correct justification model for the implementation of MAP should include a realistic cost of capital, a properly defined reference (i.e. baseline) alternative, and some means of accounting for the many benefits which cannot be easily quantified. Most corporate executives would find it difficult to believe that their real cost of capital may be as low as 8% per year (32, p. 94). They insist on using double-digit hurdle rates which include expectations of current and future inflation. These high rates not only bias against long-term investment--they also often lead to grossly inaccurate analyses. While these rates have been increased to allow for inflation, they are often used to evaluate alternatives having profit levels which are assumed to be constant. (see Appendix II). Managers must also consider decreased profitability for the reference (do nothing) alternative. They should assume that competitors who successfully implement improved technologies will be capable of producing lower cost, higher quality merchandise. Finally, the many non-monetary benefits of MAP must be considered. By non-monetary, it is meant that a market mechanism does not exist for establishing the value of an identifiable and measurable benefits or disbenefits which are incremental to the project being considered. Because these benefits may be difficult to accurately quantify, traditional economic analysis techniques simply omit them from the equation. According to Kaplan, "Conservative accountants who assign zero values to many intangible benefits prefer being precisely wrong to being vaguely right." (32, p. 92).

The primary benefit that can be directly attributed to MAP is that it will provide a relatively low-cost alternative for tying together all of the functions of a manufacturing plant, when compared to the cost of developing custom interfaces for dissimilar devices. In order to achieve total automation, however, some type of networking system must be installed. For this reason, all of the many benefits of CIM (See Figure 1) can be indirectly attributed to MAP, and MAP becomes a part of the overall CIM effort. Estimates from the automobile industry indicate that automation efforts, enhanced considerably by MAP, could lead to savings of up to two thousand dollars per car, while reducing the lead time for introduction of new models by as much as two years (13, P. 22). If these estimates prove to be accurate, an investment in MAP that leads to only a fraction of these savings would be enormously profitable!

4. ASSUMPTIONS

The model developed in this thesis relies on a few assumptions which warrant some discussion. These assumptions can be divided into two distinct categories --1) Those which dictate who should be interested in the methodology, and 2) those on which the procedures contained within the model are based. The two major assumptions comprising the first category will be addressed below. The second category of assumptions can be better dealt with as they arise in the development of the methodology.

The first assumption deals with the type of manufacturing a given corporation is involved in. While LAN technology may be desirable in many different types of industries, it may not be justifiable in all cases. Firms producing very large quantities of only a few different parts have little need for

1. INCREASED MACHINE UTILIZATION: Conventional equipment generally operates at somewhat less than 50% utilization, while a Flexible Manufacturing System may have a utilization in excess of 80%.

2. REDUCED DIRECT AND INDIRECT LABOR REQUIREMENTS: The cost of both direct and indirect labor per unit of production is significantly less for Computer Integrated Manufacturing systems than for conventional methods.

3. REDUCED DESIGN AND MANUFACTURING LEAD TIMES: Computer Aided Design and Analysis reduces design time, and improved flexibility and machine utilization reduce manufacturing lead time.

4. LOWER INVENTORY LEVELS AND FLOOR SPACE REQUIREMENTS: Improved product flow, process flexibility, and better scheduling reduce both work-in-process and finished goods inventories. The ability of fewer computer controlled machines to do the job of a larger number of conventional machines reduces the amount of floor space required in the plant.

5. HIGHER QUALITY: Automated process equipment leads to more uniform production, fewer defects, and reductions in scrap, waste, and rework. With the use of automatic gauging, virtually all manual inspection can be eliminated.

6. IMPROVED FLEXIBILITY: A higher variety of products can be economically produced in smaller lot sizes. Setup times can be reduced or eliminated so that orders can be launched with little or no downtime.

7. IMPROVED MARKET POSITION: Flexibility and shorter lead times allow a much faster response for the introduction of new product lines. Improved quality leads to greater customer satisfaction and increased sales volume.

8. INCREASED LEARNING: Experience with new process technology allows managers to test the market for new products and to keep updated on major advances in process technology.

9. COMMON DATA BASE: Total information integration, by means of some type of networking system such as MAP, allows all of the manufacturing functions to share a common data base. This greatly reduces clerical work but, more importantly, provides a means of expediting the transfer of information between the various departments.

FIGURE 1. BENEFITS OF CIM
(32, pp. 89-92)
(26, pp. 458, 459)

manufacturing flexibility, one of the chief benefits of computer integrated manufacturing. At the other end of the spectrum, manufacturers engaged in the production of many dissimilar one-of-a-kind items would have little interest in flexible manufacturing systems. Their work often involves the use of prototypes, and programmable devices are seldom used. The corporations that would have the most to gain from the implementation of LAN technology would fall somewhere in between the two previously mentioned extremes. Such firms would generally have a product mix consisting of groups of several highly similar items, each of which is produced in relatively small lot sizes.

The second assumption deals with the current level of automation within a corporation. Firms which utilize a relatively high level of automation (robots, numerical control machine tools, programmable conveyors, etc.) would be more capable of implementing an LAN than those relying primarily on human labor.

CHAPTER II

LITERATURE SURVEY

Much has been written regarding the problems associated with the application of traditional economic justification procedures to investments in state-of-the-art technology. Very few solutions to the justification issue, however, have been proposed in the literature (40). Prior to the development of the methodology described in this thesis, a search of the literature dealing with the justification of high tech investments was conducted. Some of the more interesting articles which were located during this survey are described below.

Robert Kaplan, an accounting professor at the Harvard Business School and a professor of industrial admnistration at Carnegie-Mellon University, discusses the short comings of the discounted cash flow method of economic evaluation in "Must CIM be Justified by Faith Alone?" (32, pp.87-95). Kaplan proposes the division of the benefits of CIM into tangible or quantifiable benefits (inventory savings, improved quality, etc.) and intangible or difficult to quantify benefits (greater flexibility, shorter lead times, etc.). He states that the correct justification equation should include a hurdle rate that reflects the actual cost of capital and some means of considering the intangibles.

Martin Buss, the director of planning for Philip Morris International, describes an eight-step procedure as an aid to prioritizing information processing investments in "How to Rank Computer Projects" (7, pp. 118-125). Buss discusses four factors affecting the assignment of priorities -- financial benefits, business objectives, intangible benefits, and technical importance. A procedure of ranking each of the four factors individually against financial cost and rating each of the projects under consideration against each of the factors is proposed. A

composite grid (or matrix) which considers all of the factors and all of the alternatives can then be constructed to assist with the prioritization of projects.

William G. Sullivan, an industrial engineering professor at the University of Tennessee, and Captain Steven R. LeClair, U.S.A.F., discuss the use of an expert system called XVENTURE in economic decision making in "Justification of Flexible Manufacturing Systems Using Expert Systems Technology (59). XVENTURE incorporates six categories (one of which is net present worth) of flexible manufacturing system justification issues into a pattern matching and heuristic search problem solving approach.

Stephen Evans and Peter J. Sacket, professors at the School of Engineering, University of Bath, propose a unified approach to economic justification, with finance and engineering departments working together, in "Financial Justification of State-of-the-Art Investment: A Case Study Using CAPP" (19, pp. 47-50). Their procedure utilizes a traditional economic justification along with the concept of advantage, wherein the advantages (or benefits) accrued by the introduction of new technology are listed and quantified in terms of mean, optimistic, and pessimistic values. These advantages can then assist with the visualization of both the primary and secondary effects of the implementation of new technology.

Mariann Jelinek, a professor of management policy at Case Western Reserve University, and Joel D. Goldhar, Dean of the Stewart School of Business at the Illinois Institute of Technology, discuss the advantages of economies of scope over economies of scale in the evaluation of CIM projects in "Economics in the Factory of the Future" (31, pp.21-28). The economies of scale logic emphasizes stability and standardization, while the economies of scope logic stresses flexibility and integration. The authors propose the use of strategic

evaluation methods which consider such attributes as cost to produce, turnaround time, and machine utilization, in place of traditional evaluation methods for the justfication of high tech investments.

In "Counting the Costs: New Measures of Manufacturing Performance", Chan S. Park, an industrial engineering professor at Auburn University, develops the integrated performance measure which is based on three factors: total productivity, total quality, and total flexibility (45, pp. 66-71). Total productivity consists of labor productivity, capital productivity, material productivity, and overhead productivity; process quality and product quality make up the total quality factor; and total flexibility is comprised of equipment flexibility, product flexibility, process flexibility, and demand flexibility. The integrated performance measure for each alternative can be used in conjunction with traditional economic evaluation measures to examine the tradeoffs between cost and manufacturing performance.

Israel Gitman and Howard Frark, both of Network Analysis Corporation, discuss the economics of integrated voice and data applications networks, the comparison of alternative switching technologies for such networks, and the cost-effectiveness of alternative rates and strategies for voice digitization in "Economic Analysis of Voice and Data Networks: A Case Study" (24). The authors develop a total network cost model which incorporates the transmission cost model, the switching cost model, and the cost of voice digitizing devices. Both the transmission and switching cost models utilize cost factors that are based on current procurement estimates. Comparisons of alternative switching technologies can be made on the basis of both cost and network performance.

Robert Rosenthal, editor of Computer Science and Technology, details the four step quantitative evaluation method in "The Selection of Local Area

Networks" (50, pp. 112-119). This procedure involves the specification of network requirements, the development of weighting factors for these requirements, the assignment of vendor qualification ratings corresponding to each requirement, and the development of a score for each proposal. The final selection of a bid should be made by evaluating the tradeoffs between the scores and costs of the alternatives.

A similar ranking and rating procedure for the evaluation of alternative outcomes is proposed by William T. Morris, an industrial engineering professor at Ohio State University, in Engineering Economic Analysis (44, pp. 174-175). According to Morris, the utilization of a ranking and rating procedure with an additive model is advantageous for the following reasons: it is relatively easy to use, it results in meaningful evaluations, it accomodates itself to the cognitive style of the human decision making, and it has been widely used and accepted in actual practice.

In a presentation to the MAP Users Group, David Scott of Deere and Company proposed two interesting approaches to the justification of MAP (54). The first approach is somewhat similar to that used for numerical control (NC) equipment. With this procedure, a broadband local area network covering a small area and only a few applications could be justified, purchased, and installed. The newly installed network would then be closely monitored for a period of time to determine whether or not the investment was worthwhile. If the installation proves to be cost effective, the backbone of the network can be extended to allow the connection of additional applications without a complicated justification.

A second approach suggested by Scott would charge a one-time installation cost against network equipment (cable, head end remodulator, test

equipment, etc.). The production equipment subsequently connected to the network would then incur a utility charge in the form of capital funds for the connection and pro-rated expense funds for network usage. The charge for network usage against a given device would be determined by measuring traffic to and from that device in much the same manner that consumption of electricity is measured with a meter.

Although a few interesting approaches to solving the justification problem have been documented, none detail a comprehensive approach to quantifying the intangible benefits of manufacturing automation and examining the tradeoffs between the financial (objective) measures and the intangibles (subjective measures). The seven-step economic analysis methodology proposed in this thesis consists of a multiple attribute decision analysis, similar to the quantitative evaluation method proposed by Rosenthal and the ranking and rating procedure suggested by Morris, along with a local area network cost estimation model, somewhat like the models developed by Gitman and Howard for the comparison of switching technologies. In addition, the procedure described in this document includes a clearly defined means of evaluating the tradeoffs between the subjective measures resulting from the multiple attribute decision analysis and the objective measures of purely economic desirability.

CHAPTER III

METHOD OF PROCEDURE

1. OVERVIEW OF METHODOLOGY

A seven-step methodology has been developed to assist with the justification of non-proprietary, broadband LAN technology. The model consists of several procedures, each of which will be discussed in detail in this chapter. A flowchart diagram of the methodology is shown in Figure 2.

2. PRELIMINARY TASKS

The decision analysis for an automation project, such as the implementation of a local area network, is likely to be a critical factor in the future success of a corporation. Because of the high initial cost and the strategic importance of such an endeavor, an evaluation team should be formed to conduct the analysis. The members of this committee should be from the upper levels of the corporation, and they should have some understanding of the fundamentals of industrial networks. Each of the evaluation team members should be given reference materials on baseband, proprietary broadband (Decnet, Ethernet, SNA, etc.), and non-proprietary broadband (MAP) networks, in addition to the set of LAN evaluation questions included in Appendix III, prior to the beginning of the justification procedure. The committee may also wish to hire an outside consultant with economic justification experience to serve as an unbiased chairman and moderator.

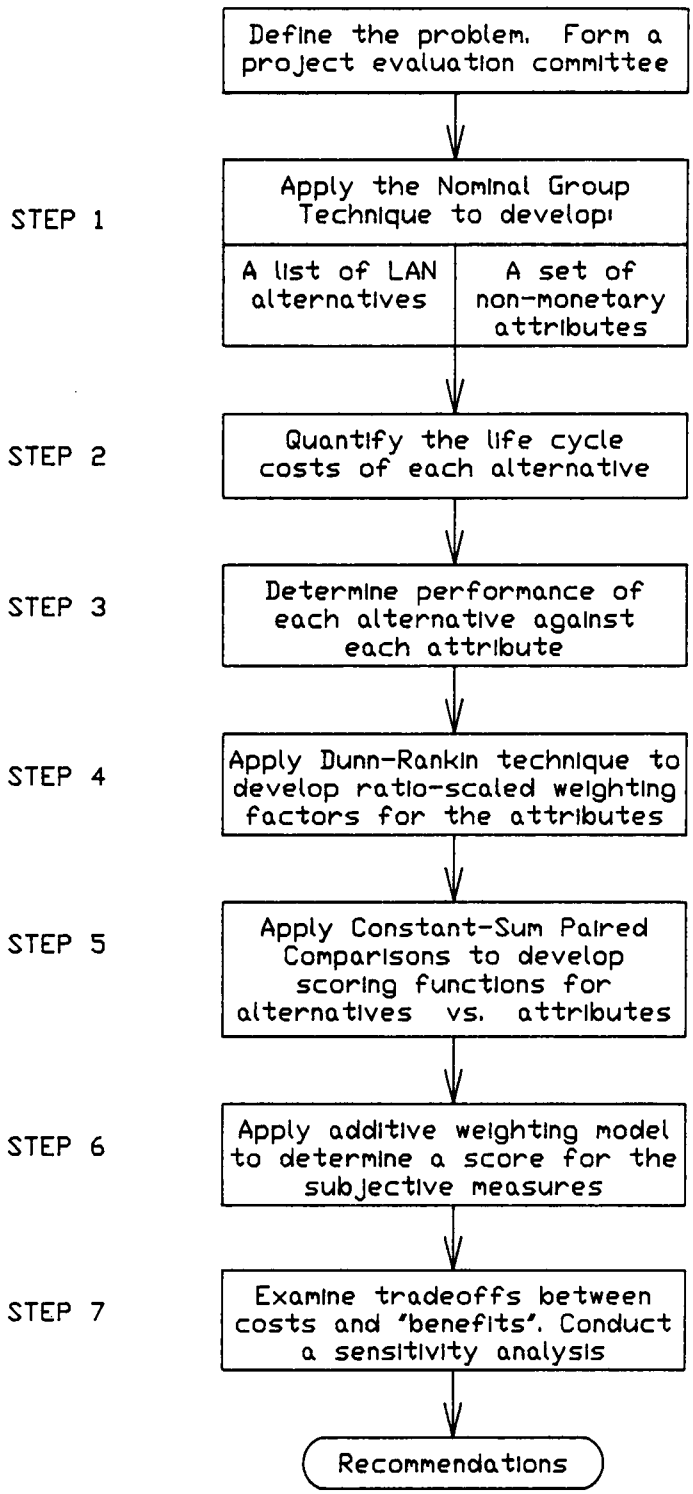

FIGURE 2. FLOWCHART OF SEVEN-STEP METHODOLOGY

3. THE NOMINAL GROUP TECHNIQUE

The Nominal Group Technique (56) is a group consensus forming procedure developed by Andre P. Delbecq and Andrew H. Van de Ven. The technique involves a structured group meeting designed to incorporate individual ideas and judgements into policy decisions. When properly applied, the procedure draws on the creativity of the individual participants, while helping to eliminate two undesirable effects of most group meetings: (1) The dominance of one or more participants, and (2) the suppression of conflicting ideas. The basic format of an NGT session is listed below.

1. Individual silent generation of ideas;
2. Individual round-robin feedback and recording of ideas;
3. Group clarification of each idea;
4. Individual voting and ranking to prioritize ideas; and
5. Discussion of group consensus results.

(56, p. 174)

The methodology developed in this thesis requires two separate NGT sessions. The purpose of the first session will be to generate a set of mutually exclusive network alternatives to be considered by the firm. The second session will develop a list of non-monetary factors to be used in a strategic analysis of the network alternatives. To avoid confusion during the subsequent steps of the methodology, each of the non-monetary factors must be clearly defined during the second session.

An NGT session begins with an explanation of the procedure and a statement of purpose by the moderator. The members of the evaluation committee are then instructed to individually list the factors which they consider

relevant to the purpose of the session, as stated by the moderator (the silent generation phase). After this has been completed, the chairman calls on each participant, in round- robin fashion, to present one factor from his list. Each factor is sequentially numbered and recorded on a flip chart, leaving plenty of space between factors for comments of clarification (see Figure 3). This process continues until all of the factors are presented and recorded.

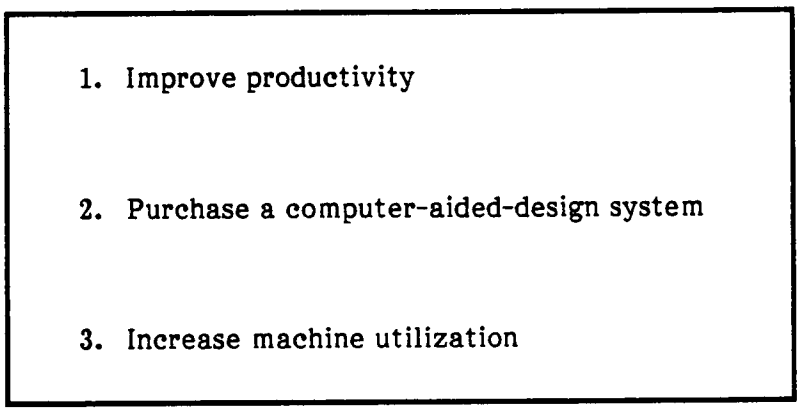

FIGURE 3. SAMPLE FLIP CHART PAGE

The next phase of an NGT session involves the clarification of the factors recorded during the round-robin feedback portion. The primary purpose of this phase is to develop a hierarchial consistency between overlapping factors that could be combined under one heading. In this manner, it is hoped that the desired level of specificity for each of the factors can be resolved prior to the voting and ranking phase. To avoid excessive discussion or debate during this portion of the NGT session, a time limit of thirty minutes can be set.

The next stage of the NGT session involves individual voting on the factors remaining after clarification. Each committee member should be given

approximately seven index cards to serve as "ballots" (see Figure 4). Each participant is instructed to select the seven most important factors and record each on a separate index card. Any perceived overlaps among the factors should be noted by recording the numbers of related factors on the back of each ballot. Each committee member is then asked to prioritize his chosen factors by assigning a rank of seven to the most important factor, one to the least important factor, etc., in an outside-in ranking process. When all of the participants have completed this phase, the facilitator collects the ballots for tabulation.

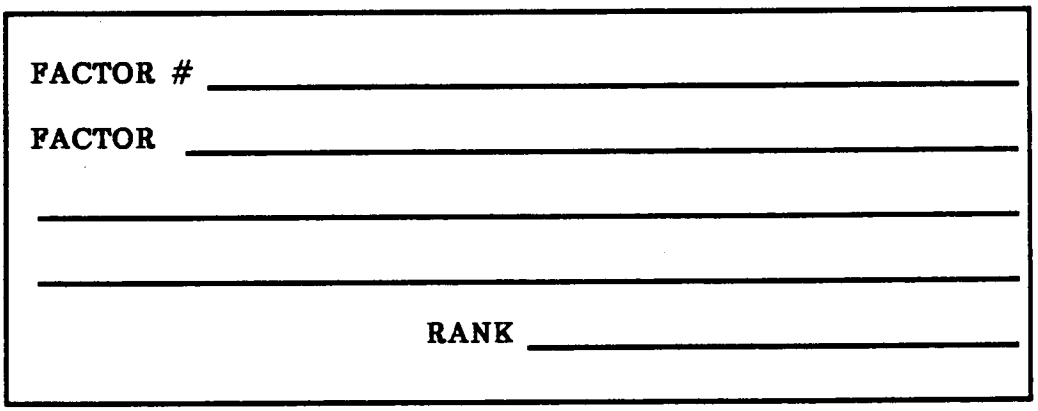

FIGURE 4. INDEX CARD FOR INDIVIDUAL VOTING PHASE (56 p.176)

After the facilitator collects the ballots, the committee members take a short break while the "votes" are tabulated. The results are recorded on the flip chart according to the number of participants selecting each factor (number of votes) and the total rank-score (summation of the rank assigned to a given factor by each participant). Any overlapping factors, as noted during the clarification phase or on the backs of the index cards, are also recorded on the flip chart. A sample of a flip chart page is shown in Figure 5.

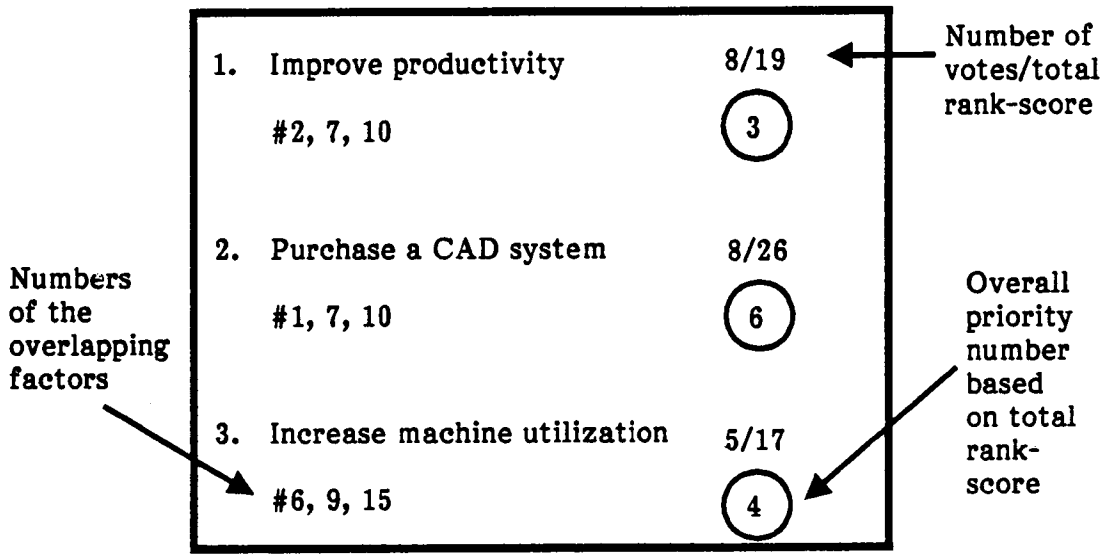

FIGURE 5. SAMPLE FLIP CHART PAGE FOLLOWING THE VOTING PHASE

The final phase of the NGT session is a group discussion of the results. This phase should result in a group consensus regarding the next logical step to follow up on the results of the NGT exercise.

The Nominal Group Technique was chosen as a component of the justification methodology in this thesis primarliy because of its ability to improve both the efficiency and the effectiveness of the group decision-making process. The procedure is easy to implement, satisfying to participants, and it inspires a commitment to act on the results (56, p. 174).

4. QUANTIFICATION OF THE LIFE CYCLE COSTS OF EACH ALTERNATIVE

The first step in the quantification of the life cycle costs of an LAN alternative is the determination of the initial cost to purchase and install the cable, splitters, network interface units (NIUs), etc. A cost estimation worksheet for broadband LANs (see Figure 6) will be used to develop these cost figures.

Several proprietary baseband configurations can also be purchased. To determine the cost of such a network, marketing personnel should be consulted. After the initial cost of an LAN alternative has been determined, a set of "rules of thumb" can be utilized to estimate the cash flows for the subsequent years. The initial software and telecommunication costs are approximately 150% of the hardware cost, and annual maintenance can be estimated at 10% of the initial hardware cost (41, p. 23). Some of the savings attributable to a CIM project can be quantified according to guidelines developed by the National Research Council (22). These estimates are based on a firm's direct labor costs, engineering costs, inventory carrying costs, etc.

Component	Cost Estimating Relationship (1986)			
1. Site Architectural Survey	$100-200 per work area drop	X ___	=	___
2. Interbuilding Connections	$100-150 per foot	X ___	=	___
3. Intrabuilding Connections	$20-50 per foot	X ___	=	___
4. Cable Installation	$20 per foot or $100 per drop (whichever is greater)	X ___	=	___
5. Equipment				
A. Broadband				
Taps	$17-20 each	X ___	=	___
Splitters	$5-15 each	X ___	=	___
NIUs: TIMS	$4000 each	X ___	=	___
RF Modems				
MAP (Head End)	$5,000	X ___	=	___
B. Carrierband				
MAP Card	$3000	X ___	=	___
No. of associations supported per interface		= ___		
C. Network Manager	$10,000-30,000			___
Network Analyzer	$30,000			___
		TOTAL		___

FIGURE 6. WORKSHEET FOR BROADBAND LAN COST ESTIMATION (58)

Following the estimation of the cash flows, a measure of financial merit can be calculated for each LAN alternative. This measure could be the net present worth, the annual worth, or the after-tax present worth of the project. Because income taxes may affect the financial desirabilities of the alternatives under consideration, an after-tax cash flow analysis to determine the present worth will be used. (16, 1984, pp. 342-384).

According to Kaplan, the present worth of the "do-nothing" or baseline alternative is usually assumed to be zero. In evaluating a CIM project, this is not a safe assumption. The correct baseline alternative should assume a loss in cash flows, market share, and profit margins (32, p. 88). For many American manufacturers, the magnitude of this decline can be seen as an historical trend. A relatively modest decline in proficts of four percent annually will be assumed in the case study in Chapter IV.

Finally, a realistic hurdle rate, or minimum attractive rate of return (MARR), will be used in the economic analyses. An after-tax rate of return of 15% will be assumed.

5. DETERMINATION OF THE PERFORMANCE OF EACH ALTERNATIVE AGAINST EACH ATTRIBUTE

The third step in the justification methodology is to determine the performance of each alternative against the criterion of each attribute. An integer rating scale ranging from +5 (best case) to -5 (worst case) will be used to rate the alternatives against the attributes. A definition of some of the performance levels is given on the following page. Other integers within this range (e.g. +4, +2, -2, -4) may also be used.

+5 = Extremely Beneficial to the Corporation

+3 = Beneficial to the Corporation

+1 = Slightly Beneficial to the Corporation

0 = Neither Beneficial nor Detrimental

-1 = Slightly Detrimental to the Corporation

-3 = Detrimental to the Corporation

-5 = Extremely Detrimental to the Corporation

The rating procedure requires that each committee member be given an m x k matrix (m being the number of attributes and k being the number of alternatives) with each alternative as a column heading and each attribute as a row heading (see Figure 7). They are instructed to enter an integer value from +5 to -5 in each cell of the matrix to indicate their perception of each alternative's ability to meet the requirements of each attribute.

Attribute	Alternative 1	Alternative 2	Alternative 3
A			
B			
C			
D			
E			

FIGURE 7. MATRIX FOR RATING ALTERNATIVES AGAINST ATTRIBUTES

After all of the committee members have completed their rating matricies, the chairman calculates an average score for each cell of the matrix. These average scores will serve as the levels of outcome for each alternative

against each attribute, and they will be used in conjunction with the constant sum paired comparisons procedure to determine ratio scale ratings.

6. DUNN-RANKIN TECHNIQUE

The Dunn-Rankin Technique provides a method of assigning ratio-scaled (see Appendix IV), weights to otherwise non-quantifiable attributes (18, pp. 315-329). This is accomplished through a series of paired comparisons to determine the relative importance of each attribute. Each of the members of the evaluation committee participate individually in this process. In order for the procedure to provide meaningful results, the participants must have an understanding of exactly what each attribute incorporates. For this reason, it is recommended that each committee member be provided with a precise definition of each of the attributes.

Each participant is given an m x m matrix (m being the number of attributes) with each of the attributes listed across the top and along the left-hand side of the matrix (see Figure 8). The participants are instructed to compare the attribute in each column with the attribute in each row and subjectively determine which is more critical in meeting the corporate objectives. If the column attribute is perceived as being the more important of the two, a one is entered in the appropriate cell. Otherwise, a zero is entered. Upon completion of this procedure, the matricies are returned to the committee chairman for compilation and calculation of the results.

After all members of the evaluation committee have completed their paired comparisons, the chairman tabulates the results by recording the total in each cell for all participants. A column total is then determined for each

Attribute	A	B	C	D	E
A	-				
B		-			
C			-		
D				-	
E					-

FIGURE 8. DUNN-RANKIN MATRIX FOR FIVE ALTERNATIVES

attribute by summing the cells in each column. An example of this with ten participants is shown in Figure 9.

The attributes are next arranged in ascending order along both the horizontal and the vertical axes of the matrix. The number of participants n, is added to each column total to produce a rank-sum (R_i) for each attribute (see Figure 10). The results of the procedure are shown in Figure 11. The following parameters must also be calculated:

$$R_{av} = \frac{n(m+1)}{2} = \frac{10(5+1)}{2} = 30 \qquad R_{min} = n = 10 \quad R_{max} = mn = 50$$

$$S = \left(\frac{mn(m+1)}{12}\right)^{\frac{1}{2}} = \left(\frac{5(10)(5+1)}{12}\right)^{\frac{1}{2}} = \left(25\right)^{\frac{1}{2}} = 5$$

$$Z_i = \text{normalized ratio for attribute i} = \frac{R_i - R_{av}}{S}$$

$$W_i = \text{weighting factor for attribute i} = \frac{\left(Z_i + |Z_{min}|\right)}{\left(Z_{max} + |Z_{min}|\right)}\left(100\right)$$

Attribute	A	B	C	D	E
A	-	6	4	10	9
B	4	-	3	10	8
C	6	7	-	10	10
D	0	0	0	-	4
E	1	2	0	6	-
Column Totals:	11	15	7	36	31

FIGURE 9. AGGREGATE MATRIX FOR TEN PARTICIPANTS

Attribute	C	A	B	E	D
C	-	6	7	10	10
A	4	-	6	9	10
B	3	4	-	8	10
E	0	1	2	-	6
D	0	0	0	4	-
Column Totals:	7	11	15	31	36
+n :	10	10	10	10	10
$=R_i$:	17	21	25	41	46

FIGURE 10. RANK-SUMS FOR EACH ATTRIBUTE

	min	C	A	B	E	D	max
R_i:	10	17	21	25	41	46	50
$R_i - R_{avg}$:	-20	013	-9	-5	11	16	20
Z_i:	-4.0	-2.6	-1.8	-1.0	2.2	3.2	4.0
$Z_i + \lvert Z_{min} \rvert$:	0.0	1.4	2.2	3.0	6.2	7.2	8.0
W_i:	0	17.5	27.5	37.5	77.5	90.0	100.0

FIGURE 11. RESULTS OF DUNN-RANKIN TECHNIQUE

Care should be taken to guard against inconsistencies by individual participants during the paired comparisons. An example of a logical inconsistency would be:

"A" is more important than "B"

"B" is more important than "C"

"C" is more important than "A"

A simple check for a logical error of this nature can be carried out by the committee chairman as each participant returns his individual matrix (10). The chairman calculates the column totals for each committee member's matrix, and any tie between these column totals indicates an inconsistency (see Figures 12 and 13). Any matricies containing such errors should be returned to the committee members for correction.

Attribute	A	B	C	D	E
A	-	0	1	1	1
B	1	-	0	1	1
C	0	1	-	1	1
D	0	0	0	-	1
E	0	0	0	0	-
Column Totals:	1	1	1	3	4

FIGURE 12. MATRIX FOR ONE PARTICIPANT SHOWING A LOGICAL INCONSISTENCY

The Dunn-Rankin Technique was chosen as a component of the justification methodolgoy in this thesis primarily because of its ability to linearly

Attribute	A	B	C	D	E
A	-	0	0	1	1
B	1	-	0	1	1
C	1	1	-	1	1
D	0	0	0	-	1
E	0	0	0	0	-
Column Totals:	2	1	0	3	4

FIGURE 13. MATRIX FOR ONE PARTICIPANT SHOWING NO LOGICAL INCONSISTENCIES

transform the results of a set of paired comparisons from several participants into ratio-scaled weighting factors. The procedure is relatively easy to apply, and it provides a scale with meaningful end points (18, p. 327).

There is one assumption underlying this procedure which should not be violated. The technique assumes that all of the attributes are independent. To ensure the independence of the attributes, care should be taken to carefully define each of them during the NGT session.

7. CONSTANT-SUM PAIRED COMPARISONS

The Constant-Sum Paired Comparison (CSPC) technique (9,pp.317-325) is next applied to develop scoring functions for each of the non-monetary attributes. The purpose of this procedure is the establishment of a set of ratio-scaled values for each attribute (see Appendix III). By matching up the alternatives under consideration with the scoring functions, the committee is able to determine how well each alternative meets the requirements of each attribute.

The feasible range of outcomes for each attribute (criterion) is first established. The scoring function for each attribute will be constructed from five points which are defined as follows:

A = Excellent

B = Very Good

C = Average

D = Below Average

E = Unacceptable

Each member of the committee must determine a set of scores for each pair of outcomes in the feasible range, for each of the attributes. The scores are assigned by "splitting" 100 points between the two outcomes in each pair. To accomplish this, each committee member is given a worksheet for each attribute with a 5 x 5 matrix. Each of the outcomes in the feasible range is represented as a column heading and as a row heading, as shown in Figure 14. The average results for each of the attribute matricies are shown in Figure 15. The score in each cell represents the number of points assigned to the outcome column when compared with the corresponding row. For i = the column number, j = the row number, and c_{ij} = the cell score for column i row j, the following equations must hold true for each matrix in Figure 15:

$$c_{ij} + c_{ji} = 100, \qquad \text{for } i \neq j$$

$$c_{ij} = c_{ji} = 0, \qquad \text{for } i = j$$

$$AV_i = \sum_{j=1}^{n} \frac{c_{ij}}{n} \qquad n = \text{number of outcomes}$$

The AV_i values represent the average raw scores for the outcomes.

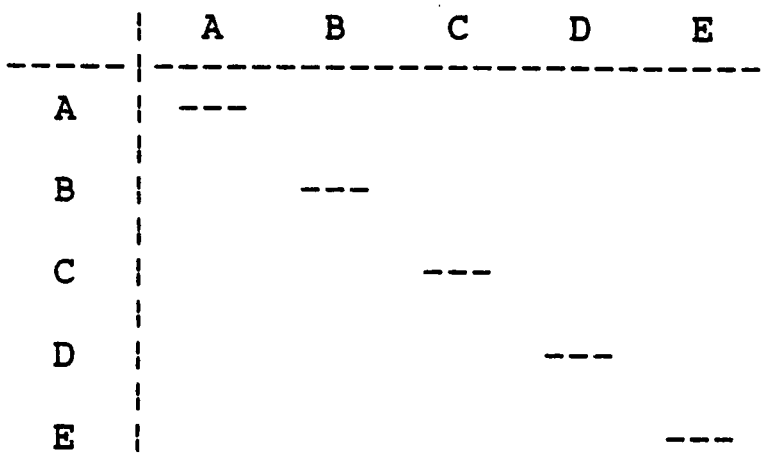

FIGURE 14. SAMPLE 5 X 5 MATRIX FOR CSPC

MACHINE UTILIZATION

	A	B	C	D	E
A	--	42	35	18	6
B	58	--	44	28	9
C	65	56	--	38	13
D	82	72	62	--	24
E	94	91	87	76	--
TOTALS:	299	261	228	160	52
AVERAGES:	59.8	52.2	45.6	32	10.4

LEAD TIME

	A	B	C	D	E
A	--	44	28	19	5
B	56	--	39	23	1
C	72	61	--	36	17
D	81	77	64	--	28
E	95	89	83	72	--
TOTALS:	304	271	214	150	61
AVERAGES:	60.8	54.2	42.8	30	12.2

QUALITY

	A	B	C	D	E
A	--	41	27	14	2
B	59	--	36	21	7
C	73	64	--	29	12
D	86	79	71	--	26
E	98	93	88	74	--
TOTALS:	316	277	222	138	47
AVERAGES:	63.2	55.4	44.4	27.6	9.4

MARKET POSITION

	A	B	C	D	E
A	--	42	29	11	1
B	58	--	34	17	6
C	71	66	--	22	13
D	89	83	78	--	23
E	99	94	87	77	--
TOTALS:	317	285	228	127	43
AVERAGES:	63.4	57	45.6	25.4	8.6

FLEXIBILITY

	A	B	C	D	E
A	--	48	33	21	7
B	52	--	39	24	11
C	67	61	--	32	17
D	79	76	68	--	32
E	93	89	83	68	--
TOTALS:	291	274	223	145	67
AVERAGES:	58.2	54.8	44.6	29	13.4

DATA BASE

	A	B	C	D	E
A	--	38	21	12	2
B	62	--	34	19	6
C	79	66	--	24	11
D	88	81	76	--	22
E	98	94	89	78	--
TOTALS:	327	279	220	133	41
AVERAGES:	65.4	55.8	44	26.6	8.2

FIGURE 15. AVERAGE RAW SCORES FROM CSPC

The second step in the CSPC procedure involves the calculation of the ratios of raw scores (R_{ij} values) for each pair of outcomes. For i = j, the R_{ij} value equals zero. If i is not equal to j, then $R_{ij} = c_{ij}/c_{ji}$. The results of this step are shown for each attribute in Figure 16.

The ratios of adjacent pairs are next developed for the purpose of supplying direct estimates of each of the outcomes. These ratios are computed by dividing each raw score ratio (R_{ij}) by the cell score immediately to its right. Thus, the adjacent pair ratio (AP_{ij}) is determined by the following equations:

$$\text{For } i = j, \qquad AP_{ij} = 0$$

$$\text{For } i = j-1, \qquad AP_{ij} = R_{ij}$$

$$\text{otherwise}, \qquad AP_{ij} = \frac{R_{ij}}{R_{(i+1)\,j}}$$

The indirect estimates of the ratios (DE_i) are then computed by summing the AP_{ij} values for each column and dividing by the number of outcomes, less one. This can be represented by the following equation:

$$DE_i = \sum_{j=1}^{n} \frac{AP_{ij}}{(n-1)}$$

The results of this procedure for each attribute are shown in Figure 17.

The next step in the process is the determination of ordinal-scaled scores for each of the outcomes. The outcome having the least desirability (E = Unacceptable) is assigned a value of one (1.0). The remaining ordinal-scaled scores (S_i) are computed according to the following formula:

MACHINE UTILIZATION

	A	B	C	D	E
A	--	0.724	0.538	0.220	0.064
B	1.381	--	0.786	0.389	0.099
C	1.857	1.273	--	0.613	0.149
D	4.556	2.571	1.632	--	0.316
E	15.667	10.111	6.692	3.167	--

LEAD TIME

	A	B	C	D	E
A	--	0.786	0.389	0.235	0.053
B	1.273	--	0.639	0.299	0.124
C	2.571	1.564	--	0.563	0.205
D	4.263	3.348	1.778	--	0.389
E	19.000	8.091	4.882	2.571	--

QUALITY

	A	B	C	D	E
A	--	0.695	0.370	0.163	0.020
B	1.439	--	0.563	0.266	0.075
C	2.704	1.778	--	0.408	0.136
D	6.143	3.762	2.448	--	0.351
E	49.000	13.286	7.333	2.846	--

MARKET POSITION

	A	B	C	D	E
A	--	0.724	0.408	0.124	0.010
B	1.381	--	0.515	0.205	0.064
C	2.448	1.941	--	0.282	0.149
D	8.091	4.882	3.545	--	0.299
E	99.000	15.667	6.692	3.348	--

FLEXIBILITY

	A	B	C	D	E
A	--	0.923	0.493	0.266	0.075
B	1.083	--	0.639	0.316	0.124
C	2.030	1.564	--	0.471	0.205
D	3.762	3.167	2.125	--	0.471
E	13.286	8.091	4.882	2.125	--

DATA BASE

	A	B	C	D	E
A	--	0.613	0.266	0.136	0.020
B	1.632	--	0.515	0.235	0.064
C	3.762	1.941	--	0.316	0.124
D	7.333	4.263	3.167	--	0.282
E	49.000	15.667	8.091	3.545	--

FIGURE 16. RATIOS OF RAW SCORES FROM CSPC

MACHINE UTILIZATION

	A/B	B/C	C/D	D/E
A	--	1.345	2.453	3.439
B	1.381	--	2.020	3.932
C	1.459	1.273	--	4.102
D	1.772	1.576	1.632	--
E	1.549	1.511	2.113	3.167
AVERAGES:	1.540	1.426	2.055	3.660

LEAD TIME

	A/B	B/C	C/D	D/E
A	--	2.020	1.658	4.457
B	1.273	--	2.140	2.417
C	1.644	1.564	--	2.746
D	1.273	1.883	1.778	--
E	2.348	1.657	1.899	2.571
AVERAGES:	1.635	1.781	1.869	3.048

QUALITY

	A/B	B/C	C/D	D/E
A	--	1.879	2.272	7.977
B	1.439	--	2.116	3.532
C	1.521	1.778	--	2.995
D	1.633	1.537	2.448	--
E	3.688	1.812	2.577	2.846
AVERAGES:	2.070	1.751	2.353	4.337

MARKET POSITION

	A/B	B/C	C/D	D/E
A	--	1.773	3.305	12.236
B	1.381	--	2.515	3.209
C	1.261	1.941	--	1.888
D	1.657	1.377	3.545	--
E	6.319	2.341	1.999	3.348
AVERAGES:	2.655	1.858	2.841	5.170

FLEXIBILITY

	A/B	B/C	C/D	D/E
A	--	1.874	1.853	3.532
B	1.083	--	2.025	2.555
C	1.298	1.564	--	2.298
D	1.188	1.490	2.125	--
E	1.642	1.657	2.298	2.125
AVERAGES:	1.303	1.646	2.075	2.627

DATA BASE

	A/B	B/C	C/D	D/E
A	--	2.306	1.949	6.682
B	1.632	--	2.196	3.675
C	1.938	1.941	--	2.555
D	1.720	1.346	3.167	--
E	3.128	1.936	2.282	3.545
AVERAGES:	2.104	1.882	2.399	4.114

FIGURE 17. DIRECT ESTIMATES OF RAW SCORES FOR ADJACENT PAIRS

$$S_i = \prod_{j=i}^{n-1} DE_j , \quad \text{for } i = 1 \text{ to } n-1$$

The calculated ordinal-scaled scores for each outcome, for each attribute, are shown in Figure 18.

The final step in the CSPC procedure is the calculation of ratio-scaled values for the outcomes. This can be accomplished or by either of two methods: graphically or by linear interpolation. To allow for ratio-scaling, the most desirable outcome (A = Excellent) is assigned a value of 1.00, and the least desirable outcome (E = Unacceptable) is assigned a value of 0.00. The ratio-scaled values of the intermediate outcomes can then be mathematically determined by linearly interpolating between the known values on the ordinal scale and the end points of the ratio scale. The results of this procedure are shown in Figure 19.

The Constant Sum Paired Comparison technique was selected as a component of the methodology in this thesis because of its ability to transform a series of subjective responses into ratio-scaled values. By splitting points between the various levels of outcome for each of the non-monetary attributes, the decision makers can develop such a scale for rating the performance of each alternative against the requirements of each attribute.

The reader should note that the labels used to identify the levels of outcome are to be treated as nominally scaled labels, regardless of their appearance. In the case study in Chapter IV, an integer scale of +5 to -5 will be used. If the integer labels are mistakenly assumed to have interval scale

MACHINE UTILIZATION	LEAD TIME	QUALITY
E = 1.000	E = 1.000	E = 1.000
D = 3.660	D = 3.048	D = 4.337
C = 7.520	C = 5.695	C = 10.207
B = 10.724	B = 10.145	B = 17.875
A = 16.518	A = 16.583	A = 37.005

MARKET POSITION	FLEXIBILITY	DATA BASE
E = 1.000	E = 1.000	E = 1.000
D = 5.170	D = 2.627	D = 4.114
C = 14.689	C = 5.452	C = 9.868
B = 27.292	B = 8.976	B = 18.576
A = 72.450	A = 11.694	A = 39.090

FIGURE 18. ORDINAL SCORES FOR THE RANGE OF OUTCOMES

	A	B	C	D	E
MACHINE UTILIZATION	1.0000	0.6266	0.4202	0.1714	0.0000
FLEXIBILITY	1.0000	0.7458	0.4163	0.1521	0.0000
QUALITY	1.0000	0.4687	0.2557	0.0927	0.0000
LEAD TIME	1.0000	0.5869	0.3013	0.1314	0.0000
DATA BASE	1.0000	0.4614	0.2328	0.0818	0.0000
MARKET POSITION	1.0000	0.3680	0.1916	0.0584	0.0000

FIGURE 19. RATIO SCORES FOR THE RANGE OF OUTCOMES

properties, the scoring functions will appear to be non-linear, thus seeming to invalidate the claimed scale properties.

When applying the CSPC technique in this model, the range of outcomes used to develop the scoring functions must be identical to the range of the scale used for rating the performance of each alternative against each attribute (see Chapter III, section 5). The ratio-scaled rating (or score) for each alternative against each attribute can then be determined by linearly interpolating between known adjacent values of the scoring functions derived by CSPC.

8. WEIGHTED EVALUATION

The next step in the justification model is an additive weighted evaluation (44, pp. 174-175). This procedure produces a ratio-sclaed score for each of the alternatives. The score for each alternative is determined by the following equation:

$$SCORE_i = \sum_{j=1}^{m} W_j O_{ij}$$

where

W_j = Ratio – scaled weight of attribute j, from the Dunn – Rankin procedure

O_{ij} = Ratio – scaled rating for alternative i against attribute j, from the CSPC technique

m = number of attributes

The score for each alternative is on a ratio scale because it consists of the summation of the product of two ratio-scaled variables. Because of this, the analysts can make the statement that one alternative is "better" than another by a known amount. For example. if the score for B is 200 and the score for C is 300, the analyst can say that Alternative C is 1.5 times as good as Alternative B.

The additive weighting model was selected as a component of the justification model in this thesis because it has been tested in actual practice, leading to excellent results (42, p. 174). One potential problem with this model, however, must be addressed. The additive weighting model, like the Dunn-Rankin Technique, assumes that no dependencies exist between the attributes. This can be assured if care is taken in defining the attributes during the NGT session.

9. TRADEOFFS BETWEEN BENEFITS AND COSTS

The final step in the justification methodology is an examination of the tradeoffs between the objective measures (after-tax present worth) and the subjective measures (non-monetary benefits resulting from the additive weighted model) for each alternative. The final recommendation of an alternative can be made on the basis of these tradeoffs.

Before attempting to evaluate the tradeoffs, the principle of dominance (16, pp. 261-262) should be applied to determine if one or more alternatives can be dropped from the analysis. This principle states that if any alternative surpasses another alternative in all of the areas considered in an evaluation, the lesser alternative can be eliminated. In a decision between mutually exclusive alternatives, dominance often simplifies the procedure by allowing the systematic elimination of one or more alternatives.

Any alternatives remaining after the principle of dominance is applied can be plotted as shown in Figure 20. In order to make a final recommendation, the relative importance of non-monetary benefits versus present worth must be established. Figure 20 indicates that the point of indifference (or equal desirability) for the two alternatives occurs where non-monetary benefits (subjective measures) are assigned a relative importance of 66% (in which case

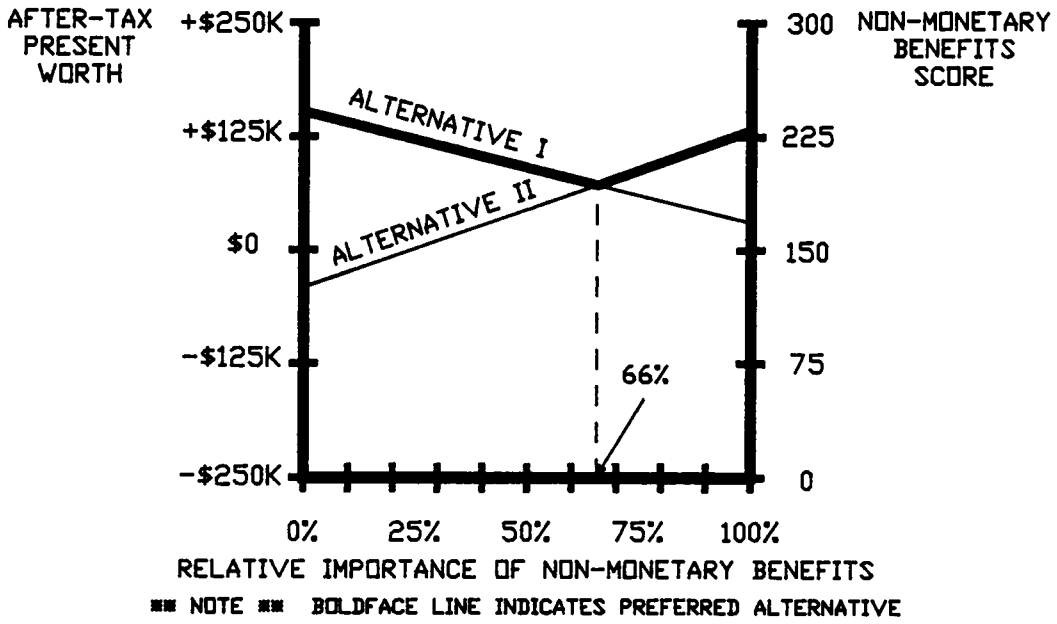

FIGURE 20. SAMPLE PLOT OF TRADEOFFS BETWEEN BENEFITS AND COSTS

present worth would have a relative importance of 34%). If the non-monetary benefits are assigned a weight of 80%, the recommendation would be Alternative II. On the other hand, if benefits are weighted at 30%, Alternative I should be recommended.

The user may wish to play "what if" with the plot of the tradeoffs by conducting a sensitivity analysis. This can easily be accomplished by altering one or more of the parameters and then redrawing the graph. In this manner, the magnitude of the change in a given parameter required to change the committee's recommendation can be determined. If the decision is highly sensitive to small changes, a further study should be undertaken before a final recommendation is made. On the other hand, if the decision is unaffected by large changes to the parameters, a strong endoresement of the preferred alternative can be made.

CHAPTER IV

CASE STUDY

1. BACKGROUND

A manufacturer of heavy equipment is investigating the possibility of automating one of their production facilities. Faced with the influx of low cost, high quality products from their foreign competition, the firm has seen a steady decline in both sales and profits throughout the past fifteen years. A CIM feasibility committee has been formed and charged with the task of determining whether or not a local area network should be implemented to provide a means of tranferring information throughout the facility.

The decisions and recommendations of the evaluation team will be a critical factor in the future success of the corporation. The committee has therefore decided to apply a seven-step justification methodology which evaluates tradeoffs between financial measures and non-monetary (strategic) benefits to assist with the decision making procedure. The committee's analysis and recommendations will be illustrated in the section which follows.

2. APPLICATION OF THE MODEL

Nominal Group Technique

The evaluation team participated in two separate NGT sessions, the first of which was intended to develop a mutually exclusive list of LAN alternatives. The list of alternatives reported during the round-robin feedback portion of the procedure is shown on the following page.

1. Broadband Proprietary
2. Point-to-Point Connections
3. Baseband Proprietary
4. Broadband Non-Proprietary (MAP)
5. Carrierband
6. Do Nothing (Baseline)

With the completion of the first NGT session, the evaluation committee had narrowed the list of LAN alternatives to three: proprietary baseband, non-proprietary broadband (MAP), and the baseline (do nothing) alternative.

For the second NGT session, the members of the evaluation committee were charged with the task of developing a set of factors critical to the success of an automation project. The results of the feedback following the silent generation phase are shown below.

1. Strategic Risk Level
2. Implementability
3. Security
4. Maintainability
5. Reliability
6. Functionality
7. Accessibility
8. IntegrityAsset Risk Level
9. Flexibility
10. Expandability
11. Manageability
12. Integrity
13. Operability
14. Connectivity
15. Stability
16. Adaptability

The final list of non-monetary attributes developed during the NGT session is listed below. The definitions for each of the attributes were developed during the discussion of results portion of the NGT session.

1. Risk Level: Minimization of the risk level to invested assets; should improve -- not worsen the corporation's competitive position.

2. Flexibility: Rapid response to the introduction of new product lines and/or design changes to existing products.
3. Security: Protection of the data base from unauthorized access and/or alteration by unqualified personnel.
4. Integration: Interconnection of all corporate functions into one common data base.
5. Expandability: Removal of existing network components and/or addition of new network components can be accomplished with minimal disruption to normal production operations.
6. Implementability: Feasible with respect to existing technology and accomplishable within a reasonable time frame.

Quantification of Life Cycle Costs for Each Alternative

The second step in the justification procedure was the deterimination of the after-tax present worth for each alternative. To determine the initial cost of the proprietary baseband alternative, a marketing representative from the vendor was contacted. The results of her configuration are shown in Figure 21. The initial cost of the non-proprietary broadband (MAP) alternative was estimated with the worksheet shown in Figure 22. The do nothing alternative would obviously incur no initial costs.

After the initial costs had been determined, the committee applied a "rule of thumb" which states that annual hardware maintenance charges for a computer network are approximately 10% of the initial costs (41, p. 23). Using this factor, the annual hardware maintenance costs were calculated to be $16,205 for the proprietary baseband option and $20,061 for the non-proprietary

Component	Cost Estimating Factors			
1. Site Architectural Survey	$150 per work area drop	X 9	=	1,350
2. Intrabuilding Connections	$35 per foot	X 1900	=	66,500
3. Cable Installation	$20 per foot	X 2075	=	41,500
4. Equipment				
Transceivers	$200 each	X 9	=	1,800
NIUs	$750 per port	X 9	=	6,750
RF Modem	$750		=	750
3COM Board & Software	$10,000		=	10,000
VAX Interface Board	$2700 each	X 2	=	5,400
VAX Interface Software	$10,000		=	10,000
Tektronix Emulation Pkg.	$250 per unit	x 2	=	500
5. Network Manager	$20,000		=	20,000
	TOTAL			$162,050

FIGURE 21. RESULTS OF PROPRIETARY BASEBAND LAN INITIAL COST ESTIMATION

Component	Cost Estimating Factors			
1. Site Architectural Survey	$150 per work area drop	X 9	=	1,350
2. Intrabuilding Connections	$35 per foot	X 1900	=	66,500
3. Cable Installation	$20 per foot	X 2075	=	41,500
4. Equipment				
Broadband				
Taps	$19 each	X 9	=	171
Splitters	$10 each	X 9	=	90
NIUs: TIMs	$4000 each	X 9	=	36,000
RF Modems				
MAP (Head End)	$5000 each		=	5,000
5. Network Manager	$20,000		=	20,000
6. Network Analyzer	$30,000		=	30,000
	TOTAL			$200,611

FIGURE 22. RESULTS OF NON-PROPRIETARY BROADBAND LAN INITIAL COST ESTIMATION

broadband alternative. A factor of 150% of initial hardware costs (41, p. 23) was applied to estimate the software and telecommunications cost, resulting in $243,075 for the proprietary baseband and $300,917 for the non-proprietary broadband LAN. Applying the same factor, annual software maintenance costs were estimated at $24,308 for the baseband and $30,092 for the broadband.

After the initial costs had been determined, the committee applied a "rule of thumb" which states that annual hardware maintenance charges for a computer network are approximately 10% of the initial costs (41, p. 23). Using this factor, the annual harware maintenance costs were calculated to be $16,205 for the proprietary baseband option and $20,061 for the non-proprietary broadband alternative. A factor of 150% of initial hardware costs (41, p. 23) was applied to estimate the software and telecommunications cost, resulting in $243,075 for the proprietary baseband and $300,917 for the non-proprietarybroadband LAN. Applying the same factor, annual software maintenance costs were estimated at $24,308 for the baseband and $30,092 for the broadband.

In order to determine the annual savings attributable to the automation proposal, as well as to estimate the costs associated with the do nothing (baseline) alternative, the committee examined the firm's financial records and market projections. The relevant information is listed below.

For the Fiscal Year 1986:

Total Sales:	$ 55,000,000
After-Tax Profit:	$ 3,500,000
Manufacturing Direct Labor:	$ 2,000,000
Manufacturing Engineering Cost:	$ 400,000
Inventory Carrying Cost:	$ 100,000

Market Projections:

The corporation's sales and after-tax profits have decreased by 25% during the last ten years. This decline is expected to continue at a rate of at least 4% per year over the next decade.

Projected Savings for Automation Proposal:

Annual savings attributable to the LAN proposal were estimated on the basis of a 1984 National Research Council report (22). The factors applied were slightly more conservative than those issued in the report. Savings of 5% in direct labor, 10% of engineering costs, and 20% of inventory carrying costs are anticipated if either of the two LAN projects is accepted. The total annual savings, based on these factors, are estimated to be $160,000.

An after-tax present worth analysis of the two LAN alternatives was conducted. An effective income tax rate of 40% (33% federal income tax rate, adjusted to include state income tax) was used in the analysis. The acclerated cost recovery system (ACRS) depreciation rates for a five year schedule as set by the Tax Reform Act of 1986 were applied, along with an after-tax miminum attractive rate of return (MARR) of 15 percent. The analyses of the proprietary baseband and non-proprietar broadband networks are shown in Figure 23 and Figure 24 respectively.

Because the after-tax profits of the firm were projected to decline throughout the next decade, the evaluation team decided to conduct an after-tax analysis of the cost of the do nothing (baseline) alternative. The 1986 after-tax profit, along with the 4% annual projected decrease, were used to determine the annual cash flows for the analysis. The loss in profits (or cost) for the first year was estimated at $140,000. The analysis is shown in Figure 25.

YR	BTCF	DEPR	TAXABLE INCOME	INCOME TAXES	ATCF	PRESENT VALUE
0	-405125.00	0.00	0.00	0.00	-405125.00	-405125.00
1	119487.00	-81025.00	38462.00	-15384.80	104102.20	90523.66
2	119487.00	-129640.00	-10153.00	4061.20	123548.20	93420.19
3	119487.00	-76973.75	42513.25	-17005.30	102481.70	67383.38
4	119487.00	-60768.75	58718.25	-23487.30	95999.71	54888.15
5	119487.00	-56717.50	62769.50	-25107.80	94379.21	46923.15
6	119487.00	0.00	119487.00	-47794.80	71692.21	30994.52
7	119487.00	0.00	119487.00	-47794.80	71692.21	26951.76
8	119487.00	0.00	119487.00	-47794.80	71692.21	23436.31
9	119487.00	0.00	119487.00	-47794.80	71692.21	20379.40
10	119487.00	0.00	119487.00	-47794.80	71692.21	17721.22
				NET PRESENT WORTH		67496.75

FIGURE 23. AFTER-TAX ANALYSIS OF PROPRIETARY BASEBAND ALTERNATIVE

YR	BTCF	DEPR	TAXABLE INCOME	INCOME TAXES	ATCF	PRESENT VALUE
0	-501528.00	0.00	0.00	0.00	-501528.00	-501528.00
1	109647.00	-100305.60	9341.40	-3736.56	105910.40	92096.03
2	109647.00	-160489.00	-50841.96	20336.78	129983.80	98286.41
3	109647.00	-95290.32	14356.68	-5742.67	103904.30	68318.78
4	109647.00	-75229.21	34417.80	-13767.12	95879.88	54819.64
5	109647.00	-70213.93	39433.08	-15773.23	93873.77	46671.86
6	109647.00	0.00	109647.00	-43858.80	65788.21	28442.06
7	109647.00	0.00	109647.00	-43858.80	65788.21	24732.22
8	109647.00	0.00	109647.00	-43858.80	65788.21	21506.28
9	109647.00	0.00	109647.00	-43858.80	65788.21	18701.11
10	109647.00	0.00	109647.00	-43858.80	65788.21	16261.84
				NET PRESENT WORTH		-31691.78

FIGURE 24. AFTER-TAX ANALYSIS OF NON-PROPRIETARY BROADBAND ALTERNATIVE

YR	BTCF	INCOME TAXES	ATCF	PRESENT VALUE
1	-14000.00	56000.00	-84000.00	-73043.48
2	-145600.00	58240.00	-87360.00	-66056.71
3	-151424.00	60569.60	-90854.40	-59738.24
4	-157480.90	62992.36	-94488.54	-54024.13
5	-163780.20	65512.08	-98269.12	-48856.62
6	-170331.40	68132.56	-102198.84	-44183.38
7	-177144.60	70857.84	-106286.76	-39957.13
8	-184230.40	73692.16	-110538.24	-36135.15
9	-191599.60	76639.84	-114959.76	-32678.74
10	-199263.60	79705.44	-119558.16	-29552.95
			NET PRESENT WORTH	-484226.53

FIGURE 25. AFTER-TAX ANALYSIS OF THE DO NOTHING (BASELINE) ALTERNATIVE

The results of the financial calculations carried out by the CIM feasibility committee are shown below.

Alternative	Present Worth
Proprietary Baseband	+$67,496.75
Non-Proprietary Broadband	-$31,691.78
Do Nothing (Baseline)	-$484,226.53

Determination of the Performance of Each Alternative Against Each Attribute

The third step in the justification model applied by the committee is a determination of how well each alternative meets the requirements of each

attribute. The rating scale shown below was applied as a means of measuring performance. The committee members were allowed to use any integer in the range +5 to -5.

+5 = Extremely Beneficial to the Corporation

+3 = Beneficial to the Corporation

+1 = Slightly Beneficial to the Corporation

0 = Neither Beneficial nor Detrimental

-1 = Slightly Detrimental to the Corporation

-3 = Detrimental to the Corporation

-5 = Extremely Detrimental to the Corporation

Each member of the evaluation committee was given a copy of the matrix shown in Figure 26 and instructed to enter a value in each cell of the matrix to indicate their perception of each alternatives performance against each attribute.

	DO NOTHING	PROPRIETARY BASEBAND	NON-PROPRIETARY BROADBAND
SECURITY			
INTEGRATION			
EXPANDABILITY			
IMPLEMENTABILITY			
FLEXIBILITY			
RISK LEVEL			

FIGURE 26. MATRIX FOR INDIVIDUAL RATING OF ALTERNATIVES AGAINST ATTRIBUTES

After all of the members of the evalution team had completed their rating forms, the chairman collected the matrices and computed an average score for each cell (see Figure 27). These outcomes would later be scaled on the ratio scale resulting from the Constant Sum Paired Comparisons procedure.

	DO NOTHING	PROPRIETARY LANS	NON-PROPRIETARY LANS
SECURITY	0.3	3.4	3.6
INTEGRATION	-5.0	2.3	4.6
EXPANDABILITY	-3.0	2.6	4.9
IMPLEMENTABILITY	0.0	4.0	2.8
FLEXIBILITY	-3.3	1.5	4.2
RISK LEVEL	-2.3	2.0	1.8

FIGURE 27. AVERAGE SCORE FOR EACH ALTERNATIVE AGAINST EACH ATTRIBUTE

Dunn-Ranking Technique

The next step in the justification model was the application of the Dunn-Rankin procedure. This technique was applied to determine a set of ratio-scaled weighting factors to be applied to the attributes. The matrix developed by the CIM feasibility committee is shown in Figure 28. The results of the procedure are shown in Figure 29.

ATTRIBUTE	SECURITY	FLEXIBILITY	EXPANDABILITY	INTEGRATION	RISK LEVEL	IMPLEMENTABILITY
SECURITY	---	6	6	7	7	8
FLEXIBILITY	4	---	5	6	7	7
EXPANDABILITY	4	5	---	6	7	6
INTEGRATION	3	4	4	---	6	6
RISK LEVEL	3	3	3	4	---	6
IMPLEMENTABILITY	2	3	4	4	4	---
COLUMN TOTALS: n: R_j:	16 10 26	21 10 31	22 10 32	27 10 37	31 10 41	33 10 43

FIGURE 28. DUNN-RANKIN MATRIX DEVELOPED BY THE CIM FEASIBILITY COMMITTEE

$$R_{avg} = \frac{10(6+1)}{2} = 35 \qquad R_{min} = 10 \qquad R_{max} = 6(10) = 60$$

$$S = \left(\frac{(6)(1)(7)}{12}\right)^{\frac{1}{2}} = 5.916$$

	MIN	SECURITY	FLEXIBILITY	EXPANDABILITY	INTEGRATION	RISK LEVEL	IMPLEMENTABILITY	MAX
R_i-R_{av}	-25	-9	-4	-3	Z	6	8	25
Z_i	-4.2	-1.52	-0.68	-0.51	0.34	1.01	1.35	4.23
Z_i+ $\lvert Z_{min}\rvert$	0	12.71	3.55	3.72	4.57	5.24	5.58	8.46
W_i*	0	32	42	4	54	62	66	100

*W_i = The ratio-scaled weighting factor for attribute i.

FIGURE 29. CALCULATIONS AND RESULTS OF THE DUNN-RANKIN TECHNIQUE

Constant Sum Paired Comparisons

The next step in the project evaluation methodology was the Constant Sum Paired Comparisons technique. This procedure was applied to develop a ratio scale for the levels of outcome which were used to rate the performance of each alternative against each attribute. The levels of outcome used to develop this scale are shown below.

+5 = Extremely Beneficial to the Corporation

+3 = Beneficial to the Corporation

+1 = Slightly Detrimental to the Corporation

0 = Neither Beneficial nor Detrimental

-1 = Slightly Detrimental to the Corporation

-3 = Detrimental to the Corporation

-5 = Extremely Detrimental to the Corporation

Each member of the evaluation committee was given six copies (one for each attribute) of the matrix shown in Figure 30 to serve as worksheets for the point-splitting portion of the procedure. The committee's results at the end of each stage of the procedure are shown in Figures 31 through 35.

After the levels of outcome for each attribute had been transformed to ratio scales, the performance ratings for each alternative against each attribute were transformed to fit the same scales. The results of this procedure are shown in Figure 36.

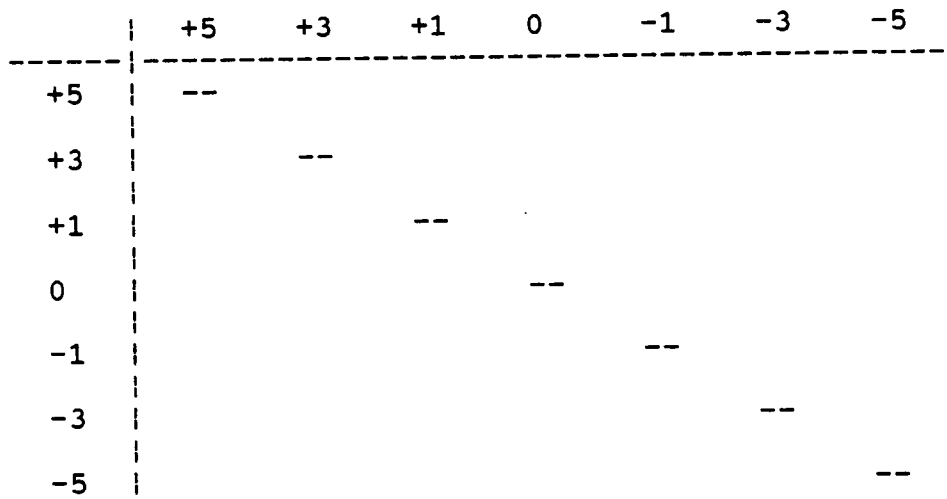

FIGURE 30. SAMPLE OF THE CSPC MATRIX USED BY THE EVALUATION COMMITTEE

SECURITY

	+5	+3	+1	0	-1	-3	-5
+5	--	42	35	30	12	8	6
+3	58	--	44	38	26	15	9
+1	65	56	--	49	33	26	13
0	70	62	51	--	46	31	16
-1	88	74	67	54	--	38	19
-3	92	85	74	69	62	--	24
-5	94	91	87	84	81	76	--
TOTALS:	467	410	358	324	260	194	87
AVERAGES:	66.71	58.57	51.14	46.28	37.14	27.71	12.42

INTEGRATION

	+5	+3	+1	0	-1	-3	-5
+5	--	44	28	20	12	5	2
+3	56	--	39	22	15	8	4
+1	72	61	--	32	25	19	10
0	80	78	68	--	31	24	14
-1	88	85	75	69	--	29	23
-3	95	92	81	76	71	--	38
-5	98	96	90	86	77	62	--
TOTALS:	489	456	381	305	231	147	91
AVERAGES:	69.85	65.14	54.42	43.57	33	21	13

EXPANDABILITY

	+5	+3	+1	0	-1	-3	-5
+5	--	38	23	18	10	6	3
+3	62	--	44	38	26	15	9
+1	77	56	--	49	39	26	13
0	82	62	51	--	46	31	16
-1	90	74	61	54	--	34	21
-3	94	85	74	69	66	--	38
-5	97	91	87	84	79	62	--
TOTALS:	502	406	340	312	266	174	100
AVERAGES:	71.71	58	48.57	44.57	38	24.85	14.28

IMPLEMENTABILITY

	+5	+3	+1	0	-1	-3	-5
+5	--	43	26	22	17	11	8
+3	57	--	39	22	15	8	11
+1	74	61	--	32	27	19	15
0	88	78	68	--	31	24	18
-1	83	85	73	69	--	29	21
-3	89	92	81	76	71	--	48
-5	92	89	85	82	79	52	--
TOTALS:	483	448	372	303	240	143	121
AVERAGES:	69	64	53.14	43.28	34.28	20.42	17.28

FIGURE 31. AVERAGE RAW SCORES DEVELOPED BY THE EVALUATION TEAM

FLEXIBILITY

	+5	+3	+1	0	-1	-3	-5
+5	--	32	28	11	6	4	1
+3	68	--	31	22	15	6	3
+1	72	69	--	28	19	11	7
0	89	78	72	--	23	17	11
-1	94	85	81	77	--	21	16
-3	96	94	89	83	79	--	24
-5	99	97	93	89	84	76	--
TOTALS:	518	455	394	310	226	135	62
AVERAGES:	74	65	56.28	44.28	32.28	19.28	8.857

RISK LEVEL

	+5	+3	+1	0	-1	-3	-5
+5	--	44	39	28	19	9	5
+3	56	--	42	36	24	17	9
+1	61	58	--	49	33	26	13
0	72	64	51	--	46	31	16
-1	81	76	67	54	--	39	19
-3	91	83	74	69	61	--	24
-5	95	91	87	84	81	76	--
TOTALS:	456	416	360	320	264	198	86
AVERAGES:	65.14	59.42	51.42	45.71	37.71	28.28	12.28

FIGURE 31. (Continued)

SECURITY

	+5	+3	+1	0	-1	-3	-5
+5	--	0.724	0.538	0.429	0.136	0.087	0.064
+3	1.381	--	0.786	0.613	0.351	0.176	0.099
+1	1.857	1.273	--	0.961	0.493	0.351	0.149
0	2.333	1.632	1.041	--	0.852	0.449	0.190
-1	7.333	2.846	2.030	1.174	--	0.613	0.235
-3	11.500	5.667	2.846	2.226	1.632	--	0.316
-5	15.667	10.111	6.692	5.250	4.263	3.167	--

INTEGRATION

	+5	+3	+1	0	-1	-3	-5
+5	--	0.786	0.389	0.250	0.136	0.053	0.020
+3	1.273	--	0.639	0.282	0.176	0.087	0.042
+1	2.571	1.564	--	0.471	0.333	0.235	0.111
0	4.000	3.545	2.125	--	0.449	0.316	0.163
-1	7.333	5.667	3.000	2.226	--	0.408	0.299
-3	19.000	11.500	4.263	3.167	2.448	--	0.613
-5	49.000	24.000	9.000	6.143	3.348	1.632	--

EXPANDABILITY

	+5	+3	+1	0	-1	-3	-5
+5	--	0.613	0.299	0.220	0.111	0.064	0.031
+3	1.632	--	0.786	0.613	0.351	0.176	0.099
+1	3.348	1.273	--	0.961	0.639	0.351	0.149
0	4.556	1.632	1.041	--	0.852	0.449	0.190
-1	9.000	2.846	1.564	1.174	--	0.515	0.266
-3	15.667	5.667	2.846	2.226	1.941	--	0.613
-5	32.333	10.111	6.692	5.250	3.762	1.632	--

IMPLEMENTABILITY

	+5	+3	+1	0	-1	-3	-5
+5	--	0.754	0.351	0.250	0.205	0.124	0.087
+3	1.326	--	0.639	0.282	0.176	0.087	0.124
+1	2.846	1.564	--	0.471	0.370	0.235	0.176
0	4.000	3.545	2.125	--	0.449	0.316	0.220
-1	4.882	5.667	2.704	2.226	--	0.408	0.266
-3	8.091	11.500	4.253	3.167	2.448	--	0.923
-5	11.500	8.091	5.667	4.556	3.762	1.083	--

FIGURE 32. RATIOS OF RAW SCORES DEVELOPED BY THE EVALUATION TEAM

	FLEXIBILITY						
	+5	+3	+1	0	-1	-3	-5
+5	--	0.471	0.389	0.124	0.064	0.042	0.010
+3	2.125	--	0.449	0.282	0.176	0.064	0.031
+1	2.571	2.226	--	0.389	0.235	0.124	0.075
0	8.091	3.545	2.571	--	0.299	0.205	0.124
-1	15.667	5.667	4.263	3.348	--	0.266	0.190
-3	24.000	15.667	8.091	4.882	3.762	--	0.316
-5	99.000	32.333	13.286	8.091	5.250	3.167	--

	RISK LEVEL						
	+5	+3	+1	0	-1	-3	-5
+5	--	0.786	0.639	0.389	0.235	0.099	0.053
+3	1.273	--	0.724	0.563	0.316	0.205	0.099
+1	1.564	1.381	--	0.961	0.493	0.351	0.149
0	2.571	1.778	1.041	--	0.852	0.449	0.190
-1	4.263	3.167	2.030	1.174	--	0.639	0.235
-3	10.111	4.882	2.846	2.226	1.564	--	0.316
-5	19.000	10.111	6.692	5.250	4.263	3.167	--

FIGURE 32. (Continued)

SECURITY

	+5/+3	+3/+1	+1/ 0	0/-1	-1/-3	-3/-5
+5	--	1.345	1.256	3.143	1.568	1.362
+3	1.381	--	1.282	1.744	1.991	1.784
+1	1.459	1.273	--	1.951	1.402	2.351
0	1.430	1.568	1.041	--	1.896	2.359
-1	2.577	1.402	1.730	1.174	--	2.613
-3	2.029	1.991	1.279	1.364	1.632	--
-5	1.549	1.511	1.275	1.231	1.346	3.167
AVERAGES:	1.738	1.515	1.310	1.768	1.639	2.273

INTEGRATION

	+5/+3	+3/+1	+1/ 0	0/-1	-1/-3	-3/-5
+5	--	2.020	1.556	1.833	2.591	2.579
+3	1.273	--	2.267	1.598	2.029	2.087
+1	1.644	1.564	--	1.412	1.421	2.111
0	1.128	1.668	2.125	--	1.423	1.940
-1	1.294	1.889	1.348	2.226	--	1.367
-3	1.652	2.698	1.346	1.293	2.448	--
-5	2.042	2.667	1.465	1.835	2.052	1.632
AVERAGES:	1.505	2.084	1.684	1.700	1.994	1.953

EXPANDABILITY

	+5/+3	+3/+1	+1/ 0	0/-1	-1/-3	-3/-5
+5	--	2.052	1.361	1.976	1.741	2.064
+3	1.632	--	1.282	1.744	1.991	1.784
+1	2.630	1.273	--	1.503	1.820	2.351
0	2.792	1.568	1.041	--	1.896	2.359
-1	3.162	1.820	1.332	1.174	--	1.938
-3	2.765	1.991	1.279	1.147	1.941	--
-5	3.198	1.511	1.275	1.396	2.306	1.632
AVERAGES:	2.696	1.702	1.262	1.490	1.949	2.021

IMPLEMENTABILITY

	+5/+3	+3/+1	+1/ 0	0/-1	-1/-3	-3/-5
+5	--	2.147	1.405	1.221	1.657	1.421
+3	1.326	--	2.267	1.598	2.029	0.704
+1	1.820	1.564	--	1.272	1.577	1.329
0	1.128	1.668	2.125	--	1.423	1.439
-1	0.862	2.096	1.215	2.226	--	1.537
-3	0.704	2.698	1.346	1.293	2.448	--
-5	1.421	1.428	1.244	1.211	3.473	1.083
AVERAGES:	1.210	1.933	1.600	1.470	2.101	1.252

FIGURE 33. DIRECT ESTIMATES OF RAW SCORES DEVELOPED BY THE EVALUATION TEAM

FLEXIBILITY

	+5/+3	+3/+1	+1/ 0	0/-1	-1/-3	-3/-5
+5	--	1.210	3.146	1.936	1.532	4.125
+3	2.125	--	1.593	1.598	2.765	2.064
+1	1.155	2.226	--	1.658	1.898	1.642
0	2.282	1.379	2.571	--	1.458	1.657
-1	2.765	1.329	1.273	3.348	--	1.396
-3	1.532	1.936	1.657	1.298	3.762	--
-5	3.062	2.434	1.642	1.541	1.658	3.167
AVERAGES:	2.153	1.752	1.981	1.897	2.179	2.342

RISK LEVEL

	+5/+3	+3/+1	+1/ 0	0/-1	-1/-3	-3/-5
+5	--	1.229	1.644	1.658	2.372	1.879
+3	1.273	--	1.287	1.781	1.542	2.071
+1	1.133	1.381	--	1.951	1.402	2.351
0	1.446	1.708	1.041	--	1.896	2.359
-1	1.346	1.560	1.730	1.174	--	2.726
-3	2.071	1.715	1.279	1.423	1.564	--
-5	1.879	1.511	1.275	1.231	1.346	3.167
AVERAGES:	1.525	1.517	1.376	1.536	1.687	2.425

FIGURE 33. (Continued)

SECURITY	INTEGRATION	EXPANDABILITY
-5 : 1.000	-5 : 1.000	-5 : 1.000
-3 : 2.273	-3 : 1.953	-3 : 2.021
-1 : 3.725	-1 : 3.894	-1 : 3.940
0 : 6.586	0 : 6.618	0 : 5.869
+1 : 8.630	+1 : 11.147	+1 : 7.404
+3 : 13.073	+3 : 23.234	+3 : 12.604
+5 : 22.716	+5 : 34.978	+5 : 33.988

IMPLEMENTABILITY	FLEXIBILITY	RISK LEVEL
-5 : 1.000	-5 : 1.000	-5 : 1.000
-3 : 1.252	-3 : 2.342	-3 : 2.425
-1 : 2.631	-1 : 5.102	-1 : 4.092
0 : 3.868	0 : 9.676	0 : 6.286
+1 : 6.190	+1 : 19.165	+1 : 8.649
+3 : 11.968	+3 : 33.583	+3 : 13.123
+5 : 14.482	+5 : 72.319	+5 : 20.009

FIGURE 34. ORDINAL SCORES DEVELOPED BY THE EVALUATION TEAM

	+5	+3	+1	0	-1	-3	-5
SECURITY	1.0000	0.5559	0.3514	0.2572	0.1255	0.0586	0.0000
FLEXIBILITY	1.0000	0.4569	0.2547	0.1217	0.0575	0.0188	0.0000
EXPANDABILITY	1.0000	0.3518	0.1941	0.1476	0.0891	0.0310	0.0000
INTEGRATION	1.0000	0.6544	0.2986	0.1653	0.0852	0.0280	0.0000
IMPLEMENTABILITY	1.0000	0.8135	0.3850	0.2127	0.1210	0.0187	0.0000
RISK LEVEL	1.0000	0.6378	0.4024	0.2781	0.1627	0.0750	0.0000

FIGURE 35. RATIO SCORES DEVELOPED BY THE EVALUATION TEAM

	DO NOTHING	PROPRIETARY BASEBAND	NON-PROPRIETARY BROADBAND
SECURITY	0.2855	0.6447	0.6891
INTEGRATION	0.0000	0.5299	0.9309
EXPANDABILITY	0.0319	0.3203	0.9676
IMPLEMENTABILITY	0.2127	0.9068	0.7707
FLEXIBILITY	0.0160	0.3052	0.7828
RISK LEVEL	0.1057	0.5201	0.4966

FIGURE 36. RATIO-SCALED SCORES FOR EACH ALTERNATIVE AGAINST EACH ATTRIBUTE

Additive Weighting Model

The sixth step in the justification methodology was the application of an additive weighting model. The input to this model consisted of the ratio-scaled weighting factors for the attributes (resulting from the Dunn-Rankin Technique) and the ratio-scaled ratings of the performance levels for each alternative against each attribute (resulting from the CSPC procedure). The ratio-scaled score for each alternative against all of the attributes was determined by the following equation:

$$\text{SCORE}_i = \sum_{j=1}^{m} W_j O_{ij}$$

where

W_j = Ratio-scaled weight of attribute j

O_{ij} = Ratio-scaled rating for alternative i against attribute j

m = the number of attributes

The ratio-scaled score for each alternative is shown in Figure 37.

ATTRIBUTE	WEIGHTING FACTOR	DO NOTHING		PROPRIETARY BASEBAND		NON-PROPRIETARY BROADBAND	
		RATIO SCORE	WEIGHTED RATING	RATIO SCORE	WEIGHTED RATING	RATIO SCORE	WEIGHTED RATING
SECURITY	32.0	0.2855	9.14	0.6447	20.63	0.6891	22.05
INTEGRATION	54.0	0.0000	0.00	0.5299	28.61	0.9309	50.27
EXPANDABILITY	44.0	0.0310	1.36	0.3203	14.09	0.9676	42.57
IMPLEMENTABILITY	66.0	0.2127	14.04	0.9068	59.85	0.7707	50.87
FLEXIBILITY	42.0	0.0160	0.67	0.3052	12.82	0.7828	32.88
RISK LEVEL	62.0	0.1057	6.55	0.5201	32.25	0.4966	30.79
WEIGHTED SCORES:			31.76		168.25		229.43

FIGURE 37. RESULTS OF ADDITIVE WEIGHTING MODEL.

Tradeoffs Between Non-Monetary Benefits and Present Worth

The final step of the justification model conducted by the evaluation team was the examination of the tradeoffs between the non-monetary (strategic) benefits scores and the after-tax present worths of each of the alternatives. A listing of each of these parameters is shown below.

	Non-Monetary Benefits	Present Worth
Proprietary Baseband	168.25	+$67,496.75
Non-Proprietary Broadband	229.43	-$31,691.78
Do Nothing	31.76	-$484,226.53

The committee first applied the principle of dominance. The do nothing (baseline) alternative was immediately eliminated from consideration because both of its parameters were dominated by the two LAN alternatives. To examine the tradeoffs between the remaining two alternatives more clearly, the committee plotted a graph of the non-monetary benefits versus present worth. This graph (see Figure 38) shows that the point of indifference (or equal desirability) for the two alterantives is at a 48% relative importance for non-monetary benefits. If the strategic benefits are weighted at greater than 48%, on a scale ranging from 0% to 100%, the non-proprietary broadband (MAP) LAN should be recommended.

Because the parameters used in this analysis were partially based on subjective measures, the committee conducted a sensitivity analysis to determine the responsiveness of the decision model to changes in the parameters. First, the benefits scores for both alternatives were decreased by 20%, and the present

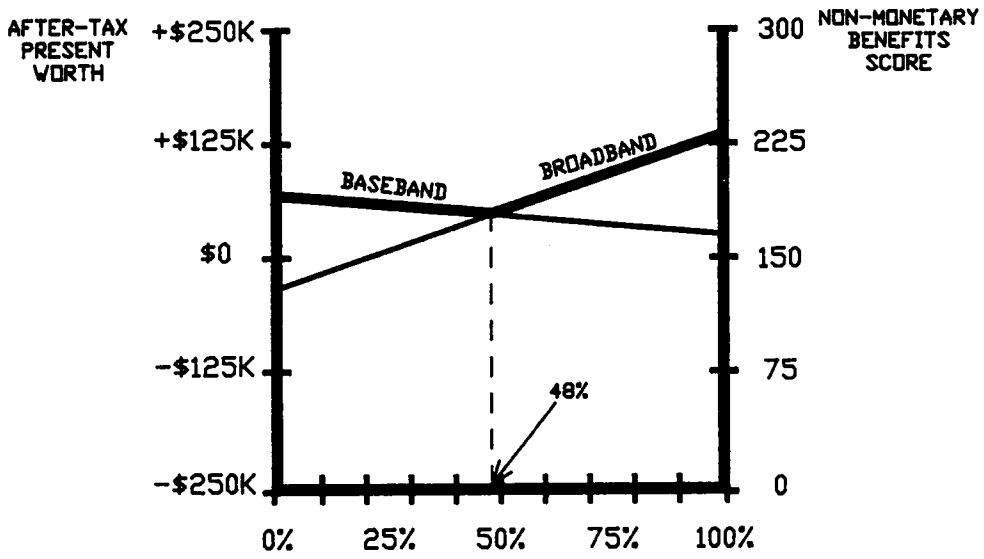

FIGURE 38. BENEFIT-COST TRADEOFF DIAGRAM

worth of each alternative was increased by 20%. This increased the point of equal desirability between the alternatives to a 57% weighting on benefits (See Figure 39). Next, present worth was decreased by 20% while the benefits score for each alternative was increased by 20%, resulting in a point of indifference of 44% weighting on benefits (see Figure 40). Thus, the sensitivity analysis resulted in a range of uncertainty from 44% to 57% relative importance on non-monetary benefits.

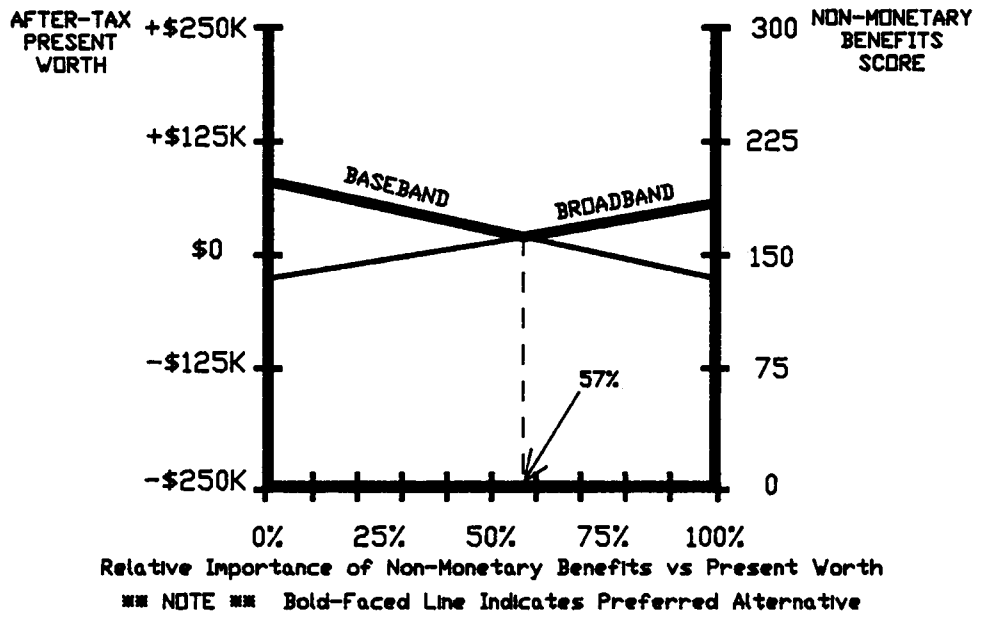

FIGURE 39. SENSITIVITY ANALYSIS: +20% COSTS AND -20% BENEFITS

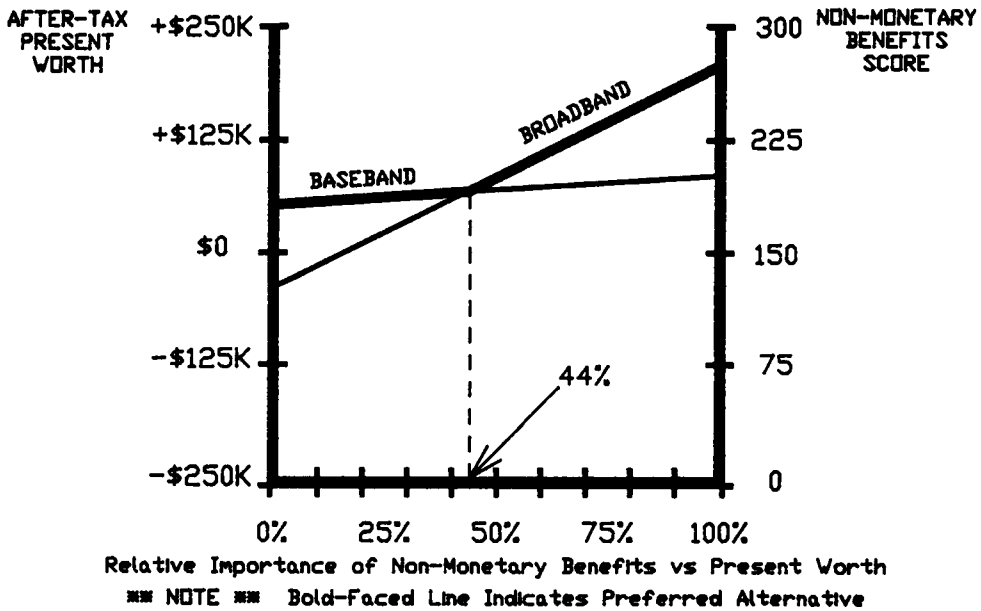

FIGURE 40. SENSITIVITY ANALYSIS: +20% BENEFITS AND -20% COSTS

3. RECOMMENDATIONS OF THE CIM FEASIBILITY COMMITTEE

Before the final results of the justification methodology were presented to the firm's chief executive officer (CEO), the committee requested a determination of the relative importance of the non-monetary attributes compared to the present worth of the automation proposal. The CEO's response was that the non-monetary benefits were at least twice as important as the direct financial impact, thus assigning a relative importance of 67% to the benefits. For both the initial diagram and the sensivitiy analysis graphs, the non-proprietary broadband alternative is the more desirable choice.

The CIM feasibility committee made a recommendation to the CEO that the corporation should implement a broadband local area network which could support the Manufacturing Protocol. A diagram of the recommended LAN is included as Figure 41.

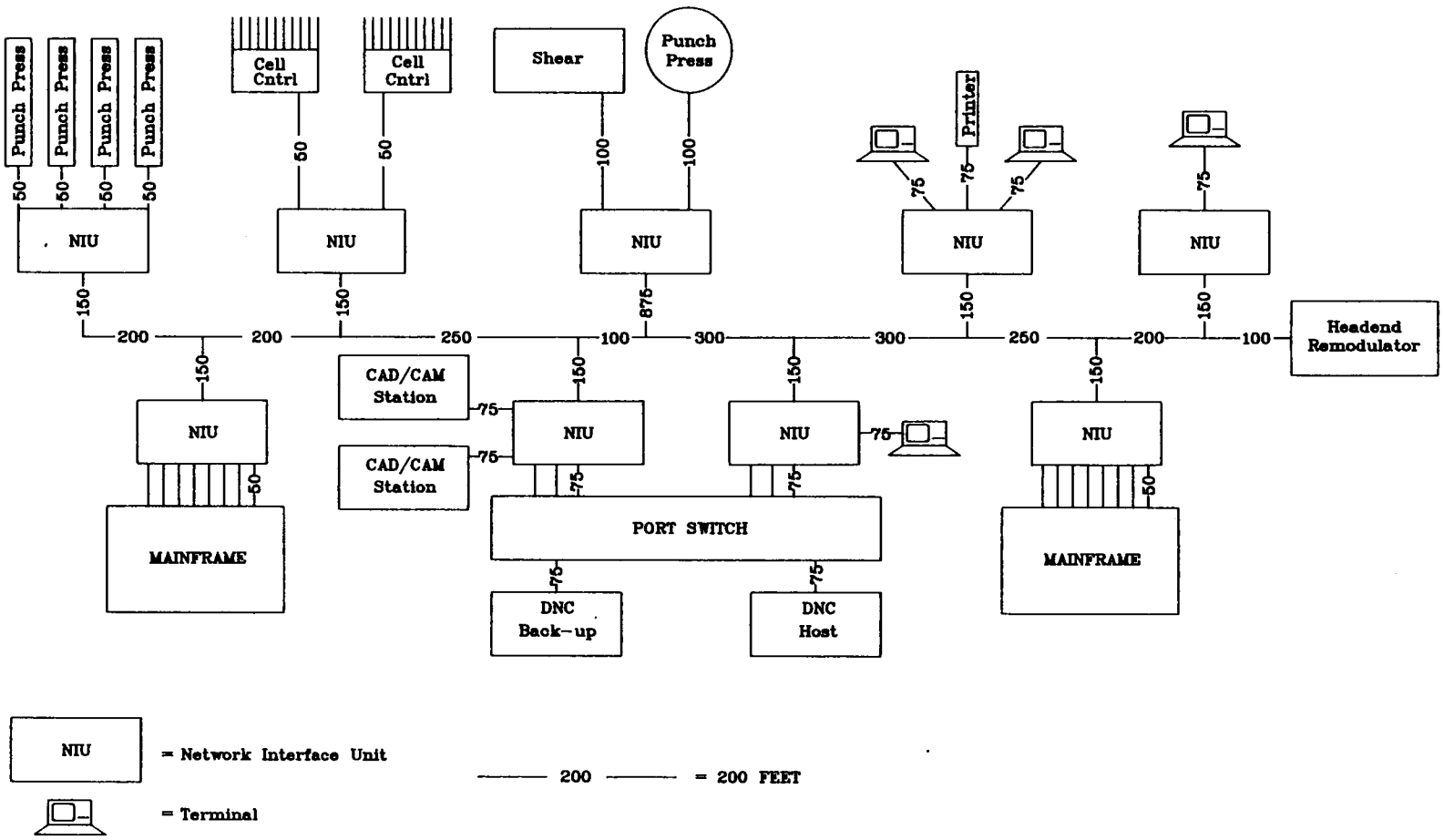

FIGURE 41. DIAGRAM OF LAN RECOMMENDED BY THE CIM FEASIBILITY COMMITTEE

CHAPTER V

SUMMARY

1. JUSTLAN: A COMPUTERIZED EVALUATION TOOL

The seven-step justification methodology developed in this thesis is designed as a mangement decision analysis tool. Some portions of the model, however, are highly quantitative and may require a substantial commitment on the part of the evaluation committee chairman. To compensate for this problem, a software package consisting of a series of interconnected computer programs has been developed. This package, JUSTLAN, automates many of the procedures which are included in the seven-step justification model. The package can be run on any IBM-PC (or compatible) with color graphics capabilities and a printer. A listing of the programs is included in APPENDIX V.

The JUSTLAN package differs from the methodology developed in Chapter III in one area. The Constant Sum Paired Comparisons (CSPC) procedure was not incorporated in the software. Although this technique could easily be coded as a computer program, the procedure itself is somewhat difficult to understand. Because JUSTLAN is intended to be a management decision analysis tool, the author feels that a simplified rating procedure of evaluating the performance of each alternative against the criterion of each attribute on a fixed scale (ranging from -5 = worst case to +5 = best case) can be more effectively applied.

2. CONCLUSIONS

New economic evaluation procedures must be developed to expedite the implementation of new technology in American manufacturing industries. Although a great deal has been written about the problems associated with the economic evaluation of technological investments, very few solutions have been proposed in the literature (40).

The ultimate success or failure of a long-term automation project often depends more heavily upon the difficult to quantify, strategic implications than on the readily quantifiable direct financial impact of the project. Many conservative managers, however, choose to ignore the non-monetary aspects in a project evaluation. They also fail to recognize the fact that in a competitive market, the choice of not investing may be a greater risk than the investment itself.

The ranking and rating procedure with an additive model is often applied when dealing with difficult to quantify factors. Psychometric techniques, such as the Constant Sum Paired Comparisons procedure and the Dunn-Rankin Technique can be incorporated into the ranking and rating procedure to produce outcomes on a ratio scale. If alternatives are compared on a scale with ratio properties, statements such as "alternative A is twice as good as alternative B" can be made.

Finally, the tradeoffs between subjective measures (non-monetary benefits) and objective measures (after-tax present worth) can be effectively examined by means of a graphical evaluation.

3. RECOMMENDATIONS

The methodology developed in this thesis has many possible applications in areas other than the analysis of LAN alternatives. The procedures could easily be applied to any decision among mutually exclusive alternatives. The JUSTLAN package can be turned into a general purpose evaluation tool by simply changing a few words in the instructions to the user.

Three areas for further research related to the methodology in this thesis are recommended. The first is the development of a spreadsheet version of the JUSTLAN software. Many of the procedures applied in the justification model could be incorporated in a single spreadsheet, thus reducing the extensive file manipulations necessary in the current version. The second area of additional research is in the area of corporate portfolio analysis. The techniques implemented in this thesis could be applied to an evaluation of multiple, interrelated projects, such as the staggered implementation of computer integrated manufacturing. Finally, an attempt to implement the JUSTLAN software on a PC-based LAN could be made. This would allow each member of the evaluation team to access the software from a common data base and have their responses written directly back to that data base eliminating the need to circulate a floppy disc among the committee members.

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APPENDIXES

APPENDIX I

MANUFACTURING AUTOMATION PROTOCOL

General Motors' Manufacturing Automation Protocol (MAP) has become widely recognized as one of the most important developments in standards (39, p. 17). MAP is intended to allow communication between heterogenous equipment throughout a manufacturing facility. This is to be accomplished by the use of the seven layer Open Systems Interconnection (OSI) model developed by the International Standards Organization (see Figure 42). The concept is based on a series of Local Area Networks, (LANs) which are linked together with a common data base by a broadband cable network similar to that used in the cable television industry.

Each LAN will consist of a work cell, such as a flexible manufacturing cell, requiring a great deal of shared information among its components. The electronic data base and/or information passing from node to node will gain access to the network by means of a token passing system (see Figure 43) which allows the various controllers to transmit data one at a time. A token passing system functions somewhat like a room full of people with a portable microphone. The microphone is passed around the room, and individuals are only allowed to speak while in possession of this "token" (46, p. 44).

Local area networks within a manufacturing firm will be interconnected by means of a broadband cable network. This type of system allows the simultaneous transmission of data over several different channels. A series of minicomputers are used to "direct traffic" throughout the network, assuring that every message is received by the device for which it is intended. The system must be capable of handling the large volumes of information to be transmitted

LAYERS	FUNCTION	LAYERS
USER PROGRAM PROGRAM	Application Programs (not included in the OSI model)	SERVER MACHINE
LAYER 7 APPLICATION	Manages lower-layer services, including application programs	LAYER 7 APPLICATION
LAYER 6 PRESENTATION	Restructures data to/from standardized format used within the network	LAYER 6 PRESENTATION
LAYER 5 SESSION	Name/address translation, access security, and synchronization and management of data	LAYER 5 SESSION
LAYER 4 TRANSPORT	Provides transparent, reliable data transfer from end device to end device	LAYER 4 TRANSPORT
LAYER 3 NETWORK	Establishes connections between equipment on the network	LAYER 3 NETWORK
LAYER 2 DATA LINK	Establishes, maintains, and releases data links	LAYER 2 DATA LINK
LAYER 1 PHYSICAL	Encodes and physically transfers messages between adjacent devices	LAYER 1 PHYSICAL

PHYSICAL LINK

FIGURE 42. OSI REFERENCE MODEL (39, p. 17)

and received through thousands of ports. This will allow all of the various manufacturing functions to utilize shared information from a common data base.

The key to the success of MAP is standardization. The cost of custom interfaces between incompatible devices is prohibitive to all but the largest corporations. Compliance to the standards on which MAP is based is an absolute necessity. No single vendor is capable of supplying all of the automation devices required for computer integrated manufacturing (CIM) (34, p. IM 30). By providing a non-proprietary set of protocols, MAP allows manufacturers and equipment vendors to work together to ensure that new production equipment can be brought on-line without disrupting other operations. Standardization will be a

- Addressed messages travel around the ring from interface to interface
- Interface scans address for match; if so, copies and marks it as "read"
- New messages can be entered when control token is encountered
- Originator removes message when it returns
- Monitor regenerates lost tokens

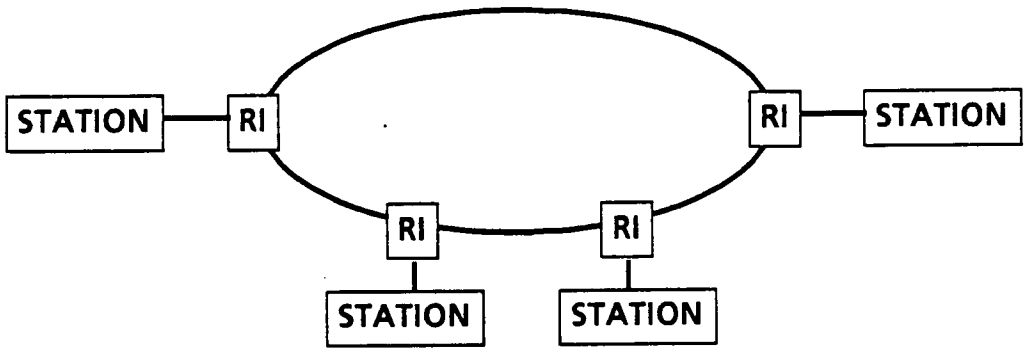

FIGURE 43. TOKEN PASSING SYSTEM (12, p. 16)

built in feature of all MAP compatible equipment. This will be accomplished by including a chip containing the MAP protocol in each computing device or controller. MAP users have stated that they will purchase only equipment containing this chip. Because of the huge predicted purchases of automation equipment, vendors are eager to comply with these standards. This was evidenced by the participation of twenty-one vendors of computers, factory automation equipment, and communications systems in a MAP demonstration at the 1985 AutoFact trade show (34, p. IM 30).

APPENDIX II

REAL $ vs ACTUAL $

REAL DOLLARS:

Dollars expressed in terms of the same purchasing power relative to a particular point in time.

ACTUAL DOLLARS: Actual number of dollars associated with a cash flow as of the point in time it occurs; includes an allowance for inflation

REAL INTEREST RATE (i_r): The marginal cost of capital that does not include a marketplace adjustment for the expected general inflation

COMBINED INTEREST RATE (i_c): The marginal cost of capital that includes a marketplace adjustment for the anticipated general inflation rate in the economy

$$i_c = i_r + f - (i_r \times f)$$

Where f is the expected general inflation rate

The Common Fallacy

The hurdle rate set by most corporations contains some provision for the expected general inflation rate as well as the real cost of capital. This is a COMBINED interest rate and should only be used in evaluation of projects for which all cash flows are in terms of ACTUAL dollars. However, the expected

annual cash flows are often expressed in terms of REAL dollars, with no provision for selling price or cost of labor inflation. This leads to erroneous results in project evaluation. The error introduced by improper application of combined interest rates is even more pronounced in after tax evaluations (16, p. 374- 378).

EXAMPLE

INITIAL COST OF PROJECT:	$ 100,000.00	
EXPECTED ANNUAL COSTS:	$ 10,000.00	(REAL Dollars)
EXPECTED ANNUAL SAVINGS:	$ 35,000.00	(REAL Dollars)
NET ANNUAL CASH FLOW:	$25,000.00	(REAL Dollars)

REAL COST OF CAPITAL (i_r): 10%/year

MARR (includes effects of inflation) (i_c): 5%/year

PROJECT LIFE: 6 years (with no salvage value)

BEFORE TAX ANALYSIS USING i_c

NET PRESENT WORTH = -$100,000.00 + $25,000.00 (P/A, 15%, 6)

= -$100,000.00 + $25,000.00 (3.7845)

= -$5387.50

BEFORE TAX ANALYSIS USING i_r

NET PRESENT WORTH = -$100,000.00 + $25,000.00 (P/A, 10%, 6)

= -$100,000.00 + $25,000,00 (4.3553)

= +$8882.50

The analysis using i_c discounts the net annual cash flows at a COMBINED interest rate, but the cash flows have not been adjusted for inflation and,

therefore, are in terms of REAL dollars. The results of a study conducted by the National Association of Accountants indicate that nine out of twenty-four firms participating in the survey are guilty of this error (11, p. 79). This incorrectly biases the analysis against the project, and the project may be turned down if it has a negative net present worth. The correct analysis shows the project to have a positive net present worth, with REAL dollars discounted at a REAL interest rate (i_r).

APPENDIX III

LAN EVALUATION QUESTIONS

(4, pp. 319-320)

1. What is the user base (how many networks have been installed)? Can users be contracted.
2. What are the results of beta test sites (i.e., customer prototyping the LAN)?
3. How many stations are supported?
4. What type of stations are supported (word processors, printers, etc.)?
5. What types of software packages or functions are available?
6. Are security features such as encryption and password logons available?
7. What are the performance statistics, given varying stations and varying traffic loads?
8. What is the cost and effort of adding stations to the network?
9. Does the LAN use layered protocols?
10. Are accepted physical cabling standards used in the architecture (RS232-C, RS449)?
11. Does the vendor have products or plans to support the ISO seven-layer model?
12. What are the failsafe and backup capabilities?
13. Is the net subject to a single-point failure?
14. What is the maximum distance allowed and the costs invovled in extending cable distances?
15. What is the maximum drop length of work stations to the cable and does this fit with the user's building or plant layout?

16. Is the network transparent to other vendor's products? If not, which vendor products are supported and at what cost?

17. What is the network protocol?

18. Is the network broadband or baseband?

19. What is the service/maintenance plan?

20. Is documentation adequate?

21. Does the vendor have a realistic and attractive plan to use the LAN for office automation?

22. Does the vendor plan to integrate its LAN with other communications products? If so, will it be transparent to the user?

23. What is the cost of the network?

24. Does the LAN support common LAN specifications, such as IEEE 802 and MAP?

APPENDIX IV

A DISCUSSION OF SCALE PROPERTIES

Both the Dunn-Rankin and the Constant Sum Paired Comparisons techniques claim to result in ratio-scaled values. In order to comprehend the significance of this claim, some knowledge of the types of scales and the properties of these scales is required. Much of the research in this area falls under the heading of psychometrics (the pyschological theory of mental measurement).

There is some consensus as to the types of measurement scaling models. The four most commonly distinguished scale types are ratio, interval, ordinal, and nominal (3, pp. 4-9). Of these four basic scale types, three are relevant in the analysis of decision making: ordinal, interval, and ratio (44, p. 164). The four scale types proposed by Torgerson are slightly different. He considers the four scale types to be ordinal, ordinal with natural origin, interval, and interval with natural origin, which is equivalent to a ratio scale (60, p. 16).

The classification of a scale type is determined by the properties of that scale. The three generally accepted scale properties are order, distance and origin (60, p. 15). The least sophisticated of the scale types is the nominal scale, which consists of a set of defined classifications without order, distance, or origin. An ordinal scale can be constructed by ranking according to preference, thus relying on order, but not distance or origin. A scale which includes both order and distance (constant unit of measurement), but not origin is an interval scale. Finally, a ratio scale is designated by a fixed (or absolute) origin (or zero point).

The three basic scale requirements of a ratio scale (order, distance, and origin) are present in the scales resulting from both the Dunn-Rankin and the Constant Sum Paired Comparisons procedures. The Dunn-Rankin Technique, as applied in this thesis, produces a rank-ordering of a set of non-monetary attributes, thus satisfying the order requirement. The differences separating these ordered attributes are quantifiable by a constant unit of measurement (distance), and the absolute minimum possible value for an attribute, regardless of the number of participants or attributes, is fixed at zero, thus satisfying the final requirement of a fixed origin. Linear transformations of the scale, such as normalization, can be carried out by multiplying all of the values by a positive constant without changing the origin or violating the order and distance properties.

The scale resulting from the Constant Sum Paired Comparisons procedure, as applied in this thesis, produces a rank-ordering of the various levels of outcome for an attribute. The distances between the levels can be quantified by a constant unit of measurement, and the minimum possible (or worst case) outcome for a given attribute is fixed at zero, thus satisfying the requirements of a ratio scale. The choice of labels for the levels of outcome, however, may cause some confusion and apparently violate some of the ratio scale properties. In the case study in Chapter IV of this thesis, integer labels in the range of +5 to -5 were used. These labels should be interpreted as having none of the three scale properties, and thus representative of a nominal scale. Upon examination of the labels along with the levels of outcome which they represent, order may be implied, but no constant unit of measurement exists. If the labels are interpreted as numbers, a constant unit of measurement apparently exists. The final scaling of the levels of outcome might then seem to take place by a non-linear

transformation, which would invalidate the property of distance. When the labels are properly viewed as only labels, the tranformation to the final scale is definitely linear.

APPENDIX V

PROGRAM LISTINGS

CONTROL.BAS

```
10 KEY OFF:COLOR 2,0,0:CLS
20 LOCATE 1,19:PRINT "JUSTLAN: ";
25 COLOR 3,0,0:PRINT "A Software Tool for Evaluating"
30 LOCATE 3,10:PRINT "the Costs and Benefits of Computer Communication ";
35 PRINT "Networks"
40 COLOR 6,0,0:LOCATE 6,36:PRINT "by":LOCATE 8,28:PRINT "Hampton R. Liggett"
45 LOCATE 9,28:PRINT "Dr. W. G. Sullivan"
50 LOCATE 11,8:PRINT "Center for Computer Integrated Engineering and ";
55 PRINT "Manufacturing"
60 LOCATE 12,29:PRINT "101 Perkins Hall"
65 LOCATE 13,15:PRINT "University of Tennessee, Knoxville 37996-2000"
70 COLOR 3,0,0:LOCATE 14,30:PRINT "(615) 974-3207"
75 COLOR 2,0,0:LOCATE 18,20:PRINT "Copyright  1987.  ";
76 COLOR 3,0,0:PRINT "All rights reserved."
80 LOCATE 19,21:PRINT "This material may not be reproduced"
85 LOCATE 20,16:PRINT "without the written permission of the authors."
90 COLOR 6,0,0
110 LOCATE 23,24:PRINT "( Press any key to continue )":Z$=INPUT$(1)
120 COLOR 6,0,0:CLS
600 CLS:LOCATE 1,8:PRINT "INPUT THE NUMBER  ";
610 COLOR 2,0,0:PRINT "( 1 to 11 )";
620 COLOR 6,0,0:PRINT "  THAT CORRESPONDS TO YOUR CHOICE"
630 COLOR 2,0,0:LOCATE 3,8:PRINT "1   ";
640 COLOR 6,0,0:PRINT "System Management Program"
650 COLOR 2,0,0:LOCATE 5,8:PRINT "2   ";
660 COLOR 6,0,0:PRINT "Load the List of Attributes"
670 COLOR 2,0,0:LOCATE 7,8:PRINT "3   ";
680 COLOR 6,0,0:PRINT "Load the List of Networking Alternatives"
690 COLOR 2,0,0:LOCATE 9,8:PRINT "4   ";
700 COLOR 6,0,0:PRINT "Run the Paired-Comparisons Program"
710 COLOR 2,0,0:LOCATE 11,8:PRINT "5   ";
720 COLOR 6,0,0:PRINT "Run the Rating  ( i.e. Scoring )  Program"
730 COLOR 2,0,0:LOCATE 13,8:PRINT "6   ";
740 COLOR 6,0,0:PRINT "Compute the Importance Weights of the Attributes"
750 COLOR 2,0,0:LOCATE 15,8:PRINT "7   ";
760 COLOR 6,0,0:PRINT "Compute the Scores for Each Alternative Against Each";
770 PRINT " Attribute"
780 COLOR 2,0,0:LOCATE 17,8:PRINT "8   ";
790 COLOR 6,0,0:PRINT "Estimate the Initial Cost for a Broadband LAN"
800 COLOR 2,0,0:LOCATE 19,8:PRINT "9   ";
810 COLOR 6,0,0:PRINT "Determine Present Worth of Each Alternative"
820 COLOR 2,0,0:LOCATE 21,8:PRINT "10  ";
830 COLOR 6,0,0:PRINT "Compute Strategic Benefits Score and Perform Benefit-";
840 PRINT "Cost Tradeoffs"
850 COLOR 2,0,0:LOCATE 23,8:PRINT "11  ";
860 COLOR 6,0,0:PRINT "Exit to Operating System  ( DOS )"
```

```
870 LOCATE 23,70:INPUT X
880 IF X=2 OR X=3 GOTO 1340
890 CLS:IF X<1 OR X>11 GOTO 120
900 IF X=4 OR X=5 OR X=11 GOTO 1000
910 LOCATE 8,10:PRINT "ONLY THE CHAIRMAN OF THE EVALUATION COMMITTEE IS"
920 LOCATE 10,14:PRINT "AUTHORIZED TO EXECUTE THIS PROGRAM !!!!"
930 COLOR 3,0,0:LOCATE 16,20:PRINT "ENTER PASSWORD TO CONTINUE --"
940 LOCATE 18,15:PRINT "OR ENTER ANY NUMBER TO RETURN TO MENU"
950 COLOR 2,0,0:LOCATE 21,25:PRINT "(the password is WIDGET)"
960 COLOR 6,0,0:LOCATE 23,65:INPUT WWW$
970 CLS:IF WWW$="widget" OR WWW$="WIDGET" GOTO 990
980 GOTO 600
990 CLS
1000 IF X=1 OR X=2 OR X=3 OR X=4 OR X=5 OR X=6 OR X=7 OR X=8 OR X=9 GOTO 1050
1010 IF X=10 OR X=11 GOTO 1050
1020 LOCATE 10,15:PRINT "INVALID ENTRY ---- TRY AGAIN":FOR I=1 TO 3:BEEP:NEXT I
1030 CLS:GOTO 600
1040 IF X=1 GOTO 1150
1050 IF X=2 GOTO 1160
1060 IF X=3 GOTO 1170
1070 IF X=4 GOTO 1180
1080 IF X=5 GOTO 1190
1090 IF X=6 GOTO 1200
1100 IF X=7 GOTO 1210
1110 IF X=8 GOTO 1230
1120 IF X=9 GOTO 1240
1130 IF X=10 GOTO 1220
1140 IF X=11 GOTO 1330
1150 CHAIN "B:SYSMAN"
1160 CHAIN "B:LOADATRB"
1170 CHAIN "B:LOADALT"
1180 CHAIN "B:PAIRCOMP"
1190 CHAIN "B:SCORING"
1200 CHAIN "B:RATIOWGT"
1210 CHAIN "B:AVRATING"
1220 CHAIN "B:WGTEVAL"
1230 CHAIN "B:COSTEST"
1240 CLS:LOCATE 3,9:PRINT "You have a choice between the following options:"
1250 LOCATE 6,9:PRINT "1.   Calculate the Before-Tax Present Worth"
1260 LOCATE 8,9:PRINT "2.   Calculate the After-Tax Present Worth"
1270 LOCATE 15,20:PRINT "Input your choice  ( 1  or  2 )"
1280 LOCATE 16,55:INPUT ZYX
1290 IF ZYX=1 OR ZYX=2 THEN 1310
1300 GOTO 1240
1310 IF ZYX=1 THEN CHAIN "B:APPC"
1320 CHAIN "B:AFTERTAX"
1330 SYSTEM
1340 CLS:LOCATE 4,10:PRINT "A SET OF ATTRIBUTES AND A SET OF ALTERNATIVES HAVE"
1350 LOCATE 6,10:PRINT "ALREADY BEEN FURNISHED, FOR DEMONSTRATION PURPOSES."
1360 LOCATE 8,10:PRINT "DO YOU WISH TO OVER-WRITE THE DEMO FILES ( Y or N ) ";
1370 INPUT ANS$
1380 IF ANS$="Y" OR ANS$="y" OR ANS$="N" OR ANS$="n" GOTO 1400
```

```
1390 GOTO 1340
1400 IF ANS$="Y" OR ANS$="y" GOTO 890
1410 GOTO 120
```

SYSMAN.BAS

```
10 KEY OFF:WIDTH 40:CLS
15 LOCATE 6,17:COLOR 2,0,0:PRINT "JUSTLAN"
20 LOCATE 12,8:COLOR 6,0,0:PRINT "SYSTEM MANAGEMENT PROGRAM":COLOR 3,0,0
30 LOCATE 23,6:PRINT "( Press any key to continue )":Z$=INPUT$(1):WIDTH 80
40 SCREEN 0:COLOR 6,0,0
50 LOCATE 2,9:PRINT "The System Management Program is designed to allow the"
60 LOCATE 4,9:PRINT "chairman of the evaluation committee to carry out the"
70 LOCATE 6,9:PRINT "necessary 'house-keeping' chores on the JUSTLAN software"
72 LOCATE 8,9:PRINT "package.  One of the MENU options of this program is to"
74 LOCATE 10,9:PRINT "initialize all of the data files."
78 COLOR 3,0,0
80 LOCATE 13,9:PRINT "THIS OPTION MUST BE EXECUTED BEFORE ANY OF THE OTHER"
90 LOCATE 15,25:PRINT "PROGRAMS CAN BE RUN.":COLOR 6,0,0
100 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
110 LOCATE 1,9:PRINT "In addition to providing a means of initializing the"
120 LOCATE 3,9:PRINT "data files, the System Management Program will allow"
130 LOCATE 5,9:PRINT "the chairman to delete an individual data file, if"
140 LOCATE 7,9:PRINT "a committee member feels that he/she was guilty of an"
150 LOCATE 9,9:PRINT "error.  In order to ensure that the proper user's file"
160 LOCATE 11,9:PRINT "is deleted, the System Management module should be run"
170 LOCATE 13,9:PRINT "to erase the erroneous data file before any other"
180 LOCATE 15,9:PRINT "portion of the JUSTLAN package is executed.  Lastly,"
190 LOCATE 17,9:PRINT "the System Management Program will allow data files"
200 LOCATE 19,9:PRINT "from the Cost Estimation and Finanacial Analysis"
210 LOCATE 21,9:PRINT "programs to be removed."
220 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
230 CLS:COLOR 2,0,0:LOCATE 1,8:PRINT "INPUT THE NUMBER WHICH CORRESPONDS WITH";
240 PRINT " YOUR CHOSEN TASK"
250 COLOR 2,0,0:LOCATE 4,5:PRINT "1. ";
260 COLOR 6,0,0:PRINT "INITIALIZE all data files"
270 COLOR 2,0,0:LOCATE 6,5:PRINT "2. ";
280 COLOR 6,0,0:PRINT "DELETE individual user's data file"
290 COLOR 2,0,0:LOCATE 8,5:PRINT "3. ";
300 COLOR 6,0,0:PRINT "DELETE cost estimation file"
301 COLOR 2,0,0:LOCATE 10,5:PRINT "4. ";
302 COLOR 6,0,0:PRINT "Return to MAIN MENU"
310 COLOR 3,0,0:LOCATE 15,40:INPUT ZZZ
320 COLOR 6,0,0:IF ZZZ=1 OR ZZZ=2 OR ZZZ=3 OR ZZZ=4 THEN 340
330 GOTO 230
340 CLS:IF ZZZ=1 THEN 1000
350 IF ZZZ=2 THEN 1500
355 IF ZZZ=4 THEN CHAIN "B:CONTROL",600
360 CLS:COLOR 2,0,0:LOCATE 1,8:PRINT "INPUT THE NUMBER WHICH CORRESPONDS WITH";
370 PRINT " YOUR CHOSEN TASK"
380 COLOR 2,0,0:LOCATE 4,5:PRINT "1. ";
390 COLOR 6,0,0:PRINT "DELETE file from Cost Estimation program"
400 COLOR 2,0,0:LOCATE 6,5:PRINT "2. ";
410 COLOR 6,0,0:PRINT "DELETE file from Present Worth program"
412 COLOR 2,0,0:LOCATE 8,5:PRINT "3. ";
415 COLOR 6,0,0:PRINT "RETURN to System Management Menu"
```

```
420 LOCATE 18,40:COLOR 3,0,0:INPUT YYY:COLOR 6,0,0
430 IF YYY=1 OR YYY=2 OR YYY=3 THEN 445
440 GOTO 360
445 IF YYY=3 THEN 230
450 IF YYY=1 THEN 750
455 CLS:OPEN "B:ANUAL" FOR INPUT AS #1:INPUT#1,NUMM:CLOSE#1
460 IF NUMM>0 THEN 485
465 LOCATE 5,9:PRINT "There are no present worth files currently on the data"
470 LOCATE 7,9:PRINT "disk.  Please verify that the proper disk is in drive B:"
475 LOCATE 9,9:PRINT "before continuing."
480 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):GOTO 230
485 XYZ$="B:ANCST"
490 FOR I=1 TO NUMM:X$=STR$(I):ZIP=LEN(X$)-1:Y$=RIGHT$(X$,ZIP):FILE$=XYZ$+Y$
495 OPEN FILE$ FOR INPUT AS #1:INPUT#1,ALTNAM$(I):CLOSE#1:NEXT I
500 LOCATE 5,9:PRINT "A listing of the present worth files will be printed."
505 LOCATE 7,9:PRINT "Please check to see that the printer is  'on-line'  and"
510 LOCATE 9,9:PRINT "that the paper is properly aligned."
515 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
520 LPRINT CHR$(10):LPRINT TAB(21) "PRESENT WORTH FILES":LPRINT CHR$(10)
525 FOR I=1 TO NUMM:LPRINT TAB(5) I;".";TAB(10) ALTNAM$(I):LPRINT CHR$(10)
530 NEXT I:LPRINT CHR$(12)
535 LOCATE 5,9:PRINT "Remove the listing of present worth files from the ";
540 PRINT "printer."
545 LOCATE 7,9:PRINT "Examine the list and determine the number of the file ";
550 PRINT "that you"
555 LOCATE 9,9:PRINT "wish to erase.  Input the number of the file to be ";
560 PRINT "deleted.":COLOR 2,0,0
565 LOCATE 10,9:PRINT "                    ----------------------------------------";
570 PRINT "--------":COLOR 3,0,0:LOCATE 17,40:INPUT YYY
575 CLS:FOR I=1 TO NUMM:IF YYY=I THEN 595
580 NEXT I
585 LOCATE 10,32:PRINT "INVALID ENTRY":BEEP
590 LOCATE 23,25:PRINT "(Press any key to continue)":Z$=INPUT$(1):CLS:GOTO 535
595 IF YYY=NUMM THEN 635
600 FOR J=YYY+1 TO NUMM:XYZ$="B:ANCST":X$=STR$(J):ZIP=LEN(X$)-1
605 Y$=RIGHT$(X$,ZIP):FILE$=XYZ$+Y$:OPEN FILE$ FOR INPUT AS #1
610 INPUT#1,ALTNAM$,YEARS,INTEREST,PW,AW
615 FOR I=0 TO YEARS:INPUT#1,K,CASH(I):NEXT I:CLOSE#1
620 M=J-1:Z$=STR$(M):ZIP=LEN(Z$)-1:Y$=RIGHT$(Z$,ZIP):FILE$=XYZ$+Y$
625 OPEN FILE$ FOR OUTPUT AS #1:WRITE#1,ALTNAM$,YEARS,INTEREST,PW,AW
630 FOR I=0 TO YEARS:WRITE#1,I,CASH(I):NEXT I:CLOSE#1:NEXT J
635 XYZ$="B:ANCST":Z$=STR$(NUMM):ZIP=LEN(Z$)-1:Y$=RIGHT$(Z$,ZIP):FILE$=XYZ$+Y$
640 KILL FILE$
645 NUMMM=NUMM-1:OPEN "B:ANUAL" FOR OUTPUT AS #1:WRITE#1,NUMMM:CLOSE#1
650 GOTO 360
750 CLS:OPEN "b:alternat" FOR INPUT AS #1
760 INPUT#1,NUMBER:FOR I=1 TO NUMBER:INPUT#1,COST$(I):NEXT I:CLOSE#1
761 IF NUMBER>0 THEN 770
762 LOCATE 5,9:PRINT "There are no cost estimation files currently on the data"
763 LOCATE 7,9:PRINT "disk.  Please verify that the proper disk is in drive B:"
764 LOCATE 9,9:PRINT "before continuing."
765 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):GOTO 230
```

```
770 LOCATE 5,9:PRINT "A listing of the cost estimation files will be printed."
780 LOCATE 7,9:PRINT "Please check to see that the printer is  'on-line'  and"
790 LOCATE 9,9:PRINT "that the paper is properly aligned."
800 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
810 LPRINT CHR$(10):LPRINT TAB(20) "COST ESTIMATION FILES":LPRINT CHR$(10)
820 FOR I=1 TO NUMBER:LPRINT TAB(5) I;".";TAB(10) COST$(I):LPRINT CHR$(10)
830 NEXT I:LPRINT CHR$(12)
840 LOCATE 5,9:PRINT "Remove the listing of cost estimation files from the ";
850 PRINT "printer."
860 LOCATE 7,9:PRINT "Examine the list and determine the number of the file ";
870 PRINT "that you"
875 LOCATE 9,9:PRINT "wish to erase.  Input the number of the file to be ";
880 PRINT "deleted.":COLOR 2,0,0
885 LOCATE 10,9:PRINT "                    ----------------------------------";
890 PRINT "--------":COLOR 3,0,0:LOCATE 17,40:INPUT XXX
900 CLS:FOR I=1 TO NUMBER:IF XXX=I THEN 910
901 NEXT I
905 LOCATE 10,32:PRINT "INVALID ENTRY":BEEP
907 LOCATE 23,25:PRINT "(Press any key to continue)":Z$=INPUT$(1):CLS:GOTO 860
910 IF XXX=NUMBER THEN 940
915 FOR J=XXX+1 TO NUMBER:XYZ$="B:INCOST":ZYX$=STR$(J):ZIP=LEN(ZYX$)-1
920 Y$=RIGHT$(ZYX$,ZIP):FILE$=XYZ$+Y$:OPEN FILE$ FOR INPUT AS #1
925 INPUT#1,A$,LOW,AVG,HIGH:CLOSE#1:M=J-1:Z$=STR$(M):ZIP=LEN(Z$)-1
930 Y$=RIGHT$(Z$,ZIP):FILE$=XYZ$+Y$:OPEN FILE$ FOR OUTPUT AS #1
935 WRITE#1,A$,LOW,AVG,HIGH:CLOSE#1:NEXT J
940 XYZ$="B:INCOST":Z$=STR$(NUMBER):ZIP=LEN(Z$)-1:Y$=RIGHT$(Z$,ZIP)
945 FILE$=XYZ$+Y$:KILL FILE$
950 NUMB=NUMBER-1:OPEN "B:ALTERNAT" FOR OUTPUT AS#1:WRITE#1,NUMB
955 FOR I=1 TO NUMBER:IF I=XXX THEN 965
960 WRITE#1,COST$(I)
965 REM
970 NEXT I:CLOSE#1
980 GOTO 360
1000 CLS:LOCATE 3,9:PRINT "This option, if executed, will initialize all of "
1010 LOCATE 5,9:PRINT "the data files.  Please check to be sure that you wish"
1020 LOCATE 7,9:PRINT "to delete all of the previously entered data before"
1030 LOCATE 9,9:PRINT "preceding."
1035 COLOR 4,0,0
1040 LOCATE 13,9:PRINT "IF YOU EXECUTE THIS OPTION, ALL OF THE PREVIOUSLY ";
1045 PRINT "ENTERED":LOCATE 15,25:PRINT "DATA FILES WILL BE LOST":COLOR 6,0,0
1050 LOCATE 19,9:PRINT "Do you wish to precede with the initialization of the"
1060 LOCATE 21,9:PRINT "data files  ( Y  or  N ) ";
1070 INPUT Z$:IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" THEN 1090
1080 LOCATE 19,9:PRINT "                                                    "
1085 GOTO 1060
1090 IF Z$="N" OR Z$="n" THEN 230
1100 OPEN "B:SCOUNT" FOR INPUT AS #1:INPUT#1,NNI:CLOSE#1
1110 OPEN "B:ANUAL" FOR INPUT AS #1:INPUT#1,NNJ:CLOSE#1
1120 OPEN "B:COUNTER" FOR INPUT AS #1:INPUT#1,NNK:CLOSE#1
1130 OPEN "B:ALTERNAT" FOR INPUT AS #1:INPUT#1,NNL:CLOSE#1
1140 RESETIT=0
1150 OPEN "B:SCOUNT" FOR OUTPUT AS #1:WRITE#1,RESETIT:CLOSE#1
```

```
1160 OPEN "B:ANUAL" FOR OUTPUT AS #1:WRITE#1,RESETIT:CLOSE#1
1170 OPEN "B:COUNTER" FOR OUTPUT AS #1:WRITE#1,RESETIT:CLOSE#1
1180 OPEN "B:ALTERNAT" FOR OUTPUT AS #1:WRITE#1,RESETIT:CLOSE#1
1190 IF NNI>0 THEN KILL "B:SCORE*"
1200 IF NNJ>0 THEN KILL "B:ANCST*"
1210 IF NNK>0 THEN KILL "B:DNRANK*"
1220 IF NNL>0 THEN KILL "B:INCOST*"
1230 GOTO 230
1500 CLS:COLOR 2,0,0
1510 LOCATE 4,9:PRINT "ONLY THE LAST-CREATED DATA FILE FROM EACH OF THE TWO"
1520 LOCATE 6,9:PRINT "INDIVIDUAL PARTICIPATION PROGRAMS ( paired comparisons"
1530 LOCATE 8,9:PRINT "and rating ) CAN BE DELETED. THE FILE TO BE ERASED MUST"
1540 LOCATE 10,9:PRINT "HAVE BEEN CREATED BY THE MOST RECENT USER.  IF THIS IS"
1545 LOCATE 12,9:PRINT "NOT THE CASE, ALL OF THE INDIVIDUAL DATA FILES CREATED"
1546 LOCATE 14,9:PRINT "AFTER THE ERRONEOUS FILE MUST ALSO BE DELETED.  THIS"
1547 LOCATE 16,9:PRINT "WILL NECESSITATE SOME OF THE COMMITTEE MEMBERS HAVING"
1548 LOCATE 18,9:PRINT "TO RE-EXECUTE ONE OF THE PROGRAMS.":COLOR 6,0,0
1550 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
1560 CLS:COLOR 2,0,0:LOCATE 1,8:PRINT "INPUT THE NUMBER WHICH CORRESPONDS ";
1570 PRINT "WITH YOUR CHOSEN TASK"
1580 COLOR 2,0,0:LOCATE 4,5:PRINT "1. ";
1590 COLOR 6,0,0:PRINT "DELETE an individual's paired comparison data file"
1600 COLOR 2,0,0:LOCATE 6,5:PRINT "2. ";
1610 COLOR 6,0,0:PRINT "DELETE an individual's ranking data file"
1612 COLOR 2,0,0:LOCATE 8,5:PRINT "3. ";
1615 COLOR 6,0,0:PRINT "RETURN to System Management Menu"
1620 COLOR 3,0,0:LOCATE 15,40:INPUT ZZZ
1630 IF ZZZ=1 OR ZZZ=2 OR ZZZ=3 THEN 1650
1640 GOTO 1560
1650 IF ZZZ=2 THEN 1710
1655 IF ZZZ=3 THEN 230
1660 OPEN "B:COUNTER" FOR INPUT AS #1:INPUT#1,NNN:CLOSE#1
1662 IF NNN>0 THEN 1670
1664 CLS:LOCATE 4,9:PRINT "There are currently no individual paired comparison"
1666 LOCATE 6,9:PRINT "files on the data disk.  Please verify that the proper"
1667 LOCATE 8,9:PRINT "disk is in drive  B:  before proceeding."
1668 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):GOTO 1560
1670 XYZ$="B:DNRANK":X$=STR$(NNN):ZIP=LEN(X$)-1:Y$=RIGHT$(X$,ZIP):FILE$=XYZ$+Y$
1680 KILL FILE$
1690 NNNN=NNN-1:OPEN "B:COUNTER" FOR OUTPUT AS #1:WRITE#1,NNNN:CLOSE#1
1700 GOTO 1560
1710 OPEN "B:SCOUNT" FOR INPUT AS #1:INPUT#1,MMM:CLOSE#1
1720 IF MMM>0 THEN XXX
1730 CLS:LOCATE 4,9:PRINT "There are currently no individual rating files on"
1740 LOCATE 6,9:PRINT "the data disk. Please verify that the proper disk is in"
1750 LOCATE 8,9:PRINT "drive  B:  before proceeding."
1760 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):GOTO 1560
1770 XYZ$="B:SCORE":X$=STR$(MMM):ZIP=LEN(X$)-1:Y$=RIGHT$(X$,ZIP):FILE$=XYZ$+Y$
1780 KILL FILE$
1790 MMMM=MMM-1:OPEN "B:SCOUNT" FOR OUTPUT AS #1:WRITE#1,MMMM:CLOSE#1
1800 GOTO 1560
```

LOADALT.BAS

```
10 KEY OFF:COLOR 6,0,0:CLS
20 LOCATE 8,13:PRINT "PROGRAM TO ALLOW THE ENTRY OF NETWORKING ALTERNATIVES"
30 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
40 REM
50 REM   THE PURPOSE OF THIS PROGRAM IS TO ALLOW THE CHAIRMAN OF THE EVALUATION
60 REM
70 REM   COMMITTEE TO INPUT A LIST OF NETWORKING ALTERNATIVES TO BE USED IN THE
80 REM
90 REM   MULTIPLE ATTRIBUTE DECISION ANALYSIS.
100 REM
110 PRINT " The purpose of this program is to allow the chairman of the":PRINT
120 PRINT " Evaluation Committee to input a list of Alternatives to be":PRINT
130 PRINT " used in a Multiple Attribute Decision Analysis. Prior to the":PRINT
140 PRINT " execution of this program, the list of Networking Alternatives"
150 PRINT:PRINT " should have been developed during a group consensus-forming"
160 PRINT:PRINT " session  ( Nominal Group Technique ).  If this procedure has"
170 PRINT:PRINT " not been executed, exit the program by simultaneously":PRINT
180 PRINT " depressing the CONTROL  ( Ctrl )  and the BREAK  ( Scroll Lock )"
190 PRINT :PRINT " keys !!!!!"
200 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
210 COLOR 3,0,0:LOCATE 3,15:PRINT "A MAXIMUM OF";
220 COLOR 2,0,0:PRINT " 5";
230 COLOR 3,0,0:PRINT " ALTERNATIVES WILL BE ALLOWED.":COLOR 6,0,0
240 LOCATE 10,4:PRINT "Enter the number of Networking Alternatives to be ";
250 PRINT "used in the evaluation"
260 LOCATE 20,65:INPUT M:CLS
270 IF M>1 AND M<6 THEN 330
280 LOCATE 3,9:PRINT "AT LEAST TWO AND NO MORE THAN FIVE ALTERNATIVES CAN BE"
290 LOCATE 5,9:PRINT "SIMULTANEOUSLY EVALUATED.  YOUR ENTRY MUST FALL IN THE"
300 LOCATE 7,9:PRINT "RANGE OF   2   TO   5 ."
310 BEEP:LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
320 GOTO 210
330 FOR I=1 TO M
340 LOCATE 6,12:PRINT "ENTER THE NAME OF ALTERNATIVE  #";I
350 LOCATE 15,25:INPUT D$(I):CLS
360 LOCATE 9,10:PRINT "'";D$(I);" '";"  IS ALTERNATIVE  #";I
370 LOCATE 15,10:PRINT "IS THIS CORRECT  ( Y  or  N ) ???":PRINT:PRINT:PRINT
380 INPUT Z$:CLS:IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" GOTO 400
390 GOTO 360
400 IF Z$="N" OR Z$="n" GOTO 340
410 NEXT I
420 FOR I=1 TO M
430 LOCATE 3,3:PRINT "ENTER AN ABBREVIATION, UP TO TEN CHARACTERS, FOR ";D$(I)
440 LOCATE 7,25:INPUT E$(I):CLS
450 OK=LEN(E$(I)):IF OK<11 THEN 470
460 CLS:BEEP:GOTO 430
470 LOCATE 5,9:PRINT "THE ABBREVIATION FOR ";D$(I);" IS ";E$(I)
480 LOCATE 7,20:PRINT "IS THIS CORRECT  ( Y or N )":INPUT Z$
490 IF Z$="y" OR Z$="Y" OR Z$="n" OR Z$="N" THEN 510
500 CLS:GOTO 430
```

```
510 IF Z$="Y" OR Z$="y" THEN 530
520 CLS:GOTO 430
530 CLS
540 NEXT I
550 COLOR 4,0,0:LOCATE 9,12:PRINT "WRITTING ALTERNATIVES TO DISK — PLEASE BE";
560 PRINT "PATIENT"
570 OPEN "B:ALTER" FOR OUTPUT AS #1
580 WRITE#1,M
590 FOR I=1 TO M:WRITE#1,D$(I),E$(I):NEXT I:CLOSE#1
600 COLOR 6,0,0:FOR J=1 TO 3500:NEXT J:CLS
610 LOCATE 12,30:PRINT "THE END !!!!!":FOR J=1 TO 3500:NEXT J:CLS
620 CHAIN "B:CONTROL",600
```

LOADATRB.BAS

```
10 KEY OFF
20 REM   THE PURPOSE OF THIS PROGRAM IS TO ALLOW THE ENTRY OF UP TO TEN  ( 10 )
30 REM
40 REM   STRATEGIC ATTRIBUTES TO BE USED IN THE EVALUATION OF A MULTI-ATTRIBUTE
50 REM
60 REM   DECISION MODEL.  THESE ATTRIBUTES, ALONG WITH THEIR DEFINITIONS, ARE
70 REM
80 REM   WRITTEN TO A FILE FOR LATER USE IN THE Dunn-Rankin AND Linearly
90 REM
100 REM  Additive Weighted Evaluation PROCEDURES.  FOR THIS REASON, ALL OF THE
110 REM
120 REM  ATTRIBUTES SHOULD BE PERTINENT TO EACH OF THE ALTERNATIVES UNDER
130 REM
140 REM  CONSIDERATION.  IN ADDITION, INDEPENDENCE BETWEEN THE ATTRIBUTES IS
150 REM
160 REM  ESSENTIAL.  CARE SHOULD BE TAKEN IN DEVELOPING THE DEFINITIONS,
170 REM
180 REM  BECAUSE INDEPENDENCE BETWEEN THE ATTRIBUTES CAN BE ASSURED BY THEIR
190 REM
200 REM  DEFINITIONS.
210 REM
220 REM
230 COLOR 6,0,0
240 DIM A$(10),B$(10,4),C$(10)
250 REM
260 REM  INSTRUCTIONS FOR ENTRY OF THE ATTRIBUTES AND THEIR DEFINITIONS
270 REM
280 REM
290 CLS:LOCATE 10,18:PRINT "PROGRAM TO LOAD THE LIST OF STRATEGIC ATTRIBUTES"
300 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
310 PRINT "BEFORE ATTEMPTING TO RUN THIS PROGRAM, A LIST OF INDEPENDENT"
320 PRINT
330 PRINT "ATTRIBUTES, AS WELL AS DEFINITIONS FOR EACH OF THE ATTRIBUTES"
340 PRINT
350 PRINT "SHOULD HAVE BEEN DEVELOPED.  IF THIS IS NOT THE CASE, DEPRESS"
360 PRINT
370 PRINT "THE CONTROL ( Ctrl ) AND BREAK ( Scroll Lock ) KEYS SIMULTANEOUSLY"
380 PRINT
390 PRINT "TO EXIT THE PROGRAM."
400 PRINT
410 PRINT "                ( Press any key to continue )"
420 I$=INPUT$(1)
430 CLS
440 PRINT "YOU WILL FIRST BE ASKED TO ENTER THE NUMBER OF ATTRIBUTES TO BE"
450 PRINT
460 PRINT "USED IN THE EVALUATION.  NEXT, YOU WILL BE ASKED TO ENTER THE NAME"
470 PRINT
480 PRINT "AND AN ABBREVIATION FOR EACH OF THE ATTRIBUTES. AFTER THIS HAS BEEN"
490 PRINT
500 PRINT "COMPLETED, YOU WILL BE INSTRUCTED TO ENTER THE DEFINITIONS OF EACH"
```

```
510 PRINT
520 PRINT "OF THE ATTRIBUTES.  YOU WILL BE ALLOWED TO ENTER UP TO FOUR  ( 4 )"
530 PRINT
540 PRINT "LINES OF TEXT TO DEFINE EACH OF THE ATTRIBUTES.  IF SOME OF YOUR"
550 PRINT
560 PRINT "DEFINITIONS REQUIRE LESS THAN  4  LINES, YOU MUST STRIKE THE RETURN"
570 PRINT
580 PRINT "KEY UNTIL YOU ARE PROMPTED TO VERIFY THE ENTERED DEFINITION OF THE"
590 PRINT
600 PRINT "ATTRIBUTE."
610 PRINT
620 PRINT "                    ( Press any key to continue )"
630 I$=INPUT$(1)
631 COLOR 3,0,0
632 CLS:LOCATE 9,15:PRINT "A MAXIMUM OF  10  ATTRIBUTES WILL BE ALLOWED."
633 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1)
640 COLOR 4,6,2
650 CLS
660 PRINT "ENTER THE NUMBER OF ATTRIBUTES WHICH ARE TO BE USED IN THE"
670  INPUT "STRATEGIC EVALUATION. ";N
680 IF N>1 AND N<=10 GOTO 760
690 CLS
700 PRINT "YOU MUST HAVE AT LEAST  2  ATTRIBUTES FOR AN EVALUATION OF THIS"
710 PRINT "TYPE.  YOU MAY USE UP TO A MAXIMUM OF  10  ATTRIBUTES IN THIS"
720 PRINT "EVALUATION."
730 FOR I=1 TO 10:BEEP:NEXT I
740 PRINT:PRINT:PRINT:PRINT
750 GOTO 660
760 COLOR 6,0,0
770 CLS
780 FOR I=1 TO N
790 PRINT "ENTER THE NAME OF ATTRIBUTE ";I:INPUT "",A$(I):PRINT:PRINT:PRINT
800 PRINT "ENTER AN ABBREVIATION  (maximum of  5  characters) FOR ";A$(I)
810 C$(I)=INPUT$(5)
820 PRINT:PRINT:PRINT:PRINT "ATTRIBUTE ";I;" IS ";A$(I);"      ";C$(I)
830 PRINT "IS THIS CORRECT   ( Y or N ) ?????"
840 J$=INPUT$(1):IF J$="Y" OR J$="y" GOTO 870
850 PRINT:PRINT:PRINT:PRINT "                TRY AGAIN !!!!!!!!!!!!!"
860 FOR K=1 TO 10:BEEP:NEXT K:CLS:GOTO 790
870 CLS
880 NEXT I
890 CLS
900 PRINT "YOU WILL HAVE UP TO A MAXIMUM OF FOUR LINES OF TEXT TO DEFINE"
910 PRINT:PRINT "EACH ATTRIBUTE.  IF ALL FOUR LINES ARE NOT USED, YOU MUST"
920 PRINT:PRINT "CONTINUE TO STRIKE THE RETURN KEY UNTIL YOU ARE ASKED TO"
930 PRINT:PRINT "VERIFY THE DEFINITION OF THE ATTRIBUTE.  DO NOT USE THE"
940 PRINT:PRINT "CHARACTER comma  ( , )  OR THE  double quotation mark  IN"
950 PRINT:PRINT "ANY OF THE DEFINITIONS, AS THIS WILL INTERFERE WITH THE"
960 PRINT:PRINT "SET UP OF THE FILE STRUCTURE.":PRINT:PRINT:PRINT:PRINT
970 PRINT "      ( Press any key to continue )":I$=INPUT$(1):CLS
980 FOR I=1 TO N
990 PRINT "ENTER THE DEFINITION OF ";A$(I):FOR J=1 TO 4:INPUT "",B$(I,J):NEXT J
```

```
1000 CLS:PRINT "THE DEFINITION OF ";A$(I);" IS :":FOR J=1 TO 4:PRINT
1010 PRINT B$(I,J):NEXT J:PRINT:PRINT:PRINT:PRINT "IS THIS CORRECT ( Y or N )";
1020 K$=INPUT$(1):IF K$="Y" OR K$="y" GOTO 1050
1030 PRINT:PRINT:PRINT:PRINT "              TRY AGAIN !!!!!!!!"
1040 FOR K=1 TO 10:BEEP:NEXT K:CLS:GOTO 990
1050 CLS
1060 NEXT I
1070 COLOR 8,2,2
1080 CLS
1090 PRINT "DO YOU WANT A HARDCOPY OF THE LIST OF ATTRIBUTES AND THEIR"
1100 PRINT:PRINT "DEFINITIONS  ( Y or N ) ??":K$=INPUT$(1)
1110 IF K$="Y" OR K$="y" GOTO 1240
1120 COLOR 2,4,4:CLS
1130 PRINT:PRINT:PRINT:PRINT "WRITING ATTRIBUTES AND DEFINITIONS TO DISK !!!"
1140 OPEN "B:ATTRIB" FOR OUTPUT AS #1
1150 WRITE#1,N
1160 FOR I=1 TO N
1170 WRITE#1,A$(I),C$(I)
1180 FOR J=1 TO 4
1190 WRITE#1,B$(I,J)
1200 NEXT J
1210 NEXT I
1220 CLOSE#1
1230 GOTO 1280
1240 FOR I=1 TO N
1250 LPRINT A$(I);"     ";C$(I):FOR J=1 TO 4:LPRINT B$(I,J):NEXT J
1260 NEXT I
1270 GOTO 1120
1280 WIDTH 40:SCREEN 0:COLOR 4,2,6:CLS:LOCATE 15,15:PRINT "THE END !!!"
1290 FOR I=1 TO 3000:NEXT I:WIDTH 80:SCREEN 0:COLOR 6,0,0:CLS
1300 CHAIN "B:CONTROL",600
```

PAIRCOMP.BAS

```
10 KEY OFF:COLOR 6,0,0:CLS
20 REM  This program allows the members of a project evaluation committee to
30 REM
40 REM  individually participate in a series of paired-comparisons for the
50 REM
60 REM  purpose of determining a ratio-scaled weighting factor for each of the
70 REM
80 REM  strategic (or non-monetary) attributes in a multi-attribute decision
90 REM
100 REM  model. The responses of each committee member are recorded on disk and
110 REM
120 REM  recalled in another program which aggregates the individual responses
130 REM
140 REM  into a matrix format.  The matrix of aggregated results serves as the
150 REM
160 REM  input for the DUNN-RANKIN procedure, which computes a ratio-scaled
170 REM
180 REM  weighting factor for each of the attributes.
190 REM
200 REM
210 REM  Each member of the evaluation committee will be called on to make a
220 REM
230 REM  total of  ((N*(N-1))/2)  paired-comparisons — N being the number of
240 REM
250 REM  attributes utilized in the evaluation.  For example, if 10 attributes
260 REM
270 REM  to be used in a strategic evaluation:  ((10*(9))/2) = 45  paired-
280 REM
290 REM  comparisons are necessary.
300 REM
310 REM
320 REM
330 CLS:LOCATE 10,26:PRINT "PAIRED-COMPARISONS PROGRAM"
340 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
350 WIDTH 40:COLOR 6,0,0:CLS
360 PRINT "THIS PROGRAM ALLOWS THE MEMBERS OF AN"
370 PRINT
380 PRINT "EVALUATION COMMITTEE TO PARTICIPATE IN"
390 PRINT
400 PRINT "A SERIES OF PAIRED-COMPARISONS FOR THE"
410 PRINT
420 PRINT "PURPOSE OF DETERMINING RATIO-SCALED"
430 PRINT
440 PRINT "WEIGHTING FACTORS FOR THE STRATEGIC"
450 PRINT
460 PRINT "BENEFITS IN A MULTI-ATTRIBUTE DECISION"
470 PRINT
480 PRINT "MODEL. YOU WILL FIRST BE GIVEN A LIST"
490 PRINT
500 PRINT "OF THE ATTRIBUTES AND DEFINITIONS."
```

```
510 PRINT
520 PRINT "THESE DEFINITIONS WILL PLAY A VITAL"
530 PRINT
540 PRINT "ROLE IN THE PAIRED-COMPARISONS PROGRAM."
550 PRINT
560 PRINT "    ( Press any key to continue )":H$=INPUT$(1):CLS
570 PRINT "BASED ON THE DEFINITIONS PROVIDED, YOU"
580 PRINT
590 PRINT "MUST DECIDE WHICH OF THE ATTRIBUTES"
600 PRINT
610 PRINT "PRESENTED IN EACH PAIR IS MORE CRITICAL"
620 PRINT
630 PRINT "IN ATTAINING THE STRATEGIC OBJECTIVES"
640 PRINT
650 PRINT "OF YOUR ORGANIZATION. IN THE PAIRED-"
660 PRINT
670 PRINT "COMPARISONS PROCEDURE, A PAIR OF"
680 PRINT
690 PRINT "ATTRIBUTES WILL APPEAR ON THE SCREEN IN"
700 PRINT
710 PRINT "THE FOLLOWING MANNER :"
720 PRINT
730 PRINT
740 PRINT "  A : LEAD TIME  vs  B : QUALITY"
750 PRINT
760 PRINT "    ( Press any key to continue )":H$=INPUT$(1):CLS
770 PRINT "  A : LEAD TIME  vs  B : QUALITY":PRINT
780 PRINT "IF YOU BELIEVE THAT  'LEAD TIME ' IS"
790 PRINT
800 PRINT "THE MORE IMPORTANT OF THE ATTRIBUTES IN"
810 PRINT
820 PRINT "THE PAIR, ENTER THE LETTER  'A '.  IF"
830 PRINT
840 PRINT "'QUALITY ' IS THE MORE CRITICAL OF THE"
850 PRINT
860 PRINT "TWO, ENTER THE LETTER 'B '. YOU WILL BE"
870 PRINT
880 PRINT "REQUIRED TO MAKE A DECISION FOR EACH"
890 PRINT
900 PRINT "POSSIBLE PAIR OF ATTRIBUTES SHOWN ON"
910 PRINT
920 PRINT "YOUR PRINTOUT. AFTER YOU HAVE COMPLETED"
930 PRINT
940 PRINT "THIS PROCESS, YOUR DECISIONS WILL BE"
950 PRINT
960 PRINT "CHECKED FOR ANY LOGICAL INCONSISTENCIES."
970 PRINT "    ( Press any key to continue )":H$=INPUT$(1):CLS
980 PRINT " EXAMPLE OF A LOGICAL INCONSISTENCY :"
990 PRINT
1000 PRINT "     a > b     b > c     a < c"
1010 PRINT
1020 PRINT "THE RELATIONSHIPS BETWEEN THE ABOVE"
```

```
1030 PRINT
1040 PRINT "VARIABLES ARE MATHEMATICALLY IMPOSSIBLE."
1050 PRINT "IF YOU ARE GUILTY OF SUCH ERRORS, YOU"
1060 PRINT
1070 PRINT "WILL BE ASKED TO MAKE A NEW SET OF"
1080 PRINT
1090 PRINT "DECISIONS REGARDING THE ATTRIBUTES"
1100 PRINT
1110 PRINT "INVOLVED. AFTER YOU HAVE COMPLETED THE"
1120 PRINT
1130 PRINT "PAIRED-COMPARISON PROCEDURE AND ALL"
1140 PRINT
1150 PRINT "INCONSISTENCIES HAVE BEEN CORRECTED,"
1160 PRINT
1170 PRINT "THE RESPONSES WILL BE WRITTEN TO A DISK."
1180 PRINT "    ( Press any key to continue )":H$=INPUT$(1):CLS
1190 PRINT "   BEFORE ATTEMPTING TO EXECUTE THIS"
1200 PRINT
1210 PRINT "PROGRAM, CHECK TO SEE THAT THE DISK"
1220 PRINT
1230 PRINT "CONTAINING THE DATA FILES IS IN DRIVE"
1240 PRINT
1250 PRINT "'B '. IF THIS DISK IS NOT IN PLACE,"
1260 PRINT
1270 PRINT "TERMINATE THIS PROGRAM IMMEDIATELY BY"
1280 PRINT
1290 PRINT "SIMULTANEOUSLY DEPRESSING THE CONTROL"
1300 PRINT
1310 PRINT "(Ctrl) KEY AND THE BREAK (Scroll Lock)"
1320 PRINT
1330 PRINT "KEY. THIS PROGRAM WILL NOT EXECUTE"
1340 PRINT
1350 PRINT "PROPERLY WITHOUT THE  'DATA DISK ' IN"
1360 PRINT
1370 PRINT "DRIVE  'B ' !!!!!!!!!!!!!!!!!!!!!!!"
1380 PRINT
1390 PRINT "    ( Press any key to continue )":H$=INPUT$(1):CLS
1400 DIM A$(10),C$(10),B$(10,4),M(10,10),R(10),P(50),S(50)
1410 OPEN "B:ATTRIB" FOR INPUT AS #1
1420 INPUT#1,N
1430 FOR I=1 TO N
1440 INPUT#1,A$(I),C$(I)
1450 FOR J=1 TO 4:INPUT#1,B$(I,J):NEXT J:NEXT I
1460 CLOSE#1
1470 CLS:LPRINT CHR$(10):FOR I=1 TO N:LPRINT CHR$(10)
1480 LPRINT TAB(5) A$(I) TAB(60) C$(I)
1490 FOR J=1 TO 4:LPRINT B$(I,J)
1500 NEXT J:NEXT I:LPRINT CHR$(12)
1510 REM
1520 REM
1530 REM  PAIRED-COMPARISON PROCEDURE BEGINS HERE !!!!!!!!!!!!!!!!!!!!!!!!
1540 REM
```

```
1550 REM
1560 FOR I=1 TO N:FOR J=I+1 TO N
1570 CLS:PRINT "A: ";A$(I);" vs B: ";A$(J)
1580 PRINT:PRINT "WHICH IS MORE IMPORTANT ? ( A  or  B )"
1590 INPUT "",Z$:IF Z$="A" OR Z$="a" OR Z$="B" OR Z$="b" GOTO 1630
1600 PRINT:PRINT "YOU MUST ENTER EITHER AN  'A' or a 'B'"
1610 PRINT:PRINT "THESE ARE THE ONLY ALLOWABLE ENTRIES !"
1620 FOR H=1 TO 10:BEEP:NEXT H:CLS:GOTO 1570
1630 CLS:IF Z$="B" OR Z$="b" GOTO 1660
1640 M(I,J)=1:M(J,I)=0:PRINT A$(I);" IS MORE IMPORTANT":PRINT "   THAN ";A$(J)
1650 PRINT:PRINT "  IS THIS CORRECT ?  ( Y  or  N )":INPUT "",Y$:GOTO 1680
1660 M(I,J)=0:M(J,I)=1:PRINT A$(J);" IS MORE IMPORTANT":PRINT "   THAN ";A$(I)
1670 PRINT:PRINT "  IS THIS CORRECT ?  ( Y  or  N )":INPUT "",Y$
1680 IF Y$="Y" OR Y$="y" OR Y$="N" OR Y$="n" GOTO 1700
1690 GOTO 1630
1700 IF Y$="N" OR Y$="n" GOTO 1570
1710 NEXT J:NEXT I
1720 REM
1730 REM
1740 REM   >>>>>>>>>>>> CHECK FOR LOGICAL INCONSISTENCIES <<<<<<<<<<<<
1750 REM
1760 REM
1770 FOR I=1 TO N:R(I)=0:NEXT I
1780 FOR I=1 TO N:FOR J=1 TO N:R(I)=R(I)+M(I,J):NEXT J:NEXT I:T=0
1790 CLS
1800 FOR I=1 TO N:FOR J=I+1 TO N
1810 IF R(I)=R(J) GOTO 1820 ELSE GOTO 1840
1820 PRINT "INCONSISTENCY !!!!!!!!!!!!!!!!":FOR E=1 TO 3:BEEP:NEXT E
1830 T=T+1:P(T)=I:S(T)=J
1840 CLS
1850 NEXT J:NEXT I
1860 CLS:PRINT "A PRINTOUT OF THE RANK ORDERING OF THE"
1870 PRINT:PRINT "ATTRIBUTES WILL NOW BE PROVIDED.":PRINT
1880 PRINT:PRINT "CHECK TO SEE THAT THE PRINTER IS 'ON'
1890 PRINT:PRINT "LINE' AND THE PAPER IS PROPERLY ALIGNED."
1900 PRINT:PRINT:PRINT:PRINT "  ( Press any key to continue )":Z$=INPUT$(1):CLS
1910 FOR I=1 TO N:AAA(I)=0:NEXT I
1920 FOR I=1 TO N:FOR J=1 TO N:AAA(I)=AAA(I)+M(I,J):NEXT J:NEXT I
1930 FOR I=1 TO N:BBB(I)=N-AAA(I):NEXT I
1940 LPRINT TAB(10) "RANK ORDERING OF THE ATTRIBUTES, AS PER YOUR INPUT"
1950 LPRINT TAB(10) "------------------------------------------------------"
1960 LPRINT TAB(10) "ATTRIBUTE" TAB(50) "RANKING"
1970 LPRINT TAB(10) "---------" TAB(50) "-------"
1980 FOR I=1 TO N:LPRINT TAB(10) A$(I) TAB(53) BBB(I):NEXT I:LPRINT CHR$(12)
1990 PRINT:PRINT:PRINT "     PLEASE REMOVE THE PRINTOUT":PRINT:PRINT:PRINT
2000 PRINT:PRINT "    ( Press any key to continue )":Z$=INPUT$(1):CLS
2010 IF T<1 THEN 2850
2020 CLS:PRINT "LOGICAL INCONSISTENCIES HAVE BEEN FOUND"
2030 PRINT:PRINT "AMONG YOUR PAIRED-COMPARISONS.  A LIST"
2040 PRINT:PRINT "OF THE RANK-ORDERING OF THE ATTRIBUTES"
2050 PRINT:PRINT "AS PER YOUR INPUT HAS BEEN PROVIDED."
2060 PRINT:PRINT "YOU MAY MAKE CORRECTIONS BY ONE OF TWO"
```

```
2070 PRINT:PRINT "METHODS:"
2080 PRINT:PRINT " 1. CONTINUE WITH THE PAIRED-COMPARISON"
2090 PRINT:PRINT "    PROCEDURE"
2100 PRINT:PRINT " 2. COMPLETE THE PROCEDURE BY RANK"
2110 PRINT:PRINT "    ORDERING THE ATTRIBUTES"
2120 PRINT:PRINT:PRINT "    ( Press any key to continue )":Z$=INPUT$(1):CLS
2130 PRINT "COMPLETING THE PAIRED-COMPARISONS"
2140 PRINT:PRINT "PROCEDURE MAY PROVE TO BE A CUMBERSOME"
2150 PRINT:PRINT "TASK.  WHEN CORRECTING AN INCONSISTENCY"
2160 PRINT:PRINT "YOU MAY CREATE NEW LOGIC PROBLEMS.  THE"
2170 PRINT:PRINT "ENTIRE PROCEDURE MAY REQUIRE SEVERAL"
2180 PRINT:PRINT "ITERATIONS.  FOR THIS REASON, THE USER"
2190 PRINT:PRINT "SHOULD CONSIDER USING THE RANK ORDERING"
2200 PRINT:PRINT "PROCEDURE IF MORE THAN THREE ITERATIONS"
2210 PRINT:PRINT "ARE NECESSARY."
2220 PRINT:PRINT:PRINT:PRINT "  ( Press any key to continue )":Z$=INPUT$(1):CLS
2230 CLS:PRINT "YOU MUST NOW SELECT BETWEEN 2 OPTIONS:"
2240 PRINT:PRINT " 1. COMPLETE THE PAIRED-COMPARISONS"
2250 PRINT:PRINT "    PROCEDURE"
2260 PRINT:PRINT " 2. TRANSFER TO THE RANK ORDERING"
2270 PRINT:PRINT "    PROCEDURE"
2280 PRINT:PRINT "INPUT YOUR CHOICE  ( 1  or  2 )";
2290 INPUT CHOICE:IF CHOICE=1 OR CHOICE=2 THEN 2310
2300 GOTO 2230
2310 IF CHOICE=1 THEN 2330
2320 CHAIN "B:RANKING"
2330 CLS:PRINT "INCONSISTENCIES EXIST AMONG THESE"
2340 PRINT "ATTRIBUTES :"
2350 FOR K=1 TO T:I=P(K):J=S(K):PRINT:PRINT A$(I);" AND ";A$(J):NEXT K
2360 PRINT "       ( Press any key to continue )"
2370 H$=INPUT$(1):CLS:PRINT:PRINT:PRINT:PRINT "     YOU STATED THE FOLLOWING :"
2380 LPRINT CHR$(10)
2390 LPRINT TAB(20) "YOU STATED THE FOLLOWING:":LPRINT CHR$(10):LPRINT CHR$(10)
2400 FOR K=1 TO T:I=P(K):J=S(K)
2410 IF M(I,J)=0 GOTO 2440
2420 PRINT A$(I);" IS MORE IMPORTANT":PRINT "   THAN ";A$(J)
2430 LPRINT A$(I);" IS MORE IMPORTANT THAN ";A$(J):GOTO 2460
2440 PRINT A$(J);" IS MORE IMPORTANT":PRINT "   THAN ";A$(I)
2450 LPRINT A$(J);" IS MORE IMPORTANT THAN ";A$(I)
2460 PRINT:LPRINT CHR$(10)
2470 NEXT K
2480 LPRINT CHR$(12)
2490 PRINT:PRINT "  ( Press any key to continue )":H$=INPUT$(1):CLS
2500 PRINT
2510 PRINT "   YOU MUST NOW CORRECT THE LOGICAL"
2520 PRINT
2530 PRINT "INCONSISTENCIES THAT EXIST IN YOUR"
2540 PRINT
2550 PRINT "DECISIONS. A LISTING OF YOUR DECISIONS"
2560 PRINT
2570 PRINT "WHICH RESULTED IN INCONSISTENCIES HAS"
2580 PRINT
```

```
2590 PRINT "BEEN PROVIDED. YOU SHOULD CAREFULLY"
2600 PRINT
2610 PRINT "EXAMINE BOTH THE LISTING OF ATTRIBUTES"
2620 PRINT
2630 PRINT "AND THE LISTING OF INCONSISTENCIES AS"
2640 PRINT
2650 PRINT "YOU MAKE THE NECESSARY CORRECTIONS."
2660 PRINT
2670 PRINT "   ( Press any key to continue )":H$=INPUT$(1):CLS
2680 FOR K=1 TO T:I=P(K):J=S(K)
2690 CLS:PRINT "A: ";A$(I);" vs B: ";A$(J):PRINT
2700 PRINT "WHICH IS MORE IMPORTANT ?  ( A  or  B )";
2710 INPUT "",Z$:IF Z$="A" OR Z$="a" OR Z$="B" OR Z$="b" GOTO 2750
2720 PRINT:PRINT "YOU MUST ENTER AN  'A ' or a  'B ' !!!"
2730 PRINT:PRINT "THESE ARE THE ONLY ALLOWABLE ENTRIES !"
2740 FOR H=1 TO 10:BEEP:NEXT H:CLS:GOTO 2690
2750 CLS:IF Z$="B" OR Z$="b" GOTO 2780
2760 M(I,J)=1:M(J,I)=0:PRINT A$(I);" IS MORE IMPORTANT":PRINT "   THAN ";A$(J)
2770 PRINT:PRINT "IS THIS CORRECT ???  ( Y  or  N )":INPUT "",Y$:GOTO 2800
2780 M(I,J)=0:M(J,I)=1:PRINT A$(J);" IS MORE IMPORTANT":PRINT "   THAN ";A$(I)
2790 PRINT:PRINT "IS THIS CORRECT ???  ( Y  or  N )":INPUT "",Y$
2800 IF Y$="Y" OR Y$="y" OR Y$="N" OR Y$="n" GOTO 2820
2810 GOTO 2750
2820 IF Y$="N" OR Y$="n" GOTO 2690
2830 NEXT K
2840 GOTO 1720
2850 OPEN "B:COUNTER" FOR INPUT AS #1
2860 INPUT#1,USERNUM
2870 CLOSE#1
2880 USERNUM=USERNUM+1
2890 OPEN "B:COUNTER" FOR OUTPUT AS #1
2900 WRITE#1,USERNUM
2910 CLOSE#1
2920 FILE$="B:DNRANK"
2930 Z$=STR$(USERNUM):ZIP=LEN(Z$)-1
2940 Y$=RIGHT$(Z$,ZIP)
2950 XYZ$=FILE$+Y$
2960 OPEN XYZ$ FOR OUTPUT AS #1
2970 FOR I=1 TO N:FOR J=1 TO N:WRITE#1,M(I,J):NEXT J:NEXT I
2980 CLOSE#1
2990 WIDTH 80:SCREEN 0:COLOR 6,0,0
3000 CHAIN "B:CONTROL",600
```

RANKING.BAS

```
10 WIDTH 80:KEY OFF:COLOR 6,0,0:CLS
20 DIM A$(15),C$(15),B$(15,4),M(15,15),R(15)
30 FOR I=1 TO 15:A$(I)="":C$(I)="":R(I)=0:FOR J=1 TO 15:M(I,J)=0:NEXT J
40 FOR K=1 TO 4:B$(I,K)="":NEXT K:NEXT I
50 LOCATE 2,9:PRINT "THIS PROGRAM PROVIDES AN ALTERNATIVE MEANS OF CAPTURING"
60 LOCATE 4,9:PRINT "THE INDIVIDUAL VIEWS OF THE COMMITTEE MEMBERS REGARDING"
70 LOCATE 6,9:PRINT "THE PROPER RANK ORDERING OF THE NON-MONETARY ATTRIBUTES,"
80 LOCATE 8,9:PRINT "IN TERMS OF STRATEGIC IMPORTANCE.  THIS IS ACCOMPLISHED"
90 LOCATE 10,9:PRINT "BY A RANKING FROM ONE TO  'N'  (where N = the number of"
100 LOCATE 12,9:PRINT "attributes)  OF THE ATTRIBUTES.  THE ATTRIBUTES SHOULD"
110 LOCATE 14,9:PRINT "BE RANKED IN ORDER OF DECREASING IMPORTANCE, WITH THE"
120 LOCATE 16,9:PRINT "MOST IMPORTANT GIVEN A RANK OF ONE."
130 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
140 LOCATE 2,36:PRINT "EXAMPLE":LOCATE 3,36:PRINT "-------"
150 LOCATE 5,9:PRINT "THREE ATTRIBUTES -- FLEXIBILITY, SECURITY, AND INTEGRITY"
160 LOCATE 8,20:PRINT "ATTRIBUTE" TAB(50) "RANKING"
170 LOCATE 9,20:PRINT "---------" TAB(50) "-------"
180 LOCATE 11,20:PRINT "FLEXIBILITY" TAB(53) "1"
190 LOCATE 13,20:PRINT "SECURITY" TAB(53) "3"
200 LOCATE 15,20:PRINT "INTEGRITY" TAB(53) "2"
210 LOCATE 18,9:PRINT "THIS INDICATES THAT THE MOST IMPORTANT ATTRIBUTE IS ";
220 PRINT "'FLEXIBILITY',"
230 LOCATE 19,9:PRINT "AND 'SECURITY' IS THE LEAST IMPORTANT."
240 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
250 LOCATE 2,9:PRINT "THIS RANK ORDERING OF THE ATTRIBUTES WILL BE TRANSFORMED"
260 LOCATE 4,9:PRINT "INTO MATRIX FORM, AND CAN THEN SERVE AS A PORTION OF THE"
270 LOCATE 6,9:PRINT "INPUT TO COMPUTE THE WEIGHTING FACTORS FOR EACH OF THE"
280 LOCATE 8,9:PRINT "ATTRIBUTES.  "
290 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
300 OPEN "B:ATTRIB" FOR INPUT AS #1
310 INPUT#1,N
320 FOR I=1 TO N:INPUT#1,A$(I),C$(I):FOR J=1 TO 4:INPUT #1,B$(I,J)
330 NEXT J:NEXT I:CLOSE#1
340 LOCATE 2,9:PRINT "A WORKSHEET WILL NOW BE PROVIDED TO ASSIST WITH THE RANK"
350 LOCATE 4,9:PRINT "ORDERING PROCEDURE.  PLEASE CHECK TO SEE THAT THE PRINTER
360 LOCATE 6,9:PRINT "IS  'ON-LINE' AND THAT THE PAPER IS PROPERLY ALIGNED."
370 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
380 LPRINT CHR$(10):LPRINT TAB(17) "ATTRIBUTE NAME" TAB(50) "RANKING"
390 LPRINT TAB(17) "^^^^^^^^^^^^^^^" TAB(50) "^^^^^^^"
400 LPRINT CHR$(10):FOR I=1 TO N:LPRINT TAB(15) A$(I) TAB(50) "_______"
410 LPRINT CHR$(10):NEXT I:LPRINT CHR$(12)
420 LOCATE 9,25:PRINT "REMOVE WORKSHEET FROM PRINTER."
430 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
440 LOCATE 2,9:PRINT "PLEASE RANK THE ATTRIBUTES (on your worksheet) IN ORDER"
450 LOCATE 4,9:PRINT "DECREASING IMPORTANCE.  THE MOST IMPORTANT ATTRIBUTE"
460 LOCATE 6,9:PRINT "SHOULD BE GIVEN A RANK OF ONE, AND THE LEAST IMPORTANT"
470 LOCATE 8,9:PRINT "SHOULD BE GIVEN A RANK OF ";N;". TIES BETWEEN ATTRIBUTES"
480 COLOR 3,0,0
490 LOCATE 9,9:PRINT "                                        ----------------------"
500 COLOR 6,0,0
510 LOCATE 10,9:PRINT "WILL NOT BE ALLOWED."
```

```
520 COLOR 3,0,0:LOCATE 11,9:PRINT "————————————————":COLOR 6,0,0
530 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
540 COLOR 2,0,0:LOCATE 10,20:PRINT "PLEASE COMPLETE THE RANK ORDERING OF THE"
550 LOCATE 12,17:PRINT "ATTRIBUTES ON YOUR WORKSHEET BEFORE CONTINUING."
560 FOR I=1 TO 2:BEEP:NEXT I
570 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):COLOR 6,0,0
580 CLS
590 LOCATE 2,9:PRINT "YOU WILL NOW BE REQUIRED TO INPUT THE RANKINGS FOR EACH"
600 LOCATE 4,9:PRINT "OF THE ATTRIBUTES.  THE ATTRIBUTES WILL APPEAR ON SCREEN"
610 LOCATE 6,9:PRINT "ONE AT A TIME.  AT THE PROMPT  ( ? )  ENTER THE RANKING"
620 LOCATE 8,9:PRINT "OF THE ATTRIBUTE."
630 LOCATE 15,20:PRINT "ARE YOU READY TO BEGIN  ( Y or N ) ";
640 INPUT Z$:IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" THEN 670
650 LOCATE 15,20:PRINT "                                                    "
660 GOTO 630
670 IF Z$="Y" OR Z$="y" THEN 690
680 CLS:GOTO 440
690 FOR I=1 TO N
700 CLS:LOCATE 5,15:PRINT "INPUT THE RATING FOR ";A$(I);"   ";
710 INPUT R(I)
720 LOCATE 9,15:PRINT "THE RATING FOR ";A$(I);" IS ";R(I)
730 LOCATE 11,15:PRINT "IS THIS CORRECT  ( Y or N ) ";
740 INPUT Z$:IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" THEN 760
750 LOCATE 11,15:PRINT "                                        ":GOTO 730
760 IF Z$="Y" OR Z$="y" THEN 780
770 GOTO 700
780 REM
790 NEXT I
800 CLS
810 CH=0
820 FOR I=1 TO N:FOR J=I+1 TO N:IF R(I)=R(J) THEN 840
830 GOTO 850
840 CH=CH+1
850 REM  DUMMY LINE
860 NEXT J:NEXT I
870 IF CH=0 THEN 1030
880 LOCATE 5,9:PRINT "YOU HAVE GIVEN TWO OR MORE ATTRIBUTES IDENTICAL RATINGS."
890 LOCATE 7,9:PRINT "AS STATED PREVIOUSLY, TIES BETWEEN ATTRIBUTES ARE NOT"
900 LOCATE 9,9:PRINT "ALLOWED. YOU WILL RECEIVE A PRINTOUT OF YOUR RESPONSES."
910 LOCATE 11,9:PRINT "YOU MUST MAKE THE NECESSARY CHANGES TO YOUR RANKINGS"
920 LOCATE 13,9:PRINT "TO ENSURE THAT NO TWO ATTRIBUTES HAVE THE SAME RANK."
930 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
940 LOCATE 3,23:PRINT "ATTRIBUTES WITH IDENTICAL RANKINGS"
950 LOCATE 4,23:PRINT "————————————————————————————"
960 LOCATE 6,20:PRINT "ATTRIBUTE" TAB(55) "RANKING"
970 LOCATE 7,20:PRINT "^^^^^^^^^^" TAB(55) "^^^^^^^^"
980 FOR I=1 TO N:FOR J=I+1 TO N: IF R(I)=R(J) THEN 1000
990 GOTO 1010
1000 PRINT TAB(20) A$(I) TAB(57) R(I):PRINT TAB(20) A$(J) TAB(57) R(J):PRINT
1010 REM  DUMMY LINE
1020 NEXT J:NEXT I
1030 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
```

```
1040 FOR I=1 TO N:FOR J=1 TO N:M(I,J)=0:NEXT J:NEXT I
1050 FOR I=1 TO N:FOR J=I+1 TO N:IF R(I)>R(J) THEN M(I,J)=0
1060 IF R(I)<R(J) THEN M(I,J)=1
1070 NEXT J:NEXT I
1080 FOR I=1 TO N:FOR J=1 TO N:IF M(I,J)=1 THEN M(J,I)=0
1090 IF M(I,J)=0 THEN M(J,I)=1
1100 IF I=J THEN M(I,J)=0
1110 NEXT J:NEXT I
1120 LOCATE 3,9:PRINT "A LIST OF YOUR RESPONSES WILL NOW BE PROVIDED. PLEASE"
1130 LOCATE 5,9:PRINT "CHECK TO SEE THAT THE PRINTER IS  'ON-LINE'  AND THE"
1140 LOCATE 7,9:PRINT "PAPER IS PROPERLY ALIGNED BEFORE PROCEEDING."
1150 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
1160 LPRINT CHR$(10):LPRINT TAB(17) "ATTRIBUTE NAME" TAB(50) "RANKING"
1170 LPRINT TAB(17) "^^^^^^^^^^^^^^^" TAB(50) "^^^^^^^^"
1180 LPRINT CHR$(10):FOR I=1 TO N:LPRINT TAB(15) A$(I) TAB(53) R(I)
1190 LPRINT CHR$(10):NEXT I:LPRINT CHR$(12)
1200 LOCATE 9,18:PRINT "REMOVE LISTING OF RESULTS FROM PRINTER."
1210 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1)
1220 CLS
1230 LOCATE 3,9:PRINT "YOU WILL NOW BE GIVEN THE OPPORTUNITY TO CHANGE ANY OR"
1240 LOCATE 5,9:PRINT "ALL OF YOUR RANKINGS.  WOULD YOU LIKE TO CHANGE ANY OF"
1250 LOCATE 7,9:PRINT "YOUR RANKINGS  ( Y or N ) ";
1260 INPUT Z$:IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" THEN 1280
1270 GOTO 1220
1280 IF Z$="Y" OR Z$="y" THEN 690
1290 CH=0
1300 FOR I=1 TO N:FOR J=I+1 TO N:IF R(I)=R(J) THEN 1320
1310 GOTO 1330
1320 CH=CH+1
1330 REM  DUMMY LINE
1340 NEXT J:NEXT I
1350 IF CH=0 THEN 1370
1360 GOTO 800
1370 COLOR 2,0,0:LOCATE 9,20:PRINT "RESPONSES ARE NOW BEING WRITTEN TO DISK."
1380 LOCATE 12,30:PRINT "PLEASE BE PATIENT":COLOR 6,0,0
1390 OPEN "B:COUNTER" FOR INPUT AS #1
1400 INPUT#1,USERNUM
1410 CLOSE#1
1420 USERNUM=USERNUM+1
1430 OPEN "B:COUNTER" FOR OUTPUT AS #1
1440 WRITE#1,USERNUM
1450 CLOSE#1
1460 FILE$="B:DNRANK"
1470 Z$=STR$(USERNUM):ZIP=LEN(Z$)-1
1480 Y$=RIGHT$(Z$,ZIP)
1490 XYZ$=FILE$+Y$
1500 OPEN XYZ$ FOR OUTPUT AS #1
1510 FOR I=1 TO N:FOR J=1 TO N:WRITE#1,M(I,J):NEXT J:NEXT I
1520 CLOSE#1
1530 WIDTH 40:COLOR 3,0,0:CLS:LOCATE 6,16:PRINT "THE END"
1540 FOR I=1 TO 3500:NEXT I:WIDTH 80:COLOR 6,0,0:CLS
1550 CHAIN "B:CONTROL",600
```

SCORING.BAS

```
10 KEY OFF:COLOR 6,0,0:CLS
20 DIM A$(15),C$(15),B$(15,5),D$(10),S(15,10)
30 REM
40 REM   THE PURPOSE OF THIS PROGRAM IS TO ALLOW THE MEMBERS OF AN EVALUATION
50 REM
60 REM   TEAM TO RATE THE PERFORMANCE OF A GROUP OF MUTUALLY EXCLUSIVE ALTER-
70 REM
80 REM   NATIVES AGAINST THE REQUIREMENTS OF A SET OF STRATEGIC ATTRIBUTES.
90 REM
100 OPEN "B:ATTRIB" FOR INPUT AS #1
110 INPUT#1,N
120 FOR I=1 TO N:INPUT#1,A$(I),C$(I):FOR J=1 TO 4:INPUT#1,B$(I,J):NEXT J:NEXT I
130 CLOSE#1
140 OPEN "B:ALTER" FOR INPUT AS #1
150 INPUT#1,M
160 FOR I=1 TO M:INPUT#1,D$(I),E$(I):NEXT I:CLOSE#1
170 CLS:LOCATE 10,26:PRINT "RATING  ( SCORING )  PROGRAM"
180 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
190 CLS:PRINT TAB(10) "ENTER YOUR LAST NAME"
200 INPUT NAM$:CLS
210 PRINT "THIS PROGRAM WILL ALLOW THE MEMBERS OF AN EVALUATION COMMITTEE"
220 PRINT:PRINT "TO RATE THE PERFORMANCE OF A GROUP OF MUTUALLY EXCLUSIVE"
230 PRINT:PRINT "ALTERNATIVES AGAINST THE REQUIREMENTS OF A SET OF STRATEGIC"
240 PRINT:PRINT "ATTRIBUTES.  A SCORING SCALE RANGING FROM  + 5  TO  - 5  WILL"
250 PRINT:PRINT "BE UTILIZED TO RATE EACH ALTERNATIVE AGAINST EACH ATTRIBUTE."
260 PRINT:PRINT "YOU ARE TO ENTER AN INTEGER VALUE BETWEEN  +/- 5 FOR EACH SET"
270 PRINT:PRINT "OF ONE ALTERNATIVE AND ONE ATTRIBUTE. A PRINTOUT OF THE SCALE"
280 PRINT:PRINT "WILL BE PROVIDED, ALONG WITH A PRINTOUT OF THE LIST OF THE"
290 PRINT:PRINT "ATTRIBUTES AND THEIR DEFINITIONS, AS WELL AS THE ALTERNATIVES"
300 PRINT:PRINT "IF YOU SO DESIRE."
310 PRINT:PRINT "     DO YOU WISH TO RECEIVE A LISTING OF THE ALTERNATIVES AND"
320 PRINT:PRINT "         THE ATTRIBUTES      ( enter  'Y'  or  'N' )"
330 INPUT Z$
340 IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" GOTO 370
350 CLS:PRINT "  YOU MUST ENTER EITHER A  'Y'  OR A  'N' !!!!!!!"
360 FOR I=1 TO 9:BEEP:NEXT I:CLS:GOTO 310
370 COLOR 6,1,1
380 CLS:PRINT "THIS PORTION OF THE PROGRAM REQUIRES THE USE OF A PRINTER."
390 PRINT:PRINT "BEFORE CONTINUING WITH THE EXECUTION OF THIS PROGRAM, CHECK"
400 PRINT:PRINT "TO SEE THAT THE PRINTER IS  'ON LINE '  AND THE PAPER IS"
410 PRINT:PRINT "PROPERLY ALIGNED.":PRINT:PRINT:PRINT
420 COLOR 22,1,1:PRINT TAB(20) "( Press any key to continue )":Y$=INPUT$(1):CLS
430 COLOR 6,0,0:CLS
440 IF Z$="N" OR Z$="n" GOTO 490
450 LPRINT CHR$(10)
460 FOR I=1 TO N:LPRINT A$(I):FOR J=1 TO 4:LPRINT B$(I,J):NEXT J:LPRINT:NEXT I
470 LPRINT CHR$(12):FOR I=1 TO M:LPRINT "ALTERNATIVE #";I,D$(I):LPRINT:NEXT I
480 LPRINT CHR$(12)
490 LPRINT "                              SCORING SCALE":LPRINT
500 LPRINT "   5 : EXTREMELY BENEFICIAL TO MEETING THE FIRM'S STRATEGIC GOALS"
```

```
510 LPRINT
520 LPRINT "   3 : BENEFICIAL TO MEETING THE FIRM'S STRATEGIC GOALS"
530 LPRINT
540 LPRINT "   1 : SLIGHTLY BENEFICIAL TO MEETING THE FIRM'S STRATEGIC GOALS"
550 LPRINT
560 LPRINT "   0 : NEITHER BENEFICIAL NOR DETRIMENTAL  ( INDIFFERENT )"
570 LPRINT
580 LPRINT " - 1 : SLIGHTLY DETRIMENTAL TO MEETING THE FIRM'S STRATEGIC GOALS"
590 LPRINT
600 LPRINT " - 3 : DETRIMENTAL TO MEETING THE FIRM'S STRATEGIC GOALS"
610 LPRINT
620 LPRINT " - 5 : EXTREMELY DETRIMENTAL TO MEETING THE FIRM'S STRATEGIC GOALS"
630 LPRINT:LPRINT:LPRINT
640 LPRINT "    ENTRIES OTHER THAN THOSE SHOWN ( eg.  4,   -2,   etc. )":LPRINT
650 LPRINT "ARE ALLOWABLE, SO LONG AS THEY ARE INTEGERS IN THE RANGE  5 to -5"
660 LPRINT CHR$(12)
670 CLS
680 PRINT:PRINT "       REMOVE THE PRINTOUTS !!!!!!!!!!!!!!!!!!":FOR I=1 TO 2
690 BEEP:NEXT I:PRINT:PRINT:PRINT:PRINT TAB(25) "( Press any key to continue )"
700 Z$=INPUT$(1):CLS
710 REM
720 REM   INSTRUCTIONS FOR RATING THE PERFORMANCE OF THE ALTERNATIVES AGAINST
730 REM
740 REM                      EACH OF THE ATTRIBUTES
750 REM
760 PRINT "IN ORDER TO RATE THE ALTERNATIVES AGAINST THE ATTRIBUTES, YOU"
770 PRINT:PRINT "MUST DETERMINE A  'SCORE '  FOR EACH ALTERNATIVE's ABILITY TO"
780 PRINT:PRINT "MEET THE CRITERIA OF EACH OF THE ATTRIBUTES.  TO ACCOMPLISH"
790 PRINT:PRINT "THIS, YOU WILL BE GIVEN ONE ATTRIBUTE AND ONE ALTERNATIVE AND"
800 PRINT:PRINT "INSTRUCTED TO INPUT AN INTEGER VALUE IN THE RANGE  -5  to  +5"
810 PRINT:PRINT "WHICH BEST DESCRIBES YOUR PERCEPTION OF THAT ALTERNATIVES"
820 PRINT:PRINT "PERFORMANCE AGAINST THAT  ATTRIBUTE.  ONLY INTEGER VALUES IN"
830 COLOR 18,0,0
840 PRINT "                                          ————————————————————"
850 COLOR 6,0,0
860 PRINT "THE RANGE  -5  to  +5  WILL BE ALLOWED."
870 COLOR 18,0,0
880 PRINT "————————————————————————————————————————"
890 COLOR 6,0,0
900 PRINT:PRINT "FOR POSITIVE VALUES ( >0 ) DO NOT USE THE PLUS ( + ) SIGN !!"
910 COLOR 18,0,0
920 PRINT "————————————————————————————————————————————————————————————————"
930 COLOR 6,0,0
940 PRINT:PRINT:PRINT TAB(25) "( Press any key to continue )":Z$=INPUT$(1):CLS
950 PRINT "  ONE ATTRIBUTE AND ONE ALTERNATIVE WILL BE GIVEN AS FOLLOWS:":PRINT
960 PRINT:PRINT:PRINT TAB(10) "ALTERNATIVE              ATTRIBUTE"
970 PRINT TAB(10) "————————————              ——————————"
980 PRINT TAB(10) "ALTERNATIVE #1           ATTRIBUTE #1"
990 PRINT:PRINT:PRINT " INPUT AN INTEGER RATING IN THE RANGE  -5  to  5":PRINT
1000 PRINT:PRINT:PRINT "THIS PROCEDURE WILL CONTINUE UNTIL YOU HAVE DETERMINED"
1010 PRINT:PRINT "A RATING FOR EACH COMBINATION OF ONE ALTERNATIVE AND"
1020 PRINT:PRINT "ONE ATTRIBUTE."
```

```
1030 PRINT TAB(25) "( Press any key to continue )":Y$=INPUT$(1):CLS
1040 REM
1050 REM                  RATING BEGINS HERE !!!!!!!!!!!!!!!
1060 REM
1070 CLS:PRINT TAB(10) "ARE YOU READY TO BEGIN  ( 'Y '  or  'N ') ":INPUT Y$
1080 IF Y$="Y" OR Y$="y" GOTO 1100
1090 CLS:GOTO 760
1100 FOR I=1 TO N:FOR J=1 TO M
1110 CLS:PRINT "         ALTERNATIVE                    ATTRIBUTE"
1120 PRINT "         ___________                    _________"
1130 PRINT USING "         \                             \";D$(J);
1140 PRINT USING "    \                        \";A$(I):PRINT:PRINT:PRINT:PRINT
1150 PRINT TAB(10) "INPUT AN INTEGER RATING IN THE RANGE  +5  to  -5 ":PRINT
1160 PRINT TAB(10) "WHICH DESCRIBES HOW WELL  '";D$(J);" '":PRINT
1170 PRINT TAB(10) "MEETS THE REQUIREMENTS OF  '";A$(I);" '":PRINT:PRINT:PRINT
1180 PRINT TAB(19) "DO NOT USE THE  +  SIGN "
1190 PRINT TAB(19) "^^^^^^^^^^^^^^^^^^^^^^^^^":INPUT Q$
1200 IF Q$="" GOTO 1150
1210 Q=ASC(Q$):IF (Q>47) AND (Q<58) OR (Q=45) GOTO 1250
1220 CLS:PRINT "YOUR ENTRY IS NOT WITHIN THE ALLOWABLE RANGE":PRINT:PRINT
1230 FOR K=1 TO 3:BEEP:NEXT K
1240 PRINT TAB(25) "( Press any key to continue )":Z$=INPUT$(1):GOTO 1110
1250 Q=VAL(Q$):R=INT(Q):IF R=Q GOTO 1290
1260 CLS:PRINT "YOUR ENTRY MUST BE AN INTEGER !!!!!":FOR K=1 TO 3:BEEP:NEXT K
1270 PRINT:PRINT:PRINT TAB(25) "( Press any key to continue )":Z$=INPUT$(1)
1280 GOTO 1110
1290 IF (Q>=-5) AND (Q<=5) GOTO 1340
1300 CLS:PRINT TAB(10) "YOUR ENTRY ISN NOT IN THE ALLOWABLE RANGE"
1310 FOR K=1 TO 3:BEEP:NEXT K
1320 PRINT:PRINT:PRINT TAB(25) "( Press any key to continue )":Z$=INPUT$(1)
1330 GOTO 1110
1340 S(I,J)=VAL(Q$):NEXT J:NEXT I
1350 CLS
1360 LOCATE 3,9:PRINT "YOU WILL NOW RECEIVE A LISTING OF THE RESULTS OF THE"
1370 LOCATE 5,9:PRINT "RATING PROCEDURE.  CHECK TO SEE THAT THE PRINTER IS 'ON'"
1380 LOCATE 7,9:PRINT "LINE' AND THE PAPER IS PROPERLY ALIGNED."
1390 LOCATE 22,25:PRINT "( Press any key when ready )":Z$=INPUT$(1):CLS
1400 LPRINT CHR$(10):LPRINT TAB(26) "RESULTS OF RATING PROCEDURE"
1410 LPRINT TAB(26) "_____________________________"
1420 LPRINT "            ";
1430 FOR J=1 TO M:LPRINT USING "\        \  ";E$(J);
1440 NEXT J:LPRINT CHR$(10)
1450 FOR I=1 TO N:LPRINT USING "\    \    ";C$(I);
1460 FOR J=1 TO M:LPRINT USING "      +#    ";S(I,J);
1470 NEXT J:LPRINT CHR$(10)
1480 NEXT I:LPRINT CHR$(12)
1490 LOCATE 5,25:PRINT "REMOVE LISTING FROM PRINTER"
1500 FOR I=1 TO 3:BEEP:NEXT I
1510 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
1520 LOCATE 3,9:PRINT "YOU WILL NOW HAVE A CHANCE TO CHANGE ANY OR ALL OF YOUR"
1530 LOCATE 5,9:PRINT "RESPONSES.  IF YOU WISH TO MAKE ANY CHANGES, YOU WILL BE
1540 LOCATE 7,9:PRINT "REQUIRED TO REPEAT THE RATING PROCEDURE."
```

```
1550 LOCATE 15,17:PRINT "DO YOU WISH TO MAKE ANY CHANGES  ( Y or N ) ";
1560 INPUT Z$:IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" THEN 1590
1570 LOCATE 15,17:PRINT "                                                    "
1580 GOTO 1550
1590 IF Z$="Y" OR Z$="y" THEN 1070
1600 CLS:PRINT TAB(15) "WRITING  'SCORES '  TO  DISK ------- PLEASE BE PATIENT"
1610 OPEN "B:SCOUNT" FOR INPUT AS #1
1620 INPUT#1,USERNUM
1630 CLOSE#1
1640 USERNUM=USERNUM+1
1650 OPEN "B:SCOUNT" FOR OUTPUT AS #1
1660 WRITE#1,USERNUM
1670 CLOSE#1
1680 FILE$="B:SCORE"
1690 L$=STR$(USERNUM):ZIP=LEN(L$)-1
1700 Y$=RIGHT$(L$,ZIP)
1710 XYZ$=FILE$+Y$
1720 OPEN XYZ$ FOR OUTPUT AS #1
1730 WRITE#1,NAM$
1740 FOR I=1 TO N:FOR J=1 TO M:WRITE#1,S(I,J):NEXT J:NEXT I
1750 CLOSE#1
1760 SCREEN 1,0,0:COLOR 22,4,4
1770 CLS:PRINT:PRINT:PRINT TAB(10) "THE  END !!!":FOR I=1 TO 1500:NEXT I
1780 SCREEN 0:WIDTH 80:COLOR 6,0,0:CLS
1790 CHAIN "B:CONTROL",600
```

RATIOWGT.BAS

```
10 DIM TOT(15),NOR(15),WGT(15),M(15,15),XCCH(5),YCCH(6)
20 DIM WEIGHT(15),LEGEND$(15),XCHR$(20),NORWGT(15)
30 KEY OFF
40 REM  ************************************************************************
50 REM  *                                                                      *
60 REM  *  THE PURPOSE OF THIS PROGRAM IS TO COMPUTE RATIO-SCALED WEIGHTING    *
70 REM  *                                                                      *
80 REM  *  FACTORS FOR A SET OF STRATEGIC ATTRIBUTES IN A MULTI - ATTRIBUTE    *
90 REM  *                                                                      *
100 REM *  DECISION MODEL.  THE FACTORS ARE CALCULATED BY MEANS OF THE DUNN -  *
110 REM *                                                                      *
120 REM *  RANKIN PROCEDURE FROM A SERIES OF INDIVIDUAL PAIRED COMPARISONS     *
130 REM *                                                                      *
140 REM *  MADE BY THE MEMBERS OF A PROJECT EVALUATION COMMITTEE.  THESE       *
150 REM *                                                                      *
160 REM *  WEIGHTING FACTORS WILL SERVE AS A PORTION OF THE INPUT FOR THE      *
170 REM *                                                                      *
180 REM *  LINEARLY - ADDITIVE WEIGHTED EVALUATION PROCEDURE, WHICH COMPUTES   *
190 REM *                                                                      *
200 REM *  A SCORE FOR EACH OF THE ALTERNATIVES UNDER CONSIDERATION.           *
210 REM *                                                                      *
220 REM ************************************************************************
230 CLS:LOCATE 10,12:PRINT "PROGRAM TO COMPUTE RATIO-SCALED WEIGHTS OF THE ";
240 PRINT "ATTRIBUTES"
250 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
260 WIDTH 40:COLOR 6,0,0:CLS
270 PRINT "THE PURPOSE OF THIS PROGRAM IS TO"
280 PRINT
290 PRINT "COMPUTE RATIO-SCALED WEIGHTING FACTORS"
300 PRINT
310 PRINT "FOR A SET OF STRATEGIC ATTRIBUTES IN A"
320 PRINT
330 PRINT "MULTI-ATTRIBUTE DECISION MODEL. THE"
340 PRINT
350 PRINT "FACTORS ARE CALCULATED BY MEANS OF THE"
360 PRINT
370 PRINT "DUNN-RANKIN PROCEDURE FROM A SERIES OF"
380 PRINT
390 PRINT "INDIVIDUAL PAIRED COMPARISONS MADE BY"
400 PRINT
410 PRINT "THE MEMBERS OF AN EVALUATION COMMITTEE."
420 PRINT
430 PRINT "THESE WEIGHTING FACTORS WILL SERVE AS A"
440 PRINT
450 PRINT "PORTION OF THE INPUT FOR THE LINEARLY-"
460 PRINT
470 PRINT "ADDITIVE WEIGHTED EVALUATION PROCEDURE."
480 PRINT
490 PRINT "   ( Press any key to continue )":H$=INPUT$(1):CLS
500 COLOR 22,8,8:CLS:PRINT:PRINT:PRINT
```

```
510 PRINT "  COMPUTING RATIO SCALED WEIGHTS":PRINT:PRINT:COLOR 22,8,8
520 PRINT "      PLEASE BE PATIENT":PRINT:PRINT:PRINT:PRINT:COLOR 6,0,0
530 REM  ************************************************************************
540 REM  *                                                                      *
550 REM  *  THIS PORTION OF THE PROGRAM READS THE INDIVIDUAL RESULTS OF THE      *
560 REM  *                                                                      *
570 REM  *  PAIRED - COMPARISONS.  THE INDIVIDUAL RESPONSES OF THE EVALUATION *
580 REM  *                                                                      *
590 REM  *  COMMITTEE MEMBERS ARE THEN SUMMED FOR EACH CELL OF THE  i x j      *
600 REM  *                                                                      *
610 REM  *  DECISION MATRIX, TO FORM A CONCATENATED MATRIX OF THE RESPONSE      *
620 REM  *                                                                      *
630 REM  *  TOTALS FOR EACH OF THE CELLS.  THIS MATRIX IS THEN SUMMED ALONG     *
640 REM  *                                                                      *
650 REM  *  EACH COLUMN (ATTRIBUTE), AND THE  d 's  ARE STORED IN THE VECTOR    *
660 REM  *                                                                      *
670 REM  *  TOT(I).                                                             *
680 REM  *                                                                      *
690 REM  ************************************************************************
700 OPEN "B:COUNTER" FOR INPUT AS #1:INPUT#1,NUM:CLOSE#1
710 OPEN "B:ATTRIB" FOR INPUT AS #1:INPUT#1,N:CLOSE#1
720 FOR I=1 TO N:TOT(I)=0:NEXT I
730 FOR K=1 TO NUM:Z$=STR$(K):ZIP=LEN(Z$)-1
740 REM
750 Y$=RIGHT$(Z$,ZIP):X$="B:DNRANK":XYZ$=X$+Y$
760 OPEN XYZ$ FOR INPUT AS #1
770 FOR I=1 TO N:FOR J=1 TO N:INPUT#1,M(I,J)
780 NEXT J:NEXT I:CLOSE#1
790 FOR J=1 TO N:FOR I=1 TO N:TOT(I)=TOT(I)+M(I,J)
800 NEXT I:NEXT J:NEXT K
810 FOR I=1 TO N:TOT(I)=TOT(I)+NUM:NEXT I
820 REM  ************************************************************************
830 WIDTH 80:SCREEN 0:COLOR 6,0,0
840 REM  *  Computing the  MINIMUM RANK-SUM, MAXIMUM RANK-SUM, EXPECTED      *
850 REM  *                                                                   *
860 REM  *  VALUE OF THE STANDARD DEVIATION, MINIMUM NORMALIZED RATIO,       *
870 REM  *                                                                   *
880 REM  *  MAXIMUM NORMALIZED RATIO, MINIMUM RATIO-SCALED WEIGHT, and the   *
890 REM  *                                                                   *
900 REM  *  MAXIMUM RATIO-SCALED WEIGHT.                                     *
910 REM  *                                                                   *
920 REM  ************************************************************************
930 TOTMIN=NUM:TOTMAX=NUM*N
940 VARIANCE=((N*NUM*(N+1))/12):STDEV=SQR(VARIANCE)
950 TOTAVG=(NUM*(N+1)/2)
960 NORMIN=(TOTMIN-TOTAVG)/STDEV
970 NORMAX=(TOTMAX-TOTAVG)/STDEV
980 WGTMIN=((NORMIN+ABS(NORMIN))/(NORMAX+ABS(NORMIN)))*100
990 WGTMAX=((NORMAX+ABS(NORMIN))/(NORMAX+ABS(NORMIN)))*100
1000 REM  ************************************************************************
1010 REM  *                                                                      *
1020 REM  *  Computing the  NORMALIZED RATIO  and  RATIO-SCALED WEIGHT  for     *
```

```
1030 REM  *                                                                  *
1040 REM  *  each of the  STRATEGIC ATTRIBUTES                               *
1050 REM  *                                                                  *
1060 REM  ********************************************************************
1070 FOR I=1 TO N
1080 NOR(I)=(TOT(I)-TOTAVG)/STDEV
1090 WGT(I)=((NOR(I)+ABS(NORMIN))/(NORMAX+ABS(NORMIN)))*100
1100 NEXT I
1110 ZZZ=NUM+2
1120 OPEN "B:ATTRIB" FOR INPUT AS #1
1130 INPUT #1,N
1140 FOR I=1 TO N
1150 INPUT#1,A$(I),LEG$(I)
1160 FOR J=1 TO 4:INPUT#1,B$(I,J):NEXT J:NEXT I
1170 CLOSE#1
1180 NORMAL=0
1190 FOR I=1 TO N:NORMAL=NORMAL+WGT(I):NEXT I
1200 FOR I=1 TO N:NORWGT(I)=(WGT(I)/NORMAL)*100:NEXT I
1210 LPRINT CHR$(10):LPRINT TAB(14) "RATIO-SCALED AND NORMALIZED WEIGHTS OF ";
1220 LPRINT "THE ATTRIBUTES":LPRINT CHR$(10)
1225 LPRINT TAB(47) "RATIO-SCALED" TAB(63) "NORMALIZED"
1230 LPRINT TAB(5) "ATTRIBUTE" TAB(50) "WEIGHT" TAB(65) "WEIGHT"
1235 LPRINT TAB(5) "---------" TAB(47) "----------" TAB(65) "----------"
1240 LPRINT CHR$(10):FOR I=1 TO N:LPRINT TAB(5) A$(I) TAB(50);
1250 LPRINT USING "####.##";WGT(I);
1270 LPRINT TAB(65) USING "####.##";NORWGT(I):LPRINT CHR$(10):NEXT I
1280 LPRINT CHR$(12)
1580 YYY=NUM+3
1590 OPEN "B:WGTRAT" FOR OUTPUT AS #1
1600 WRITE#1,N
1610 FOR I=1 TO N:WRITE#1,NORWGT(I):NEXT I
1620 CLOSE#1
1630 FOR I=1 TO N:FOR J=I+1 TO N
1640 IF WGT(I)>WGT(J) GOTO 1670
1650 WEIGT=WGT(I):WGT(I)=WGT(J):WGT(J)=WEIGT
1660 LEGND$=LEG$(I):LEG$(I)=LEG$(J):LEG$(J)=LEGND$
1670 REM
1680 NEXT J:NEXT I
1690 FOR I=1 TO N:WEIGHT(I)=WGT(I):NEXT I
1700 NATTR=N
1710 TITLE$="RATIO-SCALED WEIGHTS"
1720 LEGEND$(1)="A:"+LEG$(1)
1730 LEGEND$(2)="B:"+LEG$(2)
1740 LEGEND$(3)="C:"+LEG$(3)
1750 LEGEND$(4)="D:"+LEG$(4)
1760 LEGEND$(5)="E:"+LEG$(5)
1770 LEGEND$(6)="F:"+LEG$(6)
1780 LEGEND$(7)="G:"+LEG$(7)
1790 LEGEND$(8)="H:"+LEG$(8)
1800 LEGEND$(9)="I:"+LEG$(9)
1810 LEGEND$(10)="J:"+LEG$(10)
1820 GOSUB 1840
```

```
1830 WIDTH 80:SCREEN 0:COLOR 6,0,0
1835 CHAIN "B:CONTROL",600
1840 REM ******************************************
1850 REM *** BEGIN OF BAR GRAPH S/R               ***
1860 REM *** SCREEN 1                             ***
1870 REM *** INPUTS WEIGHT(10): WEIGHT VECTOR     ***
1880 REM ***         NATTR: NO. ATTRIBUTES        ***
1890 REM *** USE     XCCH(5),YCCH(6): DUMMY ARRAYS ***
1900 REM ***         XCHAR$ PLACED AT (XX,YY)     ***
1910 REM ***         XCHR$(20) : CHARACTERS
1920 REM *** PARAMETERS:                          ***
1930 REM ***         WATTR:BAR WIDTH              ***
1940 REM ***         WSCRN:SCREEN WIDTH           ***
1950 REM ***         DY0  :DISTANCE FROM TOP/BOTTOM***
1960 REM ******************************************
1970 CLS:KEY OFF:SCREEN 1
1980 XCHR$(0)="0":XCHR$(1)="1":XCHR$(2)="2":XCHR$(3)="3":XCHR$(4)="4"
1990 XCHR$(5)="5":XCHR$(6)="6":XCHR$(7)="7":XCHR$(8)="8":XCHR$(9)="9"
2000 XCHR$(11)="A":XCHR$(12)="B":XCHR$(13)="C":XCHR$(14)="D":XCHR$(15)="E"
2010 XCHR$(16)="F":XCHR$(17)="G":XCHR$(18)="H":XCHR$(19)="I":XCHR$(20)="J"
2020 WATTR=20
2030 WSCRN=280
2040 HX=WATTR*(NATTR+1)
2050 X0=(WSCRN-HX)/2
2060 DY0=40
2070 HY=200-2*DY0
2080 Y0=DY0+HY
2090 XMAX=X0+NATTR*WATTR+WATTR
2100 LINE (X0,DY0)-(X0,Y0)
2110 DHY=HY/10
2120 XGRID0=X0-3:XGRID00=XGRID0-24:XGRID01=XGRID0-16:XGRID02=XGRID0-8
2130 XGRID1=X0
2140 REM *********************************
2150 FOR J=1 TO 11
2160 YGRID=DY0+(J-1)*DHY
2170 YGRID00=YGRID-3
2180 LINE (XGRID0,YGRID)-(XGRID1,YGRID)
2190 IF J=1 THEN GOSUB 4040
2200 IF J>1 AND J<11 THEN GOSUB 4080
2210 IF J=11 THEN GOSUB 4110
2220 NEXT J
2230 REM *********************************
2240 LINE (X0,Y0)-(XMAX,Y0)
2250 YBOTT=Y0+5
2260 FOR I= 1 TO NATTR
2270 X00=X0+(I-1)*WATTR
2280 X11=X00+WATTR
2290 XMIDI=INT((X00+X11)/2)
2300 GOSUB 4130
2310 Y00=Y0
2320 IC=(I MOD 2)*2+1
2330 Y11=(100-WEIGHT(I))*HY/100+DY0
```

```
2340 LINE (X00,Y00)-(X11,Y11),IC,BF
2350 NEXT I
2360 REM TITLE AND LEGENDS
2370 LOCATE 1,10:PRINT TITLE$
2380 FOR I=1 TO NATTR
2390 LOCATE I,33:PRINT LEGEND$(I)
2400 NEXT I
2410 LOCATE 17,33:PRINT "Press"
2420 LOCATE 18,33:PRINT " any"
2430 LOCATE 19,33:PRINT "key to"
2440 LOCATE 20,33:PRINT " exit"
2450 XHKEY$=INKEY$:IF XHKEY$="" THEN 2450
2460 SCREEN 0:WIDTH 80
2470 RETURN
2480 REM ******************************************
2490 REM SUBROUTINE TO DRAW CHARACTER XCHAR$ AT
2500 REM POSITION (XX,YY)
2510 REM NEEDS ARRAYS XCCH(5),YCCH(6) AND SCREEN 1
2520 GOSUB 2740
2530 IF XCHAR$="A" THEN GOSUB 2780
2540 IF XCHAR$="B" THEN GOSUB 2850
2550 IF XCHAR$="C" THEN GOSUB 2930
2560 IF XCHAR$="D" THEN GOSUB 2980
2570 IF XCHAR$="E" THEN GOSUB 3040
2580 IF XCHAR$="F" THEN GOSUB 3100
2590 IF XCHAR$="G" THEN GOSUB 3150
2600 IF XCHAR$="H" THEN GOSUB 3220
2610 IF XCHAR$="I" THEN GOSUB 3270
2620 IF XCHAR$="J" THEN GOSUB 3320
2630 IF XCHAR$="1" THEN GOSUB 3370
2640 IF XCHAR$="2" THEN GOSUB 3420
2650 IF XCHAR$="3" THEN GOSUB 3480
2660 IF XCHAR$="4" THEN GOSUB 3560
2670 IF XCHAR$="5" THEN GOSUB 3610
2680 IF XCHAR$="6" THEN GOSUB 3680
2690 IF XCHAR$="7" THEN GOSUB 3750
2700 IF XCHAR$="8" THEN GOSUB 3790
2710 IF XCHAR$="9" THEN GOSUB 3890
2720 IF XCHAR$="0" THEN GOSUB 3970
2730 RETURN
2740 REM compute position
2750 FOR JG=0 TO 4: XCCH(JG+1)=XX+JG: NEXT JG
2760 FOR IG=0 TO 5: YCCH(IG+1)=YY+IG: NEXT IG
2770 RETURN
2780 REM a
2790 LINE (XCCH(3),YCCH(1))-(XCCH(1),YCCH(3))
2800 LINE (XCCH(1),YCCH(3))-(XCCH(1),YCCH(6))
2810 LINE (XCCH(3),YCCH(1))-(XCCH(5),YCCH(3))
2820 LINE (XCCH(5),YCCH(3))-(XCCH(5),YCCH(6))
2830 LINE (XCCH(1),YCCH(4))-(XCCH(5),YCCH(4))
2840 RETURN
2850 REM b
```

```
2860 LINE (XCCH(1),YCCH(1))-(XCCH(4),YCCH(1))
2870 LINE (XCCH(4),YCCH(1))-(XCCH(5),YCCH(2))
2880 LINE (XCCH(4),YCCH(3))-(XCCH(1),YCCH(3))
2890 LINE (XCCH(5),YCCH(4))-(XCCH(5),YCCH(5))
2900 LINE (XCCH(4),YCCH(6))-(XCCH(1),YCCH(6))
2910 LINE (XCCH(1),YCCH(6))-(XCCH(1),YCCH(1))
2920 RETURN
2930 REM c
2940 LINE (XCCH(2),YCCH(1))-(XCCH(5),YCCH(1))
2950 LINE (XCCH(1),YCCH(2))-(XCCH(1),YCCH(5))
2960 LINE (XCCH(2),YCCH(6))-(XCCH(5),YCCH(6))
2970 RETURN
2980 REM d
2990 LINE (XCCH(1),YCCH(1))-(XCCH(1),YCCH(6))
3000 LINE (XCCH(1),YCCH(1))-(XCCH(4),YCCH(1))
3010 LINE (XCCH(1),YCCH(6))-(XCCH(4),YCCH(6))
3020 LINE (XCCH(5),YCCH(2))-(XCCH(5),YCCH(5))
3030 RETURN
3040 REM e
3050 LINE (XCCH(1),YCCH(1))-(XCCH(5),YCCH(1))
3060 LINE (XCCH(1),YCCH(1))-(XCCH(1),YCCH(6))
3070 LINE (XCCH(1),YCCH(6))-(XCCH(5),YCCH(6))
3080 LINE (XCCH(1),YCCH(3))-(XCCH(4),YCCH(3))
3090 RETURN
3100 REM f
3110 LINE (XCCH(1),YCCH(1))-(XCCH(5),YCCH(1))
3120 LINE (XCCH(1),YCCH(1))-(XCCH(1),YCCH(6))
3130 LINE (XCCH(1),YCCH(3))-(XCCH(4),YCCH(3))
3140 RETURN
3150 REM g
3160 LINE (XCCH(1),YCCH(2))-(XCCH(1),YCCH(5))
3170 LINE (XCCH(2),YCCH(1))-(XCCH(5),YCCH(1))
3180 LINE (XCCH(2),YCCH(6))-(XCCH(5),YCCH(6))
3190 LINE (XCCH(5),YCCH(6))-(XCCH(5),YCCH(3))
3200 LINE (XCCH(5),YCCH(3))-(XCCH(3),YCCH(3))
3210 RETURN
3220 REM h
3230 LINE (XCCH(1),YCCH(1))-(XCCH(1),YCCH(6))
3240 LINE (XCCH(5),YCCH(1))-(XCCH(5),YCCH(6))
3250 LINE (XCCH(1),YCCH(3))-(XCCH(5),YCCH(3))
3260 RETURN
3270 REM i
3280 LINE (XCCH(3),YCCH(1))-(XCCH(3),YCCH(6))
3290 LINE (XCCH(2),YCCH(1))-(XCCH(4),YCCH(1))
3300 LINE (XCCH(2),YCCH(6))-(XCCH(4),YCCH(6))
3310 RETURN
3320 REM j
3330 LINE (XCCH(5),YCCH(1))-(XCCH(5),YCCH(5))
3340 LINE (XCCH(4),YCCH(6))-(XCCH(2),YCCH(6))
3350 LINE (XCCH(1),YCCH(5))-(XCCH(1),YCCH(4))
3360 RETURN
3370 REM l
```

```
3380 LINE (XCCH(3),YCCH(1))-(XCCH(3),YCCH(6))
3390 LINE (XCCH(3),YCCH(1))-(XCCH(1),YCCH(3))
3400 LINE (XCCH(2),YCCH(6))-(XCCH(4),YCCH(6))
3410 RETURN
3420 REM 2
3430 LINE (XCCH(1),YCCH(2))-(XCCH(2),YCCH(1))
3440 LINE (XCCH(3),YCCH(1))-(XCCH(4),YCCH(1))
3450 LINE (XCCH(5),YCCH(2))-(XCCH(1),YCCH(6))
3460 LINE (XCCH(1),YCCH(6))-(XCCH(5),YCCH(6))
3470 RETURN
3480 REM 3
3490 LINE (XCCH(1),YCCH(1))-(XCCH(4),YCCH(1))
3500 LINE (XCCH(1),YCCH(1))-(XCCH(4),YCCH(1))
3510 LINE (XCCH(5),YCCH(2))-(XCCH(4),YCCH(3))
3520 LINE (XCCH(4),YCCH(3))-(XCCH(1),YCCH(3))
3530 LINE (XCCH(5),YCCH(4))-(XCCH(5),YCCH(5))
3540 LINE (XCCH(4),YCCH(6))-(XCCH(1),YCCH(6))
3550 RETURN
3560 REM 4
3570 LINE (XCCH(4),YCCH(1))-(XCCH(4),YCCH(6))
3580 LINE (XCCH(4),YCCH(1))-(XCCH(1),YCCH(4))
3590 LINE (XCCH(1),YCCH(4))-(XCCH(5),YCCH(4))
3600 RETURN
3610 REM 5
3620 LINE (XCCH(1),YCCH(1))-(XCCH(5),YCCH(1))
3630 LINE (XCCH(1),YCCH(1))-(XCCH(1),YCCH(3))
3640 LINE (XCCH(1),YCCH(3))-(XCCH(4),YCCH(3))
3650 LINE (XCCH(5),YCCH(4))-(XCCH(5),YCCH(6))
3660 LINE (XCCH(5),YCCH(6))-(XCCH(1),YCCH(6))
3670 RETURN
3680 REM 6
3690 LINE (XCCH(4),YCCH(1))-(XCCH(1),YCCH(4))
3700 LINE (XCCH(1),YCCH(4))-(XCCH(1),YCCH(6))
3710 LINE (XCCH(1),YCCH(6))-(XCCH(4),YCCH(6))
3720 LINE (XCCH(5),YCCH(5))-(XCCH(4),YCCH(4))
3730 LINE (XCCH(4),YCCH(4))-(XCCH(1),YCCH(4))
3740 RETURN
3750 REM 7
3760 LINE (XCCH(1),YCCH(1))-(XCCH(5),YCCH(1))
3770 LINE (XCCH(5),YCCH(2))-(XCCH(1),YCCH(6))
3780 RETURN
3790 REM 8
3800 LINE (XCCH(2),YCCH(1))-(XCCH(4),YCCH(1))
3810 LINE (XCCH(5),YCCH(2))-(XCCH(4),YCCH(3))
3820 LINE (XCCH(4),YCCH(3))-(XCCH(2),YCCH(3))
3830 LINE (XCCH(2),YCCH(3))-(XCCH(1),YCCH(2))
3840 LINE (XCCH(1),YCCH(2))-(XCCH(2),YCCH(1))
3850 LINE (XCCH(1),YCCH(4))-(XCCH(1),YCCH(5))
3860 LINE (XCCH(2),YCCH(6))-(XCCH(4),YCCH(6))
3870 LINE (XCCH(5),YCCH(5))-(XCCH(5),YCCH(4))
3880 RETURN
3890 REM 9
```

```
3900 LINE (XCCH(2),YCCH(1))-(XCCH(4),YCCH(1))
3910 LINE (XCCH(5),YCCH(2))-(XCCH(4),YCCH(3))
3920 LINE (XCCH(4),YCCH(3))-(XCCH(2),YCCH(3))
3930 LINE (XCCH(2),YCCH(3))-(XCCH(1),YCCH(2))
3940 LINE (XCCH(1),YCCH(2))-(XCCH(2),YCCH(1))
3950 LINE (XCCH(5),YCCH(3))-(XCCH(2),YCCH(6))
3960 RETURN
3970 REM 0
3980 LINE (XCCH(2),YCCH(1))-(XCCH(4),YCCH(1))
3990 LINE (XCCH(1),YCCH(2))-(XCCH(1),YCCH(5))
4000 LINE (XCCH(2),YCCH(6))-(XCCH(4),YCCH(6))
4010 LINE (XCCH(5),YCCH(5))-(XCCH(5),YCCH(2))
4020 RETURN
4030 REM FIGURES ON Y-AXIS
4040 XX=XGRID00:YY=YGRID00:XCHAR$="1":GOSUB 2480
4050 XX=XGRID01:YY=YGRID00:XCHAR$="0":GOSUB 2480
4060 XX=XGRID02:YY=YGRID00:XCHAR$="0":GOSUB 2480
4070 RETURN
4080 XX=XGRID01:YY=YGRID00:XCHAR$=XCHR$(11-J):GOSUB 2480
4090 XX=XGRID02:YY=YGRID00:XCHAR$="0":GOSUB 2480
4100 RETURN
4110 XX=XGRID02:YY=YGRID00:XCHAR$="0":GOSUB 2480
4120 RETURN
4130 XX=XMIDI-3:YY=YBOTT:XCHAR$=XCHR$(I+10):GOSUB 2480
4140 RETURN
```

AVRATING.BAS

```
10 DIM A$(15),C$(15),B$(15,5),D$(10),NAM$(15),S(15,15,10),SQ(15,15,10)
20 DIM TOT(15,10),SQTOT(15,10),AVG(15,10),STDEV(15,10),LOW(15,10),HIGH(15,10)
30 KEY OFF:CLS:COLOR 6,0,0
40 REM
50 REM    THE PURPOSE OF THIS PROGRAM IS TO DETERMINE THE AVERAGE VALUE RATING
60 REM
70 REM    FOR EACH COMBINATION OF ONE ATTRIBUTE AND ONE ALTERNATIVE.  THIS
80 REM
90 REM    PROGRAM SHOULD BE RUN AFTER THE MEMBERS OF THE EVALUATION TEAM HAVE
100 REM
110 REM   EACH COMPLETED THE  'SCORING '  PROCESS.
120 REM
130 CLS:LOCATE 10,4:PRINT "PROGRAM TO COMPUTE THE SCORES FOR EACH ALTERNATIVE";
140 PRINT " AGAINST EACH ATTRIBUTE"
150 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
160 PRINT "THE PURPOSE OF THIS PROGRAM IS TO DETERMINE THE RATING VALUES":PRINT
170 PRINT "TO BE USED IN THE LINEARLY ADDITIVE WEIGHTED EVALUATION.  THE":PRINT
180 PRINT "EVALUATION COMMITTEE MEMBERS SHOULD ALL HAVE COMPLETED THE":PRINT
190 PRINT "RATING PROCESS BEFORE THIS PROGRAM IS RUN. BEFORE PRECEEDING,":PRINT
200 PRINT "CHECK TO SEE THAT THE  'DATA '  DISK IS IN PLACE IN DRIVE B:":PRINT
210 PRINT "IF THE  'DATA '  DISK IS NOT IN PLACE, EXIT THE PROGRAM BY":PRINT
220 PRINT "SIMULTANEOUSLY DEPRESSING THE CONTROL  ( Ctrl )  AND THE BREAK"
230 PRINT:PRINT "( Scroll Lock )  KEYS":PRINT:PRINT:PRINT
240 PRINT TAB(25) "( Press any key to continue )":Z$=INPUT$(1):CLS
250 COLOR 4,0,0:PRINT "LOADING DATA FROM  'DATA '  DISK AND COMPUTING AVERAGE"
260 PRINT:PRINT "RATINGS FOR EACH COMBINATION OF ONE ALTERNATIVE AND ONE":PRINT
270 PRINT "ATTRIBUTE  ————————  PLEASE BE PATIENT"
280 COLOR 6,0,0
290 OPEN "B:ATTRIB" FOR INPUT AS #1
300 INPUT#1,N
310 FOR I=1 TO N:INPUT#1,A$(I),C$(I):FOR J=1 TO 4:INPUT#1,B$(I,J):NEXT J:NEXT I
320 CLOSE#1
330 OPEN "B:ALTER" FOR INPUT AS #1
340 INPUT#1,M
350 FOR I=1 TO M:INPUT#1,D$(I),E$(I):NEXT I:CLOSE#1
360 OPEN "B:SCOUNT" FOR INPUT AS #1
370 INPUT#1,NUM
380 CLOSE#1
390 FOR I=1 TO NUM:Z$=STR$(I):ZIP=LEN(Z$)-1
400 Y$=RIGHT$(Z$,ZIP):X$="B:SCORE":XYZ$=X$+Y$
410 OPEN XYZ$ FOR INPUT AS #1
420 INPUT#1,NAM$(I)
430 FOR J=1 TO N:FOR K=1 TO M:INPUT#1,S(I,J,K)
440 NEXT K:NEXT J:CLOSE#1:NEXT I
450 FOR I=1 TO NUM:FOR J=1 TO N:FOR K=1 TO M
460 SQ(I,J,K)=S(I,J,K)^2:TOT(J,K)=TOT(J,K)+S(I,J,K)
470 SQTOT(J,K)=SQTOT(J,K)+SQ(I,J,K):NEXT K:NEXT J:NEXT I
480 FOR J=1 TO N:FOR K=1 TO M:AVG(J,K)=TOT(J,K)/NUM
490 STDEV(J,K)=SQR((SQTOT(J,K)-NUM*AVG(J,K)^2)/(NUM-1))
500 LOW(J,K)=AVG(J,K)-1.5*STDEV(J,K):HIGH(J,K)=AVG(J,K)+1.5*STDEV(J,K)
```

```
510 NEXT K:NEXT J
520 CLS:PRINT "THIS PORTION OF THE PROGRAM IDENTIFIES ANY RATING(S) BY ANY OF"
530 PRINT:PRINT "THE EVALUATION TEAM MEMBERS WHICH FALL OUTSIDE A  +/-  1.5"
540 PRINT:PRINT "STANDARD DEVIATION RANGE FROM THE MEAN FOR EACH COMBINATION"
550 PRINT:PRINT "OF ONE ALTERNATIVE AND ONE ATTRIBUTE.  ANY RATING FALLING"
560 PRINT:PRINT "OUTSIDE OF THIS INTERVAL WILL BE LISTED ALONG WITH THE INDIV-"
570 PRINT:PRINT "IDUAL RESPONSIBLE FOR THE RATING.  WITH THIS INFORMATION, THE"
580 PRINT:PRINT "THE COMMITTEE CHAIRMAN MAY BE ABLE TO DETERMINE IF ANY OF THE
590 PRINT:PRINT "TEAM MEMBERS HAS AN UNREALISTIC BIAS EITHER FOR OR AGAINST ANY
600 PRINT:PRINT "OF THE ALTERNATIVES.  IF SUCH A BIAS IS DETECTED, THE BIASED"
610 PRINT:PRINT "DATA FILE SHOULD BE DELETED FROM THE  'DATA '  DISK AND THIS"
620 PRINT:PRINT "PROGRAM SHOULD BE RE-EXECUTED."
630 PRINT:PRINT TAB(25) "( Press any key to continue )":Z$=INPUT$(1):CLS
640 COLOR 4,0,0
650 CLS:PRINT "THIS PORTION OF THE PROGRAM REQUIRES THE USE OF A PRINTER."
660 PRINT:PRINT "BEFORE PROCEEDING, CHECK TO SEE THAT THE PAPER IS PROPERLY"
670 PRINT:PRINT "ALIGNED AND THE PRINTER IS  'ON LINE '":PRINT:PRINT:PRINT
680 PRINT TAB(25) "( Press any key to continue )":Z$=INPUT$(1):CLS
690 PRINT "CHECKING FOR VALUES OUTSIDE THE  +/-  1.5  STANDARD DEVIATION"
700 PRINT:PRINT "RANGE FROM THE MEAN.  A LISTING OF ANY SUCH VALUES WILL BE"
710 PRINT:PRINT "PROVIDED ————— PLEASE BE PATIENT !!!!!":COLOR 6,0,0
720 DUMMY=0
730 FOR I=1 TO NUM:FOR J=1 TO N:FOR K=1 TO M
740 IF (S(I,J,K)>=LOW(J,K)) AND (S(I,J,K)<=HIGH(J,K)) GOTO 760
750 DUMMY=DUMMY+1
760 REM
770 NEXT K:NEXT J:NEXT I
780 IF (DUMMY<1) GOTO 930
785 LPRINT CHR$(10)
790 LPRINT "LIST OF PARTICIPANTS WHOSE RATINGS ARE GREATER THAN  +/-  1.5"
800 LPRINT:LPRINT "STANDARD DEVIATIONS FROM THE MEAN RATING":LPRINT:LPRINT
810 LPRINT "  NAME    ATTRIBUTE      ALTERNATIVE              SCORE  AVG SCORE"
820 LPRINT "  ———    ————————      ———————————              —————  ————————"
830 CLS:LPRINT
840 FOR I=1 TO NUM:FOR J=1 TO N:FOR K=1 TO M
850 IF (S(I,J,K)>=LOW(J,K)) AND (S(I,J,K)<=HIGH(J,K)) GOTO 910
860 LPRINT USING "\         \";NAM$(I);
870 LPRINT USING "\              \";A$(J);
880 LPRINT USING "\                       \";D$(K);
890 LPRINT USING "###     ";S(I,J,K);
900 LPRINT USING "###.##";AVG(J,K):LPRINT CHR$(10)
910 REM
920 NEXT K:NEXT J:NEXT I
930 PRINT "IF EVIDENCE OF A BIAS EXISTS, THE COMMITTEE CHAIRMAN MAY WISH"
940 PRINT:PRINT "TO CAREFULLY EXAMINE THE RESPONSES OF ONE OR MORE OF THE"
950 PRINT:PRINT "EVALUATION TEAM MEMBERS.  TWO POSSIBLE METHODS OF DEALING"
960 PRINT:PRINT "WITH A BIAS MAY BE APPLIED — (1) THE INDIVIDUAL RESPONSIBLE"
970 PRINT:PRINT "FOR THE BIASED DATA MAY BE ASKED TO RE-EXECUTE THE SCORING"
980 PRINT:PRINT "PROGRAM, AND (2) THE BIASED DATA MAY BE DROPPED FROM THE"
990 PRINT:PRINT "EVALUATION.  A MEANS OF HANDLING EITHER OF THESE METHODS IS"
1000 PRINT:PRINT "OUTLINED IN THE PROGRAM DOCUMENTATION."
1010 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
```

```
1020 PRINT TAB(10) "WRITTING DATA TO DISK --- PLEASE BE PATIENT"
1030 OPEN "B:RATINGS" FOR OUTPUT AS #1
1040 WRITE#1,NUM,N,M
1050 FOR I=1 TO N:FOR J=1 TO M:WRITE#1,AVG(I,J):NEXT J:NEXT I:CLOSE#1
1060 LPRINT CHR$(12)
1070 LPRINT TAB(15) "LISTING OF RATINGS BY ALTERNATIVE, BY ATTRIBUTE"
1080 LPRINT TAB(15) "----------------------------------------------------":LPRINT
1090 LPRINT TAB(40) "ALTERNATIVES"
1100 LPRINT TAB(40) "------------"
1110 LPRINT "ATTRIBUTES":LPRINT "----------"
1120 LPRINT TAB(13);
1130 FOR I=1 TO M
1140 LPRINT USING "\         \  ";E$(I);
1150 NEXT I
1160 LPRINT TAB(13);
1170 FOR I=1 TO M
1180 LPRINT "------------  ";
1190 NEXT I
1200 FOR I=1 TO N
1210 LPRINT:LPRINT USING "  \     \   ";C$(I);
1220 FOR J=1 TO M
1230 LPRINT USING "    ##.##   ";AVG(I,J);
1240 NEXT J:LPRINT CHR$(10):NEXT I
1250 WIDTH 40:SCREEN 0:COLOR 2,4,4:CLS:PRINT TAB(15) "THE END !!!"
1260 FOR I=1 TO 2000:NEXT I:WIDTH 80:SCREEN 0:COLOR 6,0,0:CLS
1270 CHAIN "B:CONTROL",600
```

COSTEST.BAS

```
10 DIM A(25),A$(25),ALT$(100):KEY OFF:COLOR 6,0,0
20 A$(1)=" 1. Site Architectural Survey   $100-200 per work area drop"
30 A$(2)=" 2. Interbuilding Connections   $100-150 per foot"
40 A$(3)=" 3. Intrabuilding Connections   $20-50 per foot"
50 A$(4)=" 4. Cable Installation          $20 per foot"
60 A$(5)=" 5. Cable Installation          $100 per drop"
70 A$(6)=" 6. Network Manager             $10,000-30,000"
80 A$(7)=" 7. Network Analyzer            $30,000"
90 A$(8)=" 8. CATV Amplifier  (Ethernet)  $500-1500 each"
100 A$(9)=" 9. Taps                        $17-20 each"
110 A$(10)="10. Splitters                   $5-15 each"
120 A$(11)="11. NUI's: Ethernet             $500-1000 per port"
130 A$(12)="12. NIU's: MAP                  $4000"
140 B$="          (please check no. associations supported per interface)"
150 A$(13)="13. RF Modems: Ethernet         $500-1000 each"
160 A$(14)="14. RF Modems: MAP  (Head End)  $5000 each"
170 A$(15)="15. NUI's                       $600 per port
180 A$(16)="16. Repeaters                   $1200-1500 each"
190 A$(17)="17. Taps/Transceivers           $200-300 each"
200 A$(18)="18. MAP Card                    $3000"
210 COLOR 6,0,0:CLS
220 REM ************************************************************************
230 REM *                                                                      *
240 REM *   Instructions for the execution of the cost estimation program.     *
250 REM *                                                                      *
260 REM *   This program is based on a Local Area Network cost estimation      *
270 REM *                                                                      *
280 REM *   form developed by Dr. W.G. Sullivan.                               *
290 REM *                                                                      *
300 REM ************************************************************************
310 LOCATE 3,9:PRINT "This program is based on a Local Area Network cost ";
320 PRINT "estimation"
330 LOCATE 5,9:PRINT "worksheet developed by Dr. W.G. Sullivan.  The ";
340 PRINT "estimates are"
350 LOCATE 7,9:PRINT "calculated on the basis of network configuration.  ";
360 PRINT "High, low,"
370 LOCATE 9,9:PRINT "and average estimates of the initial cost of a Local ";
380 PRINT "Area"
390 LOCATE 11,9:PRINT "Network configuration are computed with this program."
400 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
410 LOCATE 3,9:PRINT "The required input for this program consists of infor";
420 PRINT "mation"
430 LOCATE 5,9:PRINT "regarding the network configuration.  You will be given";
440 PRINT "a series"
450 LOCATE 7,9:PRINT "of three lists of network components along with their ";
460 PRINT "estimation"
470 LOCATE 9,9:PRINT "factors.  For each entry on each of the lists, the ";
480 PRINT "number of that"
490 LOCATE 11,9:PRINT "component type should be input.  At the end of each ";
500 PRINT "list, you"
```

```
510 LOCATE 13,9:PRINT "will be given the opportunity to change any incorrect";
520 PRINT " entries."
530 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
540 CLS:LOCATE 5,9:PRINT "INPUT THE NAME OF THE ALTERNATIVE WHICH YOU WISH TO";
550 PRINT " EVALUATE":LOCATE 7,30:INPUT NAMIT$
560 LOCATE 10,17:PRINT "THE NAME OF THE ALTERNATIVE IS ";NAMIT$
570 LOCATE 12,25:PRINT "IS THIS CORRECT  ( Y or N ) ";
580 INPUT Z$:IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" THEN 600
590 LOCATE 12,25:PRINT "                                                ":GOTO 570
600 IF Z$="Y" OR Z$="y" THEN 620
610 GOTO 540
620 CLS:LOCATE 12,25:PRINT "Are you ready to begin  ( Y or N ) ";
630 INPUT Z$:IF Z$="n" OR Z$="N" OR Z$="y" OR Z$="Y" GOTO 650
640 GOTO 620
650 CLS:IF Z$="N" OR Z$="n" GOTO 310
660 CLS
670 LOCATE 2,10:PRINT "COMPONENT":LOCATE 2,35:PRINT "ESTIMATION FACTOR"
680 LOCATE 2,65:PRINT "NUMBER"
690 LOCATE 3,10:PRINT "————————":LOCATE 3,35:PRINT "————————————————"
700 LOCATE 3,65:PRINT "———————"
710 LOCATE 4,3:PRINT A$(1)
720 LOCATE 6,3:PRINT A$(2)
730 LOCATE 8,3:PRINT A$(3)
740 LOCATE 10,3:PRINT A$(4)
750 PRINT "                    >>>>    or    <<<<"
760 LOCATE 12,3:PRINT A$(5)
770 LOCATE 14,3:PRINT A$(6)
780 LOCATE 16,3:PRINT A$(7)
790 COLOR 2,0,0
800 LOCATE 4,67:INPUT A(1)
810 LOCATE 6,67:INPUT A(2)
820 LOCATE 8,67:INPUT A(3)
830 LOCATE 10,67:INPUT A(4)
840 LOCATE 12,67:INPUT A(5)
850 LOCATE 14,67:INPUT A(6)
860 LOCATE 16,67:INPUT A(7)
870 COLOR 6,0,0
880 LOCATE 22,7:PRINT "WOULD YOU LIKE TO CHANGE ANY OF THE ABOVE ";
890 PRINT "INFORMATION  ( Y or N ) ";
900 INPUT Z$
905 IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" THEN 910
906 LOCATE 22,7:PRINT "                                                    ";
907 PRINT "                    "
908 GOTO 880
910 IF Z$="N" OR Z$="n" THEN GOTO 1160
920 GOSUB 2720
930 FOR I=1 TO 7:LPRINT TAB(3) A$(I) TAB(67) A(I):LPRINT CHR$(10):NEXT I
940 LPRINT CHR$(12)
950 CLS:LOCATE 10,25:PRINT "REMOVE THE LIST FROM THE PRINTER"
960 LOCATE 20,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
970 CLS:LOCATE 3,10:PRINT "INPUT THE NUMBER OF THE COMPONENT THAT YOU WISH TO";
980 PRINT " CHANGE ":INPUT J
```

```
990 IF J>0 AND J<8 GOTO 1020
1000 CLS:LOCATE 10,25:PRINT "INVALID ENTRY —— TRY AGAIN !!":FOR B=1 TO 6
1010 BEEP:NEXT B:GOTO 970
1020 COLOR 2,0,0:LOCATE 6,3:PRINT A$(J):LOCATE 6,67:PRINT A(J):COLOR 6,0,0
1030 LOCATE 9,15:PRINT "INPUT THE CORRECT NUMBER";
1040 INPUT A(J)
1050 DUMMY=A(J)
1060 LOCATE 12,3:PRINT A$(J):LOCATE 12,67:PRINT A(J)
1070 LOCATE 14,12:PRINT "IS THIS CORRECT  ( Y or N ) ";
1080 INPUT Z$:IF Z$="Y" OR Z$="y" THEN 1140
1090 A(J)=DUMMY:LOCATE 9,15:PRINT "                                                    "
1100 LOCATE 12,3:PRINT "                                                              ";
1110 PRINT "                "
1120 LOCATE 14,12:PRINT "                                                             "
1130 GOTO 1030
1140 LOCATE 17,15:PRINT "ARE THERE ANY MORE CORRECTIONS  ( Y or N ) ";
1150 INPUT Y$:IF Y$="Y" OR Y$="y" THEN 970
1160 CLS
1170 LOCATE 2,10:PRINT "COMPONENT":LOCATE 2,35:PRINT "ESTIMATION FACTOR"
1180 LOCATE 2,65:PRINT "NUMBER"
1190 LOCATE 3,10:PRINT "————————":LOCATE 3,35:PRINT "————————————————"
1200 LOCATE 3,65:PRINT "———————"
1210 LOCATE 4,2:PRINT "BROADBAND EQUIPMENT"
1220 LOCATE 6,3:PRINT A$(8)
1230 LOCATE 8,3:PRINT A$(9)
1240 LOCATE 10,3:PRINT A$(10)
1250 LOCATE 12,3:PRINT A$(11)
1260 LOCATE 14,3:PRINT A$(12)
1270 COLOR 4,0,0:PRINT B$:COLOR 6,0,0
1280 LOCATE 17,3:PRINT A$(13)
1290 LOCATE 19,3:PRINT A$(14)
1300 COLOR 2,0,0
1310 LOCATE 6,67:INPUT A(8)
1320 LOCATE 8,67:INPUT A(9)
1330 LOCATE 10,67:INPUT A(10)
1340 LOCATE 12,67:INPUT A(11)
1350 LOCATE 14,67:INPUT A(12)
1360 LOCATE 17,67:INPUT A(13)
1370 LOCATE 19,67:INPUT A(14)
1380 COLOR 6,0,0
1390 LOCATE 22,7:PRINT "WOULD YOU LIKE TO CHANGE ANY OF THE ABOVE ";
1400 PRINT "INFORMATION  ( Y or N ) ";
1410 INPUT Z$
1415 IF Z$="N" OR Z$="n" OR Z$="Y" OR Z$="y" THEN 1420
1417 LOCATE 22,65:PRINT "                                    "
1418 GOTO 1390
1420 IF Z$="N" OR Z$="n" THEN GOTO 1750
1430 IF Z$="Y" OR Z$="y" THEN GOSUB 2720
1440 LPRINT "  BROADBAND EQUIPMENT":LPRINT CHR$(10)
1450 LPRINT TAB(3) A$(8) TAB(67) A(8):LPRINT CHR$(10)
1460 LPRINT TAB(3) A$(9) TAB(67) A(9):LPRINT CHR$(10)
1470 LPRINT TAB(3) A$(10) TAB(67) A(10):LPRINT CHR$(10)
```

```
1480 LPRINT TAB(3) A$(11) TAB(67) A(11):LPRINT CHR$(10)
1490 LPRINT TAB(3) A$(12) TAB(67) A(12):LPRINT CHR$(10)
1500 LPRINT B$:LPRINT CHR$(10)
1510 LPRINT TAB(3) A$(13) TAB(67) A(13):LPRINT CHR$(10)
1520 LPRINT TAB(3) A$(14) TAB(67) A(14):LPRINT CHR$(10)
1530 LPRINT CHR$(12)
1540 CLS:LOCATE 10,25:PRINT "REMOVE THE LIST FROM THE PRINTER"
1550 LOCATE 20,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
1560 CLS:LOCATE 3,10:PRINT "INPUT THE NUMBER OF THE COMPONENT THAT YOU WISH TO"
1570 PRINT " CHANGE ":INPUT J
1580 IF J>7 AND J<15 GOTO 1610
1590 CLS:LOCATE 10,25:PRINT "INVALID ENTRY --- TRY AGAIN !!":FOR B=1 TO 6
1600 BEEP:NEXT B:GOTO 1560
1610 COLOR 2,0,0:LOCATE 6,3:PRINT A$(J):LOCATE 6,67:PRINT A(J):COLOR 6,0,0
1620 LOCATE 9,15:PRINT "INPUT THE CORRECT NUMBER";
1630 INPUT A(J)
1640 DUMMY=A(J)
1650 LOCATE 12,3:PRINT A$(J):LOCATE 12,67:PRINT A(J)
1660 LOCATE 14,12:PRINT "IS THIS CORRECT  ( Y or N ) ";
1670 INPUT Z$:IF Z$="Y" OR Z$="y" THEN 1730
1680 A(J)=DUMMY:LOCATE 9,15:PRINT "                                                    "
1690 LOCATE 12,3:PRINT "                                                               ";
1700 PRINT "                "
1710 LOCATE 14,12:PRINT "                                                              "
1720 GOTO 1620
1730 LOCATE 17,15:PRINT "ARE THERE ANY MORE CORRECTIONS  ( Y or N ) ";
1740 INPUT Y$:IF Y$="Y" OR Y$="y" THEN 1560
1750 CLS
1760 LOCATE 2,10:PRINT "COMPONENT":LOCATE 2,35:PRINT "ESTIMATION FACTOR"
1770 LOCATE 2,65:PRINT "NUMBER"
1780 LOCATE 3,10:PRINT "----------":LOCATE 3,35:PRINT "------------------"
1790 LOCATE 3,65:PRINT "------"
1800 LOCATE 4,2:PRINT "BASEBAND EQUIPMENT"
1810 LOCATE 6,3:PRINT A$(15)
1820 LOCATE 8,3:PRINT A$(16)
1830 LOCATE 10,3:PRINT A$(17)
1840 LOCATE 12,2:PRINT "CARRIERBAND EQUIPMENT"
1850 LOCATE 14,3:PRINT A$(18)
1860 COLOR 4,0,0:PRINT B$:COLOR 6,0,0
1870 COLOR 2,0,0
1880 LOCATE 6,67:INPUT A(15)
1890 LOCATE 8,67:INPUT A(16)
1900 LOCATE 10,67:INPUT A(17)
1910 LOCATE 14,67:INPUT A(18)
1920 COLOR 6,0,0
1930 LOCATE 22,7:PRINT "WOULD YOU LIKE TO CHANGE ANY OF THE ABOVE ";
1940 PRINT "INFORMATION  ( Y or N ) ";
1950 INPUT Z$
1955 IF Z$="N" OR Z$="n" OR Z$="Y" OR Z$="y" THEN 1960
1956 LOCATE 22,65:PRINT "                                "
1957 GOTO 1930
1960 IF Z$="N" OR Z$="n" THEN GOTO 2270
```

```
1970 IF Z$="Y" OR Z$="y" THEN GOSUB 2720
1980 LPRINT "  BASEBAND EQUIPMENT":LPRINT CHR$(10)
1990 LPRINT TAB(3) A$(15) TAB(67) A(15):LPRINT CHR$(10)
2000 LPRINT TAB(3) A$(16) TAB(67) A(16):LPRINT CHR$(10)
2010 LPRINT TAB(3) A$(17) TAB(67) A(17):LPRINT CHR$(10)
2020 LPRINT "  CARRIERBAND EQUIPMENT":LPRINT CHR$(10)
2030 LPRINT TAB(3) A$(18) TAB(67) A(18):LPRINT CHR$(10)
2040 LPRINT B$:LPRINT CHR$(10)
2050 LPRINT CHR$(12)
2060 CLS:LOCATE 10,25:PRINT "REMOVE THE LIST FROM THE PRINTER"
2070 LOCATE 20,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
2080 CLS:LOCATE 3,10:PRINT "INPUT THE NUMBER OF THE COMPONENT THAT YOU WISH TO"
2090 PRINT " CHANGE ":INPUT J
2100 IF J>14 AND J<19 GOTO 2130
2110 CLS:LOCATE 10,25:PRINT "INVALID ENTRY -- TRY AGAIN !!":FOR B=1 TO 6
2120 BEEP:NEXT B:GOTO 2080
2130 COLOR 2,0,0:LOCATE 6,3:PRINT A$(J):LOCATE 6,67:PRINT A(J):COLOR 6,0,0
2140 LOCATE 9,15:PRINT "INPUT THE CORRECT NUMBER";
2150 INPUT A(J)
2160 DUMMY=A(J)
2170 LOCATE 12,3:PRINT A$(J):LOCATE 12,67:PRINT A(J)
2180 LOCATE 14,12:PRINT "IS THIS CORRECT  ( Y or N ) ";
2190 INPUT Z$:IF Z$="Y" OR Z$="y" THEN 2250
2200 A(J)=DUMMY:LOCATE 9,15:PRINT "                                                    "
2210 LOCATE 12,3:PRINT "                                                               "
2220 PRINT "                "
2230 LOCATE 14,12:PRINT "                                                              "
2240 GOTO 2140
2250 LOCATE 17,15:PRINT "ARE THERE ANY MORE CORRECTIONS  ( Y or N ) ";
2260 INPUT Y$:IF Y$="Y" OR Y$="y" THEN 2080
2270 LOW=0:HIGH=0
2280 LOW=LOW+A(1)*100+A(2)*100+A(3)*20+A(4)*20+A(5)*100+A(6)*10000+A(7)*30000
2290 LOW=LOW+A(8)*500+A(9)*17+A(10)*5+A(11)*500+A(12)*4000+A(13)*500+A(14)*5000
2300 LOW=LOW+A(15)*600+A(16)*1200+A(17)*200+A(18)*3000
2310 HIGH=HIGH+A(1)*200+A(2)*150+A(3)*50+A(4)*20+A(5)*100+A(6)*30000+A(7)*30000
2320 HIGH=HIGH+A(8)*1500+A(9)*20+A(10)*15+A(11)*1000+A(12)*4000+A(13)*1000
2330 HIGH=HIGH+A(14)*5000+A(15)*600+A(16)*1500+A(17)*300+A(18)*3000
2340 AVCOST=(LOW+HIGH)/2
2350 CLS:LOCATE 10,15:PRINT "THE COST OF THE NETWORK SHOULD BE BETWEEN  $";LOW
2360 LOCATE 12,30:PRINT "  AND  $";HIGH
2370 LOCATE 15,15:PRINT "THE COST OF THE NETWORK, BASED ON THE LOW AND HIGH"
2380 LOCATE 17,25:PRINT "ESTIMATES, SHOULD BE APPROXIMATELY  $";AVCOST
2390 FOR J=1 TO 3500:NEXT J:CLS
2400 LPRINT CHR$(12)
2410 LPRINT "            COMPONENT                  ESTIMATION FACTOR          ";
2420 LPRINT "    NUMBER"
2430 LPRINT "            ---------                  ------------------         ";
2440 LPRINT "    -------"
2450 FOR I=1 TO 18:LPRINT:LPRINT TAB(7) A$(I) TAB(70) A(I)
2460 IF I=12 OR I=18 THEN LPRINT B$
2470 NEXT I
2480 LPRINT CHR$(10):LPRINT TAB(40) "LOW ESTIMATE :";
```

```
2490 LPRINT TAB(59) USING "$$##########.##";LOW
2500 LPRINT CHR$(10):LPRINT TAB(40) "HIGH ESTIMATE :";
2510 LPRINT TAB(59) USING "$$##########.##";HIGH
2520 LPRINT CHR$(10):LPRINT TAB(40) "AVERAGE ESTIMATE :";
2530 LPRINT TAB(59) USING "$$##########.##";AVCOST:LPRINT CHR$(12)
2540 OPEN "B:ALTERNAT" FOR INPUT AS #1
2550 INPUT#1,ALTNUM
2560 FOR I=1 TO ALTNUM:INPUT#1,ALT$(I):NEXT I
2570 CLOSE#1
2580 ALTNUM=ALTNUM+1
2590 OPEN "B:ALTERNAT" FOR OUTPUT AS #1
2600 WRITE#1,ALTNUM
2610 FOR I=1 TO ALTNUM-1:WRITE#1,ALT$(I):NEXT I
2620 WRITE#1,NAMIT$
2630 CLOSE#1
2640 FILE$="B:INCOST"
2650 Z$=STR$(ALTNUM):ZIP=LEN(Z$)-1
2660 Y$=RIGHT$(Z$,ZIP)
2670 XYZ$=FILE$+Y$
2680 OPEN XYZ$ FOR OUTPUT AS #1
2690 WRITE#1,NAMIT$,LOW,HIGH,AVCOST
2700 CLOSE#1
2710 CHAIN "B:CONTROL",600
2720 CLS:LOCATE 9,15:PRINT "A listing of your responses to the previous screen"
2730 LOCATE 11,15:PRINT "will now be printed.  Check to see that the printer"
2740 LOCATE 13,15:PRINT "is  'ON LINE ' and the paper is properly aligned."
2750 LOCATE 22,25:PRINT "( Press any key to continue )":V$=INPUT$(1)
2760 LPRINT CHR$(10)
2770 LPRINT "        COMPONENT                    ESTIMATION FACTOR          ";
2780 LPRINT "   NUMBER"
2790 LPRINT "        ---------                    ------------------         ";
2800 LPRINT "   ------"
2810 RETURN
```

APPC.BAS

(Modified version of a program listed in Appendix C of Engineering Economy, 7th edition, by E.P. DeGarmo, W.G. Sullivan, and J.R. Canada)

```
10 KEY OFF:COLOR 6,0,0:CLS
20 DIM C(100),PRESENT(100)
30 PRINT
40 PRINT TAB(9) "Before attempting to execute this program for the calculation"
50 PRINT
60 PRINT TAB(9) "of a measure of financial merit  (eg. Present Worth, Internal"
70 PRINT
80 PRINT TAB(9) "Rate of Return, etc.)  for a Local Area Networking  (LAN)"
90 PRINT
100 PRINT TAB(9) "alternative, the cost estimation worksheet program should be"
110 PRINT
120 PRINT TAB(9) "run. The estimation program computes an approximate value of"
130 PRINT
140 PRINT TAB(9) "the initial cost of a networking alternative.  This estimate"
150 PRINT
160 PRINT TAB(9) "can then be used as the year zero cash flow for the project."
170 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
180 PRINT:PRINT TAB(9) "PLEASE CHECK TO SEE THAT THE PRINTER IS  'ON LINE' AND"
190 PRINT:PRINT TAB(25) "THE PAPER IS PROPERLY ALIGNED"
200 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
210 OPEN "B:ALTERNAT" FOR INPUT AS #1
220 INPUT#1,ALTNUM
230 FOR I=1 TO ALTNUM:INPUT#1,NAM$(I):NEXT I
240 CLOSE#1
250 LPRINT CHR$(10):LPRINT TAB(8) "NETWORKING ALTERNATIVES FOR WHICH INITIAL ";
260 LPRINT "COSTS HAVE BEEN ESTIMATED":LPRINT CHR$(10)
270 FOR I=1 TO ALTNUM:LPRINT TAB(15) I TAB(20) NAM$(I):NEXT I
280 LPRINT CHR$(12)
290 LOCATE 12,25:PRINT "REMOVE THE PRINTOUTS FROM THE PRINTER"
300 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
310 LOCATE 3,9:PRINT "DO YOU WISH TO DETERMINE A MEASURE OF FINANCIAL MERIT"
320 LOCATE 5,9:PRINT "FOR AN ALTERNATIVE FOR WHICH THE INITIAL COST HAS BEEN"
330 LOCATE 7,9:PRINT "ESTIMATED  ( Y  or  N ) ";
340 INPUT ZBRA$:IF ZBRA$="Y" OR ZBRA$="y" OR ZBRA$="N" OR ZBRA$="n" THEN 370
350 LOCATE 7,9:PRINT "                                                    "
360 GOTO 330
370 CLS
380 IF ZBRA$="N" OR ZBRA$="n" THEN 640
390 CLS
400 LOCATE 3,9:PRINT "INPUT THE NUMBER (from the printout) OF THE ALTERNATIVE"
410 LOCATE 5,9:PRINT "THAT YOU WISH TO EVALUATE."
420 INPUT XXX:IF XXX<1 OR XXX>ALTNUM THEN 390
430 LOCATE 10,9:PRINT "YOUR CHOICE IS ";XXX;"  ";NAM$(XXX)
440 LOCATE 12,15:PRINT "IS THIS CORRECT  ( Y  or  N ) ";
450 INPUT Z$:IF Z$="Y" OR Z$="y" OR Z$="n" OR Z$="N" THEN 470
460 GOTO 390
470 FILE$="B:INCOST"
```

```
480 L$=STR$(XXX):ZIP=LEN(L$)-1
490 Y$=RIGHT$(L$,ZIP)
500 ZYX$=FILE$+Y$
510 OPEN ZYX$ FOR INPUT AS #1
520 INPUT#1,NAMIT$,LOW,HIGH,AVCOST
530 CLOSE#1
535 C(0)=-AVCOST
540 CLS:LOCATE 3,12:PRINT "THE AVERAGE INITIAL COST VALUE FOR THE ALTERNATIVE"
550 LOCATE 5,12:PRINT NAMIT$;" IS ";
560 PRINT USING "$$########.##";AVCOST
570 LOCATE 7,12:PRINT "THIS AMOUNT WILL BE THE NEGATIVE END OF YEAR ZERO CASH"
580 LOCATE 9,12:PRINT "FLOW.  THE CASH FLOW FOR YEAR ZERO HAS ALREADY BEEN"
590 LOCATE 11,12:PRINT "ENTERED.  YOU SHOULD THEREFORE BEGIN YOUR ENTRIES WITH"
600 LOCATE 13,12:PRINT "AN END OF YEAR ONE CASH FLOW."
610 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
640 REM : ************ DIRECTIONS **************
650 PRINT "1986 REVISION - INCORPORATES RATE OF RETURN METHODS"
660 PRINT
670 INPUT "DO YOU WANT TO SEE INSTRUCTIONS FOR DATA INPUT (Y/N)";Q1$
680 IF Q1$="y" OR Q1$="n" THEN PRINT "PRESS CAPS-LOCK PLEASE..."
690 IF Q1$="N" THEN CLS:GOTO 1250 ELSE IF Q1$="Y" THEN CLS ELSE 670
700 PRINT "******** INSTRUCTIONS FOR ENTERING CASH FLOW DATA *******":PRINT
710 PRINT "  THIS PROGRAM GIVES THE USER THE OPTION OF CALCULATING ANY OF "
720 PRINT "THE FOLLOWING MEASURES OF MERIT : INTERNAL RATE OF RETURN ,"
730 PRINT "PRESENT WORTH, FUTURE WORTH, ANNUAL WORTH, SIMPLE PAYBACK, "
740 PRINT "DISCOUNTED PAYBACK PERIOD, EXTERNAL RATE OF RETURN, "
750 PRINT "EXPLICIT REINVESTMENT RATE OF RETURN, OR EXTERNAL RATE OF"
760 PRINT "RETURN (METHOD 2) WHEN THE EXTERNAL RATE E IS CALCULATED "
770 PRINT "DIRECTLY FOR EACH YEAR EXPENSES EXCEED REVENUES. "
780 PRINT
790 PRINT "  END OF PERIOD CASH FLOWS ARE ENTERED IN THE FOLLOWING MANNER :"
800 PRINT:PRINT "                    C,J1,J2 ":PRINT
810 PRINT "WHERE C = CASH FLOW FOR EACH YEAR FROM THE YEAR J1 THROUGH J2."
820 PRINT
830 PRINT "  ALL CALCULATIONS ARE BASED ON YEAR 0 BEING THE PRESENT PERIOD"
840 PRINT "(IF NEGATIVE YEARS ARE ENTERED, THE PRESENT WORTH IS BASED ON"
850 PRINT "PERIOD 0 THAT WAS ENTERED BY THE USER.)":PRINT
860 PRINT:PRINT:PRINT "------> PRESS ANY KEY TO CONTINUE!"
870 IK$=INKEY$:IF IK$="" THEN 870
880 CLS:PRINT "THE NUMBER OF DIFFERENT CASH FLOW VALUES ASKED FOR IN THE"
890 PRINT "PROGRAM IS THE NUMBER OF DIFFERENT CASH FLOW SEQUENCES THAT YOU"
900 PRINT "WILL ENTER, FOR EXAMPLE :":PRINT
910 PRINT TAB(20)"    CASH FLOW    PERIOD"
920 PRINT TAB(20)"    ---------    ------"
930 PRINT TAB(20)"      10000        0"
940 PRINT TAB(20)"          0        1"
950 PRINT TAB(20)"      10000        2"
960 PRINT TAB(20)"      10000        3"
970 PRINT TAB(20)"      10000        4":PRINT
980 PRINT "FOR THE ABOVE CASH FLOWS, THE NUMBER OF DIFFERENT CASH FLOW"
990 PRINT "SEQUENCES IS 3 AND THE CASH FLOWS SHOULD BE ENTERED AS FOLLOWS :"
1000 PRINT:PRINT TAB(26)"10000,0,0"
```

```
1010 PRINT TAB(26)"    0,1,1"
1020 PRINT TAB(26)"10000,2,4":PRINT
1030 PRINT:PRINT "-------> PRESS ANY KEY TO CONTINUE!"
1040 IK$=INKEY$:IF IK$="" THEN 1040
1050 CLS:PRINT " ALL CASH FLOWS THAT OCCUR AT THE END OF A PARTICULAR TIME"
1060 PRINT "PERIOD MUST BE ENTERED AS A NET AMOUNT, FOR EXAMPLE , A -10000"
1070 PRINT "AT THE END OF YEAR 2 AND A +2000 AT THE END OF YEAR 2 WOULD BE"
1080 PRINT "ENTERED AS -8000,2,2. "
1090 PRINT " A NET CASH FLOW AMOUNT IS ENTERED IN THIS MANNER FOR EACH TIME"
1100 PRINT "PERIOD IN THE LIFE OF THE ALTERNATIVE BEING CONSIDERED.":PRINT
1110 PRINT "e.g. A PROJECT HAVING A $10000 EXPENDITURE AT END OF YEAR 0"
1120 PRINT "     FOLLOWED BY SAVINGS OF $3000/YEAR AT END OF YEAR 1 TO 6 AND"
1130 PRINT "     A FINAL SALVAGE VALUE OF $2000 AT END OF YEAR 6 WOULD BE "
1140 PRINT "     ENTERED AS FOLLOWS :"
1150 PRINT TAB(30)"-10000,0,0"
1160 PRINT TAB(30)"  3000,1,5"
1170 PRINT TAB(30)"  5000,6,6":PRINT
1180 PRINT " THE USER IS LIMITED TO END-OF-PERIOD CASH FLOW CONVENTION BUT"
1190 PRINT "HAS THE OPTION OF SELECTING DISCRETE OR CONTINUOUS COMPOUNDING."
1200 PRINT "MULTIPLE INTERNAL RATES OF RETURN CANNOT BE IDENTIFIED.":PRINT
1210 PRINT:PRINT "-------> PRESS ANY KEY TO CONTINUE!"
1220 IK$=INKEY$:IF IK$="" THEN 1220
1230 CLS:PRINT "PLEASE ANSWER THE FOLLOWING QUESTIONS:":PRINT
1240 REM ****** INPUT CASH FLOW DATA ***********
1250 INPUT "HOW MANY DIFFERENT CASH FLOW VALUES ARE THERE ? ",W
1260 PRINT "ENTER CASH FLOW, FIRST PERIOD, LAST PERIOD (SEPARATE BY COMMA)"
1270 FOR I=1 TO W
1280 INPUT C1,J1,J2
1290 IF I =1 THEN 3610
1300 FOR Z = J1 TO J2
1310 C(Z-S) = C1
1320 NEXT Z
1330 NEXT I
1340 CLS:LOCATE 5,12:PRINT "THIS PORTION OF THE PROGRAM REQUIRES THE USE OF A"
1350 LOCATE 7,12:PRINT "PRINTER.  PLEASE CHECK TO SEE THAT THE PRINTER IS"
1360 LOCATE 9,12:PRINT "'ON LINE'  AND THE PAPER IS PROPERLY ALIGNED."
1370 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
1380 PRINT:PRINT " YEAR     CASH FLOW"
1390 LPRINT CHR$(10):LPRINT " YEAR     CASH FLOW"
1400 FOR I =S TO J2
1410 I8 =0
1420 PRINT USING "####     ####,###.##";I,C(I-S)
1430 LPRINT USING "####     ####,###.##";I,C(I-S)
1440 NEXT I
1450 LPRINT CHR$(12)
1460 REM ******** ALLOW FOR ALTERATION OF DATA *********
1470 PRINT:INPUT "WANT TO MAKE ANY CORRECTIONS ON CASH FLOW (Y/N)";A$
1480 IF A$="N" THEN 1520 ELSE IF A$="Y" THEN 1490 ELSE 1470
1490 INPUT "ENTER THE YEAR # (FOR CORRECTION) = ",K
1500 INPUT "ENTER CASH FLOW FOR ABOVE YEAR = ",C(K-S)
1510 GOTO 1470
1520 REM   ******** COMPUTATION OF PRESENT WORTH *********
```

```
1530 INPUT "ENTER INTEREST RATE AS A DECIMAL  (eg. ENTER 10% as .1) = ",I3
1540 IF I3<0 OR I3>1 THEN BEEP:PRINT "INVALID!":GOTO 1530
1550 PRES=0
1560 FOR I=0 TO J2:PRESENT(I)=C(I)*(1+I3)^(-I):PRES=PRES+PRESENT(I):NEXT I
1570 ANNUAL=PRES*((I3*(1+I3)^J2)/(((1+I3)^J2)-1))
1571 IF ZBRA$="Y" OR ZBRA$="y" GOTO 1580
1572 CLS:LOCATE 5,20:PRINT "Enter the name of the alternative"
1573 INPUT NAMIT$
1580 OPEN "B:ANUAL" FOR INPUT AS #1
1590 INPUT#1,HOWMANY
1600 CLOSE#1
1610 HOWMANY=HOWMANY+1
1620 OPEN "B:ANUAL" FOR OUTPUT AS #1
1630 WRITE#1,HOWMANY
1640 CLOSE#1
1650 FILE$="B:ANCST"
1660 DUMMY$=STR$(HOWMANY):ZIP=LEN(DUMMY$)-1
1670 YYY$=RIGHT$(DUMMY$,ZIP)
1680 XYZZ$=FILE$+YYY$
1690 OPEN XYZZ$ FOR OUTPUT AS #1
1700 WRITE#1,NAMIT$,J2,I3,PRES
1710 FOR I=0 TO J2
1720 WRITE#1,I,C(I)
1730 NEXT I
1740 CLOSE#1
1750 REM : ******** SELECTION OF TRANSACTION TYPE ********
1760 PRINT "SELECT A METHOD FROM THE FOLLOWING:"
1770 INPUT "(ENTER PW/FW/AW/IRR/ERR/ERR2/ERRR/SPP/DPP/TABLE/?/END):",A$
1780 IF A$ <> "?" THEN 1910
1790 PRINT " PRESENT WORTH ==========> (PW)"
1800 PRINT " FUTURE WORTH ==========> (FW)"
1810 PRINT " ANNUAL WORTH  ==========> (AW)"
1820 PRINT " INTERNAL RATE OF RETURN ==> (IRR)"
1830 PRINT " EXTERNAL RATE OF RETURN ==> (ERR)"
1840 PRINT " 2ND ERR METHOD (BABCOCK)==> (ERR2)"
1850 PRINT " EXPLICIT REINVESTMENT RATE ==> (ERRR)"
1860 PRINT " SIMPLE PAYBACK PERIOD ====> (SPP)"
1870 PRINT " DISCOUNTED PAYBACK PERIOD ==> (DPP)"
1880 PRINT " SEE THE TABLE AGAIN ======> (TABLE)"
1890 PRINT " END THE PROGRAM ==========> (END)"
1900 GOTO 1770
1910 IF A$ = "PW" THEN 2040
1920 IF A$ = "FW" THEN 2040
1930 IF A$ = "AW" THEN 2040
1940 IF A$ = "DPP" THEN 2040
1950 IF A$ = "IRR" THEN 2160
1960 IF A$ = "ERR" THEN 2460
1970 IF A$ = "ERR2" THEN 2760
1980 IF A$ = "ERRR" THEN 3060
1990 IF A$ = "SPP" THEN 3270
2000 IF A$ = "TABLE" THEN 1380
2010 IF A$ = "END" THEN 3980
```

```
2020 PRINT " PLEASE RE-ENTER SELECTION !":GOTO 1770
2030 REM : ***************** P WORTH *********************
2040 INPUT "ENTER INTEREST RATE AS DECIMAL (e.g. ENTER 10% AS .1) = ",I3
2050 IF I3<0 OR I3>1 THEN BEEP:PRINT "INVALID!":GOTO 2040
2060 INPUT "DO YOU WANT CONTINUOUS (CON) OR DISCRETE (DIS) COMPOUNDING ";B$
2070 IF B$="CON" OR B$="DIS" THEN 2080 ELSE 2060
2080 IF B$="CON" THEN 3640
2090 IF A$="DPP" THEN 3380
2100 GOSUB 3480
2110 IF A$="FW" THEN 3740
2120 IF A$="AW" THEN 3770
2130 PRINT "==========> ";A$;" = ";P
2140 GOTO 3820
2150 REM : ***************** IRR RATE **********************
2160 E = .001
2170 E = E/100
2180 I1=0:I3=0:I2=1
2190 GOSUB 3480
2200 IF P <> 0 THEN 2230
2210 A=0:B=0
2220 GOTO 2440
2230 D= .1
2240 Z1 = ABS(P-C(0))
2250 IF ABS(C(0)) < Z1 THEN 2280
2260 PRINT "NO INTEREST RATE CAN BE FOUND "
2270 GOTO 3820
2280 P1 = P
2290 FOR I3=I1 TO I2 STEP D
2300 GOSUB 3480
2310 V=SGN(P1)*SGN(P)
2320 IF V<0 OR P=0! THEN 2350
2330 P1 = P
2340 NEXT I3
2350 IF D <= E THEN 2380
2360 I1=I3-D:I2=I3:D=D/10
2370 GOTO 2290
2380 INPUT "DO YOU WANT DISCRETE (DIS) OR CONTINUOUS (CON) INTEREST RATE ";A$
2390 A=I3-D:B=I3
2400 IF A$="DIS" THEN 2420
2410 A=LOG(1+A):B=LOG(1+B)
2420 A=A*100
2430 B=B*100
2440 PRINT "==========> IRR IS BETWEEN ";A;" AND ";B;"%"
2450 GOTO 3820
2460 REM : ***************** ERR RATE **********************
2470 E = .001
2480 E = E/100
2490 INPUT "ENTER EXTERNAL REINVESTMENT RATE E AS DECIMAL";IE1
2500 I1=0:I3=0:I2=1
2510 GOSUB 3480
2520 IF P <> 0 THEN 2560
2530 A=0:B=0
```

```
2540 GOTO 2740
2550 REM ------ ITERATE UNTIL RATE WITHIN TOLERANCE IS FOUND ------
2560 D= .1
2570 P1 = P
2580 FOR I3=I1 TO I2 STEP D
2590 GOSUB 3540
2600 V=SGN(P1)*SGN(P)
2610 IF V<0 OR P=0! THEN 2640
2620 P1 = P
2630 NEXT I3
2640 IF D <= E THEN 2680
2650 I1=I3-D:I2=I3:D=D/10
2660 GOTO 2580
2670 REM ------ ALLOW FOR DISCRETE OR CONTINUOUS AND PRINT ------
2680 INPUT "DO YOU WANT DISCRETE (DIS) OR CONTINUOUS (CON) INTEREST RATE ";A$
2690 A=I3-D:B=I3
2700 IF A$="DIS" THEN 2720
2710 A=LOG(1+A):B=LOG(1+B)
2720 A=A*100
2730 B=B*100
2740 PRINT "==========> ERR IS BETWEEN ";A;" AND ";B;"%"
2750 GOTO 3820
2760 REM : ********** ERR2 RATE **********
2770 E = .001
2780 E = E/100
2790 INPUT "ENTER EXTERNAL REINVESTMENT RATE E AS DECIMAL";IE1
2800 I1=0:I3=0:I2=1
2810 GOSUB 3480
2820 IF P <> 0 THEN 2860
2830 A=0:B=0
2840 GOTO 3040
2850 REM ------ ITERATE UNTIL RATE WITHIN TOLERANCE IS FOUND ------
2860 D= .1
2870 P1 = P
2880 FOR I3=I1 TO I2 STEP D
2890 GOSUB 3670
2900 V=SGN(P1)*SGN(P)
2910 IF V<0 OR P=0! THEN 2940
2920 P1 = P
2930 NEXT I3
2940 IF D <= E THEN 2980
2950 I1=I3-D:I2=I3:D=D/10
2960 GOTO 2880
2970 REM ------ ALLOW FOR DISCRETE OR CONTINUOUS AND PRINT ------
2980 INPUT "DO YOU WANT DISCRETE (DIS) OR CONTINUOUS (CON) INTEREST RATE ";A$
2990 A=I3-D:B=I3
3000 IF A$="DIS" THEN 3020
3010 A=LOG(1+A):B=LOG(1+B)
3020 A=A*100
3030 B=B*100
3040 PRINT "==========> ERR2 IS BETWEEN ";A;" AND ";B;"%"
3050 GOTO 3820
```

```
3060 REM : ********* ERRR RATE **********************
3070 PRINT
3080 PRINT "          THE ORIGINAL SINGLE LUMP SUM INVESTMENT "
3090 PRINT "       AND THE SALVAGE VALUE SHOULD NOT BE INCLUDED "
3100 PRINT "       IN THE COST TABLE WHEN USING THE ERRR METHOD. "
3110 INPUT "       DO YOU NEED TO ALTER THE TABLE(Y OR N)"; C$
3120 PRINT
3130 IF C$ = "Y" GOTO 1380
3140 INPUT "ENTER EXTERNAL REINVESTMENT RATE E AS DECIMAL"; I3
3150 INPUT "ENTER ORIGINAL INVESTMENT COST P"; P9
3160 INPUT "ENTER SALVAGE VALUE S"; S9
3170 GOSUB 3480
3180 REM ------ DETERMINE AW FOR CASH FLOW ------
3190 IF S=0 THEN 3210
3200 P=P*(1+I)^(0-S)
3210 P=(P*I3*(I3+1)^(J2-S))/(((I3+1)^(J2-S))-1)
3220 REM ------ ERRR CALCULATION FORMULA ------
3230 ERRR=(P-(P9-S9)*(I3/(((1+I3)^J2)-1)))/P9
3240 ERRR = ERRR*100
3250 PRINT "==========> ERRR =";ERRR;"%"
3260 GOTO 3820
3270 REM : ********* SIMPLE PAYBACK PERIOD *********
3280 P=0
3290 FOR I=S TO J2
3300 P=C(I-S)+P
3310 IF P>=0 THEN 3350
3320 NEXT I
3330 PRINT "==========> SIMPLE PAYBACK PERIOD > YEAR (I.E. NEVER) ";I
3340 GOTO 3820
3350 PRINT "==========> SIMPLE PAYBACK PERIOD = YEAR";I
3360 GOTO 3820
3370 REM : ******* DISCOUNTED PAYBACK PERIOD *******
3380 P=0
3390 FOR I=S TO J2
3400 P=P+C(I-S)/(1+I3)^(I)
3410 IF P>=0 THEN 3450
3420 NEXT I
3430 PRINT "==========> DISCOUNTED PAYBACK PERIOD > YEAR ";I
3440 GOTO 3820
3450 PRINT "==========> DISCOUNTED PAYBACK PERIOD = YEAR ";I
3460 GOTO 3820
3470 REM ------CALCULATE PW FOR IRR ------
3480 P=0
3490 FOR I=S TO J2
3500 P=P+C(I-S)/((I3+1)^I)
3510 NEXT I
3520 RETURN
3530 REM ------CALCULATE PW FOR ERR ------
3540 P=0
3550 FOR I=S TO J2
3560 IF C(I-S) > 0 THEN P=P+C(I-S)*((1+IE1)^(J2-I))
3570 IF C(I-S) < 0 THEN P=P+(C(I-S)/((1+IE1)^I))*(I3+1)^J2
```

```
3580 NEXT I
3590 RETURN
3600 REM ------FROM ORIGINAL PROGRAM------
3610 IF ZBRA$="Y" OR ZBRA$="y" THEN S=0 ELSE S=J1
3620 GOTO 1300
3630 REM ------FOR CONTINUOUS COMPOUNDING P-WORTH------
3640 I3=EXP(I3)-1
3650 GOTO 2090
3660 REM ------CALCULATE PW FOR ERR2 ------
3670 P=0
3680 FOR I=S TO J2
3690 IF C(I-S) > 0 THEN P=P+C(I-S)*((1+IE1)^(J2-I))
3700 IF C(I-S) < 0 THEN P=P+C(I-S)*((1+I3)^(J2-I))
3710 NEXT I
3720 RETURN
3730 REM -------CALCULATE FW FROM PW -------
3740 P=P*(1+I3)^J2
3750 GOTO 2120
3760 REM -------CALCULATE AW FROM PW -------
3770 IF S=0 THEN 3790
3780 P=P*(1+I)^(0-S)
3790 P=(P*I3*(I3+1)^(J2-S))/(((I3+1)^(J2-S))-1)
3800 GOTO 2130
3810 REM ********** ALLOW FOR RERUN OR END OF PROGRAM********
3820 PRINT "-------------------------------------------------------------"
3830 INPUT "WANT ANOTHER RUN (Y/N) ";A$
3840 IF A$="N" THEN 3980 ELSE IF A$="Y" THEN 3850 ELSE 3830
3850 INPUT "ENTER NEW/OLD/?/CHANGE ";A$
3860 IF A$ <> "?" THEN 3910
3870 PRINT "TO ENTER COMPLETE NEW CASH FLOW TYPE ========> NEW "
3880 PRINT "TO KEEP OLD CASH FLOWS WITH NO CHANGE TYPE ==> OLD"
3890 PRINT "TO MAKE SOME CHANGES ON OLD CASH FLOWS TYPR ==> CHANGE"
3900 GOTO 3850
3910 IF A$="NEW" THEN 1250
3920 IF A$="OLD" THEN 1770
3930 IF A$="CHANGE" THEN 3950
3940 PRINT "PLEASE RE-ENTER !":GOTO 3850
3950 INPUT "WOULD YOU LIKE TO SEE THE OLD CASH FLOW TABLE (Y/N)";A$
3960 IF A$="N" THEN 1490 ELSE IF A$="Y" THEN 3970 ELSE 3950
3970 GOTO 1380
3980 CHAIN "B:CONTROL",600
```

AFTERTAX.BAS

(Modified version of a program listed in Appendix H of Engineering Economy, 7th edition, by E.P. DeGarmo, W.G. Sullivan, and J.R. Canada)

```
10      REM: ************************************************
20      REM:  DEFINITION OF MAJOR VARIABLES
30      REM: ************************************************
40      REM: T4: INCREMENTAL INCOME TAX RATE
50      REM: T3: TAX RATE ON CAPITAL GAIN OR LOSS
60      REM: G1: GENERAL INFLATION RATE
70      REM: M1: AFTER-TAX, COMBINED DISCOUNT RATE
80      REM: T5: INVESTMENT TAX CREDIT PERCENTAGE
90      REM: P1: PERIOD OF STUDY IN YEARS
100     REM: L4: USEFUL LIFE OF INVESTMANT IN YEARS
110     REM: L5: TAX LIFE OF INVESTMENT IN YEARS
120     REM: F1: FIRST COST OF INVESTMENT
130     REM: S1: SALVAGE VALUE OF INVESTMENT IN ACTUAL DOLLARS
140     REM: U1: ANNUAL COST OF UTILITIES IN REAL DOLLARS
150     REM: A6: ANNUAL COST OF UTILITIES IN ACTUAL DOLLARS
160     REM: E3: EFFECTIVE ANNUAL ESCALATION RATE FOR UTILITIES
170     REM: L1: ANNUAL COST OF LABOR IN REAL DOLLARS
180     REM: A2: ANNUAL COST OF LABOR IN ACTUAL DOLLARS
190     REM: E1: EFFECTIVE ANNUAL ESCALATION RATE FOR LABOR
200     REM: M2: ANNUAL COST OF MATERIALS IN REAL DOLLARS
210     REM: A4: ANNUAL COST OF MATERIALS IN ACTUAL DOLLARS
220     REM: E2: EFFECTIVE ANNUAL ESCALATION RATE FOR MATERIALS
230     REM: R1: ANNUAL REVENUES IN REAL DOLLARS
240     REM: L2: ANNUAL LEASE COST IN REAL DOLLARS
250     REM: L3: LIFE OF THE LEASE IN YEARS
260     REM: A5: ANNUAL REVENUES IN ACTUAL DOLLARS
270     REM: A3: LEASE COST ADJUSTED FOR RENEGOTIATION
280     REM: I1: INVESTMENT TAX CREDIT
290     REM: D2: DEPRECIATION OF THE INVESTMENT SUMMED OVER ITS LIFE
300     REM: B1: BOOK VALUE OF THE INVESMENT
310     REM: C1: TAX ON THE CAPITAL GAIN OR LOSS
320     REM: B2: BEFORE TAX CASH FLOW
330     REM: D1: DEPRECIATION IN ACTUAL DOLLARS
340     REM: T2: TAXABLE INCOME IN ACTUAL DOLLARS
350     REM: T1: INCOME TAX IN ACTUAL DOLLARS
360     REM: P2: PRESENT VALUE OF THE CASH FLOW IN THAT YEAR
370     REM: N1: NET PRESENT VALUE OF THE INVESTMENT
380     REM: E9: ESCALATION RATE FOR REVENUES
390 DIM A1(100),A6(100),A2(100),A4(100),P2(100),B2(100),D1(100),T2(100)
400 DIM A7(100),A3(100),A5(100),S1(100),T1(100)
410 COLOR 6,0,0:KEY OFF:CLS
420 LOCATE 2,9:PRINT "Before attempting to execute this program to calculate"
430 LOCATE 4,9:PRINT "the after-tax present worth of an LAN alternative, the"
440 LOCATE 6,9:PRINT "initial cost and the annual cash flows should have been"
450 LOCATE 8,9:PRINT "estimated.  The LAN cost estimation worksheet program"
460 LOCATE 10,9:PRINT "can supply the initial cost figures for some of the"
470 LOCATE 12,9:PRINT "alternatives.  A listing of the alternatives for which"
```

```
480 LOCATE 14,9:PRINT "initial cost estimates have been developed with the aid"
490 LOCATE 16,9:PRINT "of the cost estimation program will now be provided."
500 LOCATE 18,9:PRINT "Please check to see that the printer is  'ON LINE'  and"
510 LOCATE 20,9:PRINT "the paper is properly aligned.":COLOR 2,0,0
520 LOCATE 23,25:PRINT "(Press any key to continue)":Z$=INPUT$(1):COLOR 6,0,0
530 CLS:OPEN "B:ALTERNAT" FOR INPUT AS #1:INPUT#1,ALTNUM:FOR I=1 TO ALTNUM
540 INPUT#1,NAM$(I):NEXT I:CLOSE#1
550 LPRINT CHR$(10):LPRINT TAB(8) "NETWORKING ALTERNATIVES FOR WHICH INITIAL ";
560 LPRINT "COSTS HAVE BEEN ESTIMATED":LPRINT CHR$(10)
570 FOR I=1 TO ALTNUM:LPRINT TAB(15) I;".";TAB(20) NAM$(I):NEXT I
580 LPRINT CHR$(12)
590 LOCATE 12,25:PRINT "REMOVE THE PRINTOUTS FROM THE PRINTER"
600 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
610 LOCATE 3,9:PRINT "Do you wish to determine the after-tax present worth for"
620 LOCATE 5,9:PRINT "one of the alternatives on the printout  ( Y or N ) ";
630 INPUT Z$:IF Z$="y" OR Z$="Y" OR Z$="n" OR Z$="N" THEN 650
640 LOCATE 5,55:PRINT "                          ":GOTO 620
650 CLS:IF Z$="n" OR Z$="N" THEN 800
660 CLS
670 LOCATE 3,9:PRINT "Input the number (from the printout) of the alternative"
680 LOCATE 5,9:PRINT "that you wish to evaluate."
690 INPUT XXX:IF XXX<1 OR XXX>ALTNUM THEN 660
700 LOCATE 10,9:PRINT "Your choice is ";XXX;"  ";NAM$(XXX)
710 LOCATE 12,9:PRINT "Is this correct ";
720 INPUT Z$:IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" THEN 740
730 LOCATE 12,24:PRINT "                                        ":GOTO 710
740 IF Z$="Y" OR Z$="y" THEN 760
750 GOTO 660
760 FILE$="B:INCOST":L$=STR$(XXX):ZIP=LEN(L$)-1:Y$=RIGHT$(L$,ZIP):XYZ$=FILE$+Y$
770 OPEN XYZ$ FOR INPUT AS #1:INPUT#1,NAMIT$,LOW,HIGH,AVCOST:CLOSE#1
780 F1=AVCOST
790 GOTO 810
800 XXX=0
810 CLS:INPUT "DO YOU WANT TO SEE THE DESCRIPTION OF THE PROGRAM (Y/N)";H$
820 IF H$="Y" OR H$="y" THEN CLS ELSE IF H$="N" OR H$="n" THEN 940 ELSE 810
830 PRINT TAB(13)"********  DESCRIPTION OF THE PROGRAM  ********":PRINT
840 PRINT "    THIS PROGRAM ALLOWS YOU TO CONDUCT AN ACTUAL DOLLAR ANALYSIS OF"
850 PRINT "AN INVESTMENT  ALTERNATIVE ON AN  AFTER-TAX BASIS WHEN INFLATION / "
860 PRINT "ESCALATION OF REVENUES AND COSTS ARE INVOLVED.   THE REFERENCE YEAR"
870 PRINT "FOR ALL CASH FLOWS, EXCEPT SALVAGE VALUE, IS THE TIME AT  WHICH THE"
880 PRINT "INITIAL INVESTMENT IS MADE (I.E. TIME 0).   THESE ARE TERMED  'REAL"
890 PRINT "DOLLARS'   IN THE PROMPTS BELOW.        MULTIPLE REPLACEMENTS OF AN"
900 PRINT "ALTERNATIVE  ARE  PERMITTED  WHEN THE STUDY  PERIOD IS  LONGER THAN"
910 PRINT "USEFUL  LIFE.     CONVERSELY THE STUDY PERIOD CAN BE  SHORTER  THAN"
920 PRINT "USEFUL LIFE.    SALVAGE  VALUE AT  THE END OF THE STUDY  PERIOD  IS"
930 PRINT "SPECIFIED BY THE ANALYST."
940 PRINT:PRINT
950 PRINT TAB(10)"*******************************************************"
960 PRINT TAB(10)"*                                                     *"
970 PRINT TAB(10)"*  NOTE: ENTER ALL PERCENTAGES AND RATE IN            *"
980 PRINT TAB(10)"*        DECIMAL FORM.  FOR EXAMPLE:                  *"
990 PRINT TAB(10)"*        10% SHOULD BE ENTERED AS .10                 *"
```

```
1000 PRINT TAB(10)"*                                                    *"
1010 PRINT TAB(10)"**********************************************************"
1020 PRINT:PRINT "----> PRESS ANY KEY TO CONTINUE!"
1030 INK$=INKEY$:IF INK$="" THEN 1030
1040 T4=0:T3=0:T5=0:G1=0:M1=0:S2=0:N5=0:D2=0:N1=0:J1=0
1050 P1=0:L4=0:L5=0:F1=0:U1=0:E3=0:L1=0:E1=0:M2=0:E2=0
1060 R1=0:L2=0:L3=0:C2=0:K1=0:I2=0:N2=0:N3=0:N4=0:J2=0
1070 FOR J=1 TO 100
1080 A1(J)=0:A2(J)=0:A3(J)=0:A4(J)=0:A5(J)=0:A6(J)=0:A7(J)=0
1090 B2(J)=0:D1(J)=0:S1(J)=0:P2(J)=0:T1(J)=0:T2(J)=0
1100 NEXT J
1110 CLS:PRINT TAB(16)"INVESTMENT"
1120 PRINT TAB(16)"==========":PRINT
1130 IF XXX>.5 THEN 1150
1140 INPUT "INITIAL COST OF INVESTMENT = ",F1
1150 INPUT "INVESTMENT TAX CREDIT PERCENTAGE (IN DECIMAL) = ",T5
1160 IF T5<0 OR T5>1 THEN 1150
1170 INPUT "THE USEFUL LIFE (IN YEARS) OF THE INVESTMENT = ",L4
1180 INPUT "THE STUDY PERIOD (IN YEARS) = ",P1
1190 PRINT "THE SALVAGE VALUE OF THE INVESTMENT IN ACTUAL DOLLARS FOR :"
1200 J=L4
1210 IF J>P1 GOTO 1240
1220 PRINT "YEAR ";J;" ";
1230 INPUT S1(J)
1240 IF J=P1 GOTO 1290
1250 J=J+L4
1260 IF J<=P1 GOTO 1210
1270 J=P1
1280 GOTO 1210
1290 PRINT:PRINT:PRINT TAB(16)"DEPRECIATION"
1300 PRINT TAB(16)"==========":PRINT
1310 INPUT "ACRS TAX LIFE OF INVESTMENT (IN YEARS) = ",L5
1320 PRINT "THE APPROPRIATE ACRS RECOVERY PERCENTAGE (IN DECIMAL) :"
1330 FOR J=1 TO L5
1340 PRINT "YEAR ";J;" ";
1350 INPUT A1(J)
1360 REM: **********CHECK IF A1 RECOVERY % SUM TO 1 **********
1370 S2=S2+A1(J)
1380 NEXT J
1390 IF S2<=.9999 OR S2>=1.0001 THEN 1410
1400 GOTO 1450
1410 PRINT "THE A1 RECOVERY PERCENTAGES DO NOT SUM TO ONE.  TRY AGAIN."
1420 S2=0!
1430 GOTO 1320
1440 REM: **********COLLECTING INPUT INFORMATION**********
1450 PRINT:PRINT:PRINT TAB(15)"REVENUES AND EXPENSES"
1460 PRINT TAB(15)"==========":PRINT
1470 INPUT "THE ANNUAL REVENUES IN REAL DOLLARS = ",R1
1480 INPUT "EFFECTIVE ANNUAL ESCALATION RATE FOR REVENUES (IN DECIMAL) = ",E9
1490 IF E9<0 OR E9>1 THEN 1480
1500 INPUT "THE ANNUAL COST OF UTILITIES IN REAL DOLLARS = ",U1
1510 INPUT "EFFECTIVE ANNUAL ESCALATION RATE FOR UTILITIES (IN DECIMAL) = ",E3
```

```
1520 IF E3<0 OR E3>1 THEN 1510
1530 INPUT "THE ANNUAL COST OF LABOR IN REAL DOLLARS = ",L1
1540 INPUT "EFFECTIVE ANNUAL ESCALATION RATE FOR LABOR (IN DECIMAL) = ",E1
1550 IF E1<0 OR E1>1 THEN 1540
1560 INPUT "THE ANNUAL COST OF MATERIALS IN REAL DOLLARS = ",M2
1570 INPUT "EFFECTIVE ANNUAL ESCALATION RATE FOR MATERIAL (IN DECIMAL) = ",E2
1580 IF E2<0 OR E2>1 THEN 1570
1590 INPUT "THE ANNUAL LEASE COST IN ACTUAL DOLLARS = ",L2
1600 INPUT "NUMBER OF YEARS BEFORE THE LEASE HAS TO BE RENEGOTIATED = ",L3
1610 PRINT:PRINT TAB(16)"OTHER INFORMATION"
1620 PRINT TAB(16)"═══════════════":PRINT:PRINT
1630 INPUT "INCREMENTAL INCOME TAX RATE (IN DECIMAL) = ",T4
1640 IF T4<0 OR T4>1 THEN 1630
1650 INPUT "TAX RATE ON CAPITAL GAIN OR LOSS (IN DECIMAL) = ",T3
1660 IF T3<0 OR T3>1 THEN 1650
1670 INPUT "INFLATION RATE FOR REPLACEMENT INVESTMENTS (IN DECIMAL) = ",G1
1680 IF G1<0 OR G1>1 THEN 1670
1690 INPUT "THE M.A.R.R. FOR AFTER-TAX ANALYSIS (IN DECIMAL) = ",M1
1700 IF M1<0 OR M1>1 THEN 1690
1710 REM: ********* CALCULATING THE LEASE COST FOR EACH YEAR ************
1720 A3(1)= -L2
1730 FOR L= 2 TO P1
1740 I2=L-1:K1=K1+1
1750 IF K1 >= L3 GOTO 1780
1760 A3(L)= A3(I2)
1770 GOTO 1790
1780 A3(L)=-L2*(1+G1)^I2:K1=0
1790 NEXT L
1800 REM: ************ CALCULATING THE DEPRECIATION ****************
1810 N3=N3+1
1820 FOR I= 1 TO L4
1830 N2=N2+1:N4=N3*L4:K2=N4+1
1840 A1(K2)=A1(I)
1850 D1(N2)= -(F1*(1+G1)^(N4-L4))*A1(N2)
1860 IF N2=P1 GOTO 1890
1870 IF N2<>N4 THEN 2030
1880 IF N2>=P1 THEN 2030
1890 N6=N4-L4+1
1900 FOR K=N6 TO N2
1910 D2=D2-D1(K)
1920 NEXT K
1930 B1=F1*(1+G1)^(N4-L4)-D2
1940 D2=0!
1950 IF S1(N2)>=F1 THEN 1980
1960 IF S1(N2)<=B1 THEN 1980
1970 GOTO 2010
1980 T2(N2)=S1(N2)-B1
1990 T1(N2)= -T2(N2)*T3
2000 GOTO 2030
2010 T2(N2)=S1(N2)-B1
2020 T1(N2)= -T2(N2)*T4
2030 NEXT I
```

```
2040 IF N2<P1 GOTO 1810
2050 REM: ******************** CALCULATING OTHER COSTS ********************
2060 FOR K=1 TO P1
2070 A6(K)= -U1*(1+E3)^K
2080 A2(K)= -L1*(1+E1)^K
2090 A4(K)= -M2*(1+E2)^K
2100 A5(K)=R1*(1+E9)^K
2110 B2(K)=A5(K)+A6(K)+A2(K)+A4(K)+A3(K)
2120 T2(K)=B2(K)+D1(K)+T2(K)
2130 T1(K)= -(B2(K)+D1(K))*T4+T1(K)
2140 A7(K)=B2(K)+T1(K)+S1(K)
2150 NEXT K
2160 REM: ************** ADJUSTING THE REPURCHASING PRICE ***************
2170 I1=T5*F1:F2=-F1
2180 Y1=F2+I1
2190 J2=J2+1
2200 FOR K=1 TO L4
2210 J1=J1+1
2220 J3=J2*L4
2230 IF J1<>J3 THEN 2290
2240 IF J1=P1 THEN 2290
2250 A5(J1)=A5(J1)+F2*(1+G1)^J3+S1(J3)
2260 B2(J1)=B2(J1)+F2*(1+G1)^J3+S1(J3)
2270 T1(J1)=T1(J1)+I1*(1+G1)^J3
2280 A7(J1)=A7(J1)+Y1*(1+G1)^J3
2290 IF J1<>P1 GOTO 2320
2300 A5(J1)=A5(J1)+S1(J1)
2310 B2(J1)=B2(J1)+S1(J1)
2320 NEXT K
2330 IF J1<P1 GOTO 2190
2340 REM: ************ CALCULATING THE NET PRESENT VALUE ***************
2350 FOR I=1 TO P1
2360 P2(I)=A7(I)*(1+M1)^-I
2370 N5=N5+P2(I)
2380 NEXT I
2390 N1=Y1+N5
2391 CLS:LOCATE 3,15:PRINT "Please check to verify that the printer is  'on-"
2392 LOCATE 5,15:PRINT "line'  and that the paper is properly aligned."
2393 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
2400 REM: *************** PRINTING HEADINGS AND OUTPUT ***************
2410 CLS:PRINT TAB(20)"ACTUAL DOLLAR ANALYSIS"
2415 LPRINT CHR$(10):LPRINT TAB(20)"ACTUAL DOLLAR ANALYSIS"
2420 PRINT TAB(20)"=======================":PRINT:PRINT
2425 LPRINT TAB(20)"=======================":LPRINT CHR$(10):LPRINT CHR$(10)
2430 PRINT "      UTILITY     LABOR      MATERIAL   LEASE    "
2435 LPRINT "      UTILITY     LABOR      MATERIAL   LEASE    "
2440 PRINT "YR     COST        COST       COST       COST      REVENUE    BTCF"
2445 LPRINT "YR     COST        COST       COST       COST      REVENUE    BTCF
2450 PRINT "--   --------    -------    ---------  -------   ----------  ------"
2455 LPRINT "--   --------    -------    ---------  -------   ----------  ------
2460 A$="## #######.## #######.## #######.## #######.## #######.## #######.##"
2470 PRINT USING A$;X9,X9,X9,X9,X9,F2,F2
```

```
2475 LPRINT USING A$;X9,X9,X9,X9,X9,F2,F2
2480 FOR N= 1 TO P1
2490 PRINT USING A$;N,A6(N),A2(N),A4(N),A3(N),A5(N),B2(N)
2495 LPRINT USING A$;N,A6(N),A2(N),A4(N),A3(N),A5(N),B2(N)
2500 NEXT N
2510 PRINT:PRINT:INPUT "INPUT C TO CONTINUE ";C$
2520 IF C$<>"C" AND C$<>"c" THEN 2510
2530 PRINT:PRINT
2535 LPRINT CHR$(12)
2540 PRINT "                              TAXABLE    INCOME                PRESENT"
2545 LPRINT "                               TAXABLE   INCOME                 PRESENT
2550 PRINT "YR      BTCF       DEPR       INCOME     TAXES        ATCF      VALUE"
2555 LPRINT "YR      BTCF       DEPR       INCOME     TAXES        ATCF      VALUE"
2560 PRINT "--    -------    -------    --------   --------    -------    --------"
2565 LPRINT "--    -------    -------    --------   --------    -------    --------
2570 PRINT USING A$;X9,F2,X9,X9,I1,Y1,Y1
2575 LPRINT USING A$;X9,F2,X9,X9,I1,Y1,Y1
2580 FOR J= 1 TO P1
2590 PRINT USING A$;J,B2(J),D1(J),T2(J),T1(J),A7(J),P2(J)
2595 LPRINT USING A$;J,B2(J),D1(J),T2(J),T1(J),A7(J),P2(J)
2600 NEXT J
2610 PRINT TAB(58)"------------"
2615 LPRINT TAB(58)"------------"
2620 PRINT TAB(30)"NET PRESENT WORTH";TAB(59);
2625 LPRINT TAB(30)"NET PRESENT WORTH";TAB(59);
2630 PRINT USING "########.##";N1
2635 LPRINT USING "########.##";N1
2638 LPRINT CHR$(12)
2640 IF N1>0! GOTO 2680
2650 PRINT "YOU HAVE A LOSER!!!"
2660 PRINT "------>  THE NET PRESENT VALUE OF THE INVESTMENT IS NEGATIVE."
2670 GOTO 2700
2680 PRINT "YOU HAVE A WINNER!!!"
2690 PRINT "------>  THE NET PRESENT VALUE OF THE INVESTMENT IS POSITIVE."
2700 PRINT "================================================================"
2710 IF XXX>.5 THEN 2740
2720 CLS:LOCATE 3,9:PRINT "Enter the name of the alternative ";
2730 INPUT NAMIT$
2740 OPEN "B:ANUAL" FOR INPUT AS #1:INPUT#1,HOWMANY:CLOSE#1
2750 HOWMANY=HOWMANY+1
2760 OPEN "B:ANUAL" FOR OUTPUT AS #1:WRITE#1,HOWMANY:CLOSE#1
2770 FILE$="B:ANCST":X$=STR$(HOWMANY):ZIP=LEN(X$)-1:Y$=RIGHT$(X$,ZIP)
2780 XYZ$=FILE$+Y$
2790 OPEN XYZ$ FOR OUTPUT AS #1:WRITE#1,NAMIT$,P1,M1,N1
2800 FOR I=0 TO P1:WRITE#1,I,A7(I):NEXT I:CLOSE#1
2810 INPUT "WOULD YOU LIKE TO EVALUATE ANOTHER INVESTMENT (Y/N)";I9$
2820 IF I9$="Y" THEN 940 ELSE IF I9$="N" THEN 2830 ELSE 2810
2830 CHAIN "B:CONTROL",600
```

WGTEVAL.BAS

```
10 DIM WGT(15),RATE(15,10),WGTSCOR(15,10),TOTALT(10),XCHR$(30),AW(10),SCOR(10)
20 DIM NAMIT$(10),LAST(10),INST(10),PRES(10)
30 KEY OFF
40 COLOR 6,0,0:CLS
50 REM
60 REM   THIS PROGRAM COMPUTES THE LINEARLY ADDITIVE WEIGHTED SCORE FOR
70 REM
80 REM   EACH OF THE ALTERNATIVES UNDER CONSIDERATION IN A MULTI-ATTRIBUTE
90 REM
100 REM   DECISION ANALYSIS.  THE WEIGHTED SCORE FOR EACH OF THE ALTERNATIVES
110 REM
120 REM  IS EQUAL TO THE SUMMATION OF THE PRODUCTS OF THE RATIO-SCALED WEIGHTS
130 REM
140 REM  OF THE ATTRIBUTES AND THE  'SCORES' OF THAT ALTERNATIVE AGAINST EACH
150 REM
160 REM  OF THE ATTRIBUTES.
170 REM
180 LOCATE 10,7:PRINT "PROGRAM TO COMPUTE THE STRATEGIC BENEFITS SCORE FOR ";
190 PRINT "EACH ALTERNATIVE"
200 LOCATE 22,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
210 PRINT "THIS PROGRAM COMPUTES A LINEARLY ADDITIVE WEIGHTED SCORE FOR":PRINT
220 PRINT "EACH OF THE ALTERNATIVES UNDER CONSIDERATION IN A MULTIPLE":PRINT
230 PRINT "ATTRIBUTE DECISION ANALYSIS.  THESE WEIGHTED SCORES ARE THE":PRINT
240 PRINT "SUMMATIONS BY ALTERNATIVE OF THE PRODUCTS OF THE RATIO-SCALED":PRINT
250 PRINT "WEIGHTING FACTORS FOR EACH ATTRIBUTE AND THE  'SCORES' OF THE":PRINT
260 PRINT "ALTERNATIVES AGAINST EACH ATTRIBUTE.":PRINT:PRINT:PRINT
270 PRINT TAB(5) "WEIGHTED SCORE = d ( RATIO-SCALED WEIGHT  x  SCORE )":PRINT
280 PRINT:PRINT:PRINT TAB(25) "( Press any key to continue )":Z$=INPUT$(1):CLS
290 PRINT "THIS PROGRAM SHOULD BE THE LAST PROGRAM TO BE EXECUTED IN THE":PRINT
300 PRINT "MULTIPLE ATTRIBUTE DECISION ANALYSIS PACKAGE.  PRIOR TO THE":PRINT
310 PRINT "EXECUTION OF THIS PROGRAM, EACH OF THE FOLLOWING TASKS SHOULD":PRINT
320 PRINT "HAVE BEEN COMPLETED :":PRINT:PRINT
330 PRINT "1) EACH MEMBER OF THE PROJECT EVALUATION TEAM SHOULD HAVE COMPLETED"
340 PRINT TAB(5) "THE PAIRED-COMPARISONS PROCEDURE":PRINT
350 PRINT "2) THE DUNN-RANKIN PROCEDURE PROGRAM FOR THE COMPUTATION OF RATIO-"
360 PRINT TAB(5) "SCALED WEIGHTING FACTORS SHOULD HAVE BEEN EXECUTED":PRINT
370 PRINT "3) EACH MEMBER OF THE EVALUATION TEAM SHOULD HAVE COMPLETED THE"
380 PRINT TAB(5) "INDIVIDUAL RATING PROCEDURE":PRINT
390 PRINT "4) THE PROGRAM FOR AGGREGATING THE DATA FROM THE INDIVIDUAL RATINGS"
400 PRINT TAB(5) "SHOULD HAVE BEEN EXECUTED":PRINT:PRINT
410 PRINT TAB(25) "( Press any key to continue )":Z$=INPUT$(1):CLS
420 PRINT "IF ANY OF THESE TASKS HAVE NOT BEEN COMPLETED, TERMINATE THE":PRINT
430 PRINT "EXECUTION BY SIMULTANEOUSLY DEPRESSING THE CONTROL  ( Ctrl )":PRINT
440 PRINT "AND THE BREAK  ( Scroll Lock ) KEYS.  YOU SHOULD ALSO CHECK":PRINT
450 PRINT "TO VERIFY THAT THE  'DATA ' DISK IS IN DRIVE  'B:'.":PRINT:PRINT
460 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
470 LOCATE 10,18:PRINT "LOADING DATA AND COMPUTING WEIGHTED SCORES"
480 COLOR 18,0,0:LOCATE 15,30:PRINT "PLEASE BE PATIENT":COLOR 6,0,0
490 OPEN "B:WGTRAT" FOR INPUT AS #1
500 INPUT#1,N
```

```
510 FOR I=1 TO N:INPUT#1,WGT(I):NEXT I:CLOSE#1
520 OPEN "B:RATINGS" FOR INPUT AS #1
530 INPUT#1,NUM,N,M
540 FOR I=1 TO N:FOR J=1 TO M:INPUT#1,RATE(I,J):NEXT J:NEXT I:CLOSE#1
550 OPEN "B:ATTRIB" FOR INPUT AS #1
560 INPUT#1,N
570 FOR I=1 TO N:INPUT#1,A$(I),C$(I):FOR K=1 TO 4:INPUT#1,B$(I,K):NEXT K
580 NEXT I:CLOSE#1
590 OPEN "B:ALTER" FOR INPUT AS #1
600 INPUT#1,M
610 FOR J=1 TO M:INPUT#1,D$(J),E$(I):NEXT J:CLOSE#1
620 FOR I=1 TO N:FOR J=1 TO M:WGTSCOR(I,J)=WGT(I)*RATE(I,J):NEXT J:NEXT I
630 FOR J=1 TO M:FOR I=1 TO N:TOTALT(J)=TOTALT(J)+WGTSCOR(I,J):NEXT I:NEXT J
640 CLS
650 PRINT "A PRINTOUT OF THE RESULTS OF THE WEIGHTED EVALUATION WILL NOW":PRINT
660 PRINT "BE PROVIDED.  BEFORE CONTINUING, CHECK TO SEE THAT THE PAPER":PRINT
670 PRINT "IS PROPERLY ALIGNED AND THAT THE PRINTER IS  'ON LINE '.":PRINT
680 LOCATE 23,25:PRINT "( Press any key to continue )":Z$=INPUT$(1):CLS
690 LPRINT CHR$(10)
700 FOR J=1 TO M:LPRINT TAB(33) D$(J):LPRINT CHR$(10)
710 LPRINT TAB(10) "                                                    WEIGHTED"
720 LPRINT TAB(10) "ATTRIBUTE          WEIGHT       SCORE      SCORE"
730 LPRINT TAB(10) "---------          ------       -----      -----"
740 LPRINT CHR$(10)
750 FOR I=1 TO N:LPRINT USING "   \                    \ ";A$(I);
760 LPRINT USING "  ####.##       ";WGT(I);
770 LPRINT USING "##.##     ";RATE(I,J);
780 LPRINT USING "#####.##";WGTSCOR(I,J):LPRINT CHR$(10)
790 NEXT I
800 LPRINT TAB(52) "--------"
810 LPRINT TAB(44) "TOTAL :";
820 LPRINT USING "######.##";TOTALT(J)
830 LPRINT CHR$(12):NEXT J
840 OPEN "B:WTSCORE" FOR OUTPUT AS #1:WRITE#1,M
850 FOR J=1 TO M:WRITE#1,D$(J),TOTALT(J):NEXT J:CLOSE#1
860 FOR J=1 TO M:SCOR(J)=TOTALT(J):NEXT J
870 OPEN "b:anual" FOR INPUT AS #1:INPUT#1,APPCRUNS:CLOSE#1
880 FOR I=1 TO APPCRUNS
890 FILE$="b:ancst":X$=STR$(I):ZIP=LEN(X$)-1:Y$=RIGHT$(X$,ZIP):XYZ$=FILE$+Y$
900 OPEN XYZ$ FOR INPUT AS #1:INPUT#1,NAMIT$(I),LAST(I),INST(I),PRES(I):CLOSE#1
910 NEXT I
920 LPRINT TAB(25) "PRESENT WORTH OF ALTERNATIVES":LPRINT CHR$(10)
930 LPRINT TAB(5) "ALTERNATIVE" TAB(50) "PRESENT WORTH"
940 LPRINT TAB(5) "-----------" TAB(50) "-------------":LPRINT CHR$(10)
950 FOR I=1 TO APPCRUNS:LPRINT TAB(5) NAMIT$(I);
960 LPRINT TAB(50) USING "$$########.##";PRES(I):LPRINT CHR$(10):NEXT I
970 LPRINT CHR$(12)
980 FOR I=1 TO M:CLS
990 LOCATE 4,9:PRINT "ENTER THE PRESENT WORTH OF ";D$(I);
1000 INPUT AW(I):PRES(I)=AW(I):FOR J=1 TO 1000:NEXT J:NEXT I
1010 NALT=M
1020 FOR I=1 TO M:IF I=1 THEN ROMAN$(I)="I"
```

```
1030 IF I=2 THEN ROMAN$(I)="II"
1040 IF I=3 THEN ROMAN$(I)="III"
1050 IF I=4 THEN ROMAN$(I)="IV"
1060 IF I=5 THEN ROMAN$(I)="V"
1070 IF I=6 THEN ROMAN$(I)="VI"
1080 IF I=7 THEN ROMAN$(I)="VII"
1090 IF I=8 THEN ROMAN$(I)="VIII"
1100 IF I=9 THEN ROMAN$(I)="IX"
1110 IF I=10 THEN ROMAN$(I)="X"
1120 NEXT I
1130 FOR I=1 TO M:LPRINT TAB(5) "ALTERNATIVE ";ROMAN$(I);" = ";D$(I)
1140 LPRINT CHR$(10):NEXT I:LPRINT CHR$(12)
1150 PT1$="TRADEOFFS BETWEEN BENEFITS AND COSTS"
1160 LPRINT CHR$(10):LPRINT TAB(20) "PARAMETERS FOR EACH OF THE ALTERNATIVES"
1170 LPRINT TAB(20) "                                          ":LPRINT CHR$(10)
1180 LPRINT TAB(5) "ALTERNATIVE" TAB(40) "BENEFITS SCORE";
1190 LPRINT TAB(60) "PRESENT WORTH"
1200 LPRINT TAB(5) "           " TAB(40) "              ";
1210 LPRINT TAB(60) "            ":LPRINT CHR$(10)
1220 FOR I=1 TO M:LPRINT TAB(5) D$(I);
1230 LPRINT TAB(44) USING "####.##";TOTALT(I);
1240 LPRINT TAB(60) USING "$$########.##";PRES(I):LPRINT CHR$(10)
1250 NEXT I:LPRINT CHR$(12)
1260 REM **********************************
1270 GOSUB 2310
1280 A$=INKEY$:IF A$="" THEN 1280
1290 WIDTH 80:SCREEN 0,0,0:COLOR 6,0,0:CLS
1300 LOCATE 2,9:PRINT "You will now be given a chance to conduct a sensitivity"
1310 LOCATE 4,9:PRINT "analysis.  By varying either the Present Worth or the"
1320 LOCATE 6,9:PRINT "Non-Monetary Benefits Score of one or more of the ";
1330 PRINT "alternatives,"
1340 LOCATE 8,9:PRINT "a determination of the sensitivity of the decision to a"
1350 LOCATE 10,9:PRINT "change in parameters can be made."
1360 COLOR 2,0,0:LOCATE 15,12:PRINT "DO YOU WISH TO CONDUCT A SENSITIVITY ";
1370 PRINT "ANALYSIS  ( Y or N ) ":COLOR 6,0,0
1380 LOCATE 17,38:INPUT Z$:IF Z$="Y" OR Z$="y" OR Z$="N" OR Z$="n" THEN 1400
1390 LOCATE 17,38:PRINT "                                        ":GOTO 1380
1400 CLS:IF Z$="N" OR Z$="n" THEN 2290
1410 LOCATE 3,20:PRINT "PARAMETERS FOR EACH OF THE ALTERNATIVES"
1420 LOCATE 4,20:PRINT "————————————————————————————————————"
1430 LOCATE 6,5:PRINT "ALTERNATIVE" TAB(40) "BENEFITS SCORE";
1440 PRINT TAB(60) "PRESENT WORTH"
1450 LOCATE 7,5:PRINT "———————" TAB(40) "——————————";
1460 PRINT TAB(60) "——————————":PRINT
1470 FOR I=1 TO M:PRINT TAB(5) D$(I);
1480 PRINT TAB(44) USING "####.##";TOTALT(I);
1490 PRINT TAB(60) USING "$$########.##";PRES(I):PRINT:NEXT I
1500 LOCATE 23,25:PRINT "( Press any key to continue )":R$=INPUT$(1):CLS
1510 LOCATE 2,9:PRINT "Would you like to vary Benefits Score of any or all of"
1520 LOCATE 4,9:PRINT "the alternatives ( Y or N ) ";
1530 INPUT Z$:IF Z$="y" OR Z$="Y" OR Z$="n" OR Z$="N" THEN 1550
1540 LOCATE 4,35:PRINT "                                    ":GOTO 1520
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```
1550 CLS:IF Z$="n" OR Z$="N" THEN 1890
1560 LOCATE 2,9:PRINT "Do you wish to vary the Benefits Score of each of the"
1570 LOCATE 4,9:PRINT "alternatives by the same amount ( Y or N )";
1580 INPUT X$:IF X$="Y" OR X$="y" OR X$="N" OR X$="n" THEN 1600
1590 LOCATE 4,47:PRINT "                              ":GOTO 1570
1600 CLS:IF X$="y" OR X$="Y" THEN 1780
1610 LOCATE 2,9:PRINT "Input the number ( 1 through";M;" ) of the alternative"
1620 LOCATE 4,9:PRINT "that you wish to vary.";
1630 COLOR 2,0,0:LOCATE 6,15:PRINT "Input '-1' if there are no further changes"
1640 COLOR 6,0,0:LOCATE 8,37:INPUT VVV
1650 CLS:IF VVV<0 THEN 1870
1660 MMM=M+1
1670 IF VVV>0 AND VVV<MMM THEN 1690
1680 GOTO 1610
1690 LOCATE 5,9:PRINT "Enter the  %  variation for the Benefits Score of ";
1700 PRINT D$(VVV)
1710 LOCATE 8,9:PRINT "as a decimal number  ( 10 % = .10 ). This variation can"
1720 LOCATE 11,9:PRINT "be either positive or negative "
1730 LOCATE 18,36:INPUT PCTVAR:CLS
1740 IF PCTVAR>-1 AND PCTVAR<1 THEN 1770
1750 LOCATE 5,9:PRINT "The variation cannot be greater than  +/- 100 %":BEEP
1760 FOR I=1 TO 2000:NEXT I:CLS:GOTO 1690
1770 VAR(VVV)=PCTVAR:CLS:GOTO 1610
1780 CLS
1790 LOCATE 5,9:PRINT "Enter the  %  variation for the Benefits Score of all"
1800 LOCATE 7,9:PRINT "the alternatives as a decimal number  ( 10 % = .10 )."
1810 LOCATE 9,9:PRINT "This variation can be either positive of negative."
1820 LOCATE 15,36:INPUT PCTALL:CLS
1830 IF PCTALL>-1 AND PCTALL<1 THEN 1860
1840 LOCATE 5,9:PRINT "The variation cannot be greater than  +/- 100 %":BEEP
1850 FOR I=1 TO 2000:NEXT I:CLS:GOTO 1790
1860 FOR J=1 TO M:VAR(J)=PCTALL:NEXT J
1870 FOR I=1 TO M:IF TOTALT(I)<0 THEN VAR(I)=-VAR(I)
1880 SCOR(I)=TOTALT(I)*(1+VAR(I)):NEXT I
1890 CLS
1900 LOCATE 2,9:PRINT "Would you like to vary Present Worth of any or all of"
1910 LOCATE 4,9:PRINT "the alternatives ( Y or N ) ";
1920 INPUT Z$:IF Z$="y" OR Z$="Y" OR Z$="n" OR Z$="N" THEN 1940
1930 LOCATE 4,35:PRINT "                                    ":GOTO 1910
1940 CLS:IF Z$="n" OR Z$="N" THEN 2280
1950 LOCATE 2,9:PRINT "Do you wish to vary the Present Worth of each of the"
1960 LOCATE 4,9:PRINT "alternatives by the same amount ( Y or N )";
1970 INPUT X$:IF X$="Y" OR X$="y" OR X$="N" OR X$="n" THEN 1990
1980 LOCATE 4,47:PRINT "                              ":GOTO 1960
1990 CLS:IF X$="y" OR X$="Y" THEN 2180
2000 LOCATE 2,9:PRINT "Input the number ( 1 through";M;" ) of the alternative"
2010 LOCATE 4,9:PRINT "that you wish to vary.";
2020 COLOR 2,0,0:LOCATE 6,15:PRINT "Input '-1' if there are no further changes"
2030 COLOR 6,0,0:LOCATE 8,37:INPUT UUU
2040 CLS:IF UUU<0 THEN 2260
2050 MMM=M+1
2060 IF UUU>0 AND UUU<MMM THEN 2080
```

```
2070 GOTO 2000
2080 LOCATE 5,9:PRINT "Enter the  %  variation for the Present Worth of ";
2090 PRINT D$(UUU)
2100 LOCATE 8,9:PRINT "as a decimal number  ( 10 % = .10 ). This variation can"
2110 LOCATE 11,9:PRINT "be either positive or negative "
2120 LOCATE 18,36:INPUT VARPCT:CLS
2130 IF VARPCT>-1 AND VARPCT<1 THEN 2160
2140 LOCATE 5,9:PRINT "The variation cannot be greater than  +/- 100 %":BEEP
2150 FOR I=1 TO 2000:NEXT I:CLS:GOTO 2080
2160 RAV(UUU)=VARPCT:CLS:GOTO 2000
2170 CLS
2180 LOCATE 5,9:PRINT "Enter the  %  variation for the Present Worth of all"
2190 LOCATE 7,9:PRINT "the alternatives as a decimal number  ( 10 % = .10 )."
2200 LOCATE 9,9:PRINT "This variation can be either positive of negative."
2210 LOCATE 15,36:INPUT ALLPCT:CLS
2220 IF ALLPCT>-1 AND ALLPCT<1 THEN 2250
2230 LOCATE 5,9:PRINT "The variation cannot be greater than  +/- 100 %":BEEP
2240 FOR I=1 TO 2000:NEXT I:CLS:GOTO 2180
2250 FOR J=1 TO M:RAV(J)=ALLPCT:NEXT J
2260 FOR I=1 TO M:IF PRES(I)<0 THEN RAV(I)=-RAV(I)
2270 AW(I)=PRES(I)*(1+RAV(I)):NEXT I
2280 CLS:GOTO 1260
2290 WIDTH 80:SCREEN 0,0,0:COLOR 6,0,0:CLS
2300 CHAIN "B:CONTROL",600
2310 REM ****************************************
2320 REM where the plot begins
2330 REM s/r to draw plot
2340 CLS:KEY OFF:SCREEN 1
2350 XCHR$(0)="0":XCHR$(1)="1":XCHR$(2)="2":XCHR$(3)="3":XCHR$(4)="4"
2360 XCHR$(5)="5":XCHR$(6)="6":XCHR$(7)="7":XCHR$(8)="8":XCHR$(9)="9"
2370 XCHR$(11)="A":XCHR$(12)="B":XCHR$(13)="C":XCHR$(14)="D":XCHR$(15)="E"
2380 XCHR$(16)="F":XCHR$(17)="G":XCHR$(18)="H":XCHR$(19)="I":XCHR$(20)="J"
2390 XCHR$(21)="V":XCHR$(22)=CHR$(224)
2400 REM to draw open box with color barcol
2410 XP1=60:XP2=260:YP1=40:YP2=160:YP3=156:BARCOL=1
2420 LINE(XP1,YP1)-(XP1,YP2),BARCOL
2430 LINE(XP1,YP2)-(XP2,YP2),BARCOL
2440 LINE(XP2,YP2)-(XP2,YP1),BARCOL
2450 REM vertical-axis
2460 FOR I=0 TO 10
2470 YPVAR=YP1+I*(YP2-YP1)/10
2480 XPVAR1=XP1+4:XPVAR2=XP2-4
2490 LINE(XP1,YPVAR)-(XPVAR1,YPVAR),BARCOL
2500 LINE(XPVAR2,YPVAR)-(XP2,YPVAR),BARCOL
2510 NEXT I
2520 REM grid alpha-axis
2530 FOR I=0 TO 9
2540 XPVAR=60+20*I
2550 LINE(XPVAR,YP2)-(XPVAR,YP3),BARCOL
2560 DIGXP=XPVAR-2:DIGYP=YP2+2
2570 XX=DIGXP:YY=DIGYP:XCHAR$=XCHR$(I)
2580 GOSUB 3090
```

```
2590 NEXT I
2600 XX=XP2-3:YY=YP2+2:XCHAR$=XCHR$(1):GOSUB 3090
2610 XX=XP2+3:YY=YP2+2:XCHAR$=XCHR$(0):GOSUB 3090
2620 GOSUB 4810
2630 REM get max, min of AW, SCOR
2640 GOSUB 2950:GOSUB 3020
2650 REM this call determine proper scale on ea. axis
2660 GOSUB 5350
2670 REM set optional format for aw() with more than 7 digs
2680 FRM1$="#######":FRM2$="#.#^^^^"
2690 REM determine the extremes of each line
2700 FOR I=1 TO NALT
2710 EX1=XP1:EY1=(YP1-YP2)*(AW(I)-PAWMIN)/(PAWMAX-PAWMIN)+YP2
2720 EX2=XP2:EY2=(YP1-YP2)*(SCOR(I)-PSCORMIN)/(PSCORMAX-PSCORMIN)+YP2
2730 LCOLOR=1
2740 LINE(EX1,EY1)-(EX2,EY2),LCOLOR
2750 GOSUB 4930
2760 REM print values at intersection with axis
2770 CX1=1
2780 CY1=INT(23*(EY1-3)/194+2)
2790 CX2=INT(39*(EX2-3)/314+3)
2800 CY2=INT(23*(EY2-3)/194+2)
2810 LOCATE CY1,CX1
2820 IF AW(I)>9999999!  OR AW(I)<-999999!  THEN PRINT USING FRM2$;INT(AW(I)) ELSE
PRINT USING FRM1$;INT(AW(I))
2830 LOCATE CY2,CX2:INSCOR(I)=INT(SCOR(I)):PRINT INSCOR(I)
2840 NEXT I
2850 RETURN
2860 REM this s/r finds the min and max of an array
2870 REM vector has dimension nvector
2880 VECMIN=VECTOR(1):VECMAX=VECTOR(1)
2890 FOR I=2 TO NVECTOR
2900 IF VECTOR(I)<VECMIN THEN VECMIN=VECTOR(I)
2910 IF VECTOR(I)>VECMAX THEN VECMAX=VECTOR(I)
2920 NEXT I
2930 RETURN
2940 REM return vecmin,vecmax
2950 REM this s/r find min and max of present worth
2960 FOR I=1 TO NALT:VECTOR(I)=AW(I):NEXT I
2970 NVECTOR=NALT
2980 GOSUB 2860
2990 AWMIN=VECMIN:AWMAX=VECMAX
3000 RETURN
3010 REM return awmin,awmax
3020 REM this s/r find min and max of score
3030 FOR I=1 TO NALT:VECTOR(I)=SCOR(I):NEXT I
3040 NVECTOR=NALT
3050 GOSUB 2860
3060 SCORMIN=VECMIN:SCORMAX=VECMAX
3070 RETURN
3080 REM return scormin,scormax
3090 REM ******************************************
```

```
3100 REM SUBROUTINE TO DRAW CHARACTER XCHAR$ AT
3110 REM POSITION (XX,YY)
3120 REM NEEDS ARRAYS XCCH(5),YCCH(6) AND SCREEN 1
3130 GOSUB 3370
3140 IF XCHAR$="A" THEN GOSUB 3410
3150 IF XCHAR$="B" THEN GOSUB 3480
3160 IF XCHAR$="C" THEN GOSUB 3560
3170 IF XCHAR$="D" THEN GOSUB 3610
3180 IF XCHAR$="E" THEN GOSUB 3670
3190 IF XCHAR$="F" THEN GOSUB 3730
3200 IF XCHAR$="G" THEN GOSUB 3780
3210 IF XCHAR$="H" THEN GOSUB 3850
3220 IF XCHAR$="I" THEN GOSUB 3900
3230 IF XCHAR$="J" THEN GOSUB 3950
3240 IF XCHAR$="V" THEN GOSUB 4000
3250 IF XCHAR$=CHR$(224) THEN GOSUB 4040
3260 IF XCHAR$="1" THEN GOSUB 4150
3270 IF XCHAR$="2" THEN GOSUB 4200
3280 IF XCHAR$="3" THEN GOSUB 4260
3290 IF XCHAR$="4" THEN GOSUB 4340
3300 IF XCHAR$="5" THEN GOSUB 4390
3310 IF XCHAR$="6" THEN GOSUB 4460
3320 IF XCHAR$="7" THEN GOSUB 4530
3330 IF XCHAR$="8" THEN GOSUB 4570
3340 IF XCHAR$="9" THEN GOSUB 4670
3350 IF XCHAR$="0" THEN GOSUB 4750
3360 RETURN
3370 REM compute position
3380 FOR JG=0 TO 4: XCCH(JG+1)=XX+JG: NEXT JG
3390 FOR IG=0 TO 5: YCCH(IG+1)=YY+IG: NEXT IG
3400 RETURN
3410 REM a
3420 LINE (XCCH(3),YCCH(1))-(XCCH(1),YCCH(3))
3430 LINE (XCCH(1),YCCH(3))-(XCCH(1),YCCH(6))
3440 LINE (XCCH(3),YCCH(1))-(XCCH(5),YCCH(3))
3450 LINE (XCCH(5),YCCH(3))-(XCCH(5),YCCH(6))
3460 LINE (XCCH(1),YCCH(4))-(XCCH(5),YCCH(4))
3470 RETURN
3480 REM b
3490 LINE (XCCH(1),YCCH(1))-(XCCH(4),YCCH(1))
3500 LINE (XCCH(4),YCCH(1))-(XCCH(5),YCCH(2))
3510 LINE (XCCH(4),YCCH(3))-(XCCH(1),YCCH(3))
3520 LINE (XCCH(5),YCCH(4))-(XCCH(5),YCCH(5))
3530 LINE (XCCH(4),YCCH(6))-(XCCH(1),YCCH(6))
3540 LINE (XCCH(1),YCCH(6))-(XCCH(1),YCCH(1))
3550 RETURN
3560 REM c
3570 LINE (XCCH(2),YCCH(1))-(XCCH(5),YCCH(1))
3580 LINE (XCCH(1),YCCH(2))-(XCCH(1),YCCH(5))
3590 LINE (XCCH(2),YCCH(6))-(XCCH(5),YCCH(6))
3600 RETURN
3610 REM d
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```
3620 LINE (XCCH(1),YCCH(1))-(XCCH(1),YCCH(6))
3630 LINE (XCCH(1),YCCH(1))-(XCCH(4),YCCH(1))
3640 LINE (XCCH(1),YCCH(6))-(XCCH(4),YCCH(6))
3650 LINE (XCCH(5),YCCH(2))-(XCCH(5),YCCH(5))
3660 RETURN
3670 REM e
3680 LINE (XCCH(1),YCCH(1))-(XCCH(5),YCCH(1))
3690 LINE (XCCH(1),YCCH(1))-(XCCH(1),YCCH(6))
3700 LINE (XCCH(1),YCCH(6))-(XCCH(5),YCCH(6))
3710 LINE (XCCH(1),YCCH(3))-(XCCH(4),YCCH(3))
3720 RETURN
3730 REM f
3740 LINE (XCCH(1),YCCH(1))-(XCCH(5),YCCH(1))
3750 LINE (XCCH(1),YCCH(1))-(XCCH(1),YCCH(6))
3760 LINE (XCCH(1),YCCH(3))-(XCCH(4),YCCH(3))
3770 RETURN
3780 REM g
3790 LINE (XCCH(1),YCCH(2))-(XCCH(1),YCCH(5))
3800 LINE (XCCH(2),YCCH(1))-(XCCH(5),YCCH(1))
3810 LINE (XCCH(2),YCCH(6))-(XCCH(5),YCCH(6))
3820 LINE (XCCH(5),YCCH(6))-(XCCH(5),YCCH(3))
3830 LINE (XCCH(5),YCCH(3))-(XCCH(3),YCCH(3))
3840 RETURN
3850 REM h
3860 LINE (XCCH(1),YCCH(1))-(XCCH(1),YCCH(6))
3870 LINE (XCCH(5),YCCH(1))-(XCCH(5),YCCH(6))
3880 LINE (XCCH(1),YCCH(3))-(XCCH(5),YCCH(3))
3890 RETURN
3900 REM i
3910 LINE (XCCH(3),YCCH(1))-(XCCH(3),YCCH(6))
3920 LINE (XCCH(2),YCCH(1))-(XCCH(4),YCCH(1))
3930 LINE (XCCH(2),YCCH(6))-(XCCH(4),YCCH(6))
3940 RETURN
3950 REM j
3960 LINE (XCCH(5),YCCH(1))-(XCCH(5),YCCH(5))
3970 LINE (XCCH(4),YCCH(6))-(XCCH(2),YCCH(6))
3980 LINE (XCCH(1),YCCH(5))-(XCCH(1),YCCH(4))
3990 RETURN
4000 REM v
4010 LINE (XCCH(1),YCCH(1))-(XCCH(3),YCCH(6))
4020 LINE (XCCH(3),YCCH(6))-(XCCH(5),YCCH(1))
4030 RETURN
4040 REM alpha
4050 LINE (XCCH(1),YCCH(3))-(XCCH(2),YCCH(2))
4060 LINE (XCCH(2),YCCH(2))-(XCCH(3),YCCH(2))
4070 LINE (XCCH(3),YCCH(2))-(XCCH(4),YCCH(3))
4080 LINE (XCCH(4),YCCH(3))-(XCCH(5),YCCH(5))
4090 LINE (XCCH(1),YCCH(3))-(XCCH(1),YCCH(4))
4100 LINE (XCCH(1),YCCH(4))-(XCCH(2),YCCH(5))
4110 LINE (XCCH(2),YCCH(5))-(XCCH(3),YCCH(5))
4120 LINE (XCCH(3),YCCH(5))-(XCCH(4),YCCH(4))
4130 LINE (XCCH(4),YCCH(4))-(XCCH(5),YCCH(2))
```

```
4140 RETURN
4150 REM 1
4160 LINE (XCCH(3),YCCH(1))-(XCCH(3),YCCH(6))
4170 LINE (XCCH(3),YCCH(1))-(XCCH(1),YCCH(3))
4180 LINE (XCCH(2),YCCH(6))-(XCCH(4),YCCH(6))
4190 RETURN
4200 REM 2
4210 LINE (XCCH(1),YCCH(2))-(XCCH(2),YCCH(1))
4220 LINE (XCCH(3),YCCH(1))-(XCCH(4),YCCH(1))
4230 LINE (XCCH(5),YCCH(2))-(XCCH(1),YCCH(6))
4240 LINE (XCCH(1),YCCH(6))-(XCCH(5),YCCH(6))
4250 RETURN
4260 REM 3
4270 LINE (XCCH(1),YCCH(1))-(XCCH(4),YCCH(1))
4280 LINE (XCCH(1),YCCH(1))-(XCCH(4),YCCH(1))
4290 LINE (XCCH(5),YCCH(2))-(XCCH(4),YCCH(3))
4300 LINE (XCCH(4),YCCH(3))-(XCCH(1),YCCH(3))
4310 LINE (XCCH(5),YCCH(4))-(XCCH(5),YCCH(5))
4320 LINE (XCCH(4),YCCH(6))-(XCCH(1),YCCH(6))
4330 RETURN
4340 REM 4
4350 LINE (XCCH(4),YCCH(1))-(XCCH(4),YCCH(6))
4360 LINE (XCCH(4),YCCH(1))-(XCCH(1),YCCH(4))
4370 LINE (XCCH(1),YCCH(4))-(XCCH(5),YCCH(4))
4380 RETURN
4390 REM 5
4400 LINE (XCCH(1),YCCH(1))-(XCCH(5),YCCH(1))
4410 LINE (XCCH(1),YCCH(1))-(XCCH(1),YCCH(3))
4420 LINE (XCCH(1),YCCH(3))-(XCCH(4),YCCH(3))
4430 LINE (XCCH(5),YCCH(4))-(XCCH(5),YCCH(6))
4440 LINE (XCCH(5),YCCH(6))-(XCCH(1),YCCH(6))
4450 RETURN
4460 REM 6
4470 LINE (XCCH(4),YCCH(1))-(XCCH(1),YCCH(4))
4480 LINE (XCCH(1),YCCH(4))-(XCCH(1),YCCH(6))
4490 LINE (XCCH(1),YCCH(6))-(XCCH(4),YCCH(6))
4500 LINE (XCCH(5),YCCH(5))-(XCCH(4),YCCH(4))
4510 LINE (XCCH(4),YCCH(4))-(XCCH(1),YCCH(4))
4520 RETURN
4530 REM 7
4540 LINE (XCCH(1),YCCH(1))-(XCCH(5),YCCH(1))
4550 LINE (XCCH(5),YCCH(2))-(XCCH(1),YCCH(6))
4560 RETURN
4570 REM 8
4580 LINE (XCCH(2),YCCH(1))-(XCCH(4),YCCH(1))
4590 LINE (XCCH(5),YCCH(2))-(XCCH(4),YCCH(3))
4600 LINE (XCCH(4),YCCH(3))-(XCCH(2),YCCH(3))
4610 LINE (XCCH(2),YCCH(3))-(XCCH(1),YCCH(2))
4620 LINE (XCCH(1),YCCH(2))-(XCCH(2),YCCH(1))
4630 LINE (XCCH(1),YCCH(4))-(XCCH(1),YCCH(5))
4640 LINE (XCCH(2),YCCH(6))-(XCCH(4),YCCH(6))
4650 LINE (XCCH(5),YCCH(5))-(XCCH(5),YCCH(4))
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```
4660 RETURN
4670 REM 9
4680 LINE (XCCH(2),YCCH(1))-(XCCH(4),YCCH(1))
4690 LINE (XCCH(5),YCCH(2))-(XCCH(4),YCCH(3))
4700 LINE (XCCH(4),YCCH(3))-(XCCH(2),YCCH(3))
4710 LINE (XCCH(2),YCCH(3))-(XCCH(1),YCCH(2))
4720 LINE (XCCH(1),YCCH(2))-(XCCH(2),YCCH(1))
4730 LINE (XCCH(5),YCCH(3))-(XCCH(2),YCCH(6))
4740 RETURN
4750 REM 0
4760 LINE (XCCH(2),YCCH(1))-(XCCH(4),YCCH(1))
4770 LINE (XCCH(1),YCCH(2))-(XCCH(1),YCCH(5))
4780 LINE (XCCH(2),YCCH(6))-(XCCH(4),YCCH(6))
4790 LINE (XCCH(5),YCCH(5))-(XCCH(5),YCCH(2))
4800 RETURN
4810 REM this s/r print titles
4820 LOCATE 1,4:PRINT PT1$
4830 LOCATE 2,6:PRINT "present"
4840 LOCATE 3,6:PRINT "worth"
4850 LOCATE 2,28:PRINT "non-monetary"
4860 LOCATE 3,30:PRINT "benefit"
4870 LOCATE 4,30:PRINT " score  "
4880 LOCATE 22,8
4890 PRINT "weight of benefits (% x 10)"
4900 LOCATE 23,9
4910 PRINT "press a key to continue"
4920 RETURN
4930 REM to display roman numbers
4940 IF I=1 THEN GOSUB 5040
4950 IF I=2 THEN GOSUB 5070
4960 IF I=3 THEN GOSUB 5110
4970 IF I=4 THEN GOSUB 5150
4980 IF I=5 THEN GOSUB 5190
4990 IF I=6 THEN GOSUB 5220
5000 IF I=7 THEN GOSUB 5260
5010 IF I=8 THEN GOSUB 5300
5020 IF I>8 THEN END
5030 RETURN
5040 REM I
5050 XX=EX1+10:YY=EY1-10:XCHAR$="I":GOSUB 3090
5060 RETURN
5070 REM II
5080 GOSUB 5040
5090 XX=XX+3:XCHAR$="I":GOSUB 3090
5100 RETURN
5110 REM III
5120 GOSUB 5070
5130 XX=XX+3:XCHAR$="I":GOSUB 3090
5140 RETURN
5150 REM IV
5160 GOSUB 5040
5170 XX=XX+4:XCHAR$="V":GOSUB 3090
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5180 RETURN
5190 REM V
5200 XX=EX1+10:YY=EY1-10:XCHAR$="V":GOSUB 3090
5210 RETURN
5220 REM VI
5230 GOSUB 5190
5240 XX=XX+4:XCHAR$="I":GOSUB 3090
5250 RETURN
5260 REM VII
5270 GOSUB 5220
5280 XX=XX+3:XCHAR$="I":GOSUB 3090
5290 RETURN
5300 REM VIII
5310 GOSUB 5260
5320 XX=XX+3:XCHAR$="I":GOSUB 3090
5330 RETURN
5340 REM end of plot s/r
5350 REM determine proper scale
5360 PAWMAX=1.1*AWMAX
5370 PAWMIN=AWMIN-.1*AWMAX
5380 IF SCORMAX>300 THEN PSCORMAX=SCORMAX ELSE PSCORMAX=300
5390 IF SCORMIN<-100 THEN PSCORMIN=SCORMIN ELSE PSCORMIN=-100
5400 RETURN
```

VITA

Hampton R. Liggett graduated from Tullahoma High School in June 1976. In September 1976, he entered The University of Tennessee, Knoxville. Following an unsuccessful first attempt at college, he went to work as a truck driver for Modern Supply Company, Knoxville, Tennessee in June 1979. In February 1980, he was employed as a warehouseman by Schrivner, Inc., Knoxville, Tennessee. He left Schrivner in September 1983 to return to The University of Tennessee and in August 1985 received a Bachelor of Science degree in Industrial Engineering. In September 1985, he enrolled in the Masters program in Industrial Engineering, Manufacturing Systems Option at The University of Tennessee. He received a Master of Science degree in August 1987 and enrolled in the graduate program at North Carolina State University in Raleigh.