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THESIS

DECISION SUPPORT SYSTEMS: A FRAMEWORK
FOR EVALUATION AND JUSTIFICATION

by

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Decision Support Systems have been evolving for over a decade to assist an individual or organization in the decision making process. DSS are often difficult to justify or evaluate because many of the benefits that they will provide are intangible benefits and are difficult to measure. Over the past decade there have been several methods published that can assist in evaluation or justification. In this thesis, I propose a framework designed to assist the user in selecting the best method for evaluation or justification for their organization. The framework considers:

The goals and objectives of the DSS and the organization

The tangibility of the goals and benefits

The need or requirement to quantify goals and benefits

DSS are continually evolving and are gaining importance in the information systems arena. Evaluation and justification will become increasingly more important. The framework will provide a basis for selecting the most appropriate method available for an organization.

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Decision Support Systems: A Framework for
Evaluation and Justification

by

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ABSTRACT

Decision Support Systems have been evolving for over a decade to assist an individual or organization in the decision making process. DSS are often difficult to justify or evaluate because many of the benefits that they will provide are intangible benefits and are difficult to measure. Over the past decade, there have been several methods published that can assist in evaluation or justification.

In this thesis, I propose a framework designed to assist the user in selecting the best available method for evaluation or justification for his/her organization. The framework considers:

- The goals and objectives of the DSS and the organization

- The tangibility of the goals and benefits

- The need or requirement to quantify goals and benefits

DSS are continually evolving and are gaining importance in the information systems area. Evaluation and justification will become increasingly more important. The framework will provide a basis for selecting the most appropriate method available for an organization.

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I. INTRODUCTION

A successful DSS can provide an organization the needed advantage when trying to compete in an environment that is financially burdened. The problem with DSS is: "How does an organization justify spending dollars on a DSS?"

To justify a DSS, several methods have been presented throughout literature over the past decade. I have designed a framework that will assist the user in deciding what method is most appropriate for the user's organization.

This framework is designed to take the user through a process of three steps or questions that pertain to the organization's objectives and the purpose of the proposed DSS. By following the framework, an organization can select the most appropriate method available for not only justifying a DSS, but also for evaluating a current DSS. This framework is flexible and can expand to incorporate new justification or evaluation methods if and when they become available.

A. WHAT IS A DECISION SUPPORT SYSTEM

Decision Support Systems (DSS) are defined as: "A class of information systems that draw on transaction processing systems and interacts with other parts of the overall information system to support the decision making activities of managers and other knowledge workers in organizations." [Sprague and Carlson, 1982] Other definitions differ between what an actual DSS is and what the composition of a DSS is. Some definitions are very restrictive to the criteria that involve composition of a DSS, while others are of a broader scope.

Restrictive: "DSS are an interactive computer-based system that help decision makers utilize data and models to solve unstructured problems." [Sprague and Carlson, 1982]

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Broad: "DSS are any systems that make some contribution to decision making." [Sprague and Carlson, 1982]

Both of these types of definitions have drawbacks. The restrictive definition greatly limits the DSS category, whereas the broad definition includes any available information system. A viable DSS actually falls somewhere between these two definitions.

Decision Support Systems (DSS) have been evolving for the past decade. The purpose of DSS is to provide a decision maker with the resources needed for assistance in the decision-making process. The information obtained from the DSS lends credibility to the final decision, but does not become the final decision. The final decision involves the DSS data, as well as other factors, and is arrived at by the decision maker. One strength of a DSS is that it can focus on semi-structured and unstructured problems that are not normally addressed by traditional information systems.

These points are supported by Hogue and Watson [1983], as listed in their criteria for a DSS as:

- Supports but does not replace decision making.

- Directed toward unstructured and or semi-structured decision

  making tasks.

- Data and models organized around the decision(s).

- Easy to use software interface.

- Interactive processing.

TABLE 1.1: DECISION TABLE

TYPE OF DECISION	PERCENT OF RESPONDENTS WHOSE PRIMARY USE OF THE DSS IS FOR THIS TYPE OF DECISION
General Long Range Planning	38%
Strategic Assessment	23%
Product Strategy	8%
Negotiations of budgets	8%
Reporting and Analysis	8%
Operational Planning and Control	6%
Acquisition Strategy	2%
Capital Investment Strategy	2%
Financial Strategy	2%
General Budgeting	2%
Cash Flow Management	2%

- DSS use and control is determined by the user.

- Flexible and adaptable to changes in the environment and the decision maker's style.

- Quick ad hoc DSS building capabilities.

B. DSS DECISIONS

A DSS can assist the decision maker with many types of decisions depending on the emphasis of the specific DSS. In a survey, [Meador, et al., 1984], a DSS was primarily used to support the following types of decisions (See Table 1.1):

C. DSS BENEFITS

Numerous studies addressed the benefits that an effective DSS could provide. [Hogue, et al., 1985; Keen, 1981; Meador, et al., 1984; Money, et al., 1988]. In one

survey response, eight top level executives (with little or no DSS experience) listed benefits that they perceived to be the most useful: [Alavi, 1982]

DSS BENEFITS IN DESCENDING ORDER OF USEFULNESS

- Provide information processing and retrieval capabilities

- Evaluate alternatives

- Assist in identifying problems

- Assist in interpreting information

- Provide real time analysis of current problems and opportunities

- Suggest decision alternatives

- Provide ability to ask "what if" questions

- Manage executive time by scheduling daily activities

- Increase decision confidence

This list does not include all of the benefits that can be derived from an effective DSS. However, it is important to understand what information top level management would like to see when justifying a DSS.

D. MOTIVATING FACTORS

What motivates organizations to procure a DSS to assist in the decision making process? Benefits are listed in many articles that advocate DSS, but is this enough to justify the investment? [Hogue and Watson, 1983] surveyed 18 major corporations and listed the motivating factors which led to the development of DSS.

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- *Accurate Information* was cited by 12 corporations.

- *Organizational Champion* was cited by 8 corporations.

- *New Information* was cited by 6 corporations.

- *Managerial Mandate* was cited by 4 corporations.

- *Timely Information* was cited by 3 corporations.

- *Cost Reduction* was cited by 1 corporation.

While costs and tangible benefits are crucial to an organization, these findings on motivation show how important intangible benefits have become in the DSS arena.

E.   WHY DO ORGANIZATIONS NEED DSS?

DSS can provide numerous benefits ranging from increased decision alternatives to improved communication. DSS that provide increased decision alternatives could save (or earn) thousands or even millions of dollars simply by providing the decision maker with possible alternatives which may have been overlooked. This is just one example of a potential benefit. DSS can also provide sensitivity analysis functions to assist a decision maker in choosing between alternatives. The list of benefits is long and the value of a successful DSS could be priceless.

F.   WHY DO ORGANIZATIONS NEED TO EVALUATE THEIR DSS?

While several DSS have become successful, others have been failures. DSS are only as good as their input. While it is easy to pick up a magazine and read about a successful DSS, it is not as easy to find articles on DSS that were failures. Some organizations invest in DSS which ultimately fail. Thus, there must be some method to evaluate the success of an organization's DSS.

Evaluation and feedback are very important to any operation. Before an organization implements a DSS, an evaluation process should be in place. This can help determine if the outcome is worth the investment. Evaluations should be done on a continuing basis and then the combinations of the evaluations could be used to help justify upgrade a DSS when the time comes to do so.

G. SCENARIO

The Commanding Officer for the US Army Recruiting Command knows that a decision support system can help decision making tasks such as:

- From where are the majority of recruits for the army coming?

- What can be done to increase recruiting in each geographic region?

- What effect will increased advertising have in certain regions?

- How much should be spent on advertising?

The Commander would like to procure a DSS but must justify the expenditure to his supervisors. Goals for the DSS are to increase recruitment and to increase the overall quality of the individuals that the U.S. Army recruits.

Analysis to determine proper method of justification for this DSS will be presented in Chapter IV.

H. SUMMARY

Many articles have been written about the methods used to justify or evaluate decision support systems.

Hogue and Watson's survey [1983] of 18 corporations also lists the methods used by the participants to justify building the DSS (See Table 1.2):

These and other justification methods will be examined in Chapter II.

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TABLE 1.2: JUSTIFICATION OF DSS

Justification Method	Percent of Corporations
Intuition	44%
Value Analysis	33%
Cost and Hard Benefits	17%
Cost and Intuitive Benefits	6%

A notation in the Hogue and Watson survey states, "Ninety-Four percent of the corporations surveyed made no formal attempt to measure the financial impact of the DSS after it became operational."

The purpose of this thesis is to survey the existing methods for DSS justification and evaluation and to present a framework to assist the decision maker to decide the most appropriate method available to achieve the corporate needs.

II. JUSTIFICATION

A. INTRODUCTION

The purpose of this chapter is to provide information on justification methods that are available. Justification allows for the prediction of future requirements, benefits and costs to evaluate the procurement of a DSS. Several methods of justification of DSS have been published in the literature. The discussion of each method is not intended to be a rewrite of the original author's work. Instead, its purpose is to give a user some background information on each method and to provide the user with the original author's work for further elaboration.

B. JUSTIFICATION METHODS

The following methods are described in the DSS literature:

- Excess Tangible Costs

- Value Analysis

- Benefit Profile Chart

- Incremental Analysis

- Aggregate Benefit Value

- Profit Index

- Savings/Investment Ratio

- Intuition

- Cost Benefit Ratio

1. Excess Tangible Cost

The Excess Tangible Costs method [Litecky, 1981] is used to quantify intangible benefits. The technique itselfis simple, but there are assumptions which should be met before using it:

1. Tangible costs and benefits are relatively easy to estimate.

2. Intangible benefits are most difficult to estimate.

3. Tangible costs are ordinarily much greater than tangible benefits.

4. Intangible costs are insignificant.

The steps involved in this method are:

- *Step 1.* Summarize all of the tangible costs (i.e., program development, investment in equipment, etc.).

- *Step 2.* Analyze the sum of all tangible benefits (i.e.; cost displacement benefits, decreased operating costs, etc.).

- *Step 3.* Subtract the tangible benefits from the tangible costs.

  This, according to the assumptions, will result in "Excess Tangible Costs". The Excess Tangible Costs is an important figure to management because it is the amount which must be overcome by the intangible benefits.

- *Step 4.* List the intangible benefits.

- *Step 5.* Derive a discount factor for each intangible benefit. The discount factor should reflect the probability that the particular benefit will result in overcoming one tangible dollar.

- *Step 6.* Multiply the discount factor (probability) by the Estimated Monetary Benefit (EMB). This EMB is the amount the benefit would achieve if there was 100% probability of achieving success.

The EMB and the discount factors are derived via a feasibility study.

Example

Tangible Costs	($25,000)
-Tangible Benefits	5,000
Excess Tangible Costs	($20,000)
Intangible Benefits	
Benefit #1(10,000) x Discount Factor(.3) $3,000	
Benefit #2(10,000) x DF (.5) $5,000	
Benefit #3(20,000) x DF (.4) $8,000	
Benefit #4(25,000) x DF (.3) $7,500	
Total Intangible Benefits	$23,500
NET	$3,500

Therefore, a combination of tangible and intangible benefits will offset the tangible costs by a net amount of $3,500.

The term Excess Tangible Costs relates to the dollar amount that must be overcome by the intangible benefits.

2. Value Analysis

The Value Analysis method was first introduced by Keen [1981] and was divided into eleven steps by Smith [1983]. The eleven steps are:

- *Step 1.* Define the benefits to be obtained if a prototype system is developed.

- *Step 2.* Determine the amount users are willing to pay to obtain the benefits.

- *Step 3.* Determine whether a prototype can be implemented within the "cost threshold" established by the user.

- *Step 4.* Design the prototype and measure its use and cost.

- *Step 5.* Review and extend benefits list if necessary.

- *Step 6.* Define computer hardware and software which would permit a more complete system to be evolved from the prototype.

- *Step 7.* Determine cost of expanding the system.

- *Step 8.* Ask users to determine level of benefits which must be obtained to justify investing in an expanded system.

- *Step 9.* Assuming users provide a feasible new "cost threshold", design a second version of the system.

- *Step 10.* After the second version is implemented, measure its use and costs and determine new cost threshold for a possible third stage of development.

- *Step 11.* Continue steps 5-10 until users and systems designers are satisfied that the best solution has been achieved under existing constraints.

This method allows the users to determine what benefits are important and place a monetary figure to each benefit. The monetary values are based on what the user be willing to pay to obtain a specific benefit? This approach uses the "quick hit" approach when developing a DSS and utilizes prototypes to get a working model in the users' hands as quickly as possible and at a low initial cost.

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3. Incremental Analysis

Incremental Analysis [Smith, 1983] methodology forecasts the probable need of a DSS or Decision Tool, and then determines the various ways to accomplish these items without building or buying the DSS. "The first step in using incremental analysis is to predict future workloads and to assign probabilities to the forecasted workload. Systems personnel then determine alternative methods for accomplishing the workload and assign costs to each alternative." [Smith, 1983]

Example

A marketing firm believes there is a 70% chance that they will need a DSS in the next two years to assist in determining a marketing strategy for geographic regions and advertising dollars needed to promote the strategy.

The alternative is that there is a 30% chance that a DSS will not be needed.

Problem: Determine the alternative ways to accomplish the same goal and determine costs for each.

1. Hire additional personnel to determine marketing strategy.

2. Subcontract to an outside bureau.

	DSS Needed (.7)	DSS Not Needed (.3)	Total Expected Cost
Hire Marketing Personnel	$150,000/year	0	$105,000
Using Outside Consultants	$100,000/year	0	$ 70,000

From this analysis, the least costly alternative is to hire an outside consultant at $70,000 per year. If an appropriate DSS be acquired for less than $70,000 per year, the firm should explore either buying or building a DSS.

4. Profitability Index

The Profitability Index method is simply an accounting exercise used to determine a project's worth. The profitability index is a ratio that accounts for cash inflows into a project and the amount of investment required. [Garrison 1988] It takes into account only the tangible costs and benefits that occur with a project. In most cases, DSS provide intangible benefits. This method would be inefficient if an organization is interested in any intangible benefits.

The formula for profitablity index is:

$$\frac{\text{Present Value of Cash Inflows}}{\text{Investment Required}}$$

The higher the profitability index, the more desirable the project. The profitablity index it allows for more than one project to be evaluated against other projects that may or may not provide the same service.

Project A

Hire Marketing Personnel Required $\dfrac{\$250,000 \text{ Est. cash inflow}}{\$150,000 \text{ Investment}}$

Profitability Index = 1.67

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Project B

Purchase of a Marketing DSS $\frac{\$150,000 \text{ Est. cash inflows}}{\$70,000 \text{ Investment}}$

Required

Profitability Index = 2.14

Using this simple example shows how Project B has the higher Profitability Index, thus, it should be selected over Project A.

5. Benefit Cost Ratio

The Benefit Cost Ratio [Naval Data Automation Command (NDAC), 1980] can be used when costs and benefits are unequal. To determine the economic desirability of an investment, the benefits are divided by the costs, providing a single figure for comparison. The value represents the amount of benefits obtained per unit of cost.

- BCR $= \frac{\text{Quantifiable Output Measure}}{\text{Uniform Annual Cost}}$

- (UAC) Uniform Annual Cost $= \frac{\text{Present Value}}{b_N - b_M}$

- (QOM) Quantifiable Output Measures = Tangible Benefit

[Economic Analysis Procedures for ADP, NDAC, 1980]

The terms b_N and b_M are factors taken from Appendix B. They are determined by the project life.

Example

Investment decisions occur randomly over the course of the year. The present manual system for evaluating an investment decision takes approximately 3 days (24 man-hours). An Investment DSS can analyze investment decisions more

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rapidly, allowing a manager to complete the process in one day (8 man-hours). Over the year many investment decisions are overlooked, due to the inability of the investment department to keep pace.

QOM manual = 121 Investment Analysis Opportunities per year

QOM DSS = 365 Opportunities per year

Cost Category	Manual	DSS
One-time (year one)	0	$50,000 (DSS)
Recurring (year 2-9)	$50,000 (salary)	$50,000 (salary)

$$\text{UAC manual} = \frac{50,000(6.042 - .954)}{6.042 - .954} = \frac{254,400}{5.088} = \$50,000$$

$$\text{UAC DSS} = \frac{50,000(.954) + 50,000(6.042 - .954)}{6.042 - .954} = \frac{302,100}{5.088} = \$59,375$$

$$\text{BCR manual} = \frac{QOM}{UAC}\frac{121}{50,000} = .00242$$

$$\text{BCR DSS} = \frac{QOM}{UAC} = \frac{365}{59,375} = .006147$$

The proposed DSS has a higher BCR than the current manual system. Therefore, it is the more cost effective alternative.

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6. Aggregate Benefit Value

The Aggregate Benefit Value (ABV) method [NDAC, 1980] is one of many weighted methods that are available. Weighted methods may be more applicable in the DSS arena due to the fact that many of the benefits are intangible. ABV works similarly to the Cost Benefit Ratio, method discussed above.

The example for the ABV method uses the same UAC figures derived from the previous example, with the major difference that no QOM can be derived.

Example:

The vice-president wants you to evaluate a DSS and compare it to your present manual system. His major concerns are the need for a faster response time to unexpected investment opportunities and the ability to answer "what if" scenarios. Other, less important factors include better use of resources and more effective teamwork. (See Tables 2.1 and 2.2)

Using this method, the DSS again appears more efficient because it has a higher BCR.

* The factor weights and the rankings are determined prior to the evaluation. The factor weights are determined by the user depending on the value the user has placed on each decision factor. The rankings are then determined by system personnel, normally on a scale of 1 to 10. (Faster response time is three times higher for the DSS as compare to the manual method, thus the rankings of 9 for the DSS and only 3 for the manual method.)

The Aggregate Benefit Ratio allows a user to factor in the intangible benefits, although they are difficult to quantify. However, caution must be exercised to prevent the introduction of personal opinions and biases. There always exists the

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TABLE 2.1: BENEFIT RANKING DSS

Decision Factor	*Factor Weight	*Ranking	Product
Faster Response Time	3	9	27
Ability for "What If" scenarios	3	7	21
Better Use of Resources	2	8	14
Teamwork	2	6	<u>12</u>
TOTAL			<u>74</u>
UAC (59,375 as determined in CBR example)			5.9375
BCR			12.46

TABLE 2.2: BENEFIT RANKING MANUAL

Decision Factor	*Factor Weight	*Ranking	Product
Faster Response Time	3	3	9
Ability for "What If" scenarios	3	5	15
Better Use of Resources	2	5	10
Teamwork	2	5	<u>10</u>
TOTAL			<u>44</u>
UAC (50,000 as determined in CBR example)			5.0000
BCR			8.8

possibility of adjusting factor weight or rankings as needed. Adjustments will bring about a different conclusion.

7. Savings/Investment Ratio - (SIR)

A Savings/Investment Ratio (SIR) [NDAC, 1980] is the relationship between future cost savings and the investment necessary to obtain those savings. A SIR of 1 indicates that the present value of the savings is equal to the present value of the investment. For an investment to be economically sound, the SIR value must be greater than one. SIR is a characteristic of cost only and does not consider benefits (except cost savings).

SIR is used when evaluating an alternative against the present situation.

Example:

Presently you are the head of an investment decision department that consists of four employees and four personal computers. The department is responsible for analyzing investment opportunities for a local bank. The four employees are paid $40,000 each per year as a salary. The bank has the opportunity to purchase an Investment DSS for $50,000. The Investment DSS would decrease the workload of your department by 25%, allowing you to reassign one of your four employees to a different department and saving $40,000 per year in salaries that you would have had to pay to hire another investment analyst. The DSS has a two year service guarantee but possibly could be obsolete after 2 years.

$$*SIR = \frac{PV_S}{PV_I} = \frac{\$40,000}{\$50,000}(1.821) = \frac{\$72,840}{\$50,000} = 1.4568$$

Since the SIR is greater than 1.0, the investment is economically sound. The present value of the DSS is greater than the present value of the cost.

PVS is the present value of the savings. (All future savings must be discounted by using factors from Appendix B to bring the value to a present day figure.)

PVI is the present value of the investment. (If the investment is a one time investment that is paid in full there is no need to discount the amount. However, if the investment occurs over a specified period of time the the factors from Appendix B should be applied.)

* Project Year Discount Factors such as 1.821 can be found in Appendix B.

8. Benefit Profile Chart

The Benefit Profile Chart method [Smith, 1983] uses a comprehensive checklist of benefits (See Appendix A) used by system professionals to help in preparing justification documents. The checklist can be adapted to any organization's needs. By graphically displaying the benefit charts, a system professional can better justify a DSS package to top executives. An example of a Benefit Profile Chart can be found in Appendix A.

9. Intuition

One of the most-used strategies is simply the use of intuition. [Hogue and Watson, 1983] Watson found through an empirical study that 44% of the respondents to his questionnaire used intuition over any other method when justifying procurement of a DSS.

Also along these lines is the motivation to procure a DSS because the competition has employed one. Many organizations are motivated by successful decision support systems that have been employed by like organizations. The greater degree of success from an organization's competitors, the larger the motivation factor for procuring a DSS. In Hogue and Watson's survey [1983], organizational champion was cited by 44% of the corporations as a motivating factor for procuring a DSS.

III. EVALUATION

A. INTRODUCTION

A current operating DSS should be evaluated with respect to its effectiveness, costs, and benefits. This chapter provides information on the evaluation methods that are available. The discussion of each method is not intended to be a rewrite of the original author's work. Its purpose is to give a user some background information on the method and reference to the original author's work for further investigation.

B. EVALUATION METHODS

The following methods are described in the DSS Literature:

- Return on Investment (ROI)

- Expected Value

- Value Analysis

- ROI/w Value Analysis or User Satisfaction

- Profit

- User Satisfaction

1. Return on Investment

The Savings/Investment Ratio [Garrison, 1988] can be used to calculate the actual return on investment. The savings/investment ratio is the relationship between cost savings and the initial investment with any operating/maintenance costs, to obtain those savings. A SIR of 1 indicates that the present value of the

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savings is equal to the present value of the investment. For an investment to be economically sound, the SIR must be greater than 1. The SIR ratio is a characteristic of cost only and does not consider benefits (except cost savings).

SIR is used when evaluating a new system against the current one.

Example:

The investment decision department invested in a DSS three years ago. The chief of the department would like to determine if the investment was profitable. The DSS the department utilizes had allowed them to eliminate one of the paid analyst postions. The cost savings from saved salaries is $40,000 for the first year and 42,000 and 43,000 in the second and third years. In the fourth year the DSS became obsolete because of several changes in the surrounding environment. The department was then forced to hire another analyst. The DSS had provided several intangible benefits, including increased alternative choices and faster response time. The initial investment was $50,000 with maintenance and upgrade costs of $15,000 over the four years.

$$SIR = \frac{Savings}{Investment} = \frac{\$125,000}{\$65,000} = 1.92$$

Since the SIR is greater than 1.0, the DSS was a sound investment.

This DSS returned nearly twice the investment. This is using only tangible costs. The fact that there were also associated intangible benefits makes it even more successful. The fact that the DSS was a sound investment although it eventually became obsolete, could be sufficient justification for investigating the procurement of a new DSS.

Return on Investment could also be calculated using the formula: [Polokoff, 1990]

$$ROI = \frac{Benefits - Depreciation}{Costs}$$

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The DSS in the above example had a 4-year expected life (for depreciation purposes), but in the fourth year, the department hired another analyst, thus providing no cost savings for the fourth year. The the figures would show:

$$\text{Benefits} = \frac{\$125,000}{4} = \$31,250$$

$$\text{Depreciation} = \frac{\$50,000}{4} = \$12,500$$

$$\text{Costs} = \$65,000 \ (50,000 \text{ initial} + 15,000 \text{ maintenance})$$

$$\text{ROI per year} = \frac{\$31,250 - \$12,500}{\$65,000} = .2885 X 100\% = 28.85\%$$

$$\text{ROI} = 28.85\%$$

The organization's standards would dictate if the ROI was an acceptable amount.

Other accounting methods are also available for use in determining profitability of a project. The major point to keep in mind with these methods is that intangible benefits are overlooked.

2. Profit

Profit [Garrison, 1988] is an area that can be used to evaluate the success of a DSS, but only after an extended period of time. The DSS could operate for several years before anyone would be able to attribute the change in profit level to the success of the DSS.

Example 1:

A successful organization (without the aid of a DSS) enjoys a profit of one million dollars per year over three years. A DSS is then built to help them pick better investment opportunities. The first year profits increase to 1.2 million. The second and third year profits increase to 1.3 and 1.4 million, respectively.

It could be assumed that the organization appears to be turning a bigger profit due to the use of the DSS. However, a part of the increase could be due to

many other factors which would have brought about the increase without the DSS's involvement. The true test then would be to operate without the use of the DSS and to compare profit levels. Most organizations would not attempt this strategy. The best way to evaluate a DSS using this method would entail a thorough analysis of all the environmental factors that could possibly lead to increasing or decreasing profits.

Example 2:

A successful organization (without the aid of a DSS) enjoys a profit of one million dollars per year over three years.

They then build a DSS to help them pick better investment opportunities. The first year their profits decrease to .9 million. The second and third year profits decrease to .8 and .7 million, respectively.

The organization now appears to be losing profits due to the DSS.

This situation is easier to remedy. If the DSS was scrapped or rebuilt, several more years would need to pass to check the profit levels to see if an increase results.

However, environmental factors could be causing the decreased profit. In this example, it is easier to doubt the effectiveness of the DSS. Whether or not the profits increase or decrease, it would take a long time to determine whether the DSS has been successful using this method.

3. Expected Value

The accurate use of this method [Smith, 1983] requires an experienced and knowledgeable person in the field of statistics, economics, systems analysis and DSS to follow these steps:

- *Step 1*: List the DSS benefits and assign them to a group of possible cost reduction benefits (Group A, 8, C. . .column 1).

- *Step 2*: Assign a possible cost reduction range (column 2) and a probability of occurrence (column 3) to each group.

- *Step 3*: Multiplying the midpoint of the assigned range (column 4) times the total cost of the project (assign the product to column 5).

- *Step 4*: Then multiply the probability of occurrence times (column 5) to arrive at the probable savings that is listed in (column 6).

Example

Group	Benefit
Group A	Increased number of alternatives New insight and learning Improved communications Control
Group B	Make better use of data Better understanding of business
Group C	Ability to carry out ad-hoc analysis Fast response to unexpected situations Better decisions

The actual cost measured in dollars from this example was $1,000,000.

1	2	3	4	5	6
Grp	Poss. Cost Reduction	Probability of Occurrence	Midpoint	Cost Reduction C4 x Total Cost	Probable Savings C3 x C5
A	0-10%	70%	5.0%	$50,000	$35,000
B	10-15%	50%	12.5%	$125,000	$62,500
C	15-25%	40%	20.0%	$200,000	$80,000
Total Probable Savings					$177,500

Using this method, it is shown that of the $1,000,000 in actual costs, $177,500 is the probable savings from the intangible benefits alone.

4. Value Analysis

Value Analysis [Keen, 1981] was discussed in Chapter II. However, value analysis can also be used to evaluate a DSS. Once a DSS has been up and running in an organization, the question may exist whether to update or scrap the DSS. Value Analysis allows the evaluator to determine what the user is willing to pay in order to keep his present DSS and to determine if there are other benefits that can be added to the DSS.

Steps 8 through 11 allow the organization to effectively evaluate their DSS by going back to the users and discussing expansion or scraping the present DSS.

- *Step 8* Ask the users to determine level of benefits that must be obtained to justify investing in an expanded system.

- *Step 9* Assuming users provide a feasible new "cost threshold", design a second version of the system.

- *Step 10* After the second version is implemented, measure its use and costs and determine new cost threshold for a possible third stage of development.

- *Step 11* Repeat steps 5-10 until users and systems designers are satisfied that the best solution has been achieved under existing constraints.

The evolving DSS that Value Analysis provides is an excellent way of continually evaluating an organizations DSS. If users are pleased with the initial versions of the DSS, the organization can continually update the DSS to include more functions.

5. User Satisfaction

Several methods are available to measure user satisfaction. [Baroudi and Orlikowski, 1988] However, a common method is the use of a questionnaire-type survey. Surveys can help the organization determine the features of a DSS which are the most beneficial, used, or successful and it can also help determine those features that are worthless or dissatisfying. There are cases where DSS tools and user satisfaction surveys have not produced consistent results. These studies showed that user satisfaction surveys can sometimes be deceiving. In an assessment [Aldag and Power, 1986] of computer-assisted decision analysis, users thought favorably of the decision tool, however using the decision tool did not improve their decisions. In a separate study [Gallupe and DeSanctis, 1988], the decision tool greatly enhanced the quality of the decision, however, satisfaction and confidence were lower than the group that did not use the decision tool. Despite these findings, user satisfaction surveys are still widely used and accepted. Most surveys use a Likert-type scale, allowing the respondent to evaluate on a scale of 1 to 7, the features of the DSS. Appendix C shows an example of a User Satisfaction Survey. [Baroudi and Orlikowski, 1988]

6. ROI w/Value Analysis or User Satisfaction

This method combines two methods [Baroudi and Orlikowski, 1988] [Garrison, 1988] and attempts to balance the tangible benefit side (ROI) with the intangible benefits (Value Analysis or User Satisfaction).

The methods have been described above. An organization could run both methods to determine the bottom line return on their investment and to also give consideration to intangibles by implementing value analysis or user satisfaction techniques. By implementation of this method, the organization would evaluate their present DSS and would also provide data for future justification to updated or modify the current DSS. By implementing value analysis or user satisfaction techniques, it will be easier to overcome a lower than expected ROI (provided that the user satisfaction level was high with the initial DSS).

This method help to satisfy those who want to see a bottom line figure, while at the same time taking into account the intangible benefits that are always present in the DSS arena.

IV. A FRAMEWORK FOR DSS EVALUATION AND JUSTIFICATION

A. INTRODUCTION

There are several ways to evaluate or justify an investment. Procurement of any system, whether a DSS or a traditional information system, should be thought of as an investment. This chapter presents a framework that will assist a user in selecting an appropriate method, or set of methods, to evaluate or justify a DSS. The framework that I have designed is a multi-level decision tree. (Figure 4.1)

The decision tree's purpose is to guide the user through 3 levels of questions to arrive at a methodology which will assist his/her organization when evaluating or justifying a DSS. The questions within the decision tree are designed to separate the available methods. The answers to the questions within the decision tree should be based on the user's organizational goals. Upon answering the questions, the user will arrive at a methodology which will best fit organizational needs.
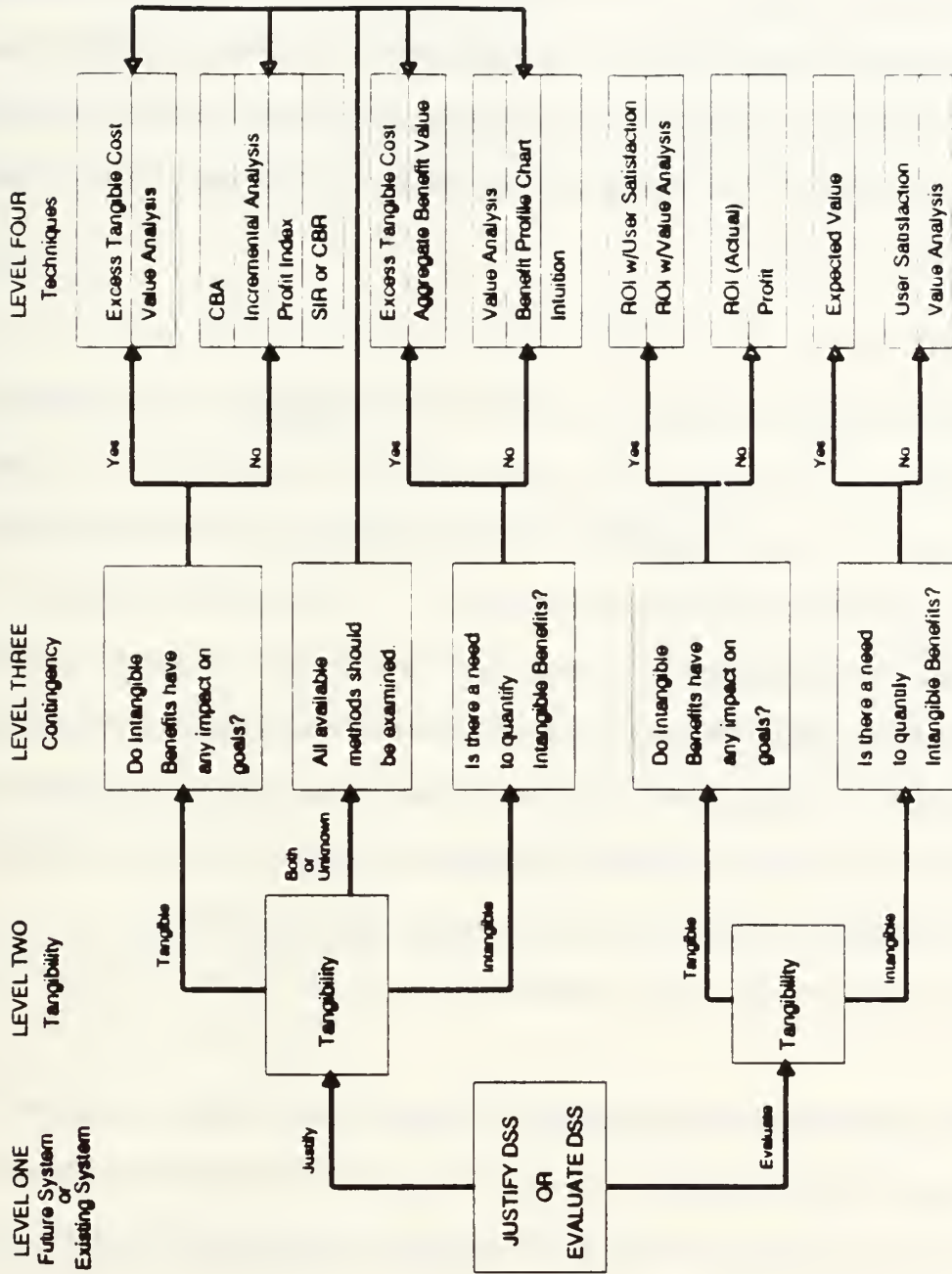
Figure 4.1: Framework For Evaluating or Justifying DSS

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B. LEVEL 1

The first level of the framework addresses the purpose of the DSS assessment. Is the user trying to justify future procurement (buy or develop) a DSS, or is he looking to evaluate the current DSS in his organization? Several methods are available to justify and to evaluate a DSS, however, most methods apply only to either justification or evaluation.

C. LEVEL 2

The second level in this framework deals with the objectives to be accomplished within the DSS. Are the goals mostly tangible goals (e.g., time savings, cost savings, profit) or are they mostly intangibles (e.g., better decisions, more alternatives, user satisfaction, improved service for the customer)?

The key to answering these questions is in knowing the organization's mission or goals. If an organization's goal is strictly increased profit, this goal is relatively easy to quantify. However, while increased profit is the primary goal, many organizations have secondary goals. If the organization wants increased profits with increased organization morale, the goals are not as easily quantifiable.

When answering the Level 2 question, the adjective "mostly" should be considered.

If the organization's primary goals are mostly tangible with some intangible secondary goals, then it should take the the "tangible route." If the organization's primary goals are mostly intangible with tangible secondary goals, then the "intangible route" should be followed.

In the case where the organization's goals are unknown or the user cannot decide between tangible and intangible, the route label "both or unknown" should be chosen. However, this route will require the user to do a thorough analysis of

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many methods to justify the DSS in order to find the method that best fits the organization.

Many DSS are geared toward functional areas and may be far removed from the primary goals of an organization. In this case, the functional area goals need to be addressed in determining the most appropriate route in the framework.

D. LEVEL 3

The third level of the proposed framework leads the user to a method or a set of available methods considered to be the most appropriate to the user's given situation.

The following routes are available for DSS Justification.

1. Justifying/Tangibles

If a user is trying to justify purchasing or developing a DSS and the benefits are mostly tangible, the third question is "Do intangible benefits have any impact on goals?" If the intangible benefits do have some impact, then the "yes" route will lead to the following methods of justification:

- Excess Tangible Cost [Litecky, 1981]

- Value Analysis [Keen, 1981]

If the intangible benefits have little or no impact on goals, the "no" route will lead to the following methods:

- Profitability Index [Garrison, 1988]

- Cost Benefit Ratio [NDAC, 1980]

- Savings Investment Ratio [NDAC, 1980]

- Incremental Analysis [Smith, 1983]

2. Justifying/Intangibles

If the user is trying to justify a DSS and the goals are mostly

intangible, the question to be addressed will be: "Is there a need to quantify intangible benefits?" An organization may desire a DSS that provides information for better decisions (intangible), however, it wants to show a "bottom line figure" (tangible). The following methods are available to help give the organization that "bottom line figure":

- Excess Tangible Costs [Litecky, 1981]

- Aggregate Benefit Value (weighted methods) [NDAC, 1980]

If the organization does not require a bottom line figure, the following methods are more appropriate:

- Value Analysis [Keen, 1981]

- Benefit Profile Chart [Smith, 1983]

- Intuition [Hogue and Watson, 1983]

- Success Stories

These methods are discussed in Chapter II.

3. Evaluate/Tangible

When evaluating a DSS designed for mostly tangible benefits with some intangible impact on goals, *Return on Investment* in conjunction with *User Satisfaction* or *Value Analysis* would be appropriate.

If the intangible benefits do not affect goals, simply *Return on Investment (Actual)* or *Profit* would be better measures.

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4. Evaluating/Intangibles

If an organization is evaluating a DSS designed for intangible benefits and there is still a need to quantify the answer, then the *Expected Value Method* would be appropriate.

If there is not a need to quantify an evaluation, the following methods would be more appropriate:

- User Satisfaction [Baroudi and Orlikowski, 1988]

- Value Analysis [Keen, 1981]

E. SUMMARY

Organizations may have any number of goals. An organization may have a goal that is tangible in nature but the user desires a DSS that provides intangible benefits (e.g., more alternatives to help produce better decisions). The objective of the DSS now falls into the realm of intangibles even though the organization's goals are tangible. To successfully use the decision tree, both the goals of the organization and the proposed purpose of the DSS must be taken into account and the appropriate measures applied as listed above.

What follows are three scenarios which demonstrate the usefulness of the proposed framework.

F. SCENARIO 1

The Commanding Officer for the U.S. Army Recruiting Command knows that a decision support system can help him with several decision making tasks such as:

- From where are the majority of recruits for the U.S. Army coming from?

- What can be done to increase recruitment in each geographic area?

- What effect will increased advertising have in certain regions?

- How much should be spent on advertising?

The commander would like to procure a DSS, but must justify the expenditure to his superiors. Goals for the DSS are to increase recruitment and to increase the overall quality of individuals that the U.S. Army recruits.

In this scenario the best response would be:

Level 1. Justification

The organization would like to procure a DSS. The DSS will require justification.

Level 2. Tangible

The scenarios goals are for increased recruitment and increased quality of recruits. These goals are tangible and can be measured. The recruiting command administers a aptitude test to judge overall quality of the recruit. These goals can be measured using traditional Cost Benefit Analysis techniques.

Level 3.

The answer to the level three question is "No", intangibles benefits do not impact on goals.

The scenario does not state any intangible benefits as either primary or secondary goals.

This information leads the analysis to the following applicable alternative justification methods:

- Incremental Analysis [Smith, 1983]

- Profitability Index [Garrison, 1988]

- Cost Benefit Ratio [NDAC, 1980]

- Savings/Investment Ratio [NDAC, 1980]

G. SCENARIO 2

The human resource manager controls pay and suggests appropriate increases for each position within the organization. He would like a DSS to assist in the decision-making process. The DSS would be a great timesaver, but would primarily be used to satisfy the organization's members and help keep morale at a high level.

The DSS would have to be able to assist in dividing up the budget dollar for annual pay raises on a semi-annual and annual basis. Keeping employees happy is an important goal since to alienate them would contribute to the loss of outstanding employees.

The DSS should be able to capture market information on what other organizations are paying (this can be accomplished through a financial service).

The DSS should be able to incorporate the consumer price index. It should be able to show where the organization stands against the market on current salaries.

It should be able to answer questions such as "What if I want to increase all programmers' salaries in my organization to account for the difference in their pay and the market leader? How much would this increase costs to the organization?"

Top management would like the tangible benefits quantified and a list of all of the intangible benefits that the DSS will provide, but there is not a need to attempt to quantify improved morale and other intangible benefits.

In this scenario, the best response would be:

Level 1. Justification

The organization would like to procure a DSS which requires justification.

Level 2. Intangible

The DSS would be used primarily to assist in the decision making process, to save valued time and to keep organization's members motivated. The scenario lists several intangible goals but makes no mention of intangible goals.

Level 3.

The answer to the level three question is "No" there is not a need to quantify the intangibles benefits).

Top management would like the tangible benefits quantified, but the intangible benefits should be listed. There is no need to place a specific dollar value to the intangible benefits.

This information leads the human resource manager to these applicable alternative justification methods:

- Value Analysis [Keen, 1981]

- Benefit Profile Chart [Smith, 1983]

- Intuition [Hogue and Watson, 1983]

H. SCENARIO 3

A major airline is currently running a decision support system for assisting allocation of planes to different flights and scheduling passengers for each flight. The DSS assists the decision-maker in insuring that planes are available for every flight. If a plane breaks down, the DSS can find another available plane to meet the grounded plane's commitments.

The primary goal of the DSS is to increase the airline's profits through increased customer satisfaction. The better the organization's ability to meet all of its commitments, the more satisfied the customers should be. The assumption is made that when an airline has to cancel flights because of breakdowns, customers will begin to switch to a more reliable carrier.

Management wants to know if an upgrade of the present system is needed. While the DSS in place is doing a satisfactory job, there is a question as to whether a newer system would be better.

In this scenario, the best response would be:

Level 1. Evaluation

In the scenario, the airline presently has a DSS and would like to evaluate the DSS to assist the airline in making decision on whether to invest more money on upgrading their system.

Level 2. Tangible

The goals in this scenario are centered around increasing the airlines profits.

Level 3.

Yes (Intangibles Benefits have an impact on goals)

The primary goal is to increase profits. However, customer satisfaction does have an impact on the goals of increased profits.

This information leads the organization to the following analysis:

- ROI w/Value Analysis

- ROI w/User Satisfaction

V. CONCLUSION

A. THERE IS A NEED FOR DSS

Decision Support Systems can play a vital link in the area of decision making. DSS are not intended to make final decisions, rather to assist the decision maker in the decision making process. Expanding a decision makers views and alternatives, combined with the ability to run sensitivity analysis on each alternative, can greatly enhance the quality of a decision. However, not every DSS is successful. There must be some means set in place to justify and evaluate a DSS. Even if the evaluation is nothing more than a user satisfaction survey, this is still a method which will provide feedback to top-level management. Without some sort of feedback method, the organization will simply run blind.

In Chapter III, several methods of justification and evaluation are presented. Each method has advantages and disadvantages.

B. COST BENEFIT METHODS

"Cost/benefit evaluations will probably provide the most meaningful results to management." [Sprague and Carlson, 1982] However, CBA runs into trouble when trying to evaluate or justify intangible benefits.

C. VALUE ANALYSIS

This method is simple to implement, using prototyping which can help limit the initial investment while testing the water to see if the system will be a success. However, it is "less rigorous than cost benefit techniques and may not include all the measures that are relevant." [Sprague and Carlson, 1982]

D. USER ATTITUDE/SATISFACTION

Using surveys to measure user satisfaction can also run into problem areas. [Sprague and Carlson, 1982] lists the following problem areas when using questionnaires:

1. In developing a questionnaire to measure attitudes, one may be trying to quantify that which is not quantifiable and the subsequent analysis may be misleading.

2. Questionnaire respondents may interpret questions differently than intended, and answers to some questions may influence others.

3. Administering questionnaires may be an inconvenience to individuals and expensive (in terms of hours lost by the respondents and hours spent by the interviewers).

4. The method does not identify the causes of any measured changes.

E. OTHER METHODS

- Expected Value

- Incremental Analysis

- Excess Tangible Costs

- Aggregate Benefit Value

Depending on the organization and its goals, these methods can be very beneficial and simple to use. However, they tend to rely on subjective judgement when establishing weighting or probability of occurrence figures. In some cases, the slightest change in weights or probabilities can drastically change the outcome of the evaluation.

F.   USE OF THE DECISION TREE

The main purpose of this thesis was to provide a framework that can be used to assist the decision maker in determining the most appropriate method for evaluating or justifying a DSS. The decision tree that is provided in Chapter IV (along with a description of the methods) allows a decision maker to quickly assess the methods that best suits his personal or organizational needs. The methods for evaluating and justifying a DSS will continually change. The decision tree can be incorporated to handle any changes. The basic premise for the decision tree is based on three questions that the organization must answer:

1. Is the decision maker attempting to justify future procurement of a DSS or is the decision maker attempting to evaluate the current DSS?

2. Are the goals of the organization mostly tangible or intangible? If the DSS is a personal DSS for an individual, then the individual's goals should be analyzed. Hopefully, the individual decision makers goals complement the organizational goals.

3. If the goals are mostly tangible, do the intangible benefits have any impact on obtaining the organizational goals?

4. If the goals are mostly intangible, is there a need to quantify intangible benefits?

By successfully answering these questions, the decision tree should lead the decision maker to a method(s) that will provide the best available results given the organization's views and goals and prove acceptable to top-level management.

G. SIX POINTS

While attempting to justify or evaluate a DSS, the following points should be kept in mind:

1. DSS can provide both tangible and intangible benefits. All appropriate benefits should be considered when the justification process begins.

2. Benefits should be viewed in light of the organizational objectives.

3. The use of a personal DSS should be viewed in light of the user's objectives, and should coincide with that of the organization.

4. Evaluation of a DSS is an important feedback mechanism that helps to provide information to top-level management.

5. Evaluations throughout the lifecycle of the DSS are necessary to minimize the risks of continually pouring money into an unsuccessful system.

6. Doing one or two things well is far better than doing several things that are mediocre. Do not try to provide a DSS that delivers everything because it can truly cost everything.

APPENDIX A
Cost Benefit Profile Chart [20]

Intangible benefits of MIS/DSS leading to improved business performance.

- Category A = Some improvement in existing system.
- Category B = Significant improvement in existing system.
- Category C = Significant new benefit.

Business Function/Activity	Degree of Performance Improvement		
Engineering/Research	A	B	C
Interactive Problem Solving within Company			
Interactive Problem Solving with Customer			
Stimulation of new ideas (i.e., graphics)			
Faster Design (i.e., computer-aided design)			
Control of Specifications/drawing			
Access to technical information			
Processing of engineering change orders			
Manpower/Project Management			
Management of Professional's time e.g., reduced clerical workload			

Business Function/Activity	Degree of Performance Improvement		
Finance/Accounting	A	B	C
Budget Preparation			
Use of operating/leverage			
Privacy of data information			
Security of data information			
Integrity (accuracy of data)			
Planning/Control of liquid assets			
Capital Budgeting			
Auditing and Internal Control			
Simplified Reporting			
Timely Reports			

Business Function/Activity	Degree of Performance Improvement		
Employee Relations/Human Resources	A	B	C
Identification of best performers (Individual and Groups)			
Strategic Manpower Planning			
Places and methods for recruiting			
Improved government reporting			
Monitoring of EEO/ERISA/OSHA Standards			
Higher motivation for workforce			
— Career planning capabilities			
— Turnover/absenteeism			
— Fringe benefits planning/control			
— Job satisfaction			
Employee Training e.g., computer assisted instructions			

Business Function/Activity	Degree of Performance Improvement		
Employee Relations/Human Resources	A	B	C
Understanding of how HRM functions			
Wage and Salary Planning and Control			

Business Function/Activity	Degree of Performance Improvement		
General Management	A	B	C
Increased Communications among departments			
Planning data more quickly/easily assessible			
Ability to provide "what if" reports			
Faster development of new systems			
Easier to use system			
Increased secretarial efficiency, effectiveness			
Better Meetings			
Provides better reliability			
Improved Accuracy/Conciseness Timeliness relevance of all information			
Cost Avoidance			
— Precludes need to hire new people			

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Business Function/Activity	Degree of Performance Improvement		
General Management	A	B	C
— Need fewer computer programs			
— Need less program maintenance			
— Reduced travel costs			
— Better use of programmers time			

Business Function/Activity	Degree of Performance Improvement		
Decision Support System	A	B	C
— Goal seeking			
— What if stimulation			
— Graphics/modeling			

The Cost Benefit profile is not meant to fit every aspect of a particular organization. It must be tailored to a specific organication. This is strictly a guideline of a Cost Benefit Profile.

APPENDIX B
Project Year Discount Factors

	TABLE A	TABLE B
	Present Value of $1 (Single Amount: Used when cash flows accrue in varying amounts each year)	Present Value of $1 (Cumulative Uniform Series: To be used when cash flows accrue in the same amount each year)
Project	10%	10%
1	0.954	0.954
2	0.867	1.821
3	0.788	2.609
4	0.717	3.326
5	0.652	3.977
6	0.592	4.570
7	0.538	5.108
8	0.489	5.597
9	0.445	6.042
10	0.405	6.447
11	0.368	6.815
12	0.334	7.149
13	0.304	7.453
14	0.276	7.729
15	0.251	7.980

Note: Table B factors represent the cumulative sum of Table A factors through any given project year.

Reference: [NDAC, 1980]

APPENDIX C
User Satisfaction Survey

This appendix provides a basic user satisfaction survey [Baroudi and Orlikowski, 1988]. The survey is not intended to meet every organizations needs. However, it does provide the basis for a user satisfaction survey, which should be tailored to an organization's needs and goals.

This survey should be administered to the users of the DSS after weights have been placed on each of the possible responses. Likert scale normal runs from 1 to 7 points. It is up to the organization to establish an acceptable score prior to administering the survey.

Please follow these instructions:

1. Check each scale in the position that describes your evaluation of the factor being described.

2. Check each scale, do not omit any.

3. Check only one position for each scale.

4. Check in space, not between spaces.

ANSWER BASED ON YOUR OWN FEELINGS

1. Relationship with the Management Information Department (MID) staff

dissonant   :___:___:___:___:___:___:___: harmonius

bad   :___:___:___:___:___:___:___: good

2. Processing of requests for changes to existing DSS

fast   :___:___:___:___:___:___:___: slow

untimely   :___:___:___:___:___:___:___: timely

3. Degree of training provided to users

complete   :___:___:___:___:___:___:___: incomplete

low   :___:___:___:___:___:___:___: high

4. User understanding of the DSS

insufficient   :___:___:___:___:___:___:___: insufficient

complete   :___:___:___:___:___:___:___: incomplete

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5. User's feeling of participation

    positive   :___:___:___:___:___:___:___: negative

    insufficient   :___:___:___:___:___:___:___: sufficient

6. Attitude of the Management Information Department staff

    cooperative   :___:___:___:___:___:___:___: belligerent

    negative   :___:___:___:___:___:___:___: positive

7. Reliability of output information

    high   :___:___:___:___:___:___:___: low

    superior   :___:___:___:___:___:___:___: inferior

8. Relevancy of output information (Does the DSS do intended function)

    useful   :___:___:___:___:___:___:___: useless

    relevant   :___:___:___:___:___:___:___: irrelevant

9. Accuracy of output information

    inaccurate   :___:___:___:___:___:___:___: accurate

    low   :___:___:___:___:___:___:___: high

10. Precision of output information

    low   :___:___:___:___:___:___:___: high

    definite   :___:___:___:___:___:___:___: uncertain

11. Communication with the Management Information Department staff

    dissonant   :___:___:___:___:___:___:___: harmonious

    destructive :___:___:___:___:___:___:___: productive

12. Time required for the new systems development

    unreasonable :___:___:___:___:___:___:___: reasonable

    acceptable   :___:___:___:___:___:___:___: unacceptable

13. Completeness of the output information

    sufficient   :___:___:___:___:___:___:___: insufficient

    adequate   :___:___:___:___:___:___:___: inadequate

14. DSS assisted in decision making process

    definite   :___:___:___:___:___:___:___: uncertain

    superior   :___:___:___:___:___:___:___: inferior

15. Is DSS easy to learn and use

    easy   :___:___:___:___:___:___:___: difficult

    fast   :___:___:___:___:___:___:___: slow

16. List the functions that are the most beneficial:

17. List the functions that are most needed:

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