San Fernando Valley State College

A GENERALIZED PRODUCT DECISION MODEL

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Science in Business Administration

by

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June, 1969
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Committee Chairman

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June, 1969
ACKNOWLEDGMENTS

I wish to thank Dr. Max Lupul and his staff for their outstanding support and advice.

I am also grateful to Mrs. Clarice Huffaker for her clerical contributions and tireless effort.

Finally, I am indebted to the members of my family: Marion, Suzanne, Cynthia, Fredrick, Jr., and Julia, for their understanding and many sacrifices during development and preparation of this thesis.
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ABSTRACT

A GENERALIZED PRODUCT DECISION MODEL

by

Fredrick Eugene Schulte

Master of Science in Business Administration

June, 1969

Nearly all functions of marketing are now supported by analytical models. Several large firms have developed such models and are currently using them as aids to making new-product decisions. These models are mostly in the descriptive form and simulate the actual environment, resources, and objectives of a particular firm. They are used chiefly as tools for the collection and processing of information, and are not particularly adapted to later decisions affecting changes in development and production. The problem, therefore, is the generalization of a decision model so that it may be used not only as an aid in the original selection of a new product effort but as a basis for guiding the continuation or discontinuation of this effort at any stage in the life cycle from idea conception to the final steps of commercialization.

The subject of this thesis is of special interest to the writer because of his varied engineering background. A large part of this background has been in the direct development of electromechanical products. Historically, engineers have been creative
individuals who have developed new concepts and products more out of the intrigue of the idea than out of the objective satisfaction of a known market need. This tendency is an inherent to the average engineer and scientist, and it is necessary that the feelings and attitudes of freedom continue. The writer contends that this important element of creative atmosphere can be present for the motivation of the engineer and still not conflict with the direction of an engineering project. This marriage of objective management and creative engineering can only be successful if good decisions are made along the way. The author therefore has elected to construct a decision model for general use in making product decisions. The model will be standardized such that it can be applied to a wide variety of situations by changes in factual inputs and by decision criteria. By exploring this avenue, the author hopes to improve the manager-engineer relationship by improving the quality of management decisions.

This thesis proposes a decision model of general nature suitable for combining both qualitative and quantitative factors into a rational sequence of decision steps. The design of this model is validated not by actual test in the market place but by logical analysis. In sample calculations, the model is applied to the decision alternatives available at each of the major phases of a product's life from conception of an idea to final obsolescence and dropping of a product. Accuracy of the model is not challenged but the inclusiveness of its features is tested. Proof is offered that
this generalized model adequately covers all phases of the product life cycle simply by providing for changes in inputs and decision criteria.
Chapter I

INTRODUCTION

Statement of Problem

Many different mathematical models are now used by companies as an aid to making product analyses and decisions. This study is undertaken because the author believes that these models can be satisfactorily represented by a single generalized model serving decisions at all phases of a product's life from conception of an idea to final termination of production.

One of the most notable works on product decisions is Edgar A. Pessamier's book *New Product Decisions*,\(^1\) In one of his final chapters Pessamier discusses his product decision concepts as they relate to decisions to market a product, to test-market a product, and to drop a product. His decision model, however, is segmented and does not present an overall flow and feedback process. Additionally, his model does not clearly use the "must" and "want" criteria\(^2\) which the author believes is mandatory to achieving efficient analysis and optimum decision results.


Statement of Hypothesis

A single product decision model may be developed which is of sufficient scope and construction to permit its direct use in analysis and decisions related to all phases of a product's life cycle from conception of an idea to the dropping of a product from production.

Definition of Special Terms

The terms appearing in the hypothesis are identified and defined as follows:

A product decision model is a logical representation of the real world decision process as it affects the direction of a company's product development and commercialization. The word single means that only one product decision model is needed for all major decisions independent of the maturity of the product.

Scope and construction refers to the boundaries and design features of the model. This model is intended to be of a control type, which means that it is descriptive (like the real world), predictive (future oriented), selective (facilitates selection from among alternatives), and controlling (senses results, compares with expectations, and applies correction). Control is based on feedback which becomes part of the inputs to the model prior to each successive use.

Analysis is a process by which an input is evaluated and con-

3Pessamier, op. cit., pp. 10-13
verted for use in the model. Evaluation consists of making value judgments and assumptions about the input; and conversion consists of expressing this evaluation in terms and dimensions used in the model. Evaluation and conversion occur simultaneously and produce a specification of the input that is suitable for direct testing against the decision criteria.

All phases of a product's life cycle include the following: ideation, patenting, designing, testing, introduction, growth, competition, obsolescence, and termination. The first four phases are related to product development, and the remainder are related to commercialization.

Method Used to Test Hypothesis

Logic is used to test this hypothesis. Decision models, and in particular the results of their predictions compared with actual outcomes, are considered proprietary by most firms and are generally unobtainable from industry. An attempt was made by the author to secure such information; however, the responses from six companies known to have activity in this area were insignificant and are not included in this report.

It is not possible, therefore, to test the complete validity of the model presented in this thesis, nor is it essential that this test be made for satisfaction of the hypothesis. Proof of such validity would probably require the execution of a detailed program
under very controlled conditions. Predictions of failure would also need to be verified by test, a costly and impractical exercise.

The hypothesis is tested by raising and answering the following questions for each phase of the product life cycle. Does the model satisfactorily account for investment, uncertainty, and risk characteristics which vary with each product life cycle phase? Does the model accommodate evaluation and conversion of its inputs into a form suitable for testing against the criteria? Does the model provide outputs suitable for comparison with one another and with the outputs of all other proposals? If the above questions can be answered in the affirmative, the hypothesis will have been tested and proven to be valid.

Preview of Text

The product life cycle is defined in Chapter II. The characteristics of investment, uncertainty and risk are discussed in detail as they relate to each of the development and commercialization phases.

Chapter III presents the basic model beginning with a description of the evaluation and decision processes, and with a decision tree based on the product life cycle. The basic model is then described, including its features, flow, and means for implementation. The important tasks of qualitative and quantitative evaluation are also identified and discussed.
A discussion of major decision criteria is given in Chapter IV. These include four categories: objectives, resources, environment, and preferences. The "must" and "want" characteristics of each criterion are discussed.

Chapter V covers the nature of the various inputs to the model. Ideas, patents, designs and products are presented as input proposals. Criteria changes and changes in the model structure are also described as inputs.

Chapter VI covers the outputs from the model. The primary outputs are the sell and hold alternatives which emerge at all points in the product life cycle.

The detailed model is presented in Chapter VII. This model embodies the principles of the basic model described in Chapter III. The decision tree is expanded so as to provide for both decision and chance events. This expansion uses forms for processing proposal inputs through the model to their major alternative outputs. The process then applies preference criteria and reverses direction to the present by identifying those decision tree branches that lead to the most desirable alternatives. The analysis and decision features of this process are described, including iterative usage of the model to update information and criteria. Qualitative and quantitative analyses, the investment/uncertainty/risk relationship, the must/want feature, and the margin concept are all discussed.

Sensitivity testing is discussed in Chapter VIII. Two approaches are covered. One is to measure how margin changes in
response to changes in particular inputs and criteria. The other
is to measure how much change in particular inputs and criteria can
be tolerated before margin is reduced to zero.

Chapter IX tests the hypothesis by summarizing the model
characteristics as presented in the text, clarifying these charac-
teristics by use of the sample calculations contained in the appen-
dix, and by developing answers to the questions raised above. The
author's conclusions are then stated.
Chapter II

THE PRODUCT LIFE CYCLE

With the approach used in this paper, the life cycle of a product may begin as early as its first conception, and may end as late as its final termination.

Product Life Cycle Phases

When a particular product proceeds from conception through development and commercialization, it experiences a sequence of distinct phases as follows:

1. Ideation - the creation, finding, developing and defining of a new product idea.

2. Patenting - the securing of exclusive (legal) use of a new product idea.

3. Designing - the conversion of a new product idea into drawings and procedures suitable for directing its manufacture.

4. Testing - the use and market testing to measure and, subsequently, improve product-market acceptability.

5. Introduction - the initial presentation of the product to its market.

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6. Growth - the adoption of the product by its market.
7. Competition - the introduction of products by competitors.
8. Obsolescence - the loss of product market to competitors or substitute products.
9. Termination - the phasing out and dropping of the product from the market.

Phases 1 through 4 are development phases, while 5 through 9 are commercialization phases. These sequential relationships are further clarified in Figure II-1, PRODUCT LIFE CYCLE.

Life Cycle Characteristics

All successfully commercialized products go through all phases of the life cycle, but not necessarily in the same firm. For example, a company might begin its part of the life cycle of a product with the purchase of a patent or license of a design. Or it might develop an idea into a design and then sell or lease that design to another firm that manufactures and sells the end product. A company's involvement in a product's life cycle may occur at any time, even in the middle of a phase. Recognition of phase characteristics is essential to predicting outcomes. Major characteristics which influence outcome predictions are uncertainty, investment, and risk.

Uncertainty exists because the future is unknown. It is determined by time and by the absence of facts. In early life cycle phases many of the eligible outcomes are not expected to occur for
Figure II-1.—PRODUCT LIFE CYCLE
several years. This long range nature, when combined with the absence of many relevant facts, makes it necessary to make many assumptions. When it is necessary to make a large number of significant assumptions, uncertainty increases.

Uncertainty deals only with the probability of a future event or outcome. It does not imply risk until also accompanied by investment. Obviously no risk can exist until something can be lost. The influence due to risk, therefore, is the influence due to uncertainty multiplied by the influence due to investment.

The relative influence of these characteristics as a function of life cycle phase is illustrated in Figure II-2, INFLUENCE OF CHARACTERISTICS ON OUTCOME PREDICTION. Uncertainty is shown to have great influence during the early life cycle phases and negligible influence in the last phases. Accumulated investment is shown to have a reversed trend with its influence being greatest at the end of the life cycle. These curves also show that risk has relatively low influence in the early and late phases, but reaches a maximum influence in the early commercialization phases. Risk is greatest where the uncertainty and investment curves cross.

The uncertainty/investment relationship is actually more complicated than depicted in Figure II-2. Various techniques are used to predict cost/volume/profit relationships in the presence of uncertainty. Jaedicke and Robichok, for example, treat these rela-

Figure II-2.—INFLUENCE OF CHARACTERISTICS ON OUTCOME PREDICTION
tionships as probability distributions.
Chapter III

A GENERALIZED DESCRIPTION OF THE MODEL

This chapter describes in model form the analysis and decision processes that are (or at least should be) followed by the typical manufacturing firm with respect to its new products. These processes and their relation to inputs and outputs are illustrated in Figure III-1, THE PRODUCT ANALYSIS AND DECISION PROCESS.

The illustration shows that input proposals undergo analysis, after which they are tested against input criteria in a decision process. This decision process results in the identification of output alternatives. The following definitions help to clarify these relationships:

An input proposal is an idea, patent, design, or product that the firm is exploiting, or that it has the opportunity to exploit.

Analysis is the evaluation of an input proposal and its conversion into a form suitable for direct comparison with input decision criteria.

An input decision criterion is a condition or standard that should be satisfied by a decision.

A decision is the actual testing of an analyzed input proposal against input criteria so as to identify acceptable and preferred output alternatives.
An output alternative is the final market or hold action that may be selected by the firm. Such action may be taken at any point in the product life cycle, but usually is taken at the end of any development or commercialization phase.

The analysis and decision processes, however, are the subject of this chapter. The input, output and criteria relationships are also discussed, but more detailed descriptions are given in subsequent chapters.

Decision Tree

As a preliminary step to understanding the analysis and decision processes, it is important to trace the evolution of ideas into products. This process is described in terms of its major tasks and decision alternatives, a diagrammatic representation of which is shown in Figure III-2, DECISION TREE. Many detailed alternatives have been purposefully omitted from the diagram to simplify explanation. In addition, the testing phase of the life cycle is included in the designing phase and does not appear separately.

The decision tree shows how an idea may progress through all the life cycle phases of development, patenting, designing, manufacturing and marketing. The tree illustrates the large number of revenue yielding alternatives that should be evaluated before making a decision with respect to any proposed idea. These may be summarized: market idea, market patent, market design, and market
Figure III-2.—DECISION TREE
product. Additionally, the tree recognizes that it is possible for an idea to progress in the life cycle to where further action is curtailed, and it is not marketed. These alternatives may be summarized: hold idea, hold patent, hold design, and hold product.

The Basic Decision Model

From observation of the decision tree, it is possible to construct a normative or prescriptive model¹ that depicts the decision process. A description of this model is given in Figure III-3, DECISION MODEL - BASIC DIAGRAM. This diagram follows the tree closely. It accepts only proposed inputs that are ideas; and it assumes that the input idea is defined sufficiently to be tested directly against the criteria established at each decision block without further evaluation and conversion. The "hold idea" task provides for reappraisal at a later time. After an established time delay, during which the idea and/or decision criteria may have changed, the idea is resubmitted to the model. The "hold patent" and "hold design" tasks feed back to the input in the same manner because these tasks are output alternatives of the input proposal which is still in the idea phase. The diagram also assumes that only one alternative needs to emerge from the maze of YES and NO decisions, and that there is no need to identify and grade the merits of any other output alternative.

Figure III-3. --DECISION MODEL - BASIC DIAGRAM
The final model as presented in Chapter VII, therefore, employs an iterative process that accepts inputs from all phases of the product life cycle, goes down every path to identify the acceptable alternatives, and produces a value statement for each of these output alternatives.

Returning to the basic diagram and examining the many decision blocks, it is evident that before proceeding down any particular branch an estimate should be made of the outcome of each remaining branch. The process of making these estimates is called analysis.

**Analysis**

As previously defined in this chapter, analysis is the evaluation of an input proposal and its conversion into a form suitable for direct comparison with input decision criteria. In response to such analysis, input proposals acquire definitions that are constructed from both qualitative and quantitative factors. Qualitative factors are definitions and value judgments of feasibility, worth, probable means of exploitation, and so forth. Quantitative factors are numerical calculations of important economic considerations such as expected investment, expected earnings, risk, and life cycle time. Recognizing these distinctions, it is also evident that qualitative factors are generally easier to acquire and manipulate. Analysis may, therefore, be divided into separate qualitative and quantitative parts.
Qualitative Analysis

Qualitative analysis formally requires the judgment of the best available sources (usually officers of the firm and consultants) concerning:

1. Feasibility of an idea.
2. Salability of the idea.
3. Patentability of the idea.
4. Salability of the patent.
5. Design capability of the company.
6. Salability of the design.
7. Manufacturing capability of the company.
8. Demand for the product.
9. Risk of product competition.\(^2\)
10. Economic life of the product.
11. Profit potential of the product.

Qualitative analysis also secures recommendations of how far to proceed in the product life cycle, what method to use in obtaining final revenue, and with what priority the project should be conducted.

Qualitative analysis is easily achieved through use of forms such as those shown in Figure III-4, QUALITATIVE ANALYSIS - CHECK LIST. Company procedures controlling its use are essential.

\(^2\)This is the maximum expected loss after consideration of competition and product substitutes. Summa, Chap. ii, p. 10.
QUALITATIVE ANALYSIS - CHECK LIST

PROPOSAL NO. ___________________________________  PROPOSAL MANAGER

PROPOSAL IS AN IDEA □ PATENT □ DESIGN □ PRODUCT(S) □

DESCRIPTION OF PROPOSAL:

NAME THE PRODUCT(S) OR POTENTIAL PRODUCT(S):

IS THE PROPOSAL COMPATIBLE WITH COMPANY OBJECTIVES? ______

IS THE PROPOSAL COMPATIBLE WITH COMPANY RESOURCES? ______

IS THE PROPOSAL COMPATIBLE WITH COMPANY PREFERENCES? ______

IS THE PROPOSAL COMPATIBLE WITH COMPANY ENVIRONMENT? ______

EXPLAIN ALL "NO" ANSWERS TO THE ABOVE QUESTIONS:

JUDGMENT SUMMARY OF FEASIBILITY AND MARKETABILITY:

<table>
<thead>
<tr>
<th>Feasibility of the Idea</th>
<th>Excellent</th>
<th>Av.</th>
<th>Very Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salability of the Idea</td>
<td>Excellent</td>
<td>Av.</td>
<td>Very Poor</td>
</tr>
<tr>
<td>Patentability of the Idea</td>
<td>Excellent</td>
<td>Av.</td>
<td>Very Poor</td>
</tr>
<tr>
<td>Salability of the Patent</td>
<td>Excellent</td>
<td>Av.</td>
<td>Very Poor</td>
</tr>
<tr>
<td>Design Ability of the Company</td>
<td>Very Suitable</td>
<td>Av.</td>
<td>Unsuitable</td>
</tr>
<tr>
<td>Salability of the Design</td>
<td>Excellent</td>
<td>Av.</td>
<td>Very Poor</td>
</tr>
<tr>
<td>Manufacturing Ability of Company</td>
<td>Very Suitable</td>
<td>Av.</td>
<td>Unsuitable</td>
</tr>
<tr>
<td>Demand for the Product</td>
<td>Very High</td>
<td>Av.</td>
<td>Very Low</td>
</tr>
<tr>
<td>Risk of Product Competition</td>
<td>Very High</td>
<td>Av.</td>
<td>Very Low</td>
</tr>
<tr>
<td>Economic Life of the Product</td>
<td>Very Long</td>
<td>Av.</td>
<td>Very Short</td>
</tr>
<tr>
<td>Profit Potential of the Product</td>
<td>Very High</td>
<td>Av.</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

RECOMMENDATIONS:

PROCEED IN THE LIFE CYCLE THROUGH THE __________ PHASE.

MARKET THE: IDEA □ PATENT □ DESIGN □ PRODUCT(S) □

MARKETING APPROACH: SELL □ LEASE □

PROCEED WITH PRIORITY: HIGH □ MEDIUM □ LOW □

BY: _______________________________  DATE: __________________

Figure III-4
Quantitative Analysis

Quantitative analysis formally acquires and processes economic data, conditions, and estimates into statements of profitability. It does this by treating each input proposal as a project and calculating the investment requirements and expected earnings for each of its output alternatives. The basic method, including a means for handling risk, cost of capital, and economic life, is described as follows:

Investment requirements are evaluated for each individual phase by use of a form as shown in Figure III-5, INVESTMENT ANALYSIS. Suppose a particular phase (for example PATENT) is scheduled for the first and second quarters. The patent phase is identified by placing an "x" in the box after "PATENT." The numbers "1" and "2" in the first column, titled "Quarter of Expected Investment," identify the first and second quarters, respectively. The estimated patent costs during each quarter are then entered in the second column, titled "Expected Investment." Next, it is necessary to correct these future expenses for the present value. The opportunity cost of capital for the firm is usually used as a discount rate for the purposes of time adjusting future expenses. This is accomplished by using present value tables to convert the discount rate into

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4Ibid., p. 603
discount factors that correspond with each time period. These are entered into the "Discount Factor" column. The last column, titled "Discounted Expected Investment," contains the result of multiplying the expected investment for each month by its discount factor. The sum of these values is the total time-corrected investment for that phase.

A table of present values suitable for converting a quarterly discount rate into a discount factor as a function of time is shown in Figure III-6, PRESENT VALUE TABLE.

Expected earnings are evaluated for each major marketing alternative by use of a form similar to that shown in Figure III-7, EARNINGS ANALYSIS. The form is used in evaluating the earnings expected from marketing an idea, patent, design, or product.

When earnings are derived from the lease of an idea, patent, or design, or from the sale of a product, analysis is performed in the same manner as investment. Revenue under this marketing situation is received over a period of time much like expenses are incurred.

When earnings are derived from the outright sale of an idea, patent, or design, analysis is performed in a different manner. The assumption here is that the sale will be a single transaction for a fixed sum payable on a given date. The price and date are uncertain, but it is possible to combine the two into a distributive definition of price at a defined earnings date. This method is used in Chapter VII.
Not only are earnings less controllable than investments, but their greater reach into the future introduces added uncertainty. This source of risk is recognized by Pessender and is handled as an added discount rate for the purpose of degrading expected results as a function of time.

Discount rate is influenced by the nature of outcome being investigated. For example, an idea is expected to yield a given return with greater certainty if the idea is also patented. The discount rate is also influenced by the amount of information available at the time of decision. Discount rate should be adjusted whenever new and significant information is accumulated. Techniques are available for directing search activity to obtain additional information.6

Final analysis is made by use of a form such as that shown in Figure III-8, ANALYSIS OF DECISION ALTERNATIVES. This form tabulates the results of the investment and earnings analyses as they apply to each major alternative. For any given alternative, the discounted net cash flow is calculated by subtracting from its discounted expected earnings the sum of all discounted expected investments required to reach that alternative. When the result is negative, the alternative fails to cover the firm's opportunity cost of capital. When the result is positive, the firm's standards


6Ibid., pp. 119-40
(depending on criteria) are met, and the alternative is permitted to compete with other alternatives for adoption.

As an additional aid to comparing alternatives, various methods can be used to reduce the discounted net cash flow of an alternative to some common basis of return on investment. One of these methods is accommodated in Figure III-8 as follows: The economic life, which is the time from start of the project to date that earnings cease, is recorded first. The discounted net cash flow per year is then calculated as an approximate means of annualizing projects that have different economic lives. Next the discounted net cash flow per year is divided by the discounted expected investment. This final value shows the sensitivity of net cash flow to invested dollar after having covered the opportunity cost of the invested capital.

Preliminary and Detailed Decisions

In consideration of the two types of analysis just described, the author proposes to take advantage of the simplicity of the qualitative analysis by using it to decide if an idea is worth developing. The cost of idea development is usually very small compared with the investment requirements of later phases. Therefore, little risk is incurred when making this preliminary decision in the absence of a quantitative analysis.

Idea development results in an improved definition of an idea
and in a more complete realization of its potential applications. Once its definition is sufficient to warrant more sizable expenditures, a detailed decision based on both qualitative and quantitative analysis is practical.

The distinction between preliminary and detailed processes is fundamental to the generalized model presented in Chapter VII. Before proceeding with this generalized model, however, a more detailed discussion of criteria, inputs, and outputs is presented in Chapters IV, V, and VI, respectively.
Chapter IV

DECISION CRITERIA

This chapter describes four major categories of criteria used in product decisions. Two additional characteristics are defined: the qualitative and quantitative forms, and the "must" and "want" conditions.

Definition

A criterion is "a standard by which a correct judgment can be made." \(^1\) A decision usually depends on many criteria, some of which are important.

The criteria used in making product decisions are influenced by the product life cycle phase. A major decision is required at each branching of the decision tree, and each decision must be conditioned by the expected outcome of all subsequent decisions and alternatives. The criteria are therefore more complex for decision points early on the tree, since application is required along more decision branches and over longer time spans.

Four Categories

A firm should develop and maintain a product policy that can

achieve satisfaction of its long and short term objectives. Further, it should seek those objectives through the optimum utilization of its resources and within its expected environment.

Product policy finds its expression in the criteria that govern product decisions. These criteria may be divided into four major categories, each of which is essential: objectives, resources, preferences, and environment.²

Objectives are specifications of what the firm wants to achieve, to what extent, by when, and by what means.

Objectives are stated in the formal sense as a list of specific profit and technological goals. Most objectives define areas for concentration of effort. Some objectives define constraints, such as maximum time to breakeven, minimum profit, and maximum investment.

Objectives are implemented through planning. The product planning period should cover the time over which events and decisions may influence a specified operating period. If the operating period is one year, for example, the planning period might need to be five or ten years. The firm's objectives, therefore, must span or even exceed this planning period, resulting in the need for generalization and flexibility.

In viewing this dependency on long range planning, product development should be made part of the master plan of the firm. By

proper integration into a centralized plan, compatibility and effectiveness are achieved.

Resources are the essential constituents and means for producing products and services. The resources of a firm are its accumulated or readily available assets in the form of plant, equipment, technical know-how, men, and money.

Resources are readily adaptable and should be developed for future planning periods. Resources are better allocated for future activity if they are entered into planning in their functional forms. These functions are management, engineering, manufacturing, marketing, and finance.

Management must be flexible, reflect the organization pattern, and be economical. Management must maintain direction and control over the firm, and maintain a management policy and organization that is compatible with the firm’s objectives. It does this through a vast array of interrelated decisions, most of which are product related.

Engineering must be especially creative and readily adaptive to the firm’s objectives and needs. All product decisions rely on some level of technical capability and support. The engineering function is usually applied through a network of policies, procedures, budgets, and schedules.

Manufacturing must be capable of producing its output in demanded quantity, at a specified quality and at minimum cost. Manufacturing can be effective only through its planning and control
functions. Planning determines the need and timing for changes to product, tooling, facilities, and manpower. Predictions are also made of the required know-how, those techniques which must be learned through experience. Control provides the necessary assurance that delivery, quality, and cost objectives will be met. All product decisions depend on the firm's manufacturing capability during commercialization phases.

Marketing as a resource of the firm must not be confused with marketing environment. The firm has control over many market-related functions, the most important of which probably is product development. The other major controllables are pricing, selection and development of market channels, and production promotion (personal selling and advertising), all of which directly influence product decisions.

Finance must be adequate in both size and composition to meet the overall demands of the firm. To insure compatibility between product decision and the firm's financial resources, engineering, manufacturing, and marketing budgets must be projected. Financial standards are then established to provide visibility and control over relevant capital investments, variable burden expenses, general and administrative expenses, plant and equipment expenses, and cash requirements.

Each product decision influences and depends on future resource allocations. Resources, therefore, must change by being added, dropped, and developed. Any directed change or shift in a
firm's product intentions must be coordinated with the direction provided to its resources.

Preferences are the partialities, allegiances, discriminations, and attitudes that influence decisions. Preferences are often subtle and not defined or formally implemented, but they play an important role. They are manifested in individuals and are present whenever these individuals are making decisions. Companies reflect the preferences of their leaders.

Preferences are qualitative in nature, and as decision criteria, they are most often found among the objective and resource categories. One very important preference, however, is included in this model as a quantitative factor. This preference is risk attitude: the attitude that the firm has toward the possible loss of money. It is explained as follows:

As the required investment for a proposed project approaches the capitalization of the firm, the firm becomes reluctant to undertake the project. In effect, it does not want to "put all its eggs into one basket." It has a strong bias against large ventures, even though the expected return on the investment may be high. This preference for smaller ventures has been labeled risk attitude, and may be determined through iterative questioning of the firm's top

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management and its decision makers. The risk attitude derived by this means may be expressed as shown in Figure IV-1, PREFERENCE CURVE FOR THE RISK ATTITUDE OF A COMPANY. This curve shows the relationship between preference (measured in units from 0 to 1) and asset value (measured in dollars from 0 to a sum large enough to span the highest expected asset value that can result from the venture). All points on the curve represent conditions of indifference. For example, at an asset value of $100,000, the preference is .7, and this means that it does not matter to the company if it has an asset position of $100,000 for certain, or if it has a .7 probability of acquiring an asset position of $360,000 with a .3 probability that it may also be $0.

A given curve is valid only for a specific firm and over a specific range of discounted asset values. A company may have several curves to cover different ranges, but their shapes will be characteristic of the company's attitude toward risk. For example: The concave downward curve of Figure IV-1 denotes an attitude of risk aversion; a straight line denotes indifference to the amount of money involved; and a concave upward curve is representative of the attitude of a long-shot gambler.

Procedural incorporation of the preference curve is defined in Chapter VII and illustrated in the Appendix.

Environment is the medium within which a firm operates. It is everything outside the firm that in some way influences its operation. This environment consists of demand, competition, market
Figure IV-1. -- PREFERENCE CURVE FOR THE RISK ATTITUDE OF A COMPANY

ASSET VALUE CONDITIONS:
Present (Beginning) Value of Venture = $100,000
Maximum Expected Discounted Loss = $100,000
Maximum Expected Discounted Gain = $260,000
nature, market size, market location, and the law. It is viewed by
the firm as relatively uncontrollable, contrasting greatly with the
controllable nature of its resources.

Demand\(^5\) is the firm's sales volume potential under given
marketing practices.

Competition is the difference between the total market poten-
tial and the firm's sales volume potential. The share-of-market
concept is based on this influence of competition.

Market nature, size, and location all influence the efficiency
with which goods can flow from the firm to its ultimate users. This
efficiency depends on the number of distribution points (wholesaler,
retailer, and so forth), the geographic concentration of buyers, and
the accepted practices for shipping, storing, and transfer of owner-
ship. The nature of this distribution system can have a large
effect on marketing costs, and, with some goods, a deterministic
effect on the overall ability to compete.

The law encourages and discourages various marketing prac-
tices. Public policy has a strong influence. The legal environment
must be anticipated so that changing interest rates, price setting
and relaxing, profit regulation, product regulation, and tax legis-
lation are included in product decision considerations.

"Musts" and "Wants"

A decision process employing qualitative and quantitative

\(^5\)Howard, op. cit., p. 6.
analyses of input proposals also uses corresponding decision criteria that are expressed in qualitative and quantitative form. Each of the four criterion categories, therefore, is divided into qualitative and quantitative forms, and each of these is further specified in terms of "musts" and "wants". 6

"Musts" are mandatory conditions that have finite acceptance limits and are measured on a GO/NO GO basis. "Wants" are preferred conditions that add value beyond the GO limits and are measured in relative terms by grading.

In summary, there are four categories with two forms for each category and two conditions for each form. A two-cycle process is presented in the model of Chapter VII that covers these combinations for each decision point.

Chapter V

INPUTS TO THE MODEL

As previously defined for this model, an input proposal is an idea, a patent, a design, or a product. This chapter discusses the nature of each of these input forms and the manner in which each is presented to the model. Special attention is given to risk and risk reduction. Criteria changes are discussed as inputs to the model, and revisions of the model itself are also viewed as inputs.

New Product Ideas

An idea is an "... impression, notion, brain storm, inspiration, concept, conception, thought, abstraction, abstract idea, obsession, idée fixe (F.), theory, surmise, sally, archetype, prenotion, preconception, stereotype, idiote (Philos.)..."1 In this thesis a new idea is considered an idea that has been conceived for the first time within the knowledge of all to whom it has been conveyed. Further, a new product idea is a new idea that can be embodied within a product.

An idea is the result of creative thinking. It occurs spontaneously and often when least expected. It is a discovery. But

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the scope and rate of this discovery can be developed.

Three methods or thought processes constitute this phase of the product life cycle. The first is known as direct creation, which is best described as simple discovery. The second is synthesis, which consists of creating a new arrangement (building up) from already known elements. Sometimes the new arrangement contains one or more elements which are new in themselves, having evolved from the direct creating process. The third method is catalysis, which consists of creating offspring by branching (breaking down) a known element into new elements.

Hullfish and Smith, when describing the education process, state that: "The situation appears to exhibit the components or phases of reflective activity: ... 1. The presence (and recognition) of a problem situation ... 2. Clarification of the problem ... 3. Hypothesis formed, tested and modified ... 4. Action taken on the basis of the best-supported hypothesis ...

Ideation, therefore, takes on the form of defining a problem and solving it, a process that usually spreads beyond the original problem because the solution often proves to be a solution for other unrelated problems.

What are the sources for new product ideas? The average

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manufacturing firm views these ideas as coming from both internal and external sources.

Internal sources for ideas include all employees of the firm. The most significant contributions are usually made by members of the engineering department, but a good firm also provides a policy and an environment conducive to creativity and disclosure by all of its personnel.

Various incentives are used by companies to encourage the disclosure of new product ideas. Some of these incentives provide payment of fixed sums at the time of disclosure and/or time of patent application. Others provide payment of sums that are scaled to the earnings derived from the idea. The latter are almost impossible to implement in a manufacturing firm because ideas normally find their way into products and product lines where accounting procedures prevent accurate determination of the idea's contribution to earnings. Incentives that are scaled to earnings are more easily implemented by engineering firms, however, because ideas and designs containing the ideas are ultimately sold for a price. Incentives that are scaled to earnings are generally preferred by the average inventor.

Many legal problems are avoided when a company decides on the product or product improvements it wants and develops them entirely within its own organization. Risk is minimized by maintaining a policy conducive to the ownership and control of proprietary information. This policy is implemented through personnel agree-
ments and training. Agreements are contractual conditions of em-
ployment which require the disclosure and assignment of inventions
to the employer. Training consists of orientation in recognizing
and securing proprietary information.

The formal procedures of most firms include means for sub-
mitting ideas through the use of a disclosure form. The inventor
completes a form similar to that shown in Figure V-1, INVENTION
DISCLOSURE, and submits it to management.

External sources for ideas are best categorized as solicited
and unsolicited.

Solicited external sources are of three types. The first
consists of individual consultants and consulting firms who provide
specialized services. The second consists of actual or potential
competitors who possess a needed technology without which it would
not be possible to produce competitively. The third consists of
individuals and groups from the general public who are invited,
through advertisement and contests, to submit ideas.

Unsolicited external sources are individuals and groups from
the general public and consulting firms who voluntarily submit their
ideas.

It is often more practical to have others find and develop
a product, provided competent legal counsel, good contracting, and
tight company security are maintained. Contracts with private con-
sultants must define clearly such items as: scope of work to be
performed, amount of payment, terms of payment, ownership of work
INVENTION DISCLOSURE

PROGRAM NO. __________________

DATE __________________

1. Object of the invention (one sentence)  ____________________________

2. Prior art (one paragraph)  ____________________________

3. Description of invention (sketches and numbers)  ____________________________

4. Advantages over prior art (one paragraph)  ____________________________

5. When was idea first conceived? (date) __________________

6. When was idea first recorded? (date) __________________ (attach records)

7. When was idea first discussed? (date) __________________

    With whom? (name)  ____________________________

8. When was idea first sketched? (date) __________________ (attach)

9. How has idea been reduced to practice? (sentence)  ____________________________

Inventor(s):  ____________________________ Read and Understood by:  ____________________________ Date(s):  ____________________________

                                      ____________________________

                                      ____________________________

                                      ____________________________

                                      ____________________________

                                      ____________________________

Figure V-1.
output, prevention of disclosure without permission, and detailed schedule items such as formal reviews, reports, and records. Contracts with actual or potential competitors should have provisions that limit competitive make and sell of the same and similar products. Such provisions must be constructed with good legal advice so as to avoid infringement of antitrust laws.

Ideas from the general public, under both the solicited and unsolicited conditions, present the constant risk of an implied obligation. Legal suits can result when the same idea is proposed by two or more sources, and when a proposed idea is already under development by the firm. Whenever a judgment is levied against a firm, implied obligation carries with it a "fair price" set by the courts. Unfortunately, this "fair price" does not always correspond with the value placed upon it by the firm. There is also risk of a "confidential relationship" being established in court, that can prevent use of an idea even when it is unpatentable and known to many. To reduce these risks one of the following policies should be established.

1. Set a policy to not accept outside ideas. In the case of unsolicited ideas, this means that the firm avoids all handling, and returns the idea to the submitter.

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4 Ibid., p. 10.
2. Set a policy to accept outside ideas. This requires special handling and a very limited circulation for evaluation. The firm then acquires and maintains proof that no confidential relationship has existed at any time; and proof that the release for internal evaluation was made only after a written agreement was signed by the submitter that limits the firm's obligations.

**Patents**

A patent is an exclusive right given to its owner by the United States Patent Office to make, use, and sell a new and useful device, process, or composition of matter, or improvement thereof for a period of seventeen years.

A patent is, therefore, a most effective means for reducing risk to its owner. In the same way, it poses a serious constraint on the owner's competition. The purpose of a patent, as viewed by the firm, is to minimize risk by using its rights to:

1. Protect a product or product line.
2. Reduce competitive activity.
3. Reduce possibility of infringements.
4. Provide income—at the expense of the competition.

In spite of the high costs related to the application for, and maintenance and enforcement of patents, many firms have large active patent departments. These departments act within allotted budgets to develop a patent structure suited to the firm. Decisions in this area are complex because patents not only cover particular
ideas, but they also have a variety of characteristics. Patents may be:

1. Broad or limited in scope.
2. Suited to offensive or defensive use.
3. Suited to conditions of make, have made, sell, lease, use, maintenance (service), tooling, or method.
4. Suited to use by customers, competitors, or subpurchasers.
5. Suited to non-exclusive or exclusive licensing.
6. Suited to cross licensing.
7. Strong or weak and of questionable validity.
8. Related to other basic, improvement, or accessory patents.

With the above characteristics in focus, it is possible to envision two major counter-strategies to avoid patent infringement. One is to obtain a legal order that forces the granting of a license under favorable conditions. The other is to alter the design so as to avoid use of the patented idea. The "designing around" approach is very common. Unfortunately, the recognition of infringement is often too late to avoid conflict, and even after making design changes, adjustment must be made to the owner of the patent—often at very high cost. By holding patents related to its products, a firm reduces risk of infringement and of revenue loss due to competition.

**Design**

A design is the definition and plan of a product. It consists
of drawings and specifications that define the configuration and performance requirements of an intended or existing product. It is established as a result of product development effort.

According to Pessemier, development is the "transformation of a new product proposal into a tangible product or process." In his book, he classifies development as the fourth of six steps:

1. Search.
2. Preliminary analysis.
3. Formal analysis.
4. Development.
5. Product testing.

Although these steps resemble the phases of the product life cycle, they are, in fact, the major tasks essential to conducting a good product program. They emphasize the need for analysis before development, and they help explain the true meaning of design.

Development effort on a design is not always performed by the firm. Designs originate from both internal and external sources in the same manner as new product ideas. The same risks and precautionary measures apply. However, designs are better defined and usually reach the commercialization phases sooner than ideas. The amount of risk, therefore, is generally less.

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Products

A product is a tangible commodity finally produced according to the dictates of the design. A product is the result of manufacturing effort.

Manufacturing requires the use of resources from both internal and external sources. The make-or-buy function of most material departments is a good example of this inside and outside activity.

The success of a product is usually predicted with higher confidence than that of its predecessors (i.e., designs and ideas). Products, therefore, constitute risk by virtue of their required investment.

Input Proposals

Ideas, patents, designs, and products are defined and discussed above. Each of these is a state of being for the product. Each is capable of input to a product decision model because each is a unique representation of a product.

Each input proposal is made up of everything known about it. Therefore, a patent includes its ideas; a design includes its ideas and patents; and a product includes its design, ideas, and patents.

Each input proposal is affected by the nature of its source. When an input proposal is from an external source, it has a price, and, therefore, it is a cost relevant to the decision. When an input proposal is from an internal source, it has already experienced
costs. These costs, however, are not relevant to the decision because they have already been experienced.

Criteria Changes

As consumers, we live in a world of changing needs, wants, technology, and abilities. The problem of change and the dire need for an adaptive managerial policy are obvious.

Howard⁶ expresses this management function as follows: "The means usually available to a marketing executive in his task of creatively adjusting to a dynamic environment are product variation, marketing channels, price, and promotion (advertising and personal selling)." To properly adjust to change, the firm must be willing to change its decisions, procedures, policies, and even its objectives on an almost continuous basis. Product decision criteria, therefore, are not treated as fixed characteristics of the model, but as separate inputs. In this way, objectives, resources, preferences, and environments are readily maintained without changes to the model proper.

Model Changes

The model presented in this paper is designed to accept product proposals and decision criteria as inputs. The analysis and decision processes are contained within the model. The outputs are

the identification and relative grading of acceptable alternative actions.

As a model is used, deficiencies are discovered and corrected, simplifications are made, methods are changed, and improvements are implemented. In effect, these changes constitute a continuing development of the model. These changes are best made at time intervals so that affected inventories of input proposals may be reprocessed through the modified model.

When a model change is large, the new model should be used along with the old until it is thoroughly debugged. After sufficient confidence has been secured, the old model can then be terminated.
Chapter VI

OUTPUTS FROM THE MODEL

As previously defined, an output alternative is the final "market" or "hold" action that may be selected by the firm. This chapter discusses the nature of these two actions for each major product life cycle phase.

The diagram presented in Figure III-2, DECISION TREE identifies them as:

Market Idea
Hold Idea
Market Patent
Hold Patent
Market Design
Hold Design
Market Product
Hold Product

Each of these is described in the following text.

Outputs That Are Ideas

Ideas are marketable by selling or leasing. However, these alternatives are rarely adopted for several reasons. First, an idea is not legally supported for exclusive use. Second, the value of an idea is curtailed whenever it is used in a product that is self-
disclosing of the idea. Third, an idea is vulnerable to adoption by the competition unless rigid controls are maintained over security.

Because of their relatively poor marketability, ideas that have value are seldom sold or leased. They either proceed on to later life cycle phases or are placed on hold.

A hold is a state of doing nothing. A hold is used to defer action. It is used for a specific period of time, or until some specific condition is satisfied. Upon termination of a hold, the idea is dropped, continued in the life cycle process, or marketed.

When all alternatives reach a hold status and their specified periods of time lapse into drop recommendations, the input proposal is omitted from the inventory.

**Outputs That Are Patents**

Patents are marketable by selling or leasing, but, unlike ideas, are more negotiable. The value of a patent is enhanced by the protection from competition it offers.

Patents that are not marketed are held in inventory. Such a hold alternative is executed when the firm wants to proceed internally in the life cycle at a later date, when it wants to market the patent and is not successful, or when it wants to market the patent at a later date.
Outputs That Are Designs

Designs are marketable by selling or leasing. In either case, they may or may not be based on ideas that are patented. When designs are not supported by patents, they generally have less marketability, and there is usually greater risk of early competition.

Designs are also held in inventory. Such a hold alternative is executed when the firm wants to proceed with manufacturing at a later date, when it wants to market the design at a later date, or when it wants to market the design but has been unable to complete the intended sale or lease.

Outputs That Are Products

Products are marketable by selling. Products are also marketable by leasing, but since leasing is much less prevalent, provision is not made for this alternative in this model.

All products are based on ideas and are defined by their designs. They are manufactured and marketed during their commercialization phases.

When a product is not marketed, it is placed in a hold status. Such a hold means that the firm no longer endorses sale of the product. The firm might terminate selling, terminate manufacturing but sell existing product inventories, maintain manufacturing and selling but terminate promotion, and so forth. A hold can occur at any time during commercialization, and it may be temporary or permanent with
respect to time.

Output Alternatives

The market and hold alternatives for each of the idea, patent, design, and product outputs are identified and graded by the decision model.

After processing an input proposal, only part of these outputs emerge from the model as acceptable alternatives. The outputs that emerge as acceptable are also graded according to their relative value. The model presented in Chapter VII achieves this result through a two-cycle operation. The first cycle identifies the alternatives that satisfy the "must" criteria. The second cycle identifies how well each of the surviving first cycle alternatives satisfies the "want" criteria.

Once the output alternatives are identified and graded for an input proposal, they are catalogued with the output alternatives from other proposals. The library formed by this approach provides a much broader base from which to select alternatives. This library consists of an orderly array of proposals covering new product opportunities as well as existing programs, where each has been evaluated, tested against relevant criteria, and reduced to a common comparable form for decision.
Chapter VII

THE PROPOSED GENERALIZED MODEL

The basic decision model presented in Chapter III describes the process by which product decisions are made. The basic model, however, accepts only proposed inputs that are ideas; and it assumes that the input idea is defined such that it needs no further analysis and is tested directly against the criteria established at each decision point. A further limitation of the basic model is that it identifies only one output alternative as acceptable or unacceptable. These deficiencies are remedied in the Generalized Model that follows.

The Generalized Decision Model

It is possible to expand Figure III-3, DECISION MODEL - BASIC DIAGRAM so as to accommodate the four types of proposal inputs, the two types of analyses, the four categories of criteria, and a larger number of outputs.

A block diagram of the Generalized Model is presented in Figure VII-1, DECISION MODEL - GENERAL DIAGRAM. This diagram includes qualitative and quantitative analyses, and accepts idea, patent, design, and product inputs.

The flow of a proposal is traced through the model as follows:

1. The proposal input enters and is subjected to qualitative
Figure VII-1. -- DECISION MODEL -- GENERAL DIAGRAM
analysis.

2. A decision is made to develop, drop, or hold the proposal.

3. If the decision is made to develop, the proposal is subjected to development, after which decisions are made to repeat qualitative analysis (because the proposal has been improved, expanded, or redefined), proceed with quantitative analysis, or drop or hold the proposal.

4. If the decision is made to repeat qualitative analysis, steps 1, 2, and 3 are repeated.

5. If the decision is made to proceed with quantitative analysis, the proposal is subjected to quantitative analysis, after which decisions are made to market, drop, or hold the proposal.

6. If the decision is made to market the proposal, the marketing alternatives are identified, and the proposal output that results is a complete listing of the expected outcome and relative preference for each acceptable output alternative. The dashed line represents the option of resubmitting the proposal to the model if desired by the firm's management.

7. If a decision is made to drop the proposal at any time, a proposal output results, and the proposal is no longer in the system.

8. If the proposal is subjected to a hold at any time, criteria are also set for its release. When these criteria are satisfied, the hold is released, and the proposal reenters the model.
The model provides for separate performance of the qualitative and quantitative analyses. It takes advantage of their different characteristics as described in Chapter III, and places them in tandem with proposal outputs positioned after each. Although the model operates in many modes, two principle modes (or cycles) are used. These are the preliminary cycle and the detailed cycle.

The Preliminary Cycle

The preliminary cycle is shown in detail in Figure VII-2, DECISION MODEL - PRELIMINARY CYCLE. As in the general diagram of Figure VII-1, the first required task is qualitative analysis. This is followed by decisions that answer the question, "Develop proposal?", the task, "Develop", and a decision that answers the question, "Repeat qualitative analysis?".

Qualitative analysis is expanded from that introduced in Chapter III. The major qualities identified in Figure III-4 are embodied in a new form, Figure VII-3, QUALITATIVE ANALYSIS - QUESTIONNAIRE, that is used to acquire conversions and evaluations from individuals who represent the knowledge and thinking of the company. In most companies, such a questionnaire is completed by each member of a product steering committee. The example given in the Appendix obtains appraisals from the President, the Controller, the Director of Marketing, the Director of Research and Development, and the Director of Manufacturing. In larger companies, the committee is composed of delegates representing these major organizational departments.
Figure VII-2. DECISION MODEL - PRELIMINARY CYCLE
QUALITATIVE ANALYSIS - QUESTIONNAIRE

COMPLETED BY: _______________________________ PROPOSAL NO: ______

POSITION: _______________________________ DATE: ____________

PROPOSAL IS AN IDEA ☐ PATENT ☐ DESIGN ☐ PRODUCT(S) ☐
DESCRIPTION OF PROPOSAL:

NAME THE PRODUCT(S) OR POTENTIAL PRODUCT(S):

- IF THE PROPOSAL IS AN IDEA - BEGIN HERE.
  1. TECHNICAL FEASIBILITY OF IDEA: Exceptional Av. Not Feasible
     CHECK IF UNKNOWN ☐
  2. MARKETABILITY OF IDEA: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐
  3. PATENTABILITY OF IDEA: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐

- IF THE PROPOSAL IS AN IDEA - ASSUME IT HAS BEEN PATENTED AND
  CONTINUE. IF PROPOSAL IS A PATENT - BEGIN HERE.
  4. MARKETABILITY OF PATENT: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐
  5. DESIGN ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED
     ENGINEERING RESOURCES) Exceptional Av. Nonexistent
     CHECK IF UNKNOWN ☐

- IF THE PROPOSAL IS AN IDEA OR PATENT - ASSUME IT HAS BEEN
  CONVERTED INTO A DESIGN AND CONTINUE. IF PROPOSAL IS A DESIGN
  BEGIN HERE.
  6. MARKETABILITY OF DESIGN: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐
  7. PRODUCT OBJECTIVES OF COMPANY: Satisfied Av. Not Satisfied
     CHECK IF UNKNOWN ☐
  8. COMMERCIALIZATION ABILITY OF COMPANY: (CONSIDER EXISTING AND
     PLANNED)
     A. MANUFACTURING RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
     B. MARKETING RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
     C. MANAGEMENT RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
     D. FINANCIAL RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐

Figure VII-3.
9. COMPATIBILITY WITH COMPANY ENVIRONMENT: (CONSIDER EXISTING
AND EXPECTED)
A. DEMAND:
   CHECK IF UNKNOWN □

B. COMPETITION:
   CHECK IF UNKNOWN □

C. MARKET NATURE:
   CHECK IF UNKNOWN □

D. MARKET SIZE:
   CHECK IF UNKNOWN □

E. MARKET LOCATION:
   CHECK IF UNKNOWN □

F. LEGAL CONDITIONS:
   CHECK IF UNKNOWN □

10. ADDITIONAL CHARACTERISTICS OF THE PRODUCT:
A. INVESTMENT:
   CHECK IF UNKNOWN □

B. LIFE CYCLE TIME:
   CHECK IF UNKNOWN □

C. PROFIT POTENTIAL:
   CHECK IF UNKNOWN □

D. PROBABILITY OF SUCCESS:
   CHECK IF UNKNOWN □

11. RECOMMENDATIONS:
    PROCEED IN LIFE CYCLE THROUGH __________ PHASE.

   MARKET THE IDEA □ PATENT □ DESIGN □ PRODUCT(S) □

   MARKET BY SELLING □ LEASING □

   PROCEED WITH PRIORITY: HIGH □ MEDIUM □ LOW □

12. EXPLANATIONS: (EXPLAIN EACH CHECK IN THE RIGHT QUARTER OF
    THE SCALE; AND EXPLAIN EACH CHECK OF AN UNKNOWN)
A method of weighting and combining the appraisals of several questionnaires is provided by a second form, Figure VII-4, QUANTITATIVE ANALYSIS - SUMMARY WORK SHEET. As illustrated in the Appendix, each appraisal is changed into a numerical equivalent which is scaled from the bar graph. The numerical values range from 0 for a most undesirable appraisal, to 8 for a most desirable appraisal. The committee chairman, in this case the President, then decides how much influence (weight) each appraiser (data source) has on each appraisal (data). In the example, a total weight of 10 is divided among the five appraisers.

The effective value of each appraisal (weighted data) is then calculated by multiplying its data and weight. When an appraiser has checked the "unknown" block on the questionnaire, the summary work sheet is also checked with an "X", and that particular weighted data calculation is disregarded.

Next, the sum of weights used and the sum of weighted data are calculated; and, finally, the averaged data is calculated by dividing the sum of weighted data by the sum of weights used. This last number represents a weighted composite of the data from all members of the committee. It is then possible to complete a Figure VII-3 questionnaire representing this composite by converting each of these numbers back to an equivalent "X" position on the form.

Although not a part of qualitative analysis, the "Data/Weight Minimum" row of Figure VII-4 contains the criteria used in subsequent decisions.
<table>
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<th>1B</th>
<th>1C</th>
<th>1D</th>
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<th>1K</th>
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Remarks:

Figure VII-4.
The diagram of Figure VII-2 replaces the original "Develop Proposal?" block with four sequential blocks: "Satisfy Objectives?", "Fit Expected Environment?", "Use Existing Resources?", and "Satisfy Preferences?". A YES or NO answer is obtained with respect to each alternative for each block by comparing the "Averaged Data" and "Data/Weight Minimum" rows of the Figure VII-4 form.

In normal practice, a company subdivides these blocks into more specific and adaptive steps. For example, the question of product objectives raises further questions as to the product's:

a. ability to satisfy a need,
b. requirements for technical service,
c. requirements for special sales training,
d. requirements for special advertising and/or merchandising aids,
e. need for proprietary protection or patenting,
f. ability to avoid legal problems related to manufacture, distribution, and use, and

g. ability to avoid legal conflict with company's goodwill and interdivisional policies.

During the preliminary cycle, output alternatives of a proposal that fail to meet the criteria take NO decision branches. These alternatives are dropped or held for later input to the model. The output alternatives that meet the criteria take YES decision branches and proceed to development. The example given in the Appendix shows all qualitative criteria to be satisfied except for
the "Market Idea" alternative.

The task "Develop" is an activity that changes the nature of the proposal and causes progress along the life cycle. Examples are as follows:

1. If the input proposal is a new idea, development might consist of effort to verify its feasibility and potential application, or to improve or expand its nature. It might become a design.

2. If the input proposal is an idea that requires no development or has received previous development that is sufficient, no effort results, and the proposal passes through unaltered.

3. If the input proposal is a patent, it might receive marketing effort to search for applications. Often a patent is submitted to the model because it has been found through search effort as a possible solution for a marketing need. The model is then a means for verifying its original objectives.

4. If the input proposal is a design, it might receive further engineering effort to incorporate improvements or extend its application, or it might be entered into production and become a product.

5. If the input proposal is a product, it might receive effort to improve tooling and processes, or it might receive effort to make it marketable as an entire product line.

The preliminary cycle includes the decision block "Repeat Qualitative Analysis?". The YES branch is taken only when
development effort has resulted in changes to the proposal since its last analysis and decision.

The Detailed Cycle

The output of the preliminary cycle is the input to the detailed cycle. When an input proposal to the preliminary cycle has no surviving output alternatives, there can be no input to the detailed cycle. The preliminary cycle, therefore, is a prerequisite, and its decision to proceed, drop, or hold is critical.

The detailed cycle is presented with the aid of Figure VII-5, DECISION MODEL - DETAILED CYCLE. It begins with quantitative analysis and proceeds with a decision matrix that identifies the type of proposal input, tests the proposal against the quantitative "must" criteria to identify acceptable output alternatives, and tests these acceptable output alternatives against the quantitative "want" criteria.

The first task performed during the detailed cycle is quantitative analysis. Unlike qualitative analysis, this task demands rigorous computation and, therefore, is given a separate discussion expanded from that described in Chapter III.

The first decision made after quantitative analysis is based on the question: Is the input proposal an idea, a patent, a design, or a product? Although the nature of the input proposal is known as early as qualitative analysis, its identification is not needed in the logic until acceptable output alternatives are to be selected
Figure VII-5.--DECISION MODEL - DETAILED CYCLE
and graded.

Identification is achieved by three decision blocks, "Is Proposal an Idea?", "Is Proposal a Patent?", and "Is Proposal a Design?". These blocks are sequentially connected so that a YES answer to the question of any one completes the identification, and a NO answer to the questions of all three identifies the input proposal as a product.

After the proposal input is identified as an idea, patent, design, or product, the alternative outputs are decided. The diagram of Figure VII-5 replaces the "Market Proposal?" block with three decision blocks that identify the proposal input, and eight additional decision blocks that lead to the output alternatives. The number of decision blocks required depends on the input proposal. For example, if the input proposal is a design, three blocks are used to identify, and three additional blocks are used to reach the output alternatives because the earlier decision blocks are bypassed. The NO branch of the "Patent Idea?" block loops back to the YES branch because subsequent decision logic applies to both ideas and patents.

During the detailed cycle, output alternatives of an input proposal that fail to meet the detailed cycle criteria take NO decision branches. These alternatives feed back to the preliminary cycle, where they are either dropped or held for input to the model at a later time. When all outputs for a given proposal are dropped, the proposal is dropped. The "Proposal Output" block at the top of
Figure VII-5 accommodates this action.

The output alternatives that meet the detailed cycle criteria take YES decision branches. These alternatives become the acceptable proposal outputs. To process all alternatives, each decision block is exercised for both YES and NO alternatives until all combinations are either accepted or dropped.

Quantitative Analysis

The approach used in this model is incremental and is based on the principles described in the Appendix. Time increments of one-fourth year are used because they represent a compromise between the short intervals desired during the early phases of the life cycle and the long intervals encouraged for use during the later phases.

Calculations are made for each of the relevant outcomes by using three forms. The first form, Figure VII-6, EARNINGS ANALYSIS, is used to determine the discounted expected earnings for all output alternatives except those from commercialization phases. This form:

a. identifies the marketing alternative as an idea, patent, or design;

b. identifies the decision branches taken to reach these alternatives: patent successful, patent not successful, patent not attempted; and design successful, design not successful, design not attempted;

c. provides an estimate of the probability of marketing by selling versus by leasing;
EARNINGS ANALYSIS: IDEA □ PATENT □ DESIGN □

PATENT:
SUCCESSFUL □
NOT SUCCESSFUL □
NOT ATTEMPTED □

DESIGN:
SUCCESSFUL □
NOT SUCCESSFUL □
NOT ATTEMPTED □

MARKET METHOD:
SELL
LEASE (Probability)

DISCOUNT RATE __%  EFFECTIVE YEAR OF MARKETING __________

COST OF MARKETING ______  DISCOUNTED COST OF MARKETING ______

DISCOUNTED EXPECTED EARNINGS IF LEASED:

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TOTAL: __________________________

DISCOUNTED EXPECTED EARNINGS IF SOLD:

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EXPECTED EARNINGS TOTAL:

© DISCOUNT FACTOR ______  TOTAL: __________________________

DISCOUNTED EXPECTED EARNINGS (BOTH METHODS): __________________________

Figure VII-6.
d. provides an estimate of the cost and time of marketing; and

e. provides the means for discounting to present value.

The use of this form is illustrated in the Appendix. When marketing is effected by leasing, the earnings are received over a period of time. The expected earnings are, therefore, listed for each year, and the discounted expected earnings are calculated for each year and summed.

When marketing is achieved by selling, the earnings are received at one time. This time is estimated and set. The amount received at this time, however, is treated as having a probability distribution. This distribution is derived from five earnings brackets, defined to have 0.1, 0.2, 0.4, 0.2, and 0.1 probabilities of occurrence from their lowest to highest amounts. The high and low earnings estimated for each bracket are immediately adjacent such that the high of the lowest bracket is the same as the low of the next highest bracket, and so forth. Calculations are completed by averaging the high and low of each bracket, multiplying each average by the probability of occurrence of its bracket, summing the results, and applying the discount factor.

A total value of discounted expected earnings (combining both selling and leasing possibilities) is calculated by multiplying each by its relative probability of occurrence and then summing. The form also provides for estimating the discounted cost of marketing and the net discounted expected earnings if marketing occurs.
The second form, Figure VII-7, EARNINGS AND INVESTMENT ANALYSIS, is used to record the expected investment costs and expected earnings on an incremental basis for the entire life cycle duration. The form also provides for applying the discount on an incremental basis. The employment of equal time increments permits use of the trapezoidal rule for numerical integration.

The third form, Figure VII-8, CASH FLOW ANALYSIS - SUMMARY, accepts the time-incremented values for discounted expected earnings and discounted expected investment from the Figure VII-7 form, calculates the discounted cash flow (earnings less investment), and calculates the accumulated discounted cash flow (algebraic sum of the discounted cash flow of the current and previous time increments). An additional column relates the time increments to the product life cycle phases.

Several clarifications are needed at this time.

First, at least one form is used for processing a single output alternative, and when the output alternative includes commercialization phases, two or three forms are used.

Second, one form can be used for more than one output alternative when the influence of an intermediate condition is negligible. An example of this is given in the Appendix, where a single form is used for both patent not successful and patent not attempted conditions.

Third, the discount rate used is a matter of policy. A three per cent per quarter year rate is used for illustration. One
PROPOSAL NO. __________
DATE: ________________

EARNINGS & INVESTMENT ANALYSIS - LIFE CYCLE

PATENT: SUCCESSFUL □ NOT SUCCESSFUL □ NOT ATTEMPTED □

$ MULTIPLIER X _______ DISCOUNT RATE PER QUARTER 3 %

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Figure VII-7.
CASH FLOW ANALYSIS SUMMARY - LIFE CYCLE

PATENT: SUCCESSFUL □ NOT SUCCESSFUL □ NOT ATTEMPTED □

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Figure VII-8.
approach is to use a rate equal to the firm's opportunity cost of capital.1 The discount rate, therefore, is actually a decision criterion that enters into the model during quantitative analysis.

Fourth, each major task is recognized to have a success/failure probability of occurrence. In this model, this is treated as a chance event immediately following performance of the task.

**Detailed Cycle Outputs**

As previously stated, the detailed cycle tests the proposal against the quantitative "must" criteria to identify acceptable output alternatives. To reach this position, the input proposal receives further processing through the model's network of decision and chance events. This network is presented by four decision tree diagrams, as follows:

The idea and patent phases are presented in Figure VII-9, DECISION DIAGRAM - INITIAL BRANCH. Any input proposal that is an idea or patent must start on this diagram. The outputs of this diagram enter hold or design blocks. The hold blocks on this diagram and on the three diagrams to follow also provide the alternative of dropping the proposal. The three design blocks are the starting decision events for each of the other three decision tree diagrams. Each of these diagrams covers the design and commercialization phases for the three possible patent conditions, and is

---

PROPOSAL NO. _______  
DATE: _________  
$ MULTIPLIER X _______

[ ] P_a( )  
[ ] YES  
[ ] DEVELOP IDEA?  
[ ] NO  
1

[ ] P_f( )  
[ ] DEVELOP IDEA?  
[ ] NO  
[ ] YES  
2

[ ] P_a( )  
[ ] YES  
[ ] ($____)  
[ ] DEVELOP IDEA  
[ ] ($____)  
[ ] NO  
3

PATENT?  
[ ] YES  
[ ] ($____)  
[ ] NO  
4

(PATENT)  
[ ] ($____)  
[ ] (PATENT SUCCESSFUL)

DESIGN?  
[ ] (PATENT NOT SUCCESSFUL)

DESIGN?  
[ ] (PATENT NOT ATTEMPTED)

[ ] ($____)  
[ ] HOLD

DISCOUNTED ASSET VALUE ($____) = BEGINNING ASSET VALUE ($____) + DISCOUNTED CASH FLOW

Figure VII-9. --DECISION DIAGRAM - INITIAL BRANCH
termed a design branch. These design branches are:

Figure VII-10, DESIGN DIAGRAM - DESIGN BRANCH (IF PATENT SUCCESSFUL)

Figure VII-11, DESIGN DIAGRAM - DESIGN BRANCH (IF PATENT NOT SUCCESSFUL)

Figure VII-12, DESIGN DIAGRAM - DESIGN BRANCH (IF PATENT NOT ATTEMPTED)

Several symbols common to the four diagrams require explanation. Each decision event is shown as a square, and is identified by a number to aid discussion. Each decision asks a question for which the answer is YES of NO. The bracket above the block will be explained later.

Each chance event is shown as a circle, and is identified by a capital letter. Each chance event has a probability of success, $P_s$, and of failure, $P_f$. Space is provided for recording specific probabilities.

Each task is shown in parentheses, and is located along a YES decision branch. A space is provided for recording the discounted expected investment of each task. The numbers used in these spaces may be abbreviated by using a multiplier, space for which is provided above the diagram title. The beginning asset value is the maximum negative cash flow that the firm is willing to experience during a product life cycle.

The computation sequence is as follows:

1. All acceptable alternatives from the preliminary cycle
Figure VII-10.—DECISION DIAGRAM - DESIGN BRANCH (IF PATENT SUCCESSFUL)
PROPOSAL NO. __________
DATE: __________

$ MULTIPLIER X __________

Figure VII-11.—DECISION DIAGRAM - DESIGN BRANCH (IF PATENT NOT SUCCESSFUL)
Figure VII-12.—DECISION DIAGRAM — DESIGN BRANCH (IF PATENT NOT ATTEMPTED)
are identified.

2. The beginning asset value is entered.

3. The probabilities of all chance events are entered.

4. The discounted expected investment for each task is entered. The investment entered under (Manufacture) reflects only the amount spent through the introduction phase, because this is defined as the point of recognizing success and failure to market the product.

5. The beginning asset value is entered next to the output alternative resulting from the performance of NO tasks. This must be a hold output, because all marketing tasks require some investment.

6. Using the beginning asset value, calculate the discounted asset values of all other output alternatives by subtracting discounted expected investments and adding discounted expected earnings.

7. Convert the discounted asset values of each output alternative to its preference number by use of a preference curve similar to that shown in Figure IV-1. Record each preference number in the brackets above its alternative.

8. Calculate the preference numbers for all events by working backwards from the output alternatives. Each decision event is determined by adopting the higher preference number of its two branch events. Each chance event is determined by multiplying the preference of each branch event by its probability of occurrence,
and summing the results.

The completed diagrams in the Appendix exemplify the above computations. The course of action having the greatest preference is readily identified by tracing the path of highest preferences. The conversions used in the Appendix are based on the actual curve of Figure IV-1.

**Final Decisions**

One last form is used to display the outputs of the model. This form, Figure VII-13, SUMMARY OF OUTPUT ALTERNATIVES, identifies:

a. the twelve success alternatives from which earnings are possible,

b. the alternatives that satisfy the "must" criteria of the preliminary cycle,

c. the alternatives that satisfy the "must" criteria of the detailed cycle,

d. the margin by which each alternative exceeds the "must" criteria of the detailed cycle, and

e. the grade of each alternative, based on the "want" criteria of the detailed cycle.

The form shows how preference and other criteria are combined to obtain final model outputs that are readily used in decision making. The four criteria used in this form are preference, maximum negative cash flow, time to reach maximum negative
### SUMMARY OF OUTPUT ALTERNATIVES

**Page 1**

"MUST" CRITERIA:
- \( W_M = \_
\)
- \( J_M = \_
\) nd
- \( Z_M = \_
\) nd

"WANT" CRITERIA:
- \( a = \_
\) nd
- \( b = \_
\) per 100 Dollars
- \( c = \_
\) per Year
- \( d = \_
\) per Year

PROPOSAL NO. ____________

DATE: ____________

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**Figure VII-13.**
SUMMARY OF OUTPUT ALTERNATIVES

(Page 2)

Procedure for Completing Form

1. Enter proposal number and date.

2. Enter an X below $P_M$ for each output alternative that meets the preliminary cycle "must" criteria. Stop here if there are no X's.

3. Enter data values of $w$, $x$, $y$, and $z$ for each output alternative that satisfies $P_M$ where: $w =$ preference, $x =$ maximum negative cash flow, $y =$ time to maximum negative cash flow, and $z =$ time to breakeven.

4. Enter values of $v_M$, $x_M$, $y_M$, and $z_M$. These are detailed cycle "must" criteria where: $v_M =$ preference limit, $x_M =$ maximum negative cash flow limit, $y_M =$ time limit to reach maximum negative cash flow, and $z_M =$ time limit to reach breakeven.

5. Calculate the margins by which the data of each output exceeds its criteria where: preference margin $\Delta w = w - v_M$, maximum negative cash flow margin $\Delta x = |x_M| - |x|$, time margin to reach maximum negative flow $\Delta y = y_M - y$, time margin to reach breakeven $\Delta z = z_M - z$.

6. Enter an X below $D_M$ for each output alternative that meets the detailed cycle "must" criteria. (All margins must be positive numbers.) Stop here if there are no X's.
7. Enter values for \( \Delta x, \Delta y, \Delta z \), and \( \Delta x \).

8. Enter values of a, b, c, and d. These are detailed cycle "want" criteria where: a = preference coefficient, b = maximum negative cash flow coefficient, c = time to reach maximum negative cash flow coefficient, d = time to reach breakeven coefficient.

9. Calculate the final "want" grade \( D_M \) for each output alternative where: \( D_M = a \Delta x + b \Delta x + c \Delta y + d \Delta z \).

10. Enter values for \( D_M \).

Figure VII-13 (cont.)
cash flow, and time to reach breakeven.

Maximum negative cash flow is the maximum investment expected to accumulate before the earnings rate overtakes the investment rate. In this model it is calculated on three-month intervals, and is the largest negative value reached.

Time to reach maximum negative cash flow is the time from the present to the time at which the maximum negative cash flow is expected. In this model it is the time at the end of the three-month interval in which the largest negative value is reached.

Time to reach breakeven is the time from the present to the time at which the accumulated cash flow first becomes positive. In this model it is the time at the end of the three-month interval at which the calculated value of accumulated cash flow is first positive.

The form provides for entry of actual values from the quantitative analysis, entry of the "must" criteria, entry of the "want" criteria, and entry of the final grades as follows:

An X is entered below $R_M$ for each alternative that satisfies the "must" criteria in the preliminary cycle.

The values for $w$, $x$, $y$, and $z$ are entered for each alternative where: $w$ is the preference obtained from Figures VII-9, 10, 11, and 12; $x$ is the maximum negative cash flow obtained from Figures VII-6 and 8; $y$ is the time to reach maximum negative cash flow obtained from Figures VII-6 and 8; and $z$ is the time to reach breakeven obtained from Figure VII-6 and 8.
Next, the values for "must" criteria $w_M$, $x_M$, $y_M$, and $z_M$ are entered where: $w_M$ is the preference limit, meaning that preference must not be less than _____; $x_M$ is the maximum negative cash flow limit, meaning that it must not be more than -$_____; $y_M$ is the time limit to reach maximum negative cash flow, meaning that it must not be more than _____ years; $z_M$ is the time limit to reach breakeven, meaning that it must not be more than _____ years.

The margins $\Delta w$, $\Delta x$, $\Delta y$, and $\Delta z$ are then calculated as follows:

$$\Delta w = w = w_M$$
$$\Delta x = |x_M| - |x|$$
$$\Delta y = y_M - y$$
$$\Delta z = z_M - z$$

The values of each of the above margins are then entered on the form; and if $\Delta w \geq 0$, $\Delta x \geq 0$, $\Delta y \geq 0$, and $\Delta z \geq 0$ for any alternative, an $X$ is entered below $D_M$ showing that the alternative satisfies the "must" criteria of the detailed cycle.

Last, the values for "want" criteria a, b, c, and d are entered on the form and the value of $D_W$ calculated. In this case, "a" is the preference coefficient; "b" is the maximum negative cash flow coefficient; "c" is the time to reach maximum negative cash flow coefficient; and "d" is the time to reach breakeven coefficient. Each of these coefficients converts a margin into a dimensionless number that is scaled according to its relative importance. The value of $D_W$, which is the "want" grade of the detailed cycle, is
then calculated from the following equation:

\[ D_w = a_w x + b_w x + c_w y + d_w z \]

In summary, \( P_M \) and \( D_M \) result from GO and NO GO decisions; and \( D_w \) is a numerical grading of the GO decisions so that comparison can be made with other GO decisions.

**Conclusions**

The Generalized Model presented in this chapter accepts proposal inputs that are ideas, patents, designs, or products. The model consists of two process cycles, a preliminary cycle and a detailed cycle. Each of these processes includes an analysis that provides for both evaluation and conversion of proposal inputs. The preliminary cycle consists of a qualitative analysis followed by a decision matrix, the criteria of which must be satisfied. These criteria are called "must" criteria. The detailed cycle consists of a quantitative analysis followed by a decision matrix, the criteria of which are divided into both "must" and "want" forms. In both cycles the criteria include each of the major categories: objectives, resources, preferences, and environments.

The outputs from the model consist of all the possible decision alternatives remaining on the decision tree. These outputs identify the alternatives which satisfy the "must" criteria of the preliminary and detailed cycles. Those alternatives surviving the "must" criteria are further graded according to the "want" criteria.
The model provides outputs that are solely dependent on the inputs. The model will provide nominal outputs when receiving nominal inputs. Therefore, it may be used iteratively to measure sensitivities, linearities, and margins as described in Chapter VIII.
Chapter VIII

SENSITIVITY TESTING

The Generalized Model presented in Chapter VII accepts proposal and criteria inputs, and delivers outputs as nominal expected values. For example, the model employs success and failure branches after each task, for which discrete probabilities are supplied as inputs. The real world, however, is more completely and accurately portrayed if these inputs are expressed as distributions.

Unfortunately, the distribution approach is impractical. First, the preparation of input distributions is complicated. This makes it costly in time and manpower. Second, the strategic nature of product decisions, with their long planning periods, causes many of the model inputs to be highly uncertain. Third, the model can process distributions only after considerable programming and finally increased computer time.

Since the purpose of the model is to sense and maintain control over the most critical and uncertain output determinants, it is not necessary to use a complete simulation. Instead, the Generalized Model is used iteratively to test its sensitivity. Inputs are perturbed about their nominal values, and new outputs obtained and compared.

Four sensitivity testing methods are discussed as follows:
Simple Sensitivity Testing

Simple sensitivity testing calculates changes in outputs in response to a change in a single input. An output is said to be sensitive when a slight change in an input results in a great change in that output. An input is usually selected for the test because it is believed to produce large changes in an output, or because the value of the input is highly uncertain.

When a proposal is under consideration for adoption, simple sensitivity tests may be used to identify high risk conditions. When a proposal is already in development or commercialization phases, simple sensitivity tests may also be used to identify and monitor high risk conditions. Such tests can aid managerial control by insuring timely and adequate action.

To illustrate simple sensitivity testing, some of the calculations of the Appendix are repeated for different input values:

If the probability of design success (for patent successful condition) is changed from .95 to .80 (a -15.8% change), the preference of the entire proposal changes from .89 to .87 (a -2.2% change). This means that the preference for the entire proposal is not very sensitive to changes in the probability of a successful design, given that the patent has been successful.

If the maximum negative cash flow is changed from -$45,300 to -$25,000 (a -45% change), the detailed cycle "want" grade changes from .63 to .71 (a +12.7% change). This means that the
desirability ("want" grade) for the entire proposal is moderately sensitive to changes in its total cost (maximum negative cash flow).

If the discounted negative cash flow of the design (if marketed) is changed from -$10,400 to -$14,000 (a +34.2% change), the preference of the market design alternative changes from .87 to .92 (a +5.8% change). This means that the preference for the market design alternative is not very sensitive to changes in the cost of design (discounted negative cash flow of the design).

An input change usually results in many output changes. Only one output change was calculated for each of the above illustrated input changes.

**Multiple Sensitivity Testing**

Multiple sensitivity testing calculates changes in outputs in response to changes in two or more inputs. In operation, the approach is identical to simple sensitivity testing, but is used to predict outcomes when a decision is contemplated or changes are expected that alter more than one input. If a change is imminent and not controllable, the newly calculated outputs represent new nominals. If a change is controllable, the newly calculated outputs are new nominals that vary with a decision. Multiple sensitivity testing, therefore, calculates changes in outputs resulting from changes in more than one input.
Linearity Testing

Linearity testing calculates changes in outputs in response to several incremental changes to a single input. In operation, it is identical to simple sensitivity testing. By repeating the calculations for different magnitudes of input, however, additional knowledge may be obtained regarding the manner in which the outputs respond over a range of input values. An output is said to be linear when changes in an input result in a proportional change in that output.

Margin Testing

Margin testing calculates the limiting value to which an input may change before an output fails to meet its "must" criteria. The difference between this new and the original input values is the margin. When an output fails to meet its "must" criteria, the margin is said to have been lost, and that output alternative is no longer acceptable.

Calculating margin is not always easy. Sometimes the equations can be rearranged and the margin explicitly derived. More often, it must be determined by successive iteration of a large part of the model. If the model has been programmed on a computer, this iteration can be effected by looping the relevant part of the program so as to converge on the new input value.
Conclusions

Sensitivity testing is a means for identifying those inputs which greatly affect the outcome of various output alternatives. It uses the model in its basic form by repeating calculations with inputs that have been perturbed about their nominal values. The calculation results reported above demonstrate use of the model and its adequacy for accommodating sensitivity testing.

Sensitivity testing can be used to measure the sensitivity of outputs to changes in inputs that are believed to be critical or highly uncertain. It is applicable to both new and continuing programs, and during all life cycle phases.
Chapter IX

CONCLUSIONS

The Generalized Model of this thesis, as presented in Chapter VII, is herein submitted for test against the hypothesis. The test method is based on logical analysis, and proceeds from re-statement of the hypothesis, to reduction of the hypothesis into three remaining key questions, to the answering of these questions, and, finally, to a conclusion and a position.

Restatement of the Hypothesis

A single product decision model may be developed which is of sufficient scope and construction to permit its direct use in analysis and decisions related to all phases of a product's life cycle from conception of an idea to the dropping of a product from production.

Reduction of the Hypothesis

The model presented in Chapter VII is a single product decision model because it deals with product decisions and its singularity is self evident.

From the definitions in Chapter I, the proposed model is of sufficient scope and construction if it is descriptive (like the real world), predictive (future oriented), selective (facilitates
selection from among alternatives), and controlling (senses results, compares with expected, and applies correction). In examining each of these:

First, the model is "descriptive" because it duplicates the real world process. Its flow duplicates the product life cycle as defined in Chapter II, and its mechanization embodies the analysis and decision processes defined in Chapter III. Does the model accommodate evaluation and conversion of its inputs into a form suitable for testing against criteria? The answer is yes, because evaluation and conversion are analysis, and analysis is successfully implemented by the model as qualitative and quantitative tasks. Qualitative analysis is performed during the preliminary cycle, where it evaluates and converts input proposals into forms suitable for testing against "must" criteria. Quantitative analysis is performed during the detailed cycle, where it again evaluates and converts input proposals into forms suitable for testing against both "must" and "want" criteria. The success of these tasks is demonstrated in the Appendix.

Second, the model is "predictive" because it provides an estimate of the expected outcomes of alternatives. A single proposal input after processing in the model is not only identified for what it is, but for what it may become in the future. Chapters V and VI provide added background.

Third, the model is "selective" because it presents alternatives in a standardized format suitable for comparison. Not only
are the inputs tested against the same criteria, but resulting outputs are presented as numerical grades emanating from the same standard. Does the model provide outputs suitable for comparison with one another and with the outputs of all other proposals? The answer is yes, because the model outputs are dimensionless numbers of magnitude determined by interaction of the proposal and criteria. The final presentation of outputs is provided on the form shown in Figure VII-13. The entire process, including this summary form, is illustrated in the Appendix as further proof that the outputs of any proposal can be presented in a form suitable for comparison.

Fourth, the model is "controlling" because its outputs are compared with prior predictions to determine corrections. As progress is made along the life cycle, previously estimated proposal data become fact or change because of new information. Decision criteria also change as objectives, resources, environments, and preferences evolve. With each iteration of the model, therefore, proposal and criteria input changes result in output changes. These new outputs not only provide direct knowledge for decisions, but, after comparison with previous outputs, also provide trend knowledge for decisions. Iterative use of the model is described in Chapter VIII.

To be usable over all phases of a product's life cycle, the model must accommodate those characteristics of the life cycle which vary with phase. Three such characteristics are identified in Chapter II: investment, uncertainty, and risk. Therefore, to
complete testing of the hypothesis, the following question is posed: Does the model satisfactorily account for investment, uncertainty, and risk characteristics which vary with each product life cycle phase? The answer is yes because these characteristics are embodied in the Generalized Model as follows:

Investment is entered directly into the quantitative analysis of the model's detailed cycle. It is entered incrementally and processed by numerical integration. Investment accumulates as the life cycle proceeds, reaching relatively high values toward the end of a life cycle. Comparison of the data on the Cash Flow Analysis Summary form in the Appendix with the curves of Figure II-2 proves this.

Uncertainty exists because the future is unknown. Uncertainty is a function of time and of discrete unpredictabilities. The curve of Figure II-2 shows that uncertainties are high early in the product life cycle. In the model, uncertainty is incorporated in two ways. First, as a function of time, it is incorporated by applying a discount rate to investments. Second, as a function of discrete unpredictabilities, it is incorporated as mutual probabilities of success and failure for each of the major tasks. The influence of these two functions of observation of the Appendix is readily shown to correlate with curve of Figure II-2.

Risk is defined as the product of investment and uncertainty. A more detailed discussion is given in Chapter II. The model includes risk through its treatment of accumulated cash flow and
risk attitude. The principal incorporation comes from the accumulated cash flow computation because it contains accumulated investment, and it is discounted. A secondary incorporation comes from the adjustment for risk attitude.

All three characteristics are clearly incorporated in the model.

**Conclusion and Position**

It is concluded from the above that the hypothesis is proven to be valid. A single product decision model has been developed and presented. It is capable of direct use in analysis and decisions related to all phases of a product's life cycle. The model accepts inputs that are ideas, patents, designs, or products, and it provides an array of possible output alternatives (hold, drop, market) that may exit from the life cycle at any time in any phase.
BIBLIOGRAPHY


APPENDIX
QUALITATIVE ANALYSIS - QUESTIONNAIRE
(Page 1)

COMPLETED BY: Hank                        PROPOSAL NO: 6
POSITION: Director of Manufacturing DATE: 10/19/68

PROPOSAL IS AN IDEA □ PATENT □ DESIGN □ PRODUCT(S) □
DESCRIPTION OF PROPOSAL: Device to restrict mechanical
motion except in the presence of an electrical
tension.

NAME THE PRODUCT(S) OR POTENTIAL PRODUCT(S): Brake and
Transmission lock to prevent theft and accidental release of an automobile.

- IF THE PROPOSAL IS AN IDEA - BEGIN HERE.
  1. TECHNICAL FEASIBILITY OF IDEA: Exceptional Av. Not Feasible
     CHECK IF UNKNOWN □
  2. MARKETABILITY OF IDEA: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN □
  3. PATENTABILITY OF IDEA: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN □

- IF THE PROPOSAL IS AN IDEA - ASSUME IT HAS BEEN PATENTED AND
  CONTINUE. IF PROPOSAL IS A PATENT - BEGIN HERE.
  4. MARKETABILITY OF PATENT: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN □
  5. DESIGN ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED
     ENGINEERING RESOURCES) Exceptional Av. Nonexistent
     CHECK IF UNKNOWN □

- IF THE PROPOSAL IS AN IDEA OR PATENT - ASSUME IT HAS BEEN CON-
 verted INTO A DESIGN AND CONTINUE. IF PROPOSAL IS A DESIGN -
BEGIN HERE.
  6. MARKETABILITY OF DESIGN: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN □
  7. PRODUCT OBJECTIVES OF COMPANY: Satisfied Av. Not Satisfied
     CHECK IF UNKNOWN □
  8. COMMERCIALIZATION ABILITY OF COMPANY: (CONSIDER EXISTING AND
     PLANNED)
     A. MANUFACTURING RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN □
     B. MARKETING RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN □
     C. MANAGEMENT RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN □
     D. FINANCIAL RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN □
9. COMPATIBILITY WITH COMPANY ENVIRONMENT: (CONSIDER EXISTING AND EXPECTED)
   A. DEMAND:
      CHECK IF UNKNOWN □
   B. COMPETITION:
      CHECK IF UNKNOWN □
   C. MARKET NATURE:
      CHECK IF UNKNOWN □
   D. MARKET SIZE:
      CHECK IF UNKNOWN □
   E. MARKET LOCATION:
      CHECK IF UNKNOWN □
   F. LEGAL CONDITIONS:
      CHECK IF UNKNOWN □

10. ADDITIONAL CHARACTERISTICS OF THE PRODUCT:
    A. INVESTMENT:
      CHECK IF UNKNOWN □
    B. LIFE CYCLE TIME:
      CHECK IF UNKNOWN □
    C. PROFIT POTENTIAL:
      CHECK IF UNKNOWN □
    D. PROBABILITY OF SUCCESS:
      CHECK IF UNKNOWN □

11. RECOMMENDATIONS:
    PROCEED IN LIFE CYCLE THROUGH **Introduction** PHASE.

    MARKET THE IDEA □ PATENT □ DESIGN □ PRODUCT(S) □

    MARKET BY SELLING □ LEASING □

    PROCEED WITH PRIORITY: HIGH □ MEDIUM □ LOW □

12. EXPLANATIONS: (EXPLAIN EACH CHECK IN THE RIGHT QUARTER OF THE SCALE; AND EXPLAIN EACH CHECK OF AN UNKNOWN)
    Not sure how easily market can be reached. Do not know legal implications. Safety and theft are receiving increasing attention from government agencies. Required investment is very high because of tooling.

BY: Hank

PROPOSAL NO. 6
QUALITATIVE ANALYSIS - QUESTIONNAIRE
(Page 1)

COMPLETED BY: Ed PROPOSAL NO: 6

POSITION: Controller DATE: 10/19/68

PROPOSAL IS AN IDEA ☐ PATENT ☐ DESIGN ☐ PRODUCT(S) ☐

DESCRIPTION OF PROPOSAL: Device to restrict mechanical motion except in the presence of an electrical voltage.

NAME THE PRODUCT(S) OR POTENTIAL PRODUCT(S): Brake and transmission lock to prevent theft and accidental release of an automobile.

- IF THE PROPOSAL IS AN IDEA - BEGIN HERE.

  1. TECHNICAL FEASIBILITY OF IDEA: Exceptional Av. Not Feasible
     CHECK IF UNKNOWN ☐

  2. MARKETABILITY OF IDEA: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐

  3. PATENTABILITY OF IDEA: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐

- IF THE PROPOSAL IS AN IDEA - ASSUME IT HAS BEEN PATENTED AND CONTINUE. IF PROPOSAL IS A PATENT - BEGIN HERE.

  4. MARKETABILITY OF PATENT: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐

  5. DESIGN ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED ENGINEERING RESOURCES) Exceptional Av. Nonexistent
     CHECK IF UNKNOWN ☐

- IF THE PROPOSAL IS AN IDEA OR PATENT - ASSUME IT HAS BEEN CONVERTED INTO A DESIGN AND CONTINUE. IF PROPOSAL IS A DESIGN - BEGIN HERE.

  6. MARKETABILITY OF DESIGN: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐

  7. PRODUCT OBJECTIVES OF COMPANY: Satisfied Av. Not Satisfied
     CHECK IF UNKNOWN ☐

  8. COMMERCIALIZATION ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED)
     A. MANUFACTURING RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
     B. MARKETING RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
     C. MANAGEMENT RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
     D. FINANCIAL RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
9. COMPATIBILITY WITH COMPANY ENVIRONMENT: (CONSIDER EXISTING AND EXPECTED)
   A. DEMAND:
      CHECK IF UNKNOWN □
      Very High □ Av. □ Very Low □

   B. COMPETITION:
      CHECK IF UNKNOWN □
      None □ Av. □ Very Great □

   C. MARKET NATURE:
      CHECK IF UNKNOWN □
      Broad Av. □ Narrow □

   D. MARKET SIZE:
      CHECK IF UNKNOWN □
      Very Great Av. □ Very Small □

   E. MARKET LOCATION:
      CHECK IF UNKNOWN □
      Very Accessible Av. □ Remote □

   F. LEGAL CONDITIONS:
      CHECK IF UNKNOWN □
      Very Favorable Av. □ Adverse □

10. ADDITIONAL CHARACTERISTICS OF THE PRODUCT:
    A. INVESTMENT:
       CHECK IF UNKNOWN □
       Very Small Av. □ Very Great □

    B. LIFE CYCLE TIME:
       CHECK IF UNKNOWN □
       Very Long Av. □ Very Short □

    C. PROFIT POTENTIAL:
       CHECK IF UNKNOWN □
       Very High Av. □ Very Low □

    D. PROBABILITY OF SUCCESS:
       CHECK IF UNKNOWN □
       A Certainty Av. □ Negligible □

11. RECOMMENDATIONS:
    PROCEED IN LIFE CYCLE THROUGH Design PHASE.

    MARKET THE IDEA □ PATENT □ DESIGN □ PRODUCT(S) □

    MARKET BY SELLING □ LEASING □

    PROCEED WITH PRIORITY: HIGH □ MEDIUM □ LOW □

12. EXPLANATIONS: (EXPLAIN EACH CHECK IN THE RIGHT QUARTER OF THE SCALE; AND EXPLAIN EACH CHECK OF AN UNKNOWN)

    Investment required is too high for company. Feasibility of the idea depends greatly on one or two automobile manufacturers. Idea is not of value without patent coverage.

    BY: ___________________________ PROPOSAL NO. _________
QUALITATIVE ANALYSIS – QUESTIONNAIRE
(Page 1)

COMPLETED BY: Russ PROPOSAL NO: 6
POSITION: Director of R&D DATE: 10/19/68

PROPOSAL IS AN IDEA ☐ PATENT ☐ DESIGN ☐ PRODUCT(S) ☐

DESCRIPTION OF PROPOSAL: A device to restrict mechanical motion except in the presence of an electrical voltage.

NAME THE PRODUCT(S) OR POTENTIAL PRODUCT(S): Brake and transmission lock to prevent theft and accidental release of an automobile.

- IF THE PROPOSAL IS AN IDEA – BEGIN HERE.
  1. TECHNICAL FEASIBILITY OF IDEA: Exceptional Av. Not Feasible
     CHECK IF UNKNOWN ☐
  2. MARKETABILITY OF IDEA:
     Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐
  3. PATENTABILITY OF IDEA:
     Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐

- IF THE PROPOSAL IS AN IDEA – ASSUME IT HAS BEEN PATENTED AND CONTINUE. IF PROPOSAL IS A PATENT – BEGIN HERE.
  4. MARKETABILITY OF PATENT: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐
  5. DESIGN ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED ENGINEERING RESOURCES) Exceptional Av. Nonexistent
     CHECK IF UNKNOWN ☐

- IF THE PROPOSAL IS AN IDEA OR PATENT – ASSUME IT HAS BEEN CONVERTED INTO A DESIGN AND CONTINUE. IF PROPOSAL IS A DESIGN – BEGIN HERE.
  6. MARKETABILITY OF DESIGN: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN ☐
  7. PRODUCT OBJECTIVES OF COMPANY: Satisfied Av. Not Satisfied
     CHECK IF UNKNOWN ☐
  8. COMMERCIALIZATION ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED)
     A. MANUFACTURING RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
     B. MARKETING RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
     C. MANAGEMENT RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
     D. FINANCIAL RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN ☐
9. COMPATIBILITY WITH COMPANY ENVIRONMENT: (CONSIDER EXISTING AND EXPECTED)
   A. DEMAND:
      CHECK IF UNKNOWN □
   B. COMPETITION:
      CHECK IF UNKNOWN □
   C. MARKET NATURE:
      CHECK IF UNKNOWN □
   D. MARKET SIZE:
      CHECK IF UNKNOWN □
   E. MARKET LOCATION:
      CHECK IF UNKNOWN □
   F. LEGAL CONDITIONS:
      CHECK IF UNKNOWN □

10. ADDITIONAL CHARACTERISTICS OF THE PRODUCT:
    A. INVESTMENT:
        CHECK IF UNKNOWN □
    B. LIFE CYCLE TIME:
        CHECK IF UNKNOWN □
    C. PROFIT POTENTIAL:
        CHECK IF UNKNOWN □
    D. PROBABILITY OF SUCCESS:
        CHECK IF UNKNOWN □

11. RECOMMENDATIONS:
    PROCEED IN LIFE CYCLE THROUGH ____________ PHASE.

    MARKET THE IDEA □ PATENT □ DESIGN □ PRODUCT(S) □
    MARKET BY SELLING □ LEASING □
    PROCEED WITH PRIORITY: HIGH □ MEDIUM □ LOW □

12. EXPLANATIONS: (EXPLAIN EACH CHECK IN THE RIGHT QUARTER OF THE SCALE; AND EXPLAIN EACH CHECK OF AN UNKNOWN)
    Idea is not marketable because without patent protection competition would begin immediately.

BY: ___________________ PROPOSAL NO. __6__
QUALITATIVE ANALYSIS - QUESTIONNAIRE

(PAGE 1)

COMPLETED BY: Joe

PROPOSAL NO: 6

POSITION: Director of Marketing

DATE: 10/19/68

PROPOSAL IS AN IDEA ☑ PATENT ☐ DESIGN ☐ PRODUCT(S) ☐

DESCRIPTION OF PROPOSAL: Device to restrict mechanical motion except in the presence of an electrical voltage.

NAME THE PRODUCT(S) OR POTENTIAL PRODUCT(S): Brake and transmission lock to prevent theft and accidental release of an automobile.

IF THE PROPOSAL IS AN IDEA - BEGIN HERE.

1. TECHNICAL FEASIBILITY OF IDEA: Exceptional Av. Not Feasible
   CHECK IF UNKNOWN ☐

2. MARKETABILITY OF IDEA:
   Exceptional Av. Not Marketable
   CHECK IF UNKNOWN ☐

3. PATENTABILITY OF IDEA:
   Exceptional Av. Not Marketable
   CHECK IF UNKNOWN ☐

IF THE PROPOSAL IS AN IDEA - ASSUME IT HAS BEEN PATENTED AND CONTINUE. IF PROPOSAL IS A PATENT - BEGIN HERE.

4. MARKETABILITY OF PATENT:
   Exceptional Av. Not Marketable
   CHECK IF UNKNOWN ☐

5. DESIGN ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED ENGINEERING RESOURCES)
   Exceptional Av. Nonexistent
   CHECK IF UNKNOWN ☐

IF THE PROPOSAL IS AN IDEA OR PATENT - ASSUME IT HAS BEEN CONVERTED INTO A DESIGN AND CONTINUE. IF PROPOSAL IS A DESIGN - BEGIN HERE.

6. MARKETABILITY OF DESIGN:
   Exceptional Av. Not Marketable
   CHECK IF UNKNOWN ☐

7. PRODUCT OBJECTIVES OF COMPANY: Satisfied Av. Not Satisfied
   CHECK IF UNKNOWN ☐

8. COMMERCIALIZATION ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED)
   A. MANUFACTURING RESOURCES: Exceptional Av. Nonexistent
      CHECK IF UNKNOWN ☐
   B. MARKETING RESOURCES:
      Exceptional Av. Nonexistent
      CHECK IF UNKNOWN ☐
   C. MANAGEMENT RESOURCES:
      Exceptional Av. Nonexistent
      CHECK IF UNKNOWN ☐
   D. FINANCIAL RESOURCES:
      Exceptional Av. Nonexistent
      CHECK IF UNKNOWN ☐
9. COMPATIBILITY WITH COMPANY ENVIRONMENT: (CONSIDER EXISTING AND EXPECTED)
A. DEMAND:
   CHECK IF UNKNOWN □
   Very High Av. Very Low
   X
B. COMPETITION:
   CHECK IF UNKNOWN □
   None Av. Very Great
   X
C. MARKET NATURE:
   CHECK IF UNKNOWN □
   Broad Av. Narrow
   X
D. MARKET SIZE:
   CHECK IF UNKNOWN □
   Very Great Av. Very Small
   X
E. MARKET LOCATION:
   CHECK IF UNKNOWN □
   Very Accessible Av. Remote
   X
F. LEGAL CONDITIONS:
   CHECK IF UNKNOWN □
   Very Favorable Av. Adverse
   X

10. ADDITIONAL CHARACTERISTICS OF THE PRODUCT:
A. INVESTMENT:
   CHECK IF UNKNOWN □
   Very Small Av. Very Great
   X
B. LIFE CYCLE TIME:
   CHECK IF UNKNOWN □
   Very Long Av. Very Short
   X
C. PROFIT POTENTIAL:
   CHECK IF UNKNOWN □
   Very High Av. Very Low
   X
D. PROBABILITY OF SUCCESS:
   CHECK IF UNKNOWN □
   A Certainty Av. Negligible
   X

11. RECOMMENDATIONS:
    PROCEED IN LIFE CYCLE THROUGH Introduction PHASE.

    MARKET THE IDEA □ PATENT □ DESIGN □ PRODUCT(S) □
    MARKET BY SELLING □ LEASING □
    PROCEED WITH PRIORITY: HIGH □ MEDIUM □ LOW □

12. EXPLANATIONS: (EXPLAIN EACH CHECK IN THE RIGHT QUARTER OF THE SCALE; AND EXPLAIN EACH CHECK OF AN UNKNOWN)
   Device will probably be more complex and will require considerable tooling.
   Idea may not be patentable.

BY: Joe

PROPOSAL NO. 6
QUALITATIVE ANALYSIS - QUESTIONNAIRE

COMPLETED BY: Fred
PROPOSAL NO: 6

POSITION: President
DATE: 10/19/68

PROPOSAL IS AN IDEA □ PATENT □ DESIGN □ PRODUCT(S) □

DESCRIPTION OF PROPOSAL: Device to restrict mechanical motion except in the presence of an electrical voltage

NAME THE PRODUCT(S) OR POTENTIAL PRODUCT(S): Brake and transmission lock to prevent theft and accidental release of an automobile.

○ IF THE PROPOSAL IS AN IDEA - BEGIN HERE.
1. TECHNICAL FEASIBILITY OF IDEA: Exceptional Av. Not Feasible
   CHECK IF UNKNOWN □
2. MARKETABILITY OF IDEA:
   Exceptional Av. Not Marketable
   CHECK IF UNKNOWN □
3. PATENTABILITY OF IDEA:
   Exceptional Av. Not Marketable
   CHECK IF UNKNOWN □

○ IF THE PROPOSAL IS AN IDEA - ASSUME IT HAS BEEN PATENTED AND CONTINUE. IF PROPOSAL IS A PATENT - BEGIN HERE.
4. MARKETABILITY OF PATENT:
   Exceptional Av. Not Marketable
   CHECK IF UNKNOWN □
5. DESIGN ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED ENGINEERING RESOURCES)
   Exceptional Av. Nonexistent
   CHECK IF UNKNOWN □

○ IF THE PROPOSAL IS AN IDEA OR PATENT - ASSUME IT HAS BEEN CONVERTED INTO A DESIGN AND CONTINUE. IF PROPOSAL IS A DESIGN - BEGIN HERE.
6. MARKETABILITY OF DESIGN:
   Exceptional Av. Not Marketable
   CHECK IF UNKNOWN □
7. PRODUCT OBJECTIVES OF COMPANY: Satisfied Av. Not Satisfied
   CHECK IF UNKNOWN □
8. COMMERCIALIZATION ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED)
   A. MANUFACTURING RESOURCES: Exceptional Av. Nonexistent
      CHECK IF UNKNOWN □
   B. MARKETING RESOURCES:
      Exceptional Av. Nonexistent
      CHECK IF UNKNOWN □
   C. MANAGEMENT RESOURCES:
      Exceptional Av. Nonexistent
      CHECK IF UNKNOWN □
   D. FINANCIAL RESOURCES:
      Exceptional Av. Nonexistent
      CHECK IF UNKNOWN □
9. COMPATIBILITY WITH COMPANY Environment: (consider existing and expected)
   A. Demand: Very High Av. Very Low
      CHECK IF UNKNOWN
   B. Competition: None Av. Very Great
      CHECK IF UNKNOWN
   C. Market Nature: Broad Av. Narrow
      CHECK IF UNKNOWN
   D. Market Size: Very Great Av. Very Small
      CHECK IF UNKNOWN
   E. Market Location: Very Accessible Av. Remote
      CHECK IF UNKNOWN
   F. Legal Conditions: Very Favorable Av. Adverse
      CHECK IF UNKNOWN

10. ADDITIONAL CHARACTERISTICS OF THE PRODUCT:
    A. Investment: Very Small Av. Very Great
       CHECK IF UNKNOWN
    B. Life Cycle Time: Very Long Av. Very Short
       CHECK IF UNKNOWN
    C. Profit Potential: Very High Av. Very Low
       CHECK IF UNKNOWN
    D. Probability of Success: A Certainty Av. Negligible
       CHECK IF UNKNOWN

11. RECOMMENDATIONS:
    Proceed in Life Cycle through Introduction Phase.

    Market the Idea □ Patent □ Design □ Product(s) □

    Market by Selling □ Leasing □

    Proceed with Priority: High □ Medium □ Low □

12. EXPLANATIONS: (explain each check in the right quarter of the scales; and explain each check of an unknown)

    Idea is not marketable unless patented.
    The required investment is high but so is the probability of success. Therefore, the risk is not unreasonable.

BY: Fred

PROPOSAL NO. 6
### Qualitative Analysis - Summary Worksheet

**Completed By:** Fred  
**Proposal No.:** 6  
**Position:** President  
**Date:** 10/19/68

| Appraisal No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| Data          | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Weight        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Weighted Data |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Data          | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Weight        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Weighted Data |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Data          | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Weight        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Weighted Data |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Data          | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Weight        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Weighted Data |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

**Sum of Weights Used:** 10.28  
**Sum of Weighted Data:** 10.28  
**Averaged Data:** 10.28  
**Data/Weight Minimum:** 10.28  

**Remarks:** Appraisal No. 2 failed to meet its criteria.
QUALITATIVE ANALYSIS - QUESTIONNAIRE

COMPLETED BY: Averaged data PROPOSAL NO: 6

POSITION: ___________________________ DATE: 10/19/68

PROPOSAL IS AN IDEA □ PATENT □ DESIGN □ PRODUCT(S) □

DESCRIPTION OF PROPOSAL: Device to restrict mechanical motion except in the presence of an electrical voltage.

NAME THE PRODUCT(S) OR POTENTIAL PRODUCT(S): Brake and transmission lock to prevent theft and accidental release of an automobile.

□ IF THE PROPOSAL IS AN IDEA - BEGIN HERE.
  1. TECHNICAL FEASIBILITY OF IDEA: Exceptional Av. Not Feasible
     CHECK IF UNKNOWN □
  2. MARKETABILITY OF IDEA: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN □
  3. PATENTABILITY OF IDEA: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN □

□ IF THE PROPOSAL IS AN IDEA - ASSUME IT HAS BEEN PATENTED AND CONTINUE. IF PROPOSAL IS A PATENT - BEGIN HERE.
  4. MARKETABILITY OF PATENT: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN □
  5. DESIGN ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED ENGINEERING RESOURCES) Exceptional Av. Nonexistent
     CHECK IF UNKNOWN □

□ IF THE PROPOSAL IS AN IDEA OR PATENT - ASSUME IT HAS BEEN CONVERTED INTO A DESIGN AND CONTINUE. IF PROPOSAL IS A DESIGN - BEGIN HERE.
  6. MARKETABILITY OF DESIGN: Exceptional Av. Not Marketable
     CHECK IF UNKNOWN □
  7. PRODUCT OBJECTIVES OF COMPANY: Satisfied Av. Not Satisfied
     CHECK IF UNKNOWN □
  8. COMMERCIALIZATION ABILITY OF COMPANY: (CONSIDER EXISTING AND PLANNED)
     a. MANUFACTURING RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN □
     b. MARKETING RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN □
     c. MANAGEMENT RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN □
     d. FINANCIAL RESOURCES: Exceptional Av. Nonexistent
        CHECK IF UNKNOWN □
9. COMPATIBILITY WITH COMPANY ENVIRONMENT: (CONSIDER EXISTING AND EXPECTED)

A. DEMAND:
   CHECK IF UNKNOWN □
   Very High □ Av. □ Very Low □
   X

B. COMPETITION:
   CHECK IF UNKNOWN □
   None □ Av. □ Very Great □
   X

C. MARKET NATURE:
   CHECK IF UNKNOWN □
   Broad □ Av. □ Narrow □
   X

D. MARKET SIZE:
   CHECK IF UNKNOWN □
   Very Great □ Av. □ Very Small □
   X

E. MARKET LOCATION:
   CHECK IF UNKNOWN □
   Very Accessible □ Av. □ Remote □
   X

F. LEGAL CONDITIONS:
   CHECK IF UNKNOWN □
   Very Favorable □ Av. □ Adverse □
   X

10. ADDITIONAL CHARACTERISTICS OF THE PRODUCT:

A. INVESTMENT:
   CHECK IF UNKNOWN □
   Very Small □ Av. □ Very Great □
   X

B. LIFE CYCLE TIME:
   CHECK IF UNKNOWN □
   Very Long □ Av. □ Very Short □
   X

C. PROFIT POTENTIAL:
   CHECK IF UNKNOWN □
   Very High □ Av. □ Very Low □
   X

D. PROBABILITY OF SUCCESS:
   CHECK IF UNKNOWN □
   A Certainty □ Av. □ Negligible □
   X

11. RECOMMENDATIONS:

   PROCEED IN LIFE CYCLE THROUGH Introduction PHASE.

   MARKET THE IDEA □ PATENT □ DESIGN □ PRODUCT(S) □

   MARKET BY SELLING □ LEASING □

   PROCEED WITH PRIORITY: HIGH □ MEDIUM □ LOW □

12. EXPLANATIONS: (EXPLAIN EACH CHECK IN THE RIGHT QUARTER OF THE SCALE; AND EXPLAIN EACH CHECK OF AN UNKNOWN)

   Idea is not marketable unless potential.
   The investment required to proceed through introduction phase is very great but with acceptable limits.
   Above average profit potential and probability of success offset this disadvantage.

   BY: Averaged data PROPOSAL NO. 6
DISCOUNTED ASSET VALUE ($____*) = BEGINNING ASSET VALUE ($/000) + DISCOUNTED CASH FLOW

DECISION DIAGRAM - DESIGN BRANCH (IF PATENT SUCCESSFUL)
**PROPOSAL NO. 6**

**DATE: 10/19/68**

**EARNINGS & INVESTMENT ANALYSIS - LIFE CYCLE**

**PATENT: SUCCESSFUL ☑ NOT SUCCESSFUL ☐ NOT ATTEMPTED ☐**

$ MULTIPLIER X 100  DISCOUNT RATE PER QUARTER 3%$

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DATE: 10/19/68

CASH FLOW ANALYSIS SUMMARY - LIFE CYCLE

PATENT: SUCCESSFUL ☒ NOT SUCCESSFUL ☐ NOT ATTEMPTED ☐

$ MULTIPLIER X 100 ☐ DISCOUNT RATE PER QUARTER ☐ 3 ☐

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EARNINGS ANALYSIS: IDEA □ PATENT □ DESIGN ✗

PATENT: SUCCESSFUL ✗ NOT SUCCESSFUL ☐ NOT ATTEMPTED ☐

DESIGN: SUCCESSFUL ✗ NOT SUCCESSFUL ☐ NOT ATTEMPTED ☐

MARKET METHOD: SELL .6 LEASE .4 (Probability)

DISCOUNT RATE 12% EFFECTIVE YEAR OF MARKETING 1½

COST OF MARKETING $1000 DISCOUNTED COST OF MARKETING $840

DISCOUNTED EXPECTED EARNINGS IF LEASED:

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TOTAL: 128,400

DISCOUNTED EXPECTED EARNINGS IF SOLD:

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EXPECTED EARNINGS TOTAL: 106,500

© DISCOUNT FACTOR .637

TOTAL: 88,300

X .6: 53,000

DISCOUNTED EXPECTED EARNINGS (BOTH METHODS): $104,300
EARNINGS ANALYSIS:  IDEA □ PATENT □ DESIGN □

PATENT: SUCCESSFUL □ NOT SUCCESSFUL □ NOT ATTEMPTED □

DESIGN: SUCCESSFUL □ NOT SUCCESSFUL □ NOT ATTEMPTED □

MARKET METHOD: SELL □ LEASE □ (Probability)

DISCOUNT RATE 12% EFFECTIVE YEAR OF MARKETING 12

COST OF MARKETING $1000 DISCOUNTED COST OF MARKETING $840

DISCOUNTED EXPECTED EARNINGS IF LEASED:

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EXPECTED EARNINGS TOTAL: 30,000

@ DISCOUNT FACTOR .837 TOTAL: 25,110

X.6: 15,070

DISCOUNTED EXPECTED EARNINGS (BOTH METHODS): $30,380
EARNINGS ANALYSIS: IDEA □ PATENT ☐ DESIGN ☐

PATENT:
SUCCESSFUL ☐
NOT SUCCESSFUL □
NOT ATTEMPTED □

DESIGN:
SUCCESSFUL □
NOT SUCCESSFUL □
NOT ATTEMPTED ☐ (Probability)

MARKET METHOD:
SELL .6
LEASE .4

DISCOUNT RATE 12%
EFFECTIVE YEAR OF MARKETING 1
COST OF MARKETING $1000
DISCOUNTED COST OF MARKETING 890

DISCOUNTED EXPECTED EARNINGS IF LEASED:

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EXPECTED EARNINGS TOTAL: 30,000

* DISCOUNT FACTOR .888

TOTAL: 26,760

* DISCOUNT FACTOR .6

TOTAL: 16,050

DISCOUNTED EXPECTED EARNINGS (BOTH METHODS): 31,370
$ MULTIPLIER x 100

DISCOUNTED ASSET VALUE ($___)* = BEGINNING ASSET VALUE ($/000) + DISCOUNTED CASH FLOW

DECISION DIAGRAM - DESIGN BRANCH (IF PATENT NOT SUCCESSFUL)
EARNINGS & INVESTMENT ANALYSIS - LIFE CYCLE

PATENT: SUCCESSFUL □ NOT SUCCESSFUL □ NOT ATTEMPTED □

$ MULTIPLIER X 100 □ DISCOUNT RATE PER QUARTER □ 3 □

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# Cash Flow Analysis Summary - Life Cycle

**Patent:** SUCCESSFUL ☐ NOT SUCCESSFUL ☒ NOT ATTEMPTED ☐

$ Multiplier x 100$  
**Discount Rate Per Quarter:** 3%

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PROPOSAL NO. 6
DATE: 10/19/68

EARNINGS ANALYSIS: IDEA □ PATENT □ DESIGN ☑

PATENT:
SUCCESSFUL ☑
NOT SUCCESSFUL ☑
NOT ATTEMPTED ☑

DESIGN:
SUCCESSFUL ☑
NOT SUCCESSFUL ☑
NOT ATTEMPTED ☑

MARKET METHOD:
SELL .6
LEASE .4
(Probability)

DISCOUNT RATE 12%
EFFECTIVE YEAR OF MARKETING 13/4

COST OF MARKETING $1500
DISCOUNTED COST OF MARKETING $1220

DISCOUNTED EXPECTED EARNINGS IF LEASED:

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<th>DISCOUNTED EXPECTED EARNINGS</th>
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EXPECTED EARNINGS TOTAL: 66,000

© DISCOUNT FACTOR .813
TOTAL: 53,600

X .6: 36,160

DISCOUNTED EXPECTED EARNINGS (BOTH METHODS): $70,960
PROPOSAL NO. 6
DATE: 10/19/68

EARNINGS ANALYSIS: IDEA ☑ PATENT □ DESIGN □

PATENT: SUCCESSFUL ☑ NOT SUCCESSFUL ☑ NOT ATTEMPTED □
DESIGN: SUCCESSFUL ☑ NOT SUCCESSFUL ☑ NOT ATTEMPTED □
MARKET METHOD: SELL 9 LEASE 1 (Probability)

DISCOUNT RATE 12% EFFECTIVE YEAR OF MARKETING 134
COST OF MARKETING $1000 DISCOUNTED COST OF MARKETING $810

DISCOUNTED EXPECTED EARNINGS IF LEASED:

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EXPECTED EARNINGS TOTAL: 5350

EX DISCOUNT FACTOR .813 TOTAL: 4350

X .9 : 3920

DISCOUNTED EXPECTED EARNINGS (BOTH METHODS): $4670
PROPOSAL NO. 6
DATE: 10/19/68

EARNINGS ANALYSIS: IDEA ☒ PATENT ☐ DESIGN ☐

PATENT:
SUCCESSFUL ☒
NOT SUCCESSFUL ☐
NOT ATTEMPTED ☐

DESIGN:
SUCCESSFUL ☒
NOT SUCCESSFUL ☐
NOT ATTEMPTED ☐

MARKET METHOD:
SELL .9
LEASE .1
(Probability)

DISCOUNT RATE 12%
EFFECTIVE YEAR OF MARKETING 1 1/4

COST OF MARKETING $1000
DISCOUNTED COST OF MARKETING $860

DISCOUNTED EXPECTED EARNINGS IF LEASED:

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EXPECTED EARNINGS TOTAL: 5350

DISCOUNT FACTOR .863
TOTAL: 4620
X .9: 4160

DISCOUNTED EXPECTED EARNINGS (BOTH METHODS): $4910
PROPOSAL NO. 6
DATE: 10/19/68

$ MULTIPLIER X 100

(MANUFACTURE)

(DESIGN)

DESIGN?

YES

NO

OUT. ($332)*

OUT. ($382)*

OUT. ($63)*

OUT. ($716)*

OUT. ($68)*

OUT. ($76)*

OUT. ($967) *

DISCOUNTED ASSET VALUE ($____) = BEGINNING ASSET VALUE ($/000) + DISCOUNTED CASH FLOW

DECISION DIAGRAM - DESIGN BRANCH (IF PATENT NOT ATTEMPTED)
EARNINGS & INVESTMENT ANALYSIS - LIFE CYCLE

PATENT: SUCCESSFUL ☐ NOT SUCCESSFUL ☐ NOT ATTEMPTED ☒

$ MULTIPLIER \times \frac{\text{DISCOUNT RATE PER QUARTER}}{100} = 3\%$

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CASH FLOW ANALYSIS SUMMARY - LIFE CYCLE

PATENT: SUCCESSFUL ☐ NOT SUCCESSFUL ☐ NOT ATTEMPTED ☑

$ MULTIPLIER X 100  DISCOUNT RATE PER QUARTER 3 ½

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EARNINGS ANALYSIS: IDEA □ PATENT □ DESIGN ☒

PATENT:
SUCCESSFUL ☐
NOT SUCCESSFUL ☐
NOT ATTEMPTED ☒

DESIGN:
SUCCESSFUL ☒
NOT SUCCESSFUL ☐
NOT ATTEMPTED ☐

MARKET METHOD:
SELL 6
LEASE .4
(Probability)

DISCOUNT RATE 12%
EFFECTIVE YEAR OF MARKETING 2

COST OF MARKETING $1500
DISCOUNTED COST OF MARKETING $1260

DISCOUNTED EXPECTED EARNINGS IF LEASED:

<table>
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<th>DISCOUNT FACTOR</th>
<th>DISCOUNTED EXPECTED EARNINGS</th>
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EXPECTED EARNINGS TOTAL: 66,000

@ DISCOUNT FACTOR .837
TOTAL: 55,200
X .6: 33,120

DISCOUNTED EXPECTED EARNINGS (BOTH METHODS): $71,920
PROPOSAL NO. 6
DATE: 10/19/68

EARNINGS ANALYSIS: IDEA ☒ PATENT ☐ DESIGN ☐

PATENT:  SUCCESSFUL ☐ NOT SUCCESSFUL ☐ NOT ATTEMPTED ☒
DESIGN:  SUCCESSFUL ☐ NOT SUCCESSFUL ☐ NOT ATTEMPTED ☒

MARKET METHOD: SELL .9  LEASE .1  (Probability)

DISCOUNT RATE 12%  EFFECTIVE YEAR OF MARKETING 1/2

COST OF MARKETING $1000  DISCOUNTED COST OF MARKETING $840

DISCOUNTED EXPECTED EARNINGS IF LEASED:

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<th>DISCOUNT FACTOR</th>
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DISCOUNTED EXPECTED EARNINGS IF SOLD:

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EXPECTED EARNINGS TOTAL: 5350

@ DISCOUNT FACTOR .837  TOTAL: 4480

I .9 .: 4030

DISCOUNTED EXPECTED EARNINGS (BOTH METHODS): $4780
EARNINGS ANALYSIS:  IDEA □ PATENT □ DESIGN □

PATENT:  SUCCESSFUL □  NOT SUCCESSFUL □  NOT ATTEMPTED □
DESIGN:  SUCCESSFUL □  NOT SUCCESSFUL □  NOT ATTEMPTED □

MARKET METHOD:
SELL  9
LEASE  .7
(Probability)

DISCOUNT RATE  12%
EFFECTIVE YEAR OF MARKETING  1
COST OF MARKETING  $1000
DISCOUNTED COST OF MARKETING  $890

DISCOUNTED EXPECTED EARNINGS IF LEASED:

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<th>DISCOUNT FACTOR</th>
<th>DISCOUNTED EXPECTED EARNINGS</th>
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DISCOUNTED EXPECTED EARNINGS IF SOLD:

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@ DISCOUNT FACTOR .888
TOTAL: 4750
X .9: 4260

DISCOUNTED EXPECTED EARNINGS (BOTH METHODS): $5030
## SUMMARY OF OUTPUT ALTERNATIVES

**Page 1**

**"MUST" CRITERIA:**

\[
\begin{align*}
W_M &= 0.77 \\
X_M &= -\frac{500}{\text{Dollars} \times 100} \\
Y_M &= \frac{2}{\text{Years}} \\
Z_M &= \frac{3}{\text{Years}}
\end{align*}
\]

**"WANT" CRITERIA:**

\[
\begin{align*}
a &= \frac{Z}{\text{nd}} \\
b &= \frac{0.0005}{\text{per 100 Dollars}} \\
c &= \frac{0.045}{\text{per Year}} \\
d &= \frac{0.033}{\text{per Year}}
\end{align*}
\]

**PROPOSAL NO.** 6

**DATE:** 10/19/68

<table>
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<th>OUTPUTS (PATENT SUCCESSFUL)</th>
<th>P_M</th>
<th>v</th>
<th>x</th>
<th>y</th>
<th>z</th>
<th>Δv</th>
<th>Δx</th>
<th>Δy</th>
<th>Δz</th>
<th>D_M</th>
<th>D_N</th>
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<th>y</th>
<th>z</th>
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Figure III-1.--THE PRODUCT ANALYSIS AND DECISION PROCESS
## Earnings Analysis

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**By:** 

**Date:**

*Figure III-7.*
Figure III-6.---PRESENT VALUE TABLE

DISCOUNT FACTOR AS A FUNCTION OF TIME AFTER DECISION FOR VARIOUS DISCOUNT RATES

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INVESTMENT ANALYSIS

PROPOSAL NO. ____________________________

PROPOSAL MANAGER ____________________________

TASK(PHASE): IDEA □ PATENT □ DESIGN □ PRODUCT □

INVESTMENT CASH FLOW DISCOUNT RATE __% QUARTERLY

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TOTAL: ____________________________

BY: ____________________________

DATE: ____________________________

Figure III-5.