IDENTIFICATION AND COMMUNICATION
OF USER NEEDS TO THE DESIGNER

A STUDY OF METHODS OF IDENTIFICATION AND COMMUNICATION OF USER NEEDS TO THE DESIGNER.

by

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ABSTRACT

With the growth of technology there is recognition of the fact that communication requires improving between decision-makers and the people who will eventually use or be affected by the system under consideration. The main thrust of this work is to explore means of facilitating clear unambiguous communication of relevant needs to all parties involved in the design process.

A number of approaches to this problem from different disciplines are reviewed. Some of these approaches are already in existence while others require adapting to the particular problems encountered in the design process.

Suggestions are put foreward as to how these techniques can be integrated to produce a unified approach to the problem of producing a Total Specification embodying all information necessary to the designer in his capacity as decision-maker.

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CHAPTER ONE

INTRODUCTION

Underlying many areas of debate today, notably topics such as ecology, is the question of the accountability of technology. A closely allied subject is how much say people should have in their future.The future today, in the industrialized nations of the world at least, can be linked with the growth and development of technology.

Societies such as these, where control of affairs is accomplished by appeals to specialized technical expertise can be called technocracies (ROY 1972). Three telling criticisms can be leveled against them :

i) Technology is 'out of control' and we are trapped in a 'spiral of progress'.

ii) The ordinary citizen cannot participate in decision-making because of the technical complexity of the issues involved.

iii) The technocracy offers only a single vision of the future; namely a shinier version of the present.

These are blanket criticisms of the whole governmental/company infrastructure, but as we shall see they can be considered valid in specific instances.

Our everyday life is shaped and conditioned by the consequences, good and bad, of living in these technocratic societies. Some of these consequences can be predicted, but many are the result of complex interactions with the environment and society, which are either incompletely understood, or not understood at all, while others are the result of inadequate, inaccurate or biased information about what people wish the powers of technology to accomplish for them. When these consequences are good, or at best indifferent, all is fine; but when they are bad people seek to attach some degree of blame to something or someone. This someone, in the engineering category at least, is the designer, the creator of technical products and processes.

It is not, however, the designer personally who is lacking, but, as we shall see, the whole structure of the design situation. Too often the designer is out of touch with the people who will actually use or be affected/afflicted by the product or process. Perhaps he is insulated from them by various interposed specialists who, although they might be able to indicate roughly what they think people will or can be persuaded to buy, cannot tell him what people would buy if they knew what they needed and it was available. Perhaps he is isolated by simple preference or ignorance but here, in the latter situation at least, we can help him.

Marketing is, in the public view anyway, a much maligned activity, perhaps because of its close connection with advertising, but does in fact do much useful work connected with both selling the product and formulating needs for new products. However, there is a large rift between marketing and the design field, and because of, or perhaps as a result of this, neither field completely understands or trusts the other. A common occurance cited by HOGNANDER (1962), is that "the designer is called in too late and too little and given only part of the picture...sometimes even a censored version of the customer's requirements...But they are asked to go ahead with what they have been given". Thus we can see the designer may be deprived of much important information which he requires.

This situation is not aided by the fact that the designer, especially in the engineering category, has a rather restricted viewpoint, produced by his education, by the compartmentalization of many designers in a manufacturing situation, and by the increasing level of technical sophistication demanded. As a result of this pressure the designer is forced, more and more, to concentrate on the technical aspects of the design, giving a purely technical solution, with the resulting tendency to ignore or disregard the user. This trend has been dubbed by GREGORY (1966, Introduction), as a "retreat from the spirit of design". This view is also held by others such as DIFFRIENT (1973) who says; "If the designer, bent on satisfying a sterile program of profit and basic function alone, fails to add concepts that are restful, pleasurable, informative, entertaining, emotive or others necessary to enrich the human sensorium then he is dangerously naive in his work."

This problem has long been recognized in management circles; to quote DRUCKER (1954), "What is our business (he writes) is not defined by the company's name, statutes or articles of incorporation...but by the want the customer satisfies when he buys a product or service... What the customer sees, thinks, believes and wants at any given time must be accepted by management as an objective fact...deserving to be taken as seriously as the reports of salesmen, the tests of the engineer or the figures of the accountant". He adds that few managements find this easy to do and evidence is that there are still far too few who give the idea more than lip service.

These views serve to illustrate that there must be a greater concern with the whole consumer/user and not just in his consumptive and economic functions. We must consider the whole man and try to explore the entire repertoire of man's emotions in their almost wholly unexplored relationships to daily life with machines.

HOGNANDER (1962) approaches the solution of this important problem by setting out guidelines which, it is hoped, will improve co-ordination between the forces of marketing and design. The approach taken here, however, will be similar to that advocated by such people as DIFFRIENT (1973), GREGORY (1966), DE NEUFVILLE and KEENEY (1972), LIFSON (1962), and SIDDALL (1972), in helping the designer directly by use of techniques which can be legitimately exploited to indirectly increase satisfaction of the customer or user.

The whole of the above problem has received much attention in recent literature under the general title of Design Participation. In these discussions, not only is the function of the designer put to scrutiny, but the whole question of the place of the designer is questioned. Many studies squarely confront the design situation with its paternalistic attitude and point the way to a situation where the user/customer can be helped, through the technical expertise of the designer, to design for himself the product he wants. The impact of these studies on the design situation will be noted and the design situation will be examined.

We can now outline the main thrust of this work, we wish to improve the communication of values, needs, and desires of the user/customer to the designer, not by hand-waving generalities, but by the use of some formalized technique. For convenience this may be looked upon as formulating a Total Specification as opposed to the technical specification presently used in the design of devices and systems. Admittedly this technical specification is supplemented to a greater or lesser extent by extra information available to the designer of a socio-politico-geographic nature. The acquisition of this information is a rather haphazard affair. We hope to improve this process of information-gathering by setting out guidelines for the designer to follow. We will make use of a growing body of knowledge dubbed 'decision analysis'. This differs from more traditional analyses in the degree to which the subjective attitudes of various people or groups involved in the decision process are encoded for formal analysis. These subjective factors are embodied through the use of judgemental or subjective probabilities and also in the scaling of preferences and values by utilities. A more thorough discussion of the scope of the subject is given by KEENEY and RAIFFA (1973).

This study attempts to answer some of the difficult problems facing design today by analysing the design process to bring out areas thought important for a deeper understanding of these problems. A number of approaches to these problems are critically examined in the light of the aforementioned analysis. This review and critique of these various approaches ,both old and new,is supplemented by a number of recommendations concerning the scope and degree of usefulness that might be expected of these methods.

CHAPTER TWO

THE DESIGN PROCESS

2.1 The Design Process and the Designer in Society

The activity of design, MARKUS (1972), is "a purposeful goal orientated search. The system is considered to consist of people and objects interacting in a complex way. The people are considered to be goal orientated, seeking to achieve objectives of an ideal kind by achieving more immediate goals (or subgoals). The search is for a physical solution to a perceived and more or less understood problem. Always the search has to be successful within certain constraints."

This perhaps characterizes the design situation in its most general terms and in contrast to many other definitions shows an awareness of the intermediate or instrumental quality of evaluation criteria often taken as fixed or final in the design process. This characterization does not define who is doing the designing, an important generalization as we shall see.

This last point leads us straight to a brief discussion of the designer in the design process. As mentioned above, thought must be given to 'user participation' in design. This movement has flowered and grown on the dissatisfactions with design today. As CROSS (1962) has noted, "For the layman who is on the receiving end of the design process, much of what the various professionals hand down to him must seem a very mixed blessing. Many developments seem to have as many harmful side effects as the promises for enrichment of society. Too frequently the most the layman can do is protest when it is too late and the element of consultation is absent. The professional designers of every field have failed in their assumed responsibilities to design out these harmful side effects. These side effects can no longer be regarded as inevitable. There is a running tide of discontent which is an indication that many people are not prepared to accept the rising price of progress."

The foregoing can be taken as a general view of the design field as a whole; certain points and descriptions hold more or less weight in the various subdivisions of design, but in general it is valid for all of them.

At the present time a high proportion of designers can be said to be conservative . This format of the professional engineer has been roundly criticised by FRIEDMAN (1962) as producing a paternalistic system where the evaluation criteria are defined in terms of a preconceived average user, (a concept we shall refer to again) and more importantly in that it separates risk-taking from decision-making; ie. designer makes the decision and the future user takes the risks. There are signs of a shift sway from this end of the continuum, notably in the field of architecture.

Recent studies in the literature indicate that, speaking generally, design participation can operate in two main ways;

a) Modify the design process so that the future users can explore the feasible solutions themselves either using some form of interactive computer system, or more restrictively and less usefully, explore some feasible solutions generated by the designer. ARCHITECTURE MACHINE GROUP (1971), MALVER (1971)

b) One can supply the designer with sufficient relevent information about individual and group preferences (not the average), aims, needs, goals, such that he can make decisions which are analegous to those made in the first type of situation. SIDDALL (1972), DE NEUFVILLE and KEENEY (1973).

2.2 Typical Design Methodology

A typical design methodology will be presented and various points arising from it will discussed in later sections. The methodology presented is summarized in Figure 2.1 and is that of ASIMOV (1962). Although primarily formulated for an engineering situation it is one of the most general. Other excellent, and basically similar formulations, such as that of KLINE and LIFSON (1971) also exist.

The Primitive Need

The initiating force behind any project is the primitive need which may have been observed currently in

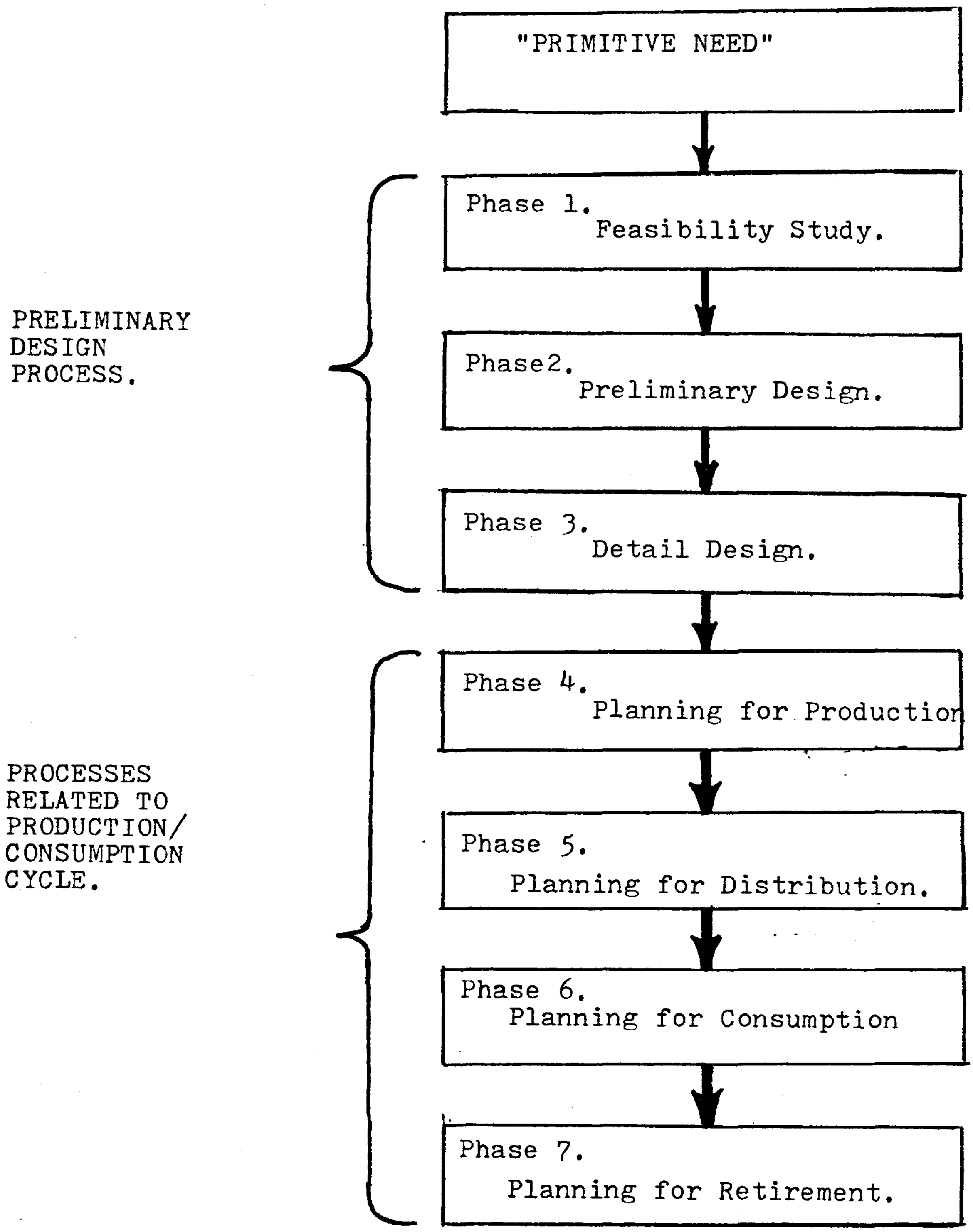

FIGURE2.1, The Phases of a Complete Project.

After ASIMOV(1962).

the socio-economic system. The need sometimes is not apparent but there will then be evidence of its latency. This primitive need may be recognized originally by sales personnel, directors, inventors, dissatisfied customers or it may be actively sought by marketing through use of advanced techniques. HALL (1962,Chap. 6) discusses some of the main aspects of this.

Phase 1 Feasibility Study

This phase begins with information - information about the needs which the system/product is being designed to satisfy, resources available, the environment in which the system will operate, and the constraints on all these factors. This input information sets the bounds of the problem.

The next operation is to verify the actual existence of the primitive need. Too often an organization will develop a product or system only to find the need was chimeric in nature and was negligeble and disappeared in the harsh light of reality.

The next step in the process is to consider the constraints on the system and to synthesize a number (if any actually can be synthesized) of feasible solutions which will fulfill the original needs within the constraints of the problem. Often during this phase new points will be raised which may require that a critical reassessment of the constraints and needs be undertaken. Very often this procedure will bring to light a set of evaluating criteria against which the 'goodness' of any particular solution can be measured.

If we take the user/customer's need to be the 'objective function', to use optimization terminology, we can list some common constraints on the solution.

Objective Function

The design must be a response to individual or social needs which can be satisfied by technological forces. The purpose is to maximize total system worth.

Constraints

Physical realisability - the object of the design is a material object or system which must be physically realisable ie. meets specifications.

Economic Worthwhileness

The product or system must have a utility to the customer/user that equals or exceeds the sum of the proper costs involved in making it available to him.

Financial Feasibility

The operations of designing, producing and distributing the product or system must be financially supportable.

Up until this stage in the design process we have been sifting and sorting the user/customer requirements and trying to consider all possible influences, showing how well we have understood the initial formulation. The next important step, which is too often neglected, is to reconsult the user/customer to see if we really have understood him.

Phase II Preliminary Design

The purpose here is to establish which of the alternatives which were synthesized, is the 'best' design concept.

Phase III Detailed Design

Up until this point the design has been characterized by great fluidity, but from here onward a specific concept must be considered and the design details worked out or the project abandoned or reformulated.

Phases IV-VII. Phases Concerned with the Production Consumption Cycle

While the previous phases were almost completely under the control of the designer, quite often, especially in the engineering field, another set of specialists move in and even though over-all control may rest with the design group, the process from here on does not directly interest us.

We have seen a typical design methodology which covers most of the important points. One point not brought out was the iterative nature of the parts of the project. Iterative steps can take place both within phases and between phases.

If we consider the early steps of the project, the recognition of primary need and certain parts of the feasibility study, we can see that they are mainly characterized by an information input to the designer and this information transfer will now be discussed.

2.3 The Information Gathering Process

KLINE and LIFSON (1971) make the point that this stage (they call it the planning period), is primarily the responsibility of the system user; "..he (the user) is intimately involved with the operation and support of the system, most directly concerned with the resources available and needs to be satisfied and therefore best able to specify requirements for an optimum. [Sometimes this is true but in many cases, especially in the consumer field, this knowledge is split between the manufacturer and the user/customer]. It is his need which must be satisfied and it is his responsibility to adequately state his need, to identify the resources which will be available to meet the need and to describe the environment and constraints in which the system is to be developed, produced, operated and supported." They then make the additional point that in most instances the users or customers cannot do this themselves. They are not able to transform their need into a set of concepts, sketches or plans. They require the help of a designer.

It is this process of how the user/customer formulates and transmits his needs that will occupy our attention in the later chapters but first we must further examine the design process.

Before a design project can get under way, certain parameters have to be identified, the goals of the decision makers should be known, why the design effort has been undertaken. Further needs must be identified and a set of design criteria must be established, [LIFSON (1962)]

The goals, in general, come from inside the design situation. It must be remembered that this is a discussion of a typical engineering design situation and that in a completely participatory situation there would not be this form of distinction between the goals and needs, and the needs would flow directly from the user/customer's goal, while in the conventional situation the requirement that the designer/organization should make a profit rather complicates the issue - the goals of the decision makers may then be to make a profit and enhance their reputation by having a satisfied customer. Under suitable circumstances both can give the same results but a distinction is still necessary here.

Next we must have a carefully defined statement of need. This need is very difficult to fully define and is often presented in an ambiguous and amorphous form, not at all suitable for use as the basis of the design process. This then is the primitive need referred to previously and this has to be clarified, expanded and verified. We shall call it a primitive need because we mean the statement represents opinion based mainly on casual observation unsupported by organized evidence. The initial ideas can come from a variety of sources, as mentioned in Section 2.2.

Of course a user can come directly to the designer, in which case his needs do not quite fit the above description, but for reasons discussed later we can still term them primitive needs.

The primitive statement suggests the problem situation which might be thought of as an alleged need, presented in primitive form ascribed to various kinds of potential users/customers, who might seek the product in some unidentified market place, acted upon by unidentified competitive influence and subject of unknown economic, political and social pressures.

Arising from this statement of need and probably from the feasibility study, we have a set of design criteria. These will express how well our solutions satisfy the original goals and needs.

The designer then has to assemble all this information, or at least the goals and needs, before he can really get to grips with the problem. This information comes from a large number of incompletely defined sources of various degrees of reliability, marketing probably supplying the most. The designer is however, usually thrown back on his own resources , his intuition, his 'social intelligence', his 'feel for the problem'. Some designers are good at this but there is evidence that many are not particularly good. This may be force of habit or by pressure of training but we shall look more deeply in later chapters at ways by which a designer can gain this further insight into user/customer needs.

Thus far we have used many terms such as need, goal, and others in ambiguous and ill-defined ways, but a full discussion of these terms will be presented in a later chapter. We shall now consider further the ideas of value systems, design criteria and the concept of optimality in design.

2.4 Value Systems as Determinants of Decision-Making

As we have seen, decision-making permeates the design process. We must postulate the existence of an underlying value system which gives meaning to each design decision and forms the basis of decision-making. Without a knowledge of the relevant values in any situation there is a strong possibility that the design effort produces solutions to problem situations other than those really wanted. This is the problem, the author believes, that is causing much of the disquiet at the moment. The powers of technology are demonstrably large but methods of directing them with sufficient fineness are relatively lacking.

LIFSON (1962) has listed three sources of value systems in a design situation.

a) The personal value system of the designer

b) The value system of the organization in which he works

[this may not always be fully applicable]

c) The value system of the society in which the designer and organization exist.

This is a useful categorization although others have listed further sources of value systems which impinge on the design situation. ASIMOV (1962) lists those of distributing and manufacturing but for convenience and generality we shall include those under headings b) or c) as may be applicable in any particular case.

It will be noticed that the value system of the customer/user is not explicitly considered unless Lifson includes it in the general heading," value system of society." This, however, is not really very useful, as the value system which can be ascribed to society must be comprised of such general and well agreed axioms that it is of no real use in any particular problem in identifying user needs (unless of course the solution is to be valid for all society in any situation - a not very usual condition). These various value systems will interact during decision-making but how and to what extent is not known.

One would hope that the user's value system is, to as large an extent as possible, the determining factor in decision-making, but again this is largely unknown. It can be argued that the user's value system is not considered enough for three main reasons;

a) The designer does not know about the user's value system.

b) The designer may resist designing for the user's value system because it conflicts with his own.

c) The designer may be subtly, or overtly, pushed by organizational pressures to design within, (and thus be restricted by), the scope of some organizational self-image.

HOGNANDER (1962) comments on aspects b) and c) by quoting the vice-president of Lever Brother Company, Robert F. Elder as saying; "One of the most common sources of product trouble is the producer's feeling that he, and not the customer knows best what the product put on sale should be. Sometimes this is sheer stuffiness, sometimes it is pride in craftsmanship, sometimes an honest conviction that the public must be educated up to the manufacturers own standards of intrinsic quality."

It can be seen that value systems have a large effect on decision making and we shall see, in a rather simplified way, how they effect it.

2.5 Optimality and Decision Making

Although not mentioned specifically in the definition of design in Section 2.1, design is connected quite closely with the idea of optimization by use of the phrase, 'seeking to achieve objectives of an ideal kind by achieving more immediate goals". This idea, optimization, is central to the design process.

A good engineering definition of optimality would be

ASIMOV (1962); "..one choice among the gamut of satisfactory choices which will be as good as or better than any other". The introduction of the words 'good' and 'better' implies the existence of a value judgement and such judgements only have meaning with reference to criteria, the design criteria as we have called them. We can say then that the choice of criteria profoundly influences the final design outcome.

Sometimes we will have to judge an object on just a single criteria (or one may be so dominant we can consider it to be judged on a single criteria) and here if we know our criteria the situation is relatively straight foreward, relatively because even in this simple situation the computational or knowledge constraints on the problem may be so difficult to circumvent that no solution is possible. There will however, be many situations where a decision will have to be made among alternatives, each of which consists of a number of subjectively disparate attributes, for example one may be big and blue, the other small and scarlet. This immediately brings us to the point that optimization is only possible with respect to one criterion, colour or size. In this case, if we wish to take account of both these 'dimensions' of attributes, we must somehow form a single criterion from these disparate criteria of colour and size. There are a number of ways of accomplishing this. ASIMOV (1962)

a) Set up a composite criterion in which each of the component criteria is given a relative weight, which expresses its importance in that particular situation, thereby establishing a single criteria.

b) Convert the lesser (importance) criteria into constraints by giving them some upper and lower limits of acceptance. This means in practice that the optimization will be accomplished while the design is pushed to the acceptance limits of these subcriteria.

c) A third method, which is in practice the same as a), but the concept behind which will be of use later, is to collapse or resolve the separate attributes onto a single good-bad evaluative continuum.

This method of setting up a composite criterion is known as Multifactor Optimization and is used mainly in the solution of problems using computer techniques, although it is used all the time by people in a purely intuitive way. An interesting question is whether the process is done in any 'optimal' way.

SHEPARD (1964) has argued that the human brain, while being an excellent analyzer of information, is relatively poor at the process of synthesis. The relative poorness of the human brain in this second phase is attributed by Shephard to the fact that this subjective non-optimality is a result of man's inability to take proper account simultaneously of the various component attributes. That is, although he will experience little difficulty in evaluating the alternatives with respect to any one of these subjective attributes, his ability to arrive at an overall evaluation by weighing and combining or "trading off" these separate variables at the same time has been demonstrated experimentally to be poor. Shepard then suggests that the analysis stage be done by humans and put in explicit form with a given set of weights for the various attributes, so the synthesis stage can be done mechanically by a computer, using simple algebraic laws of combination. He goes on to cite examples showing the success of this method in diverse fields notably, those of MEEHL (1954). It might be argued that surely the very act of expressing these factors explicitly, instead of having them as vague notions will be sufficient, and that the designer can make the synthesis stage using much more complex laws of combination to take care of other factors, perhaps factors operating at a subconscious level, than the simple linear laws used in the above examples. Shepard found this also to be untrue by questioning subjects after they had made one of these decisions and it was found that even with the information presented explicitly, the subjects tended to make their judgements on one or two attributes out of many, even though they may have at a different time acknowledged these to be of small importance. Simple mechanical combination using simple linear combinations generally gave better judgements.

This discussion is important because it illustrates that if we can obtain an explicit expression of the relevant factors then we can, by using some simple laws of combination, obtain judgements of more value than if we use unassisted human judgement. This sounds good but there are a number of pitfalls and difficulties; getting explicit expression of these factors is not easy and the laws of combination are not quite as simple as Shepard makes it appear.

If we are to combine these various factors (assuming we have identified them as criteria) we must assign a set of relative weights to them. These weightings are difficult to determine as they may change with the adoption of several incompatible but equally tenable systems of subjective sub-goals, SHEPARD (1964). These different systems of sub-goals can be linked with the various value systems, which were discussed in section 2.4, and which influence the design process. Shepard suggests that the designer tries out some of these 'value systems' or 'frames of mind' to help him make a decision in difficult situations. This seems to be borne out casually by the common observation that ' whoever this was designed for, it wasn't the person who will have to use it!' It was designed under the influence of some value system other than the users. Although, of course, it may be just faultily designed. ASIMOV (1962), brings up the point that a designer, in order to design a product that can be made, financed etc. must be able to assume the frame of mind or value system of the production or accounts department , but it can be argued that it is the designer's responsibility to concern himself with the user's value system and use these others merely for checking the feasebility of the design and not the other way around.

2.6 The Systems Engineering Approach

After the previous rather general discussion we shall recount the main elements in the design process from the systems engineering viewpoint.

The Candidate Alternatives;

These can be thought of as alternative courses of action. As the decision maker cannot be expected to identify, describe and analyze the infinity of all possible solutions, this set of alternatives is not exhaustive, it does not, for example, include those solutions not known to the decision maker. These candidate alternatives are usually mutually exclusive.

The Design Variables;

Each alternative will require a description so it can be identified and subject to analysis. We can identify a number of types of variable which are of interest to us.

a) Independent Variables; These are the variables the designer works with directly such as geometry, pressure etc.

b) Dependent Variables; These are quantities the designer works with but does not directly allot values to. They are affected by a).

c) External Variables or States of Nature:

In evaluating any alternative we must consider not only the candidate alternative but also the environment. These conditions are known as states of nature. The members of the set of states are mutually exhaustive and exclusive. In the design context they can include social, economic, political environments as well as physical environments.

As nature is associated with some future date, the states occuring cannot usually be predicted with any certainty; they are inherently probabalistic.

Outcome and Decision Criteria;

The result of implementing a candidate alternative, given a state of nature, is termed an outcome and is multi-dimensional. Each outcome dimension which is significantly affected by a choice of candidate alternatives, and/or thought important by the decision maker, can be called decision criteria.

There may be dimensions of an outcome which are not criteria. This can be for two main reasons;

a) They are not known to the decision maker.

b) They are not considered significant by the decision maker.

It is the criteria/needs/attributes (we are considering these terms to be synonymous), which the user/customer deems important, that we wish to determine and communicate to the decision maker. We shall discuss the nature of these criteria more thoroughly in 4.2.

Setting up an Objective Function;

The objective function is a means of identifying the best of the candidate alternatives. The following steps LIFSON (1972) are necessary in its formulation;

a) Identification of the relevant decision criteria

b) Identification of the limits of the criteria

c) Conversion from units used in criteria to units of 'system worth'. This will not in general be a linear relationship. (see later sections on utility)

d) Identification of the criteria relative weights

e) Formulation of the objective function. The objective function enables the designer to evaluate any given candidate alternative with respect to any other. It does not identify a 'good' alternative, only the best of those synthesized.

To complete the specifications the decision maker requires two more sets of information;

f) The states of nature

g) The associated probabilities if applicable or available

We have followed the decision process through and seen the interactions of its elements in the area which will concern us. It will not be necessary to consider stages beyond the formulation of the objective function.

2.7 Closing Comments

We have examined some of the problems facing the designer. Any outcome met in practice will have a set of multidimensional attributes. If we are to introduce an element of participation into the design process we must identify the attributes the users find important in evaluating the design. These attributes are then used as evaluatory standards in judging any candidate alternative.

As stated in the introduction, we can use some relatively recent techniques for quantifying human judgements, values etc. and use these to help in the evaluation procedure.

It will be useful to discuss the range and significance of attributes found important in design and this will be done in Chapter Three.

CHAPTER THREE

VALUES AND NEEDS

3.1 Introduction

In the previous chapter we discussed extensively the importance of the designer knowing the user/customer's needs and value system without defining , or clarifying these points. It can be said at the outset that to fully explain these terms is a difficult task even if we restrict ourselves to the area of interest to us, the person/product relationship.

The field of value enquiry has had contributions from many diverse fields and perhaps the best way of categorising these is to isolate three interrelated factors present in the value enquiry situation. (RESCHER 1969, p. 128)

a) The ANALYTIC task of characterizing, classifying and explicating the concepts of the various values that are at issue.

b) The DESCRIPTIVE task of applying the value concepts so clarifyied to the specific concrete setting of the person or group of persons at issue.

c) The NORMATIVE task of evaluating this specific pattern of values.

The second descriptive category is a matter for empirical enquiry of "values" and is commonly researched by psychologists, historians, sociologists and anthropologists.

There is another group of workers who are concerned with the more formal aspects of value enquiry putting heavy emphasis on formalisation and mathematical deductive processes. This group would include workers in the fields of economics, game theory and decision theory.

Category three is the task that philosophers have addressed themselves to through the ages. They have attempted to set up a general theory of "Value" across the multitude of diverse "values".

The remaining category is undertaken by most workers in the field of value enquiring.

It is useful to examine the contribution of these various disciplines to value enquiry and examine how and why their contributions differ.

In the field of philosophy discussions of "values" are usually inextricably linked with the problems of morals, aesthetics and ethics and are thus explorations of the ideals of mankind; statements about mans ideal relationships with the universe and himself.

Important figures in this movement have been Lotze, who may be regarded as the founding father and who started investigating into "values" or what is called axiology today. His teaching set up a dualism of two realms: that of FACT and that of VALUE in which he attempts to maintain a realm of significance for human concerns outside the area of scientific investigation, values were somehow super or extranatural. Other later philosophers including Franz

Bretano, Alexius Meinong, pupils of Lotze who tried to deemphasize his dualism of fact and value. John Dewey, R. B. Perry, Nicolai Hartmann, and others too numerous to mention carried on the tradition.

The spirit of Lotze's early teaching is, however, still prevalent and many present-day researchers in the field of value enquiry reject as inappropriate any form of scientific investigation of the field.

This sort of attempt to construct a "grand system of Values" incorporating findings from many disciplines has not, as RESCHER (1969, p. 59) says "...been impressively successful". He does, however, say that it has spawned much enquiry in the field of "values" both as the core of philosophy and as a concept capable of being tackled in an empirical manner, the extranaturalists notwithstanding. A more complete description of axiology can be found in RESCHER (1969, Chapter 5) or in any of the texts listed in his large bibliography.

The approach taken by many workers in the fields of psychology and anthropology is, as we said earlier, mainly descriptive. The task here is to identify and list in an unambigious and comprehensive manner the value subscription pattern of the group or person involved.

Examples of the type of approach used can be seen in the well-known work by the social psychologist ALLPORT et al (1951), "Study of Values: Manual of Directions for the Study of Values". In this work they take SPRANGER'S

(1928) idea of 6 basic types of men; the theoretical, the economic, the aesthetic, the social, the political and the religious. Using this rather crude catagorisation they then construct a questionnaire to measure the relative strengths of these values. Another example would be the work of Otto Von Mering (1961), an anthropologist, who attempts to develop a "... a grammar of common, possible human values" by means of an interview technique followed by an analysis and description of "values" found in the recorded interview. These two examples, although not completely representative of the whole field of research, show the basic approach used by workers in this area.

Most of the work on value just described involves a minimum of formalisation but as mentioned previously one group of workers emphasises the formal approach quite heavily. The range of work is quite large and tends to cut across boundaries between disciplines. A tendency in this type of work is to start with "self-evident truths" about mans rationallity, to define a notion of rationality and with the premise that in his behavior man is attempting to maximise something, elaborate the logical behavioral outcomes in any given situation.

This whole type of approach tends to beg the question; to what extent can any given formal model be used to describe behaviour as constrasted to the extent that it states how a given type of person should behave in some given situation? A similar type of approach can be seen in economics game theory and to some extent decision theory where the person is involved in ranking this set of preferences in order to maximize his utility or expected utility. We shall return to this idea in Chapter 5.

In the preceeding discussion we haven't actually defined value chiefly because there is no one definition that would adequately represent the range of definitions used in any particular field. We shall reserve that task for the ensuing section but we can let it suffice to say that value in the philosophic sense concerns itself with the overall picture of evaluation, the psychological/anthropological with the day to day business of evaluation, the macrostructure as it were, and the formalists with the small detail of the mechanics of evaluation, the microstructure.

In the following sections we shall discuss the idea of value a little more deeply and how the various contributions can be used in our investigation.

3.2 Value Theory

This section is a brief review of the field of value theory with the aim of introducing such concepts as informed commentary on certain techniques to be introduced later and to show some of the pitfalls awaiting the unwary.

References to the literature will be used if possible to settle matters of extensive controversy rather than attempt to illustrate both sides of the sometimes complex arguments in the text.

The whole field of value enquiry is filled with disagreement making it very difficult to develop a technique of value analysis and communication based on theories having broad consensus. These factors, as well as a difficulty in terminology, make investigations in the area difficult. Our task is, however, made a little easier by not having to investigate the general theory of value; we want to look at a small part of the field, the area of person/product relationships.

If we are going to be able to use any theory of value in a useful way in a design situation, we must somehow be able to quantify the components of our value system. This implication that values are measurable requires that we adopt a pragmatic viewpoint and don't treat values as something extra or supernatural. This may seem to fall into one of the pitfalls mentioned earlier, but we make this rather a priori decision on the sole basis that a value system is little or no use without this condition. The interested reader is invited to examine the extensive literature on this controversial (for value researchers anyway) issue.

So then, we have something, a value which we wish to quantify and identify. Its nature is not clear, however;

is it a thing, a concept, an attribute of an object or a person or perhaps of the interaction of people and things? Definitions of value which encompass all of these can be found in the review literature (ADLER 1956-7) (BARTON 1962). Our definition must be pragmatic but first we will examine some points which must be considered and also demonstrate some of the things values are and are not. In the following, values will be used to refer to all the ways in which value was used in the introductory section. The discussion is based in part on BARTON'S (1962) clear and straightforward paper "Measuring the Values of Individuals".

Values have been associated with many definitions some of which were given before; additionally a value is something that is preferred, desired, wanted, needed, esteemed, is interesting, but in the following we shall ignore the difference between these terms for the sake of simplicity.

Values as Attributes of People or Attributes of Objects:

People can be said to have values or objects can be considered as values themselves. The locus of values here can be seen to oscillate between the person and the object. In other words, there are value objects and there are value standards of people. Neither can be understood without the other. RESCHER (1968, p. 8) makes a useful distinction by saying we can distinguish three factors which are helpful in avoiding confusion.

a) The value object that is being evaluated

b) The locus of value

c) The underlying values of issue

A person may value nearly anything (eg. a Queen Anne table) but only a rather limited number of concepts are sufficiently general to count as loci of value (eg. the possession of works of fine craftsmanship) while values themselves are yet more ideological and abstract (eg.craftsmanship itself.)

Values as Attributes of Individuals or Groups:

One can speak of the values of an individual or those of a group. The logical relationship between attributes of individual and those of groups are complex and are dealt with in such texts as ARROW (1962) or WILLIAMS (1967). We shall return to this subject in Chapter 5.

Values as Implicit or Explicit Phenomena:

Can a person "hold" a particular value and yet not fully realize it? A majority opinion seems to hold this to be true. To quote ROSE (1956, pp. 14) "...Sociologists have discovered that not all values are explicit , deliberate or even concious...Anthropologists and sociologists have shown that much of a given culture is covert; not recognized and perhaps even "unimagined" by persons who conform to it".

It has been speculated that many of these implicit values are the "instinctive" values. This point of view has recently been put forward in popular form, by MORRIS (1969) but the idea is recognized by other writers.

If implicit values can exist then we have the problem of investigating phenomena that we can only infer from indirect methods, which can raise many methodological problems.

Operative Conceived and Object Values

These classes of value were proposed by MORRIS (1956) to clarify the term value. Morris maintains that the term value is used to signify different aspects of the value situation. Three uses have special importance.

a) Operative Value: Often value is used to refer to the tendency of living things to prefer, desire, want, need one kind of object etc. more then another. This is viewing value on a purely behavioural basis.

b) Conceived Value: Sometimes value is considered as a basis for behaviour that is guided by anticipation or foresight of the outcome, in other words, what is regarded as being desirable,needed or preferable.

This distinction between the preferred and the preferable occurs frequently in the literature. It can be the difference between the actual and the ideal or as in KLUCKHOAN (1951, pp. 396) the distinction between the "... desired and the desirable". In BARTON (1962, pp. 5-65) the difference is between "...these "normative" feelings of what should be and purely preferential feelings of what we like." Morris argues that there will always be some divergence between these two types of value unless we all become saints.

An example which clarifies the distinction can be given where a smoker regards smoking as something to be desired or preferred yet because of the proven health risks realizes that it is not desirable or preferable to smoke.

c) Object Values: It is a point of disagreement as to whether values are product of culture and evolution or whether some things actually have value irrespective of whether a person knows about desires or even conceives it as being desirable. Morris argues that such object values do exist and gives the example of a diabetic. Given that he wants to live, rather than die, the correct diet has "object value" to him whether he likes it or knows about it.

Values and Basic Values

If we consider values as ALL preferences, needs, etc., we must deal with a multiplicity of values since human wants, preferences, etc., are almost infinitely varied. This is not a very useful situation, millions of variables are neither manageable nor practical. One approach is to "...distinguish "basic values" from the specific wants, preferences, norms, or valuency". These basic values are assumed to be "...a relatively small number of general principles or tendencies which underlie the specific verbal or behavioural indicators and are relatively stable" (BARTON 1962, pp. S-67). If we follow this procedure we must identify these basic values.

Briefly there are two ways of accomplishing this: Ask people to verbalize the general standards which underlie specific behavioural or verbal preferences or obtain large sets of verbal or behavioural behaviour and mathematically analyse them. This can be done by processes such as factor analysis,or latent structure analysis,to see which specifics occur together and thus obtain an idea of these basic values.

This question of what we call values, whether we include all preferences, etc., some preferences, etc., or just reserve the term for the small number of "central" values is quite controversial with no general consensus of agreement and for review of the extensive arguements on the question of reader is referred to the literature.

In the foregoing we have shown, briefly, some of the more important parts which arise in any consideration of value. We have discussed the subject of what values are and are not but haven't actually given an operational definition of value. In our choice of a definition we must bear in mind the intended application, the design situation, and be as pragmatic as possible. A review of the extensive literature indicates that definitions of the form,"If X satisfies a need, X is a value"or"If X is preferred,X is a value", hold the most usefulness for our purpose.

HANDY (1969) (1970) deals with this point in some detail and finds that the definition of value as need related is most satisfactory. He says "...If X satisfies a need then

X is a generic value" ie. belongs to the class of values. This definition will not distinguish between good and bad needs and thus values and disvalues,but the view taken here and elsewhere in the value enquiry field is that these are not capable of being determined on an a priori basis but are determined on an empirical and cultural basis and as a matter for ethical and moral discourse.

This idea of needs also fits in quite well with the design situation; the design must fulfil certain needs be they technical or esthetic or whatever. In the following sections we shall discuss the idea of need. Firstly in a general manner and later in a manner relevant to the person/product relationships.

3.3 Needs

Perhaps the most general statement on needs is given by CAMERON (1947, pp. 105) when he says "...let us define need as a condition of unstable or disturbed equilibrium in an organisms behaviour, appearing typically as increased or protracted activity and tension. Need may arise directly from a change in the organisms relationship with its environment as when surrounding temperature drops or rises considerably ... It is also a common outcome of symbolic behaviour such as reading, thinking, talking. Need is characteristic of all ongoing activity sequences, covert as well as overt."

This definition is useful in illustrating the symbolic importance of need as well as its overt/covert character. Given this definition it would seem to be useful to discuss specific needs of humans and attempt to classify or categorize them. This process has received a lot of attention and a large number of classification systems have been proposed. If we realize, however, that there are a great many ways of accomplishing this classification we can see how these different systems can arise. This point is expanded in RESCHER (1969, pp. 17-28).

We shall examine a few of these proposed systems starting with one by TOLMAN (1951, pp. 321-36) who grouped needs into three levels. Primary; which comprises "viscerogenic hungers" such as thirst, hunger, sex, temperature control, oxygen intake, rest and sleep and "non-viscerogenic hungers" of fear and aggression. These are probably characteristics of all mammals but humans and a few higher species also exibit a general exploratory and curiosity need. Secondary needs are mainly social in character and include gregariousness, love, approval, dominance , submission and are found in humans and higher apes. Tertiary needs are found only in humans and are generally acquired needs that become functionally autonomous. The goals are culturally provided. In our society examples could be wanting business success or wanting to play the clarinet.

This sort of classification system may be quite useful in a rather more clinical setting but for our purposes is not particularly useful. A difficulty is that the terms of reference are much removed from those utilized in design and the scheme of classification doesn't lend itself to a further break down giving factors relevant to the design situation except in a very general manner.

MASLOW (1954, Chapter 5) in his often quoted work lists a hierarchal order of needs; physiological needs, safety needs, belongingness needs, esteem needs, and the need for self-actualization. These are structured with the most important, the physiological needs, at the head of the hierarchy. Only when higher needs have been satisfied can other needs emerge. This type of hierarchal concept of prepotent needs has been strongly criticized by a number of authors who claim that under certain circumstances lower level needs are more important than, say the physiological needs. An extreme example of this would be religious martyrs.

We can see an analogy here in the design situations; when the design functions satisfactorily (i e: when prepotent or primary needs are satisfied, other needs come into action more fully. For an example here we consider the automobile. When the automobile was in its earlier stages of development the needs of getting satisfactory performance at a primary levelwere very important and other needs tended to be small in comparison. With an increase in technical knowledge the primary function of making a reliable transport has been achieved (?) and now other needs (esteem, aesthetic) have become much more important. When the primary function (transport) had been satisfied the other needs appeared.

An addition then to Maslows hierarchal concept is that, on average, the primary or prepotent needs must be, at least, minimally satisfied before further needs can emerge. As for Maslows actual classification system we can make the same comments as we did for Tolman.

SCHREIER (1963), commenting from the marketing research point of view, gives a broad framework classified according to what the product can do for the user/customer:

a) For his body; the physiological needs
b) For his abilities; the self assertive or self actualizing needs
c) For his moods
d) For his social relations; his social needs
e) For his aesthetic needs
f) For fulfilling his duties
g) For conserving effort

This classification provides a broad idea of certain catagories which have been found useful in classifying peoples needs but as we shall see later lacks a coherent structure and this makes a breakdown into lower order factors more difficult.

SIDDALL (1972, p. 5) provides a comprehensive checklist of needs (what he calls values) for designers:

Utility Value	Appreciation of the usefulness of an object
Biological Value	Food, drink, sex, health
Aesthetic Value	Appreciation of beauty and style
Material Value	Pleasure from accumulation of material
Social Value	Friendship, power, status, good reputation, fame
Technological Value	Satisfaction from love of technology
Intellectual Value	Satisfaction of curiousity, use of intellect
Game Value	Satisfaction from playing or observing games
Basic Value	Hidden values inherited from evolutionary origins
Moral Value	Appreciation of moral rightness, goodness
Religious Value	Satisfaction from belief in a greater power

This classification, presented here in an order rearranged from the original, is quite useful, and we shall see later how this classification will reappear in a curtailed and slightly modified version.

The above examples serve to show some of the different systems of classification produced by different workers in fields from engineering to psychology. We have also noted that many of these suffer either from the difficulties of being formulated for use in fields other than design or being mere checklists with not much underlying foundation which lead to difficulties in trying to formulate a systematic technique from them.

At this point we still cannot produce a technique of use to the designer except of the type given by MCKIM (1962) in his paper "Aesthetics in Design". In this paper he gives three factors which he says should be present in any design; satisfaction of physical, intellectual and emotional needs. He then goes on to illustrate, in a general manner, how these can be incorporated in a design.

To understand need a little better we must see how need is exibited and how it controls behaviour. The concept which mediates between behaviour and our needs are considered to be attitudes and in the next section we shall discuss these and their relationship to needs. It should be remembered, however, that in all these matters great diversity of opinion can be found. This difference can be accounted for if we remember little, relatively, is known about the human mind. We are considering the mind with an input and an output between someone's personality (whatever that is) and their behaviour. That many different interpretations of the functioning of this box exist is not really surprising.

3.4 Attitudes

We said that we need to examine the idea of needs more closely to see their relationship with behaviour and in this connection it is useful to introduce the concepts of attitudes. A look at Figure 3.1 will show the relationships between the various levels of personality.

This "tree" can be looked at two ways: The personality is somehow made up of millions of small beliefs, attitudes, needs, values, etc., or that personality is somehow central and it controls values,beliefs, etc.; it is a matter of viewpoint.

Some writers make no distinction between beliefs and attitudes while still others make no distinction between attitudes and values (needs) arguing they both perform the same function with the difference being merely in the degree of abstraction considered (ENGEL, 1968, p. 166). We shall say that beliefs tend to be attitudes on specific points, while attitudes are rather larger in scope. A topical example may show the relation between them a little more clearly. A person given the choice between a standard U.S. saloon and an imported compact car,chooses the latter. We might say we are dealing with a belief, with a relatively superficial and not immutable styling preference. However, further questioning may reveal him to be concerned about

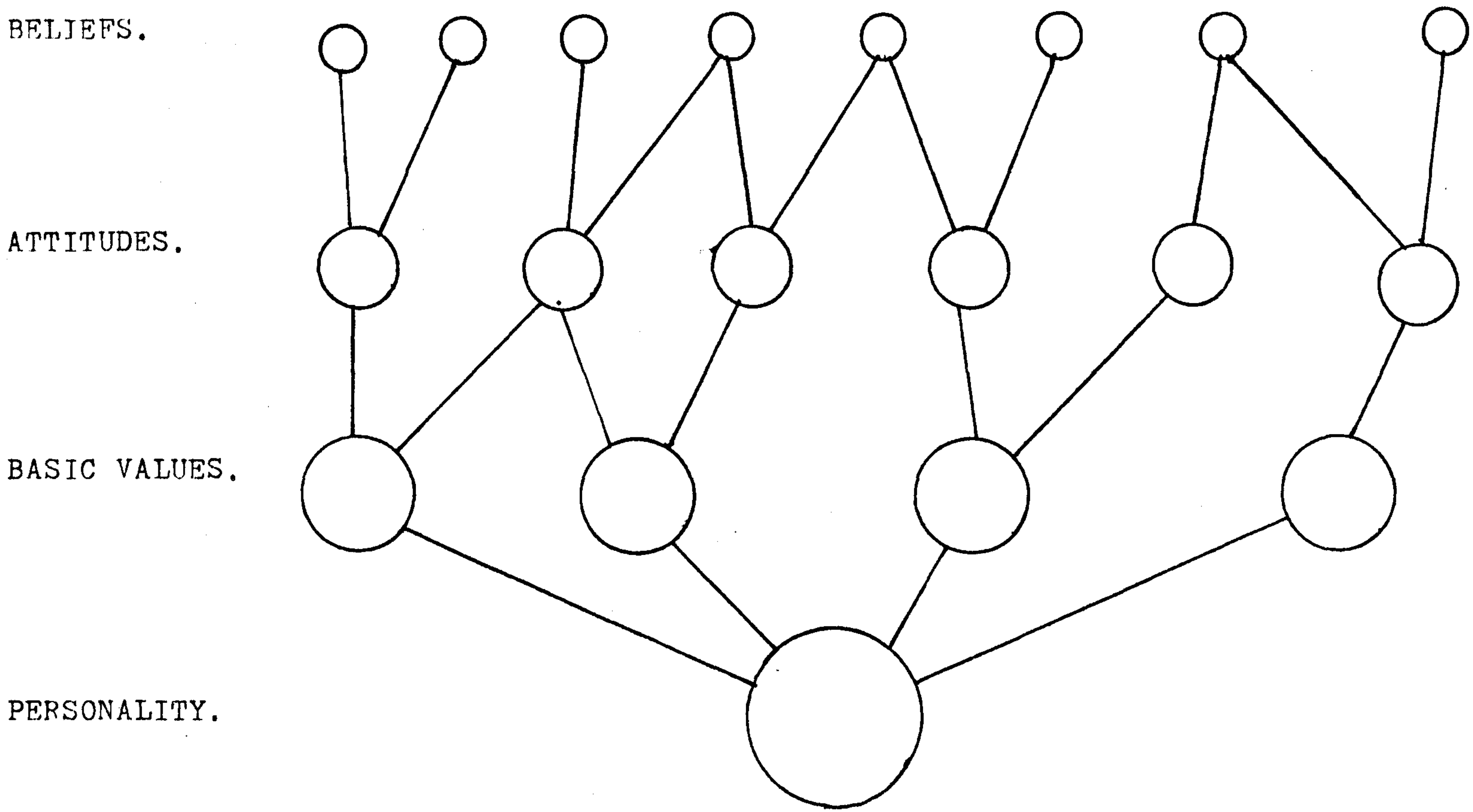

FIGURE 3.1: Hierarchical Structure of Personality. After OPPENHEIM(1966).

gas mileage and that his choice had to do with a deeper underlying attitude tothe use of natural resources. This in turn may be linked to an underlying value system that has to do with ecology and the role of man and his relationship with the planet he inhabits. This value system, in part, could derive from a "need", perhaps instinctive, and inborn, to need and prefer a natural environment.

The "cross-linking" in Figure 3.1 illustrates that different values can influence an attitude; the person may value craftsmanship and this might influence his attitude in favour of a hand built imported car instead of the mass produced U.S. model. Conversely a value will influence many attitudes; a persons ecological values will influence his thinking on pollution, urban housing, atomic weapons, etc. as well as on the choice of automobile. We see that attitudes are need expressive ie. they reveal the needs/value which underlie them. It is at the level of attitudes that the person/product relationship operates although, as we have said, the needs/values are the underlying determinants of attitudes.

ROKEACH (1968, pp. IX-XII) considers that an attitude is: "...an organization of several beliefs focused on a specific object (physical or social, abstract or concrete) or situation predisposing one to respond in some preferential manner. Some of these beliefs about an object or situation concern matters of fact and others concern matters of evaluation...While an attitude represents several beliefs focused on a specific object or situation, a value is a single concept that transcendentally guides behaviour and judgements across specific objects and situations and beyond immediate goals to more ultimate end states of existence". - - Rokeach's use of the term belief is confusing here and at odds with our previous discussion. Perhaps opinions would be a better word to substitute for beliefs.

As a consequence of this definition we see that an attitude will generally be complex and multifaceted; some of these facets will be concerned with values and needs while others may be hearsay or results of experience.

Attitudes can be considered to have three main functions (KATZ 1960)

a) Adjustment: Most people are thought to organize behaviour so as to minimize punishments and maximize rewards. Attitudes, therefore, can function to reflect desired or undesired goals and thereby orient behaviour towards the most positive alternative.

b) Value Expression: Many workers consider attitudes to be derived from values and needs and to reflect these values in more specific situations. Attitudes can give clarity and expression to these more basic orientations. These attitudes are the most accessible components of personality and thus are valuable in various empirical investigations of personality factors. The operation of attitudes can be seen in the example of choosing between automobiles given earlier.

c) Knowledge: No one can exist for long in a disorganized, chaotic universe; attitudes provide standards for evaluating and understanding ones environment. They act as a means of organizing the constant stream of information reaching our senses so the useful and relevant is sorted without our having to spend our time processing all the information reaching us.

It will be useful to view attitudes as having three basic related components (MCKEACHIE and DOYLE 1966)

a) Cognative: This refers to stored information, past experiences about objects or phenomena.

b) Affective: This refers to feeling of, say, like or dislike.

c) Behavioural

Unfortunately the relationship between these factors is not certain and knowing, say, the first two, one cannot predict the behavioural component, LEWIN (1936) expressed this in the relationship:

$$B = f(P,E)$$

or in words, behaviour (B) is an unknown function of the persons inner determinants, attitudes, temperement (P) and all environmental factors as perceived by the individual (E).

It can be seen that attitudes only have an influence on behaviour and do not control it. If we could hold the other parameters and the functional relationship constant we might be able to obtain a correspondence between attitudes and behaviour. This approach using a mock-evaluation situation will be explored in Chapter 4.

Having explored the idea of needs, value systems, and attitudes in a rather brief manner, we shall discuss the place of these concepts in the person/product relationship.

3.5 Scope of Person Product Relationships

In this section we shall attempt to define the degree of abstraction we want to consider in the person/product relationships. Much work has been done in the marketing research field on these relationships mainly in connection with consumer products and at a high level of abstraction. Here the work of DICHTER (1964) was considered a bible in its explorations of images (considered to mean the same as attitudes) or products, mainly in the consumer field. Most of the work has tended to be involved with the selling and advertising of already designed products, while the area concerned with discovering the attributes thought important by the user/customer has been rather neglected. The degree of abstraction can be taken to mean at what distance from normal engineering terms of reference we are operating.

LEVY (1958), writing from the marketing field, asked, in discussing some of the myriad of reasons for purchasing a product (again in the consumer field), what kind of person the customer is. He goes on to say that: "...it is hardly the economic man, especially as there is a lot of evidence that he doesn't buy economically.. They still talk about price and quality and durability since they are regarded as sensible traditional values. At the same time, they know other factors influence them and they believe these to be legitimate influences. This point is worth some emphasis since there are many who dissapprove of the fact that purchases may be made on grounds they think insubstantial..."

An example is useful here. When asked to rank important qualities in automobiles, qualities such as durability, reliability come first with colour about eighth. It is well known, however, that colour is one of the single most important determinants in automobile buying.

Levy continues saying "...[People] also know that practical considerations can hardly determine their choice between, say, a Buick or an Oldsmobile..."

This is an example of the point we noted earlier concerning prepotent needs. When the primary prepotent or in this case practical needs are at least minimally satisfied other needs, more ephemeral, become active.

"...When people talk about things they buy and why they buy them they show a variety of logics. They refer to convenience, inadvertence, family pressures, and other social pressures, complex economic reasonings, advertising,pretty colours and a wide range of feelings and wishes. They are trying to satisfy many aims and circumstances."

In our terminology they are trying to satisfy many needs, sometimes conflicting simultaneously. These conflicting needs are usually the non- utility values and needs.

"...The things people buy are seen to have personal and social meaning in addition to their function. Modern goods are recognized as psychological things, as symbolic of personal attributes and goals, as symbols of social patterns and strivings. In this sense all commercial objects have a symbolic character and making a purchase involves an assessment, explicity or implicit of this symbolism... In several years of research into the symbolic nature of products, of brands, of institutions and media of communication, much has been shown of the way consumers are able to gauge, subtly and grossly, the symbolic language of these objects and translate them into meanings for themselves."

Levy here is talking mainly about consumer products, a situation where many products performing the same function must be discriminated amongst. This must not, however, make us disregard the validity of his thesis for more technical or industrial products, since it has been shown by PEPLOW (1966) that many of the factors mentioned by Levy intrude into the act of purchase of these products. One can recount, as an example, the incident where a machine tool manufacturer changed the design of a machine and to present a "smooth modern appearance" encased the main frame members with sheet steel panels. This lead, as it happens, to the loss of a customer because he "couldn't see the machine was made of good solid cast iron."

Of course it is difficult to see how this discussion could be applied to, say, the purchase of rivets for boiler-making. This is because objects such as rivets can be said to have purely utility value when very few of the factors referred to earlier can intrude. A review of the applications of marketing research to industrial goods and a comparison between the consumer and industrial fields can be found in ROBERTS (1966, pp. 434-439).

3.6 Person-Product Relationships

We said previously that much work had been done in this field by marketing research personnel but while we shall use their main findings we shall use an engineering orientated approach suggested by MAYALL (1966).

We said when we were considering needs, that their categorisation could be accomplished in a great many ways, depending mainly upon the viewpoint of the author and the purpose for which the categorisation was required.

We, as designers, will be dealing mainly with the design of functional equipment and the primary need here is that it works. We can term this the primary or prepotent need by analogy to MASLOW'S (1954) categorisation described earlier. It should be noted we are not using his actual catagorisation but only his hierarchal scheme of needs so no direct analogy between these two categorisations can be made.

Mayall presents the range of person/product relationship on a unidimension spectrum. For purposes of simplicity this can be described by a series of convenient "landmarks" but it should be remembered that these factors are not distinct and merge into each other. One could question, however, whether a unidimensional spectrum of relationships is adequate to represent all possible configurations. We shall now introduce these operational needs, as we shall term them, and describe them in more detail:

a) Technical or Utility Needs

b) Ergonomic Needs

c) Basic Aesthetics Needs

d) Conceptual or Symbolic Needs

Technical or Utility Needs

These technical needs are what one might expect to find in the normal engineering specification. They would include such information as, sizes, powers, speeds, life expectations, tolerances, weights, performance, environment, etc. We shall also include economic factors in this category. We have included them here because the economics of a product are largely such that one can deal with them in the same manner as technical factors. This is not to say that the pricing of a product can be handled just like any other variable such as weight or size. One can over or under-price a product depending on the symbolic and conceptual needs present. We shall say then that the economics of the product can be included here but that the place of product price is rather difficult to acertain.

Ergonomic Needs

These involve the satisfaction of anthropometric needs such as reach, size of controls, force exerted and psysiological needs such as temperature, humidity, lighting, noise, etc. This category will also include psychological relationships between people and machines or products which directly affect the operation or use of the product.

Basic Aesthetic Needs

This refers to the basic quality of pleasing the intellect through the medium of form, colour, texture, etc. Factors three and four tend to blur together and it is difficult to distinguish between them although basic aesthetic factors tend to be involved with whether an object is perceived as pleasing to the eye; not an eyesore.

Conceptual and Symbolic Needs

These are the factors which we discussed in sections 3.5 and 3.6 which, while contributing enormously to the excellence and marketability of a product, are difficult to define or pin down. As Levy said in section 3.6 "...Modern goods are psychological things, as symbols of personal attitudes and goals, as symbols of social patterns and stowings..." People are thus trying to satisfy, esteem needs, self actualization needs, belongingness needs etc. and they are trying to satisfy them by purchasing these products.

These symbolic and conceptual needs are difficult to recognize in their subtle forms in the detail design stage but can come to the fore when coupled with advertising and exposure of the finished product.

MAYALL (1966) seems to indicate that these categories are in watertight compartments and that, for example, the technological needs can be drawn up without any reference to the other types of need. This probably is not true since these needs are not independent and interact in some way but with certain categories being prepotent.

A point which should be raised is how the designer can make use of the information about basic aesthetic and symbolic needs. It must be admitted that at the present this cannot be done in the normal engineering sense; at the nuts and bolts stage. There is, however, a branch of engineering which does work in this area and is familiar with these problems. This field is industrial design and as the designer will be working as part of a team we shall have a range of expertise at hand.

It could be argued that these basic aesthetic and symbolic needs are mere products of the stylists draftmanship and the advertisers imagery and that catering for these needs is just putting frosting on the stale cake. We are not advocating this type of approach but are saying that the "good" product will be technically, ergonomically, aesthetically, and symbolically "good".

The places where the aesthetic and symbolic needs can best be accounted for are in the initial stages where the candidate alternatives are being formulated. The "concept" of the product profoundly affects the symbolic needs one can satisfy. The other stage where these needs are particularly able to be accounted for is in the finishing stage where the other visible cladding of the product is designed. These two are the main areas which immediately strike the user/customer; the concept and the external appearance. If the technical aspects of the product don't strongly contradict these impressions, ie. if the technical needs are at least minimally satisfied, then the user/customer may well base his entire attitude on these two areas. We can thus see the importance of these needs.

Up till now we have been saying that the main studies have been done on consumer products but that some industrial goods can be subject to the same arguments. Of course, some products, as we have said, have pure utility value and are designed on technical needs alone, but for many products, especially those of a slightly ambiguous nature, such as say computer hardware, office equipment and some types of machine tools, we must take these other needs into account.

3.7 Concluding Remarks

If we are to adopt a user/customers value system as the determinants of the design criteria, we must have a manageable theory of values. We have linked value with what satisfies a need. This definition leads straightforwardly to a linking of needs with design criteria which we shall explore in the next chapter.

We can now review our system of value in the light of our discussions earlier in the chapter. We have borrowed the idea of needs from the fields of psychology and the behavioural sciences. From this we have learned that values/needs are relatively enduring components of personality and arise from a number of sources. Some of these postulated are evolution, cultural conditioning, personal experience and speculation. These central needs/values can be considered to influence the next level of personality, the person's set of attitudes, and these attitudes give us an expression of a person's central values. Because these needs can be satisfied in an infinity of ways we shall have an infinity of value objects for a relatively small number of needs.

We shall consider that a group's needs are somehow derived from its constituent's needs, but not in any simple manner. Because of the various sources of needs we shall consider that some may be implicit and also that one can have conflicting needs, sometimes without realizing their existence.

We have so far skirted the difficult question of what constitutes a good design. We shall not become involved with the very complex question of what is "good". This has been bothering philosophers for centuries without any generally agreed definition resulting. We shall simply say that a good design satisfies the user's needs in some maximal manner. This doesn't, however, account for the non-user and we must somehow trade his needs off with those of the user. This will be considered in a later section.

We have seen that we must somehow discover the user's needs and transmit them to the designer in some useful form the designer can utilise in the design process. The next chapter will deal with some of these problems.

CHAPTER FOUR

IDENTIFICATION OF USER NEEDS

4.1 Introduction

In the ensuing chapters we shall be concerned with the interrelated areas of identification, quantification, and amalgamation of the user/customer needs and their communication to the designer. The unifying concept running through these areas will be that of utility.

In Section 2.7, we saw that to formulate the objective function we must perform a number of operations, the first of which was the identification of the design criteria. We can link these with user/customer needs. This link may not identify many of what might be called 'internal design criteria', ie. criteria making for internal consistency or physical feasibility of the design, but may bring to light previously unconsidered criteria.

This chapter will deal with the identification of a COMPREHENSIVE, UNAMBIGUOUS and RELEVANT set of criteria.

4.2 Criteria and Person/Product Relationships

In Section 2.7 the different types of design criteria were briefly noted but now a fuller description should be given;

a) Effectiveness Criteria; These are connected directly with the satisfaction of user needs and the non-violation of certain of societies' needs.

b) Cost Criteria; These are concerned with the proper costs associated with the adoption of any candidate alternative.

c) Schedule Criteria; These are connected with when any candidate alternative is required, either in the market place or on shop floor.

These can be further subdivided into;

1) Quantifiable Criteria; These criteria have the properties
   a) they are measureable
   b) their measurement is considered to be practical in the particular circumstance.

2) Non-Quantifiable Criteria; Although these criteria figure very importantly in the selection of any candidate alternative they have not been quantified because
   a) a scale, convenient or otherwise, for their measurement has not been devised, and/or
   b) the trouble and expense of forming a quantifiable criteria is not considered practical in terms of additional information gained.

Chapter Three outlined some of the range of person-product relationships existing, and attempted to provide some form of simple engineering classification for them. It will now be shown how these relationships can be considered in the context of the above descriptions of criteria.

It can be seen that most of the factors elaborated upon in Chapter Three can be subsumed under the heading of effectiveness criteria. The cost and to a lesser extent the schedule criteria can be considered as falling within the person-product spectrum, but as we said the unidimensional spectrum proposed cannot handle these factors in a very convincing manner. We must recognize their existence, so we shall refer to them specifically when necessary.

We set three conditions for our design criteria; comprehensiveness, unambiguity and relevance. There is, however, no single generally accepted technique or approach for selecting such a set of criteria and to further complicate matters there is no way of determining whether any selected set satisfies the imposed conditions.

It is important to define each criterion or need as unambiguously and as explicitly as possible. This process becomes progressively more difficult as we progress towards the symbolic/ conceptual end of the spectrum as so little, relatively, is known about these needs. As will be seen in taking a fairly vague need like comfort, we are faced with an immediate problem - does the user really mean comfort rather than non-fatiguing; these concepts are not really synonymous in an operational sense, and even though the context of the design will give us additional information, the ambiguity cannot be ignored.

It may aid the process of definition to attempt to further subdivide these rather ambiguous needs using the help of the operational needs considered earlier. For the purposes of identification and subsequent quantification, we shall divide these factors into two rather arbitrary groups. These groups can be seen to correspond approximately to the two subclasses of criteria described earlier as quantifiable and non-quantifiable. This correspondence is not fixed temporally however, and in the future it can be reasonably expected that those parts dubbed as non-quantifiable today, will become more amenable to quantitative handling. The two groups can be described as;

1) Those needs which can be directly related to the independent design variables. Directly in this sense is taken to mean explicitly in the form of quantitative relationships. The groups are 1 and 2 and some of group 3. The technical, anthropomorphic, physiological and some aesthetic needs fall within this class.
2) These, at the present time at least, often cannot be related explicitly to the independent design variables. Examples of these would be group 3 and group 4.

Whether or not this second class of variable can be related to the design variables is questionable but certain basic aesthetic needs can be linked with readily measureable physical parameters. A well known example here would be the case of the 'golden section'. Another would be the case of a designer FULTON (1971) who was attempting to discover the most aesthetically pleasing form of corrugated steel wall cladding, as part of a larger problem of optimizing the section of the cladding, The sheet had the form shown in Fig. 4-1. By exposing a number of subjects to panels with differing X2/X3 ratios he was able to obtain a relationship between 'aesthetic value' and the variable factor X2/X3. A similar procedure was followed for the depth X1. Other studies in this area are by THOMSON (1942) who tried to relate aesthetic value to those shapes which can be found in nature. A review of recent investigations in the field of psychology has been made by VALENTINE (1962). LIFSON (1973 pp. 112) suggests a method by which some of these factors can be handled on a rule of thumb engineering basis. It might be objected that these determinations are rather trivial but it can be argued that it does demonstrate that, in some situations at least, these measures may not be as inherently subjective and elusive as they are often made out to be. We shall content ourselves, for the moment, with the observation that in certain circumstances it will be possible to obtain 'quantitative' relationships for certain of these factors.

As we have just intimated, the chief difference between these two areas lies in our ability to perform measure-

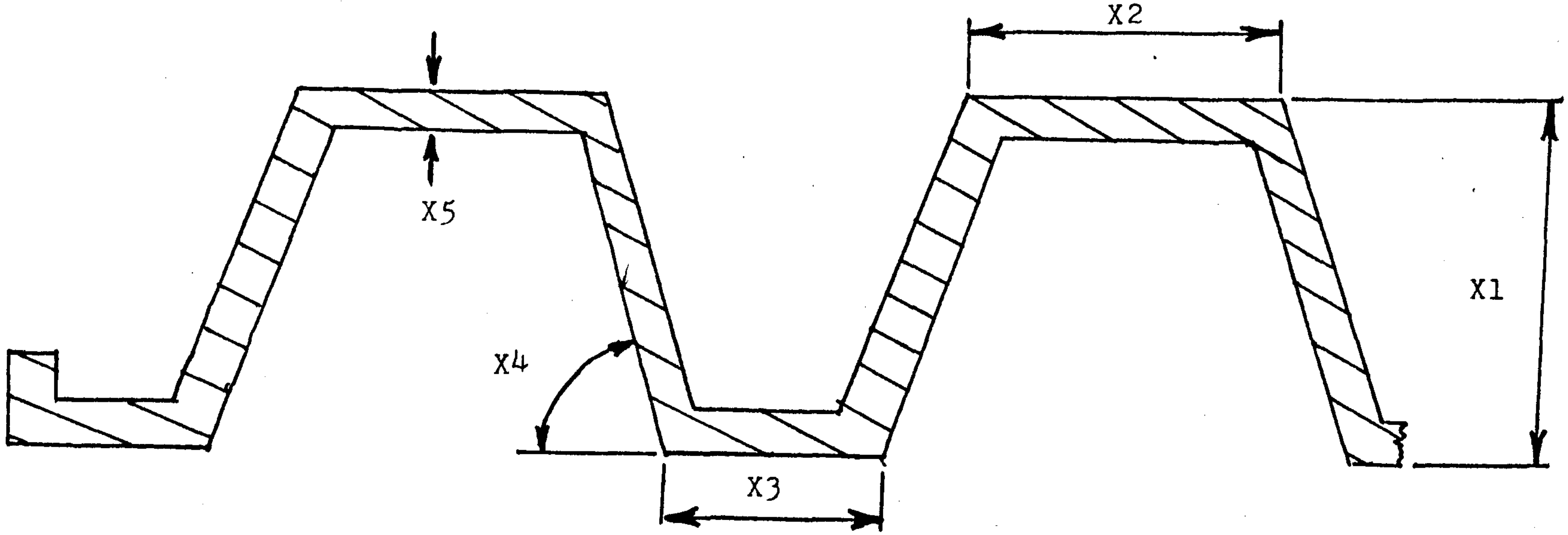

FIGURE 4.1: Section of Corrugated Cladding.After FULTON(1971).

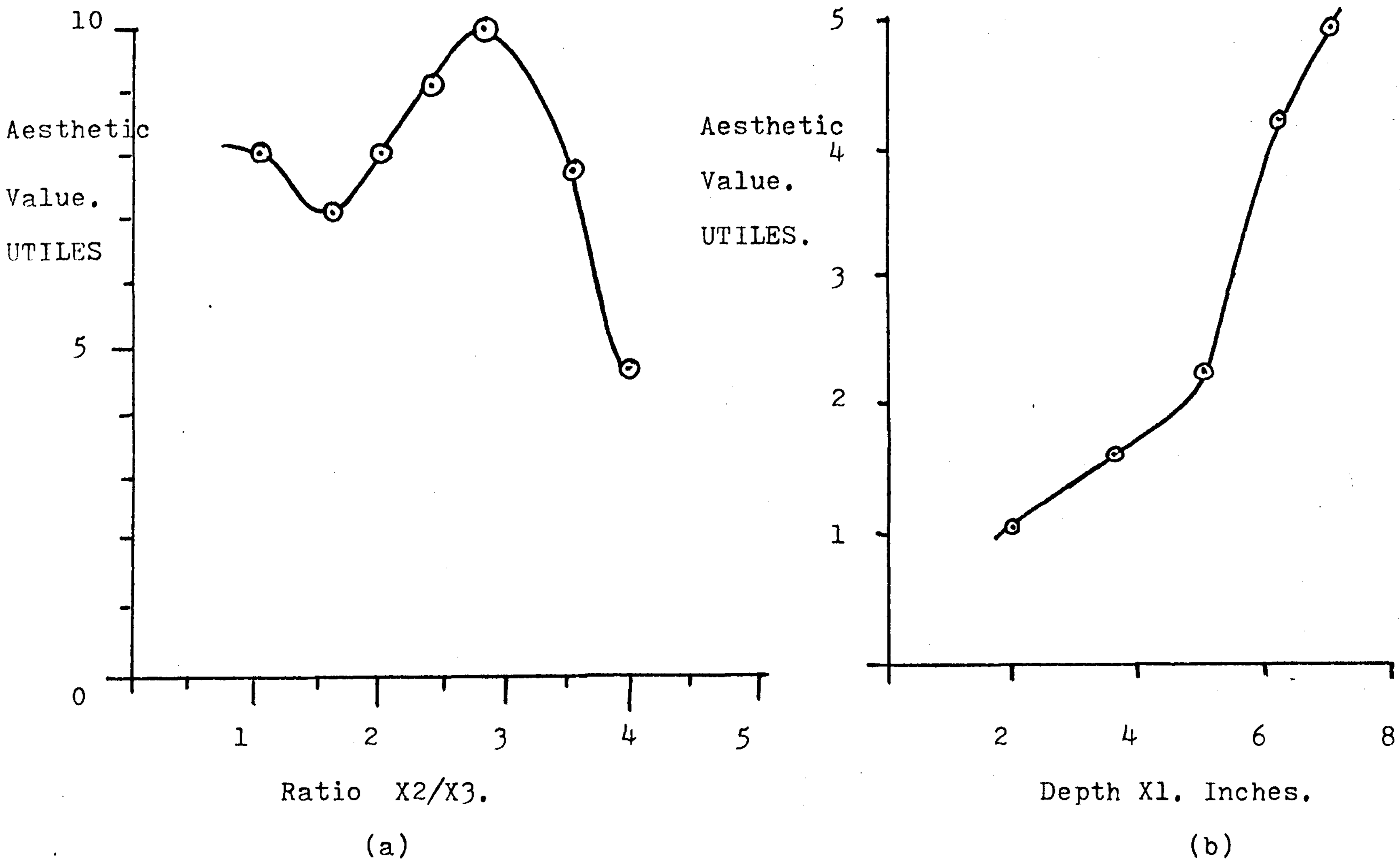

FIGURE 4.2; Aesthetic Value Curve Obtained for Cladding Shown in FIGURE 4.1.After FULTON(1971).

ment. When we consider the first group comprising technological and the other similar factors we can set maximum and minimum values for certain attributes be they design or dependent variables which we call constraints. Typical examples could be; the dimension of a certain part to be 1.00" ± .001" or the priming volume of a hemodyaliser to be less than 20cc. or input impedance of an amplifier to be greater than 1 megohm. These are everyday engineering specifications and we make them because the influence of the independent variables upon them is fairly well known and the correctness of the relationship can be proven in a prototype or model.

In any situation we will also have other types of information concerned with such factors as fuel consumption being as low as possible or blood flow turbulence being as low as possible or total harmonic distortion being as low as possible. How well any candidate alternative fulfills these requirements is a measure of its 'goodness'. Actually a constraint can be considered a special case of the above, but this will be discussed later along with utility.

When we consider ergonomic factors we will normally be considering them in the form of constraints; the controls of the lathe must be within reach of a specified proportion of the population or the force required on a control below some set value in some specified direction.

If we are involved in the design of say seating, we will have as one of our needs, comfort. This is a useful example because it illustrates that a seemingly simple attribute such as comfort may have a large number of contributing factors. The basis for comfortable seating can be said to be, among others, in the avoidance of pressure points, adequate support, and correct posture for the function intended. It also has physiological aspects such as easy dispersion of perspiration and other such factors as avoidance of mechanical vibrations of certain amplitudes and frequencies. Temperature, humidity, noise, lighting are some more of a host of factors which need considering if we hope to design comfortable seating.

The above are necessary but not, in general, sufficient for comfort. There is a symbolic aspect at work here. It is well known that certain types of seating elicits the response, "that looks comfortable", and if we ignore these factors our design may be judged inferior to seating, which although poorer on these ergonomic factors, has taken into account these symbolic factors.

Another example of this process would be in treating what are termed environmental protection aspects. The factors of interest would probably be physiological in the sense of restricting substances detrimental to the present and future health of people and animals being introduced into the environment. Aesthetic factors would be keeping the land and oceans sightly and not polluted by oil slicks or slag heaps. Symbolic factors would cater to the basic needs for a quiet, peaceful, natural environment.

We see from the above that a seemingly single attribute such as comfort or environmental protection may be made up of many other factors. The same form of approach could be employed with some of the symbolic factors. Say we are designing a hemodyaliser and the customer (the hospital) and the user (the patient) have indicated that the machine should not only be failsafe in all modes but that this should be symbolized, ie. the machine should be 'reassuring'. If we follow an 'engineering approach' we use for technical factors we immediately ask, 'how reassuring is reassuring enough?' We shall also assume that the designer and the user/customer have the same conception of reassuring or at least they are synonymous for operational purposes. This is a rather tricky problem; the attribute reassurance is very dependent on the attitude of the hospital staff, ie. states of nature. This problem will be with us in all considerations but the other problem mentioned previously is how the manipulation of the design variables contribute to 'reassurance'. Here there will be no quantitative relationships available but often there will be available a data base of relevant information compiled by psychologists and similar workers.

We have seen how we can use our earlier concept of a person-product spectrum of needs to help us in our clarification of needs and also how the classification is used. We have tried to show that, with complex attributes such as those described, they should be examined with a view to breaking them down into more easily handled variables rather than subsume everything under a vague and ambiguous title.

Having seen how the classification scheme operates we can turn to the next part of our problem; how to identidy a set of these relevant, comprehensive and unambiguous design criteria.

4.3 Identification of Criteria/Needs

In this section we shall explore a number of ways of getting the user/customer to express his needs. He can only do this, however, with respect to a pre-existing design concept, the 'primitive need' of Section 2.2. It is impractical for him to list his needs in a generalized way, and to derive the required product from them. This is because any need can be satisfied in a large number of ways which leads to an infinity of products, most of which, although satisfying these generalized needs, would not be satisfactory.

It must be admitted, however, that the process by which people determine primitive need is probably similar to the above except that the person can decide which of the many ways to satisfy the particular need or combination of needs is the best for him; we do not have this information to enable us to make these decisions for others.

So then we must know the 'primitive need'. The terminology here though, is a little confusing so we can consider the 'primitive need' to be a vague, relatively unformulated concept of what sort of product or process is needed rather than a specific need as we are using the term. We shall consider where this primitive need arises in later sections.

A factor we should consider is the time delay between initial conception and the realization of the idea in concrete form. This means that the user/customer should really express his needs as they will be in six months, a year, two years, depending on the time scale of the product under consideration. This is often difficult for the user/customer as their knowledge of their needs at these future times may be limited. Of course this type of forecasting is done quite frequently, a good example being the primary electrical generating network where system needs must be evaluated five or ten years in advance. Here one must use technological forecasting procedures if one wants an estimate of future needs.

A decision must be made in each situation on whether any form of forecasting procedure is necessary or whether the time scale is short enough to permit 'steady state' assumptions to apply.

It is also desirable that we determine, initially at least, ALL relevant needs. Ideally this includes present and future needs which will be in force during the predicted lifetime of the product. We saw how this expects rather a lot of the user and how it was difficult to achieve in practice. The phrase, all relevant needs, might require a little clarification. It is almost impossible to predict in advance what needs will be relevant,so perhaps the best approach, as we shall be caught up in some form of iterative process anyway, is to exhaust the calalogue of all seemingly relevant needs and then subject them to a critical inspection at a later stage of the project. Of course, we assume our 'dragnet' method actually did include all important needs; this is the problem of comprehensiveness. As noted in Section 4.2, no generally accepted methods for determining sets of criteria are in existence so we shall review a number of approaches to the problem.

HALL (1962, Chapter 13) gives a series of suggestions for developing a good set of objectives. He starts by stressing the logical structure of the operation which he terms the means - ends staircase. He says that, in engineering, most objectives are relatively low level and are means to higher objectives. He stresses that these lower level objectives must be consistent with the higher objectives, ie. they logically belong in the same chain of alternatives and objectives.

He then says that the ultimate objectives are usually only names, ie. only measurable on nominal scales, and tend to be set by groups of individuals with greater influence, either for reasons of power or persuasiveness. On the lower levels, say cost or technical performance, ratio scales can be used. It is impossible to use analytical decision making at the higher levels and <u>the function of good objectives is to substitute for measures one would like to optimize at a higher level</u>. Broadly speaking Hall is using the term objectives for what we have termed design criteria.

Hall then lists a set of procedural suggestions for obtaining a set of good objectives which we shall present in an abbreviated and annoted form;

a) Admit anything, setting objectives is creative work. The critical and judgemental stages come later. Here, although Hall does not suggest it, techniques such as 'Synetics' or 'Brainstorming' might be useful in the search for completeness.

b) State the objectives EXPLICITLY, in unambiguous form without the use of 'loaded terms'.

c) Identify ends and means. Use logical means to edit objectives. Eliminate from the list objectives which are only important as means. A point Hall doesn't mention is that this operation should be performed with care because we are using these lower level quantities which can be handled by well understood methods to substitute for the higher objectives. One can also eliminate those objectives which would not be affected by any choice of candidate alternatives. This can be done at the stage when the candidates have been formulated. CHURCHMAN et al (1957, p. 117) also presents these editing procedures but adds that the edited objectives should be recorded for subsequent re-evaluation.

Hall then gives some suggestions on the analysis of these objectives.

d) Attempt to formulate the logical structure of the alternatives and objectives. Identify the ultimate objectives and work down from these utilizing some scheme similar to that depicted before. Lack of theory dictates that the highest level objectives are set by appeal to authority or based on experience or on trial and error methods.

e) Make consistency checks. This can indicate whether objectives on comparable levels are independent or dependent. Inconsistent objectives reveal the possibility of substitutions or trade-off relationships.

f) It is not sufficient to dub an objective as intangible. If an objective cannot be well defined, it is probably not worth much.

g) Measure each dimension on the highest level of measurement it is capable of.

Hall then gives some suggestions for the resolutions of conflicts.

h) Real conflicts are usually nonzero-sum, and real cooperation is a known way to ensure that the sum is positive rather than negative.

i) Let all parties with an interest be heard.

j) In the case of a deadlock, search for a new principle around which all sides can rally.

k) Finally, remember that there are opportunities for checking at all stages in the process of setting objectives.

There is a method proposed which is based on the development of a hierarchy of goals. This was proposed by HALL (1962, pp. 324-5) above, and JONES (1957, pp. 423-5), utilized by PARDEE (1969), and reviewed and used by LIFSON (1972, pp. 106-11). It is an offshoot of the idea that goals can be analyzed to bring out factors which contribute toward their achievement. If necessary these subgoals are similarly analyzed until a set of decision criteria are identified. Actually this is not a technique for FINDING the design criteria, rather a method for organizing the process. The hierarchical concept helps ensure that the set of criteria obtained are relevant, derived directly from the goals of the design project, and are reasonably independent value-wise. This point of valuewise independence will be discussed later in Section 5.2. The approach is given only a guideline form and to illustrate its application, an example is shown in Figures 4-3 and 4-4 of its use to determine the criteria in a transportation system. Three main groups of people involved are categorized; the user, the operator and society.

In Chapter Two, we mentioned the various states of mind or value systems the designer had to adopt. These are the same as these categories.

This rather simple division into users may not be sufficient and further segmentation may be necessary if the product is to be made for users with widely differing needs. YANKELOVICH (1968) discusses differing ways of accomplishing this without resorting to older, often more unreliable demographic methods. These categories, it should be noted, are not mutually exclusive and persons could, at different times belong to all of them. Figure 4-4 is a further breakdown to reach the level of design criteria for the case of the operator (who is probably the customer for the system). There will be similar development for the other two categories of people considered.

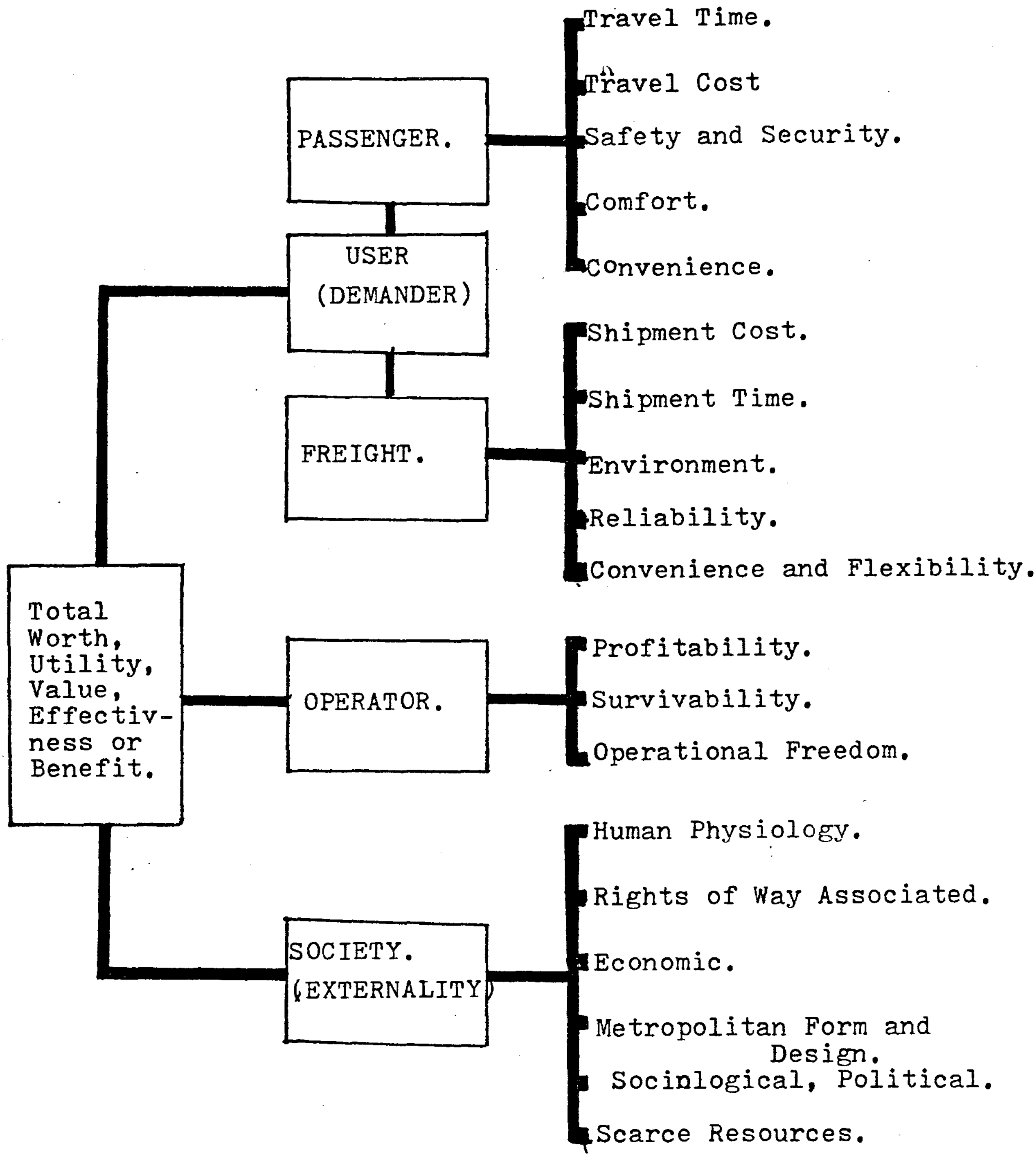

FIGURE 4.3 : Hierarchy of Outcome Dimensions(a).

After PARDEE(1969).

		ATTRIBUTE.	UNIT OF MEASURE.
Operator Attributes.	Profitability	REVENUE.	Dollars.
		INVESTMENT.	
		Right of way.	Dollars.
		Equipment.	Dollars.
		Facilities.	Dollars.
		OPERATING COSTS.	
		Right of way.	Dollars.
		Equipment.	Dollars.
		Facilities.	Dollars.
		Manpower.	Dollars.
		SUBSIDISATION.	Dollars.
	Survivability.	MARKET SHARE.	
		No. of users served.	Direct Worth.
		Geographic area served.	Direct Worth.
		Growth.	Direct Worth.
		Commodities accommodated	Direct Worth.
		INTERFACE COMPATABILITY	
		Present mode integration.	Direct Worth.
		Impact of New Mode.	Direct Worth.
		Displacement.	Direct Worth.
		Integration.	Direct Worth.
		EFFICIENCY	Direct Worth.
		SERVICE.	Direct Worth.
		IMAGE.	Direct Worth.
	OperationalFreedom	PRICE REGULATION.	
		Govt. regulations.	Degree.
		Association regulations.	Degree.
		Price of competing modes.	Degree.
		OPERATION REGULATION.	
		Weight regulations.	Degree.
		Time limitations.	Degree.
		Manpower restrictions.	Degree.
		Commodity and Territorial restrictions.	Degree.

FIGURE 4.4; Hierarchy of Outcome Dimensions.(b).

After PARDEE(1969).

This method will tend to produce a useful and relevant set of criteria, <u>if</u> we make a good choice when selecting the initial goals and when analyzing the subgoals. LIFSON (1972, pp 113) says this task should be given to knowledgeable personnel and adds that the structuring of the hierarchy will be an iterative process. He gives no guidelines for this structuring and in fact says that they are probably not desirable. A problem touched upon by Hall but not really developed, is the difficulty, [HITCH (1961, p. 47)] that when starting with given objectives, the objectives are multiple and conflicting and that alternate means of satisfying any one are likely to produce substantial and differential 'spillover' effects on others. Ends and means do not fit into neat compartments side by side. Perhaps a better way of structuring the hierarchy would be to follow another method ; initiating the hierarchy by dividing into the different groups who use or are affected by the design. The next subdivision would be into the relevant needs of the different groups and then subdivide into the derived design criteria which will usually be dependent design variables.

A group which Pardee seems to have neglected or included by implication under what are called "Externalities" in Figure 4.3, are the manufacturers of the design. For our purposes it would be better to include this group explicitly, as this group will provide most of what we called the 'internal design criteria' mentioned in Section 4.1. There are also other drawbacks to the technique; there is little provision in the present format for active participation by the user/customer. The designer defines and analyzes the goals of the system for the user. This type of analysis is not really simple and requires a fair degree of familiarity with the method to be effective. The effect of this is to debar the user/customer from effective input. This is, however, not an insuperable problem as we shall show later.

We can consider another approach which might be considered the inverse of the previous processes. To use a metaphor, instead of working from the apex to the base, let us start at the base. By this we mean let us try to elicit from those concerned, the user/customer etc., the criteria they say are important in evaluating the design concept. As we saw in Chapter Three during our discussion of the attributes people think important in evaluating something, there is a high probability that they bear but a distant relationship to the attributes they actually evaluate on. This is the difficult problem of behaviour versus attitudes which we must constantly bear in mind.

Methods for examining people's attitudes, values, and preferences have been developed in the fields of psychology and sociology, and we shall be using these sources where possible. Of the large number of inventories, checklists, ratings, scales and questionnaires available for determining various aspects of personality there are, unfortunately only a small number of any relevance to our study. Relevance here is to be taken to mean suitable for finding a comprehensive set of criteria. We would, however, be optimistic if we expected a tailor-made solution and we must expect to have to modify some existing technique. Needs in the psychological sense is used in a rather more restrictive sense than we have used and can be taken to refer to physiological-psychological-aesthetic-symbolic factors referred to in Chapter Three.

Although their book is mainly concerned with the clinical aspects of interpersonal relations, STERN et al (1956), consider the question of attributes in a manner relevant to this discussion. They say that when considering conditions underlying performance, it has been customary to consider such self evident and explicit criteria as represented in the formal statements of objects and goals made by people. As we have noted, what people say they want is not always even remotely true and that conscious verbalization concerning goals and objects are not necessarily reflected in behaviour in the actual evaluation procedure. They then state that actual criteria of performance must be sought in the implicit procedures which characterize prevailing evaluation procedures. An example of the construction of a set of criteria for the evaluation of student performance by faculty is given. This is accomplished by a set of structured discussion groups extending over ten to fifteen hours, during which information was gathered about staff, students, the teaching situation and the expectations the staff held with respect to adequate student performance. This led, Stern reports, to a conception of the ideal student which was fairly uniform across the staff. He says this is unusual and that a multiplicity of such ideals, each representative of some faction, would be more likely. This is an analogous situation to the one we wish to solve; to find what attributes are thought important in evaluating an object, system or person.

This problem has also received attention in the market research field under the general title Product Research, but as a number of papers comment, the field is rather underdeveloped and ill-integrated with the design area. A paper by MARKET FACTS, INCORPORATED (1966) explores this topic and points out some of the problems encountered in the area and embodies some useful examples.

They list ambiguity and difficulties of interpretation as major problems in the identification of product attributes. To illustrate their point they take an example of a study of soaps and detergents. The important attributes elicited by standard methods were 'suds making qualities', 'cleaning properties' and 'effect on hands'. These are not very useful attributes to aid in developing a soap powder; they lack specificity, are ambiguous and are difficult to interpret.

The company then interviewed the same respondents on a depth interview basis using people trained in clinical psychology and interviewing techniques. They show that thirty-seven distinct product attributes seemed to be involved in the respondents' over-all attitude. Their results are summarized in Fig. 4.5. These factors are much more useful to anyone interested in 'designing' a washing powder. These classes of attributes listed could be considered as factors associated with the user and we note that in this particular approach the needs are elicited directly from them. They also point out that the user/customer's criteria for evaluating any particular attribute may not be the normal workshop or laboratory methods known to the researcher or designer. Examples of this would be that of the user/customer measuring the 'strength' of a washing powder by dipping their hands into the water and gauging by the 'feel'; or that of a motorist slamming a car door 'to see if it's solidly built'. In both cases the form of measurement is of no use to the designer in his work, but it is very important that he should know about it because these forms are very important to the user/customer no matter how subjective or misconceived they may be.

CLASS OF ATTRIBUTE	NO. OF PRODUCT ATTRIBUTES	EXAMPLE
Kind of cleaning job done.	11	Getting greasy dirt out. Cleaning really dirty spots. Cleaning shirt collars.
Long run effect on clothes.	2	Clothes seem harsh.
Suds factors.	5	Amount of suds. Thickness and heaviness of suds. Time needed to make suds. Permanency of suds.
Rinse and Film Factors.	5	
Effect on Water	2	
Effects on Berson Using	2	Skin irritation.
Effectiveness for other Household Tasks.	4	Washing floors.
Volume and Cost Factors.	2	
Others	3	
Total	37	

FIGURE 4.5: Breakdown of Product Attributes.

Adapted from MARKET FACTS INCORPORATED(1966)

Both these previous two approaches will lead to difficulties in knowing whether a comprehensive set of criteria have been obtained. Because of the way they are elicited using depth interview techniques the workers would claim they are relevant and because of the interaction between the respondent and interviewer, ambiguities can be cleared up as they arise. The 'depth interview technique' is acknowledged to be impractical for field use because of the shortage of trained personnel and the expense and time involved. The use of these techniques for preliminary testing is not ruled out, but other methods would be preferable.

This information might be obtained more easily by use of other techniques such as checklists and questionnaires. Most of these methods have been developed for use in a clinical setting and are not really suitable in their present form. There are some projective type tests which are extremely flexible; examples would be the Rorschak Ink Blot Test and the Thematic Apperception Test (T.A.T.) but with these and similar projective tests there is a problem of their questionable validity. By validity, we really mean the results are subject to variable interpretations which are couched in language which is, terminologically and conceptually, difficult for anyone outside the immediate field to understand, making these techniques of marginal usefulness for our purposes. This is not to say these techniques have not been used without success in marketing research for determination of such factors as images of products, but for the reasons given above, we would prefer not to use them. Other marketing approaches , put forward by KUEHN and DAY (1968) and EASTLACK (1968) , show how to obtain a profile of users/customers product attributes for frequently purchased consumer non-durables. Much of what they report would probably be of use outside their restricted field and like many of the methods reported both here and in the literature, utilize preliminary depth interview techniques to determine desired product attributes. This is followed by some form of attitude scaling to determine the relative importance of the various attributes elicited.

We could continue to catalogue various tests with their corresponding features and limitations but this would not be a very fruitful exercise, so the interested reader is invited to consult some of the many books on the subject; a good introduction to general techniques being OPPENHEIM (1966) and CRONBACH (1960). EASTLACK (1968) shows how these problems are tackled in the field of consumer durables and non-durables. What we shall do instead is to restrict ourselves to some of the more promising looking methods investigated.

KELLY (1955) has proposed a Repertory Grid Technique for these sorts of purposes. The technique was put forward as part of his broader theoretical framework dealing with personality, but it is not really a single test but rather a very flexible test which can be applied in many fields. In Kelly's terminology the technique gives a "map" of the respondents' "personality constructs". These "constructs" are the way the respondent "sees" the world around him. They can be likened to his evaluatory constructs; how he evaluates the world around him, what attributes "things" have. Use can be made of Kelly's technique without using his theoretical framework, but for more advanced work in the field this framework would repay study.

To use Kelly's terminology again a "..construct is a way in which two things are alike and in the same way different from a third". The procedure then for identifying these constructs is to present the respondents with three objects, photographs or descriptions, and ask him to say in what ways two of them are alike and at the same time different from the third; no quantitative measures are considered. Each construct is regarded not as a matter of degree, but as a dichotomy, an attribute, either present or not. How then can this technique be useful in determining a set of design criteria?

The technique satisfies the requirements of STERN (1956), mentioned earlier, in that it gives us access to the attributes the respondent perceives associated with objects and which he evaluates upon. We have thus elicited from the respondent "...the actual criteria of performance (which) must be sought in the implicit procedures which characterize prevailing evaluation procedures".

Our procedure will be concerned with objects, to find which way these objects are seen as being different and so we shall have to modify Kelly's clinically orientated approach somewhat. In the clinical situation, the objects are people, known to and chosen by the respondent for certain roles provided for in the approach. Examples of such roles would be the respondent's mother, father, brother, disliked teacher, admired person, etc. All these people are well known to the respondent who thus has his knowledge of them to enable him to differentiate meaningfully between them. These roles were chosen because they are people well known to the respondent and also because his relations with them were found by Kelly to include most of his important constructs. When considering products these translate to the respondent being familiar with the products so the second point, comprehensiveness can be better facilitated.

Methodologically, we can consider two cases where the technique might be applied;

1) When the respondent has some familiarity with similar types of products or systems. If a similar type of

product exists and, for some reason, the respondent does not know about it he should be familiarized with it as it might fulfill his needs without further ado and also for him to gain some knowledge of it.

2) When the design concept is new - no other similar systems or products are on the market.

The procedure in the first case would be to present the respondent with either three products, or if this is not possible for size or other reasons, photographs or description will suffice. The actual presence of the products is not necessary since we said the respondent must be reasonably familiar with them if the technique is to produce meaningful results. The respondent is then asked, "In what important way are two of them alike but different from the third?" This is recorded as a construct and the respondent is then asked, "In what way is the odd one different?" This is recorded as the contrasting construct. Hopefully we now have a unidimensional continuum with the end points clearly defined. Further details for administering the procedure can be found in KELLY (1955, Chapter 5).

The similar products are conbined in three's and presented to the respondent until all combinations are exhausted, or until about forty combinations have been presented. Often there will only be a limited number of products which can be used in combination, but if there are a fair number the technique will give better results if we use an analogue of Kelly's approach. We choose product 'roles' by asking the respondent to name a product or system you generally like, generally dislike, consider good but expensive, your neighbour owns and use these as the objects. Further work would be necessary to determine which 'roles' are most useful as no a priori roles can be reasonably postulated.

Case two is more difficult, but fortunately, it is uncommon for a completely new product or system concept to be evolved. Where there are none or very few remotely similar products, there are very likely to be some which performed a similar function previously. A difficulty here may be the shortage of objects to form combinations with. Take the example of the snowmobile. At the time the primitive need for a powered toboggan for filling a want in the winter sports/leisure market was noted, the only products were crude powered sledges used by trappers and line-men. What can be used as objects here? We will have, perhaps, some conception of what is required in a snowmobile and can give the users a pencil and paper or artist's impression. We have the crude trappers' sledges. We think the machine will be of interest in the leisure/winter sports category and so could include say toboggans and perhaps cross-country skis. From our initial thoughts about snowmobiles, we can perhaps see certain analogues with go-karts and perhaps sports cars or, in their purely load-carrying capacity, pickups. We have perhaps six objects.

We are selecting 3 objects from n in an order independent manner and can thus form $n!/3! \times (n-3)!$ combinations where (n) is the number of objects available. Substituting, we find we can form 20 combinations. We can see that in many situations we could be faced with a shortage of objects. Four objects, for instance, would only provide four combinations which would not be sufficient.

There is another difficulty of a rather more basic nature. The way the test is structured means that it cannot reveal desirable attributes which all of or none of the objects possess. This is because attributes are treated on an all-or-nothing basis whereby different degrees of an attribute will not be revealed.

Say we are dealing with automobiles then; because they all have four wheels, this would not be noted as an attribute of automobiles. This example may seem a bit trivial, but when we take the example of say seat belts, which, practically all cars now have under law, we may seriously underestimate the user's concern for safety. Also if none of the automobiles chosen as objects have an uncommon but potentially desirable feature such as, say, modular construction allowing the complete power train to be removed as a unit for servicing as is presently used in some buses, the technique will not reveal this need.

In the last section, a number of approaches to identifying product attributes have been examined. Each approach leaves something to be desired. The problem of comprehensiveness is common to them all. The hierarchical goals technique is the only method providing a systematic approach to the problem; but has no provisions, at present, for direct user input. The other methods approach the task from the wrong end and tend to produce piecemeal results with little overall organization.

The Repertory Grid Technique tends to give a haphazard collection of attributes with no indication of the degree of interdependence between the attributes. It has the great advantage though, that the user/customer can be involved directly in a mock evaluation situation and we can thus hope to extract from him information which will be relevant to an actual market-place assessment. On the debit side it can be seen that the respondent must have a good knowledge of a possibly large number of similar products. Another difficulty here is the often limited number of 'objects' to combine. The other methods, of course, can have a similar objection raised about them; after all, if we are to obtain useful information from the user/customer, he must know something about the product he wants. The problem is, however, aggravated by the larger number of products he should have knowledge of. In the previous discussions of determining user/customer needs, we have explored some of the methods which can be applied before the design effort is commenced. We have, however, noted that the design process is almost always iterative in nature and some means of prototype testing is almost always carried out.

In his article "The Human Scale", DIFFRIENT (1973) notes that whereas prototype mechanical components are extensively tested, the relationship between men and machine (what we have termed the person/product relationship) is usually subject to very cursory investigation, if at all. He goes on to say that all aspects of the person/product relation should be explored if we are to achieve a good design rather than merely an adequate one. He suggests a number of techniques for examining these relationships.

He says that the techniques he describes already exist but in order to be useful in the design process, they must be, what he terms "task orientated". This is the problem we have been encountering throughout the previous discussions. He takes the example of the typing situation, recommending techniques such as the measurement of heart rate, respiration and other bodily reaction with a polygraph, videotapes, eye, cameras and psychological tests. It is possible to find out more about a person's reactions to a particular situation than a person knows himself. These means cannot identify the needs of the situation immediately, they must be used in appropriate circumstances and the results interpreted correctly.

The other techniques, mainly from the marketing field, use a depth interview as their 'method'. They have the great advantage of being extremely flexible and can produce unambiguous factors but have practical difficulties associated with the interview technique as well as showing the problem of producing a haphazard collection of factors with little or no internal organization.

The above arguments should serve to indicate that the hierarchical goals concept is a very necessary part of any technique of identifying user/customer needs. In view of its shortcomings it will require some additions, perhaps by combination with some other technique.

4.4 Concluding Remarks

We have reviewed a number of ways in which the identification of the design criteria and the user needs have been attempted.

Two aspects of the task emerged;the systems oriented approach for structuring the whole problem and what might be termed the marketing approach for determining the user needs in any situation. For the project to proceed to a satisfactory conclusion these two aspects should be integrated.

CHAPTER FIVE

QUANTIFICATION AND AMALGAMATION OF USER NEEDS

5.1 Introduction

In Section 2.6, the steps required for the formation of an objective function were noted. The first task was the identification of a set of design criteria. This was dealt with in Chapter Four. The second and third items were the identification of limits on the criteria and the conversion from units used in the criteria, length, weight, to those of 'system worth' respectively. The fourth point was the identification of the relative weights to be assigned to these various criteria. We shall treat these tasks under the general heading quantification.

If we are eliciting these criteria from a number of users, we must have some means of obtaining a consensus on the criteria. This will be treated under amalgamation.

5.2 Quantification

The design criteria will be, in general, dependent design variables. The methods discussed previously should be used to obtain a set of these criteria that are suitably 'quantitative'. By quantitative we mean the scales to be used for measurement have been identified and the estimation methods to be used, reviewed and found satisfactory. Examples of this can be found in Section 4.2. The types of scales we are talking about could include kilograms, kilometers, hours, percentage increase, etc. This type of scale is commonly used in engineering and corresponds to the first group of criteria we discussed in Section 4.2.

Often a generally accepted scale of measurement is not available for some design criteria we wish to use. These are often of the type described in the second group in Section 4.2. In cases like this it may be expedient to try a method such as that suggested by LIFSON (1972, p. 112) for 'quantifying' qualitative criteria in a particular situation.

He takes the example of 'corporate image', which we would term a symbolic factor, but many other examples are possible. As no generally accepted measure is available, even if we succeed in defining the term, he suggests the setting up of a simple scale using the following steps:

a) Identify an organization, preferably similar to the one being considered, whose image is considered excellent and would contribute as much as any to success. Assign an arbitrary positive number to this, say plus one.

b) Identify an organization whose image would contribute neutrally to success. Assign zero to this image.

c) Identify an organization whose image is terrible, whose image would contribute to failure as much as any. Assign the number minus one to this image.

Lifson argues we now have a quantitative scale, but a more important aspect of this scale is that the meaning of the qualitative criteria are identified through the use of examples. Our dependent variables acting as criteria have now been scaled and we must then perform the conversion from the units used in the criteria to those used as a measure of system worth. This is accomplished through the use of utility relationships.

The modern idea of utility theory has been developed primarily in the disciplines of economics and statistics, as we mentioned in Chapter Three. It has only relatively recently been pioneered in the field of engineering by workers such as LIFSON (1962, 1972, and 1973) who deals with the theoretical and practical aspects of using utility relationships in an engineering context and SIDDALL (1972 a) and (1972 b) who treats the matter more from the aspect of using utility as a vehicle for user participation in the design process.

We are trying to maximize total system worth and can use utility by maximizing the total utility. Actually as much of the information we have is inherently probabalistic, it is more correct to say we are maximizing total expected utility. LIFSON (1962) and SIDDALL (1972 a, Sec. 3.7) show how this probabilistic element can be combined with the concept of utility.

As utility is a function of the magnitude of the design criteria it can be considered a second level dependent quality, dependent on the first level dependent qualities acting as criteria. What we wish to do is to obtain the utility relationships of the user/customers. BERG (1972) reviews the various methods of obtaining these relationships in the"Health Status Indexes". There are two main ways of accomplishing this task -, magnitude estimation and indifference bets. The former method is developed from some of the findings in psychophysics. STEVENS (1966) has said that "...it seems clear that utility, like brightness, is the response of a human organism to an external configuration of the environment. In this sense, money is as much a stimulus as a light wave." We are using utility as HANDY (1970, p.127) puts it; "...as a buffer between a choice and its supposed psychological grounds. The use of utilities may enable the investigator to avoid direct enquiry into those grounds but at the price of making utility rather a mysterious entity".

The technique of magnitude estimation would involve, in its psychophysical form, providing the respondent with a stimulus, and assigning a number, say unity, to the magnitude of that stimulus. He is then required to assign numbers to reflect his impressions of the successive stimuli. It has been found that a power law expression fits these stimulus-response relationships. Now this type of determination is not as straightforward to arrange in the case of engineering type variables. It is questionable whether it is a rewarding task to do so in many cases except those deemed critical to success. Perhaps here the approach of SIDDALL (1972, b), where he advocates the intuitive drawing of utility curves, could be used to advantage. This could be called implicit magnitude estimation. Examples of this type of approach can be seen in the work of FULTONS (1971), shown in Figures 4.1 and 4.2 and described in Section 4.2, and by DUDA (1973). There are other methods for eliciting and scaling utility relationships. The more important methods available would include the Standard Gamble pioneered by VON-NEWMANN and MORGENSTERN (1953), (see indifference bets), and the Equivalence and Ranking Methods outlined in GUILFORD (1954) and THURSTONE (1959). The Direct Magnitude Estimation methods are demonstrated by MAC-CRIMMON and TODA (1968).

Generally it will be difficult and time consuming to set up the indifference bets method and unless this approach is particularly well adapted to the problem at hand, we will generally use the magnitude estimation type of approach. It should be noted, however, that the two types of approach do not give quite the same relationships.

Utility is, as we have said, a function of our design criteria which will, in general, be dependent design variables. A specific utility relation or curve is valid for any candidate alternative for a given user or group of users and for a given purpose.

The design criteria should be acceptably valuewise independent. We require this condition if we are to have a manageable model. A further description of this requirement can be found in LIFSON (1972, pp 92-93), or FISHBURN (1964, Chap. 9). The effects of each criterion on the achievement of goals and objectives should be independent of the levels of any other criteria. This allows us to treat each utility relationship in isolation without considering the others. It is to be emphasized that no assumptions are being made concerning independence of the criteria at the analysis stage. Changing a design variable can cause changes in many of the decision criteria. The criteria may be strongly interrelated in effectiveness computations. It is only in the value model, in the relative contributions to success, that independence is assumed.

Say we are considering an automobile and have among our decision criteria, for example speed and road-holding. As the speed rises, road-holding becomes more important for success and we should really reweigh the road-holding utility curve for each speed. Say we take the criterion of braking distance; we find this independent valuewise of vehicle speed, whereas braking deceleration is dependent, valuewise, on speed.

We said we were treating the setting up of the utility relations along with the setting of some constraints. These constraints can be incorporated into the utility curves by allowing them to have a negative utility beyond the specification thus decreasing the utility of the total design. This is called a specification point or threshold value. The shape of the curve in the region of the threshold value depends on the nature of the specification. A 'hard' specification will cause the curve to drop to minus infinity at the specification point, whereas a 'soft' specification may merely cause the utility to drop to a negative value. See Figure 5.1.

The curves are defined using any of the two main types of method mentioned earlier. The choice of method will depend upon the situation. Whichever method is used to obtain the utility relations,the basic technique will be similar. The upper and lower limits of each criterion must be specified and will define the range of interest. It is, of course, important that these should not be unduly restrictive and so tend to narrow the choice of alternatives at the synthesis stage.

A utility of, say, unity is assigned to the most preferred magnitude in the range of interest. There can be problems with this approach when the utility tends to infinity somewhere in the range, usually at the ends of the range.

Utility theory does not allow an infinite value for utility, [LIFSON (1962, p.7)] and an infinite value will make scaling difficult. This difficulty can usually be overcome by alterring the limits of the criterion. We have the choice here of setting up either an interval or ratio scale for utility measurement. A good example of the difference between these two types of scales can be seen by comparing the Fahrenheit and the Absolute scales of temperatures. Different workers in the field use different methods. SIDDALL (1972 a, Chap. 7) uses an interval type utility curve. LIFSON (1972) favours a ratio type of scale. KLEE (1971) gives an alternate method of ratio scaling. We must, to define the zero and scale, determine the zero of the utility scale. This point is a threshold which separates the desirable magnitudes of a criterion from the undesirable ones. In the desirable region we assign positive utilities and in the undesirable region we assign negative utilities.

This threshold is equivalent to the natural origin found in psychophysics. As TORGERSON (1958, p. 30) has put the matter; "In the measurement of such attributes as attitudes, aesthetics, preference and value, the natural origin occurs within the series and can be described as a neutral point such that all stimuli or individuals in one direction are favourable, pleasant, liked, or wanted as the case may be, whereas all those on the other side are unfavourable, unpleasant, or not wanted." SIDDALL (1962, pp 96-97), LIFSON (1972, pp 91-104) and (1973, pp 308-310) show engineering determinations of these curves. Other workers such as DE NEUFVILLE and KEENEY (1972), SWALM (1966) and NORTHRUP et al (1970), and KELLER (1972) show how information can be gathered from a wide cross-section of the community to set up the utility relations necessary for evaluation. MOSTELLER and NOGEE (1951) and COOMBS and KOMORITA (1958) describe the determination of the utility functions of individuals for money using indifference bets. GREEN (1963) describes the determination of the utility functions for executives for the return on investments. When utility curves are being set up it is important to isolate each variable and ignore interactions or trade-offs. Thus if we are considering maximum speed of an automobile we should ignore the fact that increasing maximum speed will increase the cost. An exception to this is where we want to include the effect of some variable we find difficult to quantify. Thus we may modify the utility curve for maximum speed to account for the deterioration at say, high speed straight line stability, which we cannot quantify in any other way.

Other methods of eliciting and scaling utility are available in the literature and include WOODSON'S (1966) method and HARRINGTON'S (1965) Desirability Function. These two approaches are reviewed in SIDDALL (1972, Section 7.11)

These relationships are scaled on an arbitrary utility scale and if we are to use them as a measure of total system worth we must determine the importance of each variable in contributing to the success of the design, ie we must determine the cross-criteria relative weights.

The eliciting of quantitative judgements about preferences among attributes of differing dimensions has an analogy in the field of psychophysics, where for instance, the brightness of lights and sound levels are compared.

A method for determining these relative weights is presented in CHURCHMAN et al (1957, pp 136-153). They do not use the concept of utility, using instead, as common in the operations research, the dollar as a unit of system worth. The method is however, perfectly applicable and they give a number of illustrative examples. LIFSON (1972, pp 115-119), KLEE (1971) and TURBAN and METERSKY (1971) also give similar comprehensive methods.

We would also like to obtain information about the external variables, the states of nature. As we said earlier, these states should be exhaustive and mutually exclusive. As they are associated with some future date, the state which will occur cannot usually be predicted with certainty. We have then the three types of decision situation. Certainty, where the states of nature are known, risk where the probablilities of each state are known and uncertainty where the required probabilities are unknown.

Techniques such as the Delphi technique DALKEY and HELMER (1963) and DALKEY (1969) exist for eliciting this information from the different groups involved.

5.3 Amalgamation

This topic has two facets:

a) Combining different users' or groups' utility relationships and,

b) Combining these various utility relations to give a measure of total system worth.

Perhaps the best introduction to the first problem is to quote the economist ARROW (1963) from his monograph, "Social Choice and Individual Values", when he says, "...we ask if it is possible to construct a procedure for passing from a set of known individual tastes to a pattern of social decision making, the procedure being required to satisfy certain natural conditions". Arrow says these natural conditions include such factors as rationality and non-dictatorship. He finds that there is no way we can obtain a social choice from individual values without violating one or more of his 'natural' conditions. Arrow also demonstrates that a commonly used technique whereby a majority vote is taken on the alternatives taken pairwise can lead to inconsistancy and irrationality. It should be remembered, however, that this type of voting procedure is used frequently in many levels of decision making with no qualms about its theoretical inconsistancies.

RESCHER (1969, pp 99-110), proposes a method of obtaining a consensus by omitting one of Arrow's conditions which he argues is not necessary. He proposes that the "..social evaluation of an alternative be simply the average (over the entire 'population' of that society) of the metrisized individual evaluations of this alternative." By metrisized evaluations he means that real number values have been assigned to the preferences of each individual.

The present means of finding the needs of groups of people used in the marketing research field consists mainly of finding the 'average' user either taking the market as a whole or segmenting it. This rather simplistic concept of the 'average user' is attacked by FRIEDMAN (1972) and KUEHN and DAY (1962) who call this the majority fallacy in that it only considers the majority needs and not their distribution.

This approach gives us no idea of the variations within the group we are considering. We can consider we know the 'mean' but not the 'variance' of users needs. We are not using a lot of the information about the market which is useful.

Arrow's and Rescher's work is concerned with preference functions and not utility relationships, but their findings can be used as a basis for aggregating utility functions.

We can, methodologically speaking, consider two cases of amalgamation where we have a mixture of rating scales and utility relationships and where all criteria can be represented by utility relations. The method proposed earlier by Lifson does permit, through the use of examples, the establishment of an elementary scale. This scale is not generally related in any known way to the independent design variables and so the user's reaction, on these particular attributes, to any given candidate alternative, cannot be predicted by the designer. The user thus has to rate each alternative himself, a situation which is less than ideal.

SIDDALL (1972 b, pp 96-97) makes a number of suggestions about combining utility relations. Where utility relations do not exist for all attributes, Siddall suggests a modified voting procedure to select the best candidate alternative. With this process the designer cannot determine total system worth during the design process; he must always refer back to the users for their evaluation. This makes it more difficult for the designer to select the most promising looking candidate alternatives after the process of synthesis.

Where all criteria can be represented by utility relationships, or those that cannot are independent of the

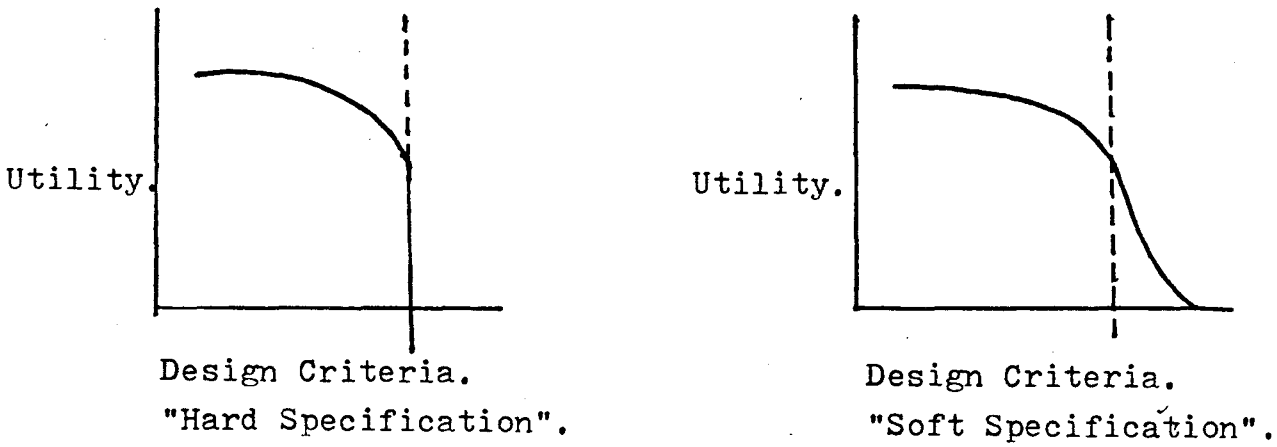

FIGURE 5.1: Hard versus Soft Specifications.

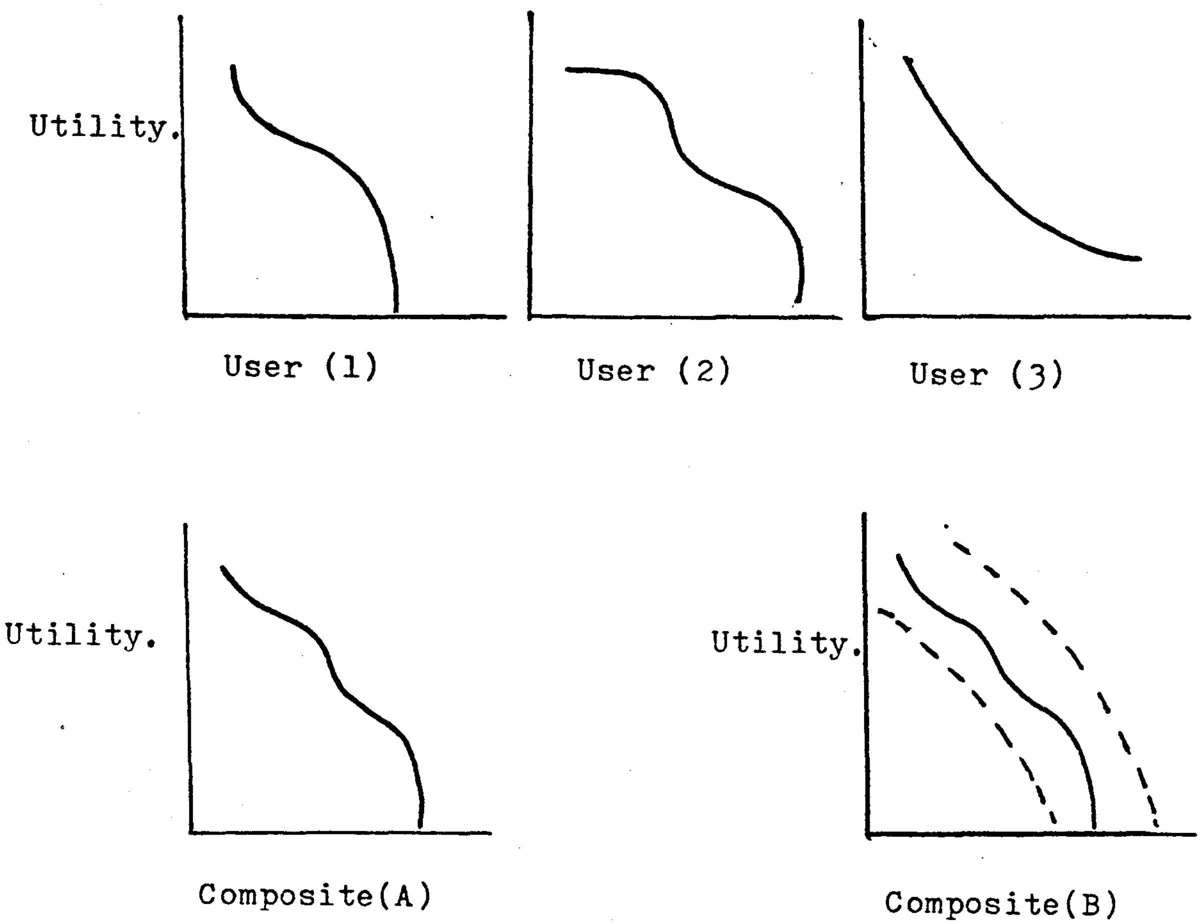

FIGURE 5.2: Amalgamation of User Utility Curves.

candidate alternatives, we can attempt to obtain a consensus utility relationship. If we can do this, the designer has substantially more information to guide him. He can determine for himself the total worth of any alternative he wishes to synthesize. He can also apply decision theory and optimization analysis as does LIFSON (1972) or SIDDALL (1972 a).

SIDDALL (1972 b, p.97) then proposes a means of aggregating the users' curves making use of a weighted mean procedure to obtain a consensus curve. In Figure 5.2, we see representations of utility curves for three users for the variable, weight. The mean of each curve is found using only positive amounts in the range of interest. Because the curves are drawn on an arbitrary scale a form of normalization is used. The curve for each design criteria is averaged by working in discrete intervals. If specification points are present this procedure breaks down. Siddall suggests that it is desirable that no specifications be permitted unless a majority of users want one. If there is to be a specification point, it is taken to be the weighted mean of those specified rather than simply the mean as suggested by SIDDALL (1972 b, p. 97). This gives a larger weight to those who rank the attribute as important. See Figure 5.2(A).

This procedure gives us no idea of the amount of agreement within the group on the resulting consensus relationship. Perhaps instead of merely indicating the mean of the consensus utility relationship, the scatter, indicated say by two standard deviations each side of the mean, could be shown. See Figure 5.2(B). While existing mathematical techniques might not be able to handle this analytically, it could give the designer insight into the unanimity of the users' needs for any particular attribute. This measure of spread in the user needs is very useful if coupled with a determination of certainty equivalents and a sensitivity analysis. For a particular alternative the certainty equivalent of a person for a given attribute is the amount of that attribute that is indifferent to its probabality distribution. The vector of certainty equivalents for each attribute allows an insight into the dominance of certain attributes. It will also give information about how much of any particular attribute it is necessary to trade-off for a given amount of any other attribute, for any alternative to be preferred to any other.

With the information about spread of user needs, we can gain valuable insights into how critical various attributes will be in contributing to overall product satisfaction.

This information can also give us clues to whether the market requires segmenting. Say we have an attribute with a large spread and which critically affects the outcomes. This is an indication that unless the attribute can be varied, the product or system is doubtful to give satisfaction to the proposed market as a whole.

The second aspect of amalgamation is how to combine the utility relations to form a measure of total system worth. We have suggested earlier that total system worth can be measured by total expected utility. While the question of combination of utility components is not wholly settled, many authors, eg. LIFSON (1973, p.304), argue for the use of maximum expected utility, ie. the simple weighted sum of weighted utilities. Others have suggested different approaches. Examples of these approaches are;

$1/Ut = \sum 1/Ui$ SUTHERLAND(1970)

$Ut = \prod Ui$ HARRINGTON(1965)

where U_t is the total combined value, and U_i is the utility of the ith attribute.

5.4 Summary

We have discussed a number of methods currently available in the literature for scaling, weighing and communicating people's needs to the designer through the use of utility relationships. We have also seen that elementary scales can be set up to 'quantify' qualitative phenomena.

This quantification of judgement serves as a link between people's so-called subjective needs, preferences, and desires, and the formal methods of decision theory or optimization. It is merely a tool which is necessary if the user and the designer are to communicate adequately.

CHAPTER SIX

CONCLUSIONS

We have seen in the previous chapters how better means of communication between all parties involved in the design process and the designer are needed. We have also seen how important it is to obtain an explicit expression of the users needs. Just as important however is the impact the system or device has on others who will be affected by it. We must therefore explicitly consider the needs of groups, other than users, by having an information input from them. We may find the needs of the user and those of society are contradictory; an example would be the motorist who likes a loud "sporty" exhaust. The resolution of conflicts is not amenable to solution by any known technique except that of consultation with all parties, as was mentioned by Hall in Section 4.3.

In our brief examination of the role of needs and values in the design process a number of useful points were raised. The user requires some involvement in the design process if he is to define his needs. He can only define his needs with respect to a pre-existing design concept; he cannot define his needs in isolation from a actual configuration. He thus cannot be aware of all possible effects the design may have until it is in service.Through the iterative nature of design these initial requirements are refined and updated to approach this ideal. We also saw how,if we are to obtain a meaningful set of criteria,the user should ideally define his needs under conditions similar to those which will prevail when he actually uses the product or device.Methods such as Kelly's Repertory Grid Technique will help us elicit a meaningful set of criteria.

We have argued that,to provide overall organisation to the process,a technique such as that used by Pardee is essential as it also tends to lead to a more comprehensive understanding of the problem.This approach of hierarchy structuring has been put to use mainly in the design of large systems,evaluation of transportation systems evaluation of airport sites,evaluation of hospital siting in earthquake regions and evaluation of a world wide weather data collection system.

Some other approaches use quantification of user needs through the agency of utility relationships.The work of DE NEUFVILLE AND KEENEY(1972) is notable here. Having set up a computer model of the airport siting problem they could input data representing different groups needs.Typical groups included passengers,residents living near proposed sites ,airlines and the operators (in this case the Mexican Government).The computer model would then output the best alternatives for the given input, needs allowing exploration of alternatives. The idea here is not to obtain a whole set of airports, but to give users feedback to enable them to see directly and immediately the effect different parameters have on the solution.

This iterative nature of the design is very important because, as we said, the user cannot define his needs completely until he can envision all possible ramifications the design may have. The recycling of the input enables this vital feedback loop to be closed allowing for the adjustment or change of perceived needs.

It can be seen that using the same basic approach we can have two ways in which design participation can operate. These correspond to those outlined in Section 2.1:

a) We can build our computer model and allow users to input their needs giving a solution to their own needs subject to non-violation of certain non-user needs.

b) Use the same computer model only input our consensus needs to obtain a 'consensus product'.

While in any project both approaches have their place, the first is best used in the exploratory stage when the users' needs are still relatively unformulated. The feedback will give them information about some of the consequences of their input needs.

If we are to explore these alternative solutions, the use of interactive computer facilities is very useful in order to process the many variables in a short period of time. This means alternative solutions can be presented to the user almost immediately for his consideration.

Some of the stages of the process of quantification of judgement could be accomplished by using an interactive computer terminal. This is proposed by SIDDALL (1973) and an example of the use of interactive terminals can be found in EVANS (1972).

We are arguing for the application of these two techniques, hierarchy structuring and quantification in the design of small as well as large systems. The advantages that accrue from the use of these techniques can benefit large and small projects alike. The benefits of these techniques include logical consistancy, explicit review, and unambiguous communication between the user and designer and also between different members of the design team.

We must remember, however, that the techniques we are advocating are relatively crude. Crude, that is, by comparison with the range and subtlety of human needs and emotions. We would be naive if we imagined that formalized techniques such as this could produce 'human' answers. They must be considered no more than convenient devices for aiding the designer in his task of designing the product the user needs. The quality of the product will still be determined by the abilities of the designer, even though these techniques might appear to have solved many of the difficulties encountered in setting up the projects.

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