THE APPLICATION OF VALUE ANALYSIS TO THE DESIGN OF AIDS FOR THE LOCOMOTOR DISABLED

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SUBMITTED TO THE UNIVERSITY OF CAPE TOWN IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER IN INDUSTRIAL ADMINISTRATION.

I. Erik Manfred KIDERLEN, submit this thesis for the degree of Master in Industrial Administration. I claim that this is my original work and that it has not been submitted in this or in a similar form for a degree at any University.

ABSTRACT

This study details one application of the technique known as Value Analysis. This technique critically evaluates the 'value' obtained by users of a product or of a service.

Value Analysis is a technique which enables an organised development and a quantifiable evaluation, all according to a Job Plan, of certain alternative choices to be made, based on an agreed set of criteria, and an agreed weighting of those criteria with relevance to the particular product or service being discussed. The technique is applied by a team of experts, in fields related to the product or service.

The Functional Analysis, as part of the Value Analysis Job Plan, is then developed by means of the Delphi questionnaire technique. The worth of this functional dissection lies in what is learnt about the product in terms of its use situation.

Having thus determined the functions, the next creative stage is to establish 'what else will do', the so-called 'Alternative Speculation Phase'. This phase involves free-range thinking concepts, e.g. brainstorm sessions and noun-verb analogies, being just two of the concepts fully discussed in this study.

After this phase,the V.A. technique now demands a return to convergent critical thinking. This is carried out on the basis of examining each idea for potential advantages before discarding it. At the end of this 'Evaluation Phase', three workable solutions appeared from this study, all acceptable to the final user.

In the Evaluation Phase of the Job Plan, the workable solutions are evaluated according to an agreed set of criteria. All the above is done by the V.A. team of experts, who then develop the Alternative Evaluation Matrix. This matrix shows on an agreed Percent Satisfaction scale, which of the alternatives will give the greatest 'Value' to the user.

The follow-on phase of the V.A. Job Plan is the Implementation Phase, in which a powerful persuasive presentation of the facts will be required and the full rigour of the value discipline is defined. This is done so as to ensure that the successful alternative emanating from the Evaluation Phase is in fact accepted, bought and specified by the end users. This phase falls outside the scope of this study. However, some suggestions are made as to how this phase may be tackled.

In an analysis of V.A. techniques it is apparent that this technique is best applied to products of a 'long-ago' type of design, presently being used in large numbers. The Perceptual Mapping method will be used to demonstrate that the axilla crutch meets both previously-mentioned requirements.

It is thought that the obvious question i.e. how can this 'simple' product be improved, coupled with the long list of complaints by crutch users, provides sufficient motivation for the selection of this aid for the locomotor disabled. When it is considered that 10% of the world's population is disabled, and that the basic design of the crutch can be traced back to Biblical times, it should be apparent that greater 'use value' of the crutch would benefit many locomotor disabled persons. It must be conceded however, that there is no immediate and obvious financial gain to any one of the parties involved in the locomotor disabled field. This financial implication forms no part of this study. The objective of this study then is the application of the techniques of Value Analysis.

The evaluation carried out in this study led to the development of the so-called 'Combo-crutch', being a combination walking stick, elbow crutch and axilla crutch, by means of a 'swop-top'.

Much of the work of the Value Analysis team leader centres around the co-ordination of ideas of the members of his team. The success of the analyst himself depends much upon his ability to understand the members of his team as persons. This continual interplay of of personalities leads to a maturity in human relations - but at the same time demands great tact from the team leader and his team. The profile of such an effective team is analysed in this study.

As the team leader must lead his team onto wild and erratic thinking paths and yet maintain the 'functional usefulness' objective of the analysis as a foremost pre-requisite, the various processes of thinking have been detailed herein.

Value Analysis was developed in 1948 by L.D. Miles of the G.E.C. in the U.S.A., mainly as an aid to the decision alternatives in purchasing. The technique has subsequently been developed to include overall strategies in the decision making areas of technology, commerce and administration, to achieve performance improvement. The technique is now applied world wide with U.S.A. and Japan being the main protagonists. Locally, the technique is formally 'looked after' by the Value Engineering and Management Society of South Africa.

It may be concluded that the technique of Value Analysis does provide a quick and cost-efficient way in which to develop and evaluate alternative designs for aids for the locomotor disabled. This study has developed the 'Combo-Crutch'; which has been found acceptable by the specifying and purchasing authorities, the orthopaedic and occupational therapy professions, and the local manufacturers of disabled equipment.

It is submitted that this study has indicated a viable and realistic way to apply the techniques of Value Analysis to the design of aids for the locomotor disabled. The study does set out a method to obtain which product of all available aids is to be Value Analysed, the study then indicates a method to determine how many of these products would be required.

The study then illustrates the use of two techniques, Delphi and Evaluation Matrix, to develop a viable alternative to the common axilla crutch.

It is submitted that the application of Value Analysis makes a marked contribution to the design of aids for the locomotor disabled. As far as could be ascertained from a literature survey, and personal interview, this approach has not yet been tried by any others.

ACKNOWLEDGEMENTS

The following persons and organisations have through their knowledge, contributed to this thesis. Without this knowledge, the thesis would not be what is presented here. It enabled me to draw up an original combination of facts to solve a unique problem.

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CHAPTER ONE

AN OVERVIEW OF VALUE ANALYSIS - THE VALUE CONCEPT

'.....quality is never an accident, it is always the result of intelligent effort, there must be the will to produce a superior thing....'

1.1 INTRODUCTION

This Chapter will give a brief description of the historical background of Value Analysis (V.A.). It will also state the various principles of operation which are applicable to V.A. eg: the concept of Value, Utility, Optimisation and the Objective and Methodology of V.A.

1.2 DEFINITION : VALUE ANALYSIS

Value Analysis may be defined as a systematic inter-disciplinary examination of design (and other factors affecting the cost and operation) of a product or service, in order to devise a means of achieving the specified purpose most economically at the required standard of quality and reliability.

1.3 HISTORICAL BACKGROUND

Value Analysis is not new. In 1947 L.D. Miles who was working for G.E.C. in the U.S.A., marshalled some ideas, which were not new, into an organised system. The Vice-President for Purchasing and Transportation at G.E.C. during the war was H.L. Erlicher. Necessarily, he was involved in the

substitution of new materials in the G.E.C. products because war-time pressure was affecting the availability and price of established materials, especially non-ferrous metals, such as nickle, chromium, cadmium and platinum. A major result of this action was that many manufacturers were compelled to use alternative materials. Not surprisingly, to enable some of the products to perform satisfactorily in the alternative materials, it was necessary to re-design them, and when war ended Mr. Erlicher observed that in many cases a return to the previous designs in the scarcer materials was not justified.

It was noted that many of the new designs performed as well, if not better, and furthermore, were less costly.

Mr. Erlicher discussed his ideas with the Vice-President for Engineering H. Winnie, argueing that the inventiveness that war-time necessity had mothered, ought to be used in peace-time. He thought it should be possible to develop a cost reduction programme that generated advantageous changes to product design, reliability and quality.

These changes would aim to improve the relationship between the cost of the product and its function, and give better value.

It was decided to second an engineer to concentrate on devising the new system, Mr.L.D. Miles. Suppliers, competitors and customers of G.E.C. became interested, one customer being the U.S. Government. Further official encouragement was provided by means of incentives. The campaign instituted in 1954 by the U.S.A. Government to ensure that defence contractors have formal Value Analysis programmes, made tremendous savings for the official procurement departments, especially in military hardware. After training a number of their personnel in Value Analysis, G.E.C. was soon saving several million dollars annually.

In the U.K. the system of V.A. is recommended by the British Government. J.Amery when Minister of Aviation stated: "I am considering whether on certain future major projects, we should ask contractors to submit value engineering programmes with their project studies".

In the meantime Mr. Miles, previously referred to, also noticed that every time he challenged the value of a product, it involved separate discussions with other departments. This tedious and time consuming process eventually led to his development of the Value Analysis Team concept to bring together specialists from the departments involved to discuss value.

In conclusion it may therefore be said that the original development of Value Analysis as a technique was constructed around two basic premises; i) the value concept and ii) the team concept, with value being defined as:

$$\text{VALUE} = \frac{\text{FUNCTION}}{\text{COST}}$$

1.4 THE CONCEPT OF VALUE

1.4.1 Value As Inherent Property

The concept of value is perhaps the most fundamental of all components of the V.A. process. Value may be defined as that which satisfies the need. It may be considered an inherent property of an engineering design. By some means the designer usually intuitively assigns a value in the philosophical sense to each of the variables that affect his design, eg: capacity, initial cost, performance etc.

This value is a measure of the satisfaction that the user will derive from the product, and each variable makes some contribution to the overall satisfaction provided. The degree of satisfaction will depend on the value quantity assigned to each variable.

1.4.2 Utility Value

Generally 'Utility' value is the category of value which is related directly to the functional reliability or usefulness of the product or service.[9]

There are other categories of value of equal importance which cannot be ignored and which are tabulated in Table I.

TABLE I

VALUE CATEGORIES

CATEGORY	PARAMETER
Biological value	Food, drink, sex, health.
Effective value	Play, sex, excitement, comfort.
Social value	Friendship, power, status, good reputation, fame.
Intellectual value	Satisfaction of curiosity, Use of intellect.
Aesthetic value	Appreciation of beauty and style.
Moral value	Appreciation of rightness, goodness, justice.
Religious value	Satisfaction from belief in a greater power.
Utility value*	Appreciation of usefulness of an object.
Game value	Satisfaction from toys, playing games, observing games.
Material value	Pleasure from accumulation of material objects.
Technological value	Satisfaction from love of technology.
Basic value	Hidden values inherited from evolutionary origins eg: need for quiet natural environment.

* Utility Value may be sub-divided in: Economic Value
Cost-Price Value
Functional Value

Despite the great importance of the non-utility values, they are not yet amenable to analytical approach, and the remainder of this study will be confined to the analysis of all components of Utility Value. It must be emphasised, however, that this restriction in no way implies that the more subtle values are unimportant; only that they must be handled in a different way, which does not form part of this thesis.

The main component of Utility Value is the economic usefulness of an object, also known as 'Economic Value'. (See footnote to Table 1.1). When discussing the above, the following definitions are to be borne in mind:

1. Value: This is determined by the lowest cost to reliably accomplish a function.

2. Function: This is that which the product or service must do to make it work.

1.4.3 Economic Value

In Value Analysis the main concern is thus with the economic value component of the Utility Value of the product. The Economic Value may be seen as the Rand/Cent value equivalent of the following four concepts:[15]

1. Cost Value: The total cost involved in producing a particular item, the sum of labour, material and overhead.

2. Exchange Value: The properties or qualities of an item which enables it to be traded for something else.

3. Esteem Value: The properties, features or attractiveness which make its ownership desirable.

4. Use Value: The properties or qualities which accomplish a use, work or service.

The cost is not to be confused with value. Added material, labour or overhead increase cost, but not necessarily value. If value is not increased, together with the added work, or if its ability to perform the necessary function is not improved, then value is in fact lessened.

1.4.4 Cost-Price Value

From the user's point of view there must naturally be a relationship between value and price, this may be expressed as:[9]

$$\text{Use Value} + \text{Esteem Value} = \text{Price}$$

A measure of 'Value Opportunity' would thus be the ratio:

$$\frac{\text{Use Value} + \text{Esteem Value}}{\text{Price}} = \text{Value Opportunity}$$

From the manufacturer's point of view, the 'Profit Opportunity' can be defined by the ratio:

$$\frac{\text{Use Value} + \text{Esteem Value}}{\text{Cost Value}} = \text{Profit Opportunity}$$

In the definition of V.A. it was stressed that quality and reliability levels should not be sacrificed in any way.[15] This means that in V.A., unlike in pure cost reduction programmes, these levels are maintained. However, these levels must be challenged as part of the V.A. process, in order to ensure that they are realistic and are what the user demands. This is best illustrated in Fig. 1.1.

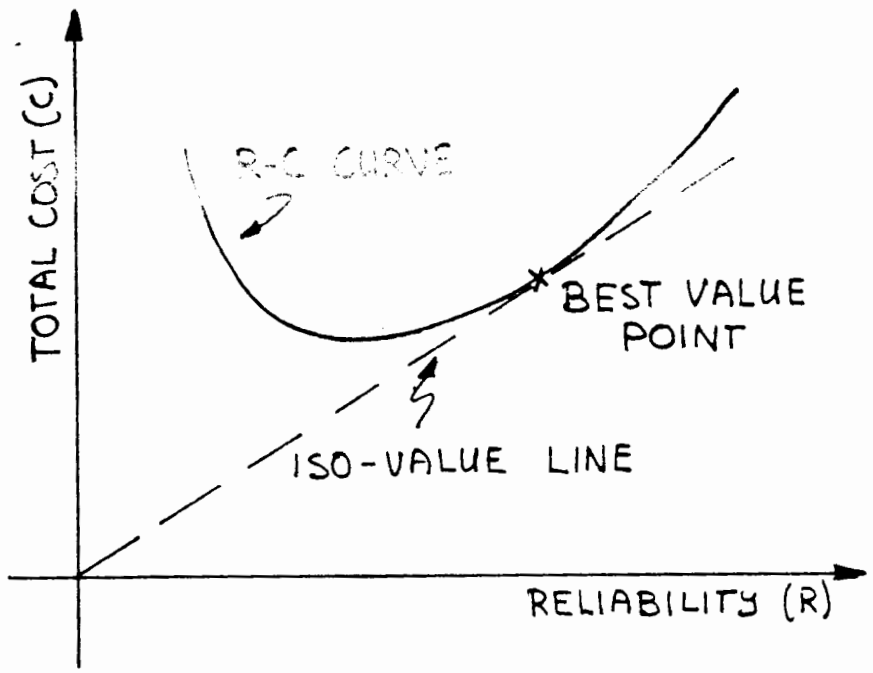


Figure 1.1
The Cost and Value of Reliability

This shows that the best value, in terms of reliability per unit cost, is not found at the point of minimum cost, but at an optimum, being the point of tangency between the reliability-cost curve and the highest 'iso-value'. In this instance iso-value is a straight line through the origin on which all points have the same value i.e. reliability per unit of cost.

1.4.5 Functional Value

Functional evaluation is the heart of Value Analysis and is a series of techniques which locate, identify and remove unnecessary cost.

There is always a new, less costly way to carry out any process. As cost saving ideas have not yet all been thought of it is axiomatic that unnecessary cost still exists in any product. If a new idea has not been thought of, it does not necessarily mean that it can never be; it means that the proper amount of initiative, knowledge, experience and creativity have not been brought to bear on this problem. The closest activity that is normally associated with Value Analysis is that which is known as cost reduction, and because many cost reduction activities are part oriented, the basic question asked is how can this part be made for less. This usually means altering manufacturing methods, relaxing tolerances, saving on materials and so on. Normally, this will produce notable savings with-

out much alteration to design. Value Analysis however strives for large improvement in value and reduction in cost by asking the general question: "What should be done to this device so that it will accomplish its function reliably and yet be produced at a lower cost".

1.5 UTILITY AND OPTIMISATION CONCEPTS

1.5.1 Utility : Variables Relationships

Utility and Optimisation are intimately related and cannot be discussed independently. Utility is that quantity which is maximised by the optimisation process. Utility is a dependent quantity, dependent on, or a function of, such design variables as strength, weight, reliability and the like. (See also Para. 1.4.2). It has been shown that Utility may be related to such variables in a general way indicated by the curves shown below. (See Figures 1.2 and 1.3.)[1]

However, when dealing with equipment for the locomotor disabled in general, there is another common class of dependent design variable which has no limiting value. Weight of a crutch, for example would have a Utility curve such as shown in Fig. 1.4.[1] The curve for serviceability would be as shown in Fig. 1.5.[1]

In general, Utility would be a function of many such dependent variables at once, and not necessarily a simple linear combination.[1] These curves and relationships are hypothetical but illustrate the concepts. It is very important in setting up these Utility curves, to isolate each variable and to ignore interactions or trade-offs. Thus in the weight curve, we are not concerned that lowering the weight may increase the cost (i.e. specially shaped section to maintain strength). We are however very concerned with the increase in Utility as the weight is reduced.

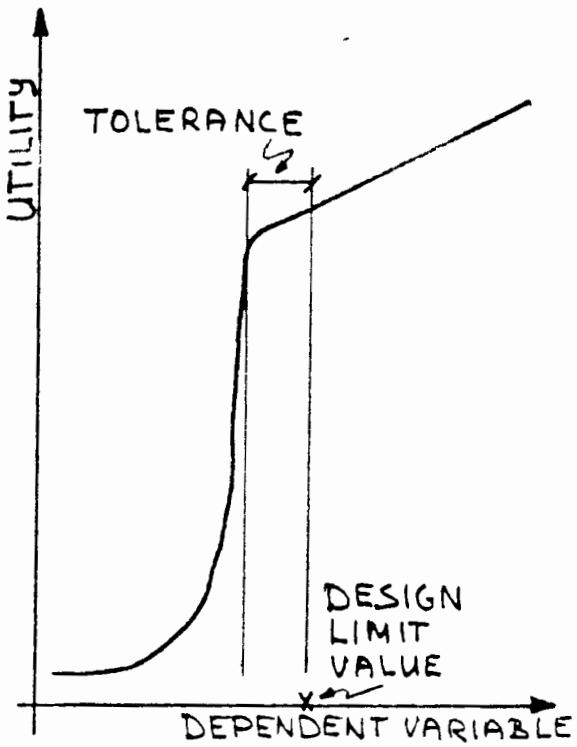


FIGURE 1.2
UTILITY FUNCTION FOR DEPENDENT VARIABLE WITH LIMITING VALUE.

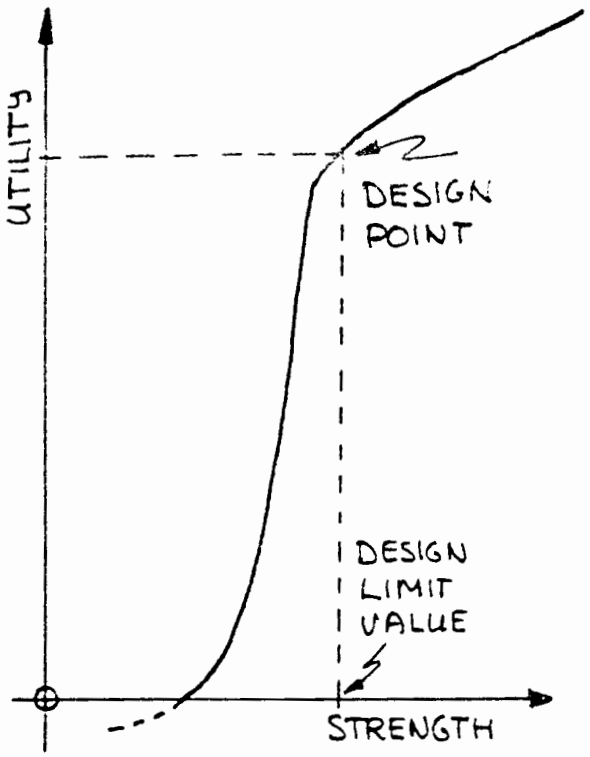


FIGURE 1.3
UTILITY FUNCTION FOR STRENGTH-DEPENDENT VARIABLE.

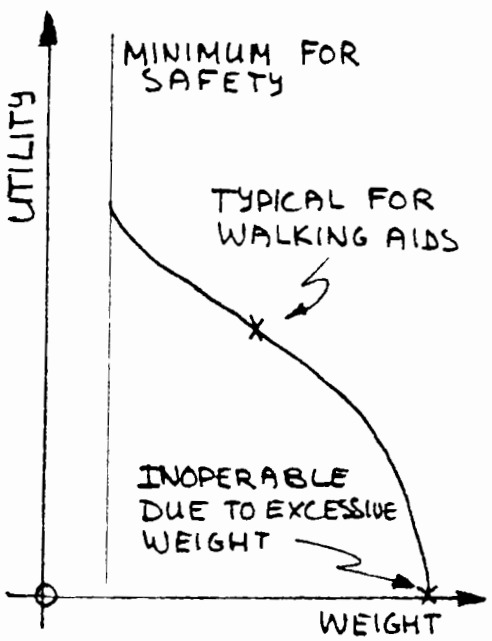


FIGURE 1.4
INVERSE UTILITY FUNCTION-DEPENDENT VARIABLE, NO LIMIT.

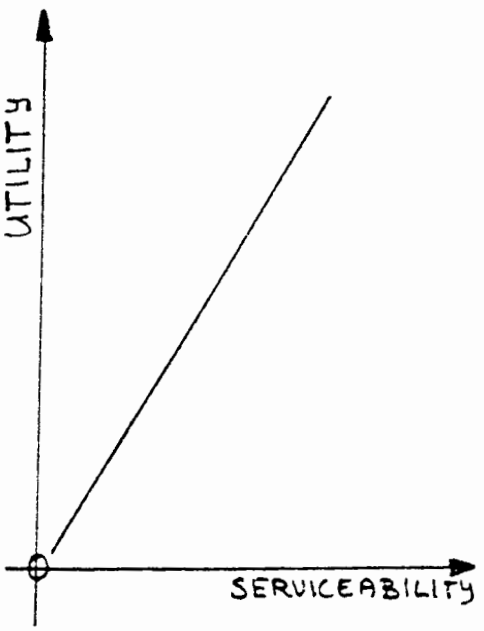


FIGURE 1.5
UTILITY FUNCTION FOR SERVICEABILITY.

1.5.2 The Three Stages of Optimisation

Optimisation is carried out on engineering elements, devices and systems. The primary optimisation occurs when the best combination of elements has been selected to synthesize the device. Or, on a higher scale, the primary optimisation occurs when the best combination of devices has been selected to synthesize a system. Use of the word 'best' immediately requires a value judgement from the analyst. The questions to be asked are: which is the best combination, what are the criteria, is there some dominant variable in the design or manufacture which obviously must be optimised? More often, there are many dependent variables in any given design or product manufacturing process which must be assigned relative values for use as a criteria in selecting the optimum design. It must be decided what relative importance each of these has before the elements of the product and the final design parameters are determined. Mostly this is done intuitively. It is particularly important to reliase that intuition is used in deciding on the relative magnitude of the Utility of each element and in selecting the elements to yield the optimum or maximum Utility of the product. After the elements have been selected, and a preliminary design has been established, the secondary optimisation can proceed. In this stage design parameters are manipulated to optimise more specifically the same set of quantities as before. Until the preliminary synthesis has been made it could not be established as to what parameters would be dealt with. At this stage the analytical optimisation procedures, such as T-Charts, Delphi techniques can be used.

It must be pointed out though that at the present stage of the art in Value Analysis, a large part of the optimisation process is still intuitive, using aesthetics as the criteria.

The tertiary stage of optimisation is in the design of the engineering elements individually. Aesthetics is again an important criterion but there is considerable scope for the analytical optimisation of elements, and all designs should be examined by the analytical optimisation procedures as described above.

It must not be forgotten that the V.A. objective is that of an organised approach which will now be detailed for the Job Plan.

The first phase is that of information, obtaining all the facts about the design of the product or service. In this case it often requires numerous examinations and data search to get the basic facts.

The second phase is that of speculation. The aspect of creative thinking, turning off the analytical mind and concentrating on brain storming, are all aspects of this phase. The brain storming technique is a technique whereby one firstly restates the problem into 'how to' and then obtains as many ideas as possible to how one is going to solve the problem. The essential factors for brain storming are to suspend judgement, free wheel the mind, generate a large quantity of ideas, use cross fertilization to generate additional ideas and let intuition be the guide.

The third phase is the analytical phase. Here one takes the ideas from brain storming sessions and scrutinises them to pick out instant winners and sorting the remaining ones into groups of manageable size. These groups can then be examined using appropriate criteria according to an agreed scale so that only the better ideas remain. These better ideas are then ranked in order of merit, using the agreed scale.

The fourth stage is the reporting on and summary of new ideas and preparations for their formal introduction and adoption whilst the fifth and final stage is the planning of, introduction of and execution of the changes necessitated by the adoption of the ideas.

1.7 SUMMARY

From the foregoing it may be seen that the Value Analysis approach is one of using an organised formal job plan to enable value judgements to be converted to numerical factors. These analyses are by means of accepted logic based techniques, reduceable to ranking. The object of ranking is to determine which of the various alternatives has the highest value. Definitions of value have been given and the difference between value and cost has been stressed.

It remains to be seen what this technique entails and how it can be applied to the improvement of equipment for the disabled, with special reference to locomotor disabled in Southern Africa. It will be seen that once the details of the techniques are worked out, the applicability of Value Analysis to the disabled field is without question.

CHAPTER TWO

PRINCIPLES OF VALUE ANALYSIS

"The characteristics of all products have different relative values, depending upon the different circumstances and times in which they may be used." [9]

2.1 INTRODUCTION

The application of Value Analysis demands inter alia that a team be established to carry out the V.A. tasks. The selection parameters of such a team as well as its authority will be detailed. The actual approaches used by the afore-mentioned team to create new ideas as well as the decisions made by the team on these ideas will be described. The various types of group decision making techniques will be illustrated. The actual factors which do apply to practicing V.A. are highlighted.The technique whereby a product may be identified for the application of V.A. will be illustrated.

2.1.1 Value Analysis and Value Engineering

It is important to distinguish here between Value Analysis (V.A.) and Value Engineering (V.E.). Value Analysis in the broadest sense is a disciplined procedure directed towards the achievement of necessary functions for minimum cost, without detriment to quality, reliability and performance. It also means the application of Value Analysis techniques to existing products. Value Engineering, however, is the application of Value Analysis techniques in the main design and development phases of new products. In brief, as is the purpose of this study, V.A. is the remedial process and V.E. a preventative process. Both V.A. and V.E. in their disciplined way do not permit a deterioration in quality or reliability, but will challenge the levels at which such factors are

specified to determine whether they are in accordance with the users requirements.

For the purpose of this study the term Value Analysis V.A. will be used throughout. Where the comments made are not applicable to V.E., special reference will be made thereto. In general therefore, the techniques outlined in this study apply equally to V.A. and V.E.

2.2 THE VALUE ANALYSIS TEAM SELECTION AND AUTHORITY

2.2.1 Function-Dominated Thinking

V.A. uses teams of specialists in a specific manner to generate and evaluate new ideas. The team selection, expertise, motivation, guidance are crucial to the success of the V.A. operation. Central to this concept is the determination of functions and functions-dominated thinking. Function improvement by V.A. demands an organised function/cost optimisation program involving a team drawn from all the disciplines connected with the product. By following a strict regime of independent sessions on data analysis, speculation, evaluation and recommendations, the technique of Value Analysis simplifies the identification of costs which add nothing to function, performance, reliability or appearance i.e. the Utility parameter, see Para 1.4.2. hereof. Often performance and reliability are improved by the resultant simplification of the product. By using a team, an immense amount of skill can be concentrated in the speculation and evaluation sessions, far beyond the capabilities of separate individuals; indeed an advantage of this technique is that existing technical staff can make dramatic cost savings, provided they have access to specialist advice.[14]

This study is based on the opinion that more functional improvement comes from studying and understanding the user's needs than from scientific breakthroughs. Value in a product or service is not physical or obvious. Improving value has a low priority and is seldom of any great urgency in the general commercial world. To make value physical and obvious requires much work and a high degree of risk for the Value Analyst who is successful in exposing poor value.

Value Analysis is unique in that it probes value in terms of function and therefore is concerned with the basic purpose of things. It is the functional approach to a problem that distinguishes Value Analysis from all other cost prevention and cost production activities.

2.2.2 Team Management Levels

This study is based on the opinion that the Value Analysis exercise is best carried out by persons in middle management who know the product and processes, and who have an immediate day-to-day decision-making involvement with them. Quite often an idea is rejected or barriers put up against it by somebody else. However, if that person is made part of the V.A. team, which has put forward the ideas for a change, then that person will be very motivated to follow through these ideas to the implementation stage, because of his committment to the new idea. At this stage in this study, it is necessary to take the overall view of a normal commercial design and manufacturing operation. Middle management representatives from the following departments should therefore form the Value Analysis team:

1. Design	Important, because here are made all design decisions and responsibility is taken for issuing manufacturing instructions.
2. Production Engineering	The department responsible for all methods of manufacture including new plant, tooling etc., required by the V.A. team's modifications.
3. Quality	Product performance and reliability often suffer by bad application of Value Analysis proposals, hence Quality Assurance is a prime responsibility.
4. Purchasing	Responsible for all bought-out materials, and sub-contract item costs.
5. Estimating	Translates all requirements and V.A. team suggested modifications to monetary values.
6. Sales	Responsible for selling the products at an agreed level of profit and meeting all the user requirements.

The V.A. team should consist of four to six persons from the varying disciplines involved in the product. The team members should have certain attributes such as the ability to think creatively, the willingness to try new ideas and the ability to get on with other people, i.e. the important aspect of human relations.

In addition, team members must have the ability to be realistic, cost conscious and persistent in the following up of ideas. These types of attributes, plus such things as the fact that members listen to each other, that criticism is free, frank and impersonal, and that from time to time the group will stop and question its own performance and identify any obstacle to improvement, all add to the profile of an effective group of people.

It is vitally important that right from the start V.A. has the backing of top management, otherwise the whole exercise will be futile.

2.2.3 Optimum Team Size

As stated before, the ideal team should consist of between 4 - 6 people as the complexity of inter-relationships greatly increases with the size of the group. If the team is too large there may not be enough opportunity for adequate communication amongst its members. (See Fig.2.1).

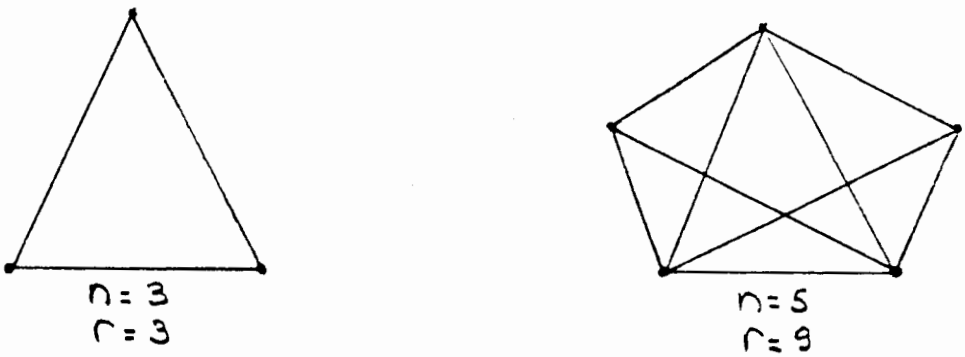


Figure 2.1

Increased complexity of relationships (r) with increased group size (n).

On the other hand, if the group consists of only 3 persons there is the possibility that 2 may form a coalition against the 3rd number. It has not been found possible to draw precise conclusions on this point.

As a general rule a team should be large enough to promote deliberation and include the breadth of expertise required for its job but not so large as to waste time or foster indecision.

Analysis of small group research has indicated that the ideal team size is 5 for smaller mechanical problems while 7 to 20 are used for large projects. The 5 members must possess adequate skills and knowledge to deal with the problems facing them. It should be obvious that the larger the team the greater the difficulty in obtaining a 'sense of the meeting' and more time will be necessary to allow everyone to contribute. This reduces the cost/benefit ratio of the whole V.A. operation, and should thus be avoided.

If a team is to have all interested parties participate in its deliberation the number may be too large. If all interests are not represented, the team's work may be rightfully subject to criticism. Where representation is important, the answer may be found in a structure of ad-hoc sub-teams. This pre-supposes that the problems to be considered properly can be broken down for handling by these ad-hoc teams. However, in many instances, the need for representation has been found to be overstressed. The true purpose of a team is often accomplished by limiting the team membership to individuals who can look at the problem as a whole rather than regard their membership as a means of protecting their narrow interest.

For a successful V.A. team the members must be suitably representative of the interests they are intended to serve, must possess the requisite authority, and they must be able to perform well in the group. It has been found that not everyone has the temperament, verbal and analytical ability, and capacity for working with others to do these things.

2.2.4 Team Origin

Although the team origin has been described previously, see Para 2.2, it should be noted that the team essentially is an organic thing, changing as circumstances and tasks require and calling in whatever expertise and specialisations are demanded by the facts of any particular task. A survey has shown that the inclusion of workshop staff manufacturing aids for disabled can have distinct advantages. Staff with clearly negative attitudes should be regarded with suspicion from a Value Analysis team point of view.

2.2.5 Team Expertise

When selecting team members for a specific meeting, the only real test to apply is: "Can he contribute towards the team meeting?".

In addition, it is required that the team keeps to compartmentalised phases, that one phase is completed fully before entering the next phase. (See Para 1.6). This has been termed a 'horizontal approach' because it reaches out across the commercial business organisation in contrast with the 'vertical' or departmental approach.

The team also has to have the ability to create new ideas both formally and informally. The real power of this approach will become apparent to the reader of this study when he fully comprehends Functional Analysis. As an example: if there is a bracket that is held on by a clip the function of the bracket is not to hold the clip. To create at this shallow level of thought will only lead to less costly clip holders. This can be done at any time without the use of Value Analysis. The team expertise should enable a direct comparison to be made in measurable terms for any given function of the cost versus the associated use value. (See Para. 1.4.3).

2.2.6 Team Task and Function Outline

Primarily the team task is determined by the team leader. This person should preferably not be involved in the design, manufacturing or selling of

the product being investigated. Nor should he be knowledgeable of what the product costs. No matter how the V.A. exercise turns out he cannot be hurt. Usually this person wields little real line authority other than through his own personality and knowledge of overall management support for his way of leading the V.A. team.

Any team member may ask any question or suggest any change but the responsibility for decision making rests with the appropriate specialist. However, each specialist must satisfy his fellow team members by considered reasoning. Making this 'government by committee' work is the function of the team leader.

The task of the Value Analysis team over a period of the product life cycle, against a fixed selling price, is shown in the following figure (Fig. 2.2):

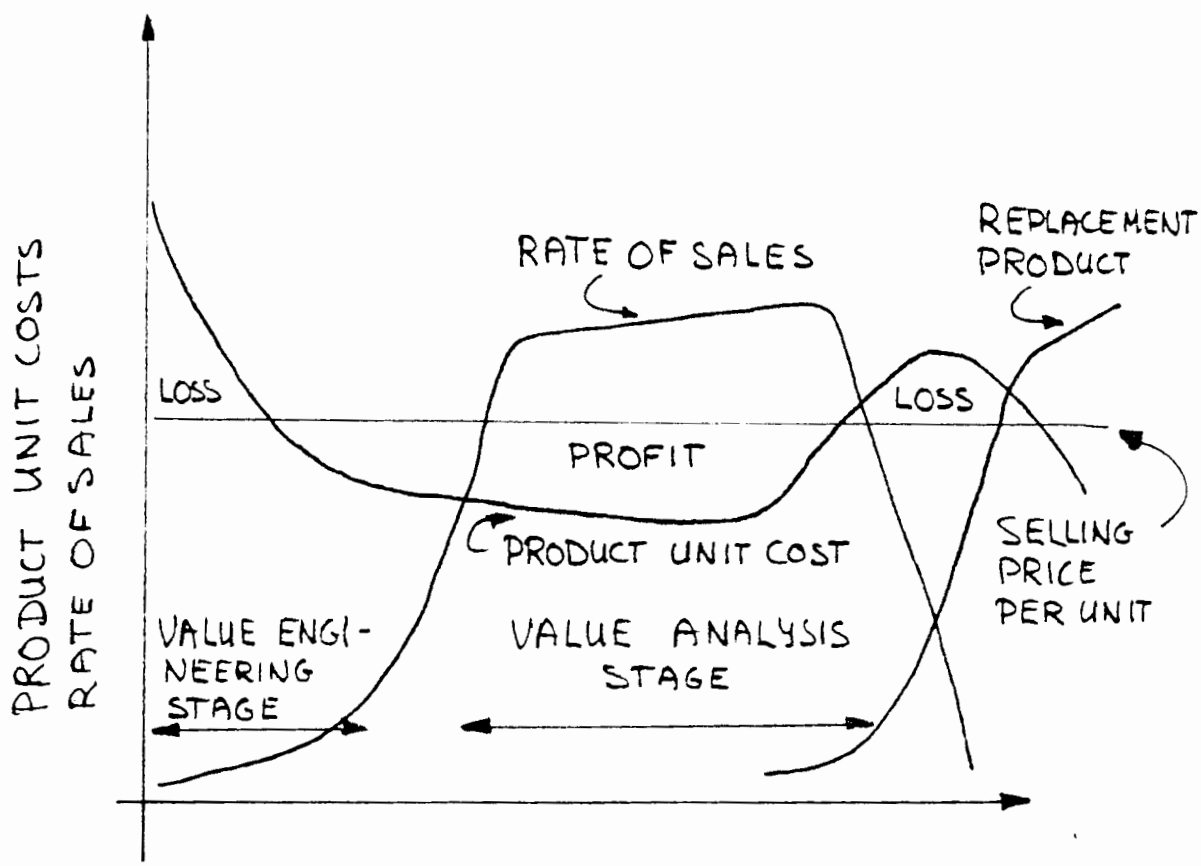


FIGURE 2.2
TYPICAL TIME-PRICE CHARACTERISTIC OF VOLUME PRODUCTS

Just as there is clearly a requirement for a determined Value Engineering effort during the development of a new product and before any substantial investment is undertaken in tooling or manufacturing equipment layout, equally clearly there is a requirement for a continuing Value Analysis effort, becoming effective as soon as the reliability and performance of the finished product have been optimally stabilised.[14] This process should continue until the product is within a year or two of obsolescence. Any product under continuous V.A. study will still yield further savings, due mainly to the continuing development of new materials, new manufacturing processes and further technological advances, developed by that industry as a whole.

A volume product should never be considered static in design or method of manufacture, but a careful and realistic assessment of the overall potential financial gain is imperative before any change is implemented. This assessment is the responsibility of the V.A. team.

Implementation into the normal manufacturing cycle of V.A. proposals is the responsibility of the individual manufacturing representative on the team. Since this will invariably involve some disruption of the manufacturing cycle, changes can only be introduced in a carefully planned manner in close co-operation with the production management. Critical path networks offer the most satisfactory method for achieving a smooth introduction of such proposals.[14]

The Value Analysis team should prepare a comprehensive statement of the team's view of the designs to be investigated and it should be available to all members of the team far enough ahead to allow them time to study it in detail. If this is done the meeting itself can concentrate its time on those aspects which are controversial. It is essential that a well indexed record should be kept of the decisions made and of the dissenting views expressed at all meetings. The main purpose of the meeting is to obtain authoritative on record advice and accountable project management and this will be achieved only when there is full documentation.

2.2.7 The Team's Place In The Corporate Structure

A literature survey of the application of V.A. shows various references to Value Analysis programmes that have failed. Indeed for some organisations only a bad taste remains. The question to be asked is where did these V.A. programmes go wrong? In the majority of cases the person assigned to lead the value programme was not given clear and specific corporate goals and objectives. At best this person had the minimum understanding of the specific tools available for carrying out a proper Value Analysis.

It is contended that chances for success of V.A. are improved if V.A. is in a separate division within the organisation. In this way the breakdown in communication, which so often occurs, can be minimised as most organisations consist of a conglomerate of specialists, the specialists always begin to draw together and become wrapped up in their own 'thing'. They therefore loose empathy with the other specialists. In particular, the nature of V.A. is such that it attempts to bring order and direction out of this confusion and generality.

Others around the V.A. team tend not to be very specific. During the practical work for this study it has been noted that effective communication of value is an abnormal phenomenon that does not come about in a natural way. It must be made to happen. When management has accepted the need for a separate V.A. division in an organisation, the team can then be picked from all the relevant sections of the organisation, dependent on task and expertise required.

This fact in itself is a major advantage of V.A., because now, within the accepted formalised corporate structure, i.e. that of functional divisions, there exists an equally accepted way to channel ideas and concepts, i.e. via the V.A. division which improve product design, function etc.

V.A. can also provide management with an additional tool of measuring cost effectiveness of all persons concerned, including design and engineering staff who are generating a significant percentage of total cost.

2.2.8 Profile Of An Effective Team

The characteristics of an effective team may be itemised as follows:

1. It is problem oriented.
2. There is a lot of interest in the team activities.
3. The atmosphere is totally informal.
4. There is considerable discussion.
5. Members listen to each other.
6. Disagreement and conflict is open and encouraged.
7. Criticism is free, frank and impersonal.
8. Decisions are taken by consensus.
9. The team will stop and question its own performance and identify any obstacles to improvement.

All the above facets point to essentially a 'creative' team. In a world that is hostile to new and inventive behaviour, the question may be asked if there exists a spark of creativity in each person which, given the right environment, could develop into new and unique courses of action. The noted motivation theorist, Abraham Maslow, named such an environment 'synergistic'. In order to develop this creativity, it will be necessary to accomplish some changes in the normal meeting environment for the purposes of the V.A. team meetings. These changes are:

1. Encourage fantasy and free association.
2. Increase the cohesiveness of and freedom of expression between the team members.
3. Systematically provide positive reinforcement for the offering of ideas and suggestions.
4. Block 'game playing'.
5. Stop all discounting.
6. Stop all copping out of the individual's responsibility to the team's purpose.
7. Provide maximum support to those who implement new and creative solutions.

The creation of the 'right' environment for an effective team, i.e. the afore-mentioned 'spark of creativity', can thus be seen to depend mainly on the interpersonal relationships within the team. The conceptual scheme of Transactional Analysis is applicable to interpersonal relationships - these relationships being defined as two, or more, persons participating in a communication transaction.

In recent years this concept has been employed in a number of Management training programmes by several U.S.A. Universities,including the management training laboratory for M.B.A. students and executives at the University of Pittsburgh.

It has been found that the utilisation of the Transactional Analysis concepts has not only improved the interpersonal relationships at work but has in many cases contributed to the improvement of productivity, profits and employee morale, i.e. the very attributes of a Value Analysis exercise. Transactional Analysis provides better awareness of existing interpersonal relationships in a given situation, the concepts being ego status, life positions, transactions (complimentary and crossed) and games people play, each concept featuring strongly in the profile of an effective Value Analysis team. A study of Transactional Analysis concepts is however, outside the scope of this study.

In addition to the usual disciplines which must be observed in managing a team and running meetings, the team leader should emphasize the following:

a. Full time attendance is expected from all team members. If any individual is unable to do this the team leader should ask for his withdrawal from the team and request a substitute.

b. Sub-groups must produce information by the required dates.

c. If a standard questionnaire sheet has been developed for the team use, it must be used throughout the team's activities.

d. Every team member should be encouraged to put his ideas forward.

e. Proposals should be submitted for function and cost evaluation on a progressive basis throughout the Value Analysis exercise to avoid a last minute overload of team tasks.

2.3 ALTERNATIVE VALUE ANALYSIS APPROACHES AND METHODOLOGY

During a review of the various forms of Value Analysis for the purposes of this study it has been found that no two activities are exactly alike. They differ as circumstances and the team personalities and unique abilities of team individuals differ. To formalise these various approaches, they have been divided into six separate categories.[13] In what follows these categories will be ranked by 'levels' to signify (in a crude way) the degree of expertise, intellectual ability and cleverness required of the individual team leader, or 'Value Analyst' who is applying a particular approach.

2.3.1 Level 1 : Clearing House / Reporting Approach

There are a number of so-called Value Programmes which primarily act as a clearing house in reporting on various types of cost reduction and cost prevention activities performed by others. Essentially they are a vehicle for providing outlet and recognition for other activities that they report on. In many cases the input lacks formal use of the V.A. techniques mentioned in the foregoing, and is limited to a sporadic public relations type effort and/or the collection of data that ends up being reported on. These other activities referred to might be, for example, work simplification programmes, 'make or buy' studies, design review committees, zero-defect programmes, suggestion systems, motivation programmes etc. These activities should be individually evaluated as to their reliance on the V.A. techniques, before they can be credited as a Value Analysis exercise.

2.3.1 Level 1A : Setting Cost Reduction Targets

The uniqueness of this sub-category is that here, the Value activity is involved in setting annual cost reduction targets for each of the various ongoing programmes in the organisation to meet or exceed. Usually an auditing and/or approval of savings claimed is also involved. This is not a strict V.A. activity as the supposed savings are not formally related to the maintenance of quality and reliability standards.

2.3.1 Level 1B : Purchasing Value Analysis

This sub-category is concerned with the approach used by many purchasing activities where they report on before and after examples of cost reduction, better-buy decisions, etc, that are accomplished.

2.3.2 Level 2 : Access To Engineering Approach

This refers to a collection of approaches used where the primary intent is to gain access to and influence the Value decisions made by engineers. A 'locked door' and thick wall traditionally surrounds the engineering activity whenever Value judgements are involved. Quite a few Value activities are centered on gaining access to this fortress, often with marginal results. This is a critical problem since engineering is one of the key Value influences. The Value analyst must therefore obtain the full support of the engineering department of the organisation (See also Para. 2.2.2).

2.3.2. Level 2A : Purchasing Centered

The problem here is that the purchasing official tries to design the product with little or no responsibility if the product fails. At the same time, the designer has little empathy for the purchasing official's problems. Located in the purchasing department this Value activity can have little neutrality. TheValue analyst must be aware of this bias.

2.3.2 Level 2B : Manufacturing Centered

Heavy concentrations of Value activities are located in industrial, tooling and manufacturing operations. Again, neutrality is difficult to maintain in these environments when daily unnatural friction-prone situations are taking place.

2.3.2 Level 2C : Design Centered Approach

Often unconsciously, Value activities are centered in the design department as a means of self-protection. When Value Analysis is interpreted as a threat, one sure way to protect oneself is to control the threat, i.e. by applying all of the V.A. techniques in the product design stage.

This approach has led to high benefit:cost ratios, and tends to optimise 'Use Value' of a product already at the design stage. This approach will be used in this study.

2.3.3 Level 3 : Mass Motivations / Training Approach

There are two variations of this approach:

2.3.3. Level 3A : Training Without Follow-Up

Traditionally, large groups of individuals from dissimilar company backgrounds study and apply most of the V.A. techniques noted in the foregoing, on 'live' projects. A large number of company employees are engaged in drawing up the V.A. 'Job Plan' and on the last day of their study course report their findings to top management. Usually, outside consultants might be used to do the training and most often management has a good feeling that the individuals have learned much, that for perhaps the first time, company people have actually talked to one another and that the future goodwill will result. Unfortunately, no in-house specialist is assigned to carry on a Value activity. Without this all important follow-on, little real implementation of recommended ideas can be expected. This has been a major cause for practical disillusionment with V.A.

2.3.3 Level 3B : Training With Follow-up

Here the activities noted in 3A above are the same, except that now an individual has been assigned to work within the organisation to implement a Value Programme after the study course has been completed.

2.3.4 Level 4 : Information Transfer Approach

The information transfer approach is based on the premise 'few of us have time for facts and details'. Most key Value-influencing individuals are extremely busy people within the business organisation. The problem here is that good Value decisions cannot be made unless the right information is in the hands of certain key people at the precise instant in time. The absence of any one element usually compromises a good value decision. The odds of having all elements present at the precise point in time required are not very good. V.A. practitioners who use an approach that tries to fill these requirements require great skill. An understanding of people-chemistry, timing, human relations, pride of authorship, and corporate jungle fighting tactics is critical. The Value analyst must have the freedom to roam the organisation to overcome these problems as and when they arise. It is implicit that company managements fully support the V.A. Programme.

2.3.4 Level 4A : Transfer Normal Information

We are not concerned here with the case where information is not available. The advent of computer, inventory control, management information systems, standard cost systems geared to produce profit and loss statements and the like, guarantee an ample supply of electronic data process printouts. The difficulty is that all this information is not in a form for timely use in making Value decisions. The approach to be used by the Value analyst is to ensure that the right information is digested and packaged (such as cost, quantity, product fault, etc) and available at the right time to influence a Value decision.

2.3.4 Level 4B : Transfer Information by Function

This approach is the same as in 4A above, except that information is now provided by function.

2.3.5 Level 5 : Conduct Team Study Approach

There are four variations of this general approach. Basically, the Value analyst is given an assignment or product to study and he then suggests or assists in selecting the V.A. team, collects all stages of the information and hardware needed, and controls the team through the Job Plan.

2.3.5 Level 5A : Study Existing Products

Typically this approach is called Value Analysis and is very common in industry. Cost reductions in the range of 20% to 60% can be expected. This approach will be utilised in this study.

2.3.5 Level 5B : Study New Products

Typically this approach is called Value Engineering (or value control). A start is usually made with a tested prototype or mock-up that works. Obviously the potential for saving is greater than when studying existing products, as the cost to implement any changes is less.

2.3.5. Level 5C : Invent New Products

This is a new and rather rare approach. Here a team using a modified form of the functional analysis systems technique literally invents a new product. As a starting point, the team uses the definition of the overall product need, (the task), starting with typical examples which presently are available but do not meet overall product need. The product, in terms of low cost hardware concepts, is then evolved. This approach is a very useful future development direction of V.A., particularly in the special equipment for disabled field.

2.3.5 Level 5D : Overcoming Personality / Organisational Problems

On occasion, V.A. teams have been used as a constructive cover-story to cause individuals from various areas or factions of the organisation to interact to solve a value-related problem, at a time when they cannot, or will not, co-operate on any other basis. Quite often, it is the problem that ends up being re-defined with the context of all the 'factions' represented on the V.A. team. The Value analyst must use these team meetings to improve communication between the 'factions'.

2.3.6 Level 6 : Value Research Approach

The Value analyst who practices this approach are relatively few in number. On the other hand, it is contended that in the next 10-15 years, the real impact of V.A. will be felt by applying Value Research. As a definition of Value Research it can be stated that this is a technique that, with reasonable accuracy, determines and gives to the user less of what he does not want and more of what he does want. As Value can only be determined by comparison, both alternative products on the market place as well as the organisation's own product should be looked at in great depth. What users really want is to be determined in quantified terms. By relating the results of function-cost and function-attitude surveys, it will be possible to measure the true worth of the product. As shown above, Value Research requires a high investment in manpower, competitive product market research and an extremely complex inter-action of marketing, sales engineering and all levels of management. This type of study can often take a year or more to complete and during that time much could happen to alter the outcome[13], well beyond the control of the Value analyst.

2.4 GROUP DECISION MAKING PRINCIPLES

In this section the group decision making principles will be discussed. The techniques will be outlined in a following Chapter.

The various kinds of decisions will now be outlined.

a) INTUITIVE DECISIONS

These are decisions based on 'gut feeling'. Like decisions in love, intuitive decisions are sometimes good and sometimes bad. Some of the best and some of the worst decisions in history were made intuitively. A purely intuitive decision is primarily a property of the mind rather than the property of the object about which a decision is made.

b) SYSTEMATIC DECISIONS

If the properties of the design object are measured and used to make a decision between design alternatives, this is a systematic way of reaching a decision. It can be repeated and reviewed by another design authority. It can be audited (design auditing). It is an objective decision.

c) EXPERT-INTUITIVE DECISIONS

A person making an intuitive decision may have much expertise on the subject matter and really be basing it on considerable collective experience which is not readily explicable. It could be said then that the expert makes a decision within his field of knowledge, it may still be based upon intuition and gut feeling. This is very different from a person having the authority to make a design decision, not knowing what it is about, and insisting on having his or her own way. This could lead to numerous problems.

d) INTUITIVE-SYSTEMATIC DECISIONS

Many decisions cannot be based on the measured performance parameters alone. There are many intangibles that must be evaluated as well; aesthetics and convenience of use would be typical examples. Intuitive judgements can be converted to numerical scales in a systematic way. Then the decision can be reviewed and revised as well as explained. For the purposes of this study the intuitive-systematic decision will be regarded as being both rational and objective.

1.6 VALUE ANALYSIS OBJECTIVE AND METHODOLOGY

Value Analysis may be described as an organised creative approach directed at the efficient identification and elimination of unnecessary cost, that is, cost which provides neither quality, nor use, nor life, nor appearance nor customer features.

Having defined the objective of Value Analysis, the following recommended methodology could be used to achieve the objective.

A team is formed, vide para 1.3 hereof, and this team sets out to tackle the Value Analysis using well described phases, forming the agreed 'Job Plan'. The phases of this Job Plan[15], together with the tasks forming part of each phase can be summarised as follows:

a)	Information Phase:	Obtain all details, specifications, user requirements from the best sources. Define all functions of the product or service.
b)	Speculative Phase:	Do creative thinking, turn off the analytical mind, concentrate on developing new ideas to provide the functions. Use intuition freely.
c)	Analytical Phase:	Review ideas, put a value on each idea according to an agreed Value scale, develop the good facets of each idea. Rank the ideas in order of merit.
d)	Program Planning Phase:	Set out the approach to be followed to institute the good ideas in practice in a formal plan.
e)	Program Execution Phase:	Follow the afore-mentioned plan.

The technique of Value Analysis, by using the above detailed plan, allows all facets to be considered which are relevant to the solution of the problem. In the evaluation of functions the team must answer such questions as 'What is it, what must it to, what does it cost, what else will accomplish this function, what will that cost?" A quotation often used in this regard is 'In character, in manner, in style, in all things the supreme excellence is simplicity.'

2.4.1 Judgement Converted To Systematic Numerical Scales

In what is presented below, an attempt is made to convert subjective judgements into a percentage scale[1]. All judgements operate between two limits namely that of threshhold acceptance and that of saturation. Between these two limits the judgement, with whatever criteria is being considered, can be rated from no satisfaction to complete satisfaction.

TABLE I

CONVERSION OF JUDGEMENT SCALE TO COMMON PERCENT SATISFACTION SCALE

Percentages	Degree of Satisfaction	Description
100%	Complete satisfaction	Objective satisfied in every respect.
90%	Extensive satisfaction	Objective satisfied in all important aspects.
75%	Considerable satisfaction	Objective satisfied in the majority of aspects.
50%	Moderate satisfaction	A middle point between complete satisfaction and no satisfaction. (Also a point of uncertainty).
25%	Minor satisfaction	Objective satisfied in some but less than half of the aspects.
10%	Minimal satisfaction	Objective satisfied to a very small extent.
0%	No satisfaction	Objective not satisfied in any aspect.

Using the above scale, any intuitive decision may be related to a percentage value. Obviously, the intuitive decision, if not obtained by independent judgement, has to be obtained by team judgement.

2.4.2 Decision Scales

In order to progress from pure judgement to objective measures the following scales can be used: Nominal, ordinal, internal and ratio scales. They can be used to improve the discrimination power of any criteria, i.e. a pass or fail category.

a) The nominal scale is the definitive, qualitative judgement, i.e. yes/no, for any named characteristic or category of the product under consideration.

b) The ordinal scale implies a rank ordering i.e. selection between usage/longevity of a product would be an ordinal scale ranking.

c) Interval, this being the most commonly known scale, e.g. temperature X or speed Y which the criteria must meet. It is to be noted that there is no zero on this scale.

d) Ratio scale, this specifies specifically a value (e.g.speed) which is related to a zero value. This is the most discriminating scale and leads to an objective assessment with a quantitative figure.

2.4.3 Decision Making Conditions

During the V.A. procedure various decision making points arise, using techniques as detailed before. It is to be noted that attitudes towards decision making vary with events, as well as with people and their position within the organisation.

The conditions under which such decisions can be taken are certainty, risk and uncertainty.[3]

Certainty is present when it is known exactly what the outcome of a certain decision will be. This is particularly applicable when dealing with fixed quantities such as raw materials etc. The prime goal when making decisions under certainty is of determining the desired objective. Once this is accomplished, the Value analyst can simply evaluate the alternatives and choose the best one.

Mostly however decisions are made under risk conditions; that is some information is available but it is insufficient to answer all questions about the outcome. In this instance the decision could be made by using probability estimates. Such probability estimates could be commonly called 'gut feel'. These probability estimates are, when based on past experience, known as objective probability and when based on subjective estimates, known as subjective probability.

Uncertainty decisions are those decisions in which there is no way of gauging the likelihood of the various alternatives. It is very difficult to say precisely when this type of decision point appears. Many individuals contend that experience and the ability to generalise from similar situations make uncertainty decisions impossible.

When dealing with the V.A. team approach, it is contended that team decisions generally fall under the risk condition of decision making. It is therefore important that the full Information Phase (See Para. 1.6) be completed so as to reduce the level of risk to the team's decisions. This will demand special skill of the team leader.

2.5 PERCEPTUAL MAPPING

2.5.1 Prime Determinants

Having detailed the techniques which are to be used in establishing the V.A. team and the various approaches such a team may use to achieve decisions, it will now be of value to determine a technique whereby the actual product which is to be value analysed may be established in an efficient manner.

One of the techniques available is known as Perceptual Mapping.[4] Perceptual Maps identify many characteristics of products already in use. They are a prime basis for gathering other information important to product planning and the design thereof. Generally the difficulty with information is that it comes from various sources and often is more confusing than useful. The objective therefore is to establish a base of concise information so that the V.A. team can agree on what must be done.

Perceptual Maps condense a great deal of information into a graphic display which serves to act as focus for team discussions. Perceptual Maps usually use two or more prime characteristics or 'determinants' of a product, such as cost and weight (mass) to relate to a group of alternatives. Such maps can be used to present the results of early Information-gathering Phases before the V.A. team go on to establish the whys and hows of the product. This is done with a view to developing a sensible design, or improvements in existing designs, so that the Utility Value (see Para. 1.4) of the product is increased.

2.5.2 The Primary Objective

To ensure that the user satisfaction remains the primary objective, the following steps are mandatory:

1. Outline what 'control information' i.e. that used to form a product, the V.A. team must generate and what information the V.A. team must not waste time on. This is best done by fully describing the product ranges.

2. Structure and present the information in an evaluation package. Arrange for the collection of missing information, and have this included in the package.

3. Collect and structure legal, economic, competitive and other information from the environment in which the product is to be used, and fully describe each constraint on product design, as imposed by the environment.

2.5.3 Information and Product Planning Strategies

In what follows the use of various investigating teams for obtaining information for Perceptual Mapping is described.[4] It will be noted that the teams as described are very similar to those used in the commercial world. However, these are just as applicable when dealing with the design and manufacture of aids for locomotor disabled.

A Consumer Research team examines trends and demands for product features, styling and human usage factors. There are many approaches for producing useful projectible information from this research such as 'focus groups' and 'diaries'. A Market Analysis team then studies the channels of distribution to determine the inherent constraints and opportunities. Finally there is the Environmental Assessment team, where factors such as legal restrictions, economic restrictions, residential restrictions and race of the user are taken into account. Depending on the particular project, the proportion of effort spent on each of the above investigations varies. The work will result in a vast amount of data drawn from primary and secondary sources. This data is used in the Perceptual Mapping technique.

2.5.4 The Perceptual Map

The drawing up of a map is best illustrated by the following example. It is assumed that the map is to be used for determining which of the walking aids for disabled persons should be Value Analysed.

The consumer research team would concentrate on obtaining the following data for all the walking aids presently available or being prescribed by the medical treatment profession:

a) all available types, classified into functional categories,
b) all materials of construction in which these types are available,
c) all material finishes,
d) all unit weights, and
e) all unit costs to the eventual user.

From the above, the average weight and costs for each type is calculated, both these prime determinants being applicable to each type of walking aid and being a directly measurable product attribute.[4]

The Market Analysis team would concentrate on obtaining the 'size' of the market in terms of annual usage of each type as classified under (a) above.

Now the Perceptual Map may be plotted using the percentage of market size for each type of aid as the diameter of that type's 'volume circle', and weight and costs as horizontal and vertical axis parameters.The map shown in Fig 2.3 results.

On this map we have placed walking aids type A through to type Q, according to each type's unit mass and cost.

The total market of all walking aids would be the sum of all circle diameters, on a suitable scale. Market sales volume would apply to a fixed time interval, say one year, hence the map is shown on a p/a basis.

Average Mass is shown by M_{av} and Average Cost by C_{av}. The optimum point, for all the walking aids listed would be the intersection of M_{av} and C_{av}, as shown by $P_{(ave)opt}$. For the common crutch variants (type A_G, A_M, A_I) the optimum point is shown by P_{opt}.

The actual location of the P_{opt} on the Perceptual Map is obviously also dependent on certain structural and material property considerations, below which the walking aid would fail in use, or could just not be manufactured for the price level.

The main advantage of the map shown is that it is based on practically prevailing weights and costs.

The map may thus be assumed to relate to what is a commercial reality in to-day's environment, being based on actual survey carried out as part of this study.

Inspection of the map shows that the large volume types (i.e. A_G,P, W, G) are far removed from the optimum point due to A_G- weight too high, P and G - costs too high.

The very advantageous types A_m and A_I, having low weight (mass) and low costs, are significant in that they share only a small volume of the total market. Type E appears to suffer from a too high price, as indicated by its small share.

Type W (walking stick) need not be considered here due to its limited application to aid the truly locomotor disabled.

Using the above interpretation, the Perceptual Map indicates that a Value Analysis needs to be carried out on types A_I, A_m and A_G, to determine which one of these types most closely meets the users requirements i.e. increases user satisfaction at the lowest cost.

In practice , this would result in say type A_G being selected due to its large market share . A Perceptual Map may then be drawn up in say a year's time, which would indicate if type A_G has increased its market share and if it has moved closer to P_{opt}. In this way, a repeatable numeric method of evaluation of the success of the V.A. operation has been established.

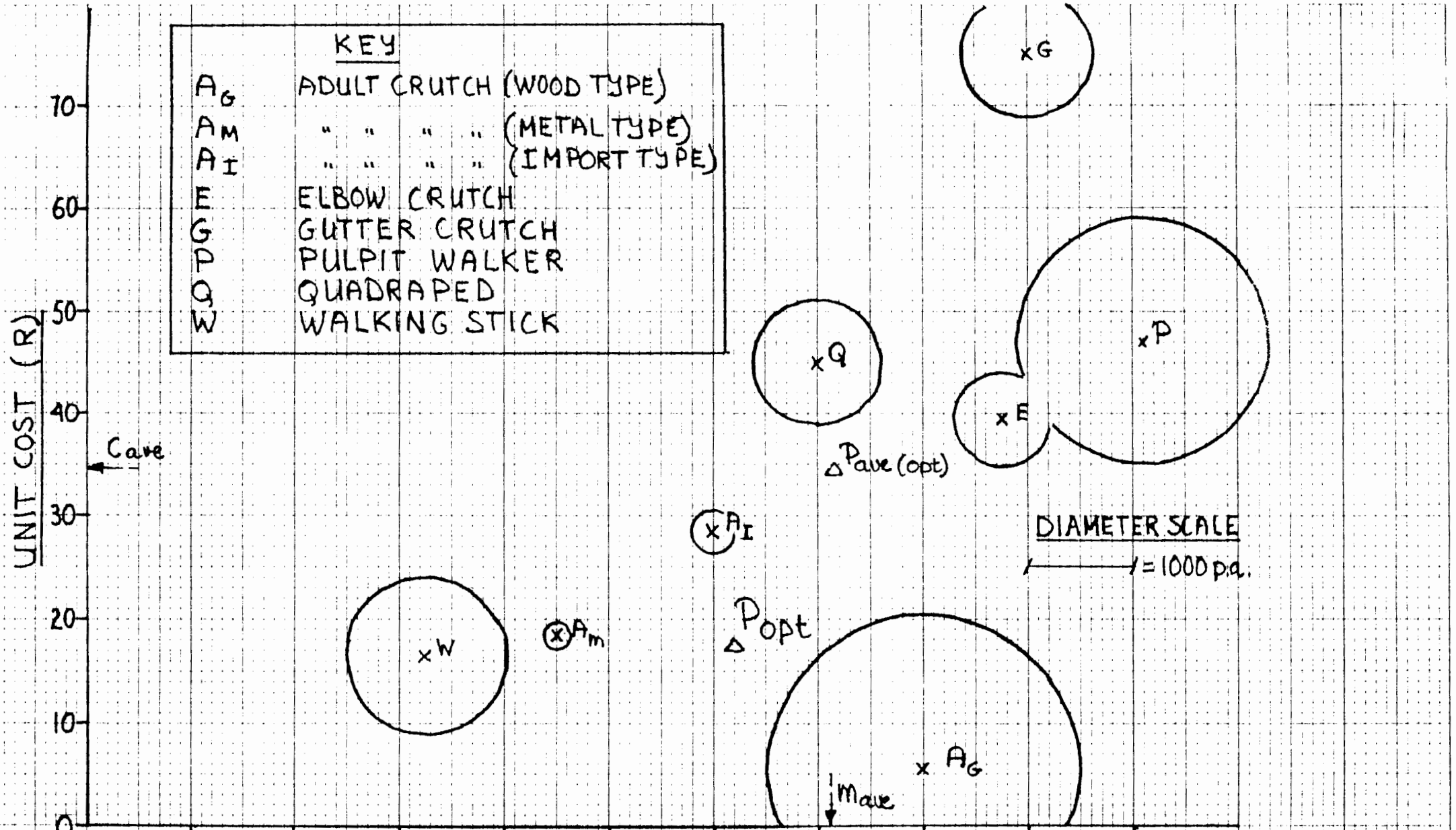


FIGURE 2.3: PERCEPTUAL MAP FOR WALKING AIDS POSITIONED BY VOLUME (P.A.)

2.6 PARAMETERS FOR PRACTICING VALUE ANALYSIS

When introducing Value Analysis the following factors are relevant and must be followed. The factors apply equally in the case where the V.A. is applied as a function improvement exercise (the purpose of this study) or a cost reduction exercise (most often used in the commercial environment).

1. The product to be Value Analysed is to be selected (read previous paragraphs). Here the problem is to identify that product which will give the greatest return for the costs incurred in the analysis itself.[8] The following factors are indicative of a product which would give worthwhile results.

   A. A multiplicity of components.
   B. A large forecast usage.
   C. A small difference between use value and cost value.
   D. Considerable competition.
   E. A 'long-ago' type of design.

2. The recording of the numbers required of the product currently and in the forseeable future give the magnitude of the effort which can be expended and the costs incurred in the analysis.

3. Consideration of appearance, quality and reliability can often lead to a better appreciation of what is required and in itself lead to functional improvements in the usefulness of the product. (The so-called functional Value Analysis).

4. If properly organised the Value Analysis sessions need not be time consuming and time limits must be put on session length and session numbers to achieve a certain goal.

5. The V.A. team will require proper training and guidance. The selection of team chairman is therefore crucial.

6. The training and subsequent analysis team sessions help to generate a team spirit through a better understanding of problems and viewpoints, and offer an outlet for 'bright ideas'.

7. Value Analysis has been used successfully by a wide range of companies in reviewing products, services and systems. In the correct situation it has been estimated that manufacturing companies can expect benefits in the order of at least 10 - 1 (savings to cost of exercise). The key factor to obtain these savings is the total commitment by senior management to Value Analysis.

The following basic principles are suggested as a successful Value Analysis exercise programme:

a) Adopt the attitude 'there is a better way to do it, it has to be discovered'.
b) Apply creative thinking at all times.
c) Establish teamwork and good human relationships.
d) Avoid the temptation to generalise.
e) Identify and define the real problem with the present product or products.
f) Establish the objective and prepare a V.A. job plan.
g) Obtain all the relevant facts.
h) Use information from the best sources.
i) Establish meaningful cost/function relationships.
j) Determine and evaluate each primary and secondary function required or performed.
k) Separate the relevant from the irrelevant and the useful from the useless information.
l) Encourage and test new ideas.
m) Recognise and overcome 'road blocks' to team progress - road blocks being attitudinal resistance to team operation from the team members themselves.

n) Do not be influenced by past custom and habit.

o) Use and pay for expert suppliers know-how and skills.

p) Establish cost of all important tolerances used in manufacturing.

q) Use experts on an ad-hoc basis to extend specialised knowledge when required.

r) Use proprietary functional products and processes whenever possible, to save on costs and gain on reliability.

s) Use Governmental standards and standard parts wherever relevant.

The above various factors are best handled in the format of a check list where this check list is filled in by each team member and the resultant information co-ordinated by the team chairman. The design and layout of these check lists will be discussed later on in this study. (see Table 3.1 figures 3.2 and 3.3, Chapter 3).

2.7 SUMMARY

The above principles and techniques show the various facets involved in applying Value Analysis to any group of products. The team, the type of decisions, and the determination of which type of product should be Value Analysed have been discussed. The methods of practicing Value Analysis have been stated.

It remains to quantify the creativity, the decision making, and the ranking techniques. This will form the heart of the quantitative formulation process of Value Analysis.

CHAPTER 3

VALUE ANALYSIS TECHNIQUES

"It is said that people can be divided into three groups, those who make things happen, those who watch things happen and those who wonder what happened".

3.1 INTRODUCTION

In this Chapter the various techniques which may be used in the Value Analysis Job Plan,will be explained. The techniques presented herein relate particularly to the creativity phase of the Job Plan, in other words the development of new ideas, and to the examination or evaluation phase of the Job Plan, that is, techniques whereby the created ideas may be evaluated. Some suggestions will be made whereby these evaluated alternatives may be ranked. The ranking procedure will be used to quantitatively determine which alternative idea meets the purpose of the Value Analysis, i.e. to obtain maximum functional usefulness at lowest cost, that is, highest Utility Value.

3.2 DEFINITIONS

At this stage, the various facets of a product and of the procedure whereby this product is evaluated, have to be defined.

3.2.1 Objective

The objective may be viewed as the goal of the Value Analysis exercise. The objective can be thought of as a statement of meeting the user's needs. This statement is of what is to be achieved and not how it is to be achieved. It is also oriented towards the user's need. The objective can be cast in a framework of three dimensions which are independent in themselves but will become related in a final object. These three dimensionsare the following:

a) Performance Objective: These are the features of the design solution when it is in place and working. These include all the functional performance parameters plus those appearance and convenience aspects which are important.

b) Time Objectives: These are the target times for a design schedule. They reflect the best estimates of time required either to obtain a solution or better still, the time when the users would best be served by the newly designed equipment.

c) Cost Objective: These objectives include all of the investment of material and human resources in preparing the Value Analysis and the new design resulting therfrom, and for the materials and labour of constructing the newly designed aid or equipment. All monetary considerations should be included in the cost objective, even those pertaining to income and profit (where applicable).[10]

A comprehensive set of objectives should include statements about what is to be achieved as target performance, as well as what target amount of resources or costs are to be assigned to the project. Any set of objectives which does not include all of these three major dimensions is lacking in one important aspect and is likely to guide the Value Analysis effort to an unbalanced result.

3.2.2 Criteria

The criteria can be defined at the start of the V.A. process as target specifications. Towards the end of the process the criteria solidify into mandatory specifications for the construction or manufacturing of the alternative equipment.

It may be argued that the criteria as defined above could be precisely the needs of the users. However, this could only be so with the perfect piece of equipment, which is never achieved. It is well to remember that the criteria are deliberately established by the V.A. team, taking into account many factors (as if the team were a God). The criteria are frequently somewhat less than the identified needs or requirements of the users, since the resources and time for a solution are not infinite.

As described above, before deciding on a design solution, the V.A. team sets objectives which describe what is to be achieved. These descriptions form a new state of affairs. How is it known if the objectives are achieved? The answer here is by criteria. Each objective will result in from one to hundreds of criteria. The more criteria we have, the better our expectation of having met the objective. To get criteria, one takes each objective in turn and finds as many measures as possible which will reflect some degree of achievement of this objective.

To be effective as a criteria, it must discriminate, that is, there must be a positive yes or not answer as to whether the new solution, being sought by the V.A. team, meets each element of the objectives. Obviously in between the positive yes and no there is the full range of opinions as previously detailed in the degree of satisfaction analysis (see Para. 2.4, Chapter 2).

3.2.3 Trade-Offs

During the evaluation phase many criteria are being considered for the specific product being value analysed. Because we live in a real world, some of these criteria will have to be neglected, alternatively will have

to be omitted from the design solution to meet the objectives. This omission of criteria can be defined as trade-offs.

Such trade-offs may be caused by dimensional constraints, laws of nature, laws of man, social and cultural constraints, man-imposed constraints, and special technical difficulties. The basis for evaluating these trade-offs are the afore-mentioned performance, cost and time attributes of the various criteria.

3.3 THE DEVELOPMENT PROCESS

The process whereby a Value Analysis team develops its concepts can be diagramatically shown as in Figure 3.1 below:

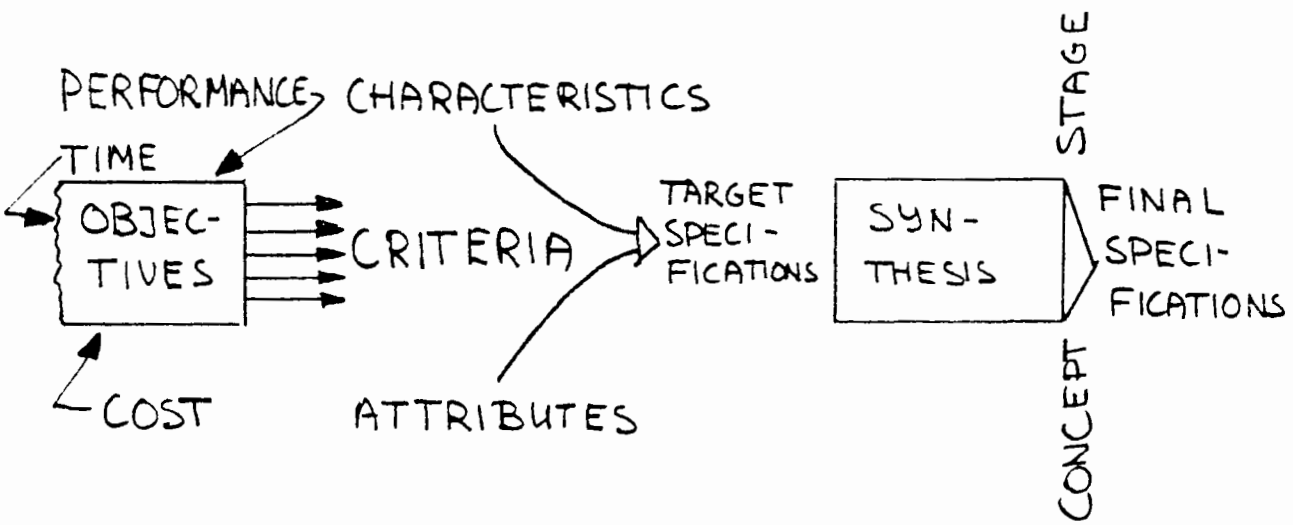


Figure 3.1
The V.A. Development Process

From the above, it may be seen that the objectives are used to draw up the criteria, the criteria have various attributes which act as constraints. The criteria are then used to develop target specifications or preliminary design. These specifications or designs are synthesized into a final specification or a final design. The above process has been carried out by the V.A. team as part of this study.

3.4 CREATIVITY TECHNIQUES

In this paragraph an outline of the various creativity techniques will be given. The creativity comes into play when using 'brain storms' to analyse alternative solutions to the particular problem. There is a real need for becoming creative in this analysis of design of locomotor aids. We must get off the beaten path if we are to find obscure relationships between bits of information. Methods of analysis are not straightforward and they involve much speculation. There is a considerable number of analytical methods for use,if we can look in more remote places or in fields not normally associated with the field of endeavour of the V.A. team. It can be shown that much could be learned about solid state control systems by understanding human beings. Also much can be learned about the functioning of economic systems by the study of card games. The need for creativity is as acute in analysis as it is in the other phases of problem solving.

According to psychological research which was surveyed as part of this study, it has been determined that producing new ideas is a three-stage process. Firstly the initial conscious work, secondly the incubation period where the conscious is idle but the unconscious is at work. When people speak of putting the problem to bed they are trying to get the unconscious going. Thirdly, the sudden flash of insight which psychologists call 'the Eureka experience'. The typical core questions which can produce the new ideas are shown in Figure 3.2

CORE QUESTION	NEW IDEA GENERATORS
SUBSTITUTE ?	Who else? What else? Other place ? Other time?
COMBINE ?	A blend? An assortment ? Combine purpose?
ADAPT ? ALTER?	What is like this? What does it suggest?
MODIFY? MAGNIFY? MINIFY?	Change material, colour, motion, sound, odour, taste, form, shape? What to add? Stronger, larger, smaller, Lighter, split up?
PUT TO OTHER USE?	New ways to use ? Other uses if modified?
ELIMINATE?	Is it neccessary ? Is it worth the cost?
REVERSE?	Opposite ? Turn it upside down?

Figure 3.2

The Idea Spurring Question Matrix

It is to be remembered that the ability to be creative is as natural as the ability to swim, breathe or walk. The physical environment also has a profound effect on creativity.

All the techniques are designed to help the V.A. team to get a different perspective on a problem by loosening the filter in their consciousness that assesses all the thinking and ideas on a 'normal, rational' basis - and keeps them thinking conventionally.

All of the techniques use wild erratic swinging of thinking in a think-tank type meeting and could be distressing to anyone who is disciplined in sequential reasoning. Worse still, new ideas have an odd appearance which irks any mind attuned to the conventional. Finally, the time-honoured association of creativity with eggheads may threaten the Value Analysis' team self-image of no-nonsense virility. Yet the guiding line should always be to 'blast' old concepts out of the way when 'creating' new ones.

In what follows, the various creativity techniques as surveyed for this study, have been listed:

3.4.1 Brain Storming

A group of people solving a problem by blurting out whatever comes into their heads. No idea or comment is evaluated - so that no possibility is ignored because of fear that the idea will be shot down.

3.4.2 Scenario

A group of people get together to try and guess what the future holds - thereby giving them some idea how their product should develop. They pick a year in the future and identify with that period, allowing all their imagination to soar as they build a picture of conditions that will likely exist at that time.

3.4.3 Bionics

The study of the animal world with a view to developing processes which can be reproduced technologically and used for our purposes - for example, developing radar from seeing how bats navigate.

3.4.4 Synectics

Trying to get new perspectives on a problem by approaching through an entirely different but analagous situation - for example, imagine the V.A. team to be part of the machine it is trying to design or trying to imagine how a grasshopper would see the problem.

3.4.5 Morphology

This is the most rational of the creativity techniques, this involves drawing a two-dimensional or three-dimensional grid or pyramid of the variables in the problem and trying out all sorts of combinations on the grid. (Including the crazy ones).

3.4.6 Noun-Verb Analysis

Creativity is a mental process which is 'associated'. We store in our minds various families of association. But supposing we ask the brain to establish association across these families of ideas, this poses real difficulty. This technique though, works best when evaluating functions of any product in terms of one noun and one verb.

3.4.7 Random Word-Play

Random word-play takes place in two steps. The first step is finding a random word which has no logical connection whatsoever with the problem being discussed by the V.A. team. The second step is to play around with the random word. This random word-play is used to establish in which direction we should think of our solution. It has been established that random word generators are commercially available. One of these generators shuffles 13000 words in a plastic sphere and then presents them to the observer in a plexiglass window.

To sum up, the steps in random word-play are:

1. Write down the problem.
2. Find a random word.
3. Play with the word.
4. Test each new thought the word gives you to see if it is a solution to your problem.
5. Keep at it for 10 minutes to half an hour.
6. Record the best ideas the random word-play has produced.
7. Put the ideas into operation.

In summary, creative thinking may thus be defined as the relating of things or ideas which were previously unrelated. To become creative, the mind must be allowed to 'free-wheel', this allows for situations to develop in the mind which are unrelated and in many respects, impracticable, yet their creativity can give birth to new ideas which can be feasible. As brain-storming will form the major process whereby this study's V.A. team has carried out its creative thinking phase, the following four guidelines are applicable. (See also Figure 3.3).

1. Criticism is ruled out.
2. Free-wheeling is welcomed.
3. Quantity is wanted.
4. Combinations and improvements are sought.

1. Criticism is Ruled Out:

Judgement is suspended until a later screening or evaluation session. Allowing yourself to be critical at the same time you are being creative is like trying to get hot and cold water from one tap at the same time. Ideas aren't hot enough - criticism isn't cold enough. Results are tepid. (Do not analyse while you synthesize).

2. Free-Wheeling is Welcomed:

The wilder the ideas, the better. Even offbeat, impractical suggestions may 'trigger' practical suggestions which might not otherwise occur.

3. Quantity is Wanted:

The greater the number of ideas, the greater the liklihood of winners. It is easier to pare down a long list of ideas than puff up a short list.

4. Combinations & Improvements are Sought:

In addition to contributing ideas of their own, team members should suggest how the ideas of others can be turned into better ideas, or how two or more ideas could be combined into an even better idea.

Figure 3.3

The Four Principles of Brainstorming

The creative thinking approach may be summarised in the following 'speculation check list': (See Table I).

TABLE I

SPECULATION CHECK LIST	
1	Can any function be eliminated?
2	Suppose this was left out?
3	What else can it be made to do?
4	What other material can be used?
5	Can any part be combined?
6	What if it were not done at all?
7	Where else can this be done?
8	Can a cheaper specification of the same material be used?
9	How can this be made more compact?
10	Can waste material be reduced?
11	Can any dimension be reduced?
12	Can any tolerance be relaxed?
13	Why does it have this shape?
14	Can any component be replaced by a standard component?
15	How much of this is the result of tradition?
16	Could we purchase this item for less?
17	Can another supplier supply it cheaper?
18	Can another process make it cheaper?

3.5 EVALUATION TECHNIQUES

The evaluation or decision making techniques are essentially needed because of the large number of possible ideas or solutions. These are generated by the creativity techniques as described previously, when evaluation or judgement of these ideas was suspended.

In the evaluation phase, as being discussed here, judgement is required but it must be objective judgement unspoiled by habits, attitudes or pre-conceived notions. In particular it must be remembered that it is not only a question of assessing the cost saving of an idea which determines whether it should be considered further. Such a practice would degenerate into cost cutting, whereas better value may lie in choosing a more costly idea.

The methods of evaluating ideas as used in Value Analysis have been developed to enable objective assessment to be made of their likely worth, starting with simple methods for the initial weeding out process of the totally impossible ideas. Initially therefore, all the ideas should be broadly classified into types in order to bring similar ideas together and then each idea should be investigated.

For the purposes of this study the following methods will be deatiled.

a) T-Chart Analysis
b) Forced Decision
c) Delphi Technique
d) Modified Delphi Technique

3.5.1 T-Chart Analysis

This method of selection obviously supposes that, where necessary, ideas are developed to the stage where an assessment of the good and bad points can be appreciated.

When subjecting ideas to the T-Chart Analysis, quite obviously one bad point may be so bad as to outweigh all the good points and then the idea could have been rejected.[15] As each idea is subjected to this procedure, fresh ideas often suggest themselves and they in turn are added to the initial list for subsequent evaluation.

The following Table gives a simple T-Chart Analysis (See Table II).

TABLE II

IDEA T-CHART	
GOOD POINTS	BAD POINTS
Fewer parts	More costly material
Lighter	Harder to machine
Smaller	
Easier to service	

The above T-Chart analysis is based on basic machining procedures in the production of any type of equipment. This basic T-Chart evaluation method may be modified to include an appropriate check list of yard-sticks, or criteria, by which to measure the possible efficiency of the ideas. At this stage it is sufficient to establish the yard-sticks or the criteria as merely better or worse in relation to the level achieved in the present design or present item.

This modification would result in a new form of T-Chart as shown in Table III.

TABLE III

CRETERIA T-CHART

BETTER GOOD	CRITERIA	WORSE BAD
Less	Number of parts	
	Mechanical reliability	Worse
No change	Electrical reliability	No change
Less	Design & development cost	
Less	Tooling costs	
Less	Manufacturing costs	
Better	Sales potential	
Accept	Decision	

The above Table enables a simple quantification of each important criteria to be made and recorded. When all ideas have been subjected to the T-Chart assessment as shown above, those accepted are then analysed in more detail. The type of detail required is mainly quantification of the criteria affected expressed in absolute or percentage form. Again the common percent satisfaction scale, see Para.2.4.1 hereof, will be referred to. Using the scale, the Criteria Value T-Chart may be drawn up as shown below in Table IV.

TABLE IV

CRITERIA VALUE T-CHART

BETTER EFFECT	CRITERIA	WORSE EFFECT
-10%	Number of parts	
	Mechanical reliability	-20% *
	Electrical reliability	-5% *
-10%	Design & development costs	
-30%	Tooling costs	
-10%	Manufacturing costs	
+25%	Sales potential	
	Decision	REJECT

* Note: Reduction in reliability level on these two key characertistics.

In this instance a reject decision is taken based on the reduction in mechanical reliability since in Value Analysis a reduction in the specified levels of this criteria is not permitted.

3.5.2 Forced-Decision Analysis

When each idea has been T-Charted as described above, it may be that one stands out amongst all the others making its choice almost automatic. However, it is not unusual to have a number of apparently equal ideas and further analysis is then required.

This analysis is best done by the simple weighting process and the forced decision technique.

The simple weighting procedure involves assigning to each of the criteria chosen in the previous T-Charts, a numerical coefficient (i.e. weight or rank) based on the specified relative important to each other. The next step would then be to proceed to weight the percent satisfaction values using these coefficients. The calculation procedure is as will be shown for the alternative evaluation matrix. (See Para. 3.6.1 hereof).

The idea resulting in the highest weighted score is then selected for further investigation. It should be noted that the specified relative importance, i.e. weight or rank, is by this method purely arbitrary. It does, however, offer a repeatable numerical value determination for each of the ideas.

When confronted with a complex combination of criteria, the subjective distribution of weights can hinder a realistic evaluation. One way to reduce this subjective judgement is by the forced decision technique, which attempts to assign a numerical value to each solution by comparing each criterion with each of the others. This determines an order of importance of the criteria, and then each solution may be compared with each of the other ones on this weighted criteria basis.

3.5.3 Delphi Technique

Sometimes educated guesses form important base line information for statistical analytical procedures. The so-called Delphi Technique (a systematic utilisation of the intuitive judgement of groups of experts) is a case in point.[11] It is based on the premise that when nobody has perfect knowledge of the future, many heads are better than one or a few.

The technique is based on a prepared questionnaire which is distributed in the first instance to a team of experts on the particular problem at hand. Each expert is asked to make his predictions, estimates, suggestions, anonymously. Each team member then gets a feedback of the way the other members have answered the questions, and a second round of forecasting begins. This process may be repeated 2, 3, 4 or more times. Since the identities are kept anonymous, even on the first round of questioning, a team member can more easily change his mind after hearing about the other opinions. The refinement of judgement of experts is thus obtained. The first time around, definitive answers are not expected. Successive iterations improve individual answers, and better individual responses add up to a better group judgement.

It must be accepted that the Delphi Technique is a new and controversial method for dealing with future uncertainties.[12] The possible variations on this technique appear to be endless, larger projects usually have required electronic data processing and in principle the Delphi is a method of cybernetic arbitration.[11] This method thus lends itself to eventual computer programming.

3.5.4 Modified Delphi Technique

A literature survey has shown that the Delphi Technique is often not used directly as detailed above. The main modification is in the method of response. The Delphi questionnaire is retained. However, the response which is obtained initially from each inidivdual separately is then combined in a group response, this response being obtained in a group decision-making session.

By the above procedure the individual decision making advantages of Delphi have been retained. The beneficial effect of full group sessions are combined to result in a group decision.[12] Each respondent has thus to mentally reproduce some of the reasoning which went into his initial response to the questions.

The group decision would then form the median of the various responses.[11] In this way the well-known limited capacity of persons to notice and process data (a drawback) is eliminated, because of the full discussion opportunity in the group environment. In addition, this facilitates the attention of the group on one factor in what is essentially a multi-dimensional choice space. This has obvious advantages in obtaining clear-cut answers. It is for these reasons that this technique is used in this study.

3.6 RANKING TECHNIQUES

The afore-mentioned evaluation techniques leave one with a number of alternative solutions. These alternatives now have to be ranked to determine which one alternative has to be further developed and design-detailed, selected for production etc., as obviously, the time and cost constraints prohibits simultaneous development of all alternatives.

3.6.1 Alternative Evaluation Matrix

This ranking method uses basic arithmetic procedures to quantify the Value Analysis' team decisions on alternatives.[2] As such it is repeatable and totally objective, as it converts subjective judgements to objective numerical quantities, called Overall Percentage Satisfaction. Hence this technique is used as part of this study.

This technique relies heavily on the 'Percent Satisfaction' Conversion Scale (See Para. 2.4.1).

Full details of the technique are given in Appendix II hereof. The technique results in a numerical ranking of various alternative solutions based on pre-selected criteria and the weighting of those criteria.

3.6.2 Inconclusive Results of the Alternative Evaluation Matrix

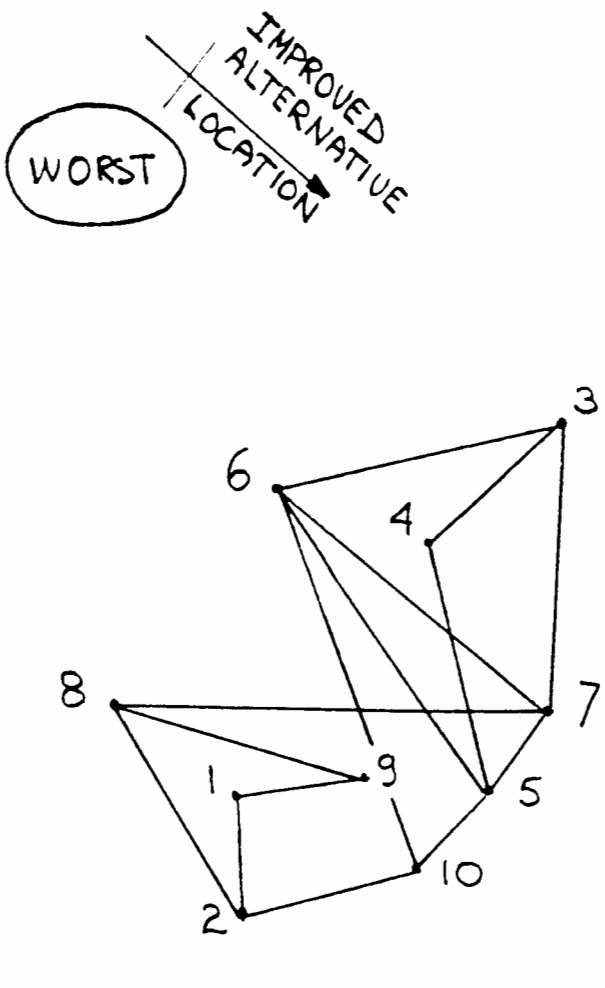
In order to make a systematic decision amongst alternatives, there must be a common system of units for comparison. This unit is known as the 'Percentage Satisfaction' of Objectives (as described previously). It can be weighted and summed into a figure which will give the 'Overall Percentage Satisfaction' of objectives. (See previous work on this in Para. 3.6.1 and Appendix II). Should the highest Percentage Satisfaction as the result of the analysis not be defined, i.e. very close rating between alternatives, then a technique needs to be developed to further refine distinctions between such close rating alternatives. For the purposes of this technique it is assumed that a set of alternatives has been defined, and each alternative has been given Percent Satisfaction values on a set of criteria.

The following refining techniques have been investigated for use in this study, namely, Structural Mapping of indifferences, Utility Values, Lexiographic Ordering, Factor Analysis and Concordance Analysis.

3.6.3 Structural Mapping

Recent publications suggest the method of using indifferences amongst alternatives as input to a multi-dimension scaling algorithm (MDS) in order to produce a 'structural map'. Given a possible set of alternatives together with the relevant criteria and the requirement to reach the maximum Percent Satisfaction of Objectives, the structural mapping technique derives a solution by the evaluators' own judgement of this data. No formal arithmetic rules are applied. The indifferences between the data are used as input into a multi-dimensional scaling algorithm to generate a map (See Figure 3.4). The map is interpreted to give an ordering of the alternatives from 'worst' to 'best'.

Upon investigation for the purposes of this study, it has been found that there is heavy reliance on subjectivity for classifying the alternatives prior to input into the MDS algorithm. It is argued that this prior intervention by the evaluator is a weakness of this technique.



INDIFFERENCE MATRIX						
1	2	2	8			
2	8	1	3	10		
3	4	6	7	2		
4	3	5				
5	10	6	4	7		
6	3	7	5	10		
7	5	8	6	3		
8	1	2	7	9		
9	10	1	8			
10	2	9	5			

TWO-DIMENSIONAL MAP WITH PRE-FIXED 'WORST-BEST' LOCATIONS (ON PRE-SELECTED SCALE).

Figure 3.4

Two Dimensional Map - Ordering of 10 Alternatives and Indifference Matrix

Note: This Matrix is determined by subjective judgement of each of the given 10 alternatives as to which combination of alternatives gives the same degree of indifference.

Example: Alternatives 1, 9, 2 and 8 display the same indifference, hence are joined on the map.

It is stated that for the purposes of this study, such subjective intervention could in fact be a limiting factor. Several evaluators may well produce different sets of indifferences, and even one evaluator may generate different sets on different occasions. Further, subjective judgement has to be used to determine the 'best' and 'worst' parts of the multi-dimensional space in order to produce a ranking of the alternatives.

It should be noted that a multi-dimensional scaling map has no preferred orientation. The map could be rotated without any loss of information. Different evaluators may make different suggestions and a formal criterion or rule is needed by which to judge each suggestion, making the application of this method, to further refine distinction between alternatives, very laborious indeed.

3.6.4 Additive Utility

The second method employs an additive utility model. In this approach the initial data are converted to a set of personal attribute utility values. The values for all criteria are then summed to give each alternative a final score and the alternatives are ordered on the basis of these final scores. It appears from the literature that the conversion of this data to Utility Values does not involve any formal arithmetic procedure, and would thus suffer from a lack of formal repeatability. This method need thus not be considered any further here.

3.6.5 Lexiographic Ordering

The next method, Lexiographic Ordering, can be used to search for a 'best' alternative, the method requiring that criteria can be ordered from most to least important.

This is usually the case. Each alternative receives a score for each criteria. (See Appendix II). The scores on each criteria allow the alternatives to be compared, and the Lexiographic principle of ordering by the first significant difference is then used. The alternatives are compared first with respect to the most important criterion.

The dominant alternative is declared to be the best. However, if two or more alternatives tie for the best then these are compared using the scores on the second most important criteria. This process is continued down the ranked list of criteria until only one alternative remains. This is then declared as the best as it has received the maximum number of highest scores on the criteria. The greatest weakness for the above method is that there is no way in this method to trade-off scores amongst criteria. The method is thus heavily influenced by the initial ordering of the criteria from most to least important, as referred to above. This requirement of ordering the criteria is valid, and indeed decision makers should have some idea of the comparative importance of the criteria.

Lexiographic Ordering does not produce a complete ranking of all the alternatives and it does not indicate the degree of difference between the ranks. It represents the closest approximation to a summary of the relative attractiveness of alternatives. It is contended that due to the heavy influence of initial ordering of the criteria, this method lacks validity when applied to the investigations as detailed in this study.

3.6.6 Factor Analysis

The alternative choice problem is analogous to the traditional classification problem addressed by Factor Analysis. The purpose of this approach is to reduce a complex array of data to a format that will help identify the relative attractiveness of each alternative.

To this end it is suggested that a hypothetical alternative, which has the best scores on each criteria, be incorporated into the data. This serves as a benchmark against which the existing alternatives can be judged.

The outcome of Factor Analysis is a set of factors which explains statistically as much as possible about the correlations among the criteria. It therefore will also highlight the validity of the criteria.

The application of this technique to evaluating the results of the Evaluation Matrix appears to be only suitable when the set of alternatives considered in the Evaluation Matrix is unusually large i.e. alternatives N equals or greater than 5, and when the set of criteria is also unusually large. For the purpose of this study it has been established that the average evaluation matrix technique is based on a limit of 3 alternatives and 5 criteria. The application of Factor Analysis is therefore not required for this particular study.

3.6.7 Concordance Analysis

Concordance Analysis is a form of arithmetic procedure by which multi-criteria alternatives can be classified. The results could be used as input for a multi-dimension scaling algorithm (MDS). This procedure is thus similar to the structural mapping approach (Para. 3.6.2), except that the alternatives are classified objectively rather than subjectively, a much preferable method. Specifically, the determination of the Concordance Index and of the Coefficient of Concordance will be discussed below.

Concordance Analysis is a technique whereby all possible pairs of alternative solutions are compared with regard to their impact on each criterion. For each pair-wise comparison there will be one of the following three outcomes. For two alternatives i and j, alternative i is preferred to alternative j ($i > j$), alternative i is equal to alternative j ($i = j$) or alternative j is preferred to alternative i ($j > i$).

A Concordance Index is calculated for every pair-wise comparison of the alternatives and is found by summing the scores for the outcomes of the comparison for each criterion. A score may be derived as follows. For the Concordance Index C_{ij}, one is comparing the performance of alternative i with alternative j. If i is greater than j for a criterion; then the score is equal to the weight of that criterion (See Para. 3 Appendix II).

If i is equal to j then the score is the criterion weight divided by 2. If j is greater than i then the score is zero. The sum of these scores is then divided by the sum of all the criteria weights, which is normally set at one. (Refer to previous work on Alternative Evaluation Matrix Analysis as per Appendix II).

The result is then the Concordance Index. The Index indicates the degree of unanimity of preference for alternative i over alternative j.

The Concordance Indices are summarised on a Concordance Matrix, which will be square, with the alternatives on each axis. This matrix can be interpreted per se, to determine the relative attractiveness of the alternatives, by calculating a row sum scale.

It is however more accurate to transform the matrix into a dissimilarity matrix which can then be put into a multi-dimension scaling algorithm (MDS) (See Para. 3.6.2).

This technique however, is beyond the scope of this study.

Alternatively, the Coefficient of Condordance W may be calculated to establish the degree of agreement between the alternatives, or the absence thereof. Should W calculate out at value 1, then complete agreement is indicated, whilst for W = 0 there is no agreement between alternatives, implying that the alternative with the numerically higher overall Percent Satisfaction should be selected for further work.

The method whereby W may be determined is stated below.

If M is the number of alternatives, based on N criteria, (See Matrix in Appendix II) and the criteria columns are summed for each of the N criteria, and if S is the sum of the squares of deviations of these sums from their common mean $\frac{1}{2}$ M (N + 1), the Coefficient of Concordance W is given by:

$$W = \frac{12S}{M^2 \ (N^3 - N)}$$

Again, as the number of alternatives and of criteria is relatively low in this study, the above technique need not be applied in this instance.

3.7 SUMMARY

In the foregoing the various creativity and evaluation techniques have been highlighted. A method to rank these ideas has been given and the various methematical constraints have been shown.

It remains to analyse the results of a practical Value Analysis experiment to determine the applicability of these techniques.

CHAPTER FOUR

HYPOTHESIS STATEMENT

"...Disabled people share the rights of all humanity to grow and learn, to work and create, to love and be loved, but they live in societies that have not yet learned to fully protect those rights..."[5]

4.1 INTRODUCTION

Having detailed the various V.A. techniques in the preceeding chapters, this study will now set out the present position of locomotor aids, that is, aids for getting about by physically handicapped persons, in South Africa.

It will be shown that the present position is not satisfactory, both from the disabled person's point of view and from society's overall socio-economic responsibility point of view. It also makes efficient application of Government funding very difficult indeed.

The hypothesis will then be made that one way to ameliorate this position will be by the application of Value Analysis to the design of a selected locomotor aid, to improve its function. The background to the selection of the particular aid will be detailed.

4.2 PRESENT SITUATION OF S.A.DISABLED POPULATION

Generally, should a person in S.A. become physically disabled, through accident or disease, this person would be treated by anyone of the State, Provincial or Homeland government hospitals. Some of these hospitals provide a full orthopedic service, i.e. the design, manufacture and fitment of aids for the locomotor disabled.

This service is normally supplied to the patient upon recommendation by the local District Surgeon. The District Surgeon in turn relies on the advice given to him by the patient's Orthopedic Surgeon and/ or his Occupational Therapist.

The District Surgeon's recommendation also implies that the State, via its Department of Social Welfare and Pensions becomes responsible to carry a part, or all, of the costs associated with the recommendation. The actual costs carried vary according to the branch of State (e.g. Provincial), the type of government (e.g. Homeland), the origins of the disability (e.g. Dept. of Defence , Dept. of Manpower), the employment group of the patient (e.g. private industry, mining) and the race and socio-economic standing of the patient.

These factors do all have a definitive bearing on the present situation of S.A.'s physically disabled, but the analysis thereof falls outside the scope of this study.

4.2.1 The Numbers Issue

Due to the above outlined diversity, it is at present not possible to present a valid analysis of the numbers of physically disabled persons in S.A.[6] A rough guide only can be obtained by establishing the numbers of recipients of pensions and grants paid out to disabled persons by the afore-mentioned Department of Social Welfare and Pensions. This figure is distorted though, due to no distinction being made between new/ existing recipients, disabling injury or disease, extent of disability, and more importantly; nature of disability (e.g. visual, locomotor impediment). Also no distinction is made if the grant or pension fully covers or partly covers the disablement.

4.2.2 The Diversity Issue

Then again, due to the diversity of physical disabilities, and the number of suppliers of aids for the locomotor disabled, there exists a large number of types of aids for each type of disability.

As at present there are a large number of disabled aid equipment supply companies operating within S.A., all in commercial competition for valuable State equipment supply contracts, there is very little economic motivation to reduce equipment variety by the suppliers themselves.[7]

4.2.3 The Standards Issue

At present, only some of the aid equipment is fully specified by S.A.'s specifying authority, i.e. the S.A.B.S. Generally, each of the four Provincial Authorities, the Homeland governments and the Defence Force, through their respective Departments of Health, buy out on tender aid equipment against the relevant S.A.B.S. or their own specifications. In an attempt to standardise on requirements etc, there exists a Hospital Equipment Co-ordinating Committee, under the aegis of the S.A.B.S., through which all four provincial administrations attempt to standardise their requirements.

Research carried out as part of this study in the above-mentioned issues of numbers, diversity and standards has clearly indicated that a real contribution to the plight of the physically disabled can be made by applying V.A. to the design of aids, with a view to improve function. This improved design could then be formalised by acceptance by the specifying authorities.

4.3 HYPOTHESIS

4.3.1 Traditional Methods

When attempting to reduce costs to the eventual user of locomotor disabled aid equipment the following 'traditional' cost cutting techniques could be considered:

i) Reduce variety of equipment
ii) Reduce labour force making this equipment
iii) Reduce quality of equipment
iv) Employ the disabled themselves to manufacture equipment,

Upon a survey of the above techniques it was established that these could not be used, due to:

i) numerous and varied types of injuries, causing a large vairety of disablements,

ii) manufacture is very labour-intensive due to the nature of product and low numbers of each product being made,

iii) the end user, i.e. the S.A. physically disabled person, is very poorly placed to optimise his selection of equipment on quality as he "has to have it",

iv) Lack of a supporting 'social fabric' amongst all population and socio-economic groups in S.A., as well as lack of technical skills and training facilities, would make 'disabled-labour' very cost-intensive.

4.3.2 Hypothesis Statement

Resulting from the above, it may be hypothesized that one way of obtaining improved function, and hence cost saving, of locomotor disabled equipment, is by applying the techniques of Value Analysis to the design of such equipment.

Details of the application of Value Analysis to devices for locomotor disabled in South Africa are given in Appendix IV, to which the reader is now referred.

4.3.3 Commercial Advantages of Value Analysis

When V.A. is applied to locomotor disabled aid equipment, the resulting improved function would lead to a quicker return to normal health and gainful occupation, hence a lower socio-economic load on S.A.'s economy - and offer the opportunity to gain new skills (where permanently disabled) in a more efficient way.

When cost savings on the equipment can be made due to V.A., this would enable more disabled persons to be supplied with the equipment either by direct purchase or by Government agency purchase and subsequent lease to patient.

As cost savings would also indicate a V.A. search for commonality of components,[7] the very necessary survey of numbers of disabled persons and their needs (See Para. 4.2.1 hereof) would be hastened. Although not part of this study, such a 'numbers survey', together with the V.A. methodology of this study would greatly enhance the commercial benefits. A fully detailed method on the 'Determination of total number of disabled in South Africa' is given in Appendix V hereof, to which the reader is now referred.

4.4 SELECTION OF PRODUCT FOR VALUE ANALYSIS

At this point, the actual locomotor aid which is to be Value Analysed has to be selected. The range of available aids is shown in Table I.

TABLE I

LOCOMOTOR AIDS

TYPE OF AID	CLASSIFICATION
Single stem support	Walking stick
	Axilla crutch
	Trough crutch
	Arthritic crutch
Multi-stem support	Quadraped/and walking frame
Wheeled support	Rollator
	Wheelchair

Note: The classification listing in the above Table has been based on increasing technical complexity.

4.4.1 Application of Perceptual Mapping Technique

In view of the numbers of aids available, being 8 classifications (see Table I above) and the variations of each classification (in practice this has been found to average 3) there are thus 24 potential products to be Value Analysed.

When it is borne in mind that in South Africa there are at present represented at least one manufacturer from each of the following countries; England, Germany and the U.S.A., for each of the 24 products, the actual distinct products available are about 72 in number. Not included are the three or so local South African manufacturers, which could increase the product count to 84.

The only mathematically justified way out of the above problem would be the application of the Perceptual Mapping technique, to indicate as to which locomotor aid could benefit most from the Value Analysis techniques.

All data required for the Perceptual Map, See Para 2.5.4 hereof, has been tabulated in Appendix III, to which the reader is now referred.

The results of Appendix III are pictorially shown in the Perceptual Map, see Figure 2.3 hereof.

The map indicates that the common axilla crutch, type A_G could benefit most from V.A. and this has thus been selected for this study.

4.4.2 Validity of Perceptual Mapping Technique

As in any study of this type, each suggestion needs to be critically examined as to its theoretical as well as practical justification.

Much fragmentation of products and services to the disabled is evident. The questions that perhaps need attention are whether, despite many facilities, community needs are being met; whether by joint effort a more effective and economic product (the 'aid') could be offered.

The facilities required by the disabled, the problems experienced by them and the extent of co-ordination of State services (based on the Western Cape Region) have been tabulated in Table II.

TABLE II

DISABLED REQUIREMENTS

Facilities Required by Physically Disabled	a) Improvement of residential care i) own home, ii) possible foster home, iii) technical aids for independent living, iv) attendant care scheme. b) Technical aids design and information centre. c) Liaison in design and marketing of products made for and by disabled. d) Research into extent of need: i) total numbers ii) required standards
Problems experienced in the field.	i) Co-ordination of aid service when patient is transferred from hospital to community to be improved. ii) Severe manpower shortage, therefore need to apply one evaluation technique for design and function of all aids.

TABLE II (Cont'd)

Co-ordination of services supplied by State and Provincial bodies	i) Western Cape Council for Physically Disabled. ii) Western Cape Regional Welfare Board. iii) Regional Welfare Baord for the Cape Peninsula. iv) Dept. of Social Welfare and Pensions v) Dept. of Co-operation and Development

Information on the facilities and products required by the disabled is the basis for all design of locomotor aids. The difficulty, as outlined above, is the large number of sources of information, the users of that information and the constraints or validity of the information. The usefulness of Perceptual Maps is that they organise and condense that information into a graphic display.

4.5 SUMMARY

The fragmented nature of the position of aid products for the South African disabled person has been sketched. The absence of reliable statistics for the incidence of disabling conditions, as well as a proposed method to obtain this information, has been detailed.

The application of Value Analysis to the design of aid equipment has then been detailed and validated.

A quantitative technique for evaluating all the information has been used to determine that the common axilla crutch would benefit most from the application of Value Analysis. This technique, Perceptual Mapping, has been illustrated and validated.

It remains to be shown how the techniques were practically applied in obtaining a maximum functional usefulness of the axilla crutch.

CHAPTER FIVE

PRACTICAL OPERATION OF THE VALUE ANALYSIS EXERCISE

"...the standards of medicine as practiced in South Africa compare favourably with the best anywhere in the world,...rehabilitation... by modern standards (is) virtually non-existent...rehabilitation... being the process by which the individual is restored, as nearly as possible, to his or her pre-illness or pre-accident state of activity..."

5.1 INTRODUCTION

This chapter serves to outline the practical operation of a Value Analysis team, as assembled by the author. The team had the specific objective of Value Analysing the common axilla crutch, as issued by all four Province's hospitals, the State and Homeland hospitals, and the Defence Force hospitals.

The selection of the team, the authority levels and team expertise will be detailed. The team's operation according to the V.A. Job Plan and the functional analysis techniques mentioned previously, will be stated.

The evolvement of the Alternative Decision Matrix, from all the data gathered and developed by the team, will be illustrated.

So as to facilitate reference, a summary of Value Analysis techniques relationships has been given in Table I.

TABLE I

VALUE ANALYSIS TECHNIQUES RELATIONSHIPS

FUNCTIONAL APPROACH	JOB PLAN	KEY TECHNIQUES	SUPPORTING TECHNIQUES	V.A. QUESTIONS
1. Define Approach	Information Phase	Get all the Facts Determine Costs. Define the functions. Put rand value on specifications	Get information from the best source Work on specifics. Use good human relations. Overcome bottlenecks. Divide product into functional areas.	What is it? What does it do? What does it cost?
2. Evaluate Functions	Information Phase (cont'd)	Evaluate by comparison. Evaluate basic function. Put Rand value on each idea. Refine ideas.	Use good business judgement. Analyse costs. Evaluate ideas. Evaluate functional areas.	What is the value of the function?
3.	Speculation Phase	'Blast and Create'	Creative thinking: deferred judgement. Use teamwork.	What else will do the job?
4. Develop alternatives	Speculation Phase (cont'd)	Consult retailers Use Medical and Industrial specialist. Use SABS and Industrial Standards. Use speciality products,processes and materials. Determine costs.	Overcome bottlenecks. Develop ideas. Apply new information Positively approach this challenge.	What else will do the job? What will that cost?
5.	Implementation Phase	Motivate positive action.	Prepare an action plan. Use good human relations. Spend company money as you would your own Develop & sell or implement the V.A. solution.	

5.2 TEAM SELECTION

The team selection was to be such that the stated V.A. Objectives in terms of Performance, Time and Cost (See Chapter 3 hereof) were being met. In addition, team skills have to meet at least the requirements of Para. 2.2.2 hereof. The key element of input from Engineering (Vide Level 2, Para 2.3.2) has to be present on the team. The team leader impartiality and his insistence on maintaining quality and reliability standards have to be ensured for a relevent Value Analysis exercise.

After investigation, by personal interview, of crutch usage, medico-technological support systems, and methods of distribution to users, the following expertise was selected to serve on the V.A. team:

a) Orthopedic treatment and occupational theraputic staff - 2 representatives,
b) Specifying and purchasing authorities - 1 representative,
c) Manufacturing entrepreneurs - 2 representatives,
d) Value Analyst - 1 (Team leader).

Total team size thus was 6 - considered to be optimum for this study (Vide Para. 2.2.3 hereof)

5.3 TEAM MANAGEMENT LEVELS

Regarding the management levels of the team, the following applied:

a) Orthopedic treatment and occupational therapeutic staff - Chief orthopedic surgeon and Chief therapist of a local Orthopedic hospital.
b) Specifying and purchasing authorities - Chief Engineer of Cape Provincial Hospital Administration Department.
c) Manufacturing entrepeneurs - Chief Design executive and Marketing Director of local disabled and hospital equipment manufacturer, and

d) Value Analyst - Professional Engineer, trained as Mechanical Engineer, employed by Biomedical Engineering Dept., University of Cape Town.

Ad-hoc expertise and advice was provided by two senior industrial engineering managers, one from a major local chemical industry and one from a local pharmaceutical manufacturer. Both these companies have active Value Analysis programs operating on a continuous basis.

5.4 TEAM MEETING SCHEDULE

Altogether 6 full team meetings were held, over a consecutive period of 9 weeks. One of these meetings was held at the premises of the afore-mentioned pharmaceutical manufacturer, who delivered an audio-visual presentation on that company's in-house V.A. programme as well as a practical training session on V.A. as presented to that company's own personnel.

The team meetings were of no specified duration, in keeping with the informal approach as part of V.A. (vide Para 2.2.8 hereof). Generally the meetings lasted about 3 hours each, with considerable extension of that time by individual team members who stayed on after meeting conclusion for further discussions.

5.5 MEETING PROCEDURES

The team meetings were of the 'open house' informal type, with the team leader providing guidance only. There was no rigorous agenda and no minutes were kept. As part of the V.A. process, only the team leader made notes of the proceedings.

The team leader presented the V.A. Job Plan as detailed in Appendix VI.

The meetings were structured around this Job Plan.

Discussion was initiated by the team leader. Each team member was asked to comment on matters pertaining to his expertise, as well as any other opinions he may have had. This structured questioning was carried out at each step of the Job Plan, to ensure maximum free flow of ideas.

Where data was available e.g. S.A.B.S. (S.A. Bureau of Standards) and C.P.A. (Cape Provincial Administration) specifications, supplier's catalogues, these were used to discuss their validity for the Value Analysis exercise. The team member supplying this data was asked to give the initial comments to start off the discussions.

At the conclusion of each meeting, the discussions were summarised and the 'next meeting's' topic was initiated by the team leader.

The team meetings were held at a local Orthopedic Hospital which had a full repair and maintenance workshop for equipment for the locomotor disabled. Sample crutches as well as practical failures were made available to the team.

As the first phase of the Job Plan (Appendix VI) information was gathered, using all sources, based on the questions listed in Part 3, Appendix IIX.

5.6 JOB PLAN INFORMATION PHASE

5.6.1 Data Available and Data Exchange

Each individual team member was supplied with the data as listed in Table II. This data was supplied one meeting ahead of it being required for discussion purposes to enable assimilation by the team. Team leader was contactable by telephone.

TABLE II

INFORMATION DATA FOR V.A.TEAM	
TITLE	PREPARED BY
Alternative Evaluation Matrix	Team leader
Aluminium Specifications ex Hulett's Aluminium	Manufacturer
Function listing	Team leader
S.A.B.S. and C.P.A. Specifications	Purchaser
Value Analysis Work Sheets	Team leader
Wooden Axilla Crutch Sketch and Cost Data	Manufacturer

5.6.2 Information Recorded

During the team meetings, the information as listed in Table III were recorded by the team leader.

TABLE III

INFORMATION RECORDED AT V.A. TEAM MEETINGS
a) Results of team discussions, brainstorms etc.
b) Summary of important issues, and of side issues, raised by team for further investigation.
c) Group behavior and inter-group dynamics.
d) External environmental factors, likely to influence meeting decisions.
e) Offers of assistance received from team to aid V.A. exercise.

5.6.3 Functional Evaluation

As part of the Job Plan's Information Phase, the team was asked to carry out a functional evaluation of the axilla crutch. Functions had to be ranked as primary and as secondary.

The responses were summarised by the team leader and are shown in Table IV below. The item numbers refer to crutch components as shown in Figure I, Appendix II.

TABLE IV

FUNCTIONAL EVALUATION FOR AXILLA CRUTCH		
Item No. and Description	Function	
	Primary	Secondary
1.Crutch shoe	Stop slipping Weight bearing Stop jarring Non-slip stability	Non-marking Supply fulcrum point Cushion device
2.Foot piece	Weight bearing adjustment device	Keep bows together
3.Wing nuts	Height adjustability	Keep bows together
4.Handrest	Weight bearing Hold crutch Gripping point	Keep bows together
5.Running thread	Adjust links	Allow adjustment
6.Bows	Weight bearing	
7.Arm piece	Stabilise user keep bows together	Supportive cushion
8.Arm pad	Distribute pressure Anti-slip device	Non-marking support

Note: Functions have been analysed in terms of the 'noun-verb' analogy.

5.6.4 Cost Determination

As, by definition, value is only improved if better function is obtained at less cost with the same, or improved, reliability, the actual costs of the axilla crutch are now relevant.

A full cost analysis is given in Appendix IX hereof, to which the reader is now referred.

The cost analysis (Vide Table II, Appendix IX), i.e. shows that materials make up about 70% of total costs, thus indicating that the investigation should concentrate on materials. When perusing Table III it is observed that two of these materials, the ferrule and the hand piece, contribute only 13,8% to total cost, yet are functionally the most vital components in the whole crutch. From the functional evaluation, vide Table IV, (Para. 5.8), it is evident that crutch user's stability is dominant in these two components.

5.7 JOB PLAN ALTERNATIVE SPECULATION PHASE

5.7.1 Methodology

The team was then asked to develop a viable alternative to the axilla crutch, using the previously mentioned idea-generating techniques (vide Chapter II hereof), summarised in Part II, Appendix VI and Part III, Appendix IIX.

The Delphi questionnaire sheet (see Appendix VII) was repeated for three iterations, so as to pool team opinion and maximise individual expertise input (vide Para. 3.5.4 hereof).

Each of the proposed alternative crutch designs, as detailed in Appendix II, was functionally evaluated by means of the Value Analysis sheet (see Appendix VII).

The above procedure established three alternative designs to effect improved performance to the common axilla crutch.

5.7.2 Alternative Description

The alternative designs developed by the team were based upon the existing crutch variants presently being manufactured according to S.A.B.S. and C.P.A. standards:

i) Wooden axilla crutch
ii) Metal elbow crutch, and
iii) Metal walking stick.

Full descriptions of the alternatives are given in Appendix II. Summary descriptions are given below.

Model 1: Shape as for S.A.B.S. type, with improvements on hand rest, arm pads and adjustment hardware.

Model 2: Shape as for Model 1, but using plastic/ aluminium materials throughout.

Model 3: Shape a combination of present walking stick and elbow crutch, with a 'swop top' piece to convert from elbow to axilla duty. Plastic/ aluminium construction used throughout.

5.8 JOB PLAN EVALUATION STAGE

Having available the three alternative designs, the criteria against which these designs are to be evaluated, the weightings of each criteria, the degree of overall satisfaction was determined by the team, using the modified Delphi questionnaire technique.

The team developed the alternative evaluation matrix, all as detailed in Appendix II and VI.

From the evaluation procedure, the team selected Model 3 as being the crutch design with the highest value to the user.

5.9 JOB PLAN IMPLEMENTATION STAGE

As part of the Value Analysis exercise, the implementation stage forms a definitive part of the Job Plan. As such, an outline of this stage has been given in Appendix VI.

As this stage is not central to the theme of this study, it will not be further considered here.

5.10 SUMMARY

This section of the study has detailed the practical operation of a Value Analysis exercise. For brevity, all details have been stated in the Appendices. The study has shown that a valid alternative to the common wooden axilla crutch can be developed, with improved user value.

As the 'new' design ensures interchangeability between the walking stick, elbow crutch and axilla crutch the economics of mass production now become an achievable goal for crutch manufacturers.

CHAPTER VI

ASSESSMENT OF THE VALUE ANALYSIS PROCEDURES AS USED BY THE AXILLA CRUTCH V.A. TEAM

...'Man is well known for his inhumanity to man. Fortunately, the doctor and the engineer already combined their resources in the times of the ancient Greeks to be human to man.

Artificial limbs are known to have been used them. They might have been crude, ugly, of inferior material, with no proper fittings and joints, but they served their purpose and, what is more important, people without limbs were able to walk again'...

The Value Analysis experiment as detailed in this study was applied to the design of aids for the locomotor disabled. V.A. originated in the engineering design and purchase field. This V.A. depends on two basic techniques i.e. the Delphi process and the Alternative Evaluation Matrix.

It is necessary at this stage therefore, to assess each of these techniques on their validity for the V.A. exercise and to establish what may be concluded from them.

In a literature survey of the Delphi techniques, it was established that the authors have attempted to...'utilise...the growing swing to parcipitative management...as well the contributions of the decision analysis and behavioral schools to develop a decision process that... can be used in practical decision or multiple choice situations...In order to facilitate a meaningful exchange...amethod called the Delphi technique was used'.[14]

This well-documented technique eliminates some of the problems associated with group decision making. The technique involves anonymous team response, controlled feedback of all information to the team and repeated team consideration of the problem until a consensus is reached. Obviously the team leader acts as the central information point and is responsible for information flow.

The technique therefore avoids direct confrontation of experts with one another...'The questions are designed to bring out the respondent's reasoning that went into his reply to the primary question, the factors he considers relevent to the problem, his own estimate of these factors, and information as to the kind of data he feels would enable him to arrive at a better appraisal of these factors and, thereby, a more confident answer to the primary question'...[11]

The Delphi technique, as used in this study, appears to be more conducive to independent thought. Direct confrontation...'all too often induces the hasty formulation of preconcieved notions, an inclination to close one's mind to novel ideas, a tendency to defend a stand once taken or, alternatively and sometimes alternately, a predisposition to be swayed by persuasively stated opinion of others...'[12]

When, during the application of this technique, quantitative decisions were requested from the experts making up the team, it was found that even if the initial quantities were very divergent, the individual estimates showed a tendency to converge as the experiment continued. This is perhaps inevitable in view of the progressively more penetrating analysis of the problem, achieved partly by means of the procedural feedback.

The following points represent a summary of items which may need refinement for any future study:

i) The expert's responses to the Delphi questionnaire were not strictly independent, due to employment contacts.

ii) Some 'leading' has taken place by the very nature of the questions and the type of controlled feedback as supplied by the team leader.

iii) The technique as employed in this study is of the 'modified' Delphi type - in that the team together determined criteria and alternatives. Therefore some of the normal group behavioural problems (e.g. dominance) may well have played a role.

The only truly Delphi component for this study was the function questionnaire as detailed in Appendix VII which was filled in independently and to which controlled feedback was given.

It is submitted though, that as by definition, Value is obtained by the best function at the least cost, only the function determination need to be subjected to a full Delphi technique.

...'The choice between engineering alternatives is often presented as a rational, objective decision, which is based upon a thorough analysis of performance and design characteristics. The practising engineer is already aware of the fallacy of this concept by virtue of his practical experience. Despite this general awareness, he is often lacking the tools to help him choose between fuzzy alternatives. This lack is in large measure due to the failure on the part of the disciplines of management science...'to develop or fully explain a methodology for attacking these problems'[2]...

In the course of this study, the situation was found to be totally similar when attacking problems in the design of aids for the locomotor disabled.

The approach used in this study allowed three alternative designs of the common crutch to be evaluated to the degree to which they fulfil a set of criteria; the criteria themselves having been weighted in terms of their relative importance.

This study sets out to establish a design and decision process by combining the modified Delphi process with the alternative evaluation matrix. In essence, the combination is between the decision analysis techniques and the behavioural school, to give an optimum result. This process forms the actual Value Analysis exercise.

With the background as detailed in this study...'we can formulate an objective for Value Analysis, this being to demonstrate that unnecessary cost does exist...in the form of low functional usefulness...in products and systems, and that whilst retaining value and quality, it can be eliminated by an organised creative approach'...

It is contended that V.A. is a relevant and applicable technique when designing aids for the locomotor disabled.

The agreement, by the team, that Value Analysis is relevant, is shown firstly by the success of the exercise, in that within about 15 meeting hours a complete alternative design was developed, and secondly by the positive comments made by the team on their own performance as shown by the Assessment responses. (See Appendix X).

The benefits of the Value Analysis exercise are obvious when listing some of the comments made by the team members:

i) 'At least we are now all talking to one another.'
ii) 'We will complete the design, no matter that existing specifications are archaic'.
iii) 'I will arrange for the manufacture of the new design'.
iv) 'This approach should have been started long ago'.
v) 'Can we not draw up a list of other disabled equipment that we can Value Analyse?'.

That the correct team expertise balance, team discipline, information transfer was maintained is again shown by the relative short time required to develop the alternative design. The result was so clear-cut that the quantitative refinement techniques did not have to be used.

In conclusion, it may be stated that Value Analysis is a way of life. As such it has no formal beginning, and no formal end. All the benefits available from the combo-crutch design, can only be obtained provided that this design is now manufactured and distributed as the oficially specified aid for the locomotor disabled.

APPENDIX I

ALTERNATIVE EVALUATION MATRIX

1. NUMERICAL JUDGEMENT SCALES

As most evaluation of criteria will be on a qualitative (i.e. judgemental) basis, the scale given in Para. 2.4.1, Table I, may be used to convert these judgements to quantitative percentage quantities.

2. ILLUSTRATIVE EXAMPLE

Say it is required to go from point A to point B. The alternatives available are to go by car or to go by train. The criteria applicable to making the journey are speed, cost and comfort.

A successful journey would be carried out in comfort at some speed. Cost is not so important, but should be low.

Using the above, the weights assigned to the criteria could be as follows:

Speed	:	0,3	)
Cost	:	0,2	) Total 1
Comfort	:	0,5	)

Now the criteria have to be judged against the two alternatives and the results could be tabulated as below, using the percentage conversion scale given in Appendix II.

Criteria / Alternative	SPEED	COST	COMFORT
CAR	90%	25%	90%
TRAIN	10%	90%	25%

In the Alternative Evaluation Matrix, the Weights and Percentage satisfaction data are combined and an Overall Percentage Satisfaction is now calculated by summing the row Alternative figures to show which alternative meets all of the criteria.

Criteria / Weights / Alternative	SPEED	COST	COMFORT	OVERALL PERCENT SATISFACTION
	0.3	0.2	0.5	1.0
CAR	90X0,3 = 27	25X0,2 = 5	90X0,5 = 45	77%
TRAIN	10X0,3 = 3	90X0,2 = 18	25X0,5 = 12,5	23,5%

Obviously, the CAR journey is the best alternative, as quantitatively proved in the above Evaluation Matrix.

APPENDIX II

ALTERNATIVE EVALUATION MATRIX FOR AXILLA CRUTCH

1. BACKGROUND

During brainstorm sessions on the shortcomings of existing S.A.B.S. standard wooden axilla crutch as shown in Figure 1 hereof, three alternatives were developed. The object of this evaluation is to establish how these three alternatives meet the criteria for a 'successful' crutch.

2. ALTERNATIVES (Material, shape, location of parts)

2.1 Model I: As for existing wooden S.A.B.S. Type I, but with the following modifications:

Materials: All as existing type, with self skin urethane foam arm pad and hand rest. Bows to be of laminated wood, ferrule to be non-slip.

Shape: Crutch head to be rounded off, fitted with turnback radius to tenon/mortice joint, joint to be dowelled. (See Figure II hereof). Hand rest to be increased in diameter and length. Bolts and nuts to be fitted with large washers and wing type nuts. Foot piece to be parallel sided and bevelled to take ferrule. Ferrule to be hard wearing rounded tip type. Bows to be 'Brentwood' shaped type.

Location: All parts as for S.A.B.S. Type I, but adjustment holes all located in parallel sided surfaces only to ease adjustment pin replacement.

2.2 Model 2: All as described for Model I above, but changes to materials as follows:

Arm pad and crutch head to be one piece moulded plastic construction, with suchion properties on the top. Bows to be aluminium flat bar type.

Foot piece and ferrule to be one piece moulded plastic construction.

2.3 Model 3: This type will be a combination of present elbow crutch and walking stick, fitted with 'swop-top' piece to convert from elbow duty to axilla duty. Height adjustment will be possible in the foot piece and the 'swop top' piece.

Materials: All as specified for metal crutches by S.A.B.S. and by C.P.A. The axilla cushion will be a selfskin urethane foam, whilst the hand grip will be a shock absorbent plastic type.

Shape: The general shape will be as shown in Figure 3 hereof.

3. CRITERIA FOR SUCCESSFUL CRUTCH

The following criteria have evolved out of previous brainstorm sessions and are now to be evaluated against the three alternative crutch designs.

All criteria originate from the objective[2], which may be stated as:
"to stably support the user when moving, unassisted by any other means".

TABLE I

EVALUATION MATRIX : CRITERIA
1. Mass
2. Ease and safety of using.
3. Reliability and service life.
4. Ease of adjustment and repair by user.
5. Ease of cleaning by user.
6. Appearance and surface finish.
7. Cost.

These criteria are now to be weighted or ranked in their relative importance for any type of crutch design i.e. the 'successful' crutch, from the alternatives 1, 2 and 3 as detailed in Para. 2 hereof.

The weighting (ranking) scale is to be from 0 to 1, half units (e.g.0,25) permissible.[2]

The total of all the weights accorded to the above criteria is not to exceed 1.

During the practical evaluation, the following weights were agreed upon by the V.A. team (see Table II).

TABLE II

EVALUATION MATRIX	WEIGHTS
Mass	0,2
Ease and safety of use	0,3
Reliability and service life	0,2
Ease of adjustment	0,05
Cleaning by user	0,05
Appearance and finish	0,05
Cost	0,15

For convenience, the conversion scale for converting judgements to percentage quantities is repeated below in Table III.

TABLE III

PERCENT SATISFACTION SCALE		
Satisfaction		Percentage
1.	Criteria satisfied in every respect.	Complete satisfaction 100%
2.	Criteria satisfied in all important respects	Extensive satisfaction 90%
3.	Criteria satisfied in majority of aspects	Considerable satisfaction 75%
4.	Middle of the road	Moderate satisfaction 50%
5.	Criteria satisfied in less than half of aspects	Minor satisfaction 25%
6.	Criteria satisfied to a very small extent	Minimal satisfaction 10%
7.	Criteria not satisfied in any aspect	No satisfaction 0%

4. EVALUATION MATRIX

All the above data was used to draw up the Evaluation Matrix shown overleaf.

Due to the use of the modified Delphi technique, each team member individually completed the matrix. The 'average' matrix as shown, is an arithmetic combination of each team member's results.[n]

The matrix shows that the V.A. team selected Model 3 as the preferred type.

TABLE IV

WEIGHT ALLOCATION / CRITERIA	OVERALL PERCENT SATISFACTION	MASS	EASE + SAFETY OF USE	RELIABILITY + SERVICE LIFE	EASE OF ADJUSTING	CLEANING BY USER	APPEARANCE + FINISH	COST
ALTERNATIVE		.2	.3	.2	.05	.05	.05	.15
MODEL 1 ALL WOOD TYPE - LAMINATED BOWS - NEW CRUTH HEAD SHAPE	75.8	72.5	82.5	72.5	72.5	76.3	63.8	76.3
MODEL 2 MOULDED HEAD - ALU. BOWS POLYURETHANE FOOT PIECE	66.3	86.3	62.5	52.5	78.8	82.5	72.5	56.3
MODEL 3 COMBINATION ALL ALU. ELBOW/AXILLA CRUTCH	81.2	91.3	86.3	85	83.8	86.3	86.3	50

ALTERNATIVE EVALUATION MATRIX

SPEC: SABS 491 - 1956 AS AMENDED 19-8-1963 TYPE 1

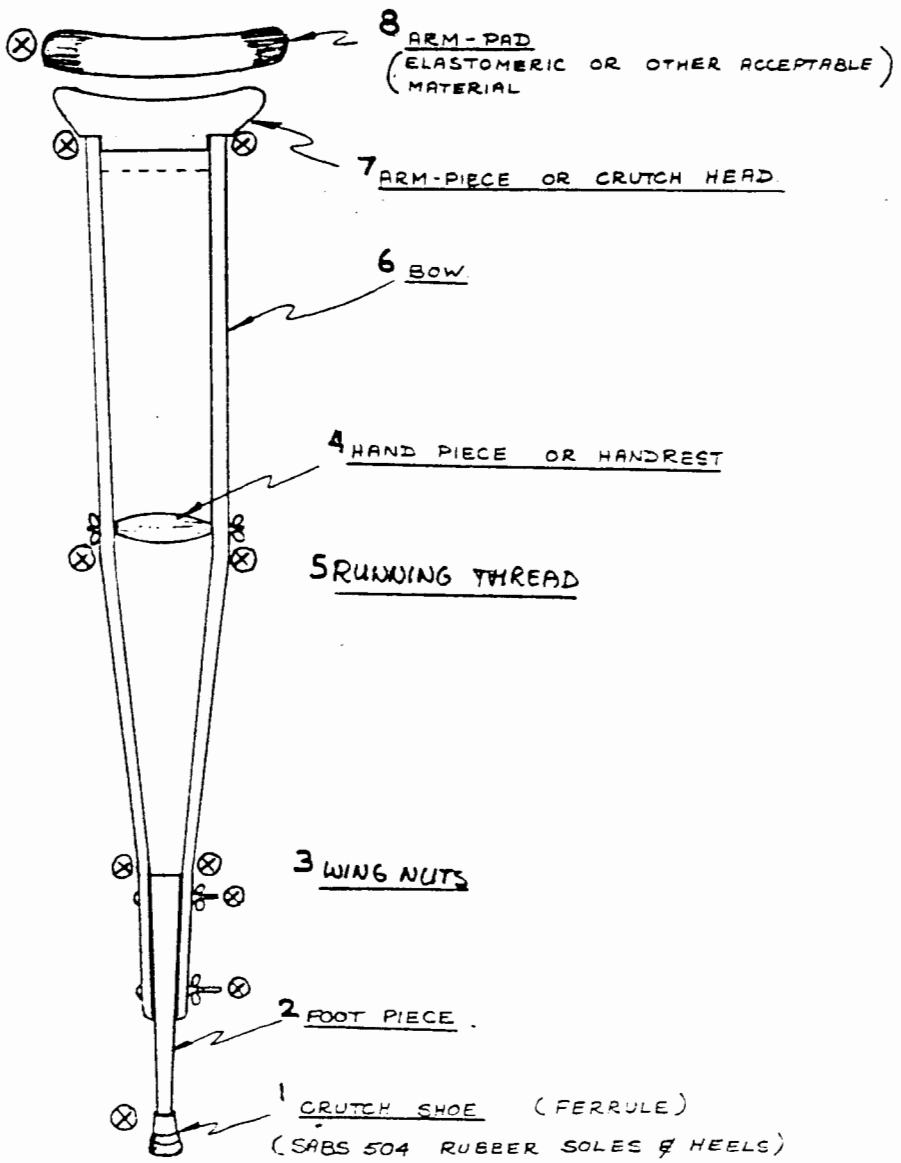


FIGURE 1: SABS STANDARD AXILLA CRUTCH.

NOTE : ⊗ POINTS WHERE FAILURE HAS OCCURRED IN PRACTICAL USE.

JOINT DETAIL ARM-PIECE TO BOW

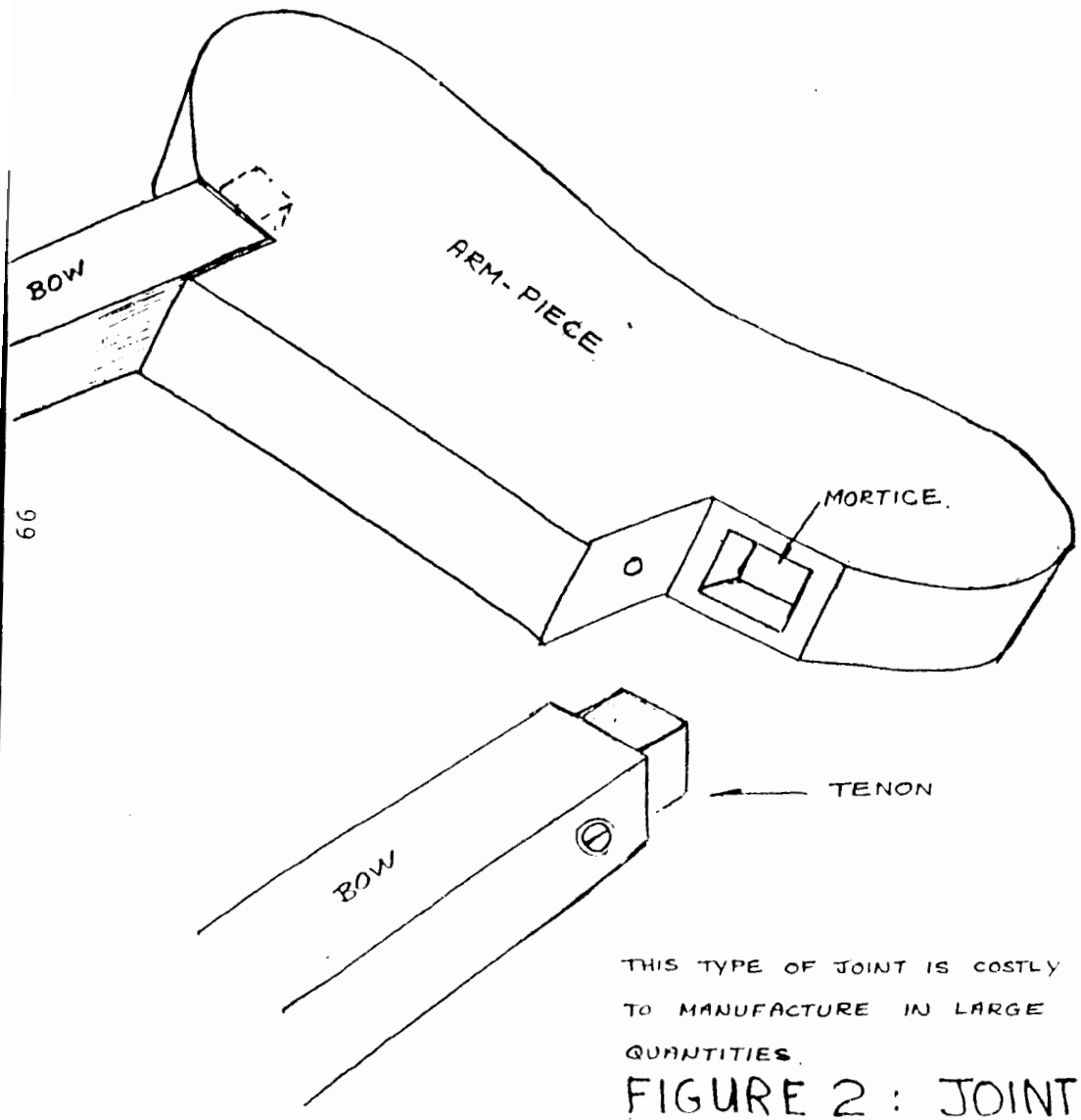
MORTICE AND TENON TYPE JOINT, GLUED AND SCREWED USING COUNTERSINK WOOD SCREWS.

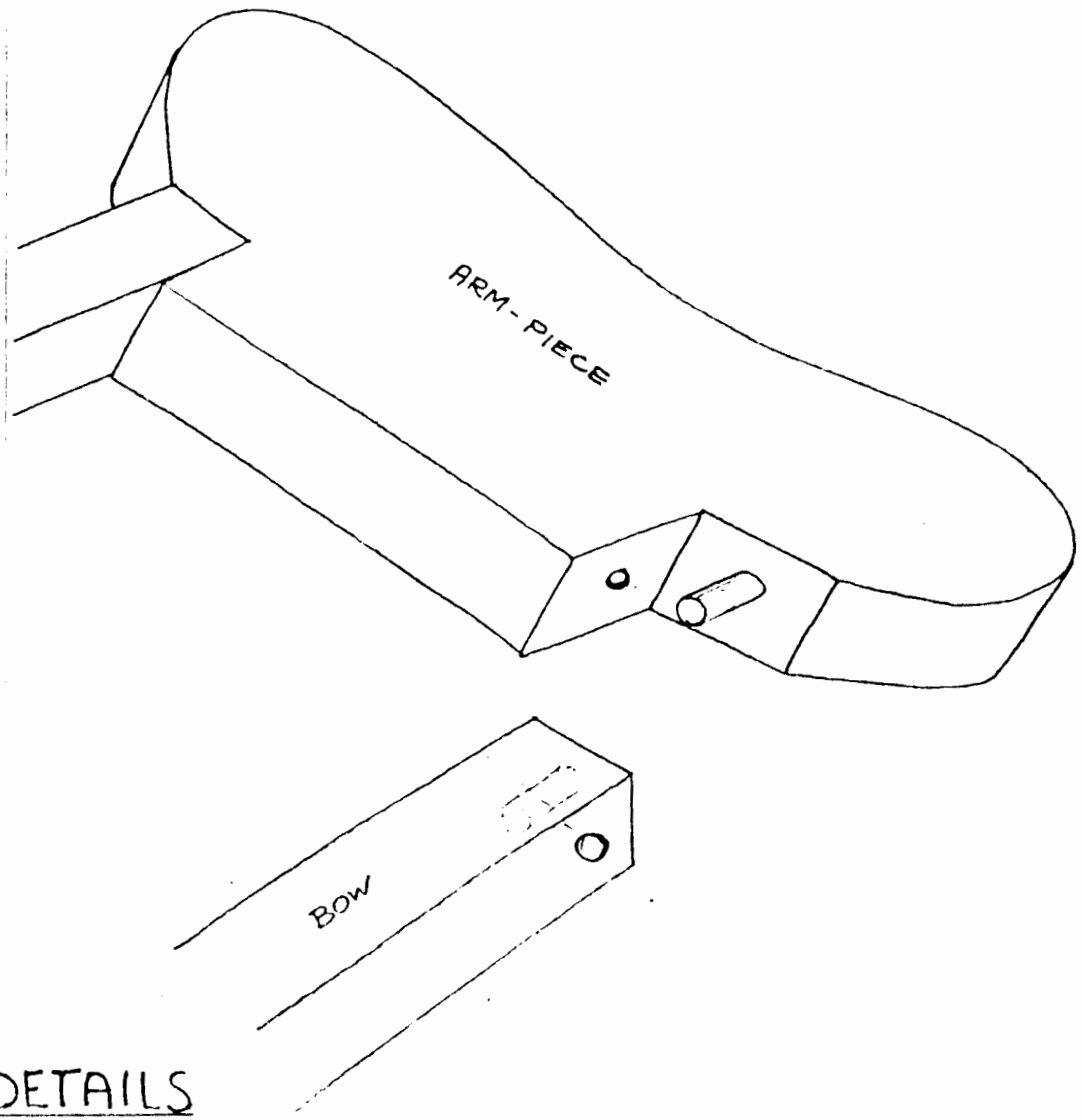
(AS SPECIFIED BY S.A.B.S)

ALTERNATIVE JOINT DETAIL (NOT SPECIFIED)

DOWELED & SCREWED TYPE JOINT

THIS SYSTEM, FROM A PRODUCTION POINT OF VIEW IS FASTER AND CHEAPER TO MANUFACTURE

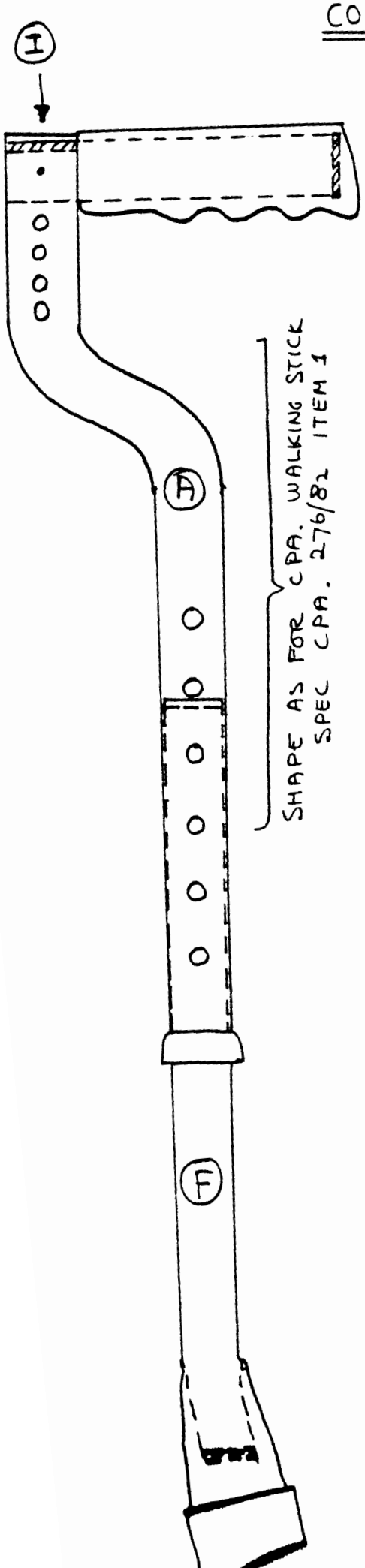




THIS TYPE OF JOINT IS COSTLY TO MANUFACTURE IN LARGE QUANTITIES.

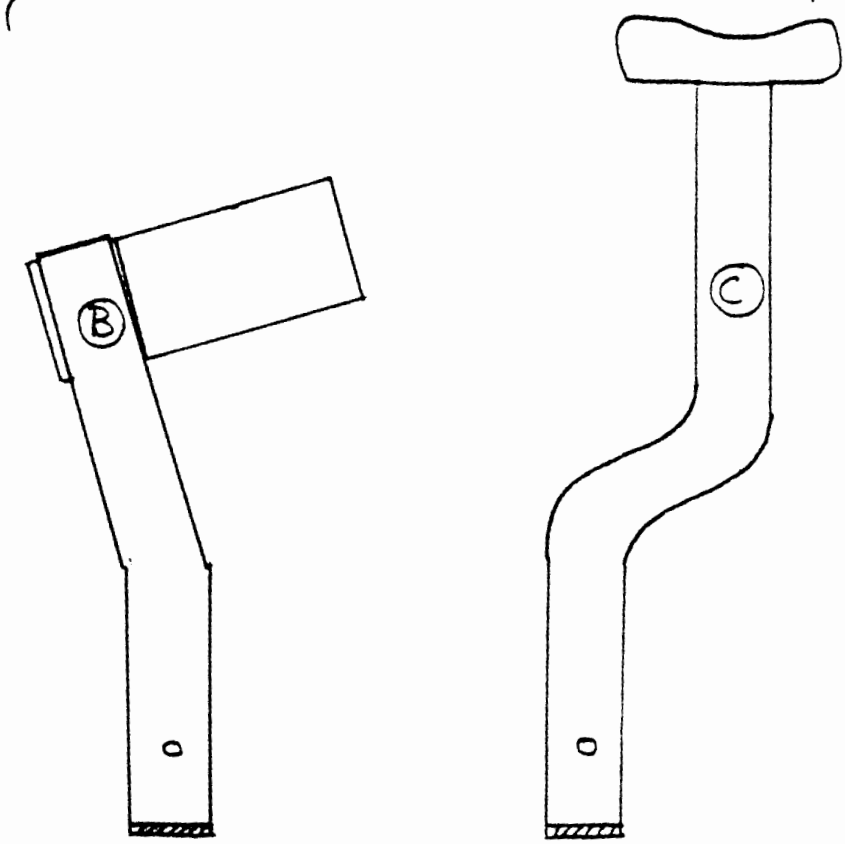
FIGURE 2 : JOINT DETAILS

COMBO CRUTCH.



THIS CRUTCH CAN FUNCTION AS WALKING STICK, ELBOW CRUTCH AND AXILLA CRUTCH.

"SWOP-TOPS"; SHAPE AS FOR SABS METAL CRUTCH. SPEC. CKS. 112-1972.



(A) HANDPIECE FOR USE AS WALKING STICK.

(B) ELBOW PIECE FOR USE AS ELBOW CRUTCH.

(C) UNDERARM PIECE FOR USE AS AXILLA CRUTCH.

(F) COMMON FOOTPIECE.

(I) INSERTION OF (B) OR (C) TO ALTER CRUTCH FUNCTION.

FIGURE 3 : COMBO - CRUTCH.

APPENDIX III

PERCEPTUAL MAP DATA

TABLE I

BASIC DATA		
Type of Aid	Classification	Materials/Finish
Single Stem Support	Walking stick	Wood, aluminium
	Axilla crutch	Wood, aluminium
	Trough crutch	Aluminium, plastic
	Arthritic crutch	Aluminium, plastic
Multi-stem Support	Quadraped	Mild steel tubing
	Walking frame	Mild steel tubing
Wheeled Support	Rollator	Mild steel rubber
	Wheelchair	Mild steel, rubber

TABLE II

Classification	Annual Market *	Mass kg	Cost R	Map Class
Axilla crutch:				
Government type	6000 pr	1,660	5,85	A_G
Metal type	500 pr	0,900	18,60	A_M
Imported type	800 pr	1,200	28,50	A_I
Elbow crutch	1800 pr	1,750	39,50	E
Gutter crutch	2400 pr	1,800	75,00	G
Walking stick	3000 units	0,650	16,50	W
Quadrapeds	2400 units	1,400	45,00	Q
Pulpit walker	4800 units	2,025	47,00	P

NOTE: Annual market relates to actual pairs or units sold country wide, based on personal surveys for Cape Town and Pretoria, and extrapolated to the other centres e.g. Witwatersrand, East London/Port Elizabeth, Durban/Pinetown on known populations for those centres.

TABLE III

MONTHLY NUMBERS OF ASSISTIVE DEVICES ACTUALLY SOLD BY LOCALITY		
Type of Device	Numbers sold	Location
Wheelchairs (all types)	13	Cape Town (Medical Supply Company)
Walkers	5	Cape Town (Medical Supply Company)
Wheelchairs (all types)	2	Pretoria (Criple Care Assn)

NOTE: Wheelchairs and Walkers have been selected as being technically and cost-wise on the high and low level respectively.

TABLE IV

MONTHLY NUMBERS OF ASSISTIVE DEVICES HIRED OUT AND SOLD FOR MEDICAL SUPPLY COMPANY : CAPE TOWN		
Item	Sold	Hired Out
Axilla crutches	-	18 pairs
Elbow crutches	6 pairs	5 pairs
Arthritic gutter	1 paid	9 pairs
Quadrapeds	3	5
Pulpit walker	5	5
Wheelchairs	12	8
Commodes	6	3
Charnley stool	-	3
Bed cradles	2	2
Surgical beds	1	1
Ripple beds	-	1
Raised toilet seat	2	1

TABLE V

SPINAL UNIT PATIENTS AT THREE SOUTH AFRICAN HOSPITALS

AS AT DECEMBER 1982

Medical History \ Treatment Centre		Conradie Cape	HF Verwoerd Tvl	Natalspruit Tvl
		1978-80	1979-81	1979-81
New admissions	Total for period	557	224	208
	Per month	23	6	6
Beds available		208	28	65
Length of hospitality (in months)	P*	6m	5m	3-6m
	Q	12m	9m	6-9m
Nurses to beds ratio		1 trained:6 6 staff nurse :30 14 orderlies	at present 2 full time 3 part time 12 N.aids	1:2
Outpatients: 1. on books		± 2000	720	± 250
2. been treated		± 1200 (7490 visits)	275	± 50
3. had examinations		± 1500 (± 3000 exam)	504	Routine to all inpatients
Re-admissions		± 1000 (1300 re-adm to date)	129	23
Waiting list		None at present	24 urological 19 orthopaedic	None at present

NOTE:* P = Paraplegic : total or partial paralysis of any two limbs.

Q = Quadraplegic : total or partial paralysis of all four limbs.

APPENDIX IV

THE APPLICATION OF VALUE ENGINEERING (V.E.) TO DEVICES FOR LOCOMOTOR DISABLED IN SOUTH AFRICA

1. Reasons for applying V.E. to assistive devices for locomotor disabled

It is accepted that the only way to reduce costs of devices is by applying V.E. to the design, and manufacture of devices in South Africa.

Any other cost cutting method is doomed to failure, possibly in a very short term, by distorting present pricing marketing and distribution channels. In such an eventuality only the the disabled themselves will be the sufferers.

High costs of devices presently are caused by:

i) Importation costs and taxes;

ii) Low-volume or one-off imports;

iii) No Governmental support for design and development of locally produced devices;

iv) Low volume production sums applicable to local products;

v) Total absence of application, manufacturing and quality standards for local and for imported devices.

It has been claimed by various medical and occupational therapy sources that some devices now on the S.A market are "inappropriate" to the physical and mental needs of the disabled user. Furthermore, the local disabled community (all race groups) receive a fixed grant (upon having been certified as disabled by the local medical Superintendent). This grant does not include any Attendance Allowance (as is the case in the U.K). This further reduces the user's ability to pay for the aid devices.

2. Reasons for product diversity in disability aids

Product diversity is caused by the suppliers, and by the users themselves.

At present, the retail supply trade in aids operates on import basis - this with a view to reduce stock holding costs on im-

ported goods. The variety of disability causes is shown in table 1.

TABLE I

Main cause of impairment
1) Infective an parasitic diseases
2) Neoplasms
3) Allergic, endocrine, metabolic and nutritional diseases
4) Diseases of blood and blood-forming organs
5) Mental, psycho-neurotic and personality disorders
6) Diseases of central nervous system
7) Diseases of circulatory system
8) Diseases of respiratory system
9) Diseases of digestive system
10) Diseases of genito-urinary system
11) Diseases of sense organs (including blindness)
12) Diseases of skin and cellular tissue
13) Diseases of bones and organs of movement
14) Congenital malformations
15) Injuries
Amputations
16) Senility and ill-defined conditions

When evaluating what types of aids are required, the degrees of disability (impairment) need to be considered, normally these being:

Very severe

Severe

Appreciable

Minor

The total number of conditions for which aids have to be provided may thus shown to be 64.

Assuming that say four different sources of supply exist for each type of aid, the total (theoretical) number available to the user may thus be shown to be 256; truly a formidable number.

Catalogues of overseas suppliers are distributed passively (by mail) and actively (by representatives) to most practising Occupational and Physio-therapists.

Given the large number of possible conditions and the marketing methods, a large product diversity is being imported into S.A annually.

In the case of knife and fork sets, for example, it has been established that 24 different sets are now available to the local user.
It is suggested that given a Value Analysis of this use, probably no more than 5 different kinds of knife and fork sets will be required.
When looking at other outer end of the disability aid cost spectrum, it has been established that wheelchairs imported from a Continental manufacturer are available in 14 different types of configurations.
As there are three makes of chairs imported, it may be shown that there are 52 combinations of chairs available to the local user.
Again a Value Analysis of this product would enable this variety to be reduced.
Obviously, the main originators of diversity when specifying devices, e.g the local therapists and medical practitioners, will have to accept that certain training methods for their patients will have to be adapted to suit this reduced product variety range.

3. Value Engineering as applied to product diversity

In order to reduce product diversity it is suggested that V.E be applied to aids for the locomotor disabled, initially to the more common products such as wheelchairs, crutches (plain and elbow type), commodes and walking aids (e.g pulpits).

1) Wheelchairs

V.E to be applied to:

a) chair motive power (e.g electric, hand)
b) chair driving mechanism (e.g motor, wheel, lever)
c) chair wheel configuration (e.g front or rear wheel)
d) chair wheel tyre design (e.g solid, pneumatic)
e) chair seat, arm rest, back rest adjustments
f) chair material selections (frame, seats, cushions)
g) chair design adaptability (e.g convert for sports)
h) chair repair facility (modular exchange units)
i) production costs vs reliability costs.

2) Crutches

a) construction design (A-frame, single pillar type)
b) floor support pad type (pvc plugtop, rubber bump)
c) length adjustment pin design (clip, spring load)
d) materials (wood, bamboo, aluminium)
e) sizes and cross sectional areas
f) elbow gutter and joint design
g) handgrip and control design.

Similar analysis to be applied to the other two products mentioned.

This V.A could generally be divided into:

a) Product design - relating to standardised components
b) Product cost - evaluation of overdesign to meet specifications
c) Functional evaluation
d) Alternative solutions to function
e) Saving on design complexity
f) Saving on repair costs due to inherent design.

4. V.E AS APPLIED TO ACHIEVE COST IMPROVEMENTS

Cost improvements can only be achieved through V.E of the product regarding:

a) design constraints
b) meeting specified or legal standard requirements
c) choice of raw meterials, methods of manufacture, methods of performance testing and final assembly.

Obviously the above is dependent upon knowing

a) production sum (e.g numbers off each type)
b) expected life cycle of each product.

5. Proposed method of applying Value Engineering

1) Set up V.E. teams contrywide, containing:
   1) Medical doctors representatives
   2) Occupational therapist representatives
   3) Disabled users
   4) Manufacturers, agents and supplier representatives
   5) Value Engineer, and

6) Specifying authorities representatives.

2) These teams are to investigate only those products making up to 80% of present day Government and Provincial authority spending on assistive devices.

3) These teams are to report back to institute remedial action with:

a) Training of medical support staff

b) Specifying authority e.g SABS, Provincial Hospital Departments, local medical practitioners

c) Government departments

d) Manufacturers.

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APPENDIX V

DETERMINATION OF TOTAL NUMBER OF DISABLED IN SOUTH AFRICA

1. PROBLEM IDENTIFICATION

Because of South Africa's heterogeneous population, and the separated Governments administering to each, there exists at the moment no figures for how many persons are afflicted by each type of disability.[6]

These figures are urgently needed by inter alia:-

(i) Government and Provincial Departments dealing with welfare grant and pension allocation.

(ii) Private Welfare institutions and support organisations.

(iii) Training institutions for medical and paramedical (e.g. occupational therapist) personnel.

Only by using these figures could, for example, the work done by the sitting Government Commission of Enquiry into Health Services, be meaningfully related to the actual and the future health demands of South Africa' population.[6]

Up to the present, various efforts have been made by the Government and by private institutions to determine these numbers by:-

(i) Concensus questionnaire.

(ii) Newspaper and target-oriented reply-type coupon questionnaires.

(iii) Publicity efforts during the International Year of the Disabled/Aged.

(iv) Establishment of AID Centres, where suppliers' equipment is on display and staff in attendance to assist in questionnaire answering.

Although considerable data had been gathered, this data is not useful because of the following limitations:-

(a) Only certain socio-economic groups were surveyed.

(b) Distinction as to type of assistive device required not been fully considered in these surveys.

(c) Only certain racial groups were surveyed.

(d) Statistical errors, due to sampling techniques as used in these surveys, have not been accounted for.

(e) Limitations on surveys, both manpower and financial, reduce the results validity.

2. SUGGESTED SOLUTION

To overcome the inherent problems of all the aforementioned surveys, it is suggested that a random door-to-door type country-wide survey be carried out in both urban and rural areas, taking due regard of each area's:-

(i) income level;
(ii) population age distribution;
(iii) population employment class; and
(iv) known statistics on disability aids required - from past surveys.

As an alternative, knowing that the statistics for the U.S.A. are available (detailed as above), a random sampling method be employed over the whole of South Africa, which is then statistically adjusted, using U.S.A. data, to obtain country-wide figures.

3. FINANCIAL IMPLICATIONS

The suggested solution is very demanding, both in manpower and in financial requirements.

It is suggested that the actual "on the ground" work is best carried out by an established Market Research Company - as volunteer labour would demand an equally costly administrative and organisational back-up to make results meaningful and control the volunteer's activities.

The alternative solution is best carried out by professionals, e.g. Human Sciences Research Council, and would be financially less demanding.

It is suggested that the cost of these surveys be borne by some agreed formula by:-

(a) The four relevant Government Departments (e.g. Health & Welfare, Internal Affairs, Indian Affairs, Cooperation & Development);
(b) The Department of Customs and Excise;
(c) All the suppliers of assistive devices, and
(d) all the manufacturers of assistive devices;
(e) The Motor Vehicle Assurance Fund; and
(f) The Workmen's Compensation Fund.

APPENDIX VI

AXILLA CRUTCH

VA TEAM JOB PLAN

1. INFORMATION PHASE

1.1 Get all specifications

standards

drawings

existing costs

numbers off required

1.2 Get all user requirements

1.3 Define Objective:

1. Identify Primary/Secondary Function

2. Place a Value by Comparison

3. Develop Value Alternatives

1.4 Describe Objective in terms of Criteria.

2. ALTERNATIVE SPECULATION TECHNIQUES

2.1 Brainstorm Questions: The Product

Its components

What does it do

How well does it do it

2.2 To Generate Brainstorm ideas use:

a) Random Word Play

b) Noun-verb function

c) Noun-verb attribute listing

2.3 Develop Alternatives using:

Materials, Shape, Location of parts) Use as guides only to new crutch alternatives

2.4 List and Describe features of alternatives stating all their characteristics

3. EVALUATION STAGE

Giving due regard to Performance, Cost, Time to Produce, Evaluate Brainstorm ideas using Delphi questionnaire and modified Delphi technique.

3.1 Criteria

From objectives and attributes to objectives, develop criteria for use in Alternative Evaluation Matrix.

3.2 Weighting

Develop weighting for each of the above criteria, using Delphi technique.

3.3 Degree of Satisfaction

Develop degree of satisfaction scale with which to rate each criteria or use scale already given.

3.4 Develop Evaluation Matrix

Use Delphi questionnaire technique to allocate values to each alternative by:

1. personal value allocation by each team member independently.
2. combined team effort allocation.

3.5 Develop Satisfaction of Objectives

Using above results plotted into Matrix develop whichever alternative has highest overall satisfaction rating.

4. IMPLEMENTATION STAGE

4.1 Develop Detail Specifications

Using alternative selected as per 3.5, develop detail tech. specs, using re-iterative brainstorm and reverse brainstorm. This spec to contain description,sketches, material details.

4.2 Forecast Advantages

a) User effectiveness

b) Costs

4.3 Submit Alternative to Authorities

Prepare written memorandum to SABS, hi-lighting how alternative will be improvement to present specifications issued by them.

Submit same memo for inclusion at next 'Hospital Equipment Co-ordinating Committee', via CPA Hospital Services Department.

APPENDIX VII

VALUE ANALYSIS

DELPHI QUESTIONNAIRE SHEET

1. Does any component on the product contribute to its use value? (i.e. Customer satisfaction).
2. Is its cost proportionate to its usefulness?
3. Are all product features needed?
4. Is there any better product for the intended use?
5. Can any item be eliminated without sacrificing usefulness?
6. Can any item be replaced by a standard component?
7. Does any feature of the product have an obvious greater capacity to perform than is required at its location in the product?
8. Can the weight be reduced?
9. Are all stress paths in one line?
10. Are tolerances as specified necessary?
11. Is all specified machi-ning necessary and if so,to achieve what function?
12. Is grading or quality specified necessary and if so, to achieve what performance?
13. Is intended application being met in practical use?

APPENDIX VII

VALUE ANALYSIS SHEET

Reference No.
Date
Done by

Title of product or part .....

Keyword	Facts about Product	Alternatives
Purpose	WHAT ARE ITS FUNCTIONS? WHY ARE THESE NECESSARY? *Causes* *Desired results*	WHAT ELSE COULD BE DONE? (Elimination: avoid the need, do not achieve; modification and inversion)
Place	WHERE IS IT LOCATED? WHY THEN?	WHERE ELSE COULD IT BE LOCATED? (Modification only)
Time	WHEN DOES IT FUNCTION? (Sequence and Timing) WHY THEN?	WHEN ELSE COULD IT FUNCTION? (Modification only)

P.T.O.

Keyword	Facts about Product	Alternatives
Means	HOW DOES IT FUNCTION? *1. Made of action* *2. Material of construction* *3. Materials content* *4. Material value and waste* *5. Limits/tolerances* *6. Method of manufacture* *7. Surface finish* *8. Standardisation* *9. Labour costs* *10. Material costs* WHY THAT WAY? *1.* *2.* *3.* *4.* *5.* *6.* *7.* *8.* *9.* *10.*	HOW ELSE COULD IT BE DONE? (Elimination of materials, wastage and effort, then modification)

APPENDIX IIX

PART I :: INFORMATION

DATA EVALUATION

PRODUCT : COMMON CRUTCH

USAGE : MANUFACTURE

1.	MATERIAL PARTICULARS	Type/Form/Size & Amount Required/ Finished Weight/Rough Weight
2.	OUTSIDE SUPPLIES	Type/Source of Supply/Cost for Total Numbers per one off product
3.	IN-HOUSE SUPPLIES	Type/Direct Material Cost/Direct Labour Time & Cost (Allocate o'heads)/Inspection Cost/ Total per one off Product
4.	DESIGN HISTORY	Why This Material/Alterations required during Production/Special Problems
5.	PRODUCTION HISTORY	Machining Difficulties/Material Difficulties/ Scrap Problems/Delivery Problems/Special Problems

APPENDIX IIX

PART II :: INVESTIGATION

1. SERVICE HISTORY — Reliability/Main Breakdowns/Comparison with Competitors/Special Problems

2. FUNCTION DEFINITION — i. What are its functions?

ii. Why are these necessary : Causes and Desired Results.

IDENTIFY FUNCTION			EVALUATE FUNCTION
VERB	/	NOUN	CLASS/WORTH/COST/ FUNCTION GROUP

APPENDIX IIX

PART III :: ALTERNATIVES

1. BRAINSTORM — (Suspended Judgement) (Individual)

Describe/Classify According to Functional Area/Number (Consequential)

2. EVALUATION — (Judge) (Team)

For each number list Advantage/Disadvantage : Decide to Accept/Reject

APPENDIX IX

BASIC COST STRUCTURE FOR AXILLA CRUTCH AS PER S.A.B.S. SPEC.

NO.491-1956 AS AMENDED AUG 1963

NOTE:
1. A fully detailed sketch of the above item is shown in Figure 2, Appendix II.
2. Cost shown is per crutch (two crutches per pair), projected over a 10 000 pair annual production, of the adult crutch type.
3. Costs are based on 1982 prices, and are nett manufacturing costs.

TABLE I

MATERIAL COSTS			
ITEM NO.	DESCRIPTION	COSTS R-c	% OF TOTAL COST
8	Rubber arm band	0.68	10,0
4	Hand piece	0.29	4,2
6,2,7	Timber: bows,foot,arm-piece	2.32	33,7
3,5	Wing nuts and bolts	0.80	11,6
1	Rubber ferrule sanding, sealer and varnish	0.28	4,0
	Wood screws	0.04	0,6
	Totals (Materials)	4.78	69,5

TABLE II

PRODUCTION COSTS		
Item	Costs R-c	% of Total Costs
Totals (Materials) b/f	4.78	69,5
Consumables and tooling	0.95	13,8
Labour	0.72	10,5
Overheads	0.43	6,2
Total	6.88	100

TABLE III

FUNCTION VS. PERCENTAGE TOTAL COSTS COMPARISON		
Item	Function	% Total Cost
Ferrule	Vital	7.8
Bows, foot, arm-piece	Important	54,2
Wing nuts and bolts	Secondary	17,6
Hand piece	Vital	6,0
Rubber arm pad	Important	14,4

APPENDIX X

ASSESSMENT OF V.A. AS CARRIED OUT BY THE AXILLA CRUTCH TEAM

82.10.25

ASSESSMENT OF VALUE ANALYSIS AS CARRIED OUT BY COMBO-CRUTCH VA TEAM

1. PURPOSE

The purpose of this assessment is to obtain individual team members' honest opinion on the V.A. process. The data thus obtained will be used to formulate an approach through which V.A. is to be applied in the techno-medical field.

2. METHODOLOGY

Questions generally have 'yes/no/don't know' answers. In a few instances, comments are requested. In general any question may be commented on by the respondent, this will be beneficial to the assessment. Use the space provided.

3. THE V.A. PROCEDURE

3.1 Was the reason for each team action always hi-lighted and the purpose clear to you?

3.2 Was sufficient data provided at each stage of the V.A. job plan, and if not, when did you feel the lack of data hampered the team effectiveness?

3.3 Is there an alternative method, describe briefly, by which the same result could be achieved in a shorter contact time span?

3. THE V.A. PROCEDURE cont'd

3.4 What was most unnecessary in the whole V.A. operation from your point of view? Nothing - a sufficiently tight rein was maintained so that unnecessary discussions and deviations were eliminated

3.5 Did you think that the brainstorm sessions were helpful to your own understanding of the problem at hand? Yes

3.6 Would you like to have the brainstorms more/less : wide ranging, structured (e.g. time limits)? Our session was adequate with one short review period at the start of the next meeting also being adequate

3.7 Do you consider enough stress was laid on:
a) Cost/function relationships?
b) Reliability/ease of operation relationships?

Yes
Yes

4. THE V.A. TEAM

4.1 Did you consider that the relevant expertise levels for the V.A. were available on the team? (i.e. was the team balanced?)

Actual manufacturers should have been present - in this case we were lucky as members from industry were manufacturers with a specific interest in the subject

4.2 Did you consider the absence of the training/educating profession hampered the success of the V.A. in any way? No

4. THE V.A. TEAM cont'd

4.3 What other profession, trade etc would you have liked to have been represented on the team? patient

4.4 Was the team the right size? More or less members?

possibly one more member

4.5 Was the openess and frankness beneficial to the team reaching its objectives? yes

4.6 Regarding team leadership, has the varying, dominance (i.e. from person to person) as opposed to rigid chairman dominance, really benefitted the team operation? yes as long as chairman dominance is only to stop unnecessary repetition by talkative person and personality dominance.

4.7 Who was dominant and at what time for what reason?

Both sides; user and maker, were dominant; each in their own field.

4.8 Did the team leader succeed in:

a) Establishing team objectives, yes
b) Creating team cohesiveness, and yes
c) Maintaining team norms? yes

5. THE V.A. ENVIRONMENT

5.1 You are aware that V.A. is an industrial engineering technique. Do you consider this technique applicable to the techno-medical field? What is the main benefit of this technique? – short time required to effect problem and solution finding

(Yes)

5.2 Is there any other technique that you would prefer? What would be the benefits of such a technique above V.A.?
VA is performed above meeting held, in order to achieve the same purpose, but run along local lines.

5.3 Besides the Team Project (Common Crutch) please list in order of importance what you consider, in your professional field, should be V.A. investigated next in the techno-medical field.
Other orthopaedic appliances
Wheel chairs
Hospital beds
Hospital patient trolleys
Hospital furniture.

5.4 How do you rate the chances of S.A.B.S. and Govt. Provincial acceptance of the V.A. approach - what could be the stumbling blocks towards this acceptance?
The approach would be acceptable. The problem would be started VA staff. It may be an idea for SABS meeting to be run by VA staff

5.5 Who, or what, will be the main benefactor when V.A. is applied in the techno-medical field? The province will be the main benefactor in having the most versatile equipment ~~for~~ from a medical user and patient point of view and the best price because of standardisation.

5.6 Should V.A. teams be set up for other areas (both geographical and for other projects) or should one roving team be used?
A team of experts should be used for each project (equipment type). Geographic considerations should be secondary.

Thank you for your co-operation.

ERIK M. KIDERLEN (Pr.Eng.)
452416

OCTOBER 1982
CAPE TOWN

82.10.25

ASSESSMENT OF VALUE ANALYSIS AS CARRIED OUT BY COMBO-CRUTCH VA TEAM

1. PURPOSE

The purpose of this assessment is to obtain individual team members' honest opinion on the V.A. process. The data thus obtained will be used to formulate an approach through which V.A. is to be applied in the techno-medical field.

2. METHODOLOGY

Questions generally have 'yes/no/don't know' answers. In a few instances, comments are requested. In general any question may be commented on by the respondent, this will be beneficial to the assessment. Use the space provided.

3. THE V.A. PROCEDURE

3.1 Was the reason for each team action always hi-lighted and the purpose clear to you?

yes

3.2 Was sufficient data provided at each stage of the V.A. job plan, and if not, when did you feel the lack of data hampered the team effectiveness?

yes

3.3 Is there an alternative method, describe briefly, by which the same result could be achieved in a shorter contact time span?

no

3. THE V.A. PROCEDURE cont'd

3.4 What was most unnecessary in the whole V.A. operation from your point of view?

3.5 Did you think that the brainstorm sessions were helpful to your own understanding of the problem at hand?

yes

3.6 Would you like to have the brainstorms more/less : wide ranging, structured (e.g. time limits)?

no

3.7 Do you consider enough stress was laid on:
a) Cost/function relationships?
b) Reliability/ease of operation relationships?

yes

4. THE V.A. TEAM

4.1 Did you consider that the relevant expertise levels for the V.A. were available on the team? (i.e. was the team balanced?)

yes

4.2 Did you consider the absence of the training/educating profession hampered the success of the V.A. in any way?

no

4. THE V.A. TEAM cont'd

4.3 What other profession, trade etc would you have liked to have been represented on the team?

none / ? plastics man.

4.4 Was the team the right size? More or less members?

yes

4.5 Was the openess and frankness beneficial to the team reaching its objectives?

yes

4.6 Regarding team leadership, has the varying, dominance (i.e. from person to person) as opposed to rigid chairman dominance, really benefitted the team operation?

yes

4.7 Who was dominant and at what time for what reason?

as per aspect being discussed.

4.8 Did the team leader succeed in:

a) Establishing team objectives,

b) Creating team cohesiveness, and

c) Maintaining team norms?

yes.

5. THE V.A. ENVIRONMENT

5.1 You are aware that V.A. is an industrial engineering technique. Do you consider this technique applicable to the techno-medical field? What is the main benefit of this technique?

yes. appropriately designed & priced medical aids.

5.2 Is there any other technique that you would prefer? What would be the benefits of such a technique above V.A.?

no. Except that generally more consultation & communication between all parties concerned would be a v. good thing

5.3 Besides the Team Project (Common Crutch) please list in order of importance what you consider, in your professional field, should be V.A. investigated next in the techno-medical field.

Wheelchairs.
Hospital beds.

5.4 How do you rate the chances of S.A.B.S. and Govt. Provincial acceptance of the V.A. approach - what could be the stumbling blocks towards this acceptance?

I can't see that there should be any block to acceptance of approach but the practical implication would be a major problem.

5.5 Who, or what, will be the main benefactor when V.A. is applied in the techno-medical field?

The patient.

5.6 Should V.A. teams be set up for other areas (both geographical and for other projects) or should one roving team be used?

yes, for both geographical & other projects. I guess a nucleus roving team with added members as per expertise would be ideal. How would a roving team cope geographically & cope with "quality"?

Thank you for your co-operation

ERIK M. KIDERLEN (Pr.Eng.)
452416

OCTOBER 1982
CAPE TOWN

82.10.25

ASSESSMENT OF VALUE ANALYSIS AS CARRIED OUT BY COMBO-CRUTCH VA TEAM

1. PURPOSE

The purpose of this assessment is to obtain individual team members' honest opinion on the V.A. process. The data thus obtained will be used to formulate an approach through which V.A. is to be applied in the techno-medical field.

2. METHODOLOGY

Questions generally have 'yes/no/don't know' answers. In a few instances, comments are requested. In general any question may be commented on by the respondent, this will be beneficial to the assessment. Use the space provided.

3. THE V.A. PROCEDURE

3.1 Was the reason for each team action always hi-lighted and the purpose clear to you?

at all times.

3.2 Was sufficient data provided at each stage of the V.A. job plan, and if not, when did you feel the lack of data hampered the team effectiveness?

OK

3.3 Is there an alternative method, describe briefly, by which the same result could be achieved in a shorter contact time span?

NO.

3. THE V.A. PROCEDURE cont'd

3.4 What was most unnecessary in the whole V.A. operation from your point of view?

3.5 Did you think that the brainstorm sessions were helpful to your own understanding of the problem at hand?

Yes: I feel that getting the medical input really assists in the technical design aspects of the problem.

3.6 Would you like to have the brainstorms more/less : wide ranging, structured (e.g. time limits)?

I feel that a happy medium was reached

3.7 Do you consider enough stress was laid on:
a) Cost/function relationships?
b) Reliability/ease of operation relationships?

Yes to A & B, but as to cost/function which is a deciding factor, I think that an accountant on the team may have assisted the team effort, as we were mostly technically orientated.

4. THE V.A. TEAM

4.1 Did you consider that the relevant expertise levels for the V.A. were available on the team? (i.e. was the team balanced?)

Other than 3:7 above as a possible improvement yes.

4.2 Did you consider the absence of the training/educating profession hampered the success of the V.A. in any way?

No. but could only improve matters by getting their point of view.

4. THE V.A. TEAM cont'd

4.3 What other profession, trade etc would you have liked to have been represented on the team?

See 3:7 & 4:2.

4.4 Was the team the right size? More or less members?

More members for general V.A discussions and a smaller, technical V.A team for design proposals to submit to General team.

4.5 Was the openess and frankness beneficial to the team reaching its objectives?

Yes

4.6 Regarding team leadership, has the varying, dominance (i.e. from person to person) as opposed to rigid chairman dominance, really benefitted the team operation?

Yes

4.7 Who was dominant and at what time for what reason?

/

4.8 Did the team leader succeed in:

a) Establishing team objectives, — yes

b) Creating team cohesiveness, and — yes

c) Maintaining team norms? — yes

5. THE V.A. ENVIRONMENT

5.1 You are aware that V.A. is an industrial engineering technique. Do you consider this technique applicable to the techno-medical field? What is the main benefit of this technique?

Very much so. The main benefit of this technique is the wide input available from the team and their various points medical, technical and user

5.2 Is there any other technique that you would prefer? What would be the benefits of such a technique above V.A.?

No. However I do feel that the new ideas should be tested practically when possible, and user education finally applied.

5.3 Besides the Team Project (Common Crutch) please list in order of importance what you consider, in your professional field, should be V.A. investigated next in the techno-medical field.

A) Wheel Chairs
B) Beds
C) Toilet & Bath aids
D) Bed system should be applied to all hospital equipment in ward use

5.4 How do you rate the chances of S.A.B.S. and Govt. Provincial acceptance of the V.A. approach - what could be the stumbling blocks towards this acceptance?

Slim politically the different departments do not relate & think a seperate V.A committee is the only chance.

5.5 Who, or what, will be the <u>main benefactor</u> when V.A. is applied in the techno-medical field?

Tax-payer as more efficient hospital equipment will be designed.

5.6 Should V.A. teams be set up for other areas (both geographical and for other projects) or should one roving team be used?

One neutral team (Commission) located at a central point (Teaching Hospital, so that research & development can be undertaken.

Thank you for your co-operation.

ERIK M. KIDERLEN (Pr.Eng.)
452416

OCTOBER 1982
CAPE TOWN

82.10.25

ASSESSMENT OF VALUE ANALYSIS AS CARRIED OUT BY COMBO-CRUTCH VA TEAM

1. PURPOSE

The purpose of this assessment is to obtain individual team members' honest opinion on the V.A. process. The data thus obtained will be used to formulate an approach through which V.A. is to be applied in the techno-medical field.

2. METHODOLOGY

Questions generally have 'yes/no/don't know' answers. In a few instances, comments are requested. In general any question may be commented on by the respondent, this will be beneficial to the assessment. Use the space provided.

3. THE V.A. PROCEDURE

3.1 Was the reason for each team action always hi-lighted and the purpose clear to you?

yes

3.2 Was sufficient data provided at each stage of the V.A. job plan, and if not, when did you feel the lack of data hampered the team effectiveness?

No

Data lacked a) Costs

b) over-enthusiasm

3.3 Is there an alternative method, describe briefly, by which the same result could be achieved in a shorter contact time span?

No

3. THE V.A. PROCEDURE cont'd

3.4 What was most unnecessary in the whole V.A. operation from your point of view?

Nothing. no extraneous matters brought up.

3.5 Did you think that the brainstorm sessions were helpful to your own understanding of the problem at hand?

Yes, but insufficient time allocated to brain-storming!

3.6 Would you like to have the brainstorms more/less : wide ranging, structured (e.g. time limits)?

more time.
and wider ranging.

3.7 Do you consider enough stress was laid on:
a) Cost/function relationships? yes
b) Reliability/ease of operation relationships? NO

Reliability could have been further investigated.

4. THE V.A. TEAM

4.1 Did you consider that the relevant expertise levels for the V.A. were available on the team? (i.e. was the team balanced?)

Not having a user was detrimental to team effectiveness

4.2 Did you consider the absence of the training/educating profession hampered the success of the V.A. in any way?

NO. N/A.

4. THE V.A. TEAM cont'd

4.3 What other profession, trade etc would you have liked to have been represented on the team?

NONE

4.4 Was the team the right size? More or less members?

YES
One additon would be a user.

4.5 Was the openess and frankness beneficial to the team reaching its objectives?

YES

4.6 Regarding team leadership, has the varying, dominance (i.e. from person to person) as opposed to rigid chairman dominance, really benefitted the team operation?

YES,

4.7 Who was dominant and at what time for what reason?

Team leader to stop transgression as and when this occurred during deliberation, and to limit waffling.

4.8 Did the team leader succeed in:

a) Establishing team objectives, YES

b) Creating team cohesiveness, and YES

c) Maintaining team norms? YES.

5. THE V.A. ENVIRONMENT

5.1 You are aware that V.A. is an industrial engineering technique. Do you consider this technique applicable to the techno-medical field? What is the main benefit of this technique?

YES Standardisation, producing what is necessary.

5.2 Is there any other technique that you would prefer? What would be the benefits of such a technique above V.A.?

NO

None.

5.3 Besides the Team Project (Common Crutch) please list in order of importance what you consider, in your professional field, should be V.A. investigated next in the techno-medical field.

Hospital Beds
Bedside equipment
Patient handling equipment.

5.4 How do you rate the chances of S.A.B.S. and Govt. Provincial acceptance of the V.A. approach - what could be the stumbling blocks towards this acceptance?

limited.

→ lack of communication between SABS, Govt Bodies and "Balloon approach".

5.5 Who, or what, will be the main benefactor when V.A. is applied in the techno-medical field?

patient, Cost-wise (local issuing authority)

5.6 Should V.A. teams be set up for other areas (both geographical and for other projects) or should one roving team be used?

a geographical team with appropriate specialists on such a team, supplying team results to other areas.

Thank you for your co-operation.

ERIK M. KIDERLEN (Pr.Eng.)
452416

OCTOBER 1982
CAPE TOWN

APPENDIX XI

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- Department of Mechanical Engineering
- University Insurance
- Department of Statistics
- News and Information Bureau
- Engineering Students' Council
- Baxter Theatre Management

Cripple Care:
- National Office, Johannesburg
- George Centre
- Cape Town Centre
- Krugersdorp Centre
- Northern Transvaal Region

S.A. Bureau of Standards:
- Cape Town Regional Office
- Quality Control Division
- Performance Testing Division

Rotary Anns: Port Elizabeth

S.A. Broadcasting Corporation:
- Radio Today (Cape Town)

Stripform Packaging: Cape Town

Steve Bromfield Ensemble:
- Cape Town

Community Chest: Cape Town

S.A. Institute for the Blind:
- Worcester

Cape Manufacturing Engineers:
- Maitland

Groote Schuur Hospital: Photographic Section
- Public Relations Section

SHAWCO: Health Management Committee
- Chief Administration

Camphill Village: Philadelphia, Cape

Conradie Hospital: Occupational Therapy Section

Checkers Stores:	Claremont Centre (Cape)
Nampak (Pty) Ltd.:	Epping (Cape)
Rosedon Activity Centre:	
	Lansdowne (Cape)
Department of Internal Affairs:	
	Regional Repreeantative (Cape Town)
	Head Office (Pretoria)
Department of Health and Welfare:	
	Regional Representative (Cape Town)
	Head Office (Pretoria)
Department of Indian Affairs:	
	Regional Representative (Cape Town)
	Head Office (Pretoria)
University of Stellenbosch:	
	Business Management School
	Mechanical Engineering Department
Pick n Pay Stores:	Head Office (Claremont)
	Rondebosch
	Durban
	Johannesburg
	Brackenfell
Cape Provincial Administration:	
	Provincial Engineering Department
	Director of Hospital Services
Pollsmoor Adult Training School:	
	Pollsmoore (Cape)
Mr. E. Kyle:	Private Manufacturer
Mr. K. Jarvis:	Marketing Consultant
Mr. Bill Smith:	Private Manufacturer
Mr. A. Wallace:	Marketing Consultant
Mr. Harry Hamer:	Manufacturer
Mrs. Barbara Johnson:	Coordinator
Dr. H. Goldberg:	Private
Mr. A. Bernstein:	Private
Mrs. D. Ward:	Private Bookkeeper
Clinical Emergencies (Pty) Ltd.:	
	Foreshore, Cape Town
Cape Times (Pty) Ltd.:	Cape Town
K. Jaqoe:	Witwatersrand University

Rand Mutual Hospital: Spinal Unit (Johannesburg)

SHAP Project Coordinator:
Soweto, Johannesburg

S.A. Council for Professional Engineers:
Marshalltown, Johannesburg

Engineer's Association: Pretoria

Headly Burn Advertising: Cape Town

Senior District Occupational Therapist:
District Surgeon's Office, Johannesburg

M.S.L. Management Consultants:
Johannesburg

University of the Orange Free State:
Bloemfontein

Arthritis Foundation: Cape Town

Campco Oil Seals Company:
Cape Town

Elvinco Plastics: Cape Town

Western Province Hardware:
Cape Town

Western Province Agricultural Society:
Cape

Disabled Sports Association:
Pretoria

Secretary, Commission of Enquiry into Health Services:
Pretoria