

AN ERGONOMICS MODEL FOR PRODUCT DESIGN*

This paper models the integration of ergonomics knowledge to the design process. It is suggested that, neither a single methodology, nor an information system will be sufficient to cover all the requirements of an ergonomic product. The relative emphasis given to ergonomics varies with the types of design problem. Nonetheless, it is assumed that the design process will always involve the user, thus ergonomics. The difficulties arise from ill-defined nature of design, inadequate knowledge background or inadequate data which requires a long-term approach where everything should be thought at macro level. For this purpose, the aim of the paper is to propose a communication model for ergonomists and designers who believe in the value of experts. Therefore, this model presents a macro outlook onto ergonomics and product design, whereas further studies may extend the scope by presenting sub-models for reaching details in the design process or existing micro models (expert or aiding systems) will be valuable sources if they are inserted into this system.

The research is focused on literature search, accident analysis and design strategy analysis. The chief questions to be addressed in the literature search are:

- What is the relation between design and ergonomics?
- What is designer's responsibility in terms of design, manufacturing and products liability?
- What kind of ergonomics information do designers need? How reliable are they?
- What is meant by product-user interaction?

The chief questions to be addressed in accident analysis are:

- What kind of information does accident analysis provide?
- What is the reliability of accident data?
- How is this information used in design?

The chief questions to be addressed in design strategy analysis are:

- What is a model and what type of models exist in design?
- What is design management?
- What is a product life-cycle?
- What are the benefits of product safety in terms of company's reputation?

DESIGN AND ERGONOMICS

There is a big confusion in the definition and methods of design. It is evident that the way that arrive at design solutions differs from other professionals like engineers or managers.

A designer, like any other professional has a special knowledge background for solving the problems that are faced. The difference that exists here comes from the way of handling the problems in addition to the designer's subjective contribution.

Another confusion exists in what does design mean: Meaning, either the discussions about the definition of design concepts or the categorization of design

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professions (e.g. industrial design, engineering design, interior design, etc.) are confused.

Literature is full of examples about the subjectivity of the designer. Although the role of subjectivity in the design process is accepted by most of them, the discussions are still going on about the limits of subjectivity.

For the designer the integration of ergonomics to the design process is unclear. Mostly, designers see ergonomic design as a design that fulfills anthropometric requirements. The other side of the problem for the designer is the difficulty which lies in the organization and application of ergonomics knowledge. Although there is an increasing amount of ergonomics information related with design in the technical literature (Adams,1989; Bailey,1981; Burgess,1986; Diffrient et. al, 1991; Galer,1987; Hutchingson,1981; Osborne,1987; Pheasant,1986; Salvendy, 1987; Woodson,1981) it is not in a form which is accessible to designers.

It is evident that designers need a considerable amount of information to come up with good solutions and are willing to utilize information coming from different disciplines such as, human factors, psychology, management, engineering etc., but this willingness does not show itself in practice (See Figure 1).

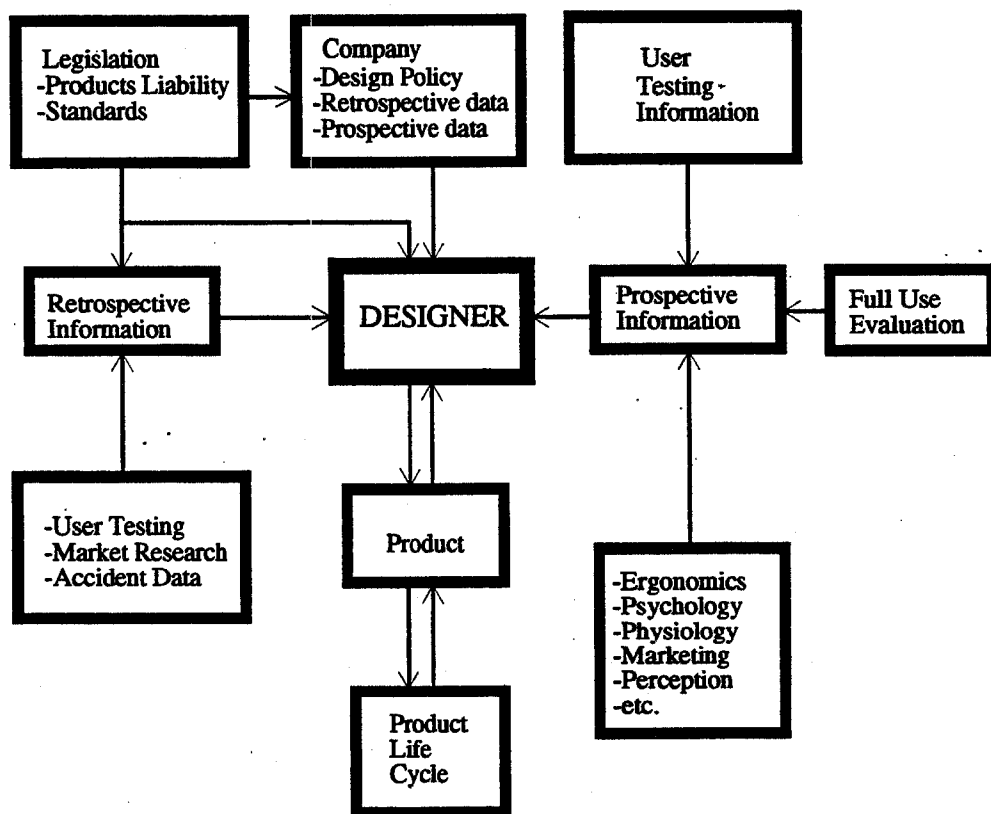


Figure 1. Designer's Information Needs

The question which arises is whether this occurs because of insufficient information systems, and/or because of the ill-defined nature of design and/or because of the designer's education? Keeton's concern in this respect is (Keeton, et al., 1980), "The industrial design engineer pays first allegiance to the trilogy of cost, marketability, and competitive position within the context of product function. Although safety is a factor in his design plan, it can not and does not become the focal point of his endeavors. The engineer does not sit down to design a product with safety at the head of his list of features and concerns. The products liability case provides that shift in focus whereby society reexamines the design, taking into account all the factors that the design engineer must account for".

Considering the nature of ergonomics and design, it is clearly understood that it is difficult to manipulate the design process by proposing strict methods for designers. Design can be considered as a continuous process, that has feedback from all the stages of the product life cycle. For this reason, an ergonomics model which helps providing information about the usage of ergonomics data and strategic stages for using this data through the product life cycle may help designers. Such a model will not limit the designers' own way of reaching solutions but will help to realize the contribution of ergonomics.

To manipulate the constraints designers have to get familiar with them, in other words they have to absorb them. Therefore, if this is provided for the design process, a designer will be familiar with the techniques of ergonomics and their contribution to design, and will have more freedom to apply this knowledge. The decision support systems (expert criticizing systems) that have been surveyed so far offer a set of alternative solutions and compare them in order to eliminate or to select some of them. Although it seems that these systems improve design, solutions remain limited. The reasons of the difficulties in transferring ergonomics data to ergonomics information is illustrated in Figure 2.

To overcome obvious problems in various fields of design Rapoport (1969) proposes new types of specialists-a series of middlemen who can communicate with other specialists and put the information in a form which designers can and will use. At this point, the goal definition, the nature of the facts in design and the way of obtaining them are very important.

As it was mentioned before, designers are fully aware of the fact that ergonomics information should be integrated to the design process but it is hard to say that this information is applied throughout the design process. And this research has confirmed that the ergonomics information required for the design process may become so complicated that it can not be handled by the designer alone. And, this introduces the interdisciplinary product development process where professionalization of knowledge gains importance.

To overcome most of the problems stated above, there may be a need for a macro approach, which would begin with designers' education, continue with design management and end with an ergonomics model, because the problem as a whole is too wide to be solved by proposing one method of design.

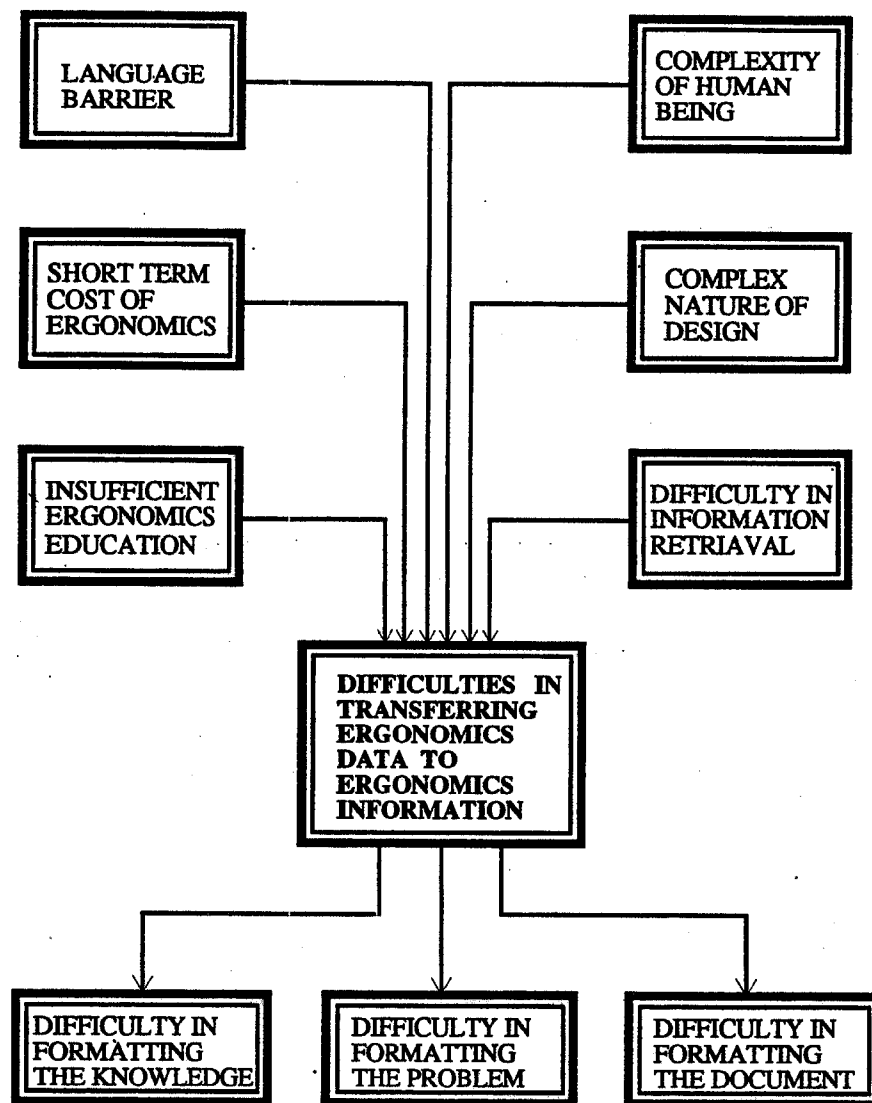


Figure 2. Difficulties in transferring ergonomics data to ergonomics information.

PRODUCT LIFE CYCLE

The success or failure of a product is largely conditioned by a systematic analysis of its life cycle, as all the products are created, used and become obsolete. The quality of information related to these stages and the way of integrating it to the product design for appropriate stages are very important. Also an overall view is important for selecting a particular design principle and will affect the properties of the total product, e.g. ease of use, production price, development time etc.

Actually, all stages in the life of a product provide feed-back information, mostly at the design stage. According to Archer (1969), "A design project is, in fact, a sequence of design problems, each aspect of the problem and each component of

the product becoming a new design problem, to be resolved in the context of what has been decided so far". Therefore, there is a need for a total design process, to solve the problems of manufacturing, installation, ease of use, reliability, repair, maintenance, appearance and ultimate disposal of a product. Most ergonomics researchers like Wilson (1983), agree that many of these processes require an ergonomics input, as their successful resolution will depend on knowledge of the types, abilities, limitations and projected behavior of the users of these products.

According to Zhiliang (1991), "Industrial designing must be from practice to cognition, and then from cognition to practice, a cycle which will be repeated many times, even endlessly". The view of Zhiliang stresses the importance of the product life cycle (PLC) analysis, because every step in the product's life provides feed-back to the other steps of a design and to future designs. In this attempt, an ergonomics model which feeds each stage through the PLC and repeats itself with the information feed-back, can be considered as a valuable aid for designers to reach a user centered product.

Ivergard (1976) summarizes the importance of PLC analysis for the designer and the manufacturer. He mentions that "One must examine what happens in the consumer environment. Firstly, of course, one must see if the product fulfills its intended function (i.e., function as a knife, functions as a washing powder, etc.). Then one should see whether the product can cause accidents or other troubles, and also whether it is easy and comfortable to use. Another important question is whether the product is effective when used by the ordinary consumer and also by special consumer groups such as the elderly and handicapped. Finally, the form of waste caused by the product, and whether there is any suitable way of using the waste, must be examined". This point of view focuses on the other side of PLC analysis, where the situation is examined after a product is marketed.

The importance of PLC analysis, in terms of ergonomics, lies in the effective coordination between the designer, the manager (company) and the ergonomist. Through this interaction, PLC analysis will be helpful in three ways:

1. The definition of the specific information needs of the PLC stages will lead to an organized information framework for design.
2. The continuing structure of the PLC will act as a retrospective information source.
3. The formal representation of design through the stages of PLC will be a useful guide for the design management.

THE PROPOSED ERGONOMICS MODEL

Throughout the literature survey for this study, not a single design model managing all the design information has emerged and this is mainly due to the interdisciplinary nature of design. To integrate information coming from different disciplines or to communicate with people having different backgrounds (e.g., client, manufacturer, engineer, etc.) the designer uses a number of models. In this sense, ergonomics is considered to be one of the models in design which should be applied throughout the design process.

It is clear that ergonomics is involved at every phase of design for a successful user-product interaction and the success of a product is mostly affected by its appearance and ease of use in the competitive market. This relation brings forth

the fact that ergonomics research and knowledge are important tools to create a successful product.

The Ergonomics Model proposed in this paper provides an integration between different fields and encourages a multidisciplinary approach. Believing in the value of experts, this model proposes a soft collaboration between the designer, the ergonomist and the manufacturer by systematized advisory interactions. It is assumed in this model that each expert can be considered as an inexperienced person in another field and has difficulty in coding a rough description given directly by an expert. Therefore the information exchange in this model is based on the role of experts and imposes onto the ergonomist to do more than provide a solution and some description or justification of the solution process: He should also be able to participate in the problem solving process.

When the problem is discussed at the macro level and if safety is the major concern, the model simply suggests that there are certain classes of activities which must be carried out and certain type of information that must be fed into the design process through the product life cycle. It is noteworthy that this model is not proposed to be used for every product design: Its utilization depends on the complexity of the product.

The macro approach of the model is illustrated in Figure 4. The author has investigated in great detail the methods and techniques used in the different stages of the model. However because of the scope of this paper it is only illustrated symbolically in Figure 5. In relation to this approach Figure 3 illustrates the basic inputs and outputs of the Ergonomics Model.



Figure 3. Inputs and Outputs of the Model.

The first part of the model suggests that whenever a design problem emerges, it should be discussed at the top level between designer, manufacturer and ergonomist. At that stage, it is beneficial for the designer, to have an ergonomics background. This does not mean designers should be specialized in ergonomics but they should at least understand the need for ergonomics research for product success and know when to collaborate with an ergonomics expert. Education is one of the ways to create this awareness. The manufacturer's responsibility is considered to be, regulatory reporting, record keeping, keeping in touch with safety agencies, and developing their firms standards. The accumulation of such information will not only bring a clear outlook to the design process but also minimize the efforts and time required for design research.

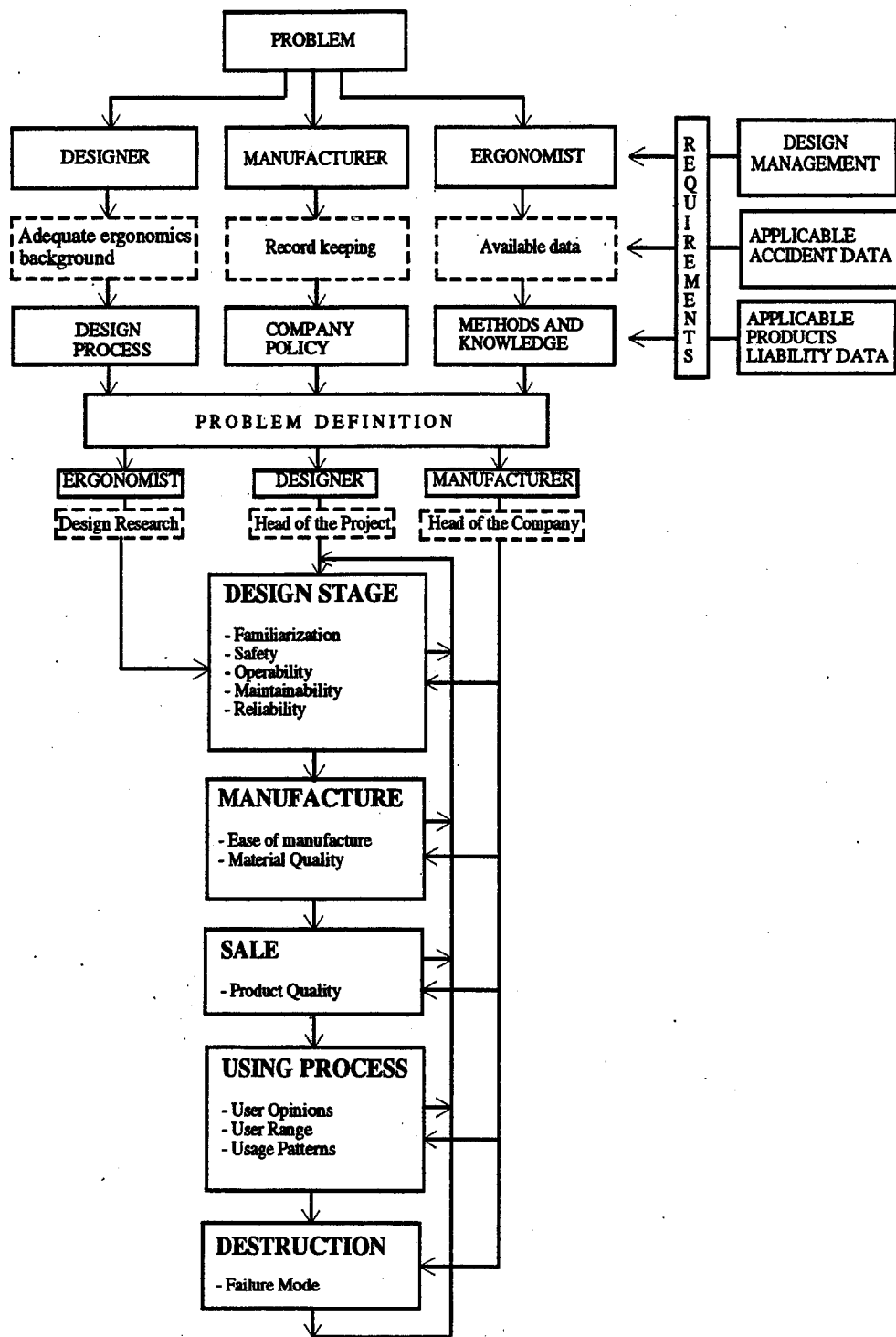


Figure 4. The Macro Approach of the Ergonomics Model

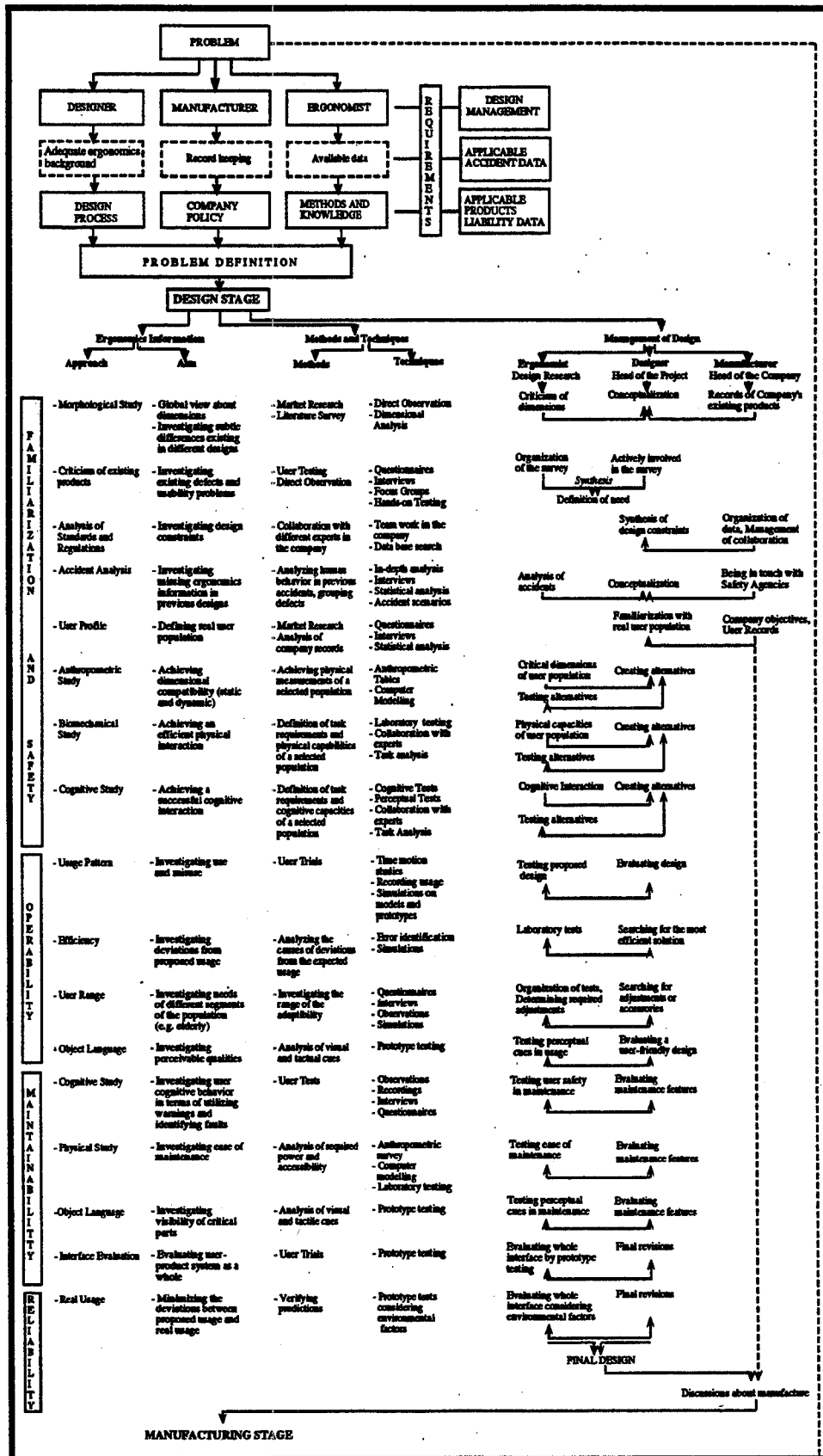


Figure 5. Ergonomics Model For Industrial Design

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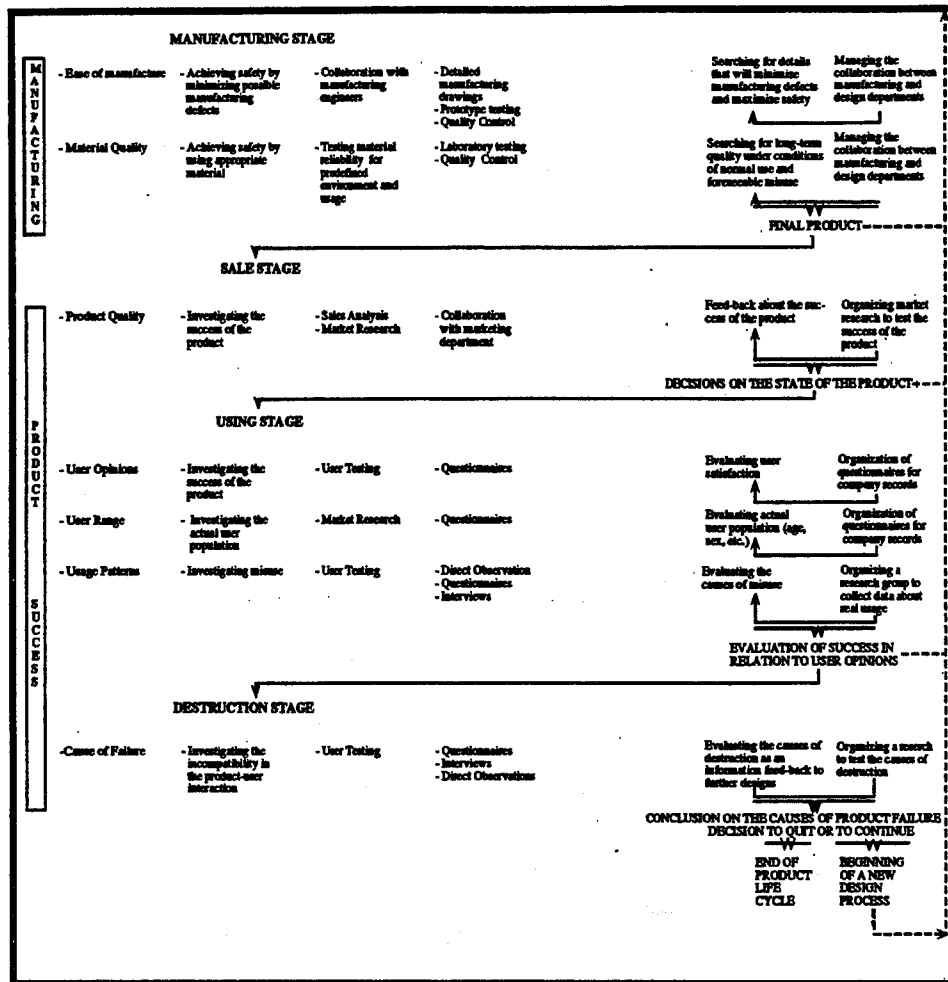


Figure 5. Ergonomics model for Industrial Design

At this stage the ergonomist searches for the accessibility of required information. Because there is another non-controllable factor, that is the applicable retrospective information is not available. Available accident and products liability data should be modified according to the needs of safety and should be made accessible for designers and ergonomists. Therefore, the proposed macro approach mainly serves for the first part of the model, as it constitutes its basic structure by defining a healthy organization before the design process. It is assumed that fulfilling these preconditions will lead to a successful design policy where the designer defines a clear design process, the manufacturer develops a consistent company policy and the ergonomist determines the required methods and knowledge.

Having reached to a healthy definition with the completion of the first part, the second part of the model states the required ergonomic information, methods and techniques of ergonomics research by assigning responsibilities in terms of design management. This organization is developed through the product life cycle. Believing in the value of experts, it is suggested that the collaboration between designer, manufacturer and ergonomist should continue all through the product

life cycle. Although, the ergonomist's role seems finished at the end of design stage, it is not the case. Because any redesign decision taken during the product development will restart the process from the design stage and requires collaboration between experts. For this reason, the responsibilities assigned to designer, ergonomist and manufacturer do not change all through the model. The designer is considered to be the head of the design process, whereas the ergonomist is expected to perform design research and the manufacturer is thought to be the head of product development.

WHY THIS MODEL?

The results of the literature search, accident data and design strategy analysis show that;

- There is a language barrier between the designer and the ergonomist and the designer is overloaded by user oriented information coming from different disciplines.
- Retrospective information (product liability cases and accident data) is a valuable source for designers but is not easily applicable.
- Data on accident analysis is not detailed enough and does not provide any information on near-accidents.
- Both design and ergonomics processes are composed of models and their interdisciplinary nature makes the communication more difficult.
- Due to insufficient knowledge background the integration of ergonomics to design is unclear for designers.
- Design is a continuous process and involves dynamic interaction during the different stages of product life cycle.
- To create a successful product, design has to be managed from a corporate point of view.
- It is delicate for the designer to use expert systems and aiding systems without knowing when and how to integrate this information to the design process.
- Design without sufficient ergonomics knowledge will possibly result with loss of reputation, stress, discomfort, accidents, product recall or short term success.
- Positive consequences of design with consciously applied ergonomics information will be long - term success, a user friendly design, a better performance and is a non-price competitive factor in the marketing mix.

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