A DECISION-BASED PERSPECTIVE for the DESIGN OF METHODS for SYSTEMS DESIGN

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MOTIVATION

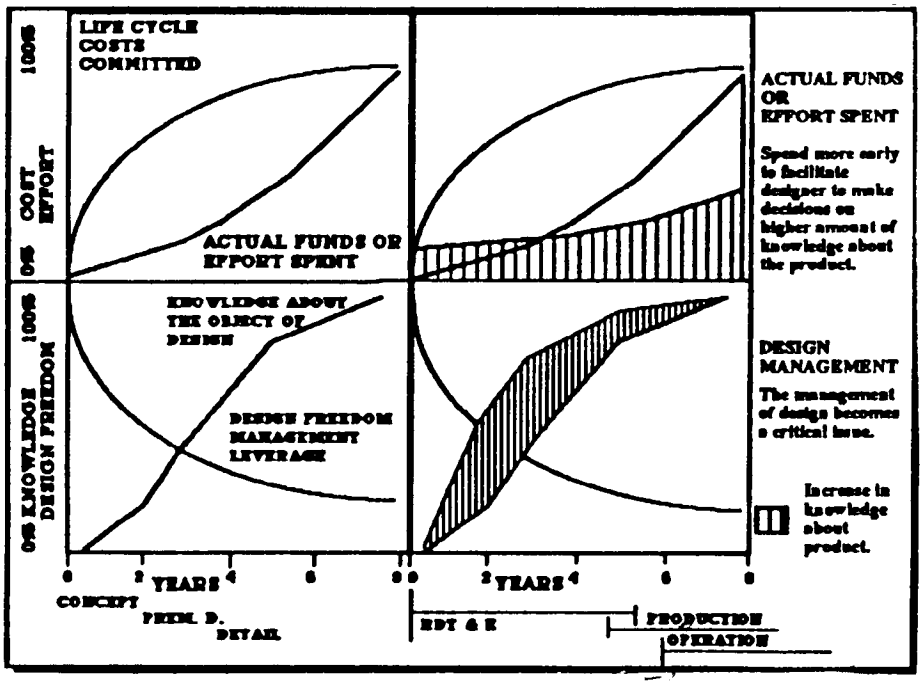
By system definition we mean the establishment of a construct which characterizes the needs and requirements of a system for a particular application. The importance of system definition and concept design in the development of new, major engineering systems cannot be overemphasized. A popular representation that has been used to illustrate this importance with respect to life cycle cost is reproduced below. As can be seen design freedom or management leverage rapidly decreases once a project is underway. In other words, the freedom to make modifications to a concept becomes increasingly expensive as one gets further into the project. In effect, a significant amount of the life cycle costs have been committed at the time when relatively little knowledge about the object of design has been generated. Usually, this occurs by the end of the conceptual and preliminary design phases.

We believe that the design research community --- the theorists, the academics and engineers in industry --- must all contribute to the common goal of striving to develop a recognized science of design. In an ultimate sense, the purpose of developing the science of design is to ensure that our manufacturing industries can become more effective as well as efficient and that the designers, manufacturers and maintainers of our products will be working in an environment where their subdisciplines are considered simply as parts of the continuous technological spectrum which spans what we have come to call life cycle engineering.

Our recent work and research interests suggest that there is a viewpoint of design research - three-faceted and tightly organized within itself - which should be considered. The issues we include in our view of design research do not exist separately but as a single interactive entity. They are

1 Meta-design - the way in which we define and partition a problem using generic discipline-independent modeling techniques.
2 Computer-based design supports holistic or systems thinking.
3 Adaptive Action Learning - a way of learning through doing.

We believe this tripartite view of design research is unique and is essentially congruent with the principal elements required to establish the philosophy and practice of the science of design which, when accepted and used in industry and academe, will ensure the continued growth and improved productivity of our industries.



ORGANIZATION OF MATERIAL

"Everyone designs who devises courses of action aimed at changing existing situations into preferred ones." Simon [1, p 129].

The preceding definition is not discipline specific. It can be used as the basis for categorizing the activities of groups of individuals in other science-based disciplines than engineering, for example, management science, systems science, economics and the social and behavioral sciences. The members of the groups are designers in the context of Simon's definition. They design artifacts and machines (engineers), industrial organizations (managers), including their communication and information networks (behavioral scientists and experts in information science) and accounting information systems (accountants, managers and experts in information science). We subscribe to Simon's definition of a designer. In this paper our comments are directed principally towards engineering design, but are not limited to it. The organization of the material is given below.

DEFINITIONS

- **Decision-Based Design**
- **Heterarchy and Hierarchy**
- **System**

THE DECISION SUPPORT PROBLEM TECHNIQUE: CONCEPTUAL MODELS

- **Short Term Goal: Design that can be Produced and Maintained**
- **Long Term Goal: Design, Manufacture and Maintenance as a Continuous Process**

DECISION-BASED DESIGN

- **Meta-Design, Computer-Based Design and Adaptive Action Learning**
- **The Characteristics of Decisions**
- **Decision Activities to Decision Entities**
- **Types of Design**

THE DECISION SUPPORT PROBLEM TECHNIQUE: STATUS

- **Designing for Concept and Designing for Manufacture**
- **Designing for Concept: A Scenario**
- ***Status: Software, Decision Hierarchies and Applications***

ISSUES THAT NEED TO BE CONSIDERED TO FOSTER DEVELOPMENT

DECISION-BASED DESIGN

Decision-Based Design [2,3] is a term we have introduced to provide a new focus from which design methods can be developed. In the context of Decision-Based Design, we assert that the principal role of an engineer is to make decisions associated with the design of an artifact. This seemingly limited role ascribed to engineers is useful to provide a starting point for developing design methods based on paradigms that spring from the perspective of decisions made by designers (who may use computers) as opposed to design that is assisted by or based on the use of computers, optimization methods (computer-aided design optimization) or methods that evolve from specific analysis tools such as finite element analysis. In other words, we do not consider Decision-Based Design as a subset or superset of Computer-Aided Design or Computer-Based Design. We see it in another role. Many design approaches were developed originally for purposes and uses now considered outmoded. Their continued use by designers is contingent largely upon custom, tradition and familiarity, and the innate conservatism of most engineers. Enter Decision-Based Design; considering design as a decision-based process offers designers a new and different perspective for viewing established approaches and provides them with the basis for extending and developing anew these established tools of the trade.

The implementation of DBD can take many forms. One implementation of Decision-Based Design is the Decision Support Problem Technique [4,5].

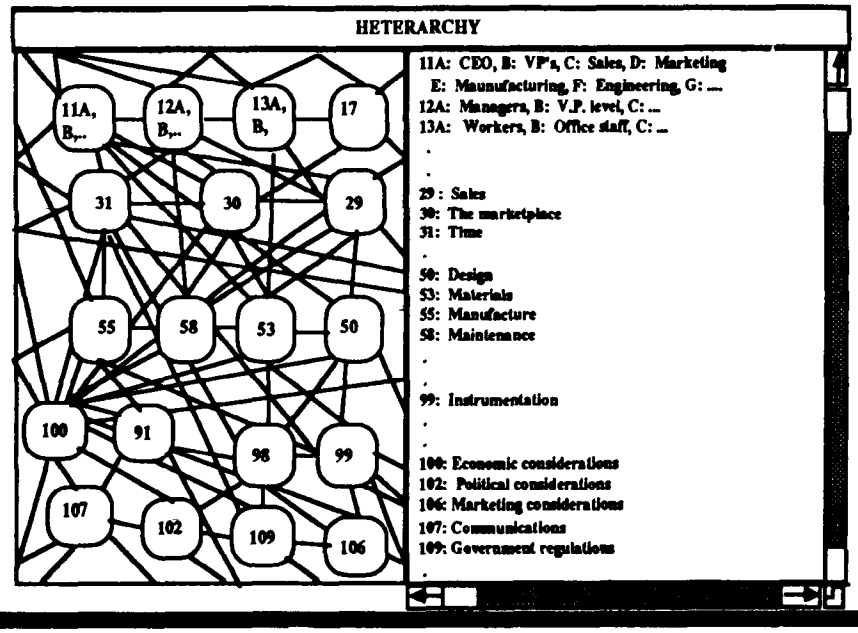
- **A new term - to provide a new focus from which to develop methods that support**
  - **systems thinking, and**
  - **the making of decisions by designers of engineering systems.**
- **Principal role of engineer in DBD is to make decisions associated with the design of an artifact.**
- **Starting point for developing design methods based on paradigms that spring from the perspective of decisions made by designers (with or without computers).**
- **DBD has as its content a heterarchical set of constructs that embody a researcher's perception of the design environment and the real world.**
  - **definition of "system"**
  - **types of design: original, adaptive and variant**
  - **open and closed environments**
  - **the nature of decisions and the type of decision activities.**
- **There is NO SINGLE unique TECHNIQUE or METHOD for the implementation of DBD. The development of a major class of design technique or method will be a result of a researcher selecting a subset of constructs and establishing a hierarchy between them.**

DECISION-BASED DESIGN: DEFINITION

We define Decision-Based Design as a heterarchical set of constructs that embody a developer's perceptions of the design environment and the real world.

The heterarchical constructs associated with a product's life-cycle are the product's market, the product (the design must meet or exceed the criteria related to the product's function, meeting its market, its capability for being manufactured in serial and, when it reaches its market, that it be free of unreasonable dangers), its manufacture (tooling and assembly), its maintenance and its subsequent retirement. A portion of the heterarchical set of constructs for a product's life-cycle are shown below. The relationships between the constructs are not ordered and hence not directed.

DECISION-BASED DESIGN is a heterarchical set of constructs that embody a designer's perception of the real world.



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