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Chapter 2

Bringing Systems Into Being

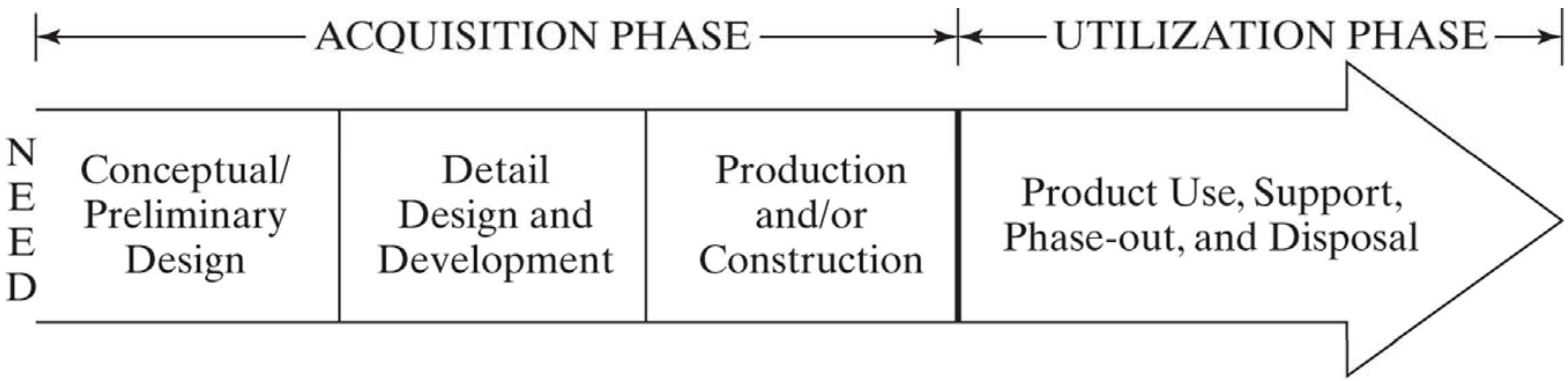
Defining the Engineered System

- Have a *functional purpose* in response to an identified *need*
- Have the ability to achieve some stated *operational objective*
- Are *brought into being* and *operate* over a life cycle, beginning with a need and ending with phase-out and disposal
- Are composed of a *combination of resources*
- Are composed of *subsystems* and related *components* that *interact* with each other to produce the system response or behavior
- Are part of a *hierarchy* and are influenced from external factors from larger systems of which they are a part
- Are *embedded* into the natural world and *interact* with it in desirable as well as undesirable ways

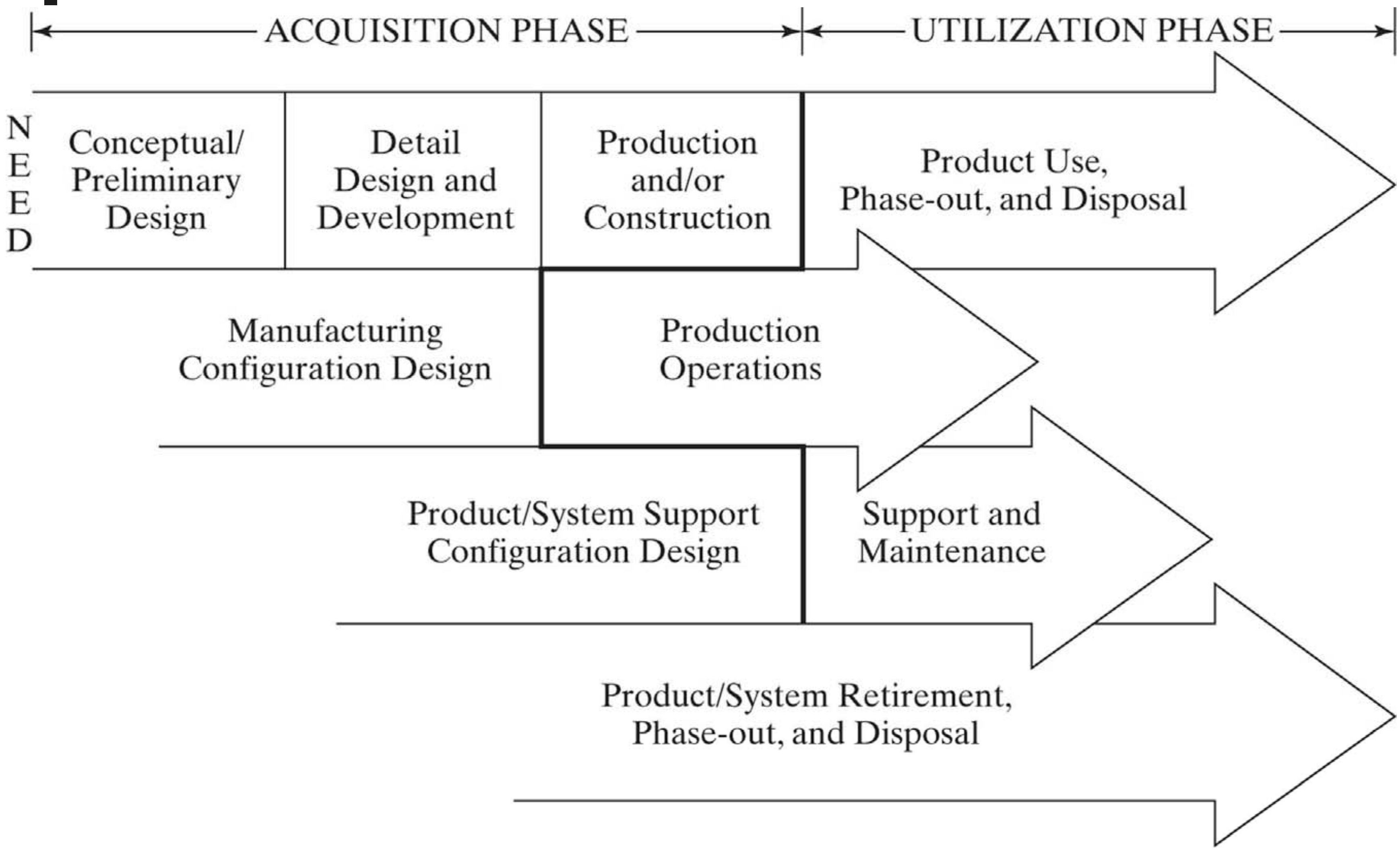
Enhancing Product Competitiveness by Systems Engineering

- Improving methods for defining product and system requirements as they relate to true customer needs
- Addressing the total system with all its elements from a life-cycle perspective, and from the product to its elements of support
- Considering the overall system hierarchy and interactions between various levels
- Organizing and integrating the necessary engineering and related disciplines in a timely concurrent manner
- Establishing a disciplined approach with appropriate review, evaluation, and feedback provisions

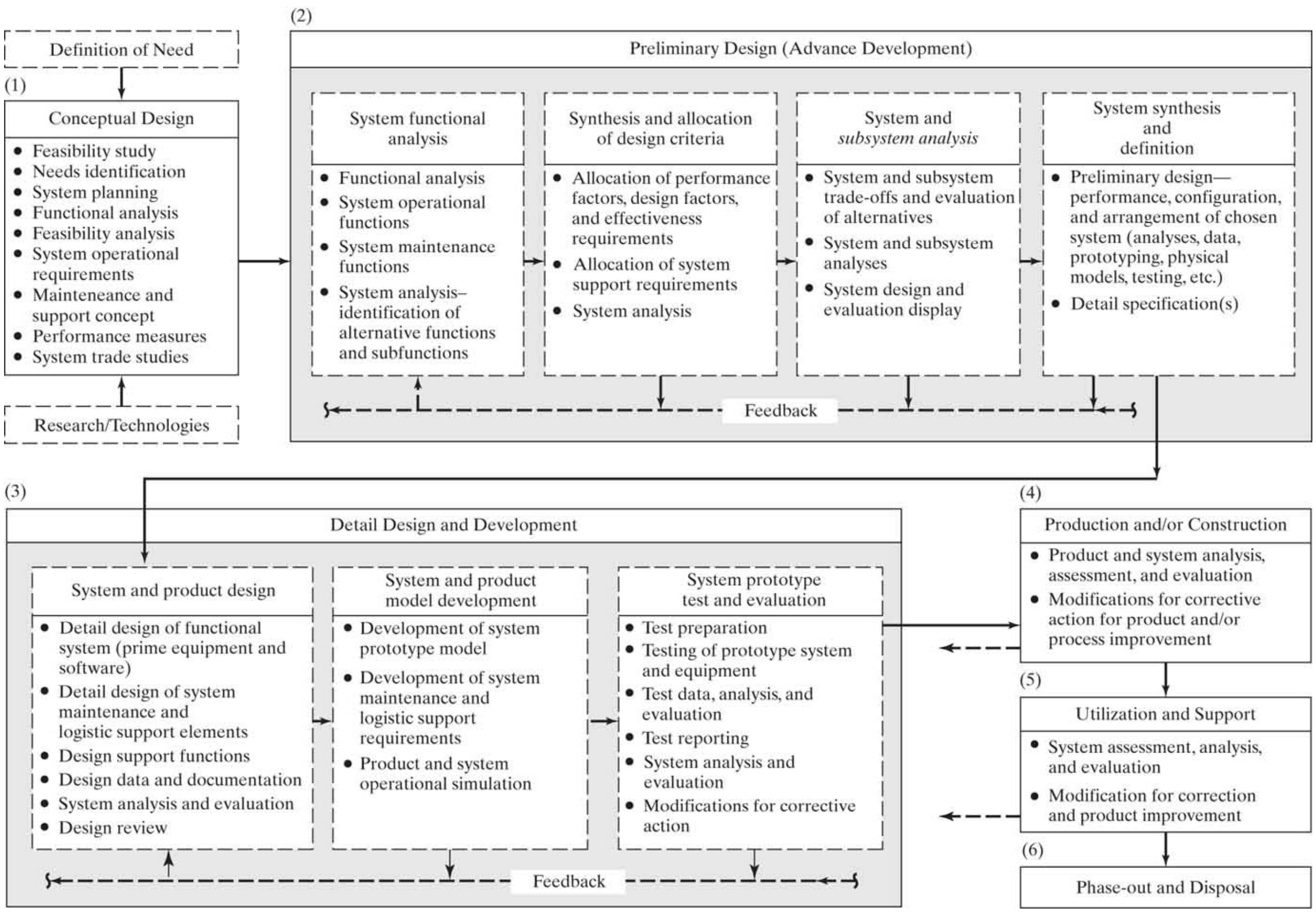
The Product Life Cycle



The Product AND System Life Cycle



Diving INTO The System Life Cycle (View 1)



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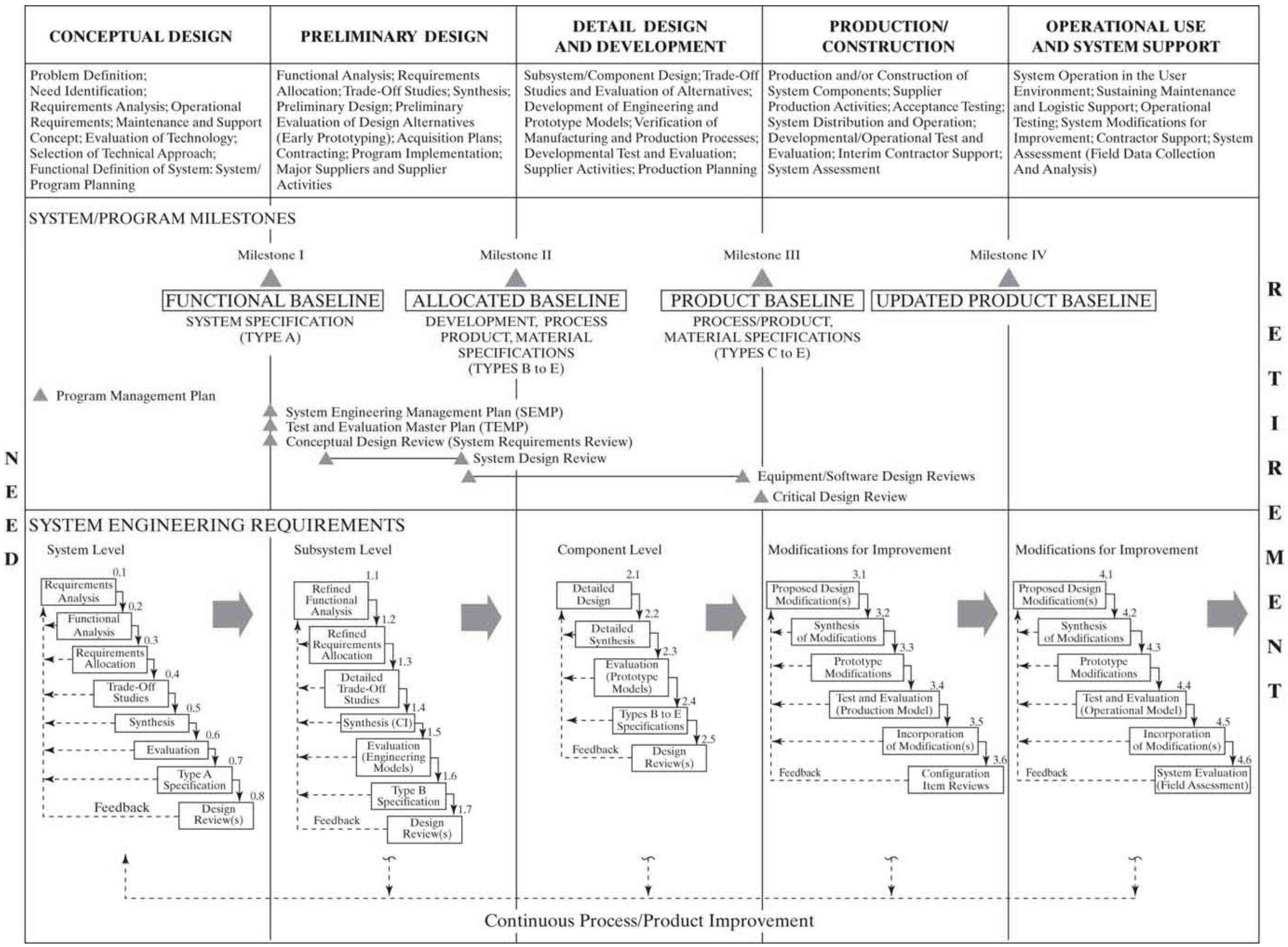
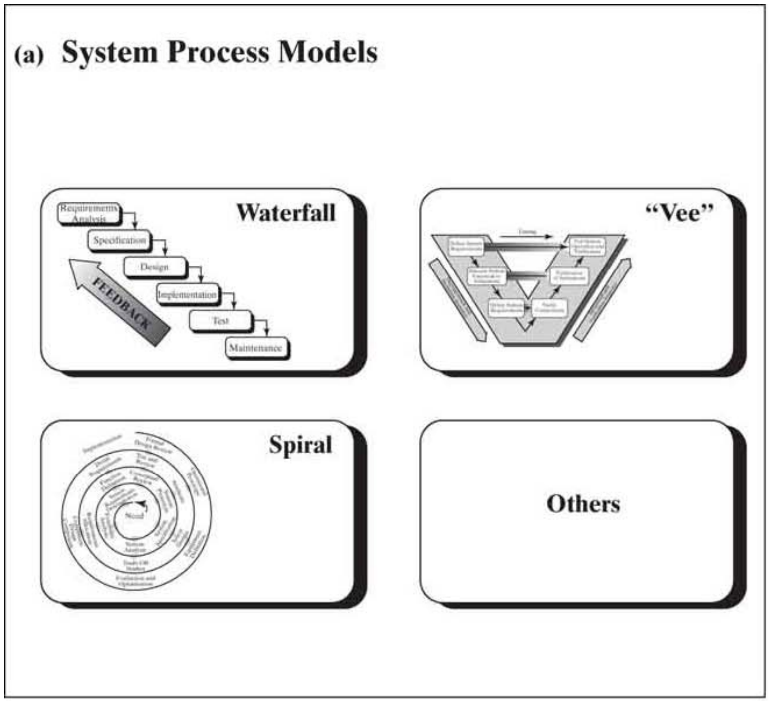
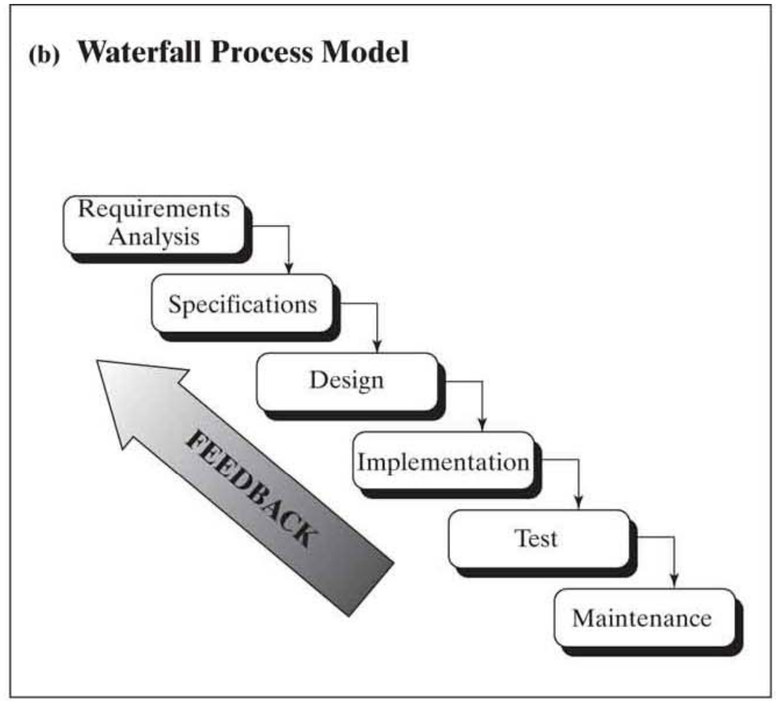
Diving INTO The System Life Cycle (View 2)



System Process Models





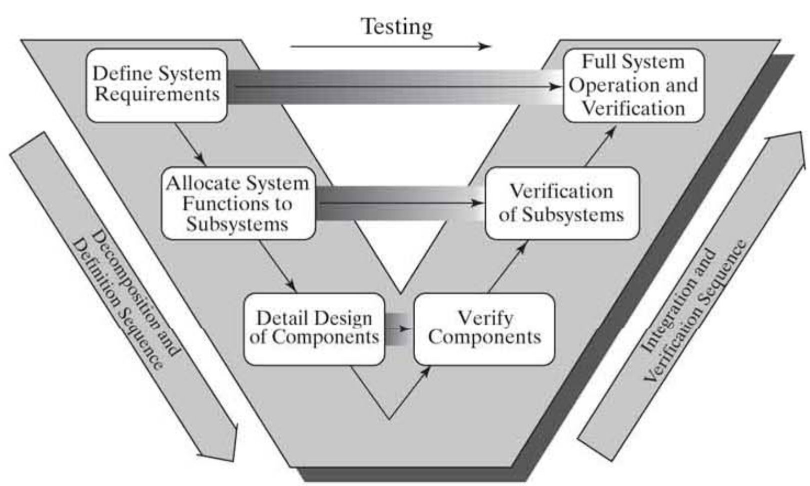
- It is observed that the preference expressed by individuals and groups for one of the system models is subjective.
- A study of the literature and current practice is needed to identify which model fits a specific situation best. Refer to Appendix G.

- The waterfall model, introduced by Royce in 1970, initially was used for software development. This model usually consists of five to seven series of steps or phases for systems engineering or software development. Boehm expanded this into an eight-step series of activities in 1981.
- A similar model splits the hardware and software into two distinct efforts. Ideally, each phase is carried out to completion in sequence until the product is delivered. However, this rarely is the case. When deficiencies are found, phases must be repeated until the product is correct.

System Process Models

(c) Spiral Process Model

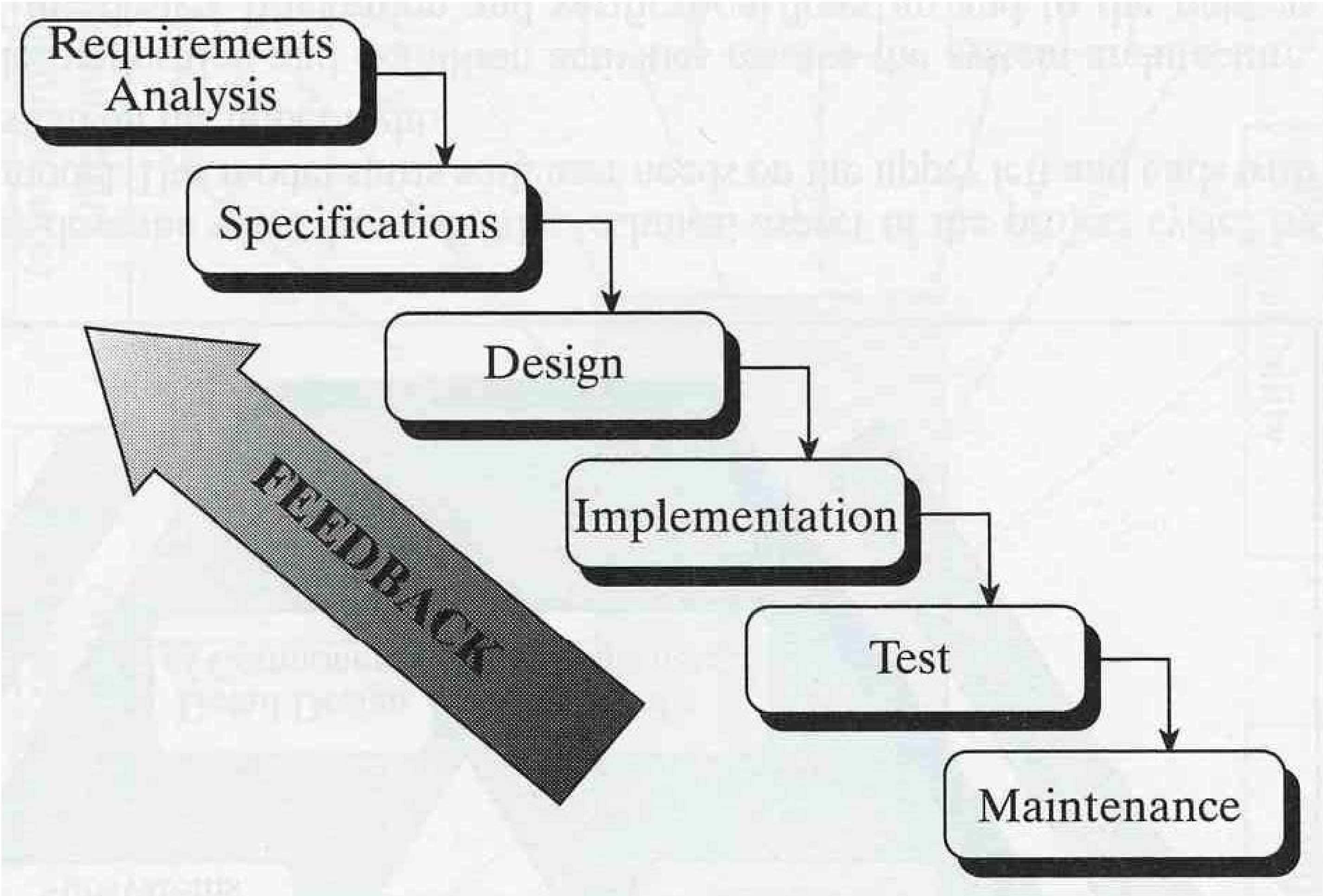
(d) "Vee" Process Model



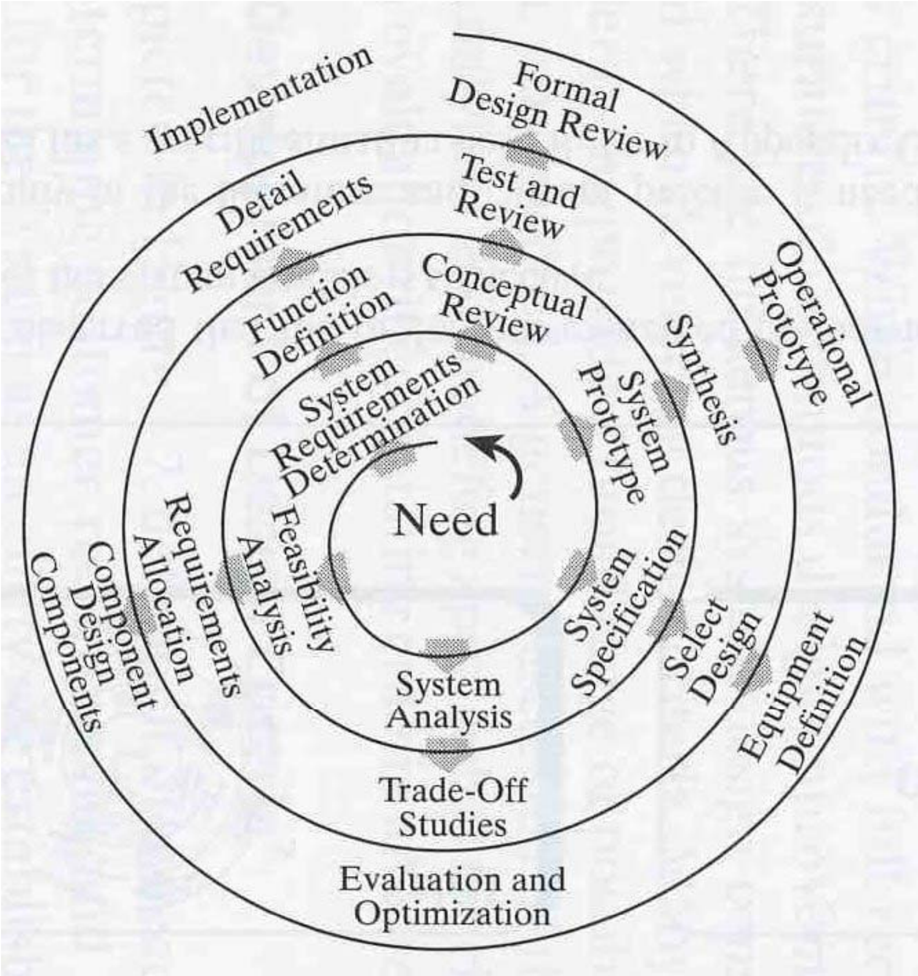
- The spiral process model of the development life cycle (developed by Boehm in 1986 using Hall's work in systems engineering from 1969) is intended to introduce a risk-driven approach for the development of products or systems.
- This model is an adaptation of the waterfall model, which does not mandate the use of prototypes. The spiral model incorporates features from other models, such as feedback, etc.
- Application of the spiral model is iterative and proceeds through the several phases each time a different type of prototype is developed. It allows for an evaluation of risk before proceeding to a subsequent phase.

- Forsberg and Mooz describe what they call "the technical aspect of the project cycle" by the "Vee" process model. This model starts with user needs on the upper left and ends with a user-validated system on the upper right.
- On the left side, decomposition and definition activities resolve the system architecture, creating details of the design. Integration and verification flows upward to the right as successively higher levels of subsystems are verified, culminating at the system level.
- Verification and validation progress from the component level to the validation of the operational system. At each level of testing, the originating specifications and requirements documents are consulted to ensure that component/subsystems/system meet the specifications.

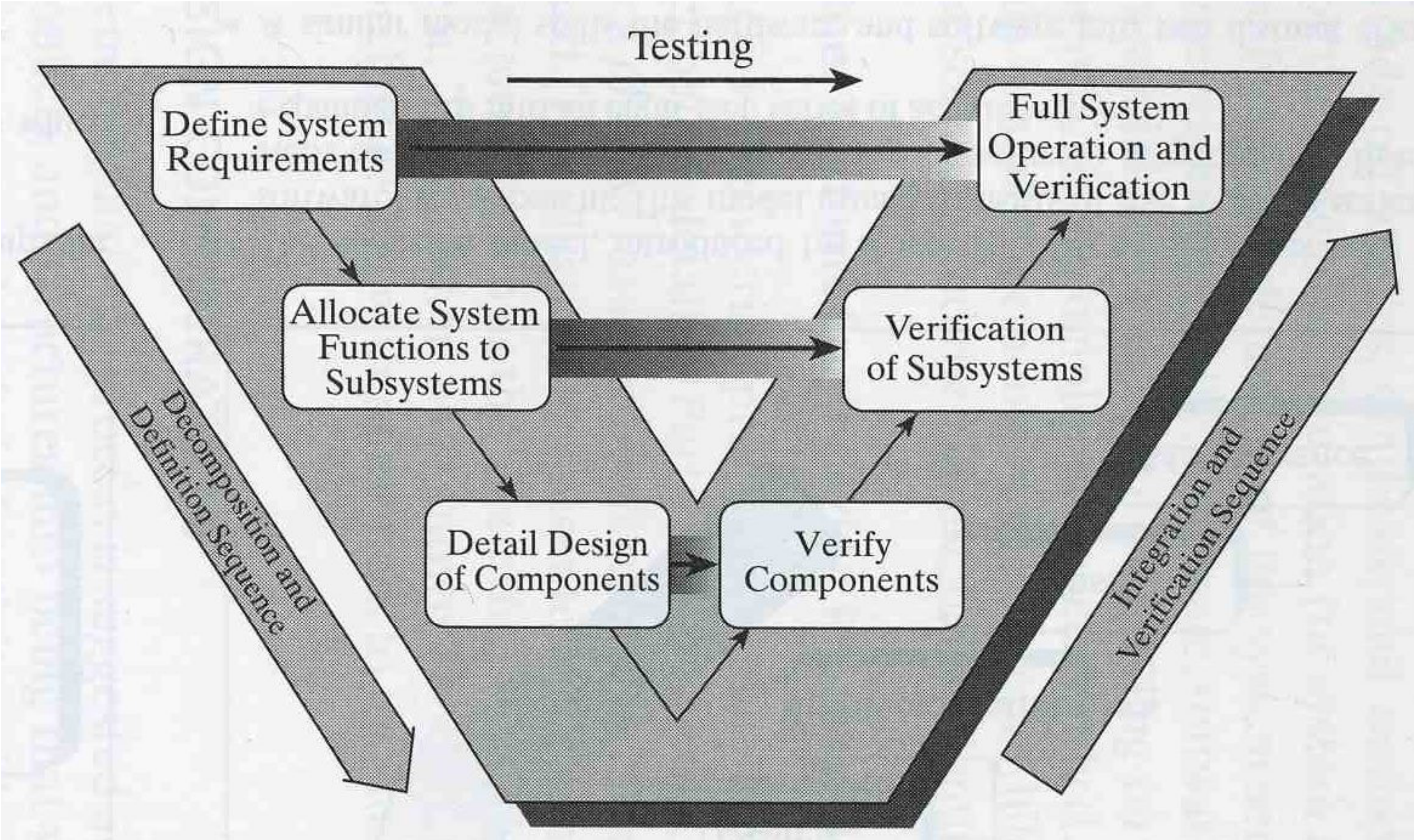
Waterfall Process Models



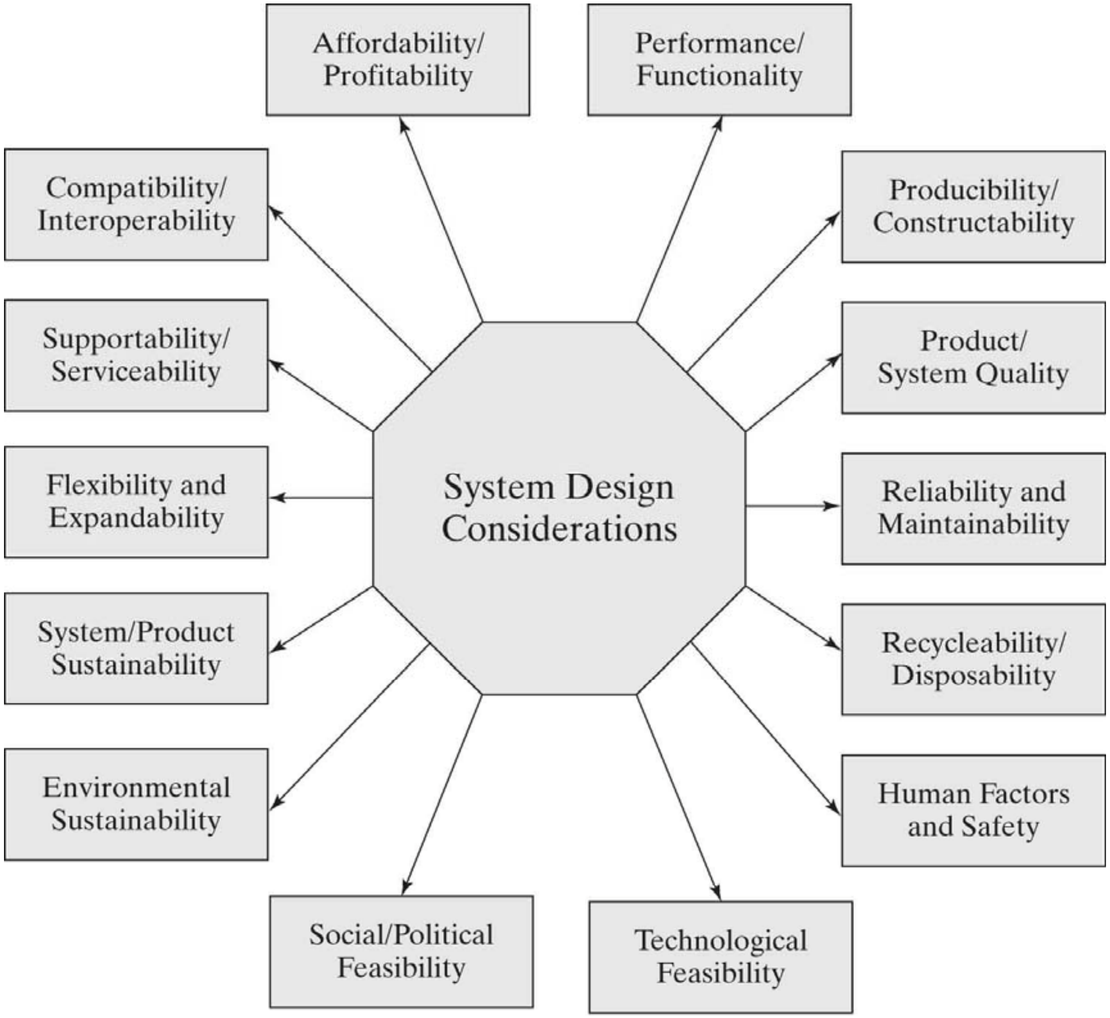
Spiral Process Models



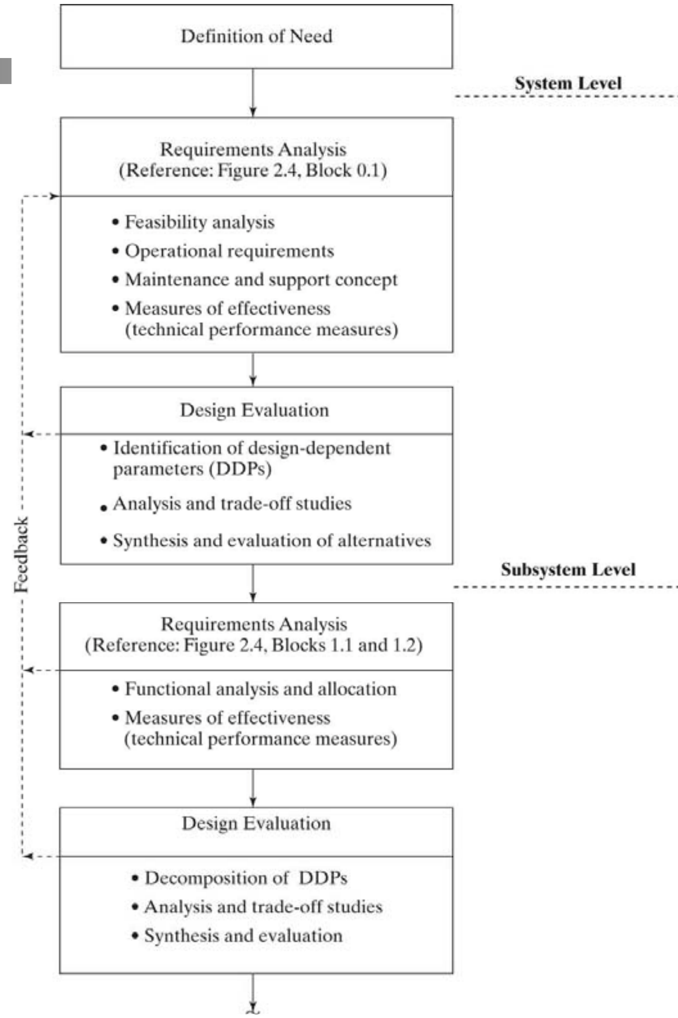
“Vee” Process Models



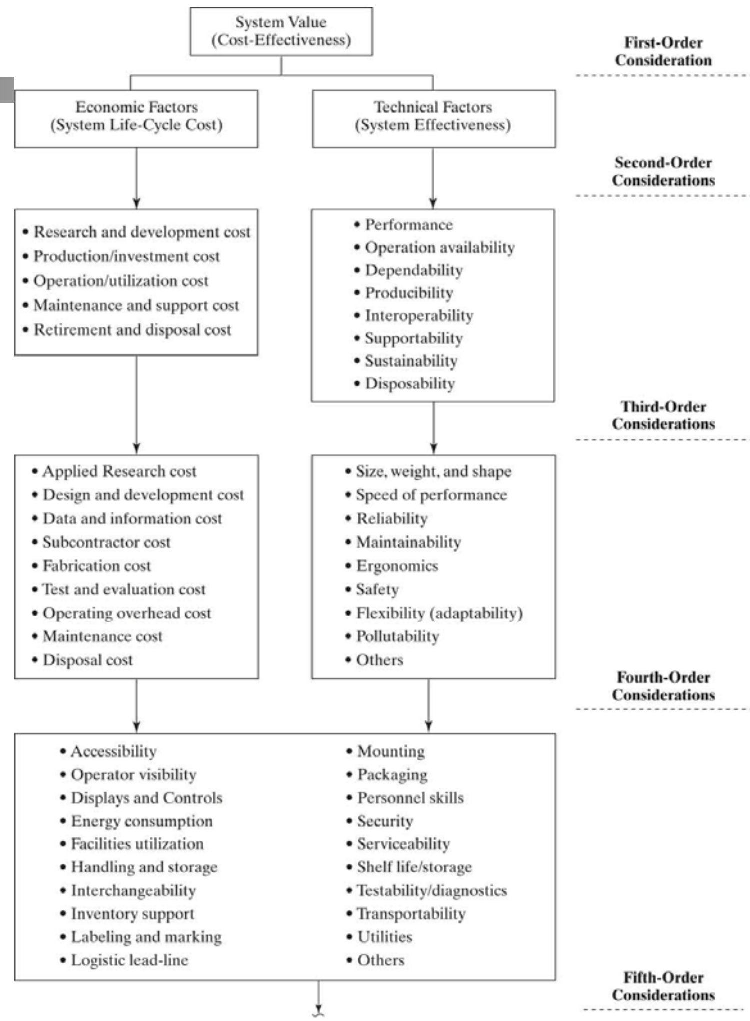
Identifying System Design Considerations



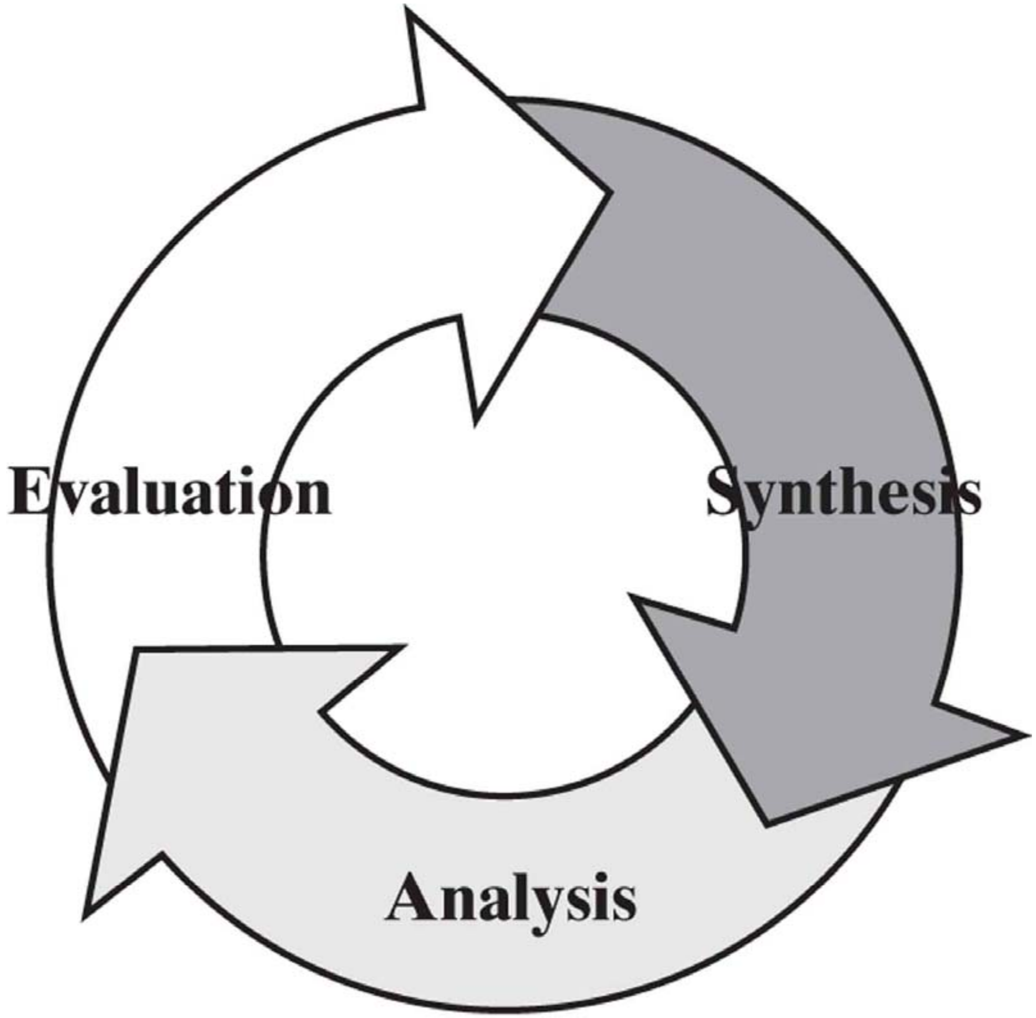
Decomposing System Design Requirements



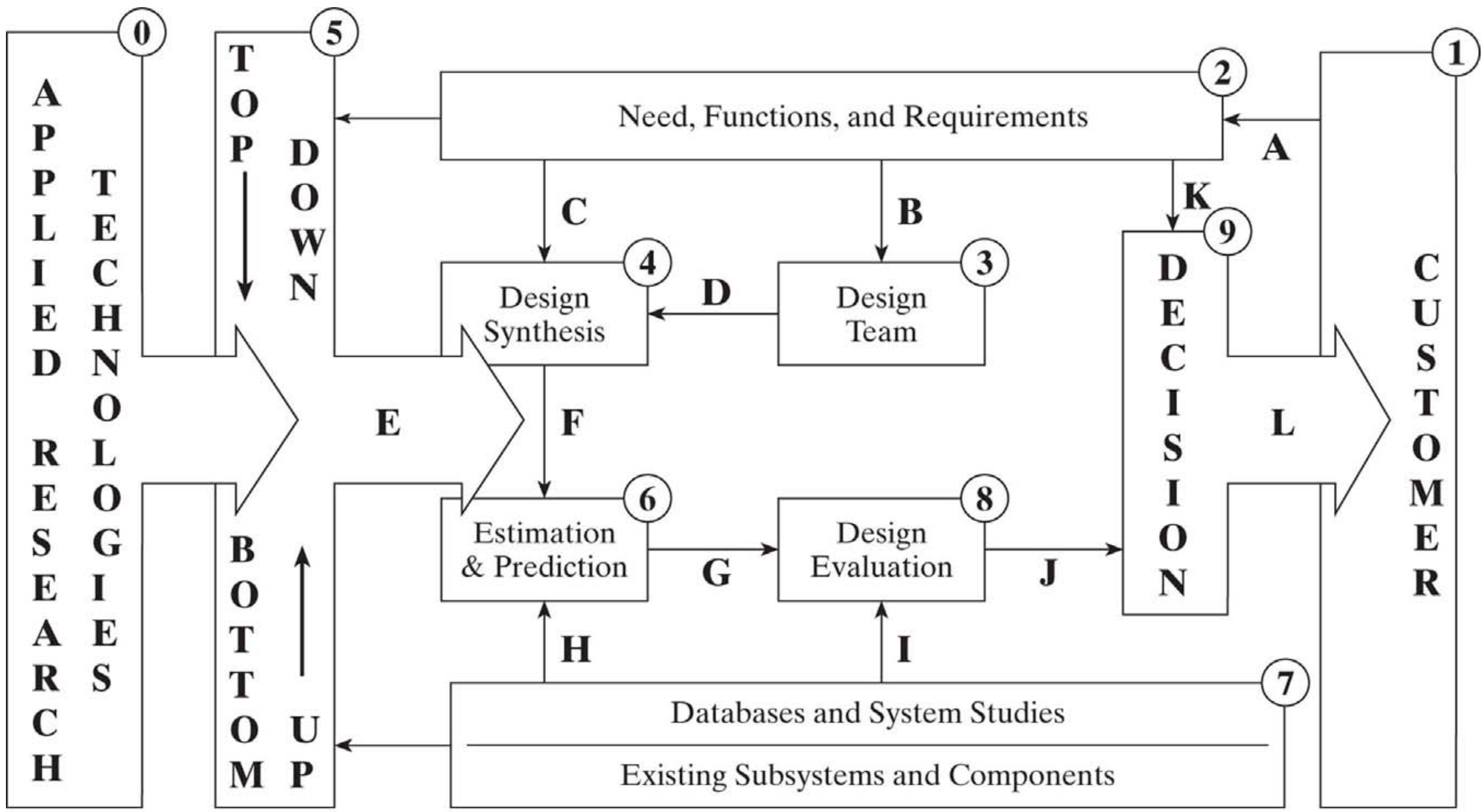
Hierarchy of Design Considerations



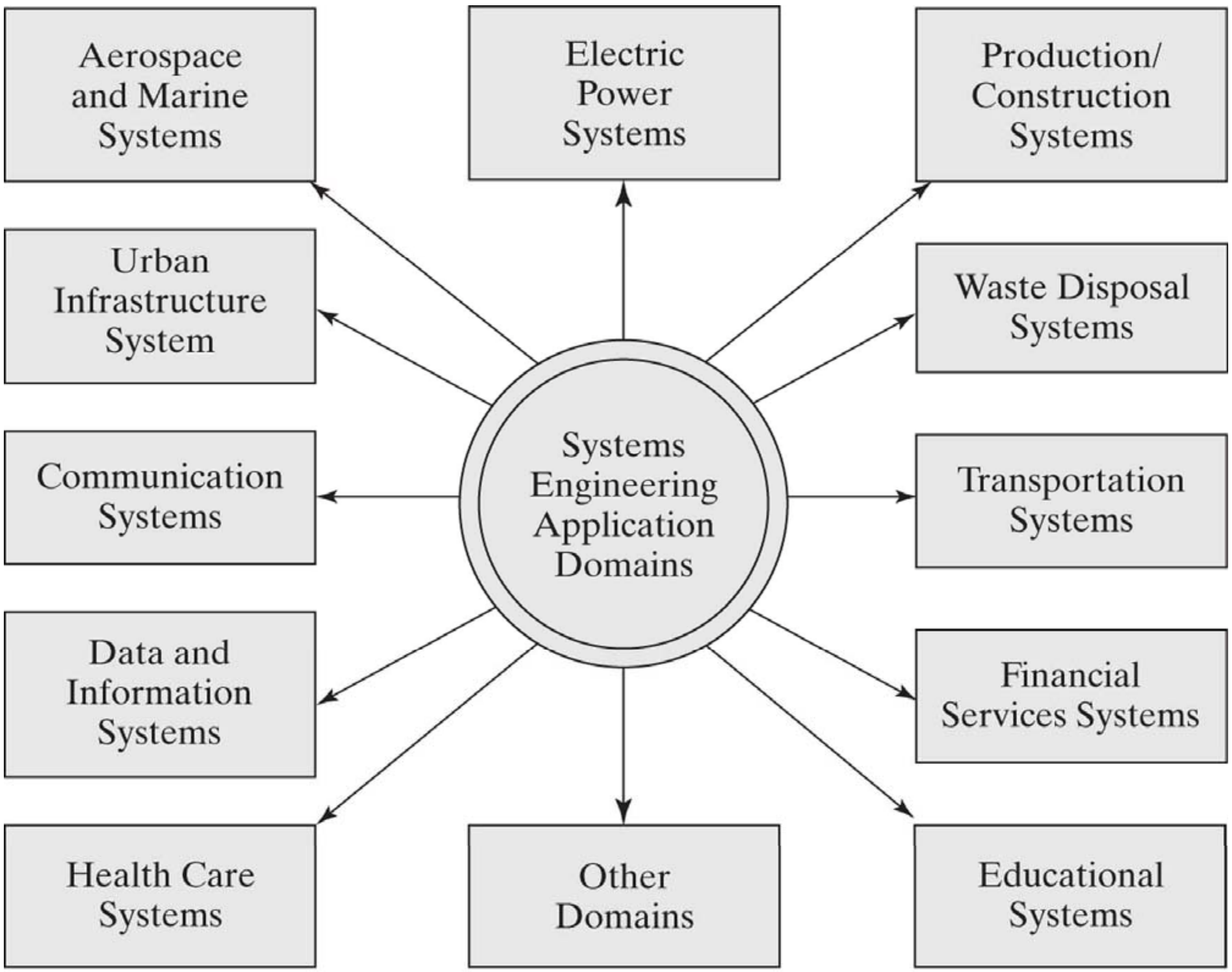
Synthesis, Analysis, and Evaluation Relationships



System Engineering Morphology for Product Realization



Application Areas for Systems Engineering



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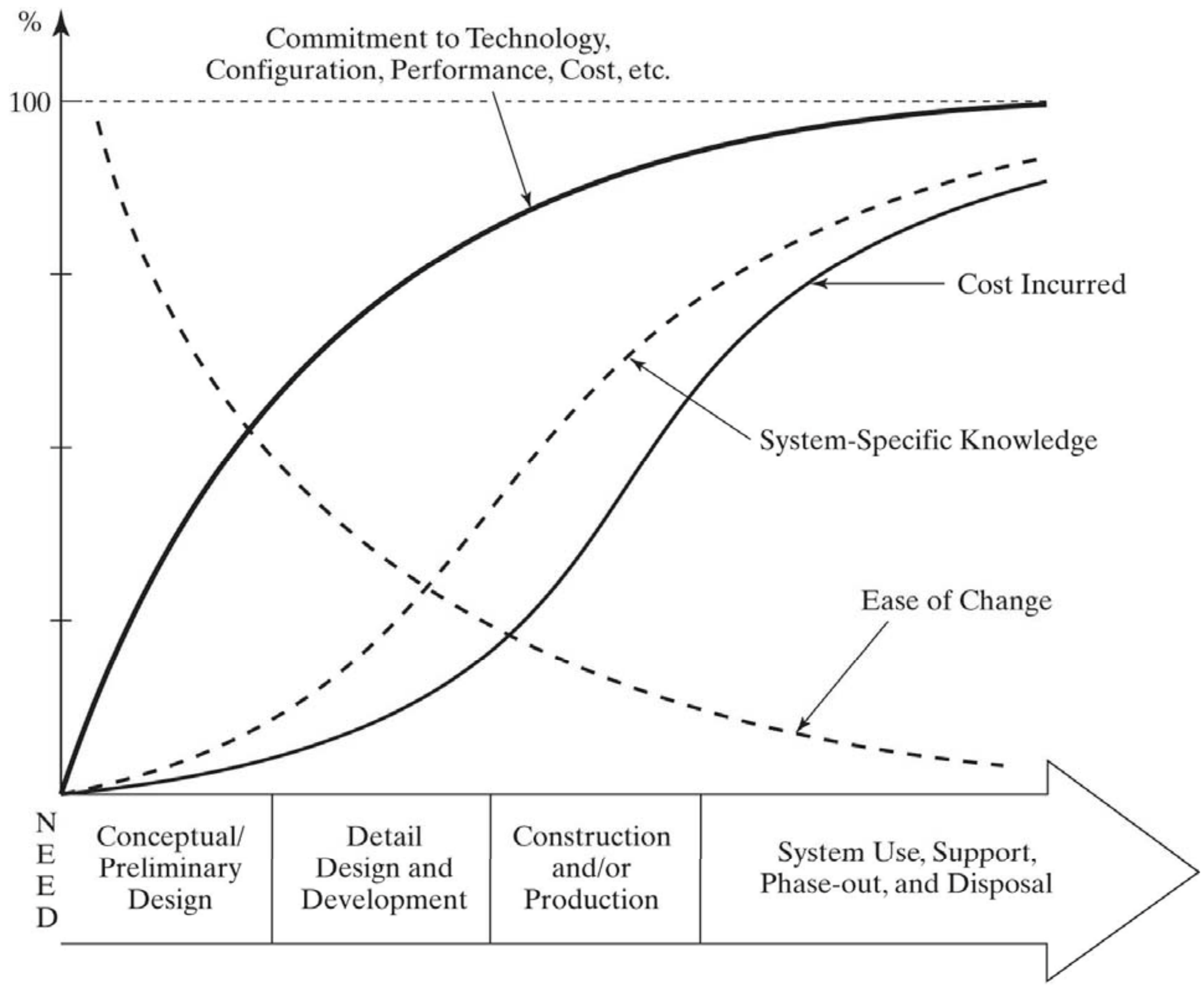
Systems Engineering Impact on Life-Cycle



How Design Is Influenced