Chapter 4

Preliminary System Design

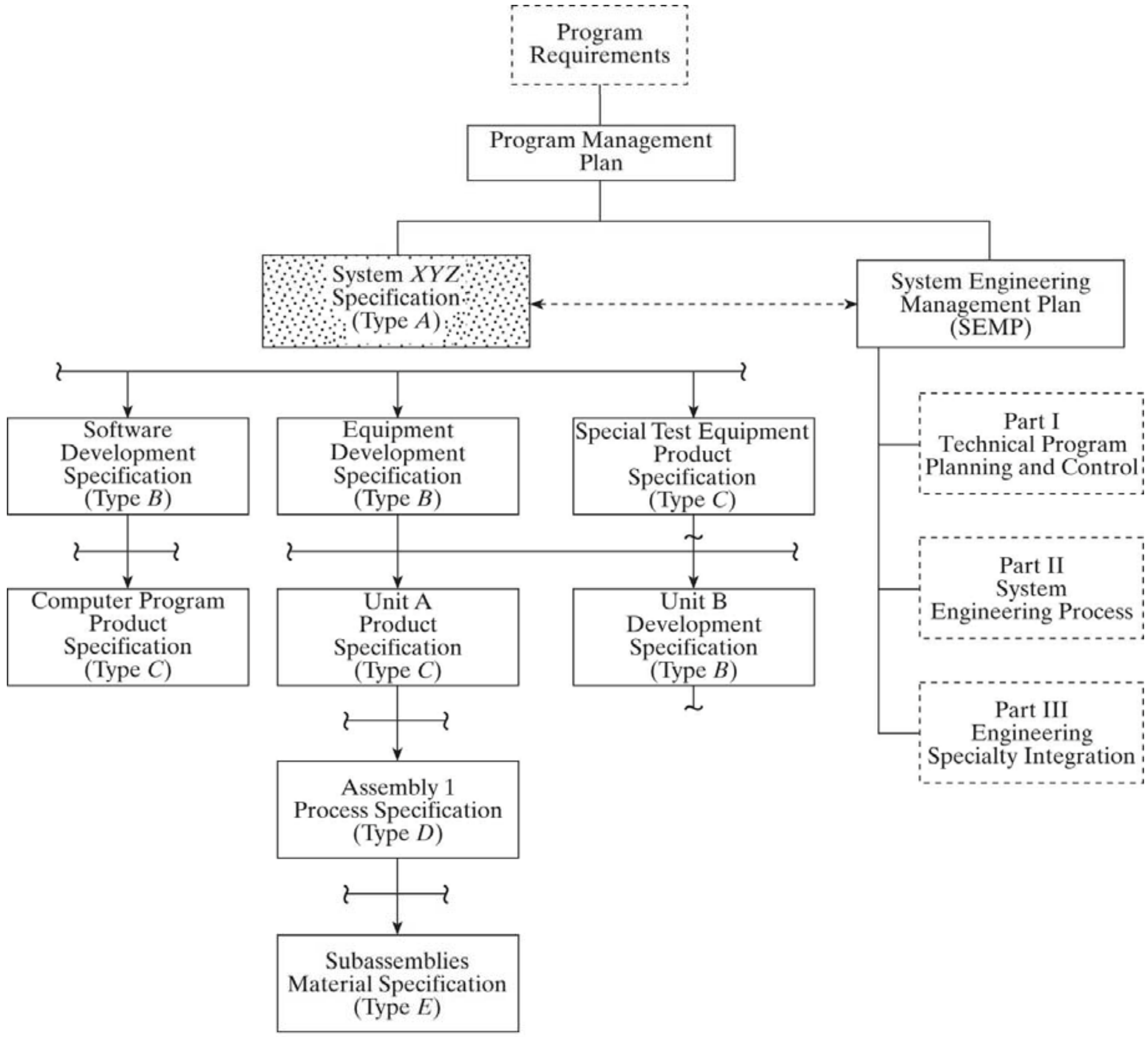
Electrical & Computer Engineering
School of Engineering
THE COLLEGE OF NEW JERSEY

What is it?

- Developing design requirements from system-level requirements for subsystems and major system elements
- Preparing *development*, *product*, *process*, and *material* specifications that are applicable to subsystems
- Accomplishing functional analysis and allocation at the and below the subsystem level
- Establishing detailed design requirements and developing plans for their allocation to engineering specialties
- Identifying and utilizing appropriate engineering design tools and technologies
- Conducting trade-off studies for both design and operational effectiveness
- Conducting design reviews at predetermined points in time

} Preliminary System Design Process

Program Documentation Tree



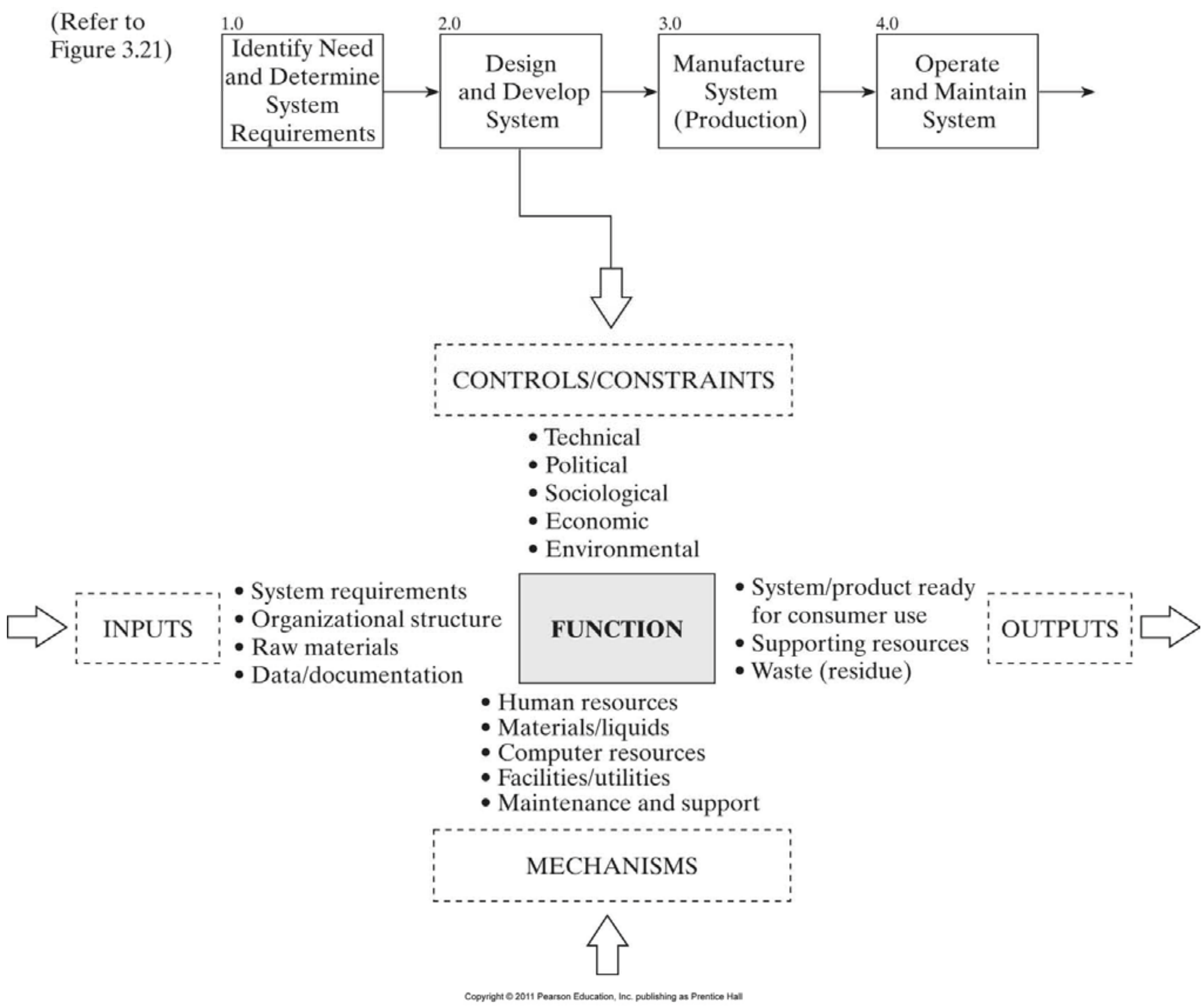
Program Documentation Tree

- System Specification (Type A)
  - Technical, performance, operational, and support characteristics
  - Results of feasibility analysis
  - Operational requirements
  - Maintenance and support concept
  - Appropriate TPMs
  - Functional description
  - Design requirements
  - Subsystem allocation
- Development Specification (Type B)
  - Technical requirements for items below system level
  - Similar to System Specification

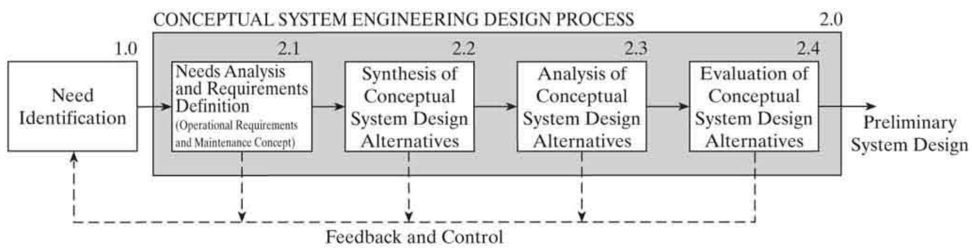
Program Documentation Tree

- Product Specification (Type C)
  - Technical requirements of “off-the-shelf” items below system level
- Process Specification (Type D)
  - Technical requirements associated with processes
  - Technical requirements associated with services
- Material Specification (Type E)
  - Technical requirements of raw materials

Identification of Resource Requirements (mechanisms)



Some Documentation Formats



Activity Number	Activity Description	Required Inputs	Expected Outputs	Resource Requirements
1.0	Need identification	Customer surveys; marketing inputs; shipping and servicing department logs; market niche studies; competitive product research.	A specific qualitative and quantitative needs statement responding to a current deficiency. Care must be taken to state this need in functional terms.	Benchmarking; statistical analyses of data (i.e., data collected as a result of surveys and consolidated from shipping and servicing logs, etc.).
2.1	Needs analysis and requirements definitions	A specific qualitative and quantitative needs statement expressed in functional terms.	Qualitative and quantitative factors pertaining to system performance levels, geographical distribution of products, expected use profiles, user/consumer environment; operational life cycle, effectiveness requirements, the levels of maintenance and support, consideration of the applicable elements of logistic support, the support environment, and so on.	Quality function deployment (QFD), input–output matrix, checklists; value engineering; statistical data analysis; trend analysis; matrix analysis; parametric analysis; various categories of analytical models and tools for simulation studies, trade-offs, etc.
2.2	Synthesis of conceptual system design alternatives	Results from needs analysis and requirements definition process; technology research studies; supplier information.	Identification and description of candidate conceptual system design alternatives and technology applications.	Pugh's concept generation approach; brainstorming; analogy; checklists.
2.3	Analysis of conceptual system design alternatives	Candidate conceptual solutions and technologies; results from the needs analysis and requirements definition process.	Approximation of the "goodness" of each feasible conceptual solution relative to the pertinent parameters, both direct and indirect. This goodness could be expressed as a numeric rating, probabilistic measure, or fuzzy measure.	Indirect system experimentation (e.g., mathematical modeling and simulation); parametric analyses; risk analyses.
2.4	Evaluation of conceptual system design alternatives	Results from the analysis task in the form of a set of feasible conceptual system design alternatives.	A single or short-listed set of preferred conceptual system designs. Further, a "feel" for how much better the preferred approach(es) is relative to all other feasible alternatives.	Design-dependent parameter approach; generation of hybrid numbers to represent candidate solution "goodness"; conceptual system design evaluation display.

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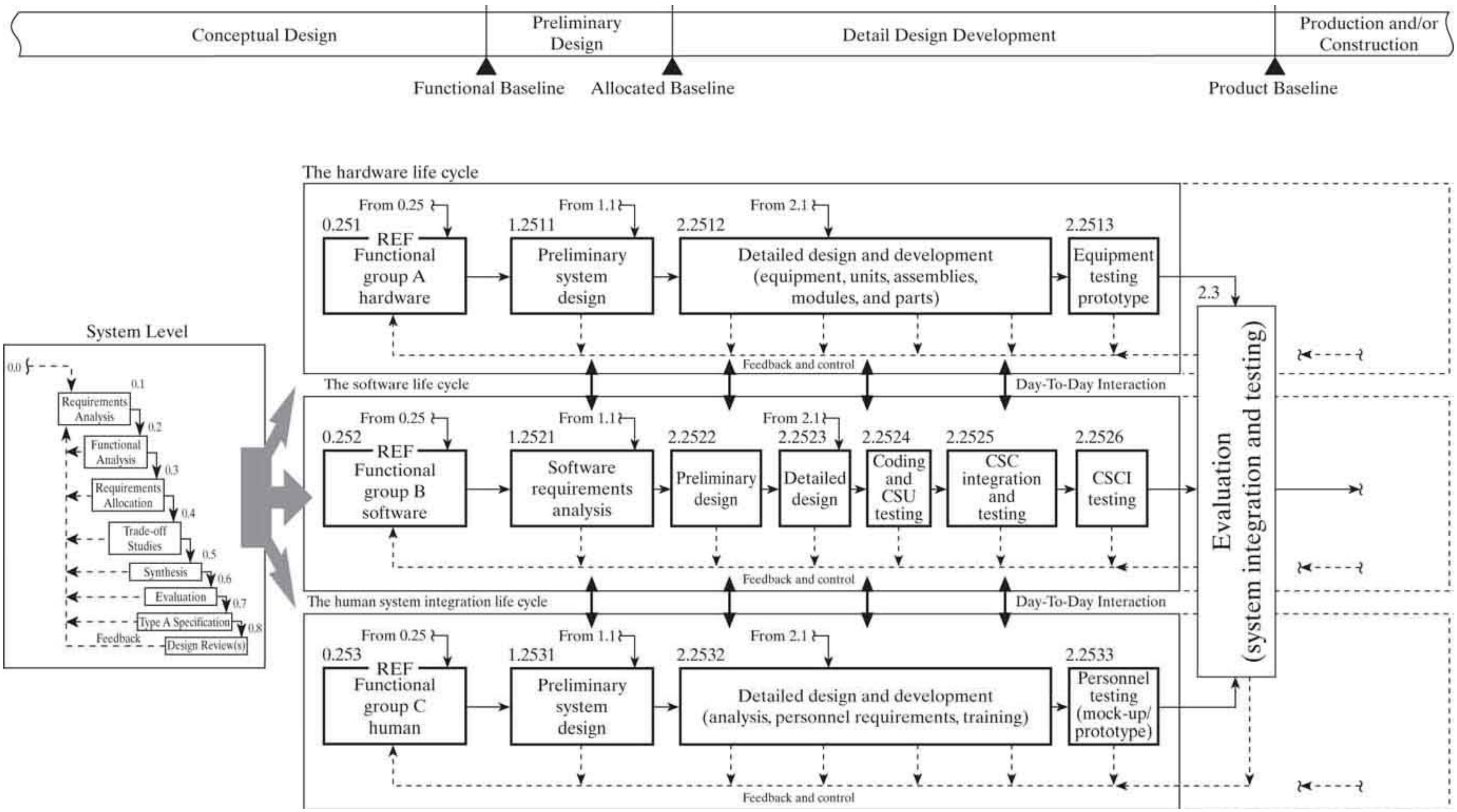
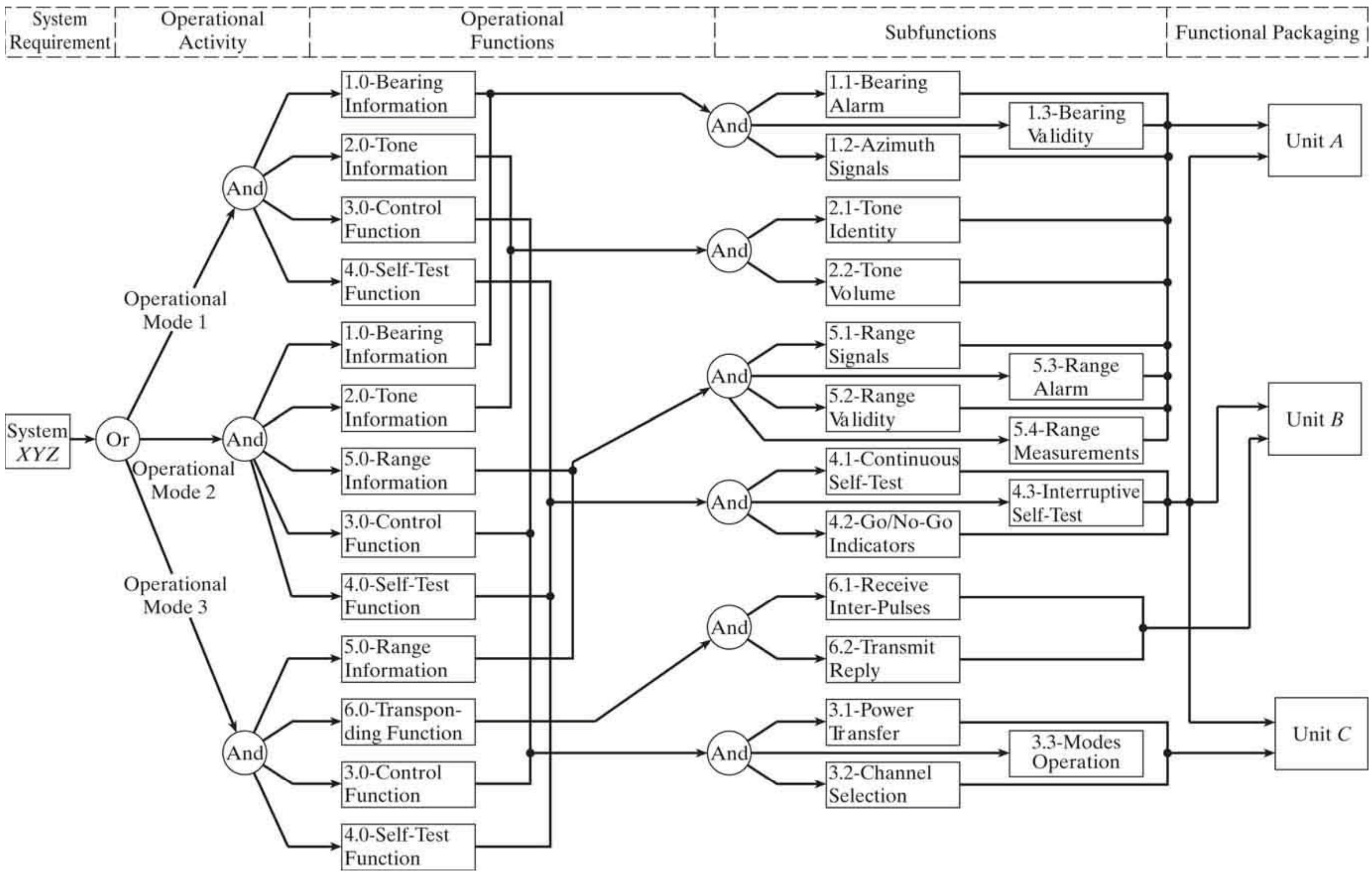
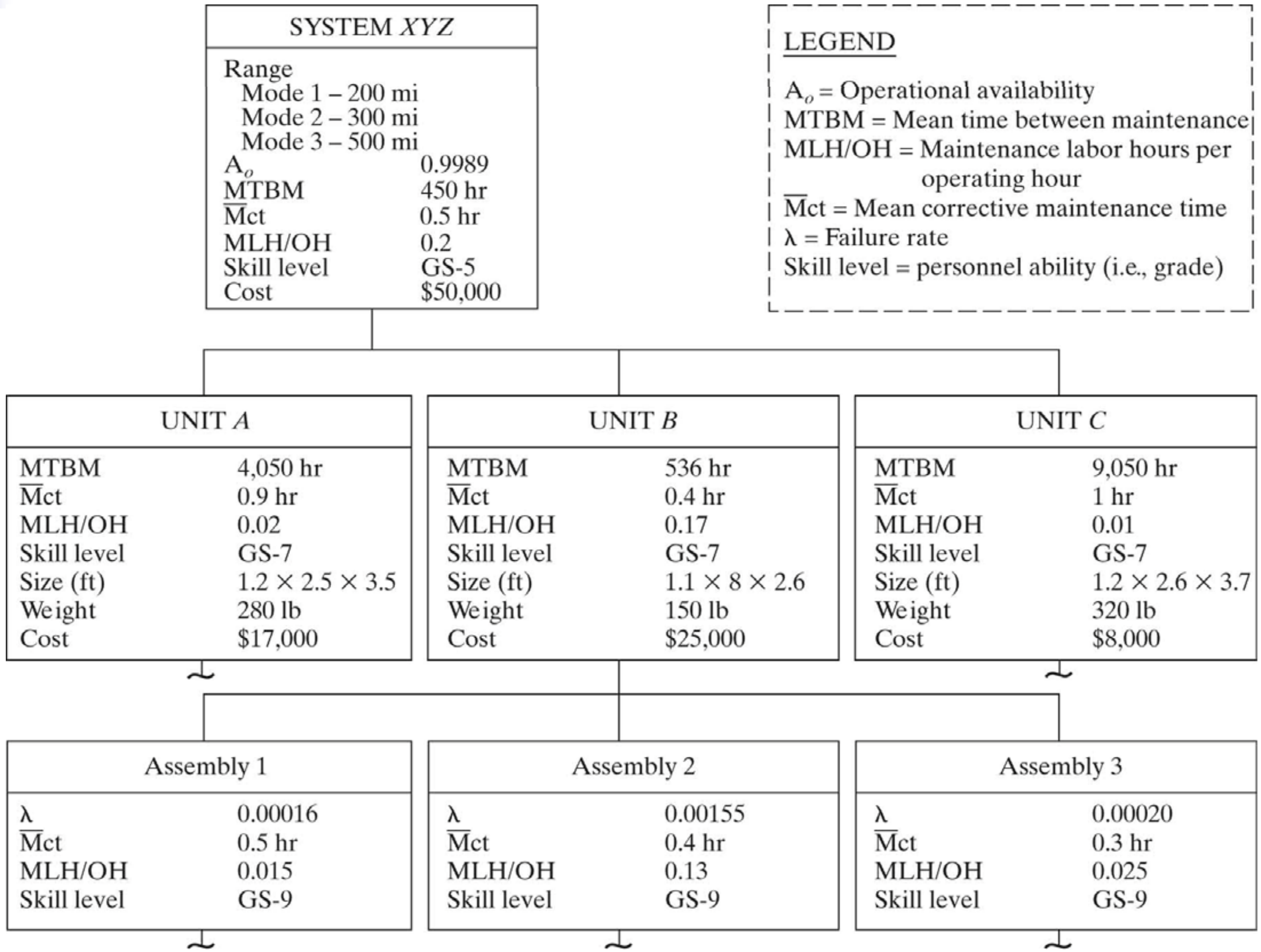
Evolution Example



Functional Packaging into Major Elements



Requirements Allocation Example



Functional Analysis As An Input To ...

- Functional packaging of system elements
- Reliability analysis
- Maintainability analysis
- Human factors analysis
- Maintenance and logistics support
- Producibility and disposability analysis
- Economics analysis

Detailed Design Considerations

- Design for functional capability
- Design for reliability
- Design for maintainability
- Design for usability and safety
- Design for supportability and serviceability
- Design for producibility and disposability
- Design for affordability

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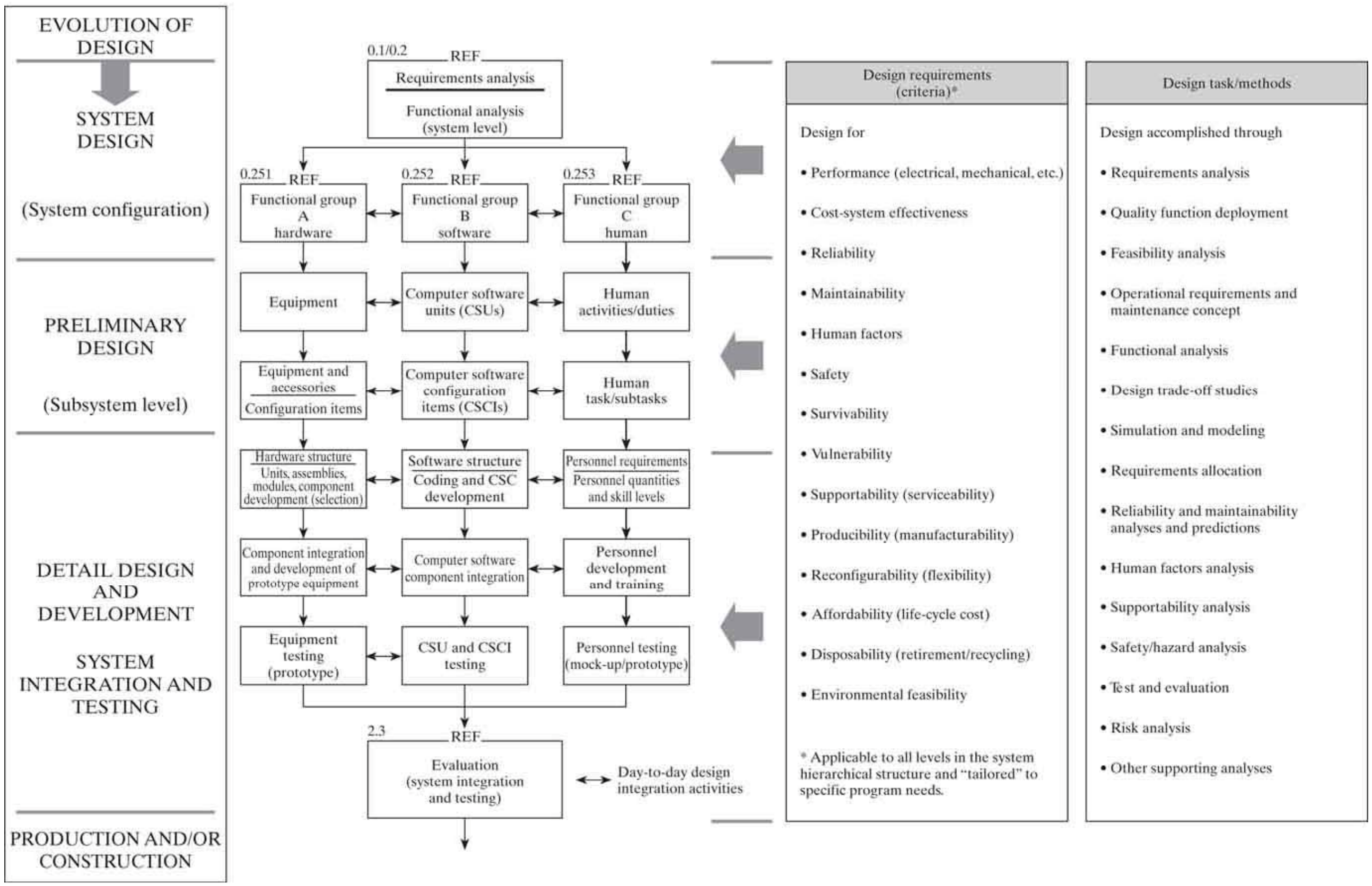
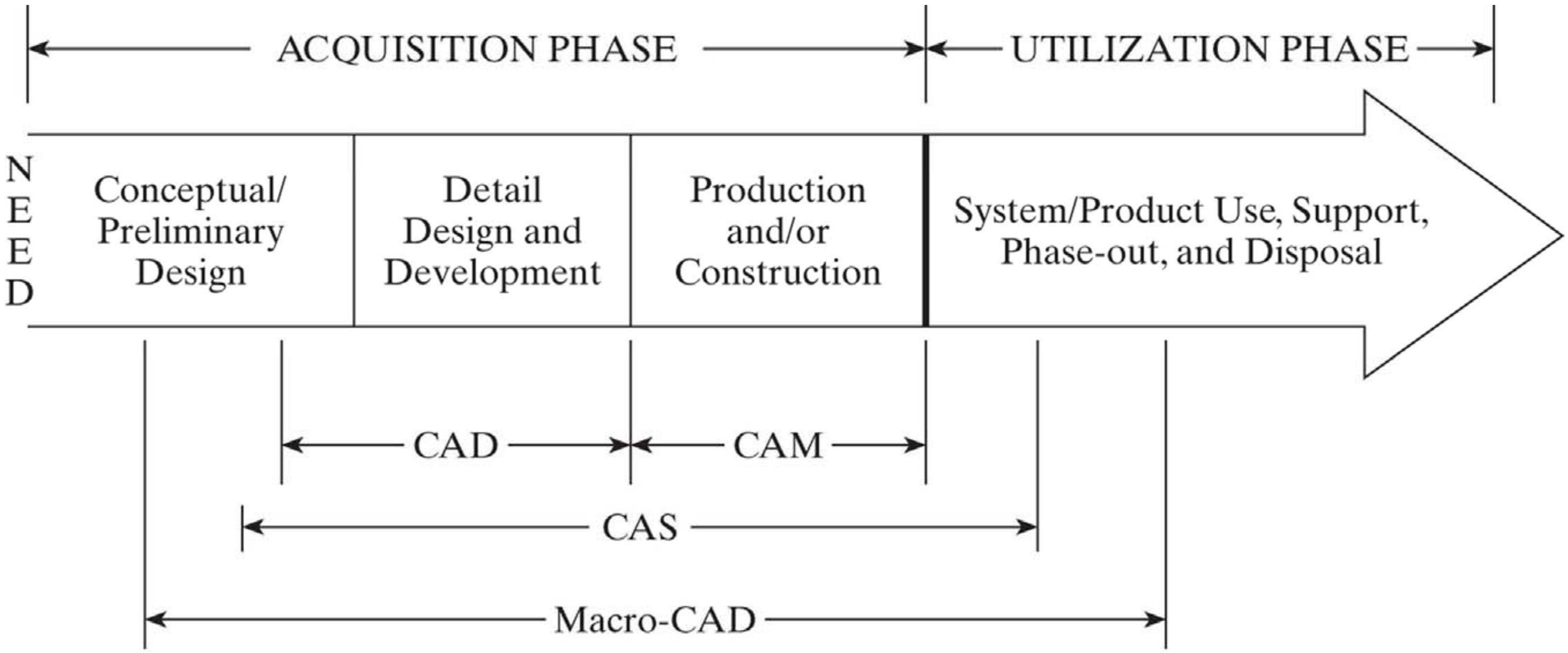
… Example

INTEGRATION OF THE HARDWARE, SOFTWARE, AND HUMAN LIFE CYCLES



CAD, CAM, CAS, Macro-CAD



Some CAD, CAM, CAS, Macro-CAD Advantages

- Designer can address many different alternatives in a relative short time frame
- Designer is able to simulate, and verify design, fro a greater number of configurations
- The ability to incorporate design changes is enhanced, both in terms of the reduced time for accomplishing them and in the accuracy of data presentation
- The quality of design data is improved, both in terms of methods for data presentation and in the reproduction of individual data elements
- The availability of an improved database earlier in the system life cycle facilitates the training of personnel

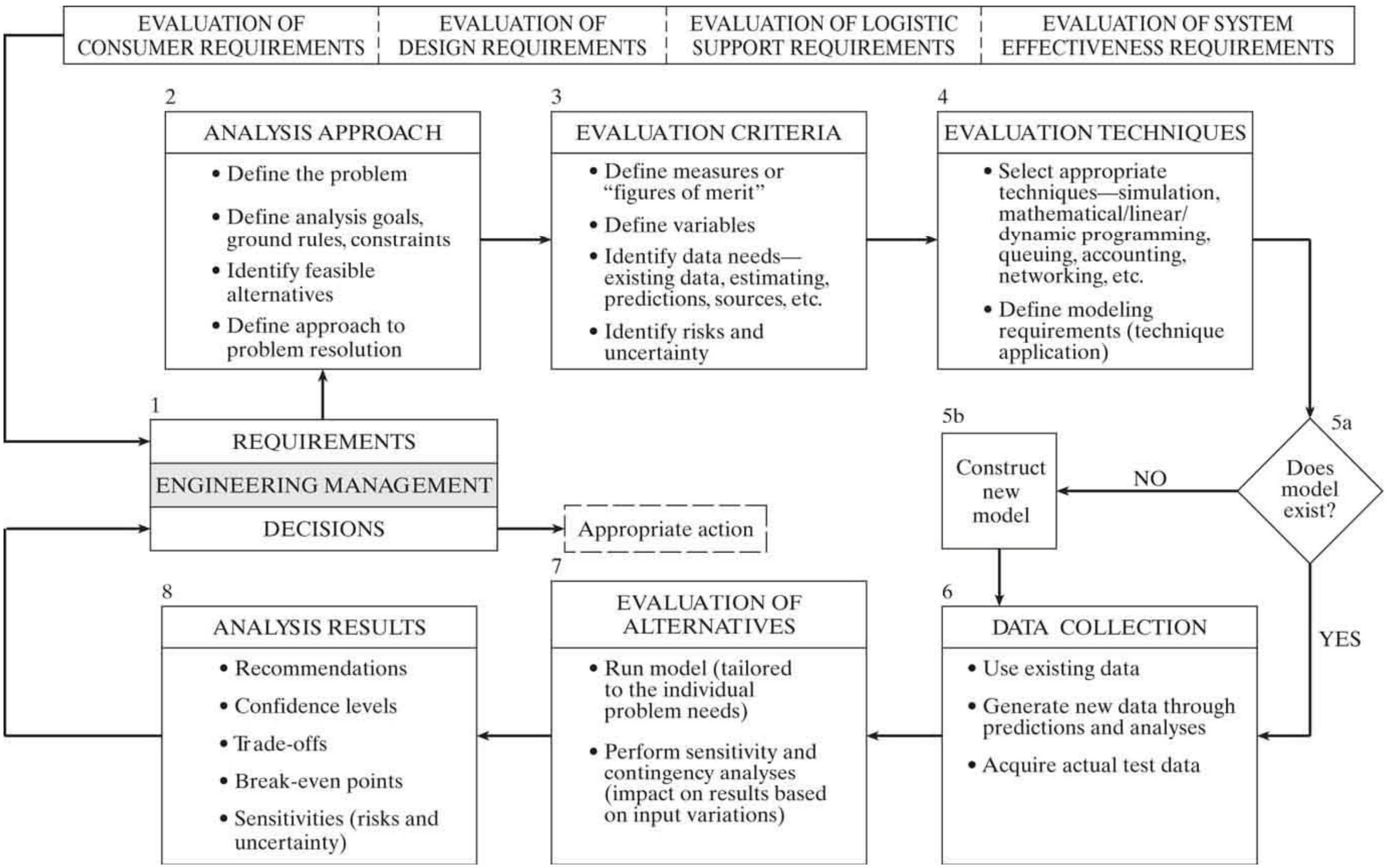
Analytical Models Usage

- The model should represent the dynamics of the system configuration being evaluated
- The Model should highlight those factors that are most relevant to the problem at hand
- The model should be comprehensive by including *all* relevant factors and be reliable
- Model design should be simple enough to allow for implementation in problem solving
- Model design should incorporate provisions for ease of modification or expansion

Mathematical Models

- Will uncover relationships between the various aspects of a problem that are not apparent in the verbal description
- Enable a comparison of *many* possible solutions and aids in the selecting the best among them rapidly and efficiently
- Explain situations that have been left unexplained in the past by indicating cause-and effect relationships
- Readily indicate the type of data that should be collected to deal with the problem in a quantitative manner
- Facilitate the prediction of future events
- Aid in identifying areas of risk and uncertainty

A Generic Systems Analysis Process



Example of the Application of Models