Chapter 5

Detailed System Design and Development

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

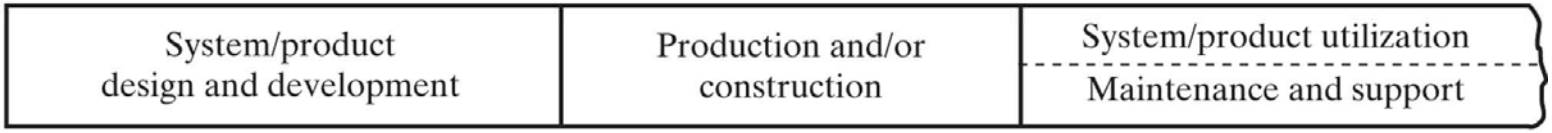
What is it?

- Developing design requirements for all lower-level components of the system
- Implementing the necessary technical activities to fulfill all design objectives
- Integrating system elements and activities
- Utilizing design tools and aids
- Preparing design data and documentation
- Developing engineering and physical prototype models
- Implementing design review, evaluation, and feedback capabilities
- Incorporating design changes as required

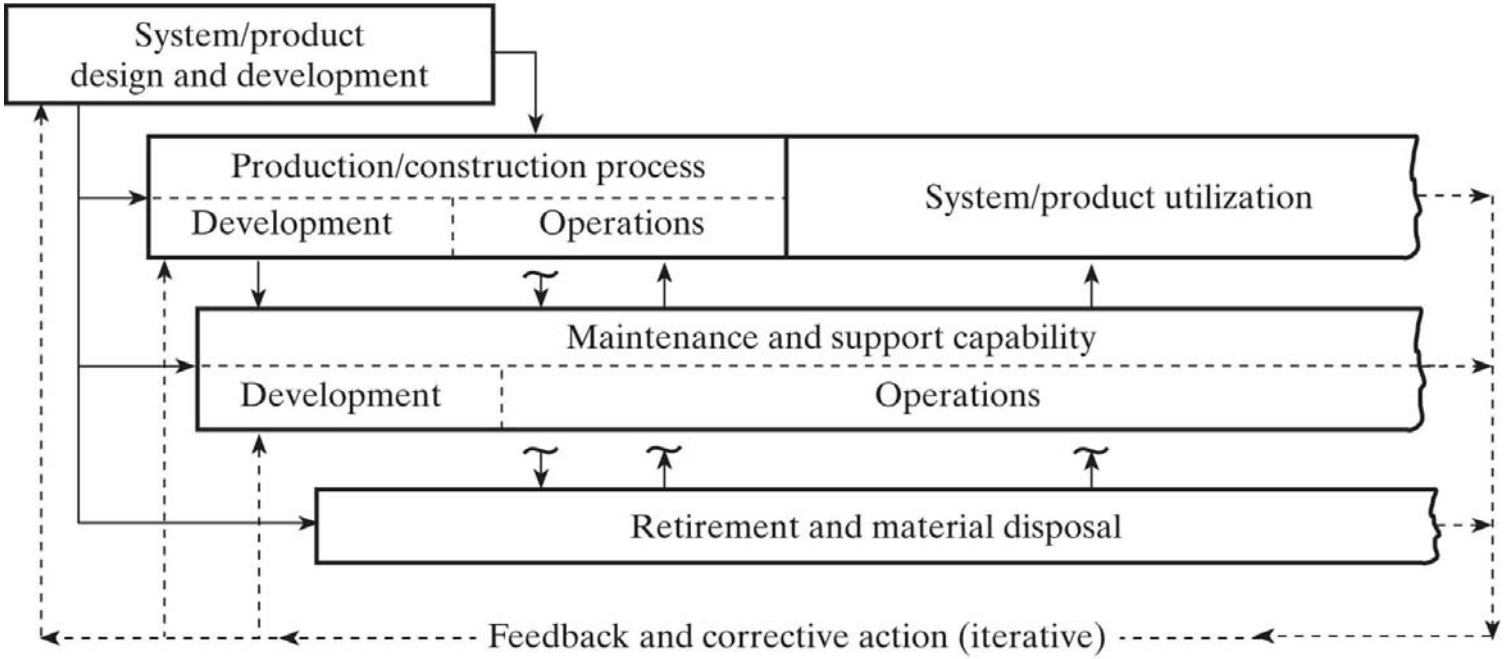
Detailed System Design And Development

Sequential vs. Concurrent Approaches ...

THE SYSTEM/PRODUCT LIFE CYCLE—SERIAL APPROACH



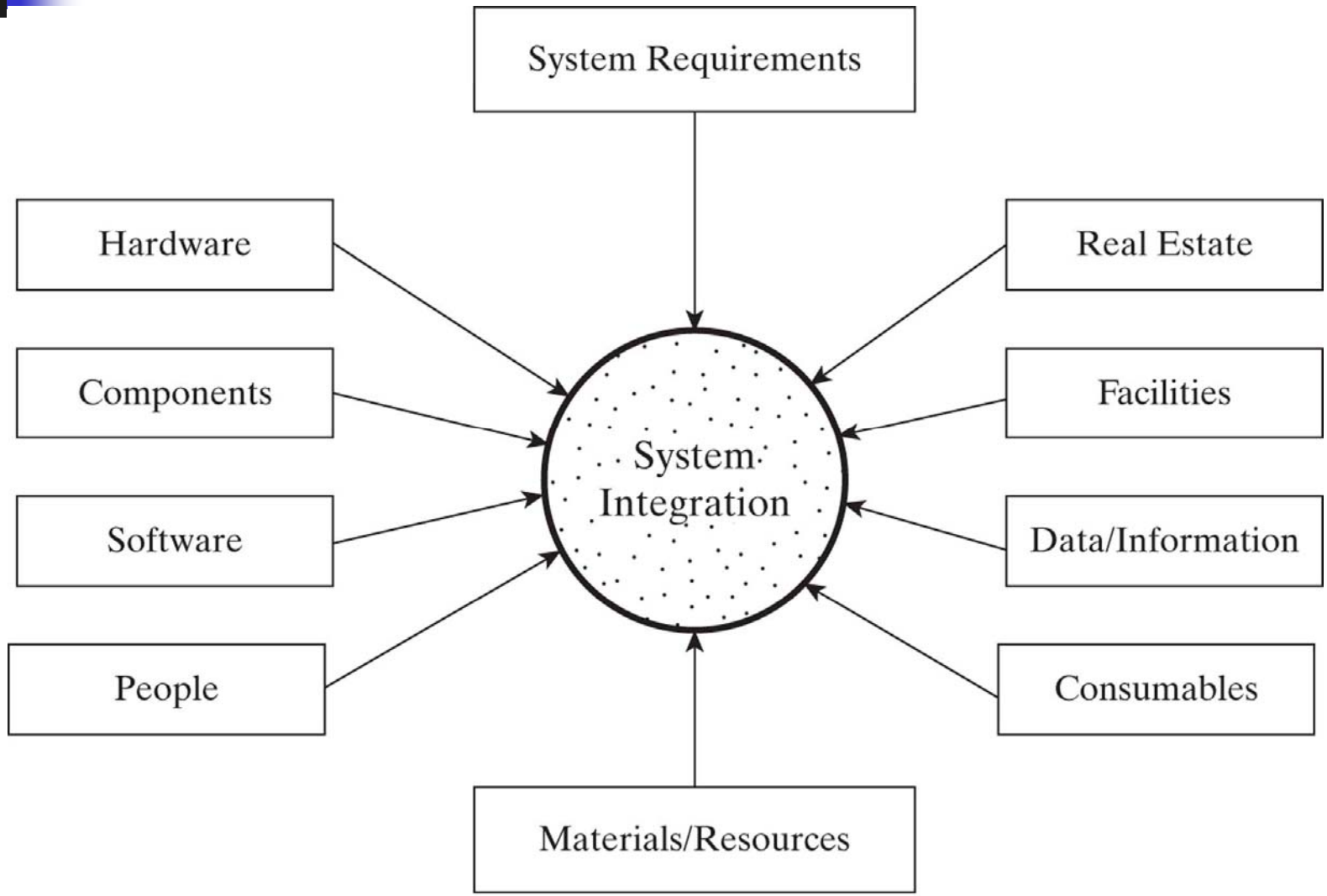
THE SYSTEM/PRODUCT LIFE CYCLE—CONCURRENT APPROACH



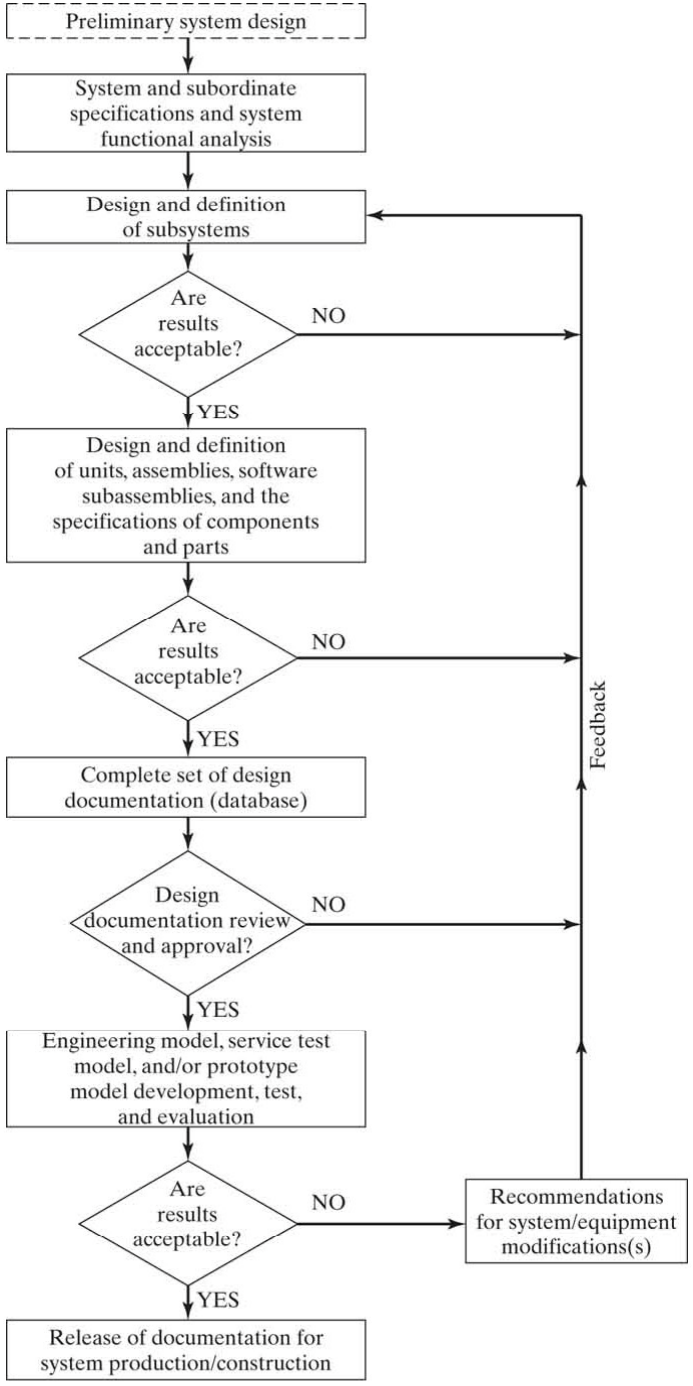
Integration of Engineering Disciplines

- Engineering expertise
- Engineering technical support
- Non technical support

Integration of Engineering Disciplines



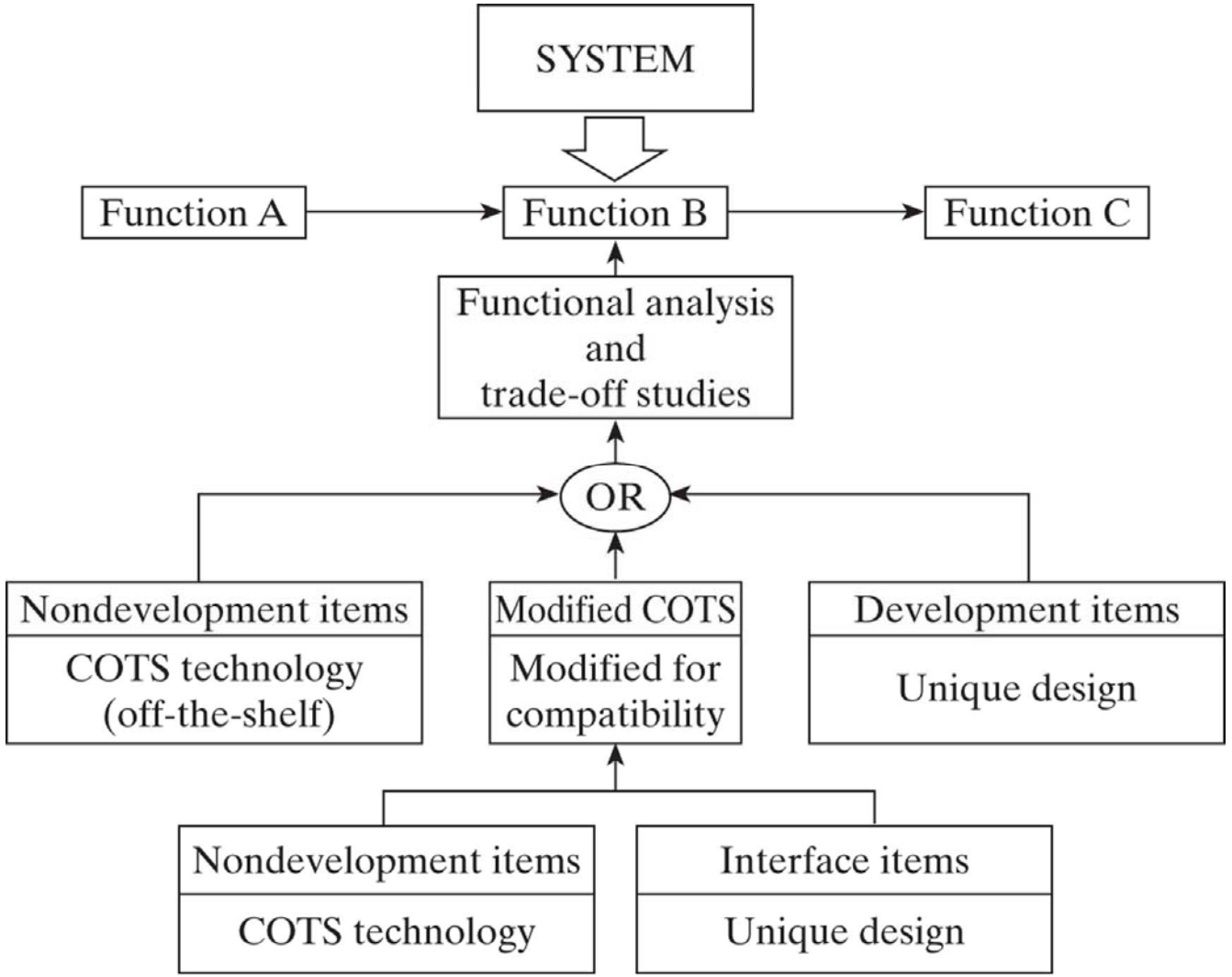
Basic Design Sequence



Alternative Approaches in the Selection of Resources

- Select a standard component that is commercially available and for which there are a multiple quantity of viable suppliers
- Modify an existing commercially available off-the-shelf item
- Design an develop a new and unique component to meet a specific functional requirement

Alternative Approaches in the Selection of Resources



Muck-Ups

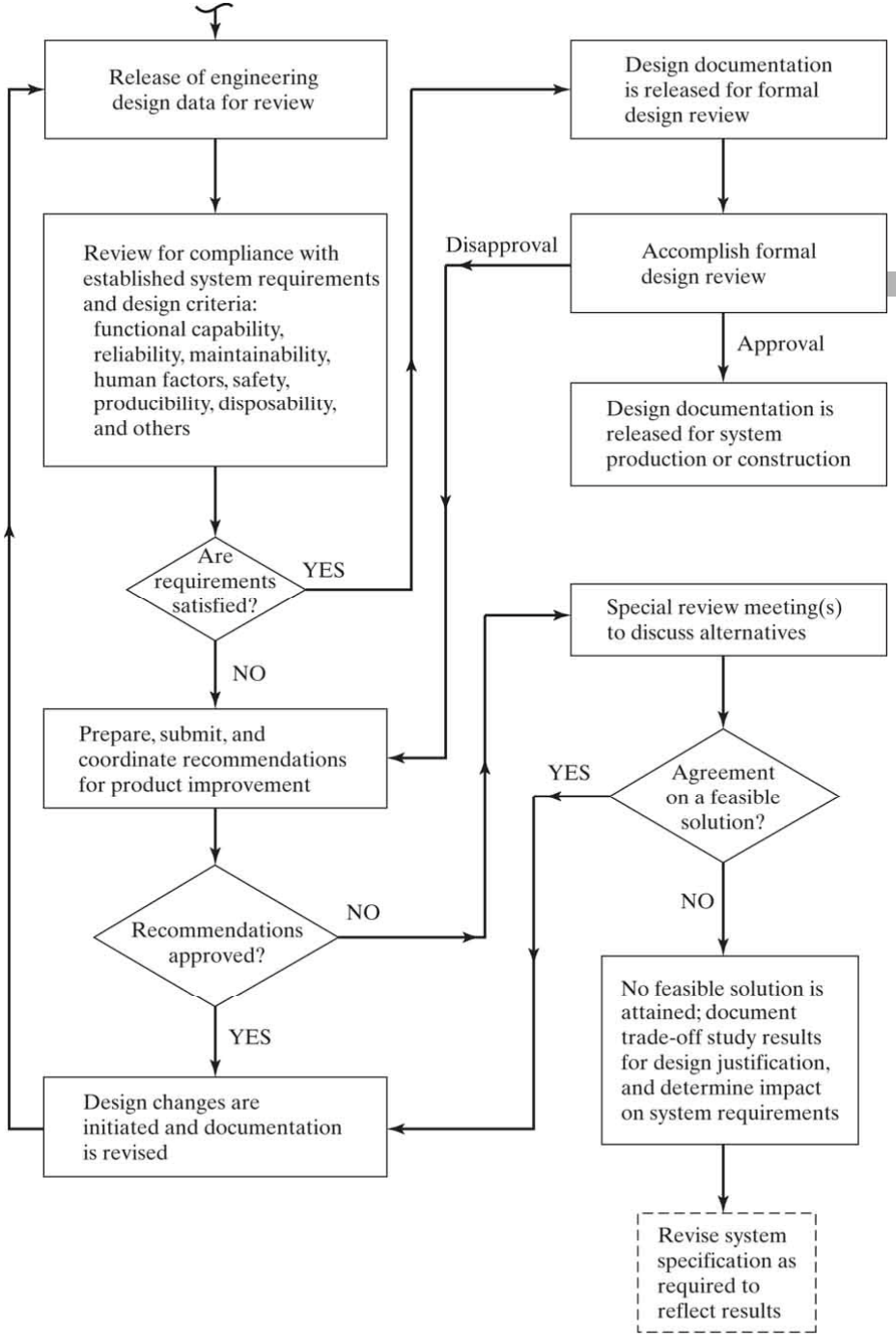
- Provides the design engineer with the opportunity of experimenting with ...
- Provides the reliability-maintainability-human factors engineer with the opportunity to accomplish a more effective review of a proposed design
- Provides the maintainability-human factors engineer with a tool for prediction and detailed task analyses
- Provides the design engineer with a tool to convey the final design approach
- Serves as a marketing tool
- Facilitates the training of personnel
- Is utilized by production and industrial engineering personnel in developing fabrication and assembly processes, and in the design of factory tooling and fixtures
- May serve as a tool for the verification of a modification kit

Methods of Design Documentation

- Design drawings
- Materials and parts lists
- Analyses and reports

Engineering Drawing Classifications

1. *Arrangement drawing*—shows in any projection or perspective, with or without controlling dimensions, the relationship of major units of the item covered.
2. *Assembly drawing*—depicts the assembled relationship of (a) two or more parts, (b) a combination of parts and subassemblies, or (c) a group of assemblies required to form the next higher indenture level of the equipment.
3. *Connection diagram*—shows the electrical connections of an installation or of its component devices or parts.
4. *Construction drawing*—delineates the design of buildings, structures, or related construction (including architectural and civil engineering operations).
5. *Control drawing*—an engineering drawing that discloses configuration and configuration limitations, performance and test requirements, weight and space limitations, access clearances, pipe and cable attachments, support requirements, etc., to the extent necessary that an item can be developed or procured on the commercial market to meet the stated requirements. Control drawings are identified as envelope control (i.e., configuration limitations), specification control, source control, interface control, and installation control.
6. *Detail drawing*—depicts complete end item requirements for the part(s) delineated on the drawing.
7. *Elevation drawing*—depicts vertical projections of buildings and structures or profiles of equipment.
8. *Engineering drawing*—an engineering document that discloses by means of pictorial or textual presentations, or a combination of both, the physical and functional end product requirements of an item.
9. *Installation drawing*—shows general configuration and complete information necessary to install an item relative to its supporting structure or to associated items.
10. *Logic diagram*—shows by means of graphic symbols the sequence and function of logic circuitry.
11. *Numerical control drawing*—depicts complete physical and functional engineering and product requirements of an item to facilitate production by tape control means.
12. *Piping diagram*—depicts the interconnection of components by piping, tubing, or hose, and when desired, the sequential flow of hydraulic fluids or pneumatic air in the system.
13. *Running (wire) list*—a book-form drawing consisting of tabular data and instructions required to establish wiring connections within or between items.
14. *Schematic diagram*—shows, by means of graphical symbols, the electrical connections and functions of a specific circuit arrangement.
15. *Software diagrams*—functional flow diagrams, process flows, and coding drawings.
16. *Wiring and cable harness drawing*—shows the path of a group of wires laced together in a specified configuration, so formed to simplify installation.



Design Data Review Cycle

Sample Design Review Checklist

System Design Review Checklist

General

1. System operational requirements defined
2. Effectiveness factors established
3. System maintenance concept defined
4. Functional analysis and allocation accomplished
5. System trade-off studies documented
6. System specification and supporting specifications completed
7. System engineering management plan completed
8. Design documentation completed
9. Logistic support requirements defined
10. Ecological requirements met
11. Societal requirements met
12. Economic feasibility determined
13. Sustainability requirements met

Design Features—Does the design reflect adequate consideration of

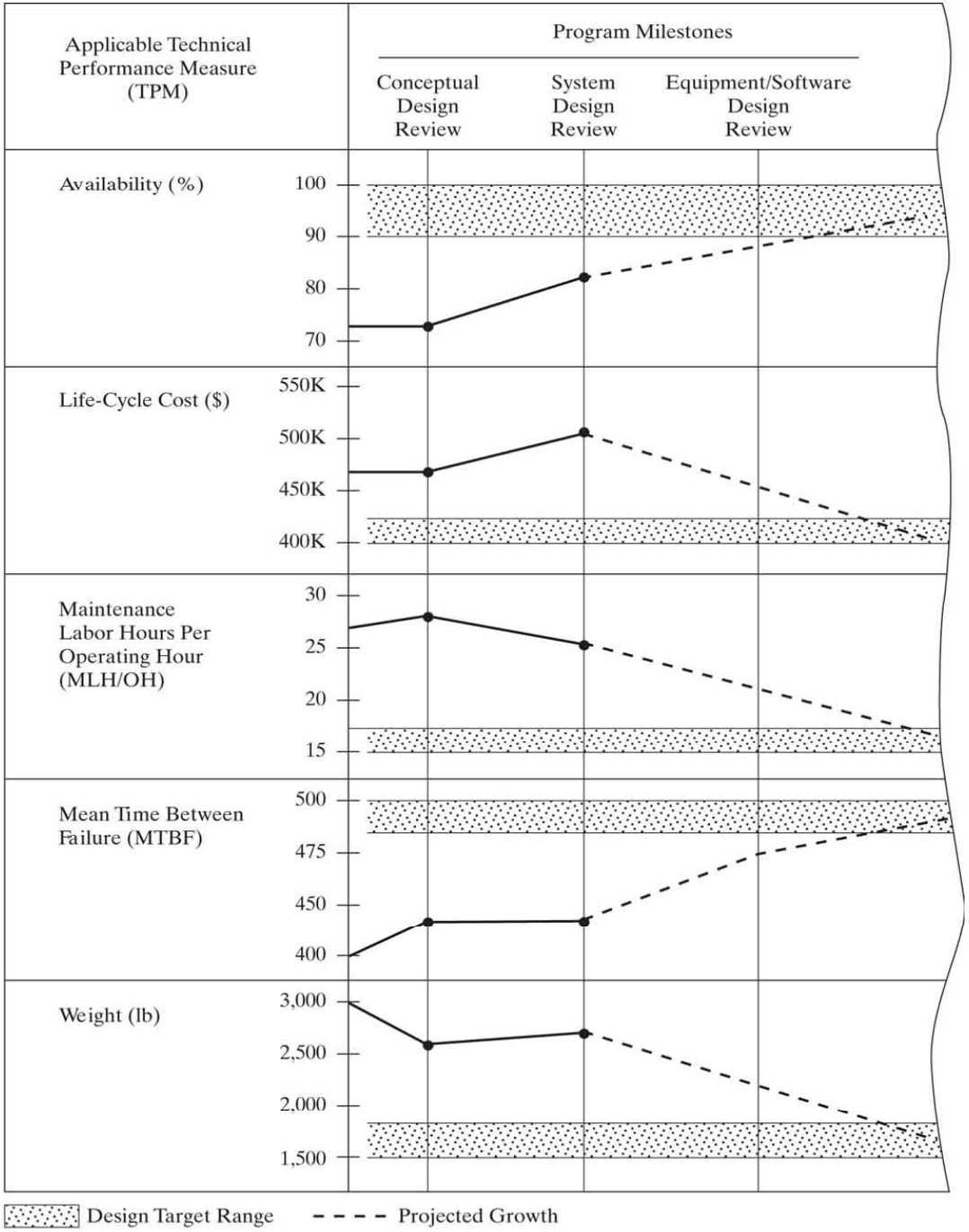
1. Accessibility
2. Adjustments and alignments
3. Cables and connectors
4. Calibration
5. Disposability
6. Environment
7. Fasteners
8. Handling
9. Human factors
10. Interchangeability
11. Maintainability
12. Packaging and mounting
13. Panel displays and controls
14. Producibility
15. Reliability
16. Safety
17. Selection of parts/materials
18. Servicing and lubrication
19. Software
20. Standardization
21. Supportability
22. Testability

When reviewing design (layouts, drawings, parts lists, computer graphics, engineering reports, program plans), this checklist may prove beneficial in covering various program functions and design features. The items listed can be supported with more detailed criteria as discussed in Appendix B. The response to each item listed should be YES.

You Know These …

- Development of engineering models
- System prototype development
- Team discussion and paper exercise …

Parameter Measurement and Evaluation (Example)



Relationship Between TPMs and Responsible Design Disciplines (Example)

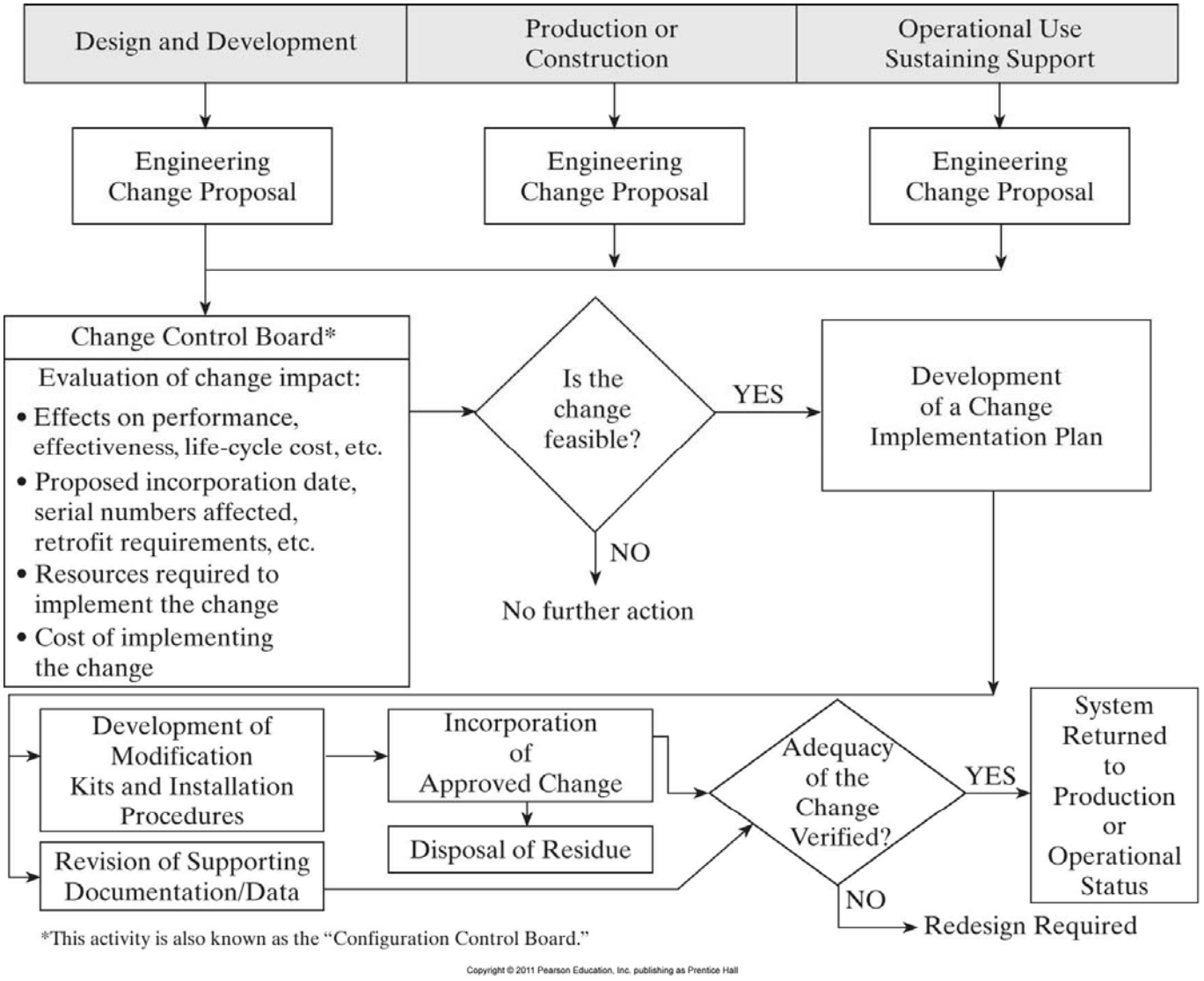
- H = high interest
- M = medium interest
- L = low interest

Technical Performance Measures (TPMs) \ Engineering Design Functions	Aeronautical Engineering	Components Engineering	Cost Engineering	Electrical Engineering	Human Factors Engineering	Logistics Engineering	Maintainability Engineering	Manufacturing Engineering	Materials Engineering	Mechanical Engineering	Reliability Engineering	Structural Engineering	Systems Engineering
Availability (90%)	H	L	L	M	M	H	M	L	M	M	M	M	H
Diagnostics (95%)	L	M	L	H	L	M	H	M	M	H	M	L	M
Interchangeability (99%)	M	H	M	H	M	H	H	H	M	H	H	M	M
Life cycle cost ($350K, unit)	M	M	H	M	M	H	H	L	M	M	H	M	H
$\overline{M}$ct (30 min)	L	L	L	M	M	H	H	M	M	M	M	M	M
MDT (24 hr)	L	M	M	L	L	H	M	M	L	L	M	L	H
MLH/OH (15)	L	L	M	L	M	M	H	L	L	L	M	L	H
MTBF (300 hr)	L	H	L	M	L	L	M	H	H	M	H	M	M
MTBM (250 hr)	L	L	L	L	L	M	H	L	L	L	M	L	H
Personnel skill levels	M	L	M	M	H	M	H	L	L	L	L	L	H
Size (150 ft by 75 ft)	H	H	M	M	M	M	M	H	H	H	M	H	M
Speed (450 mph)	H	L	L	L	L	L	L	L	L	L	L	M	H
System effectiveness (80%)	M	L	L	M	L	M	M	L	L	M	M	M	H
Weight (150K lb)	H	H	M	M	M	M	M	H	H	H	L	H	M

Factors Affecting the Success of Design Reviews

- Identification of the items
- Date
- Location
- Agenda
- Representation
- Equipment
- Design data
- Funding
- Reporting

Change Control Process



*This activity is also known as the "Configuration Control Board."