Chapter 3

Conceptual System Design

What is it?

- Identifying problems and translating them into a need
- Accomplishing system planning
- Conducting feasibility analysis
- Developing system operational requirements
- Proposing a sustainability model
- Identifying and prioritizing technical performance metrics
- Accomplishing a system-level functional analysis (recursively)
- Performing system analysis
- Developing system specifications
- Conducting review

Requirements Definition Process

Problem Definition

- A comprehensive statement of the problem in specific qualitative and quantitative terms
- want -> *need analysis* -> system-level requirements

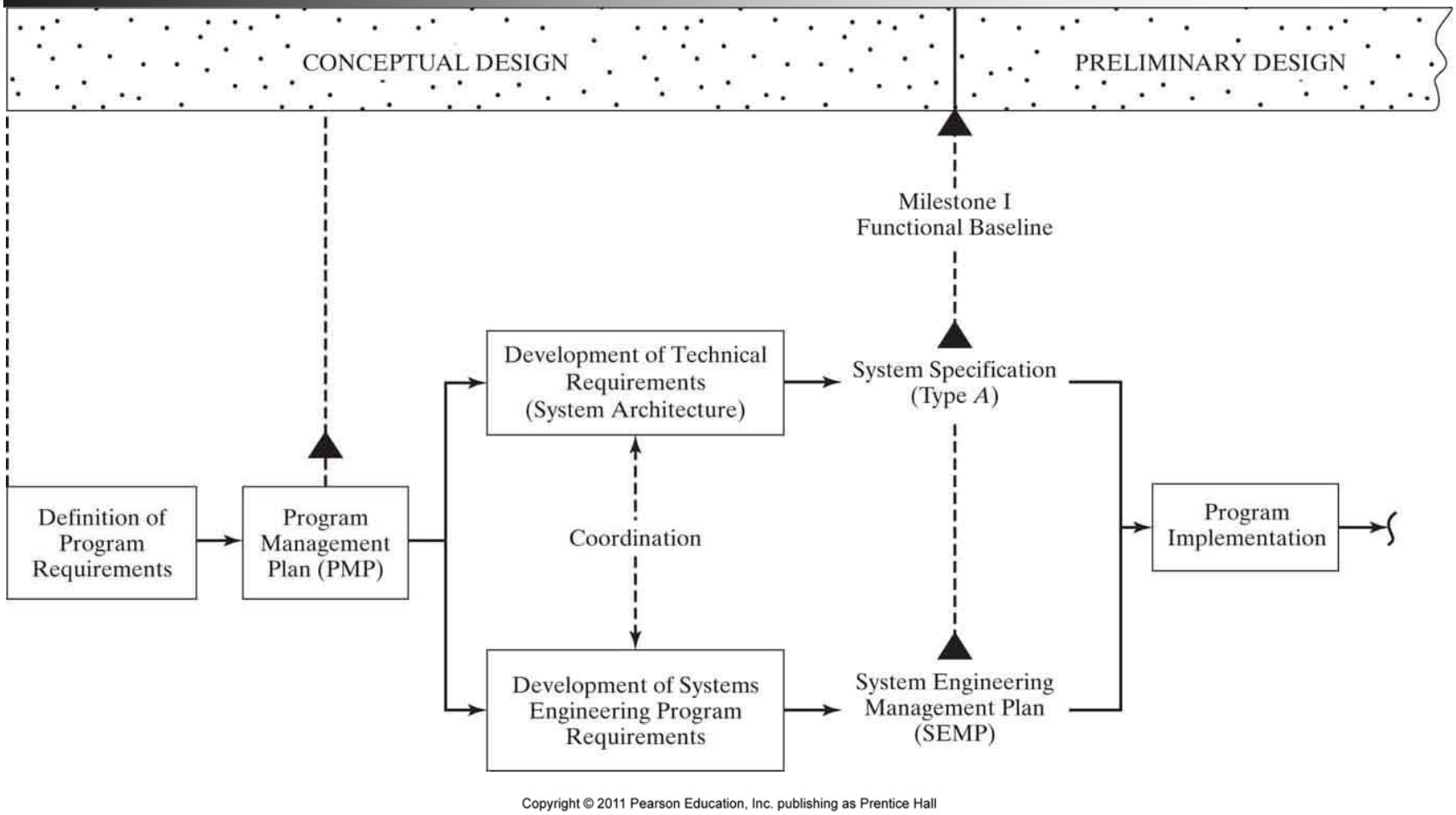
Need Analysis

- What is required of the system in "functional" terms?
- What functions must the system perform?
- What are the "primary" functions?
- What are the "secondary" functions?
- What must be done to alleviate the stated deficiency?
- When must this be accomplished?
- Where is it to be accomplished?
- How many times and at what frequency must this be accomplished?

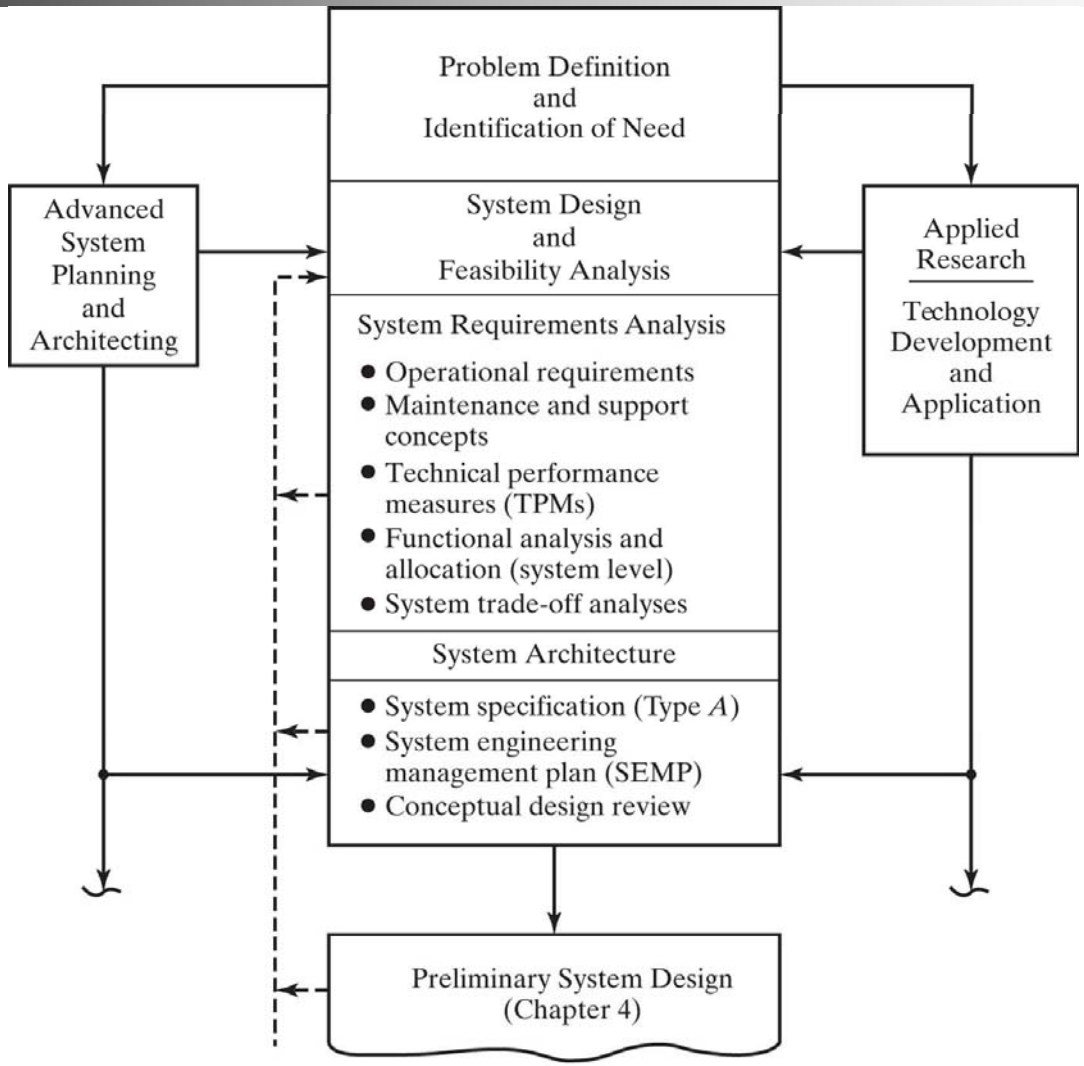
WHAT,
NOT how

* pair practice

Early System Requirements and Advanced Planning



System Requirements Definition Process



What's next?

- SYSTEM FEASIBILITY ANALYSIS
- Mission definition
- Performance and physical parameters
- Operational deployment and distribution
- Operational life cycle
- Utilization requirements
- Effectiveness factors
- Environment

SYSTEM OPERATIONAL REQUIREMENTS

Questions

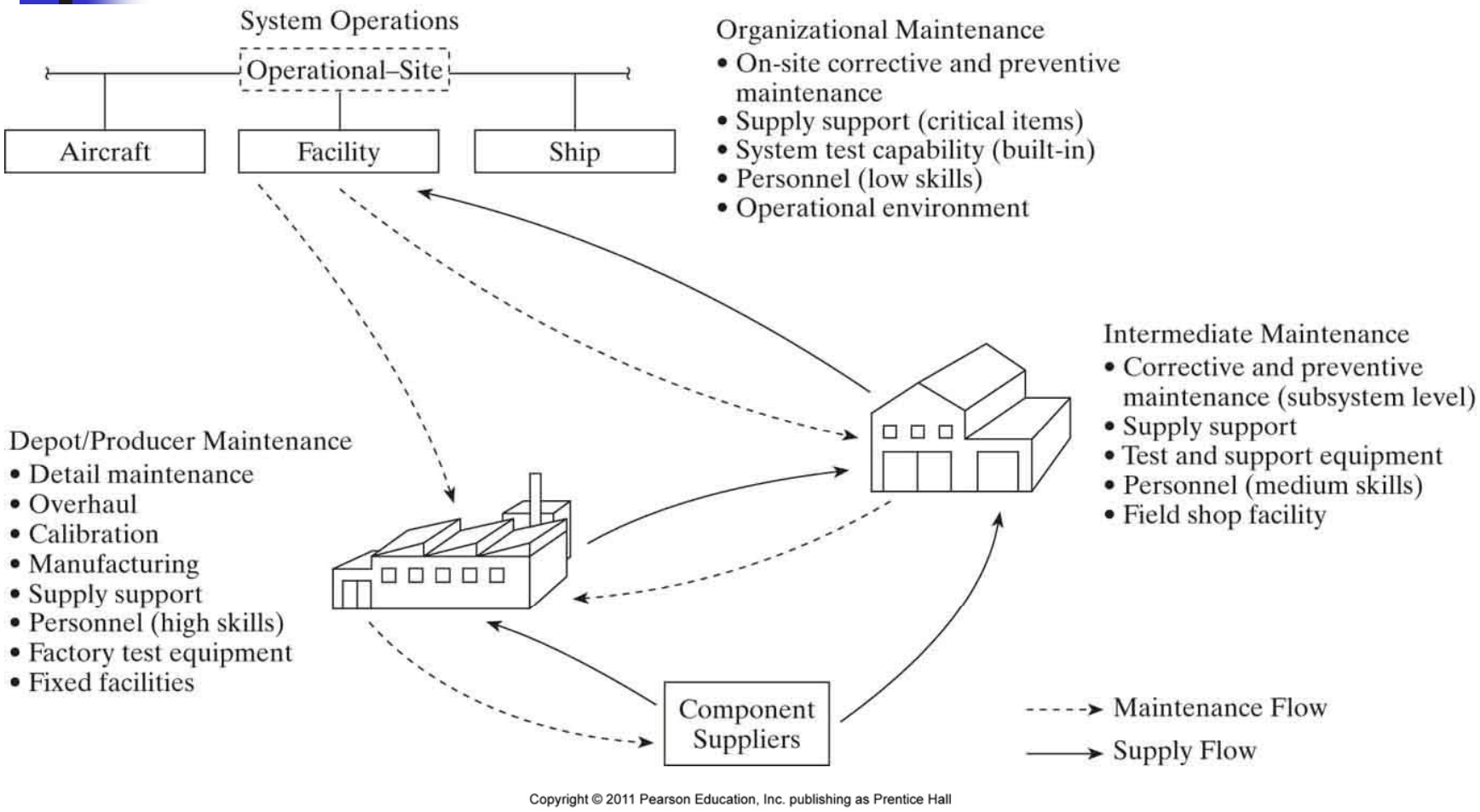
- What are the anticipated type and quantities of equipment, software, personnel, facilities, etc., required, and where are they to be located?
- How is the system to be utilized, and for how long?
- What is the anticipated environment at each operational site?
- How is the system to be supported, by whom, and for how long?

- **TEAM EXERCISES OF ILLUSTRATIONS 2 - 4 IN PP 64 - 72**

Maintenance and Support Concept

- Levels of maintenance
- Repair policies
- Organizational responsibilities
- Maintenance support elements
- Effectiveness requirements
- Environment

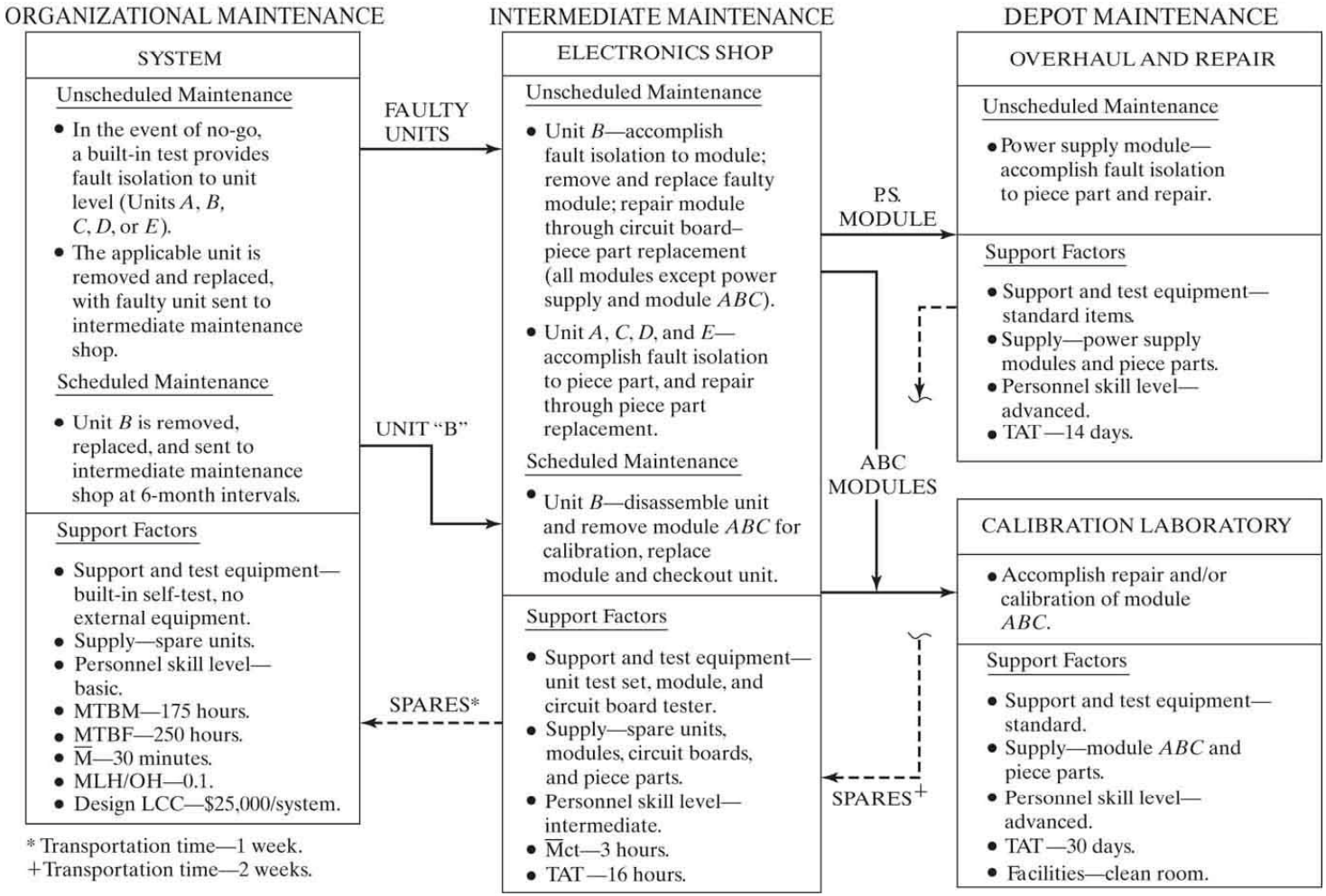
System Operation and Maintenance Flow Example



Major Levels of Maintenance

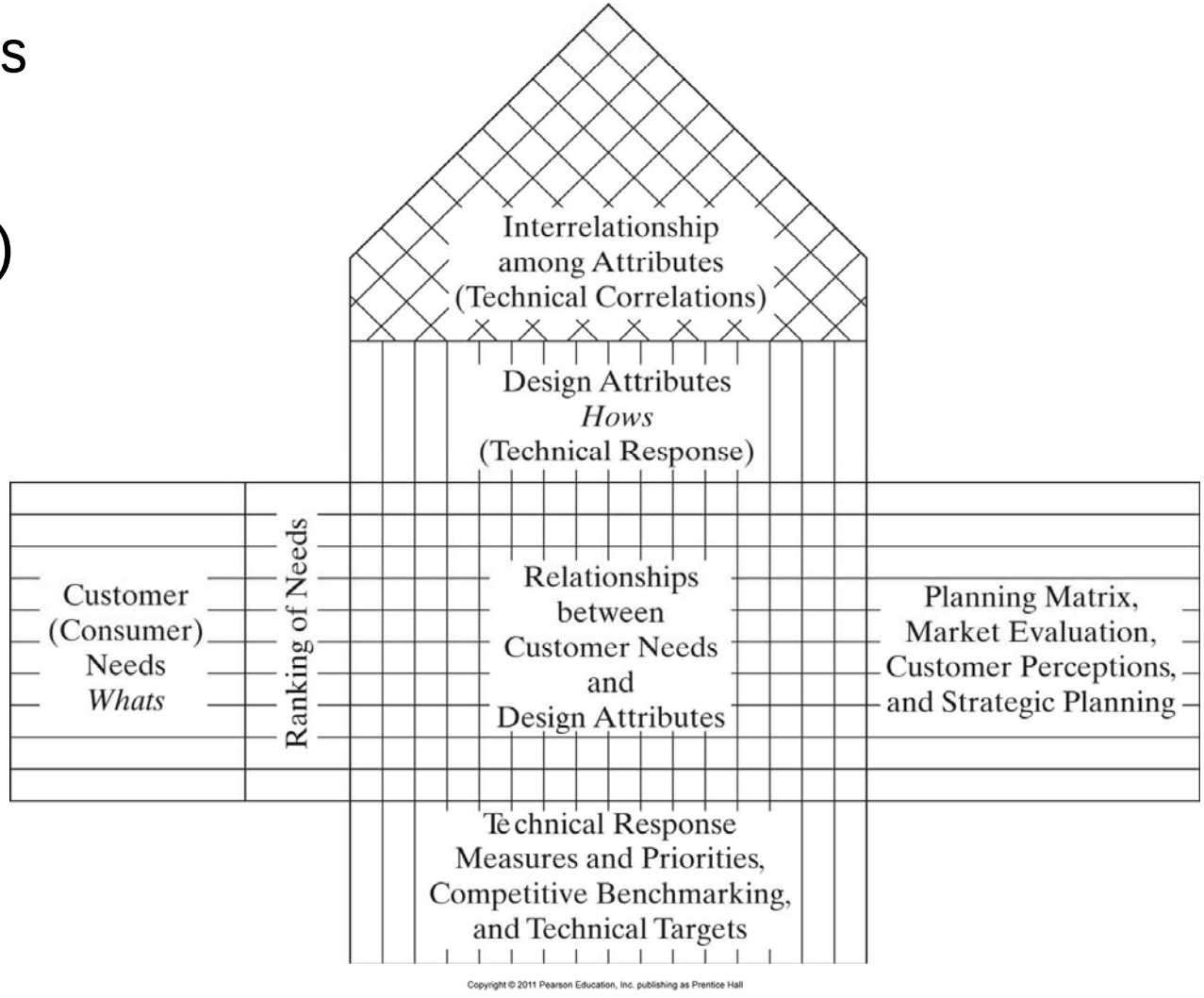
Criteria	Organizational Maintenance	Intermediate Maintenance		Supplier/Manufacturer/Depot Maintenance
Done where?	At the operational site or wherever the prime elements of the system are located	Mobile or semimobile units	Fixed units	Supplier/manufacturer/depot facility
		Truck, van, portable shelter, or equivalent	Fixed field shop	Specialized repair activity or manufacturer's plant
Done by whom?	System/equipment operating personnel (low-maintenance skills)	Personnel assigned to mobile, semimobile, or fixed units (intermediate-maintenance skills)		Depot facility personnel or manufacturer's production personnel (high-maintenance skills)
On whose equipment?	Using organization's equipment	Equipment owned by using organization		
Type of work accomplished?	Visual inspection Operational checkout Minor servicing External adjustments Removal and replacement of some components	Detailed inspection and system checkout Major servicing Major equipment repair and modifications Complicated adjustments Limited calibration Overload from organizational level of maintenance		Complicated factory adjustments Complex equipments repairs and modifications Overhaul and rebuild Detailed calibration Supply support Overload from intermediate level of maintenance

System Maintenance and Repair Policy Example

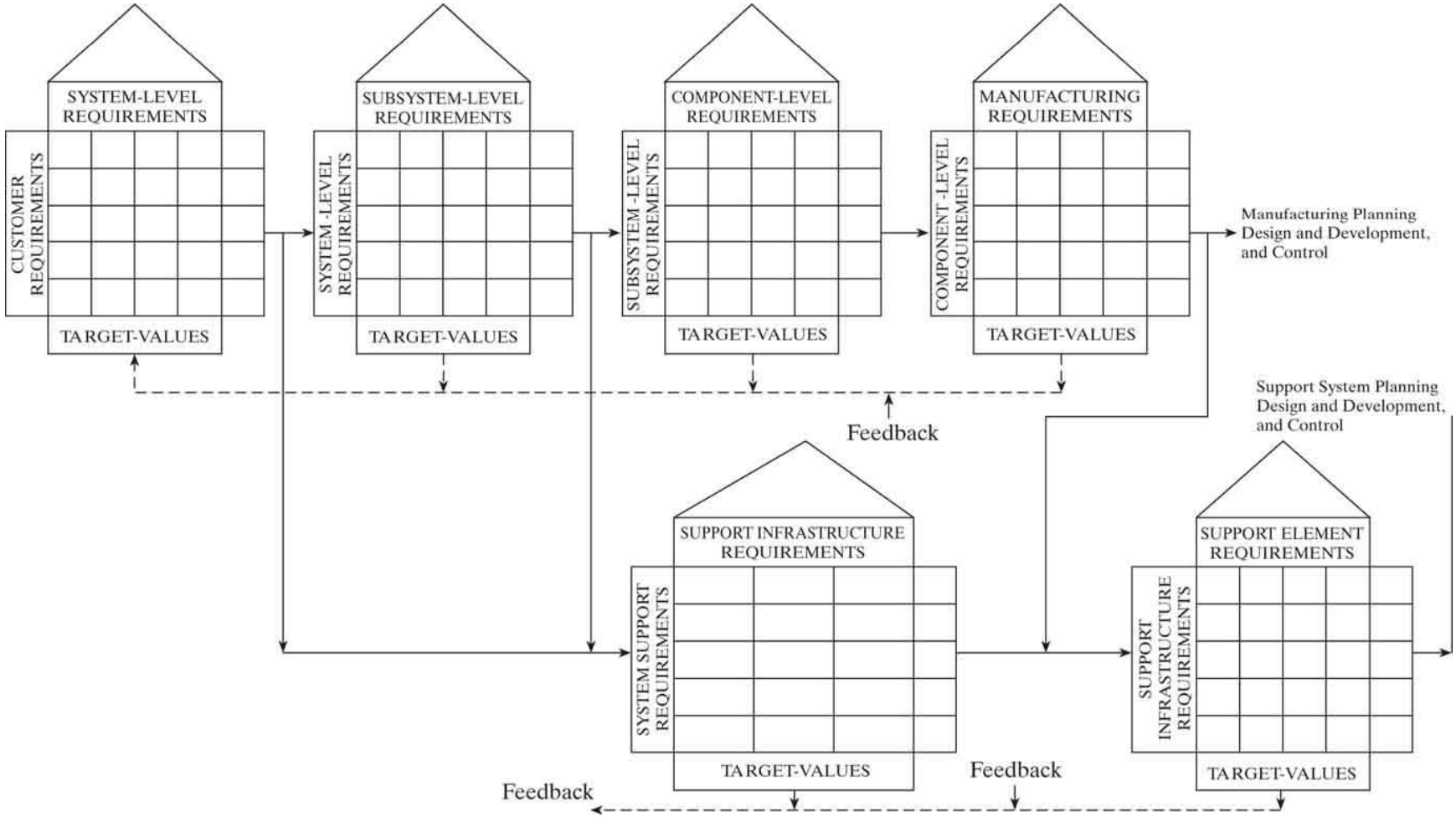


Technical Performance Measures (TPMs)

- TPMs are measures of the *design-dependent parameters* (DDPs)
- TOOL
  - Quality Function Deployment (QFD)
    - House of Quality (HOQ)



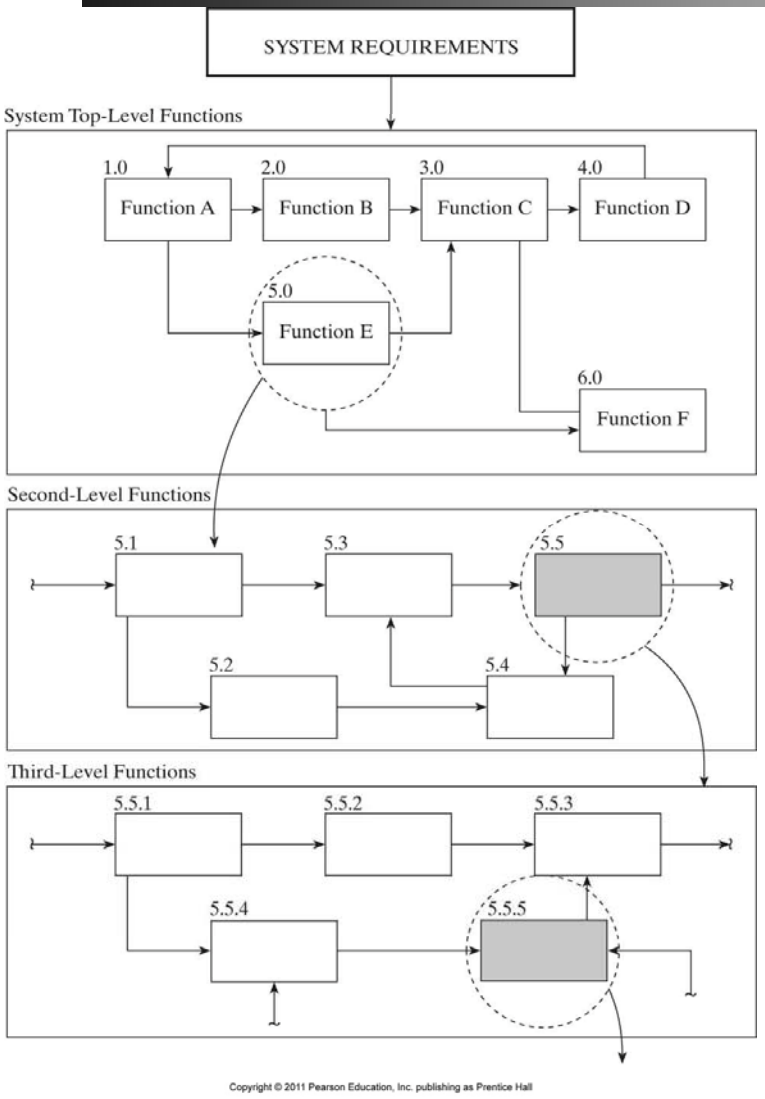
Traceability of Requirements through a Family of Houses



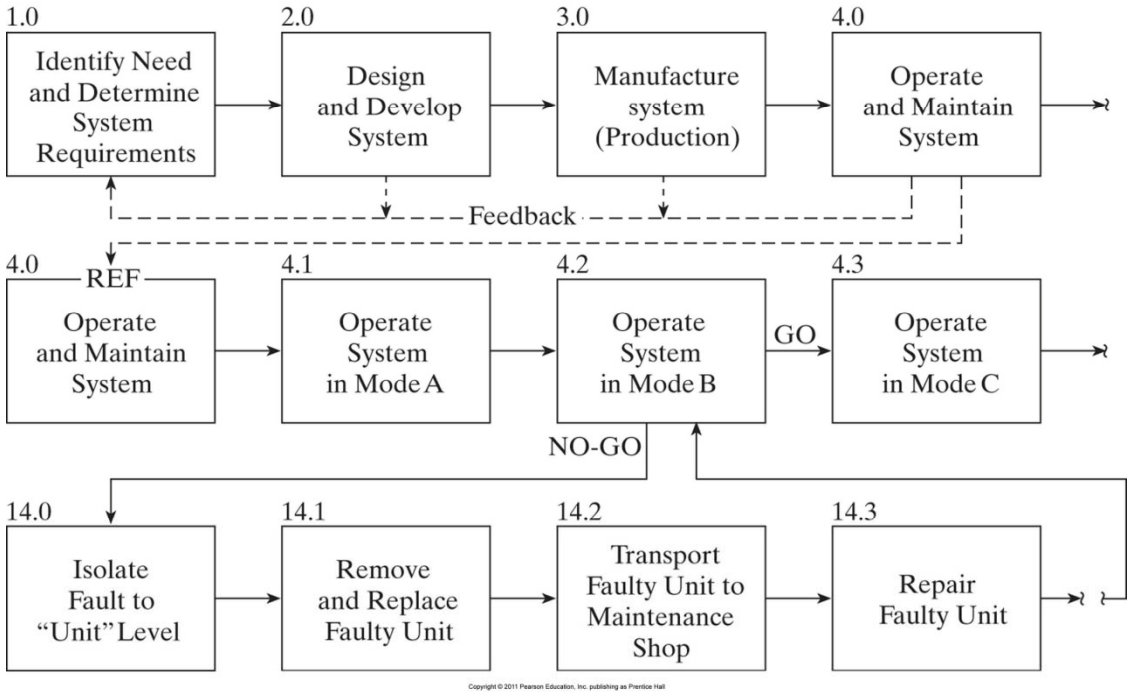
Functional Analysis and Allocation

- *Functional* description of the system
- *Function* refers to a specific action
- The *whats*, not the *hows*
- *Functional analysis* is an iterative process of translating system requirements into detailed design criteria and the subsequent identification of the resources required for system operation and support
- Purpose: Develop the top-level *system architecture*
  - Requirements
    - *Functional architecture*
  - Structure
    - *Physical architecture*

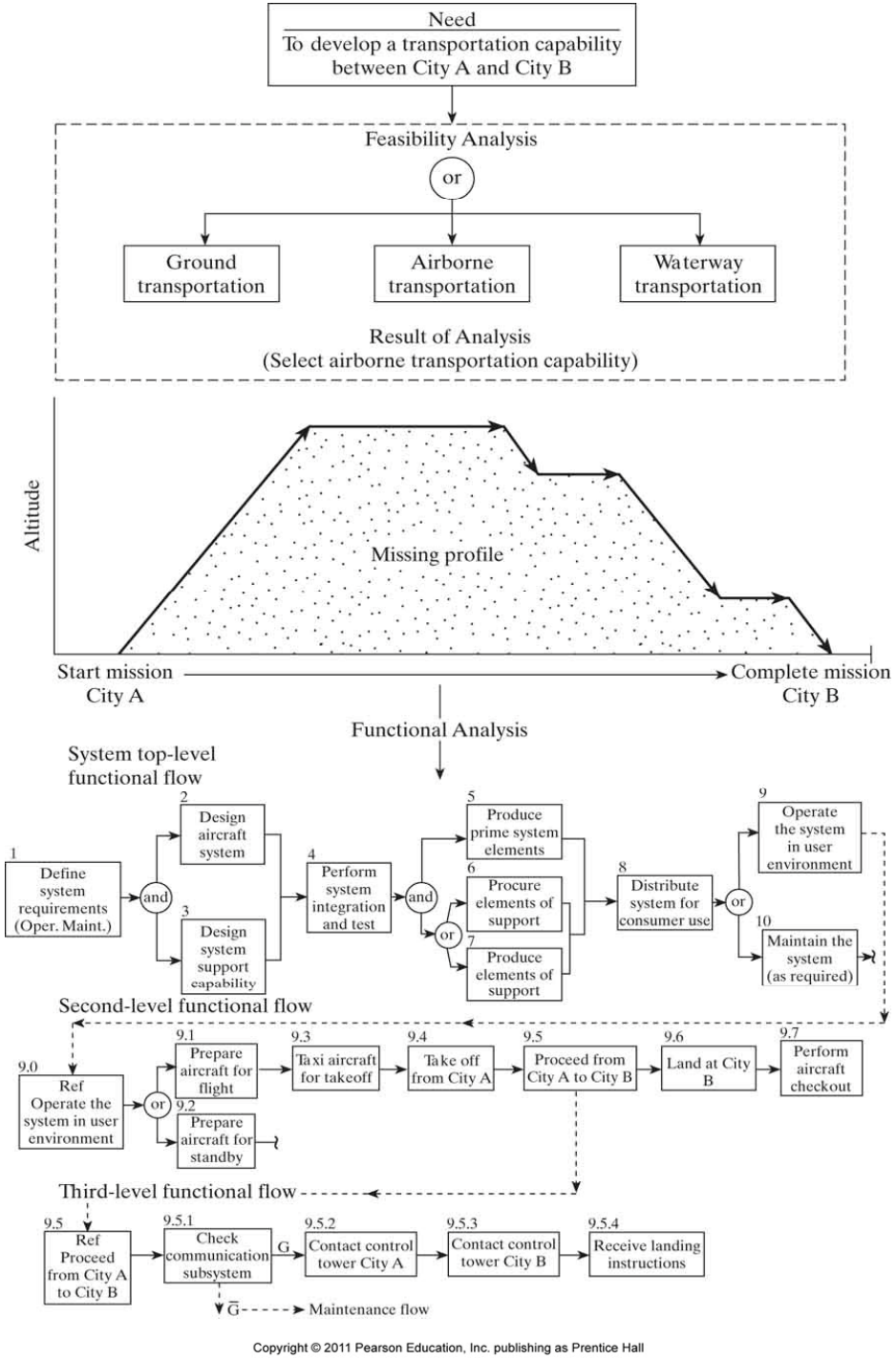
Functional Flow Block Diagrams (FFBDs)



- The *whats*, not the *hows*



Progression from the "need" to the Functional Analysis (example)



The Functional Approach

- All facets of system design and development, production, support, and phase-out are considered
- All elements of the system are fully recognized and defined
- A means is provided for relating system packaging concepts and support requirements to specific system functions
- The proper sequence of activity and design relationships are established along with critical design interfaces

The Functional Approach

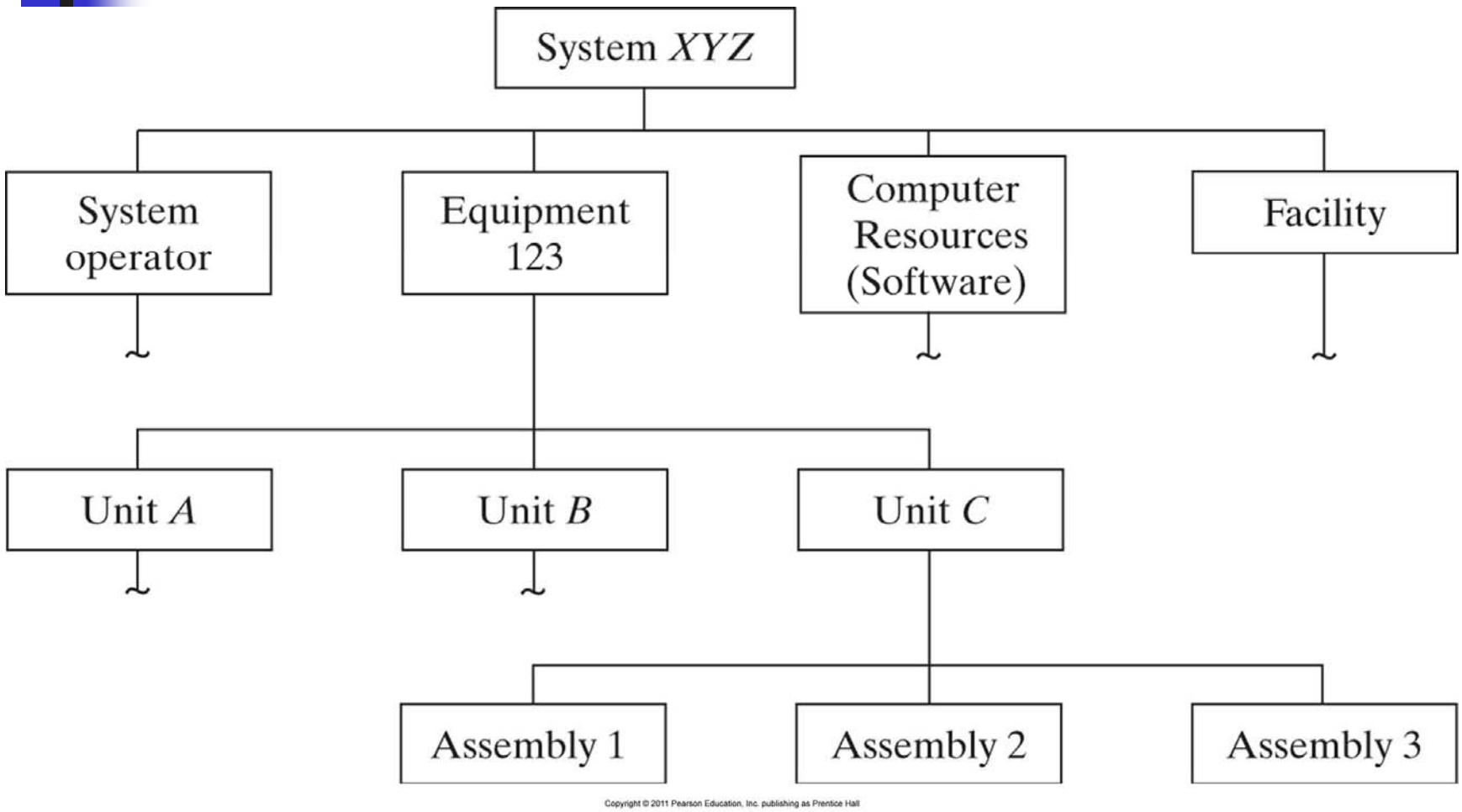
- Provides the *functional* baseline for:
  - Reliability requirements
  - Reliability model
  - Maintainability requirements
  - Human factors requirements
  - Supportability requirements
- Functional baseline -> allocated baseline -> product baseline

Functional *allocation, partition, apportion*

- *What elements can be selected that can perform multiple functions reliably, effectively, and efficiently?*
- *How can new functional requirements be added without adding new physical elements to the system structure?*
- Elements can be grouped by geographical location, a common environment, or by similar types that have similar functions
- Individual system packages should be as independent as possible with a minimum of "interaction effects"
- Select a configuration in which the "communications" between the subsystems is minimized

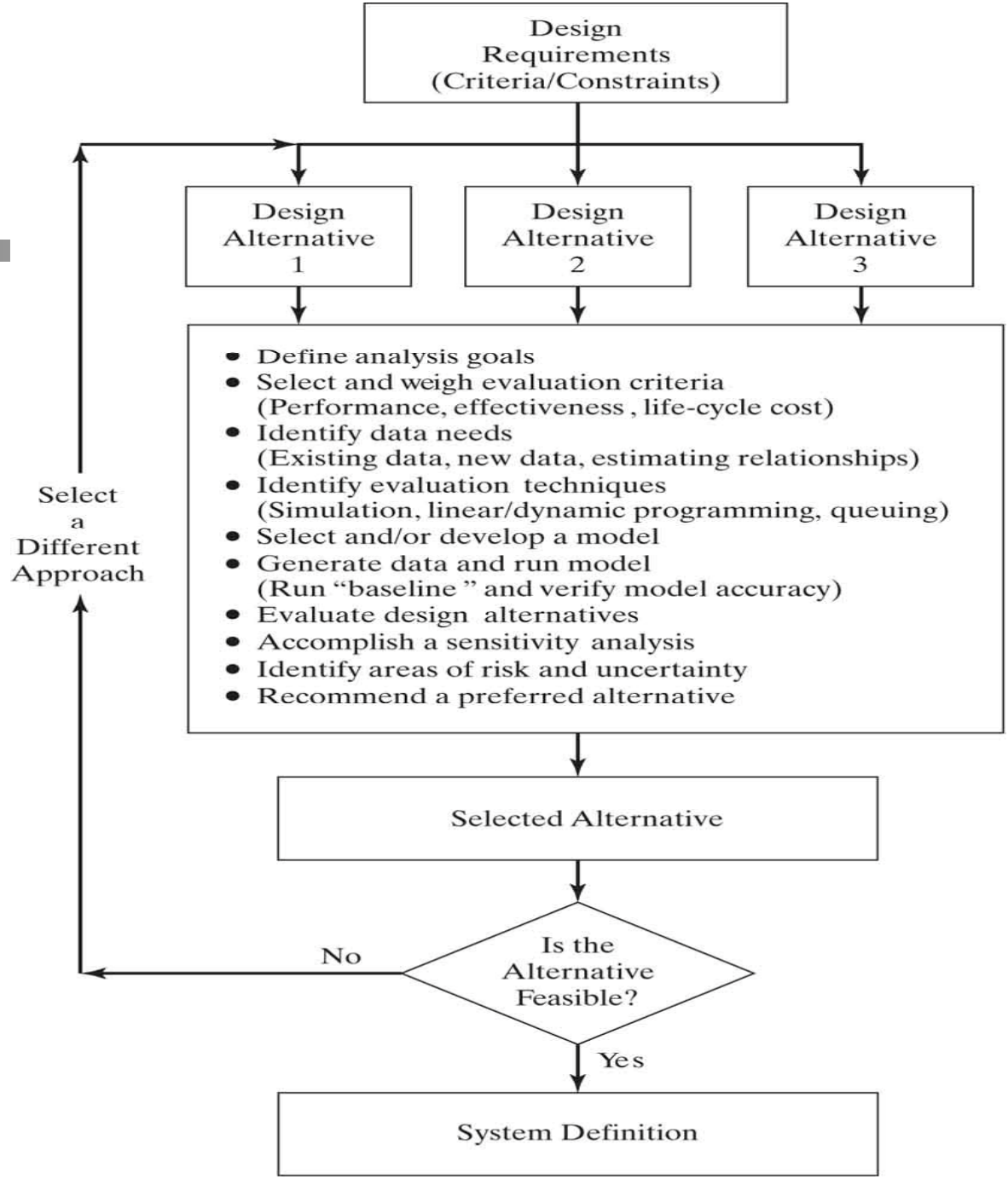
- Thus both *functional* and *physical* architectures emerge and the *hows* start to evolve from the *whats*

Functional *allocation, partition, apportion* (example)



System Trade-Off Analyses

- Functional baseline -> allocated baseline -> product baseline



The Outcome ...

- System Specification ->
- Then ...
- Design Review

System Specification

1.0 Scope
2.0 Applicable Documents
3.0 Requirements
- 3.1 System Definition
  - 3.1.1 General Description
  - 3.1.2 Operational Requirements (Need, Mission, Use Profile, Distribution, Life Cycle)
  - 3.1.3 Maintenance Concept
  - 3.1.4 Functional Analysis and System Definition
  - 3.1.5 Allocation of Requirements
  - 3.1.6 Functional Interfaces and Criteria
- 3.2 System Characteristics
  - 3.2.1 Performance Characteristics
  - 3.2.2 Physical Characteristics
  - 3.2.3 Effectiveness Requirements
  - 3.2.4 Reliability
  - 3.2.5 Maintainability
  - 3.2.6 Usability (Human Factors)
  - 3.2.7 Supportability
  - 3.2.8 Transportability/Mobility
  - 3.2.9 Flexibility
  - 3.2.10 Sustainability
  - 3.2.11 Security
- 3.3 Design and Construction
  - 3.3.1 CAD/CAM Requirements
  - 3.3.2 Materials, Processes, and Parts
  - 3.3.3 Mounting and Labeling
  - 3.3.4 Electromagnetic Radiation
  - 3.3.5 Safety
  - 3.3.6 Interchangeability
  - 3.3.7 Workmanship
  - 3.3.8 Testability
  - 3.3.9 Economic Feasibility
- 3.4 Documentation/Data
- 3.5 Logistics
  - 3.5.1 Maintenance Requirements
  - 3.5.2 Supply Support
  - 3.5.3 Test and Support Equipment
  - 3.5.4 Personnel and Training
  - 3.5.5 Facilities and Equipment
  - 3.5.6 Packaging, Handling, Storage, and Transportation
  - 3.5.7 Computer Resources (Software)
  - 3.5.8 Technical Data/Information
  - 3.5.9 Customer Services
- 3.6 Producibility
- 3.7 Disposability
- 3.8 Affordability

4.0 Test and Evaluation
5.0 Quality Assurance Provisions
6.0 Distribution and Customer Service
7.0 Retirement and Material Recycling/Disposal

Conceptual Design Review

- Provides a formalized check of the proposed system and subsystems designs with respect to specification requirements
- Provides a common baseline for all product personnel
- Provides a means for solving interface problems and promotes the assurance that all system elements will be compatible
- Provides a formalized record of what design decisions were made and the reasons for making them
- Promotes a higher probability of mature design, as well as the incorporation of the latest techniques