Overview of the EIA 632 Standard - "Processes for Engineering a System" (TUTORIAL G)

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EIA 632 Working Group Chairman
Raytheon Systems Company

- **Background**
  - » Role of the Standard
  - » Evolution of the Standard
- **Document Contents**
  - » Process Description
  - » Key Concepts

Background

- **US National Standard Co-Developed by**
  - » Electronic Industries Alliance (EIA)
  - » International Council on Systems Engineering (INCOSE)
- **Under Development since 1994**
  - » Release as ANSI/EIA Standard planned for November 1998
- **Intended for Voluntary Compliance**
  - » Should not be imposed on contract
  - » Should be used to develop company practices

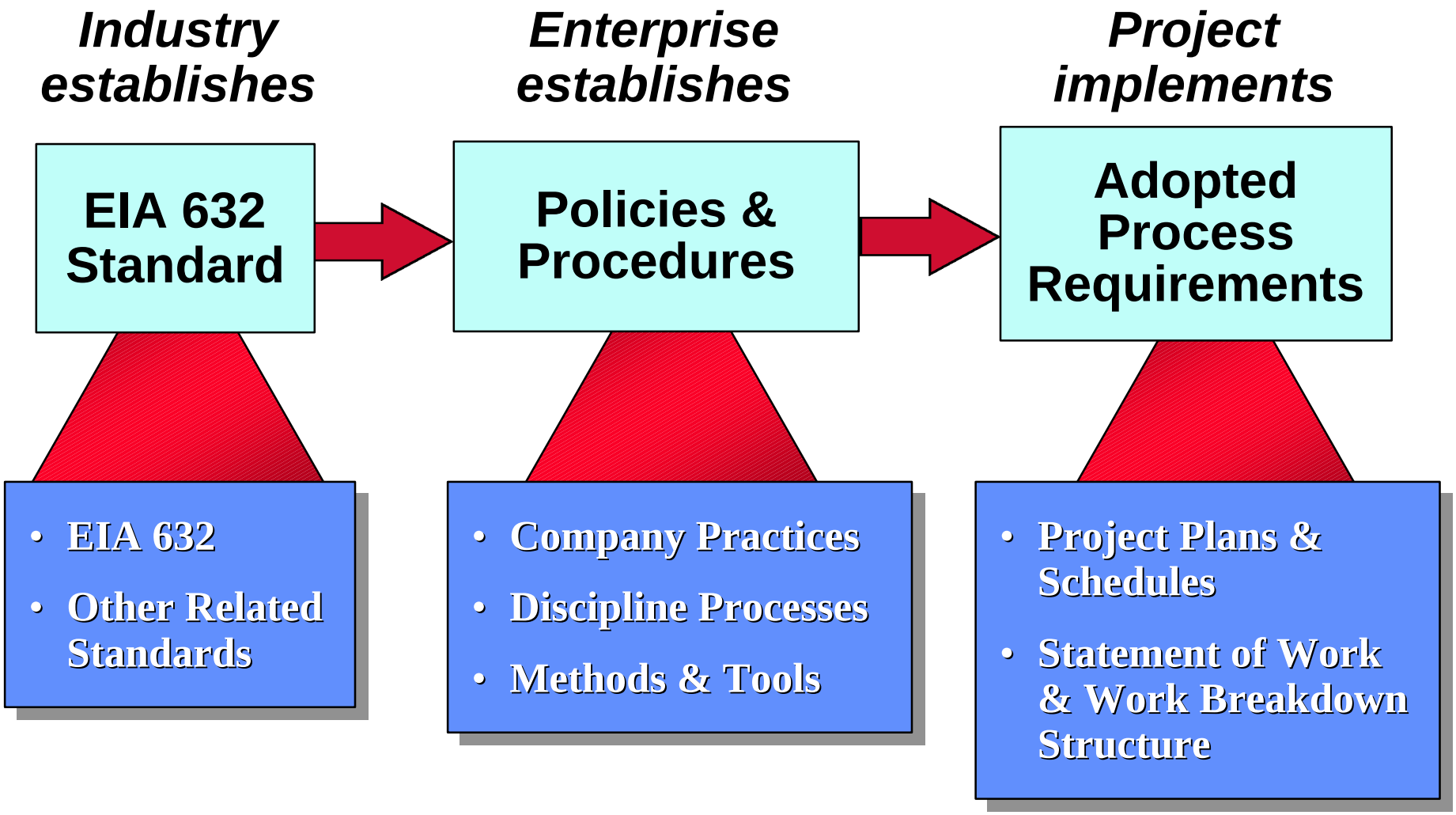
Contents

- **Thirteen Processes**
  - » Representative Tasks for each Process
  - » Expected Outcomes for each Task
- **33 Requirements on these Processes**
- **Key Concepts**
  - » System includes not just *End Products*, but also *Enabling Products*
  - » *Building Block* is the basic unit of a System
  - » Systems developed in “layers”

What is the role of Systems Engineering?

- **This Standard does NOT define "Systems Engineering"**
  - » **What SE is**
  - » **What SE does**
  - » **Who does SE**
- **SE should be "Keeper" of the Process, Methods & Tools**
  - » **Coordinator of the process activities**
    - Like a conductor of an orchestra
    - This standard is like the original composition
    - The engineering plan is the musical score specially arranged for a particular project
  - » **Establishes the "Shared Vision" of the System Solution**
    - Maintains the requirements and architecture
    - Leads the technical effort

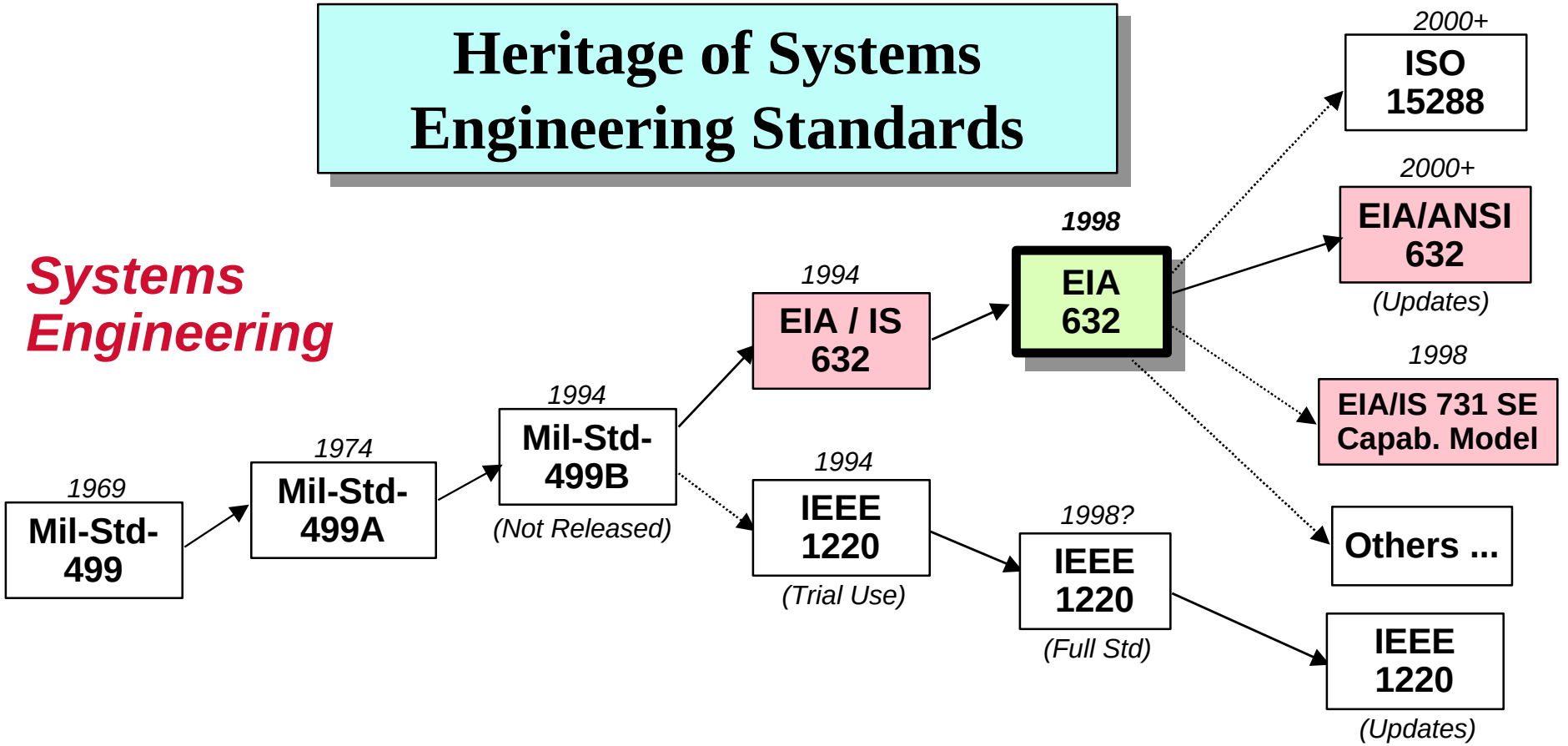
Role of the EIA 632 Standard

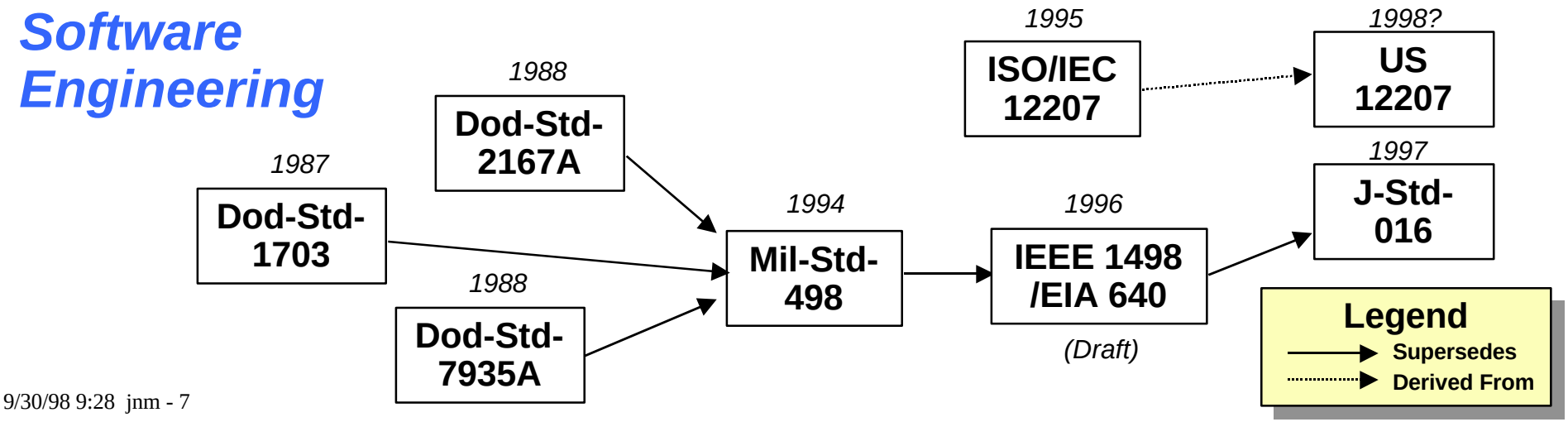


Evolution of EIA 632 from an Interim Standard to a Full Standard

- **Heritage of this Standard**
- **Systems Engineering vs. "Engineering a System"**
- **Comparison between Old and New**
- **New Concepts**

Heritage of Systems Engineering Standards



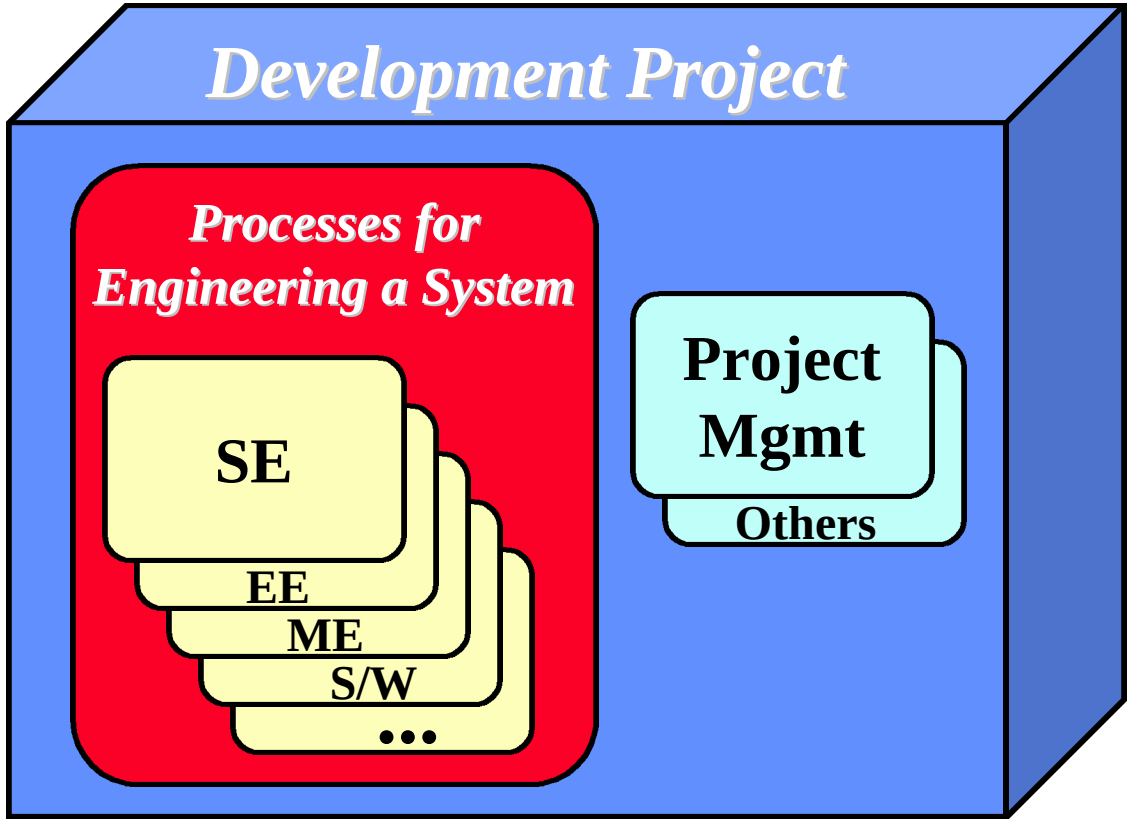


Systems Engineering vs. All Engineering

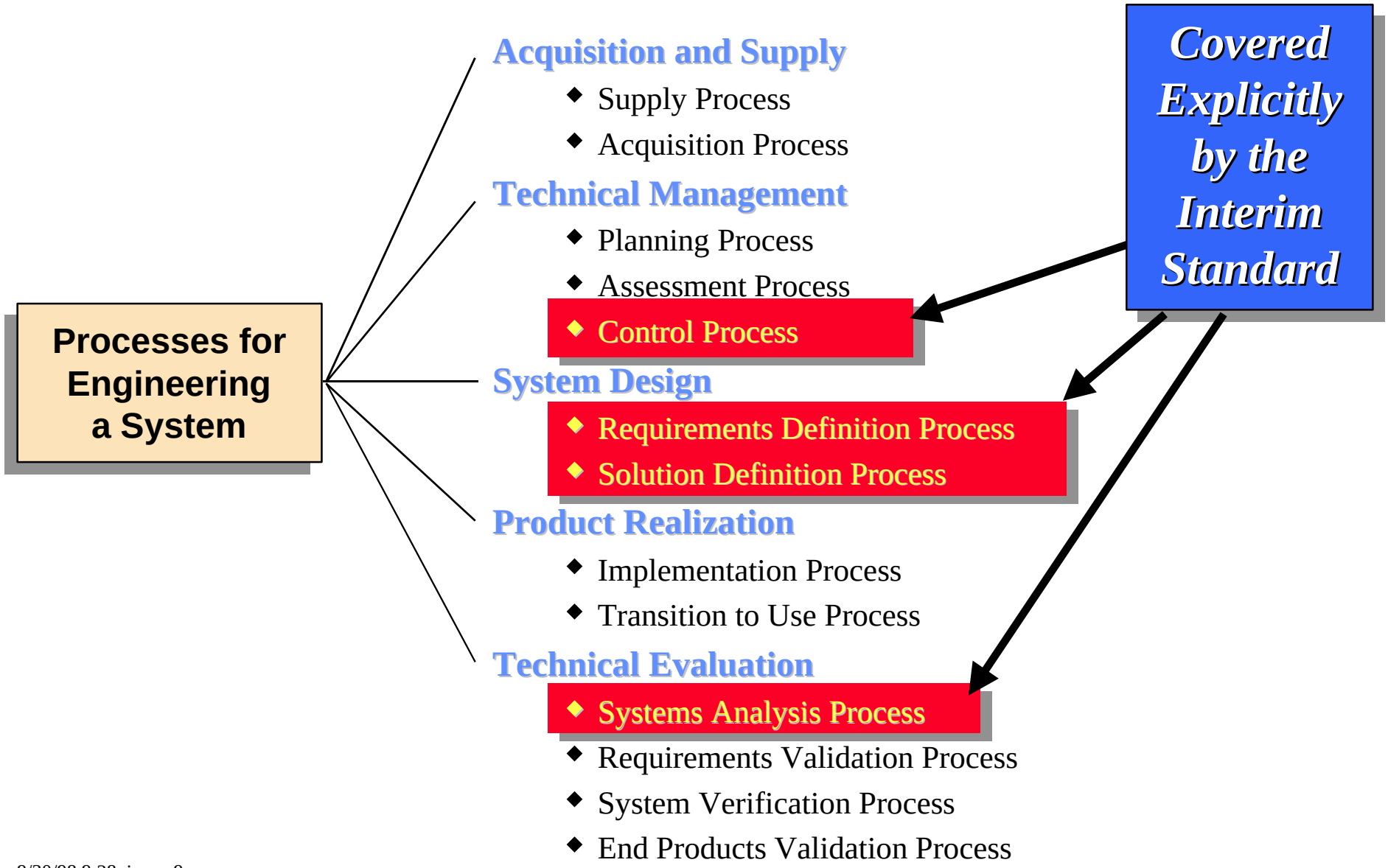
EIA 632
(Interim Standard)

Systems Engineering Process

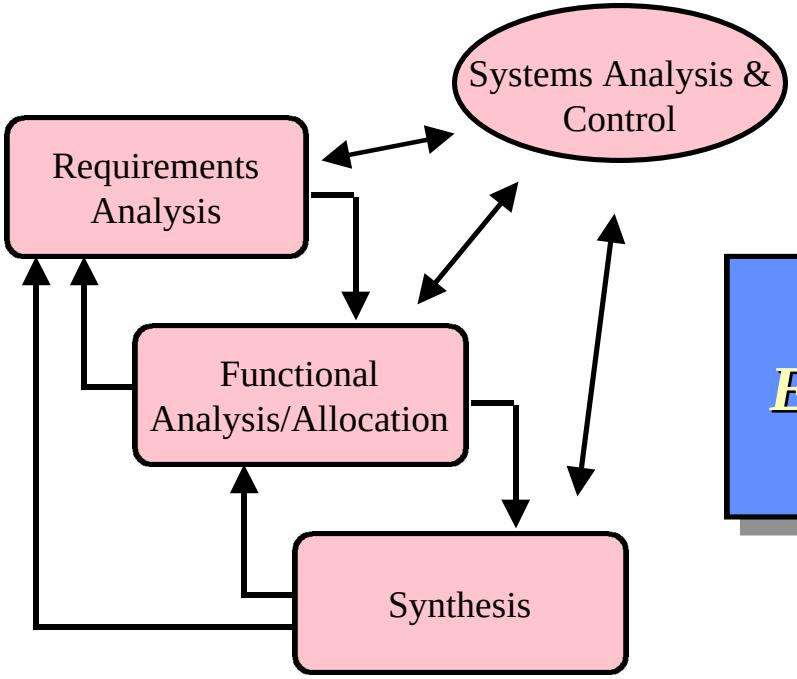
EIA 632
(Full Standard)



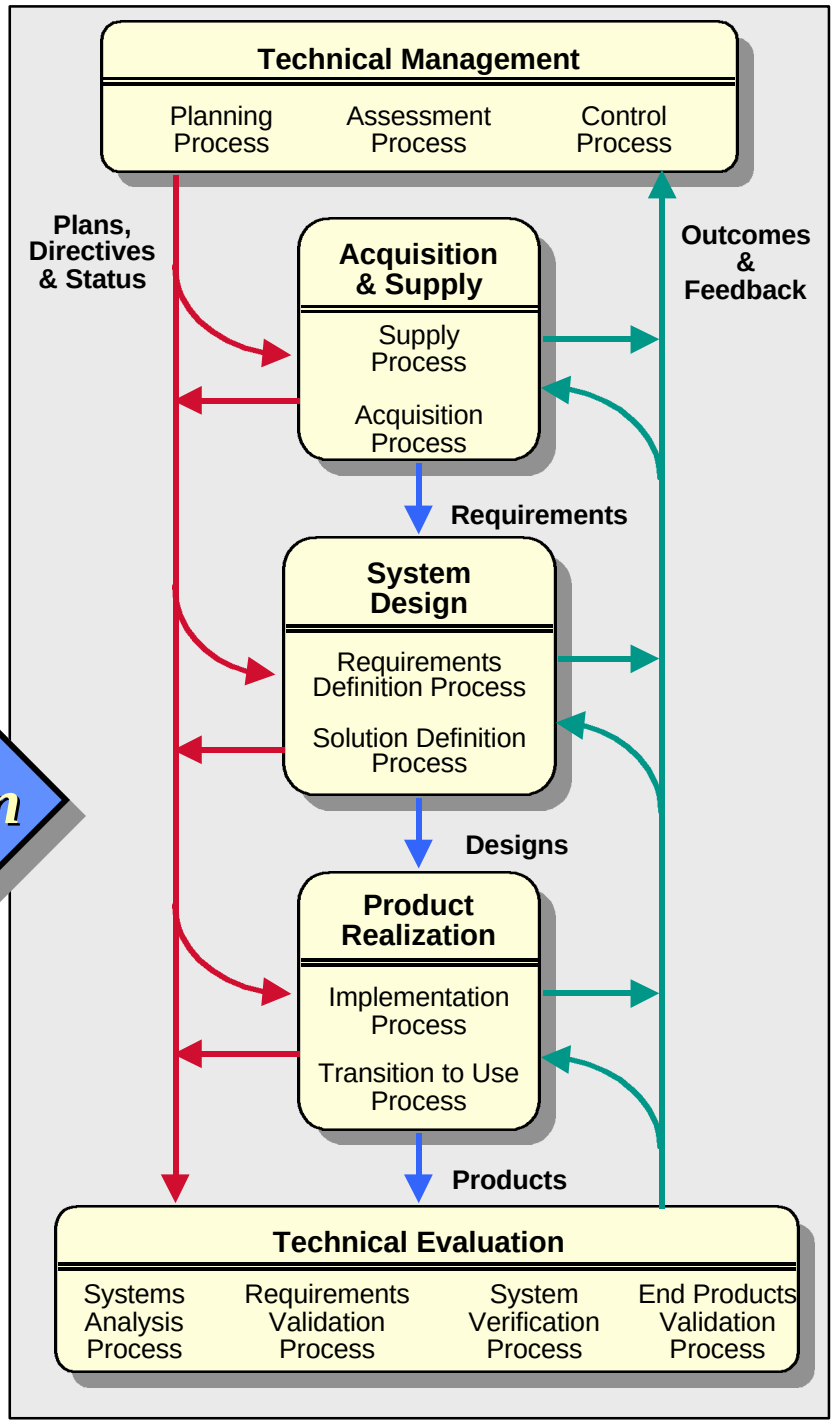
Comparison to Interim Standard Version



Evolution from Old to New

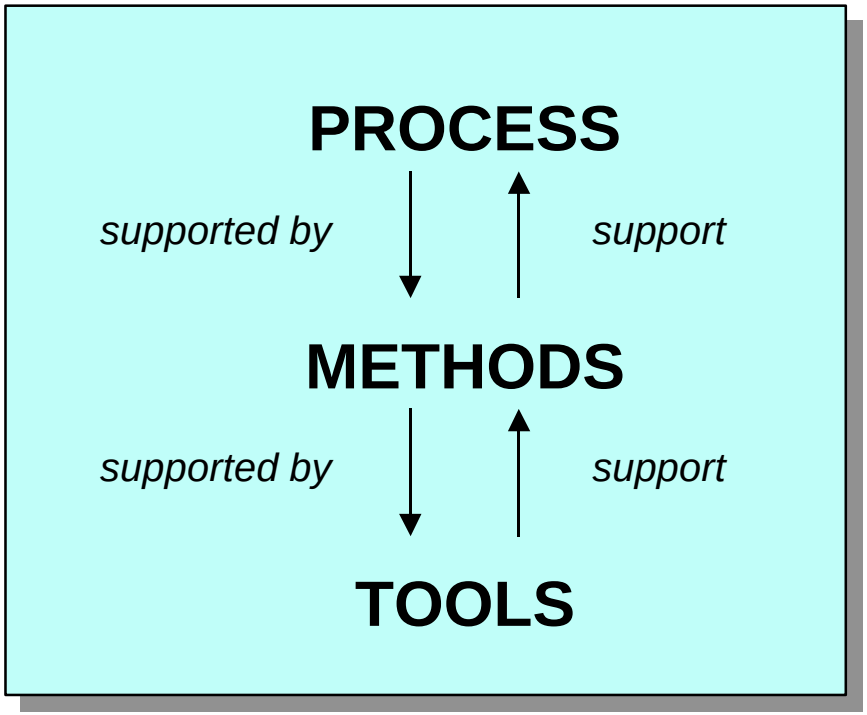


Evolution



Process vs. Methods

- **This standard does not specify Methods or Tools**
  - » Quality Function Deployment (QFD)
  - » Object-Oriented Analysis/Design
  - » Functional Analysis
  - » Finite State Machines
  - » etcetera
- **Left to the purview of 2nd-Tier Standards and Company Policy & Procedures**



New Concepts

- **System = HW + SW + Others**
- **System = End Products + Enabling Products**
- **Stakeholder Requirements**
- **Evolution of Requirements**
- **Emphasis on Validation**

Document Structure

45 Pages

- **Foreword**
- **Introduction**
- **Acknowledgments**
- **Scope**
- **Normative References**
- **Definitions & Acronyms**
- **Requirements**

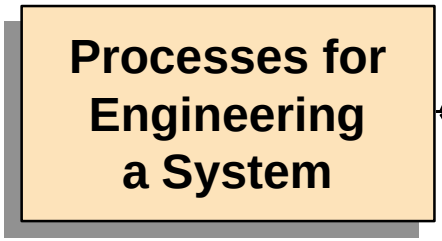
38 Pages

  - » Acquirer-Supplier
  - » Technical Mgmt
  - » System Design
  - » Product Realization
  - » Technical Evaluation

- **Application Context**
- **Application Key Concepts**
  - » Building Block
  - » System Structure
  - » Engineering Life Cycle
- **Annexes**
  - » Glossary
  - » Enterprise-Based Life Cycle
  - » Process Task Outcomes
  - » Planning Documents
  - » System Technical Reviews
  - » Unprecedented and Precedented Development
  - » Requirement Relationships
- **Index**

70 Pages

Process Hierarchy



Acquisition and Supply *(Subclause 4.1)*

- Supply Process
- Acquisition Process

Technical Management *(Subclause 4.2)*

- Planning Process
- Assessment Process
- Control Process

System Design *(Subclause 4.3)*

- Requirements Definition Process
- Solution Definition Process

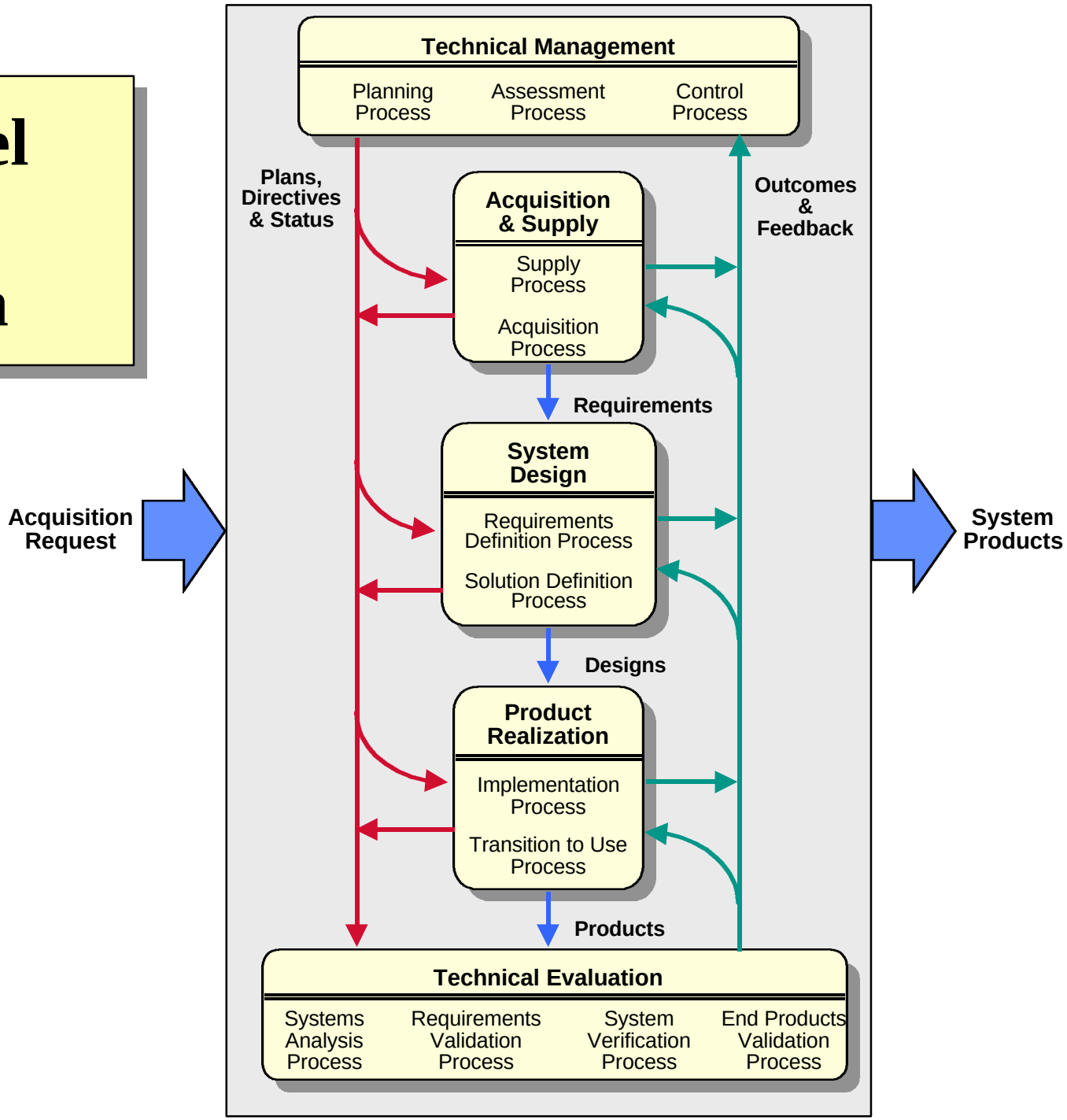
Product Realization *(Subclause 4.4)*

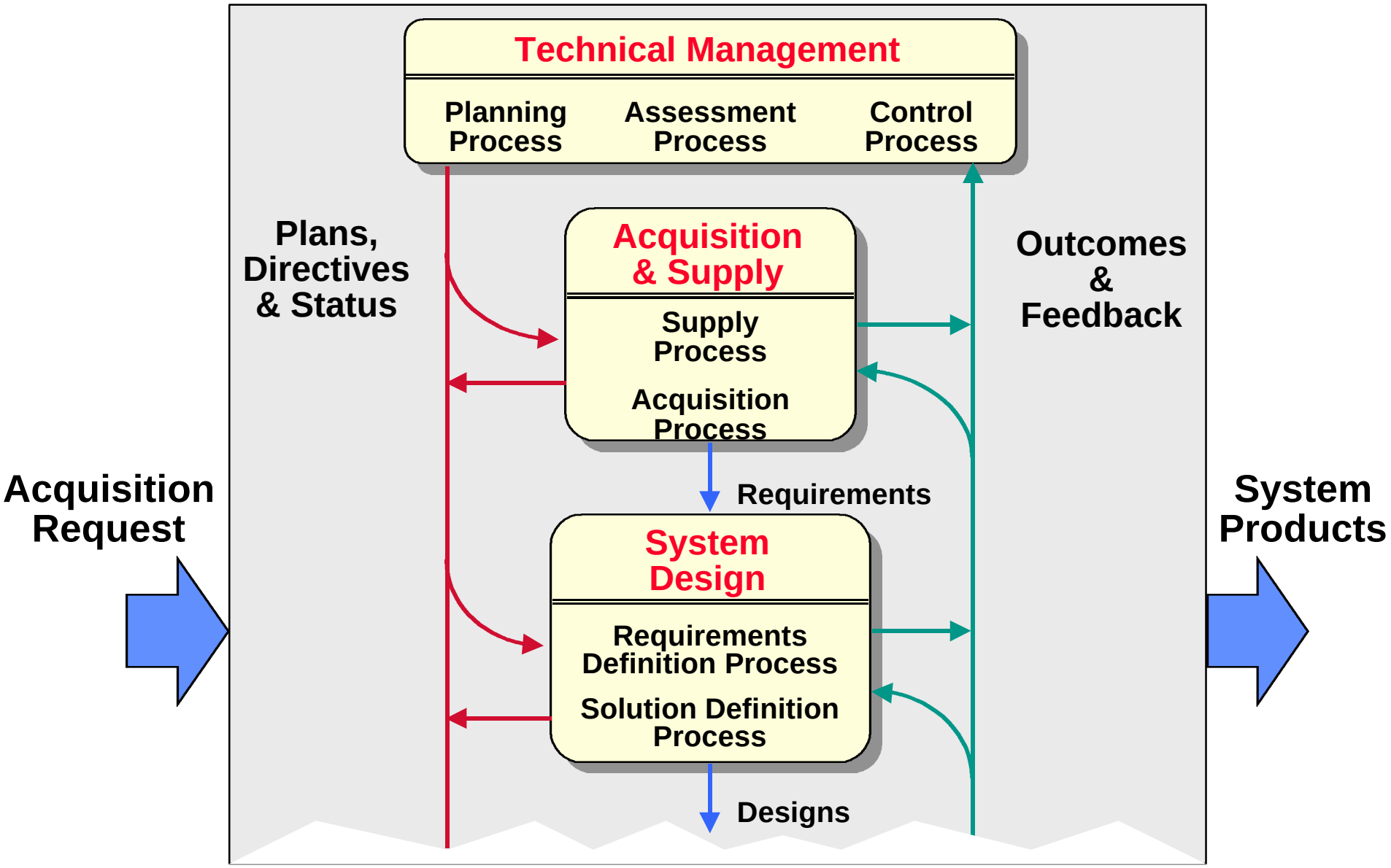
- Implementation Process
- Transition to Use Process

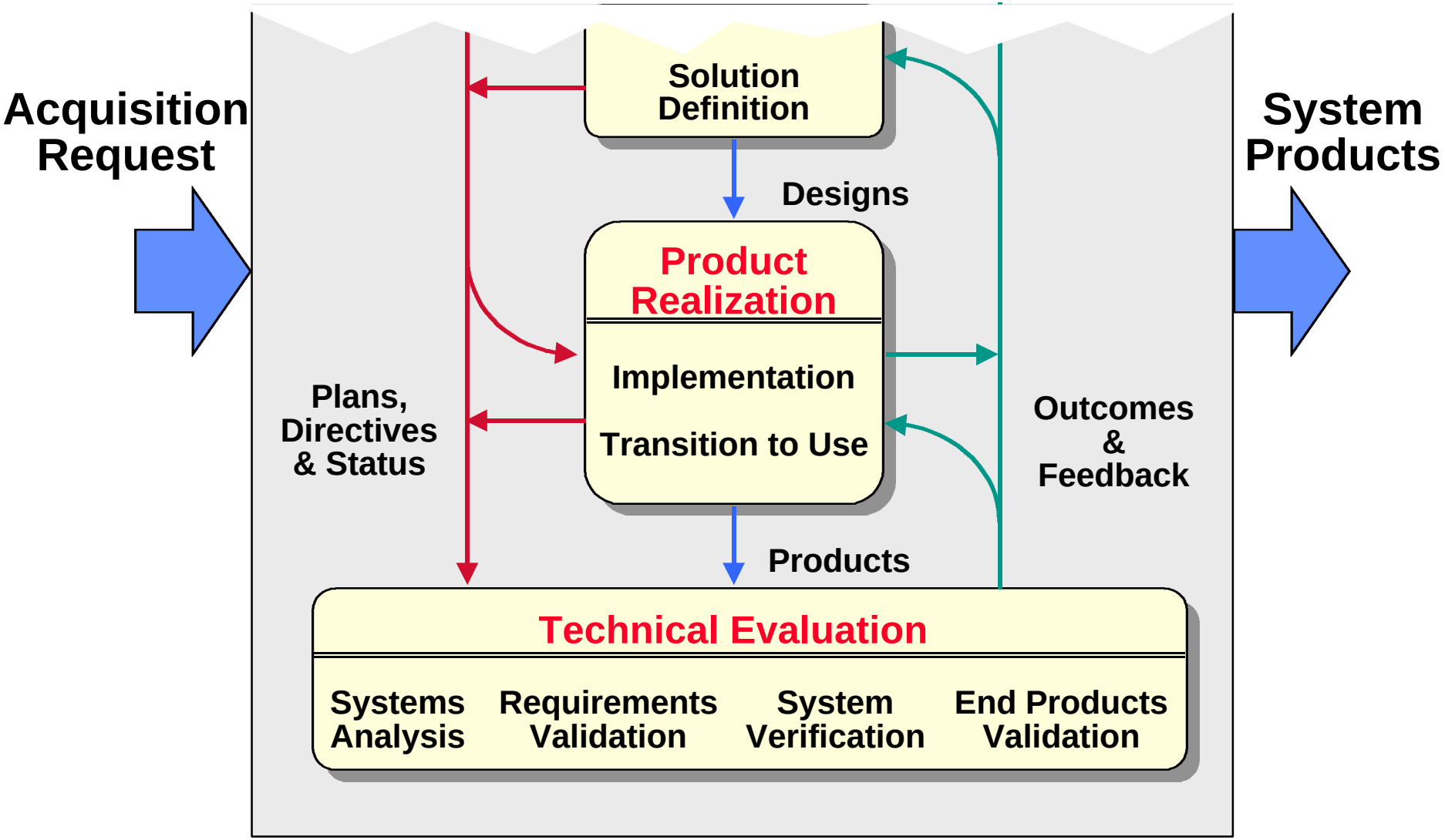
Technical Evaluation *(Subclause 4.5)*

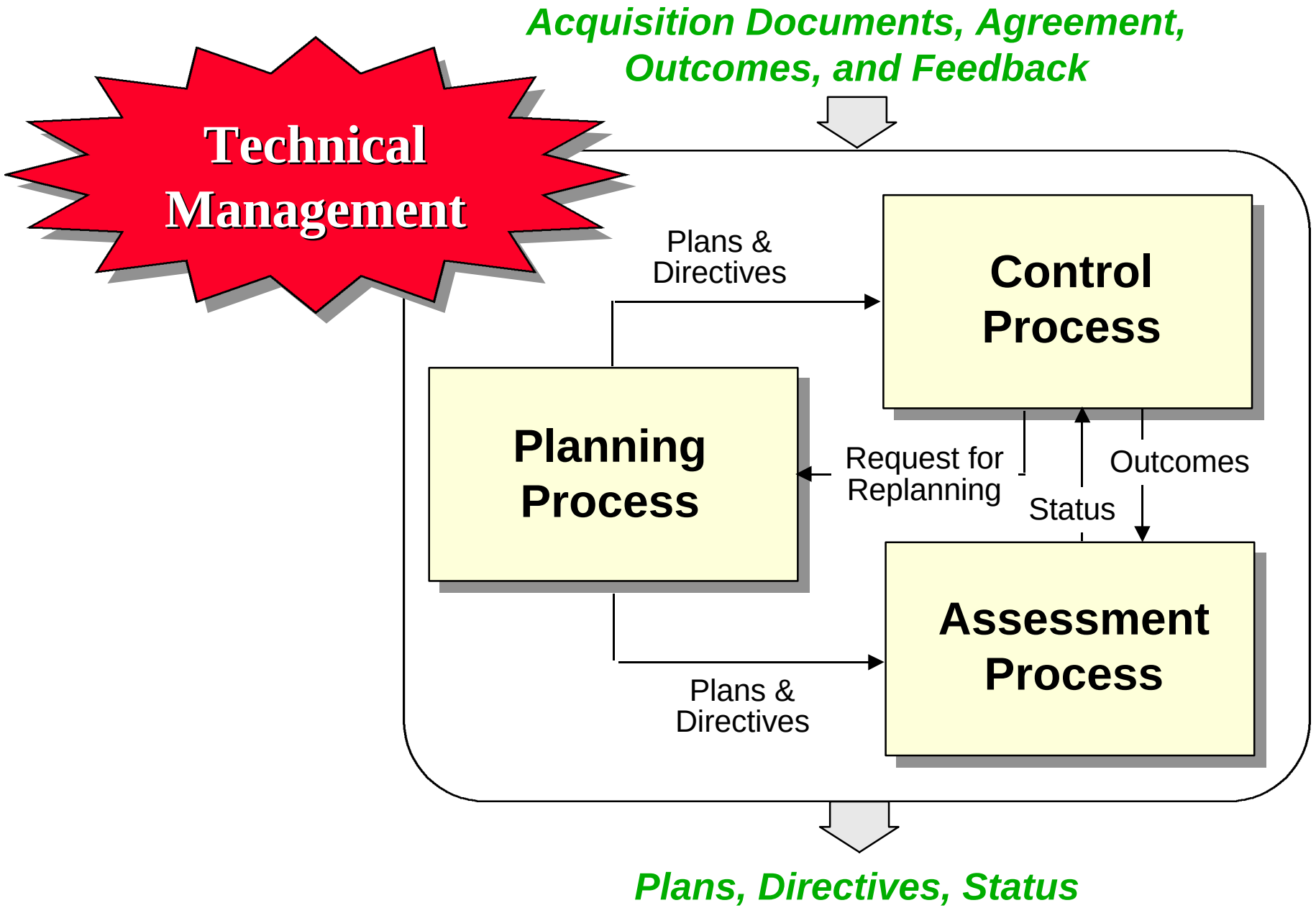
- Systems Analysis Process
- Requirements Validation Process
- System Verification Process
- End Products Validation Process

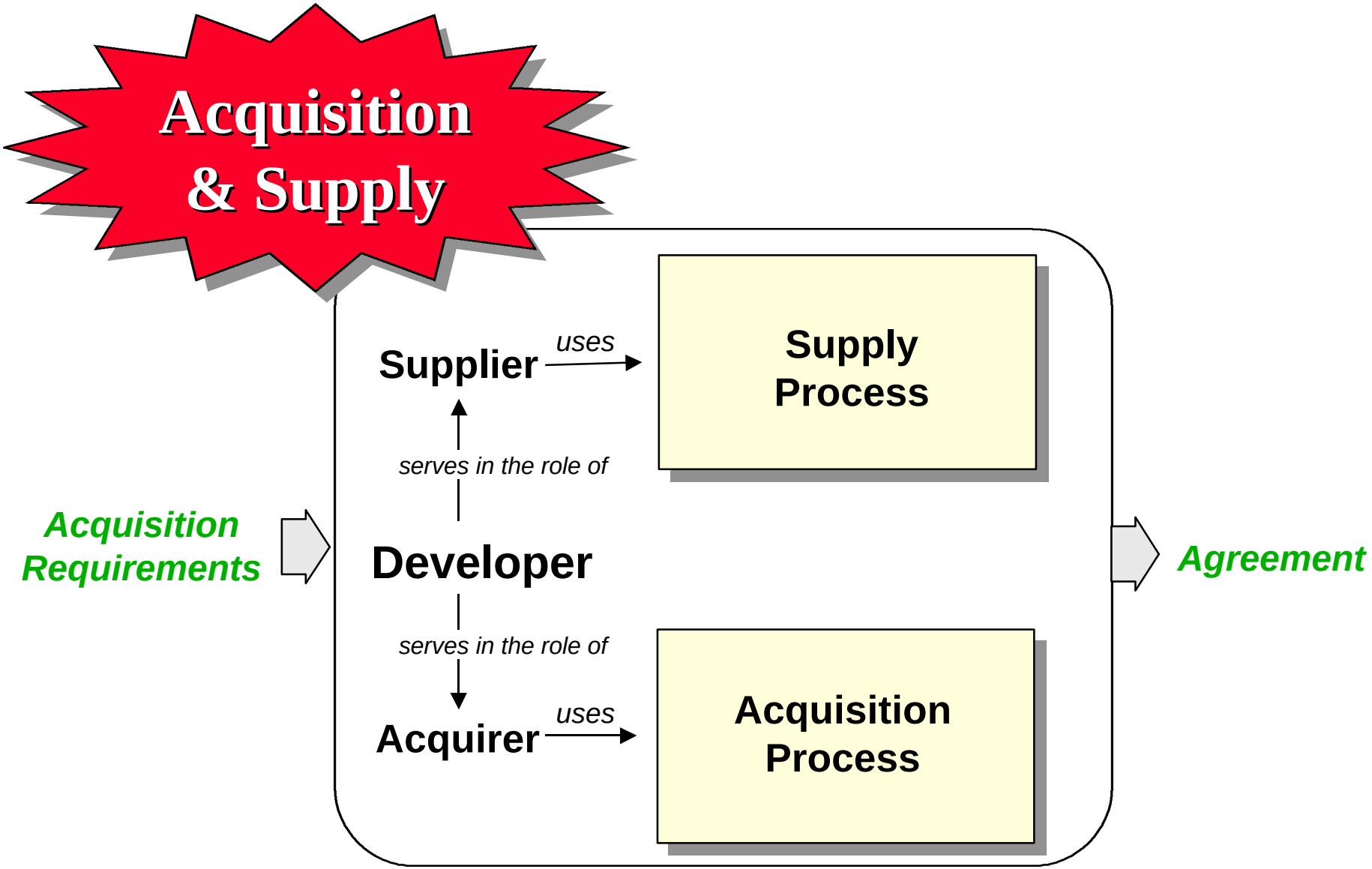
Top-Level Process Diagram

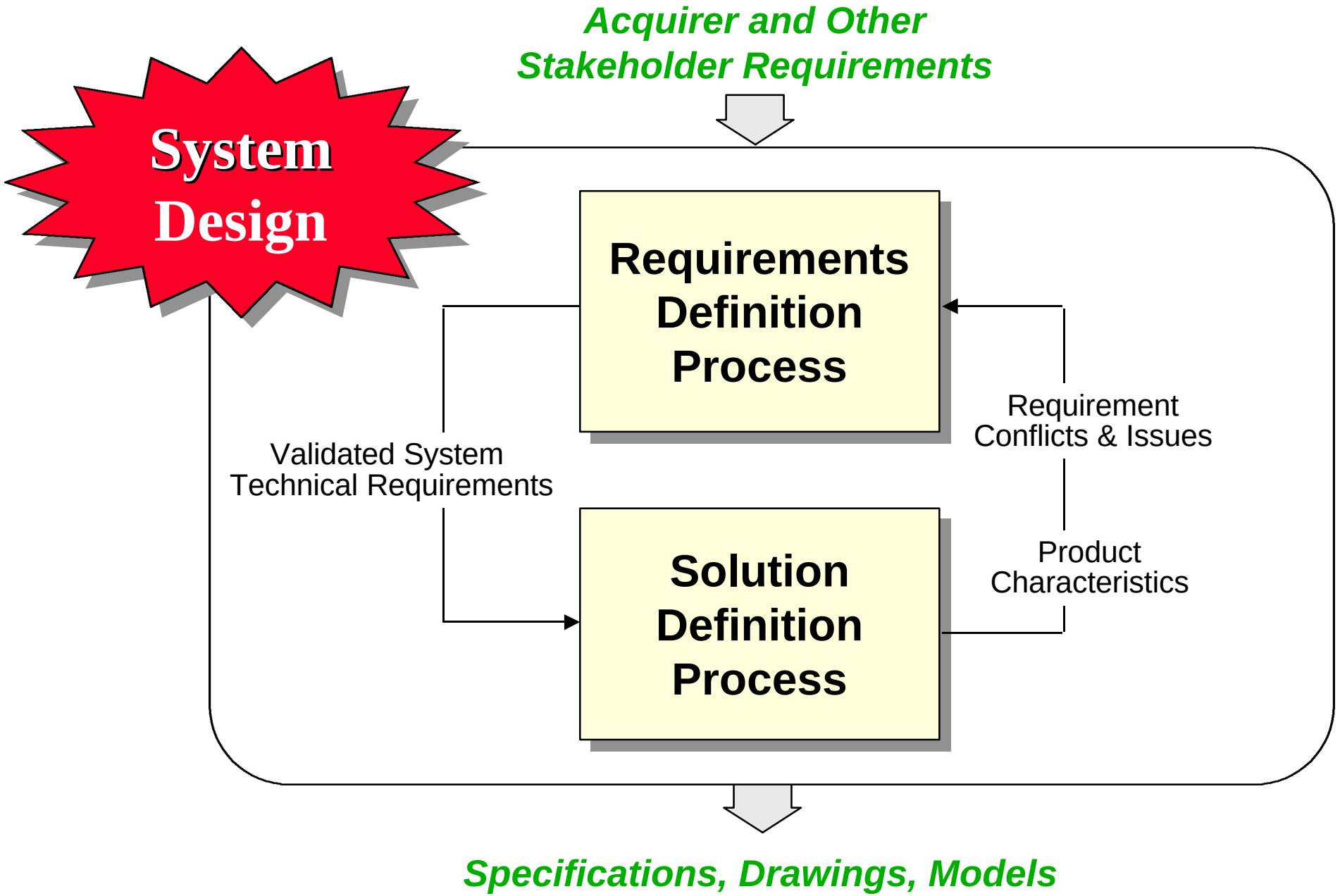


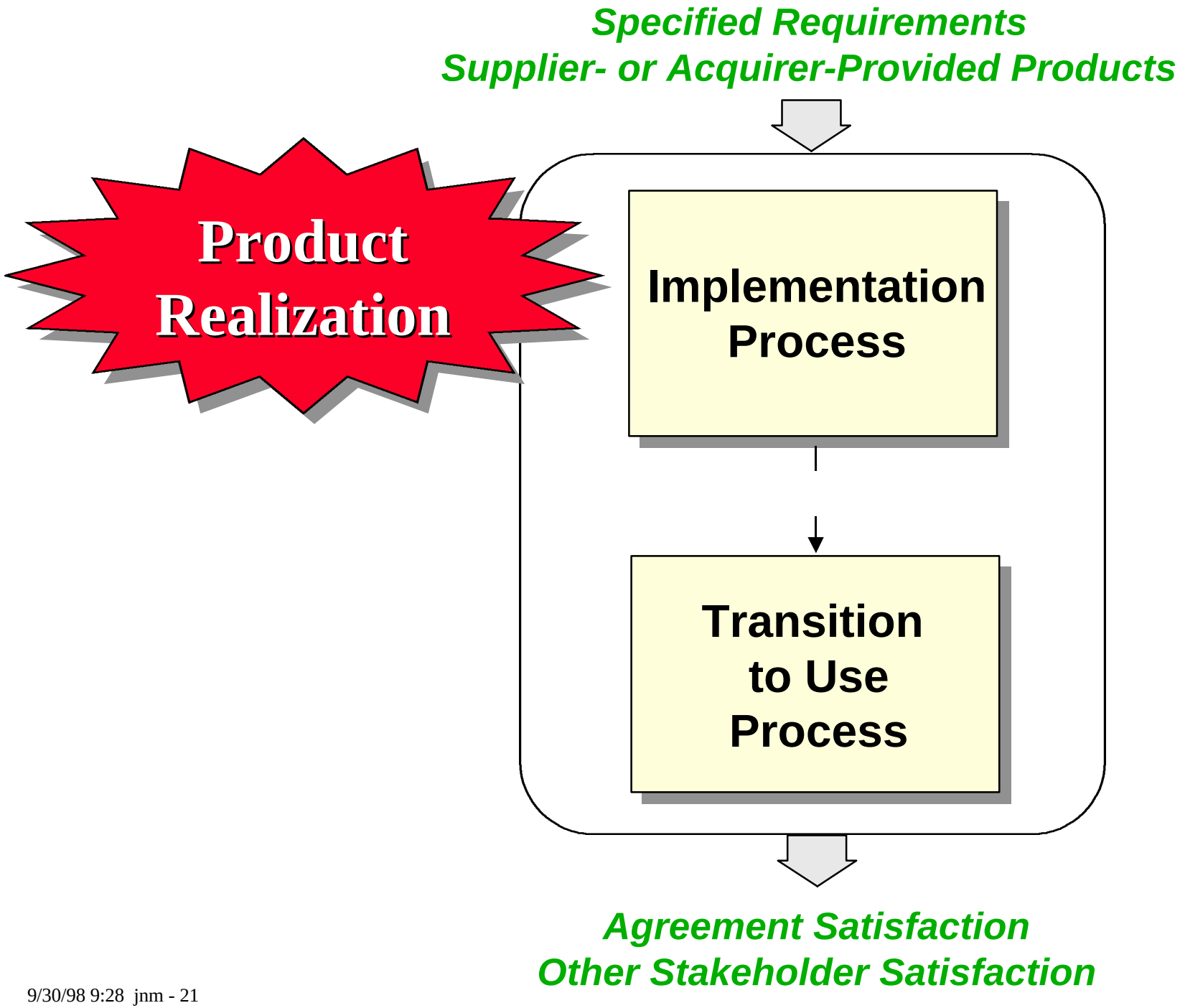

Technical Management
Planning Process
Assessment Process
Control Process
Plans, Directives & Status
Acquisition & Supply
Supply Process
Acquisition Process
Outcomes & Feedback
Acquisition Request
Requirements
System Design
Requirements Definition Process
Solution Definition Process
System Products
Designs

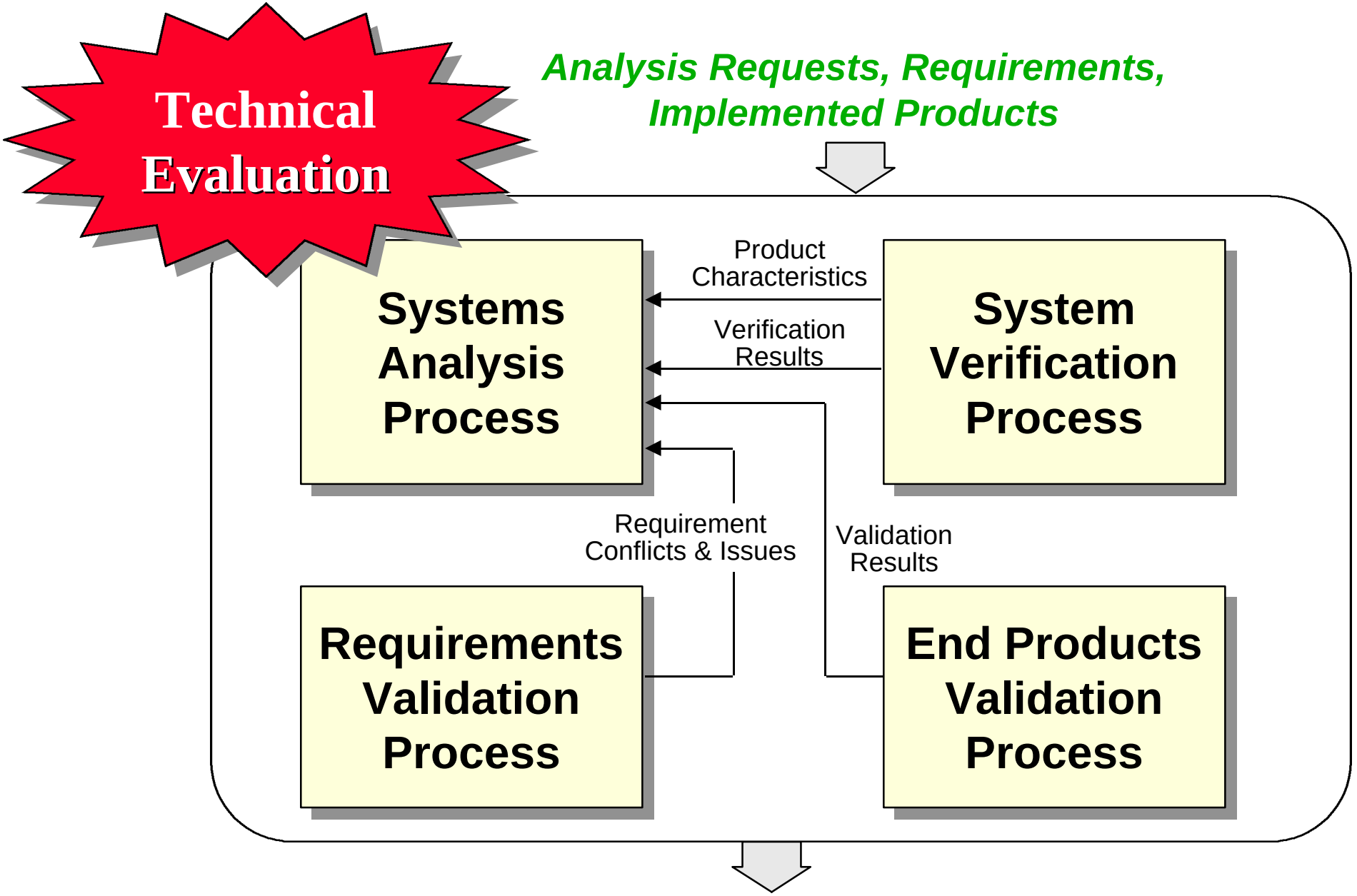

Acquisition Request
Solution Definition
Designs
Product Realization
Implementation
Transition to Use
Plans, Directives & Status
Outcomes & Feedback
Products
System Products
Technical Evaluation
Systems Analysis
Requirements Validation
System Verification
End Products Validation


Acquisition Documents, Agreement,
Outcomes, and Feedback
Technical Management
Plans & Directives
Control Process
Planning Process
Request for Replanning
Status
Outcomes
Assessment Process
Plans & Directives
Plans, Directives, Status


Acquisition & Supply
Supplier
uses
Supply Process
serves in the role of
Acquisition Requirements
Developer
Agreement
serves in the role of
Acquirer
uses
Acquisition Process


Acquirer and Other
Stakeholder Requirements
System
Design
Requirements
Definition
Process
Validated System
Technical Requirements
Requirement
Conflicts & Issues
Solution
Definition
Process
Product
Characteristics
Specifications, Drawings, Models


Specified Requirements
Supplier- or Acquirer-Provided Products
Product Realization
Implementation Process
Transition to Use Process
Agreement Satisfaction
Other Stakeholder Satisfaction


Technical Evaluation
Analysis Requests, Requirements, Implemented Products
Systems Analysis Process
System Verification Process
Requirements Validation Process
End Products Validation Process
Product Characteristics
Verification Results
Requirement Conflicts & Issues
Validation Results
Analytical Models & Assessments, Validated Requirements, Verified Products, Validated Products

SUPPLY PROCESS REQUIREMENTS

1—Product Supply

ACQUISITION PROCESS REQUIREMENTS

2—Product Acquisition

3—Supplier Performance

PLANNING PROCESS REQUIREMENTS

4—Process Implementation Strategy

5—Technical Effort Definition

6—Schedule and Organization

7—Technical Plans

8—Work Directives

ASSESSMENT PROCESS REQUIREMENTS

9—Progress Against Plans and Schedules

10—Progress Against Requirements

11—Technical Reviews

CONTROL PROCESS REQUIREMENTS

12—Outcomes Management

13—Information Dissemination

REQUIREMENTS DEFINITION PROCESS REQUIREMENTS

14—Acquirer Requirements

15—Other Stakeholder Requirements

16—System Technical Requirements

SOLUTION DEFINITION PROCESS REQUIREMENTS

17—Logical Solution Representations

18—Physical Solution Representations

19—Specified Requirements

IMPLEMENTATION PROCESS REQUIREMENTS

20—Implementation

TRANSITION TO USE PROCESS REQUIREMENTS

21—Transition to Use

SYSTEMS ANALYSIS PROCESS REQUIREMENTS

22—Effectiveness Analysis

23—Tradeoff Analysis

24—Risk Analysis

REQUIREMENTS VALIDATION PROCESS REQUIREMENTS

25—Statements Validation

26—Acquirer Requirements Validation

27—Other Stakeholder Requirements Validation

28—System Technical Requirements Validation

29—Logical Solution Representations Validation

SYSTEM VERIFICATION PROCESS REQUIREMENTS

30—Design Solution Verification

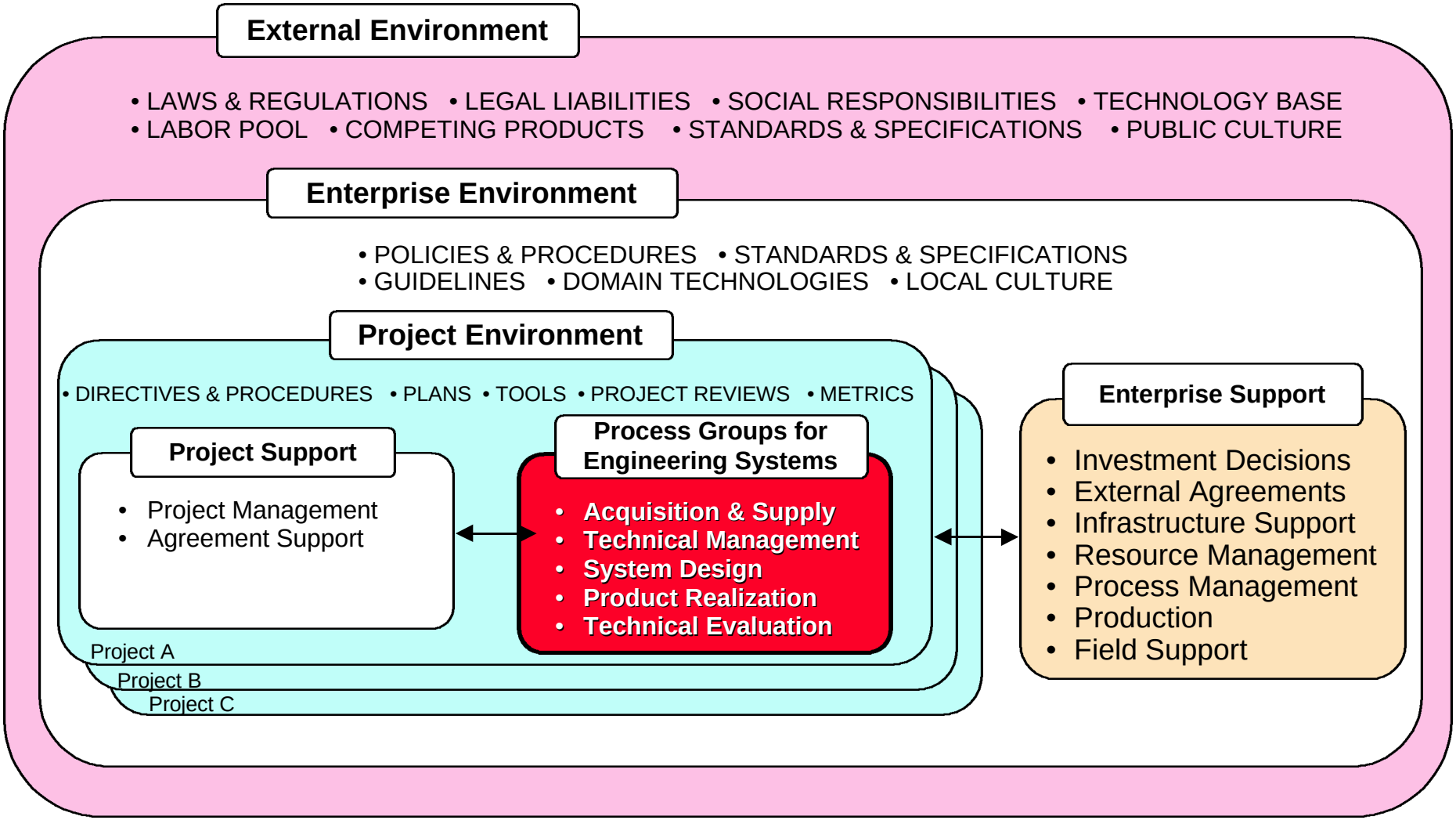
31—End Product Verification

32—Enabling Product Readiness

END PRODUCTS VALIDATION PROCESS REQUIREMENTS

33—End Products Validation

Project Environment

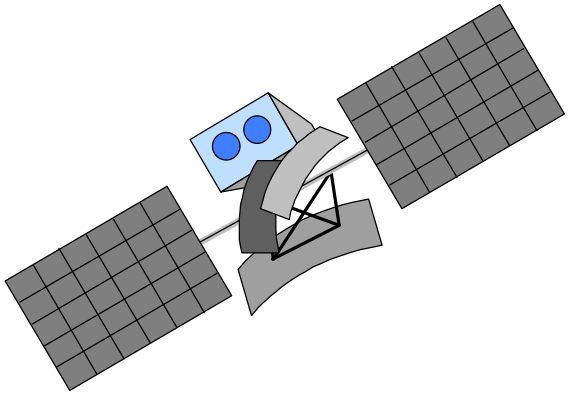


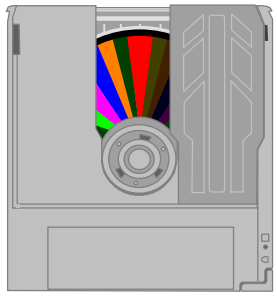
Key Concepts

- What is a Product?
- What is a System?
- Building Block
- Development Layers

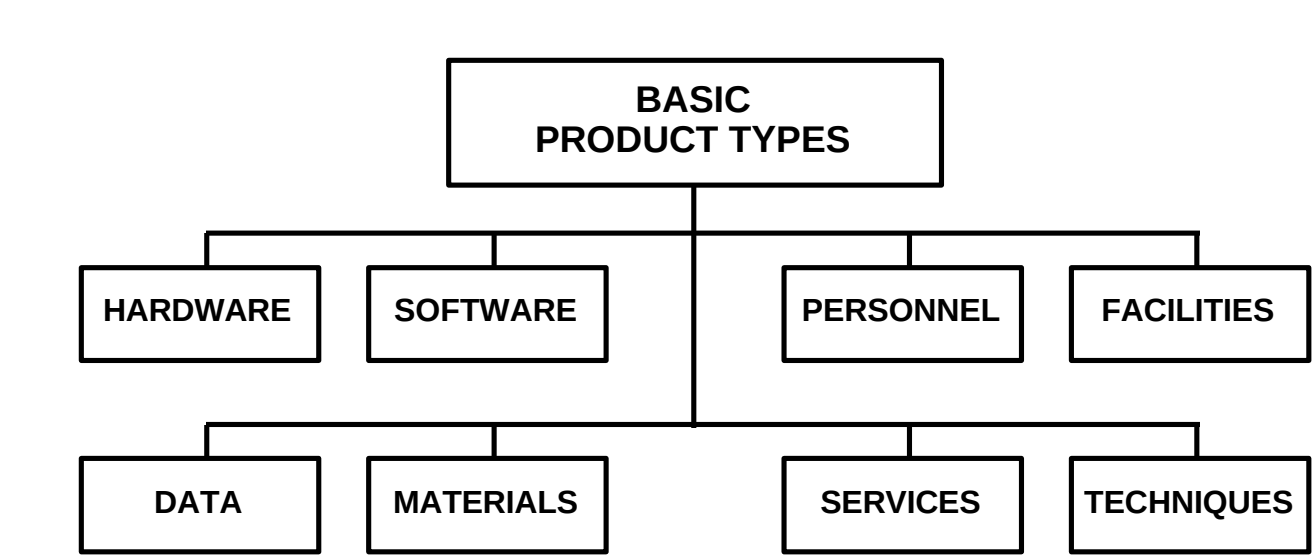
What Types of Products Constitute a System?

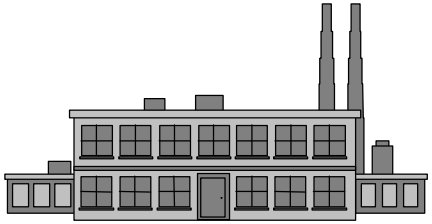
- **Hardware and Software ??**
- **Hardware and Software and People ??**

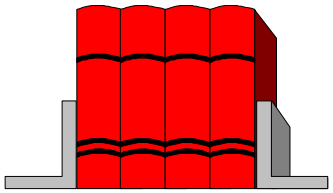


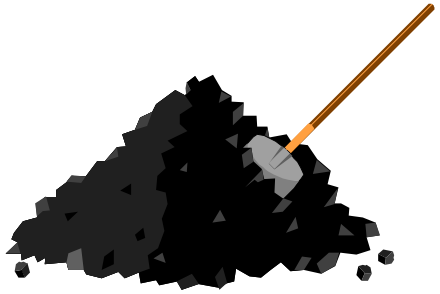


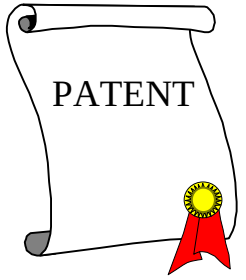
Basic Product Types









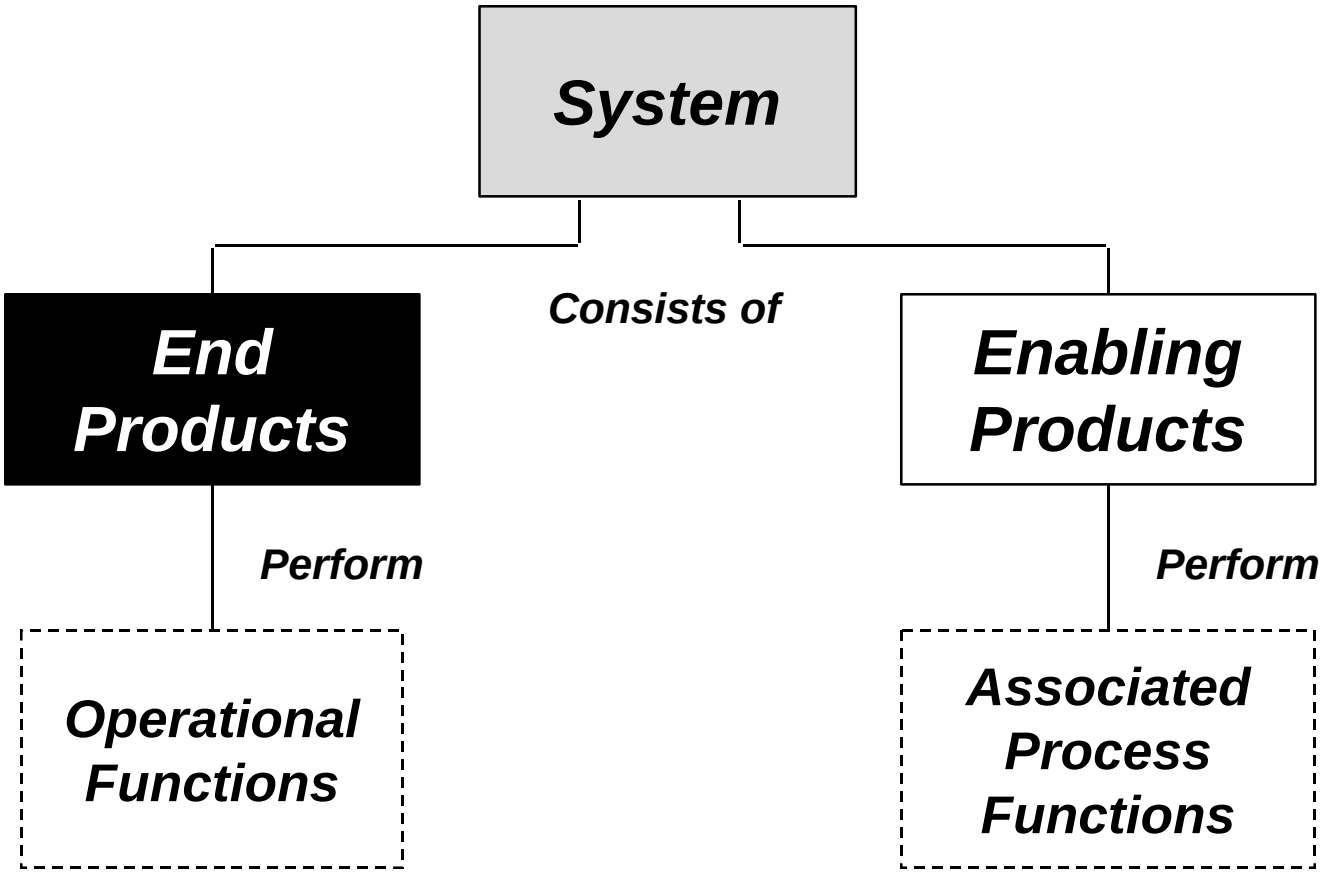


Other Possible Product Types (Needing Development or Acquisition)

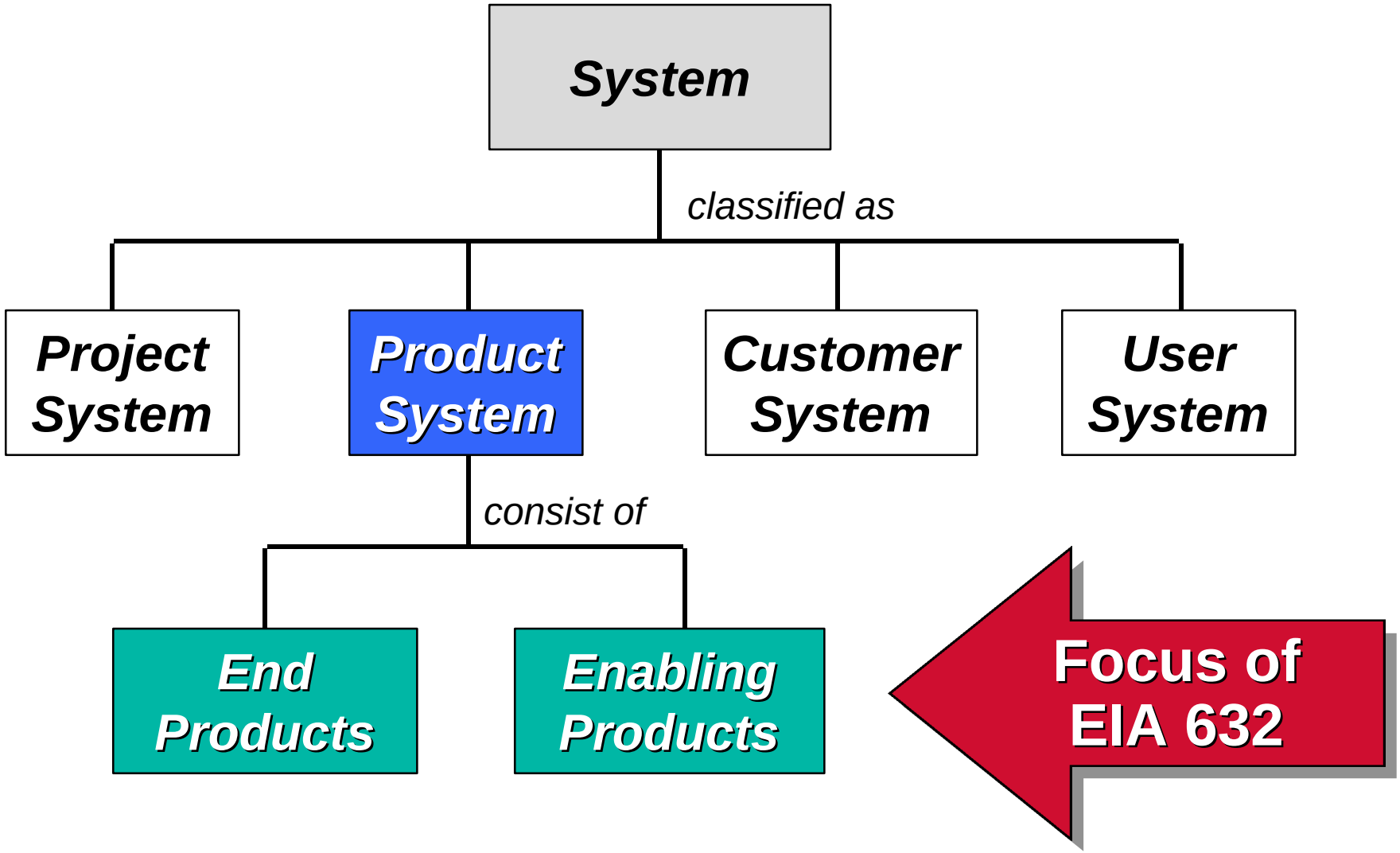
- Media
- Documents
- Procedures
- Information
- Ships
- Structures (e.g., Bridges, Oil Derricks)
- . . .

. . . Whatever is necessary for <u>your</u> application domain

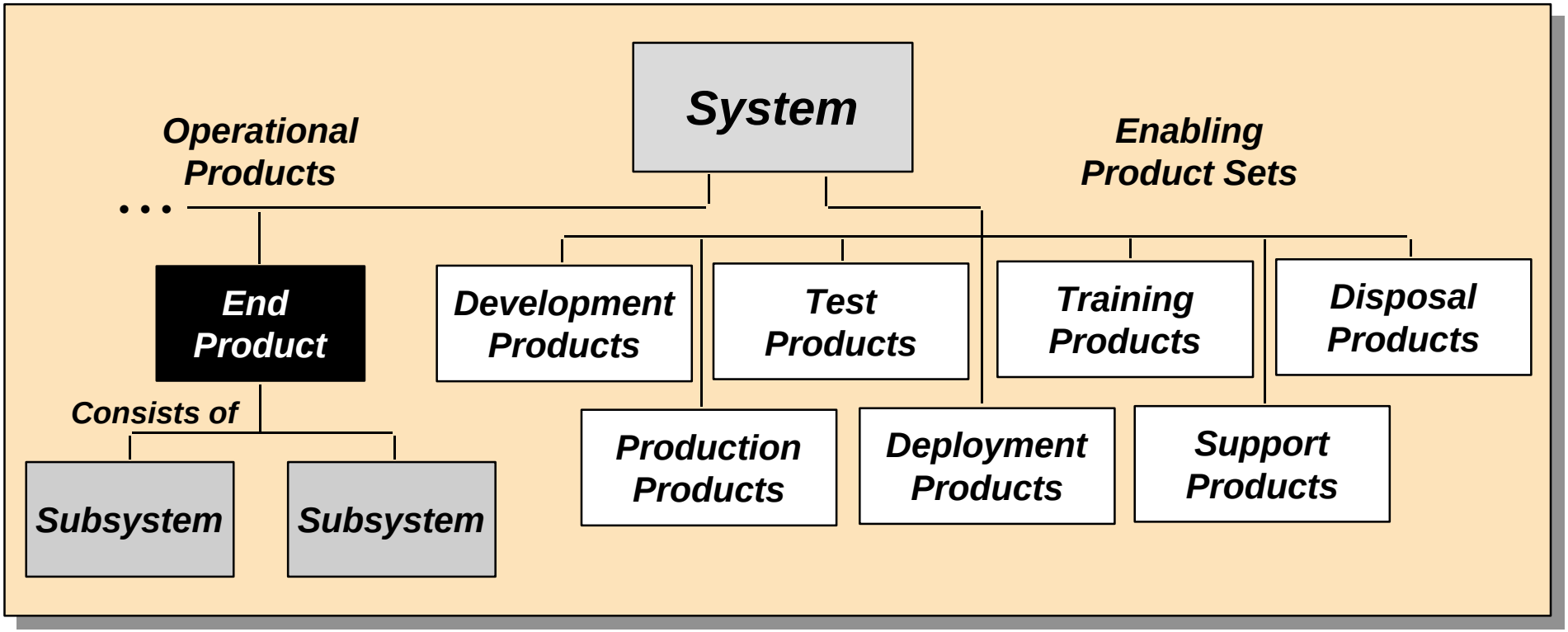
What is a System?



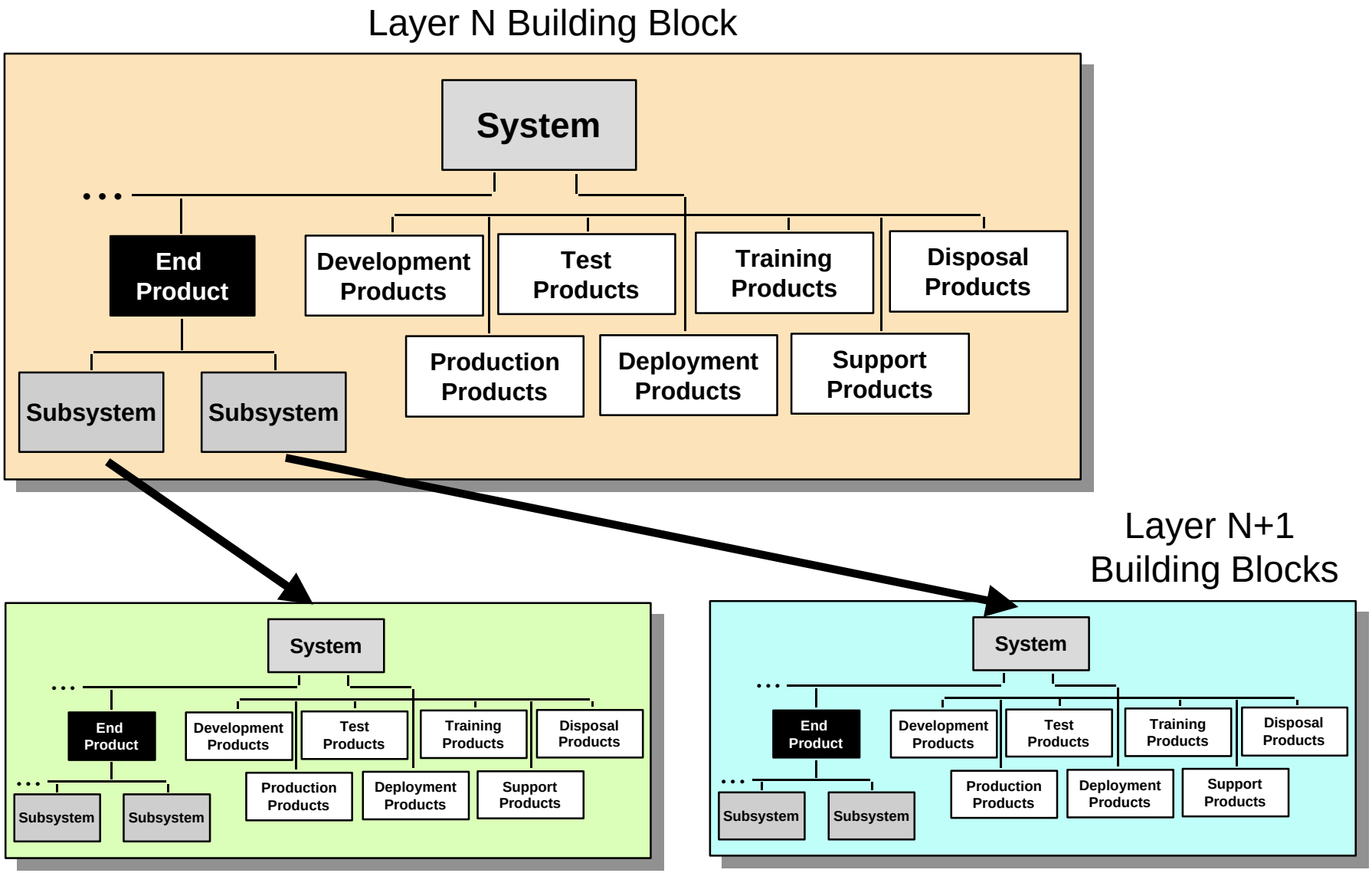
Types of Systems



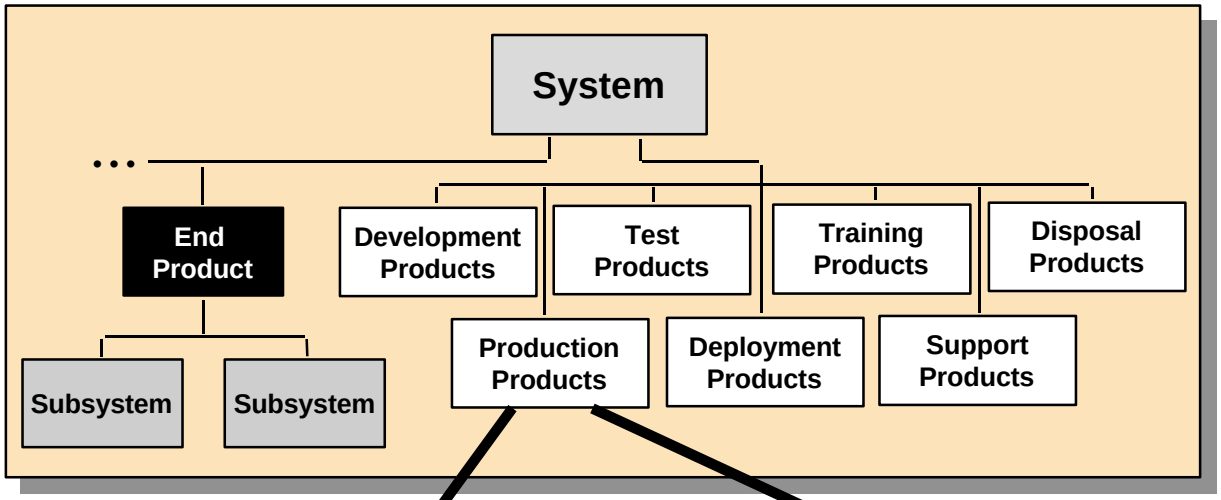
The Building Block Concept



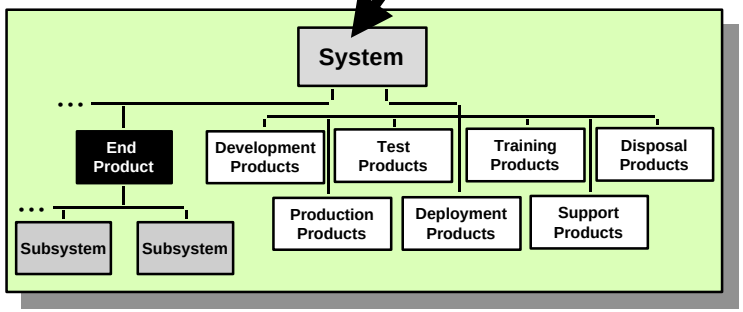
Development Layers Concept



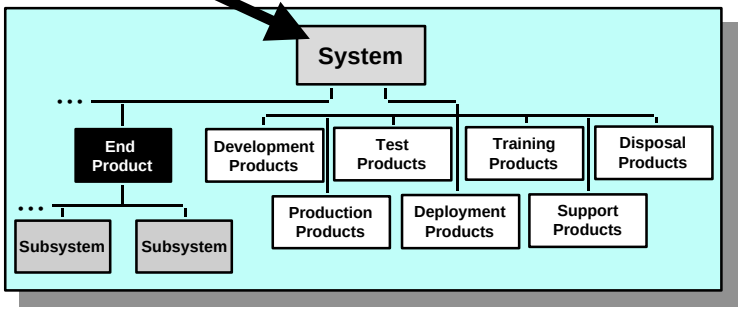
Development of “Enabling Products”



Example: Production Equipment



Example: Production Facilities

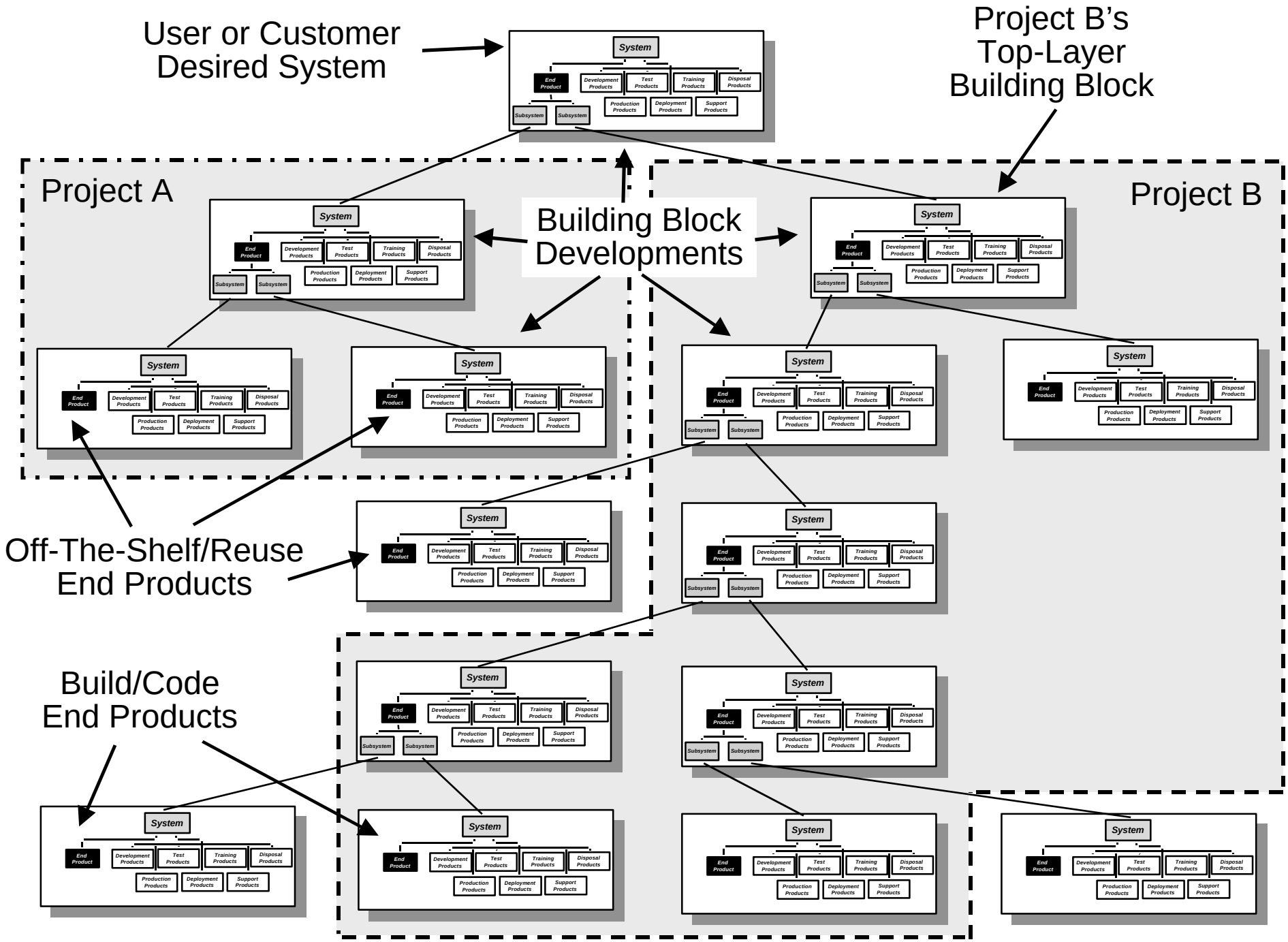


Other Production Enabling Products Possibly Needing Development:

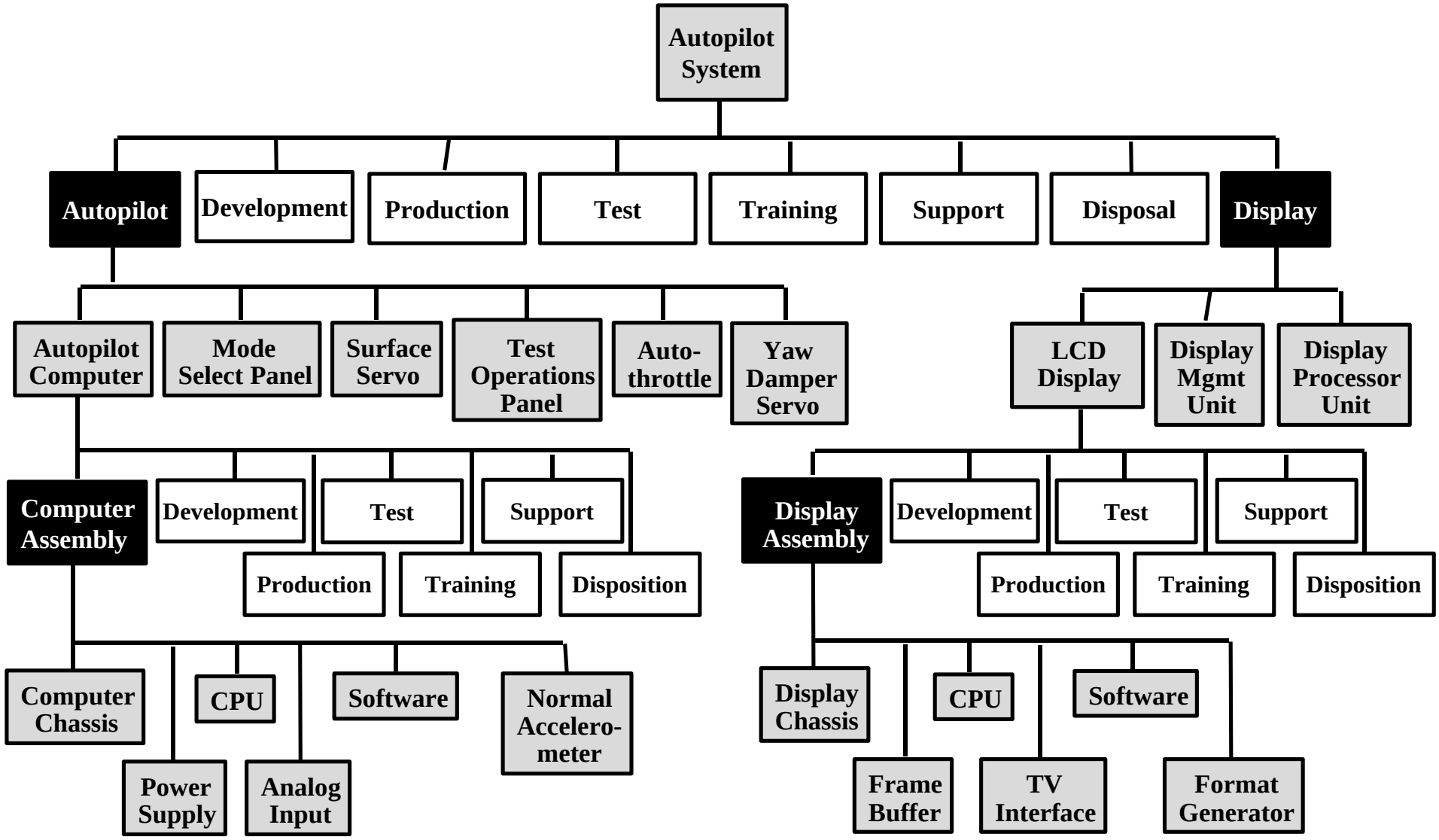
- **Manufacturing Procedures (e.g. soldering, jigging)**
- **Manufacturing Personnel (e.g. test operators, assembly technicians)**
- **Manufacturing Services (e.g. shipping & receiving, JIT deliveries)**

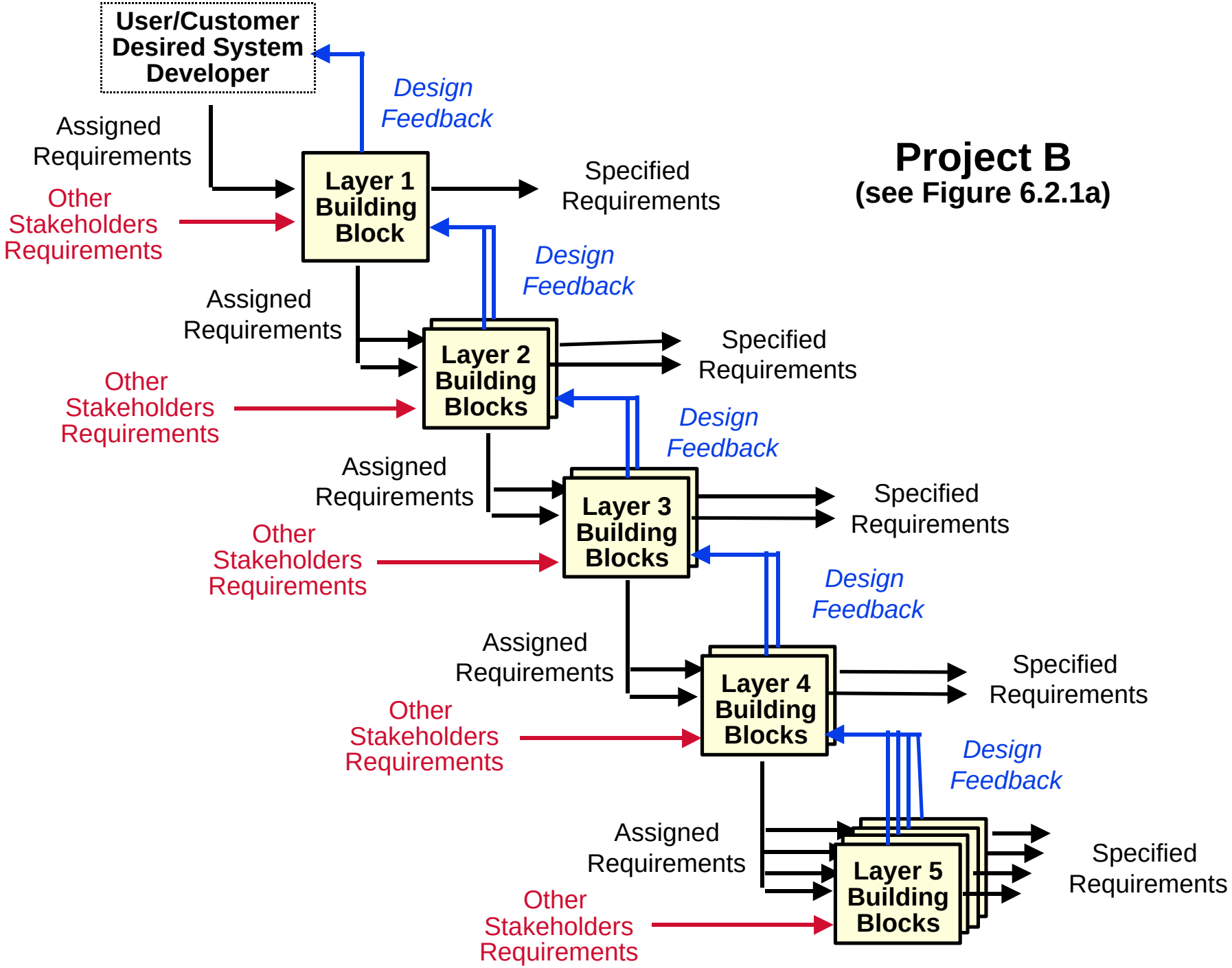
Example Enabling Products

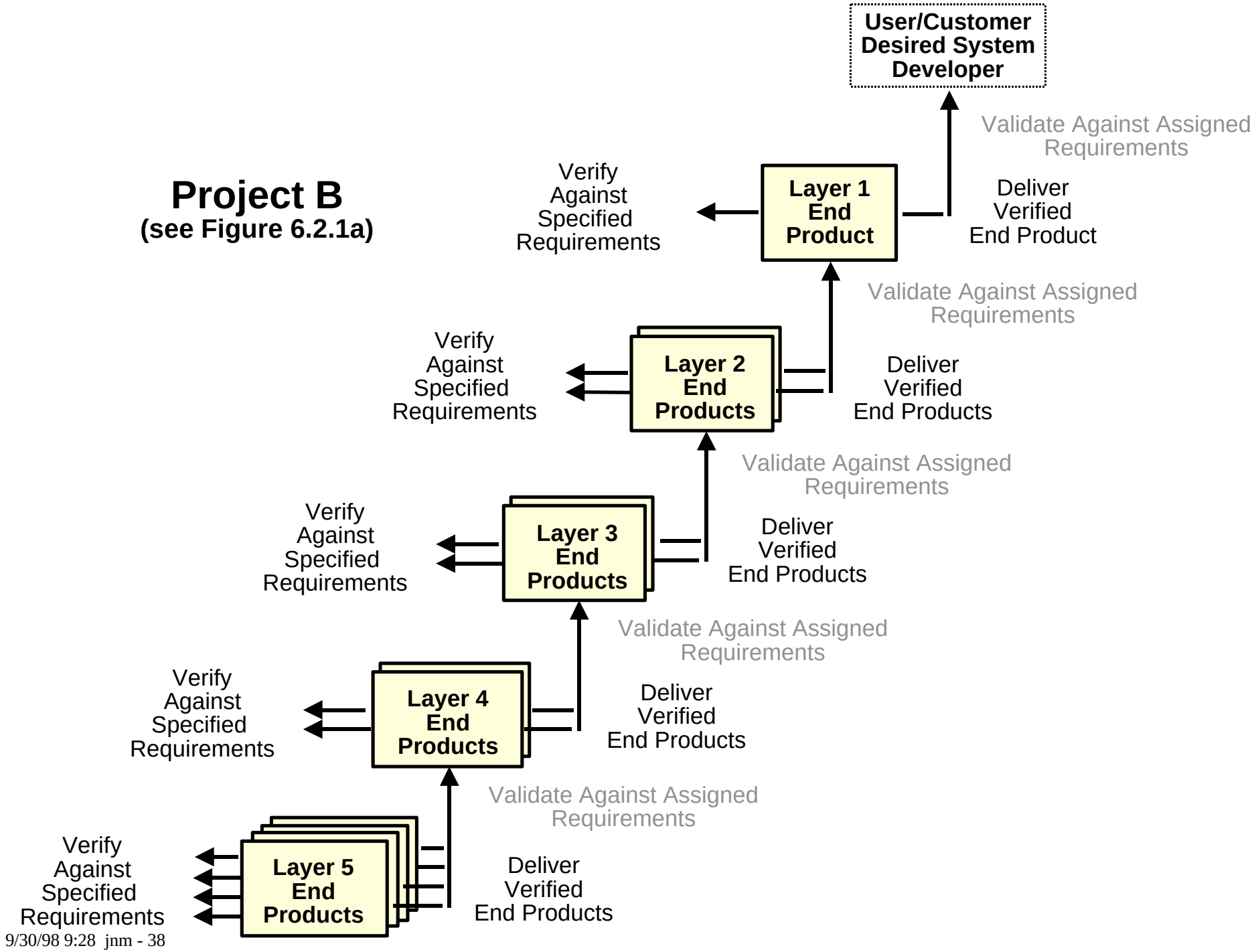
- **Development**
  - » Development Plans and Schedules
  - » Engineering Policies and Procedures
  - » CAE Tools
  - » Prototypes
  - » Engineers and Managers
- **Production**
  - » Production Plans and Schedules
  - » Production Tooling and Facilities
- **Test**
  - » Test Equipment and Software
  - » Test Plans and Procedures
- **Deployment**
  - » Staging facilities
  - » Warehouses
  - » Shipping Containers
- **Training**
  - » Class Rooms
  - » Flight Simulator
  - » Instructors
- **Support**
  - » Customer Hot Line
  - » Repair Facilities
  - » Diagnostic Equipment
  - » Overnight Shipping Service
- **Disposal**
  - » Disposal Site
  - » Refurbishment Facilities
  - » Removal Tools
  - » Public Safety Bulletins


User or Customer
Desired System
Project B's
Top-Layer
Building Block
Project A
Project B
Building Block
Developments
Off-The-Shelf/Reuse
End Products
Build/Code
End Products
System
End Product
Development Products
Test Products
Training Products
Disposal Products
Production Products
Deployment Products
Support Products
Subsystem

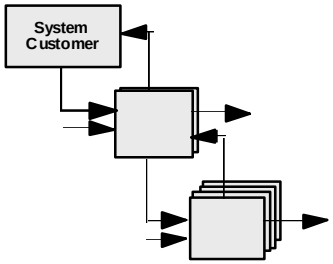
Example Building Block Hierarchy



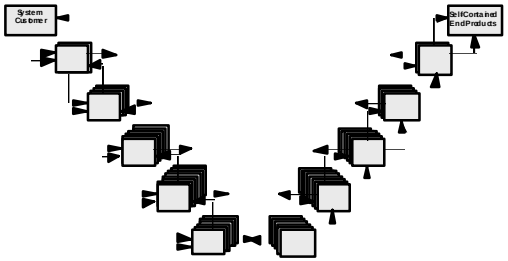

User/Customer
Desired System
Developer
Design
Feedback
Assigned
Requirements
Other
Stakeholders
Requirements
Layer 1
Building
Block
Specified
Requirements
Project B
(see Figure 6.2.1a)
Design
Feedback
Assigned
Requirements
Layer 2
Building
Blocks
Specified
Requirements
Other
Stakeholders
Requirements
Design
Feedback
Assigned
Requirements
Layer 3
Building
Blocks
Specified
Requirements
Other
Stakeholders
Requirements
Design
Feedback
Assigned
Requirements
Layer 4
Building
Blocks
Specified
Requirements
Other
Stakeholders
Requirements
Design
Feedback
Assigned
Requirements
Layer 5
Building
Blocks
Specified
Requirements
Other
Stakeholders
Requirements


User/Customer
Desired System
Developer
Validate Against Assigned Requirements
Project B
(see Figure 6.2.1a)
Verify Against Specified Requirements
Layer 1 End Product
Deliver Verified End Product
Validate Against Assigned Requirements
Verify Against Specified Requirements
Layer 2 End Products
Deliver Verified End Products
Validate Against Assigned Requirements
Verify Against Specified Requirements
Layer 3 End Products
Deliver Verified End Products
Validate Against Assigned Requirements
Verify Against Specified Requirements
Layer 4 End Products
Deliver Verified End Products
Validate Against Assigned Requirements
Verify Against Specified Requirements
Layer 5 End Products
Deliver Verified End Products

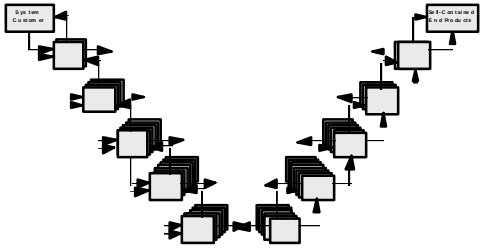
Assessment of Opportunities	Investment Decision	System Concept Development	Subsystem Design & Pre-Deployment	Deployment/ Installation, Operations & Support



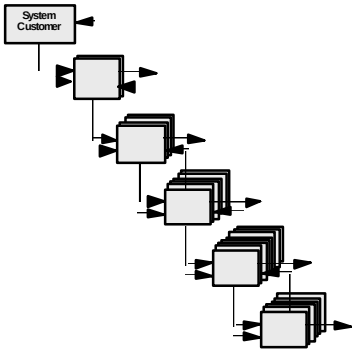
Simulation



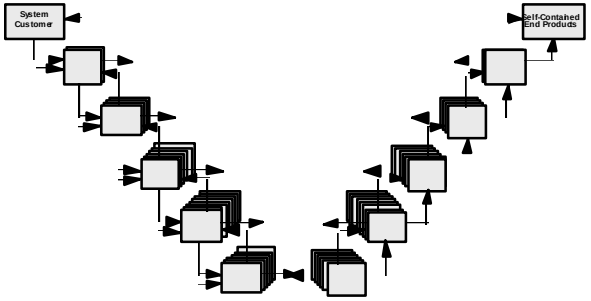
Advanced Technology Prototype



Improvements, As Necessary

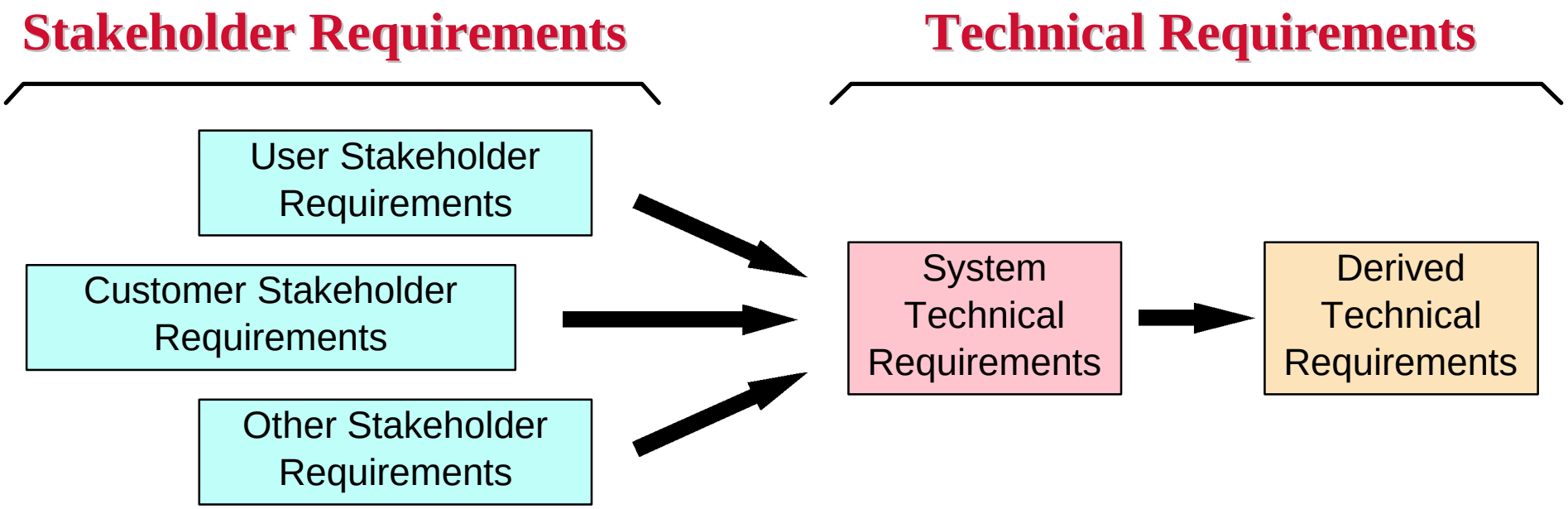


Simulation, Physical or Functional Prototype



Pre-Production Prototype, Production Runs

Evolution of Requirements



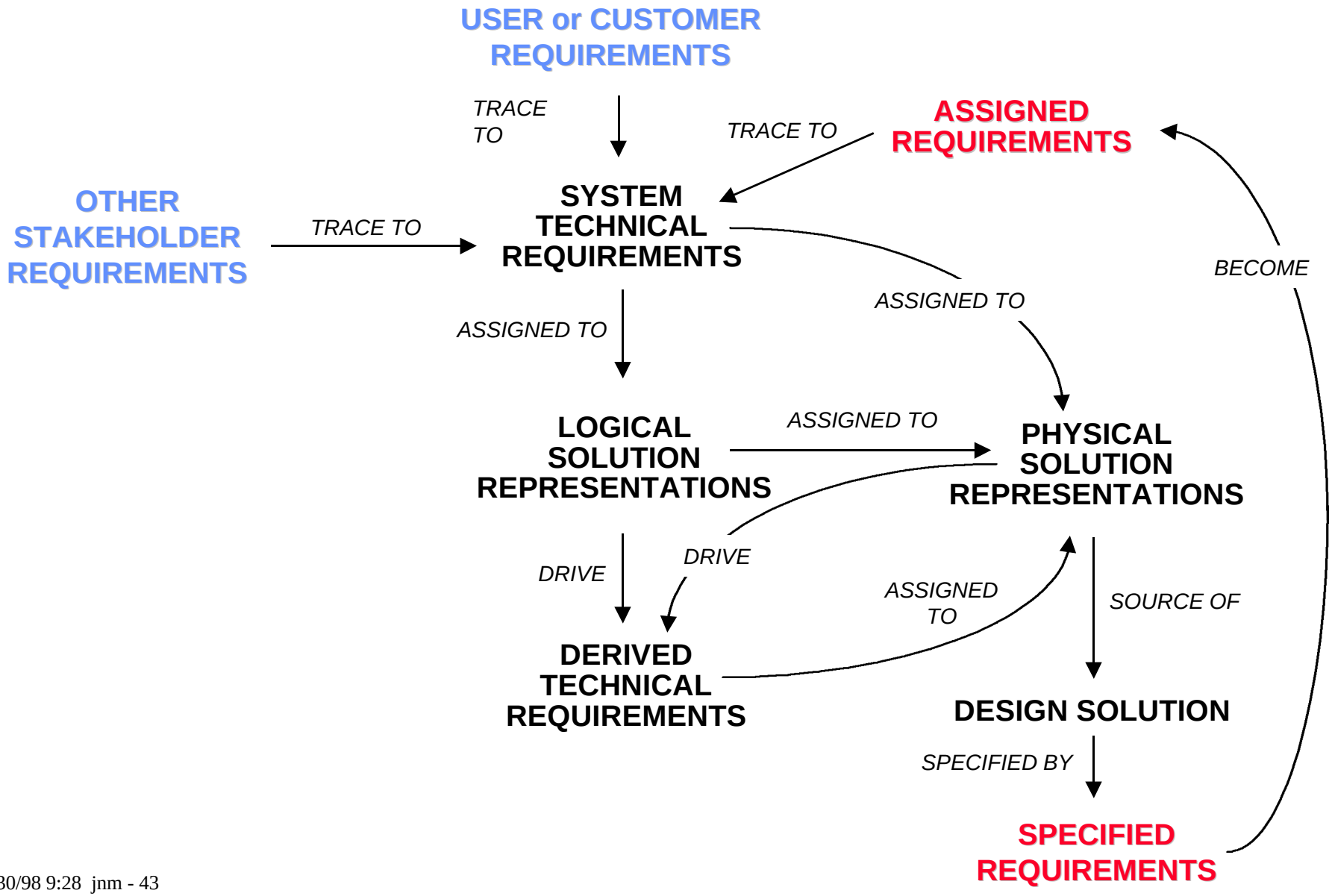
Types of Requirements

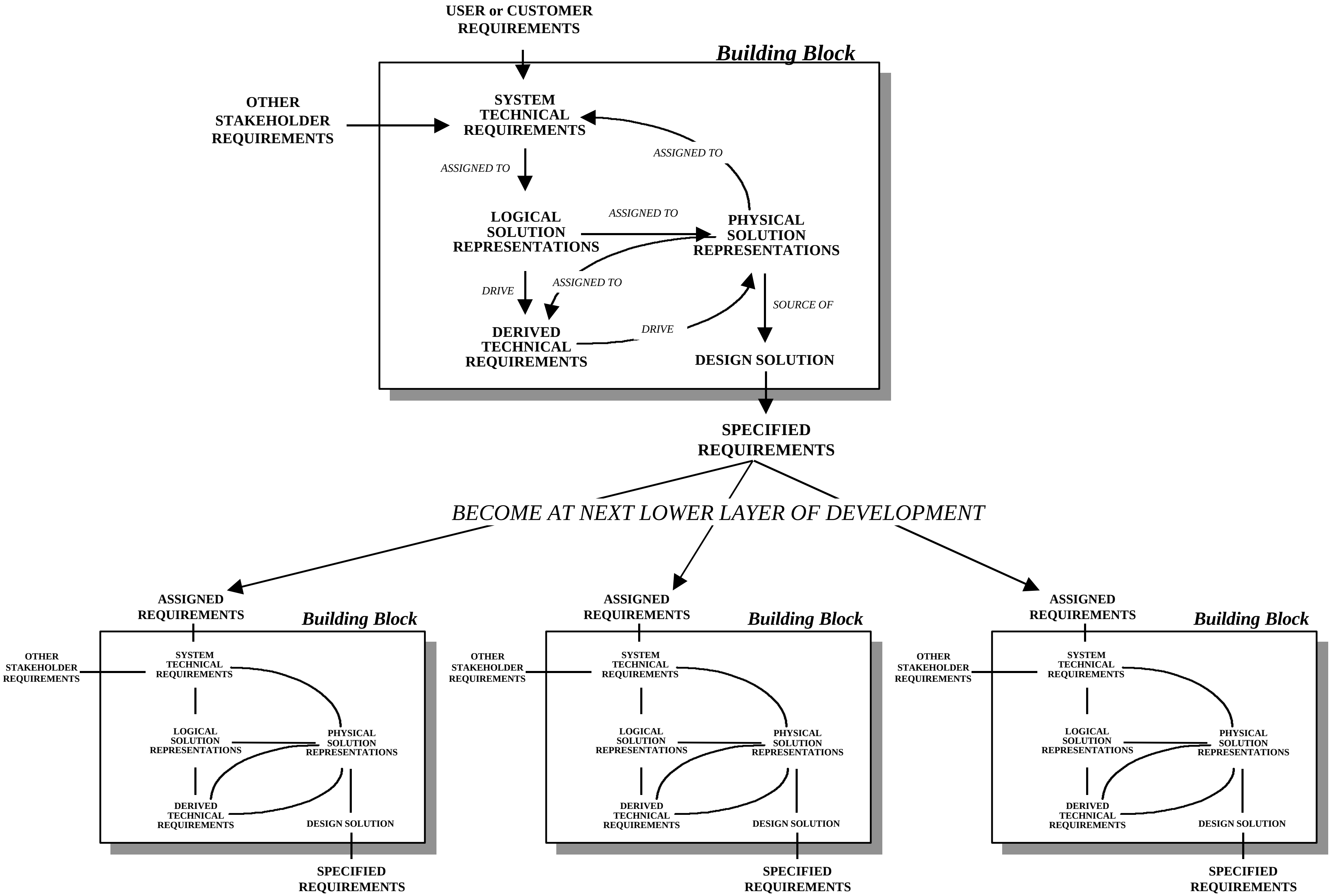
- **Functional Requirements**
  - » *What* an item is to accomplish
    - Behavior of an item
    - An effect produced
    - Action or service to be performed
- **Performance Requirements**
  - » *How well* an item is to accomplish a function
    - ... like how much, how often, how many, how few, . . .
- **Interface Requirements**
  - » *Conditions* of interaction between items
    - ... could be functional, physical, logical, . . .

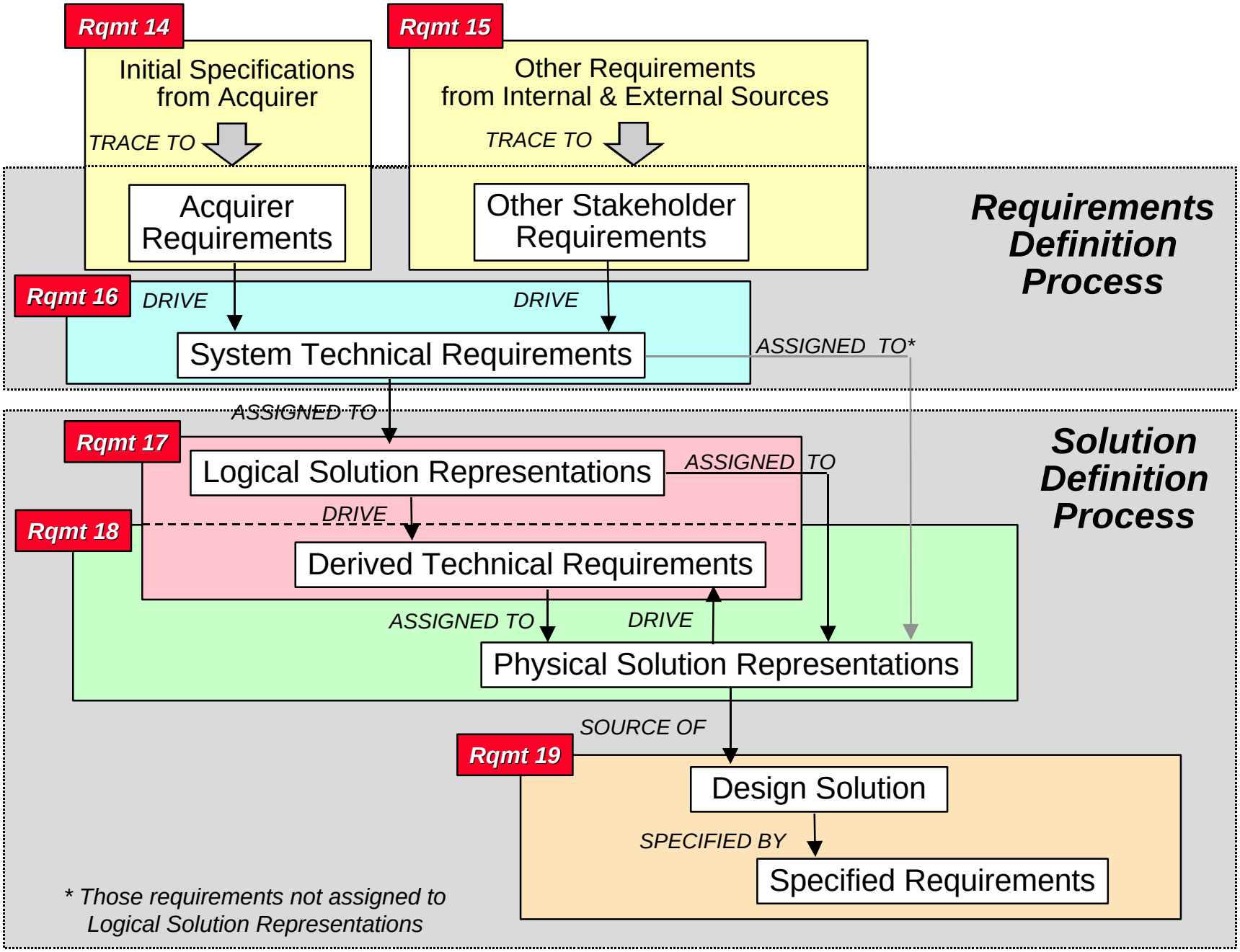
Other Information Related to Requirements

- **Not to be confused with "Requirement Statements" . . .**
  - » Which are sentences or phrases that contain *one or more* of the basic types above (functional, performance, interface)
    - "The ABC subsystem shall identify internal failures within 2 seconds of their occurrence after the 'BIT Test Start' command is received."
    - ... which contains all 3 basic types of requirements
- **Also need to know Conditions for each type . . .**
  - » Conditions under which the requirement is valid
    - Environmental
    - States and modes
    - Physical configurations
    - Geographic locations
    - . . .
- **Constraints are those special requirements where trade-offs cannot be made**

Requirement Relationships



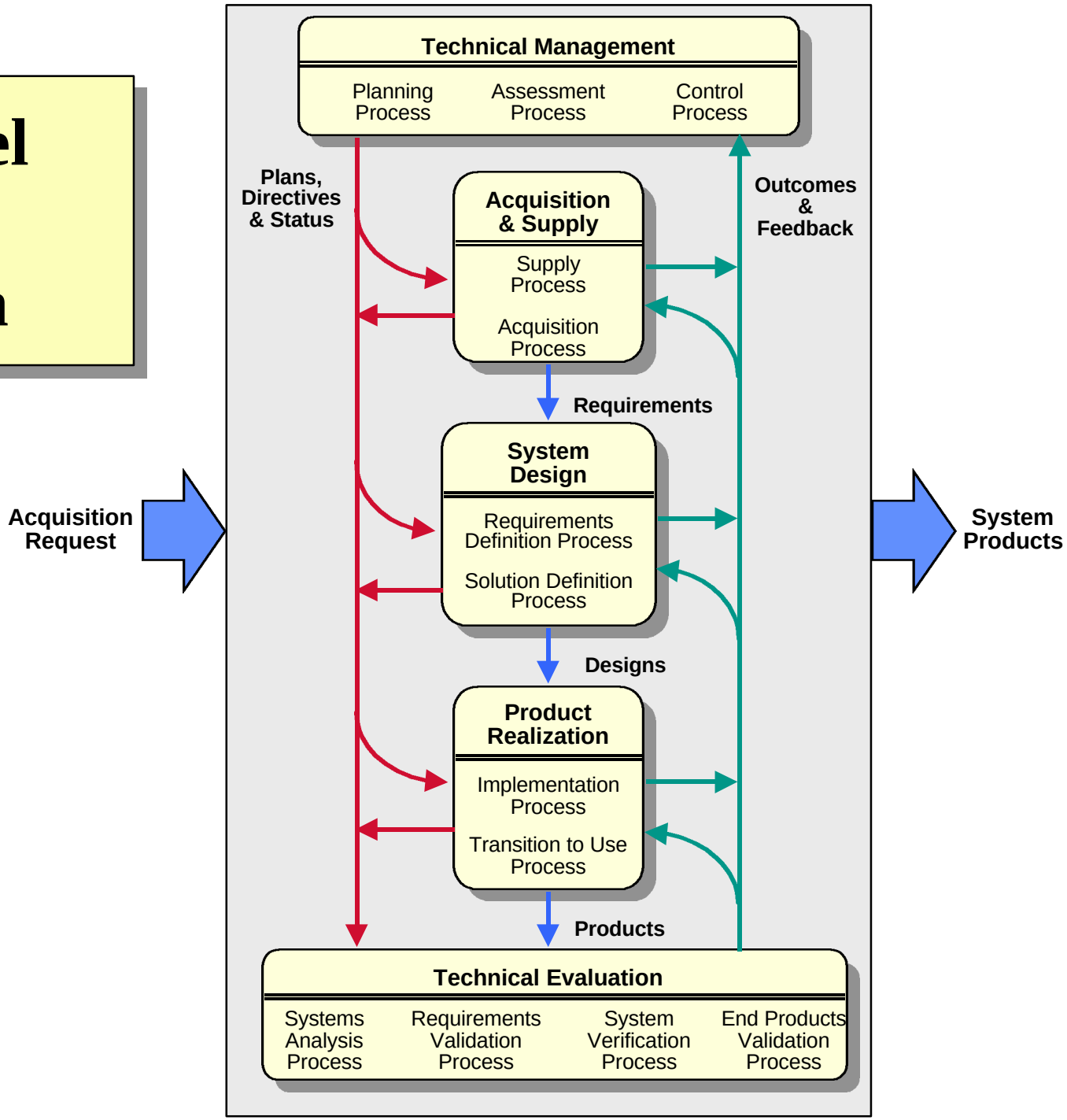

USER or CUSTOMER REQUIREMENTS
Building Block
OTHER STAKEHOLDER REQUIREMENTS
SYSTEM TECHNICAL REQUIREMENTS
ASSIGNED TO
ASSIGNED TO
LOGICAL SOLUTION REPRESENTATIONS
ASSIGNED TO
PHYSICAL SOLUTION REPRESENTATIONS
DRIVE
ASSIGNED TO
SOURCE OF
DERIVED TECHNICAL REQUIREMENTS
DRIVE
DESIGN SOLUTION
SPECIFIED REQUIREMENTS
BECOME AT NEXT LOWER LAYER OF DEVELOPMENT
ASSIGNED REQUIREMENTS
Building Block
OTHER STAKEHOLDER REQUIREMENTS
SYSTEM TECHNICAL REQUIREMENTS
LOGICAL SOLUTION REPRESENTATIONS
PHYSICAL SOLUTION REPRESENTATIONS
DERIVED TECHNICAL REQUIREMENTS
DESIGN SOLUTION
SPECIFIED REQUIREMENTS


Rqmt 14
Initial Specifications from Acquirer
TRACE TO
Acquirer Requirements
Rqmt 15
Other Requirements from Internal & External Sources
TRACE TO
Other Stakeholder Requirements
Requirements Definition Process
Rqmt 16
DRIVE
DRIVE
System Technical Requirements
ASSIGNED TO*
ASSIGNED TO
Rqmt 17
Logical Solution Representations
ASSIGNED TO
Solution Definition Process
DRIVE
Rqmt 18
Derived Technical Requirements
ASSIGNED TO
DRIVE
Physical Solution Representations
SOURCE OF
Rqmt 19
Design Solution
SPECIFIED BY
Specified Requirements
* Those requirements not assigned to Logical Solution Representations

Verification & Validation

- **Verification**
  - » Check compliance against specified requirements
  - » "Have you done the *job right*?"
  - » Two Types
    - Product & Process Qualification
      - Full compliance to specification
      - Product requalification may be necessary when Product is "redesigned"
      - Process requalification may be necessary when Process is "restarted"
    - Product Acceptance
      - Full compliance to key criteria
      - Done on every unit or on sample basis
      - Can be done prior to shipment or after installation
- **Validation**
  - » Check satisfaction of stakeholders
  - » "Have you done the *right job*?"
  - » Two Types
    - Requirements Validation
      - Check for "traceability"
      - "Have we missed any requirements?"
      - "Do we have extraneous requirements?"
    - Product Validation
      - Check if meeting "needs and expectations" of stakeholders

Top-Level Process Diagram



Summary & Recommendations

- **EIA 632 will be the US National Standard on Engineering of Systems**
  - » Should be used to develop Corporate Policies & Procedures
  - » Corporate Standard Practices should be Fully Compliant with EIA 632
- **This standard should be made available to all Systems Engineers**
  - » They will be expected to “Lead the Way”
  - » Industry Methods & Tools will use EIA 632 as a baseline for development and upgrades

For More Information

- **EIA Engineering Operations Council**
  - » http://www.eia.org/gd/gdeoc/
- **EIA G47 Systems Engineering Committee**
  - » Hal Wilson, Chair
  - » Wilson_Hal@prc.com
- **EIA 632 Working Group**
  - » James Martin, Chair
  - » j-martin@ti.com
  - » (972)575-0182
- **International Council on Systems Engineering (INCOSE)**
  - » http://www.incose.org/
  - » incose@halcyon.com

Get Your Own Copy

- **Global Engineering Documents**
  - » http://global.ihs.com/
  - » SP-3537 (Standards Proposal) Available Now
  - » Production Release in November 1998

Conclusions

- **EIA 632 has significant enhancements over the Interim Version**
  - » Acquirer/Supplier Processes
  - » Commercial Environment
  - » Stakeholder Requirements
  - » Entire Engineering Effort
- **Useful as a Framework for Corporate Practices and 2nd-Tier Standards**
  - » Company Policies & Procedures
  - » Industry-Specific Standards