Human Systems Engineering (Part 1)

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Contents

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- Publication Date: October 2011
- ISBN 978-1-105-58810-5 (paperback edition)

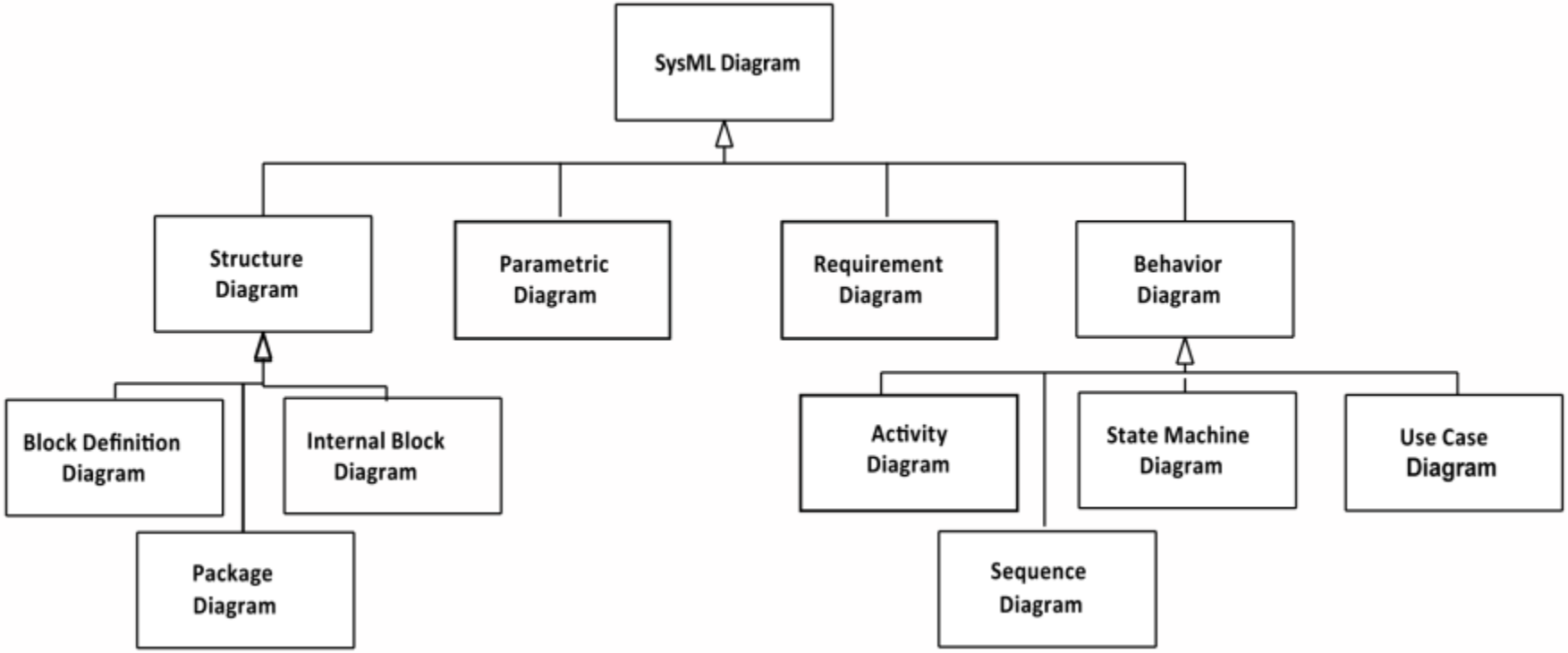
Abstract

- How do we systems engineer humans?
- How do we engineer systems that include humans?
- Do all systems include humans?
  - If so, which humans, how are they included in a system, and how do we perform systems engineering on them?
  - Are they elements of the system like hardware and software are?
  - Do we have hardware, software, and humanware? (Yes, you heard it here first folks, humanware!).
  - How do we model the behavior of humans?
- Are there any systems that do not include humans in any way whatsoever?
- This presentation discusses these questions from the SE Standards and INCOSE SE Handbook perspectives, going back to their earlier versions and coming up to date, including the two most recent approaches.
- At the end of this presentation we ask you to answer the question: Which of the two most recent approaches do you consider to be the optimum and for what reasons?

Abstract (cont)

How Do We Model the Behavior of Humans?

SysML Diagram Types



INCOSE SE Handbook V3.2.2

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          - Tutorial ID : 01_October 2015
            - Tutorial Session: 00_Shared Documents
              - Human Systems Engineering
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        - Leadership Skills for SEs Tutorial – Zane Scott
        - SE Technical Processes Tutorial – Dick Fairley

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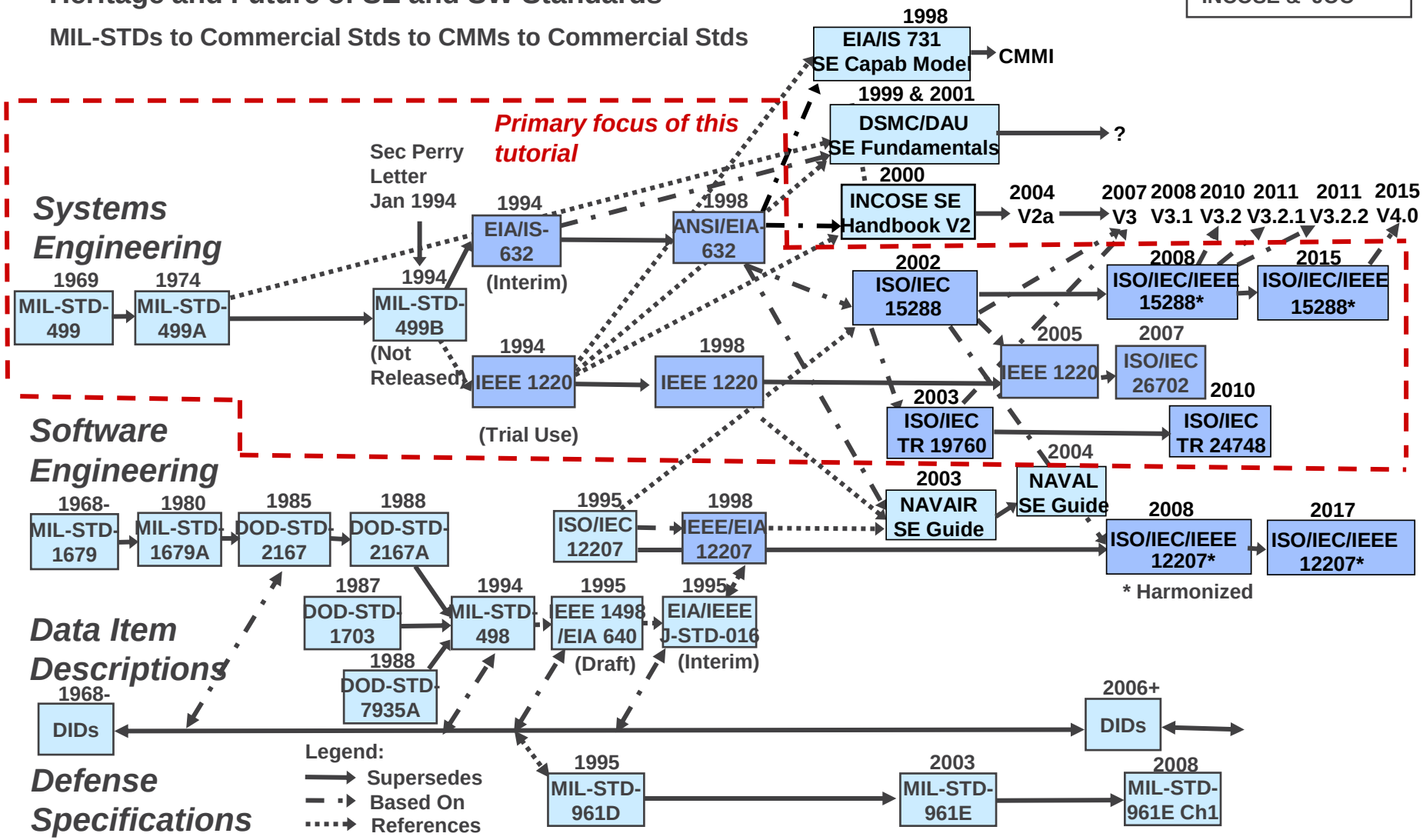
SE Standards Discussed in this Tutorial

Heritage and Future of SE and SW Standards

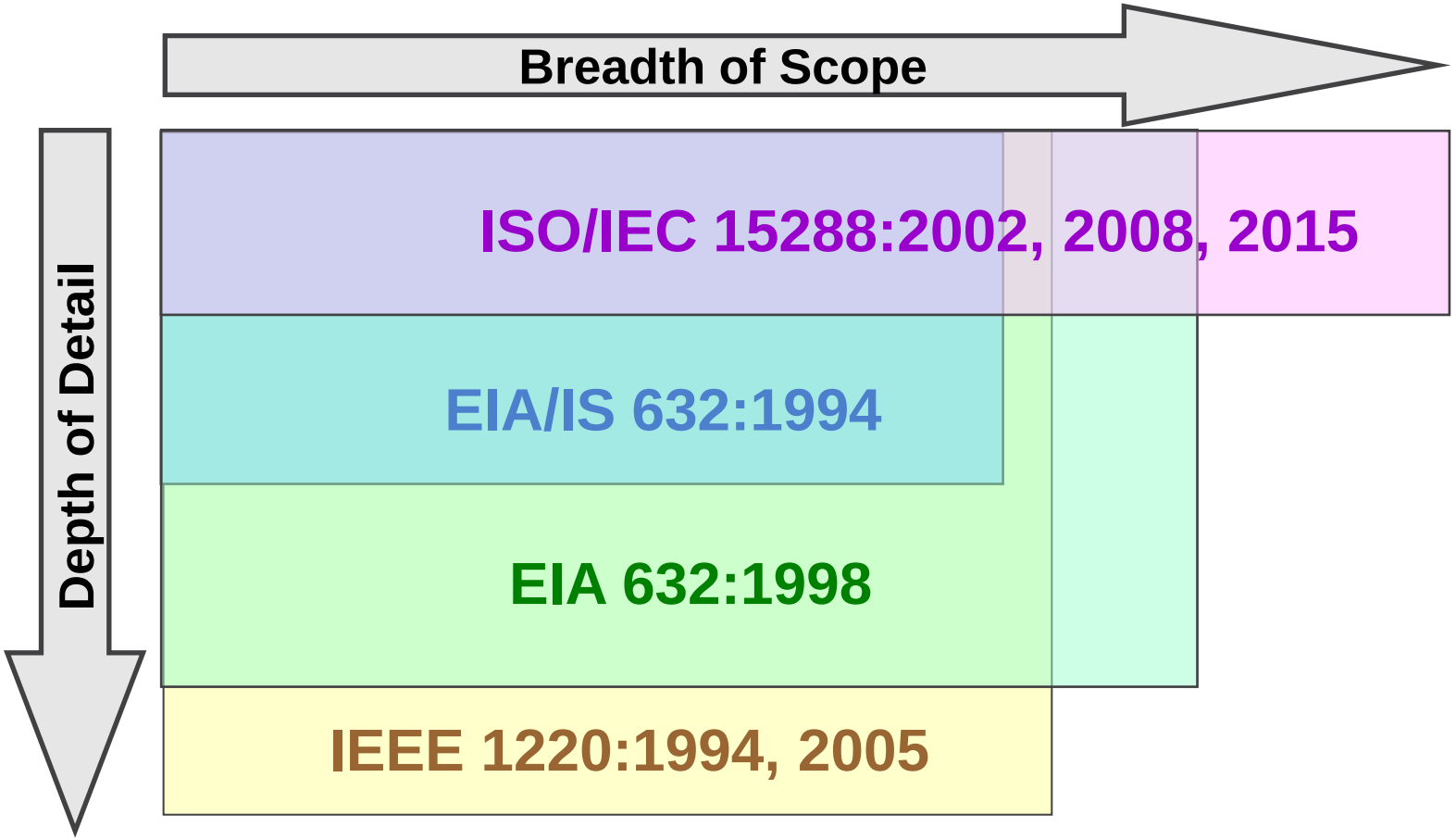
MIL-STDs to Commercial Stds to CMMs to Commercial Stds

INCOSE & JOC



Breadth and Depth of SE Standards

Sheard and Lake



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Sheard, Sarah A., Software Productivity Consortium (SPC), and
Lake, Jerome G., Systems Management international (SMi),
Systems Engineering Standards and Models Compared, July 1998.

Contents

What is a System?

SEVOCAB, EIA, ANSI, IEEE, ISO/IEC/IEEE

SE Standards Definitions of System

- A system is a composite of equipment, skills, and techniques capable of performing and/or supporting an operational role. A complete system includes all equipment, related facilities, material, software, services, and **personnel** required for its operation and support to the degree that it can be considered a self-sufficient unit in its intended operational environment. (MIL-STD-499-1969)
- A composite of subsystems, assemblies (or sets), skills, and techniques capable of performing and/or supporting an operational (or non-operational) role. A complete system includes related facilities, items, material, services, and **personnel** required for its operation to the degree that it can be considered a self-sufficient item in its intended operational (or non-operational) and/or support environment. *(DOD-STD-480A-1978)*
- An integrated composite of **people**, products, and processes that provide a capability to satisfy a stated need or objective. *(MIL-STD-499B became EIA/IS-632-1994)*
- An aggregation of end products and enabling products to achieve a given purpose. *(ANSI/EIA-632-1998)*
- The top element of the system architecture, specification tree, or system breakdown structure that is comprised of one or more products and associated life cycle processes and their products and services. *(IEEE 1220-1994)*
- A set or arrangement of elements [**people**, products (hardware and software) and processes (facilities, equipment, material, and procedures)] that are related and whose behavior satisfies customer/operational needs, and provides for the life cycle sustainment of the products. *(IEEE 1220-1998)*
- A set or arrangement of elements [**people**, products (hardware and software) and processes (facilities, equipment, material, and procedures)] that are related, and whose behavior satisfies operational needs and provides for the life cycle sustainment of the products. *(IEEE 1220-2005)*
- A combination of interacting elements organized to achieve one or more stated purposes. System element: Member of a set of elements that constitutes a system. *(ISO/IEC/IEEE 15288-2008 & 2015)*
- **Humans** can be viewed as both users external to a system and as system elements (i.e., operators) within a system. *(ISO/IEC/IEEE 15288:2008)*

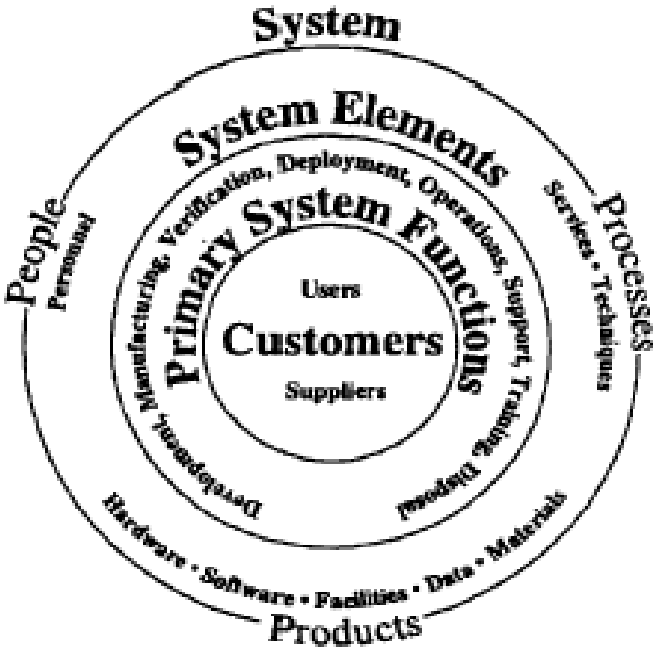
Software and Systems Engineering Vocabulary (SEVOCAB), http://pascal.computer.org/sev_display/index.action

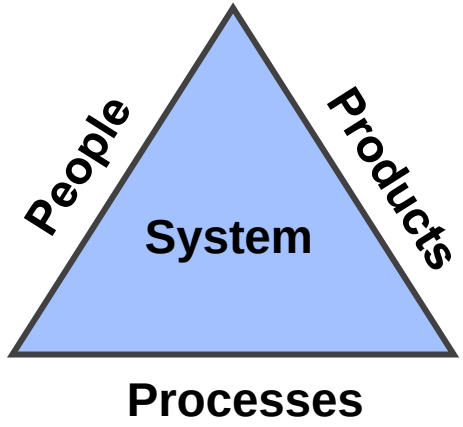
What is a System? (cont)

MIL-STD-499B
EIA/IS-632 & J Clark

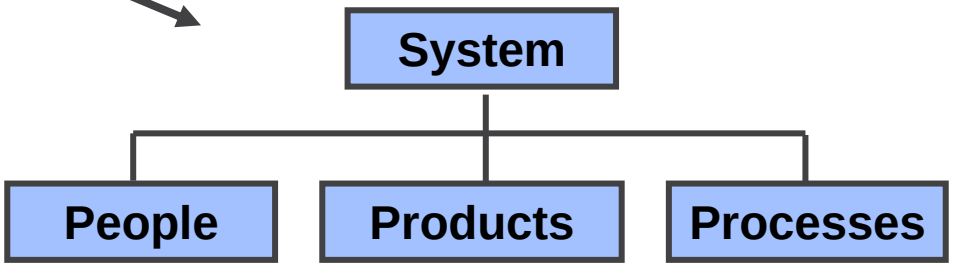
Key Terms

System Context Diagram





System Block Diagram



What is a System? (cont)

ISO/IEC TR 24748-1

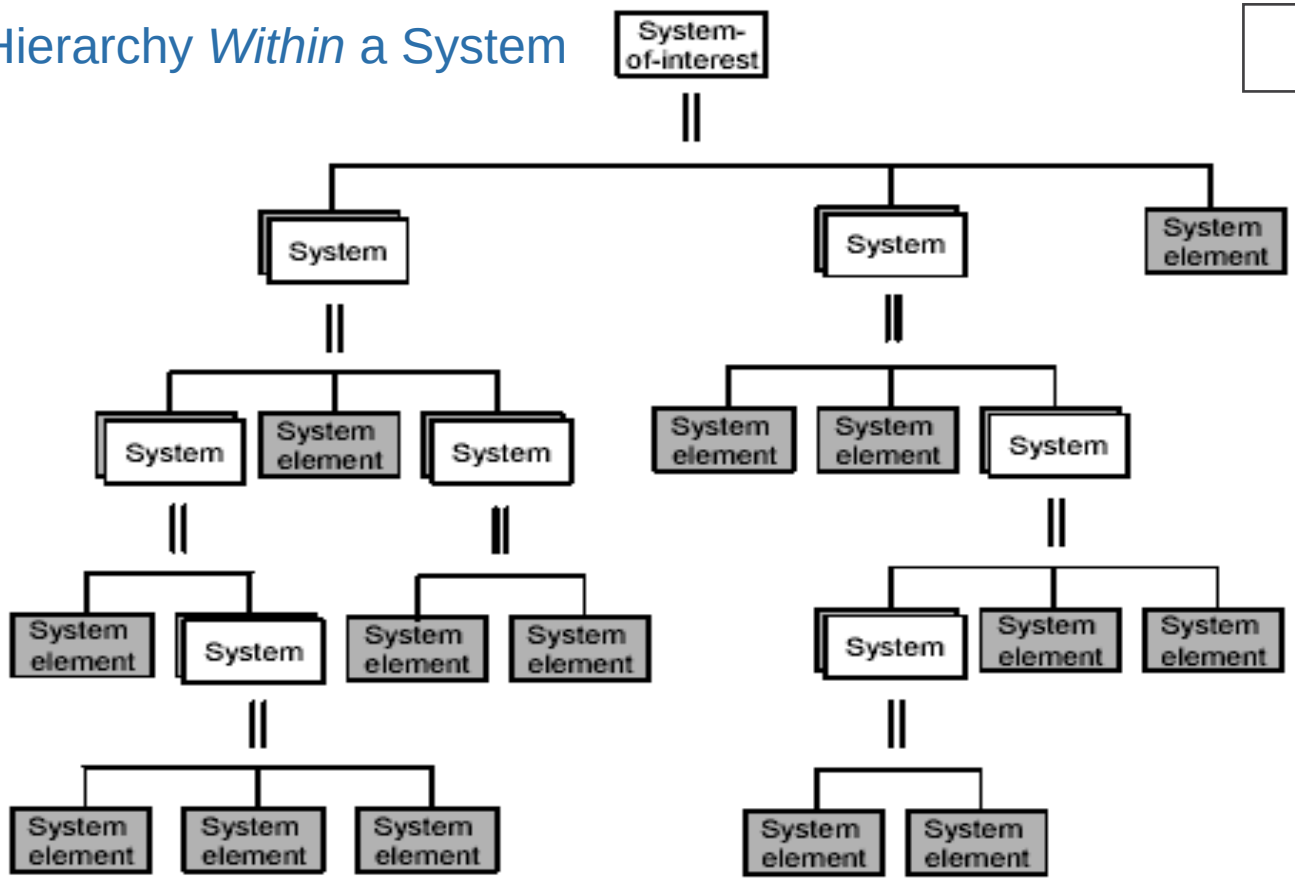
System and System Element Relationship

Refer to ISO/IEC TR 24748-1, Figure 2

What is a System? (cont)

INCOSE SEH V3.2.2

The Hierarchy *Within* a System



System of systems applies to a system-of-interest whose system elements are themselves systems; typically these entail large scale inter-disciplinary problems with multiple, heterogeneous, distributed systems. (INCOSE SE Handbook, V3.2.2, V4.0)

What is a System? (cont)

SEVOCAB, EIA, ANSI, IEEE, ISO/IEC/IEEE

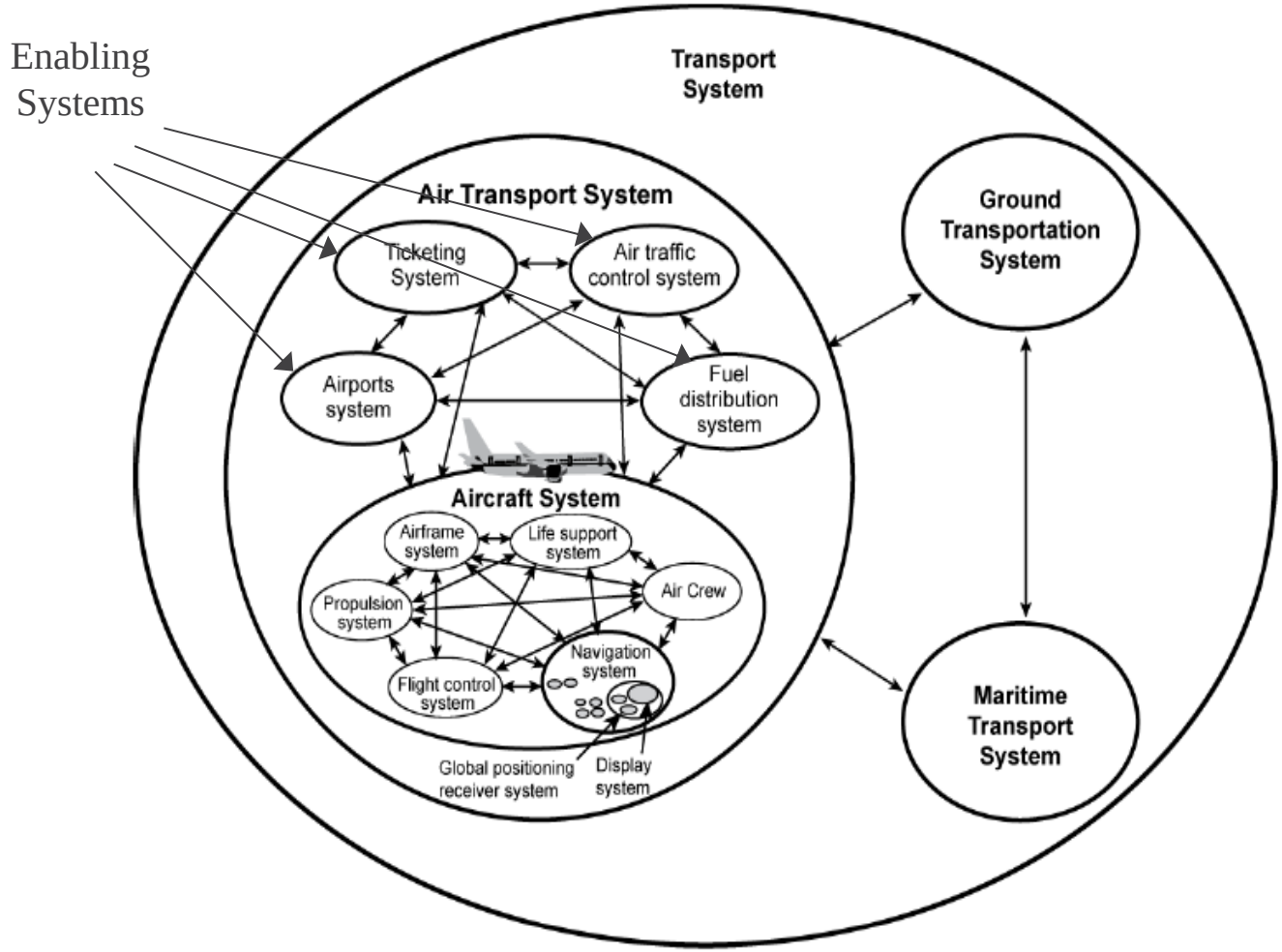
INCOSE SE Handbook Definitions of System

- An integrated composite of **people**, products, and processes that provide a capability to satisfy a stated need or objective. System Elements - The basic constituents (hardware, software, facilities, personnel, data, material, services, or techniques) that comprise a system and satisfy one or more requirements in the lowest levels of the functional architecture. *(SEH V1)*
- These include hardware, software, firmware, **people**, information, techniques, facilities, services, and other support elements. *(V2, V2a)*
- A combination of interacting elements organized to achieve one more stated purposes. System Element – A member of a set of elements that constitutes a system. *(SEH V3, V3.1)*
- A combination of interacting elements organized to achieve one more stated purposes. An integrated set of elements, subsystems, or assemblies that accomplish a defined objective. These elements include products (hardware, software, firmware), processes, **people**, information, techniques, facilities, services, and other support elements. (INCOSE) An example would be an air transportation system. System Element – A member of a set of elements that constitutes a system. *A* major product, service, or facility of the system, e.g. the aircraft element of an air transportation system (commonly used, but subsystems can be used instead of elements). *(SEH V3.2, 3.2.1, 3.2.2)*
- An integrated set of elements, subsystems, or assemblies that accomplish a defined objective. These elements include products (hardware, software, firmware), processes, **people**, information, techniques, facilities, services, and other support elements *(INCOSE).* A combination of interacting elements organized to achieve one or more stated purposes. System Element – A member of a set of elements that constitutes a system. *(ISO/IEC/IEEE 15288-2008 & 2015).*

Software and Systems Engineering Vocabulary (SEVOCAB), http://pascal.computer.org/sev_display/index.action

What is a System? (cont)

Typical System of Systems Environment



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What is Systems Engineering?

EIA & IEEE

Standards Definitions

- An interdisciplinary approach encompassing the entire technical effort to evolve and verify an integrated and life-cycle balanced set of system **people**, product, and process solutions that satisfy customer needs. Systems engineering encompasses:
  a. the technical efforts related to the development, manufacturing, verification, deployment, operations, support, disposal of, and user training for, system products and processes;
  b. the definition and management of the system configuration;
  c. the translation of the system definition into work breakdown structures; and
  d. the development of information for management decision making.
  (EIA/IS-632-1994)
- None *(ANSI/EIA-632-1998)*
- An interdisciplinary collaborative approach to derive, evolve, and verify a life cycle balanced system solution that satisfies customer expectations and meets public acceptability. *(IEEE 1220-1994)*
- None *(IEEE 1220-1998 and IEEE 1220-2005)*
- Interdisciplinary approach governing the total technical and management effort required to transform a set of stakeholder needs, expectations, and constraints into a solution and to support that solution through its life. *(ISO/IEC/IEEE 15288:2015)*

SEVOCAB: Software and Systems Engineering Vocabulary, http://pascal.computer.org/sev_display/index.action

What is Systems Engineering? (cont)

INCOSE SE Handbook Definition of Systems Engineering

- Systems engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem: operations, cost and schedule, performance, training and support, test, manufacturing, and disposal. SE considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs. (INCOSE)

What is Systems Engineering? (cont)

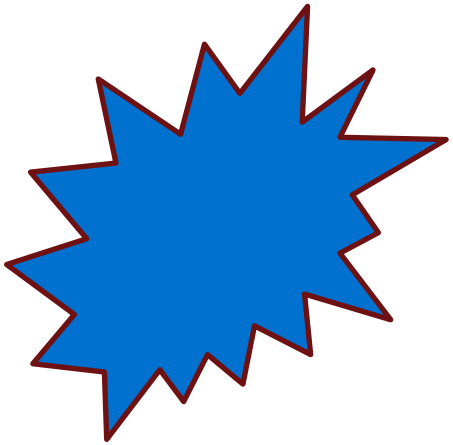
JOC

Problem and Solution Space for Systems Engineering

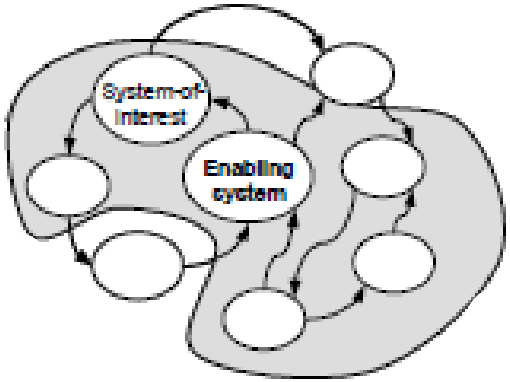
Problem Space

Translate to

Solution Space



Systems Engineering



Systems Engineering is the process of translating the problem space to the solution space. (John Clark)

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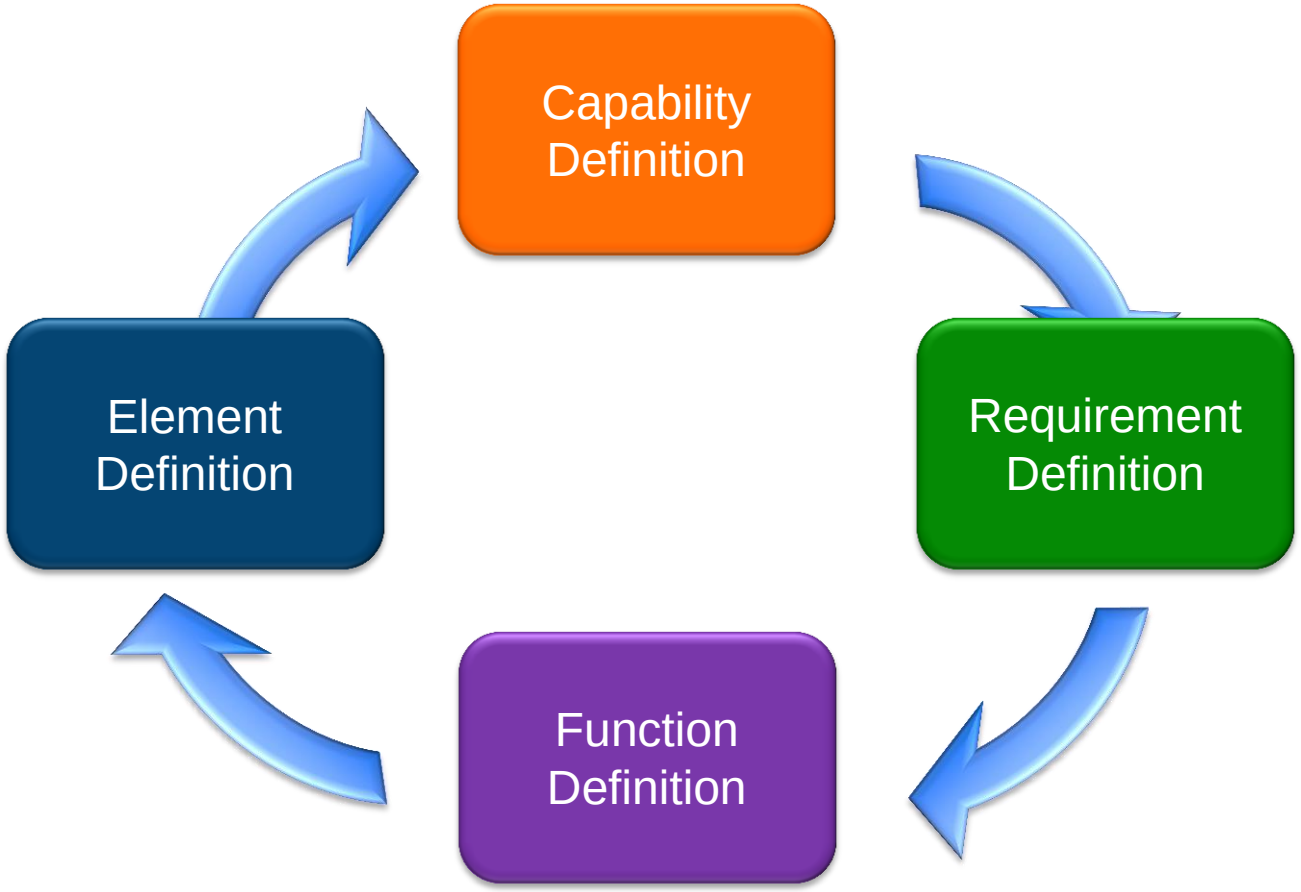
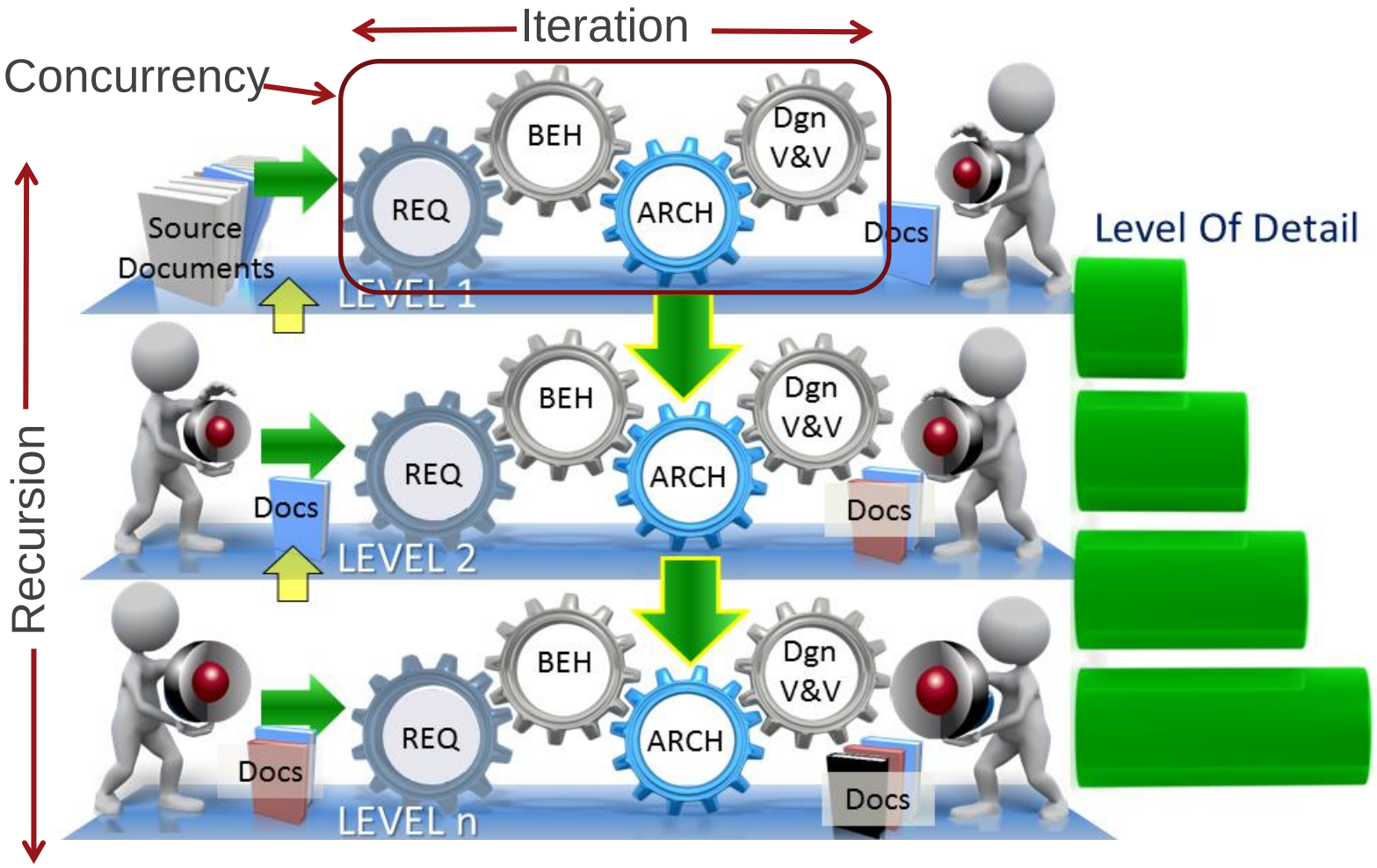
What is the SE Process?



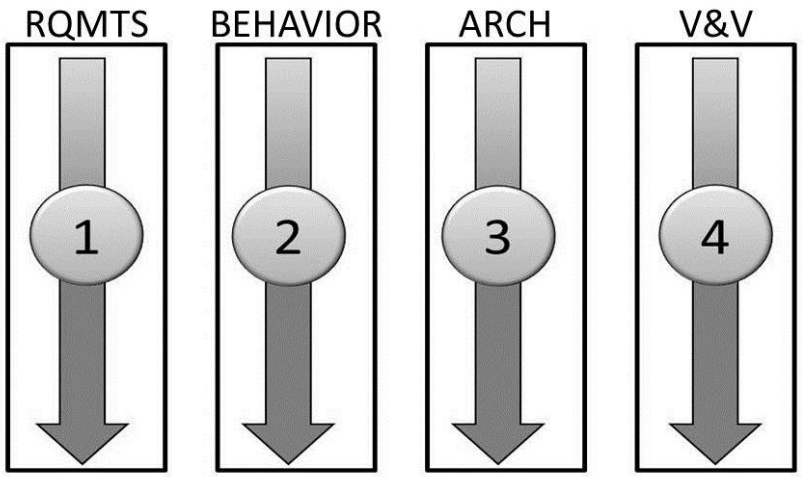
The SE Processes are Iterative, Recursive, and Concurrent (In Parallel)

What is the SE Process (cont)?

What are Iteration, Recursion, and Concurrency?

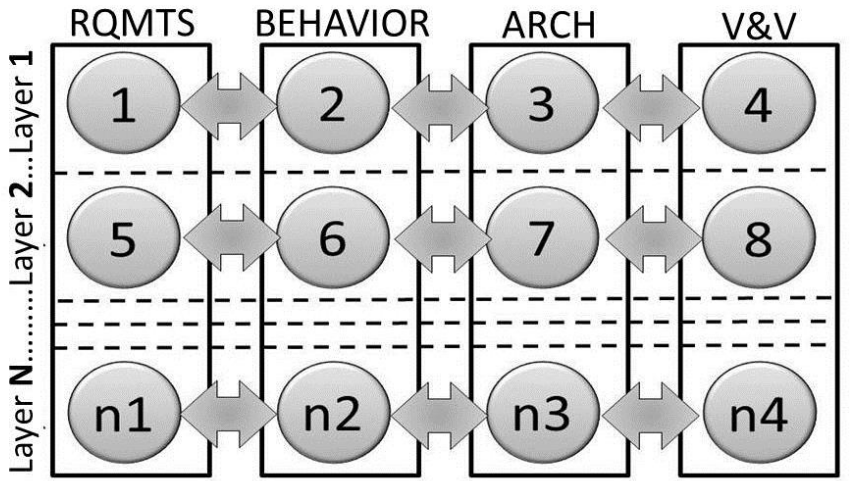


What is the SE Process (cont)?



TRADITIONAL DEEP-DIVE SE

(SERIAL SE)

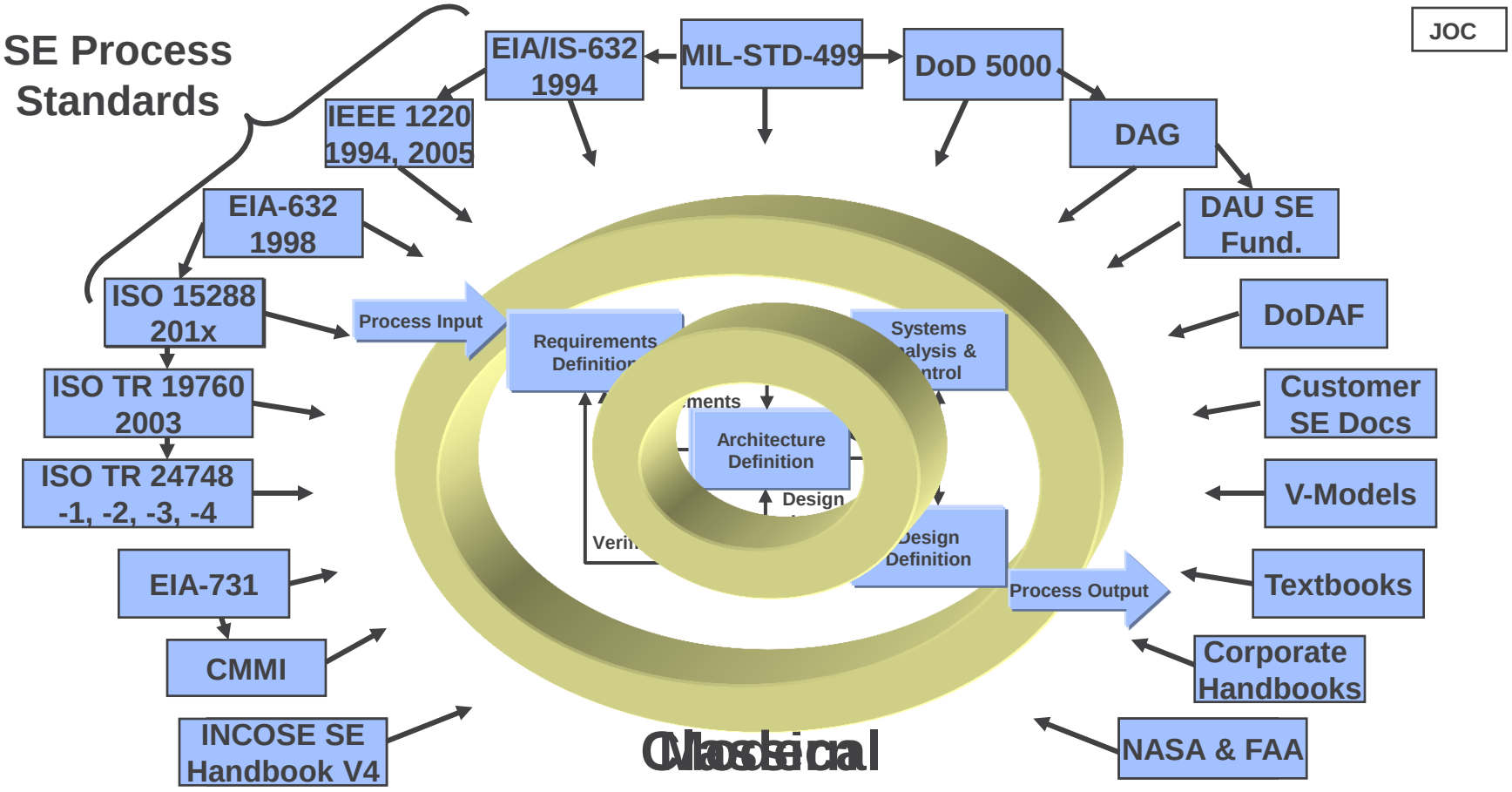


LAYERED MBSE

(CONCURRENT SE)

Expanded on next slide.

What is the SE Process (cont)?

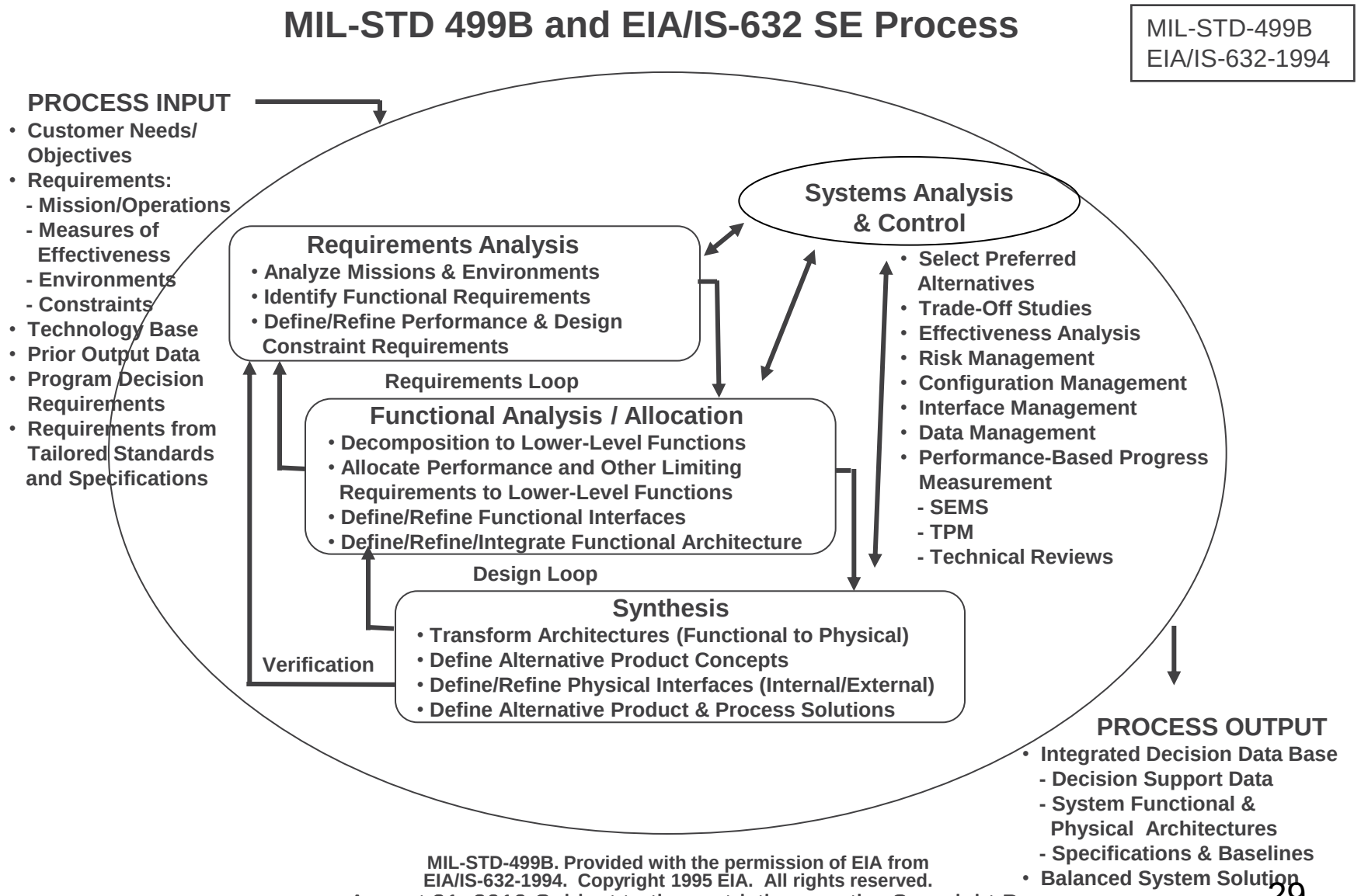


Systems Engineering Process

Center figure from MIL-STD-499B Draft:1993 and also provided with the permission of EIA from EIA/IS-632-1994. Copyright 1995 EIA. All rights reserved. Updated by J. Clark

Multiple views provide a comprehensive view.

What is the SE Process (cont)?



What is the SE Process (cont)?

EIA/IS-632 & JOC

MIL-STD-499B and EIA/IS-632 SE Process, John Clark Amplified Version

PROCESS INPUTS
- Customer Needs/ Objectives
- Legacy Requirements
- Subject Matter Expert Defined Requirements
- Technology Base
- Prior Output Data
- CDRL Definition
- Standards
- EIA/IS-632
- IEEE 1220

Systems Analysis & Control
- Trade -Off Studies
- Configuration Management
- Interface Management
- Data Management, etc.

Requirements Analysis
- Define Requirements and Interfaces
- Allocate Capabilities to Requirements
- Decompose and Derive Requirements to Sub Requirements
- Allocate Sub Capabilities to Sub Requirements
- Define Requirements Architecture
- Develop Requirements Traceability
- Establish Requirements Baseline

Requirements Loop

- Requirements Architecture
- System Requirements Doc (SRD)
- Interface Requirements Specs
- Capabilities Traced to Requirements
- Requirements Baseline

Functional Analysis / Allocation
- Define Functions and Functional Interfaces
- Allocate Requirements to Functions
- Decompose and Derive Functions to Sub Functions
- Allocate Sub Requirements to Sub Functions
- Define Functional Architecture
- Develop Functional Flow Block Diagrams
- Establish Functional Baseline

Inside - Out

- Functional Architecture
- System/Subsystem Specs (SSS)
- Requirements Traced to Functions
- Functional Baseline

Design Loop

Synthesis (Design)
- Define Elements and Element Interfaces
- Allocate Functions to Elements
- Decompose and Derive Elements to Sub Elements
- Allocate Sub Functions to Sub Elements (and thereby Sub Requirements)
- Define Physical Architecture
- Develop Physical Flow Block Diagrams
- Establish Allocated Baseline
- Establish Product Baseline

- Physical Architecture
- Component Specs/SSDDs
- Functions Traced to Components
- Interface Design Specs
- Allocated Baseline
- Product Baseline

Verification Loop

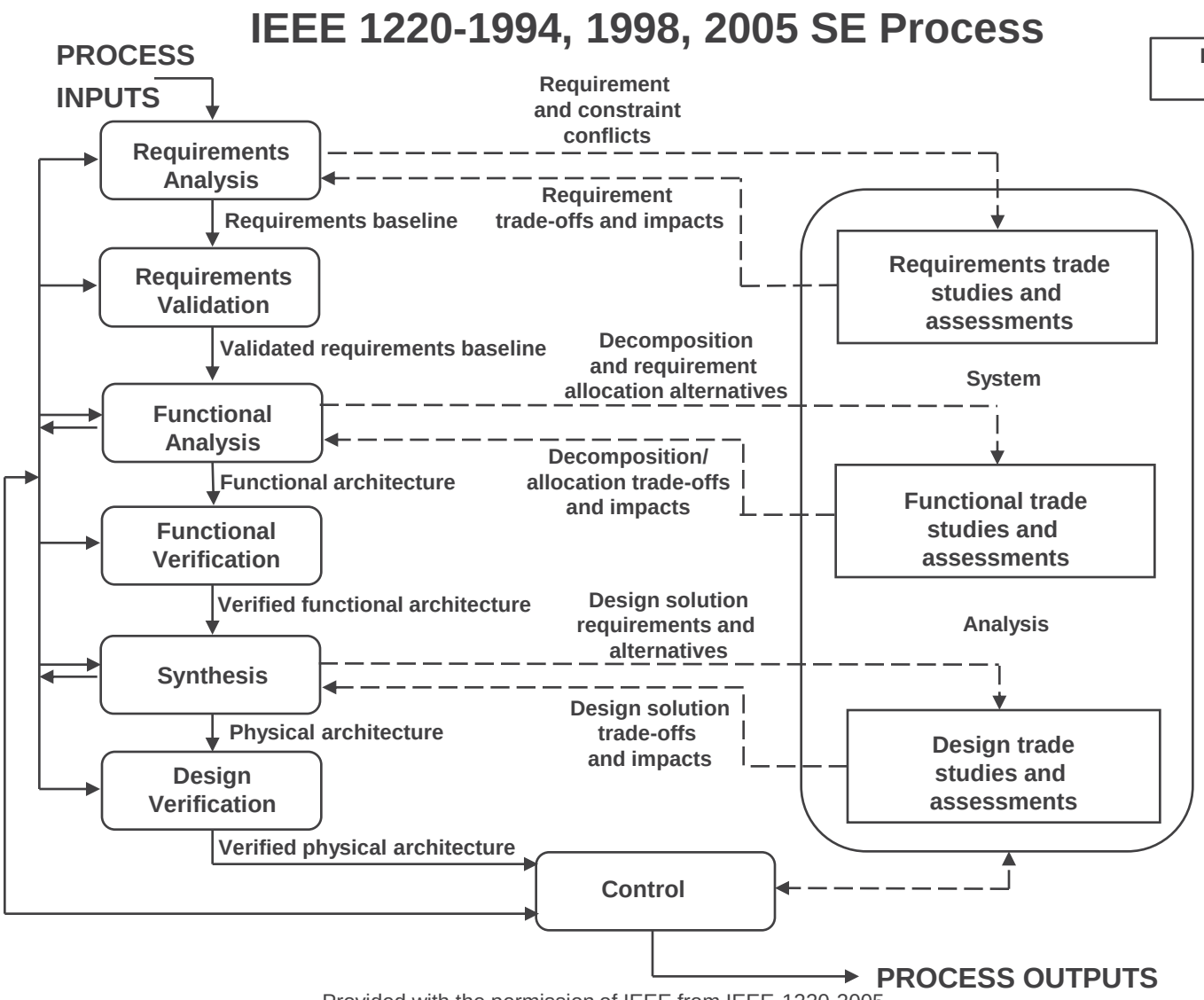
Forward Engineering

Reverse Engineering

ROCESS OUTPUTS
- quirements, Functional & Physical Architectures & Baselines
- System, Subsystem & Component Specs (SSS/ SSDDs)
- Reqs Verification Matrix
- FCA & PCA Reports

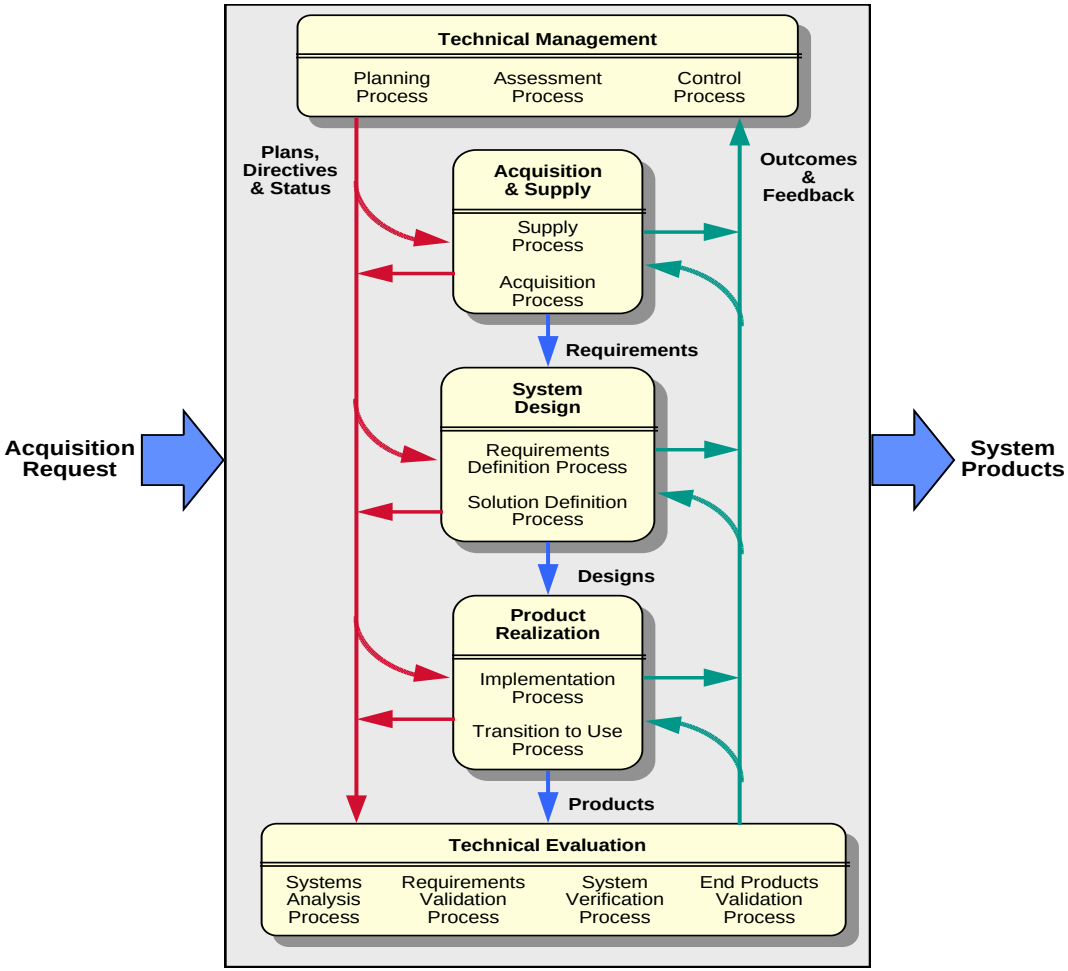
Verification Loop:
- Develop Verification Framework
- Define Key Performance Parameters
- Define Verification Methods
- Develop Requirements Verification Matrix
- Trace Requirements Verification Matrix to Test Procedures
- Conduct Functional and Physical Configuration Audits

What is the SE Process (cont)?



What is the SE Process (cont)?

ANSI/EIA-632 Relationship of Processes for Engineering a System



ANSI/EIA-632-1998

INCOSE SEH V2a

What is the SE Process (cont)?

ANSI/EIA-632 Requirements for Engineering a System

ANSI/EIA-632-1998

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—Requirement 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

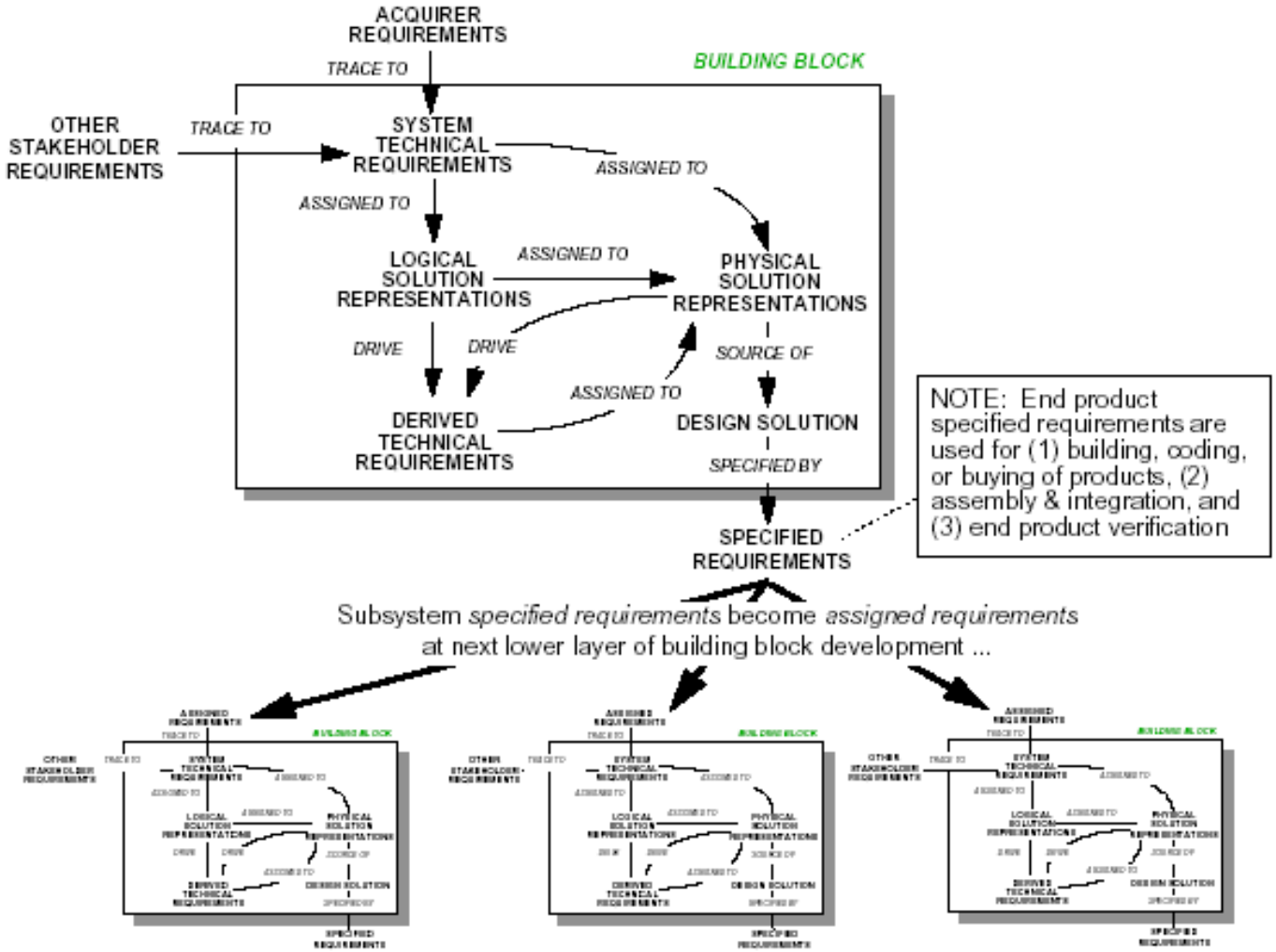
END PRODUCTS VALIDATION PROCESS REQUIREMENTS

33—End Products Validation

What is the SE Process (cont)?

Role of Specified Requirements

ANSI/EIA-632-1998



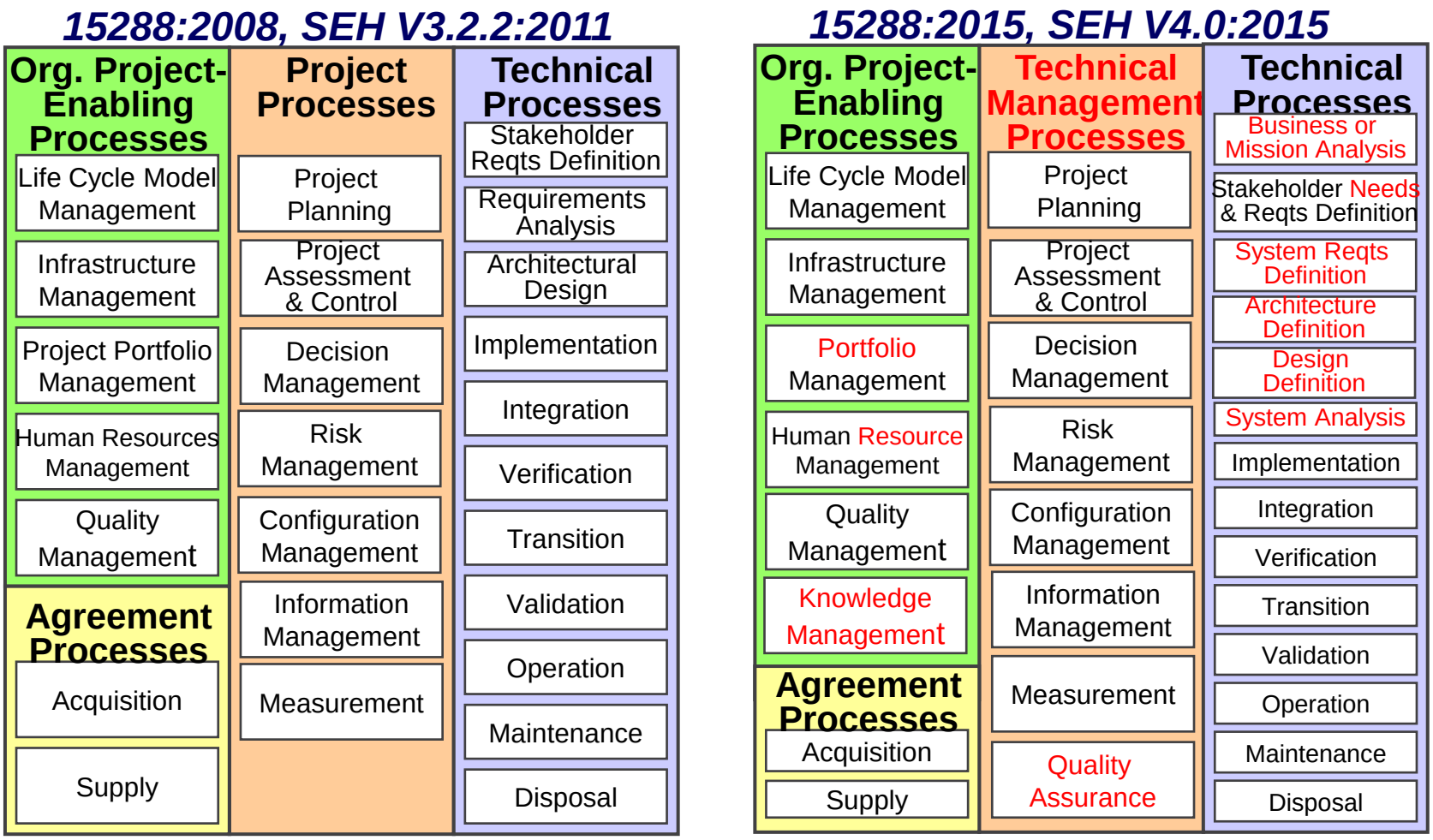
What is the SE Process (cont)?

ISO/IEC TR 19760-2003 Application of Technical Processes to Engineer a System of Interest

ISO/IEC TR 19760-2003

Refer to ISO/IEC TR 19760:2003, Figure 13

What is the SE Process (cont)?



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Contents

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Preliminary
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over 40 Plenary address, Papers & Posters on Human Systems Integration
Wednesday - Friday

4 Inspiring Keynote Speakers

Guy André Boy CentraleSupélec and ESTIA Institute of Technology, Chair of INCOSE HSI WG
Mica Endsley Former US Air Force Chief Scientist, President of SA Technologies
General Frédéric Parisot French Air Force State Staff
David Sirkin Stanford University

14 Countries Represented in Papers

Australia - Austria - Belgium - Canada - France - Germany - Hong Kong - India - Israel - Norway - Romania - Slovenia - United Kingdom - United States

18 Application Domains

Top Domains
Adaptive Systems, Aeronautics, Automotive, Air Traffic Management, C2, Defense, Healthcare, Manufacturing, Maritime, Medicine, Nuclear, Oil & Gas, Public safety & security, Social Media, Space, Tangibility, Training, UAV

19 Topics Represented

Top Topics
Agile Development, Artificial Intelligence, Certification, Cognitive Engineering, Complexity Analysis, Decision Making, Design Thinking, Digital Human Modeling, Human Centered Design, HCI, Human Factors & Ergonomics, Human Machine Teaming, Machine Learning, MBSE, Modeling & Simulation, Organization Design & Management, Performance Monitoring, Situation Awareness, Systems of Systems

3 Panels

With Global Leaders in Human Systems Integration
- **Technological and organizational situation awareness for public security/safety**
- **Do We Need to Develop a New Discipline of Human Systems Integration?**
- **HSI Implications of Adaptive Human-Machine Teaming**

more information at www.incose.org/hsi2019

The End!

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