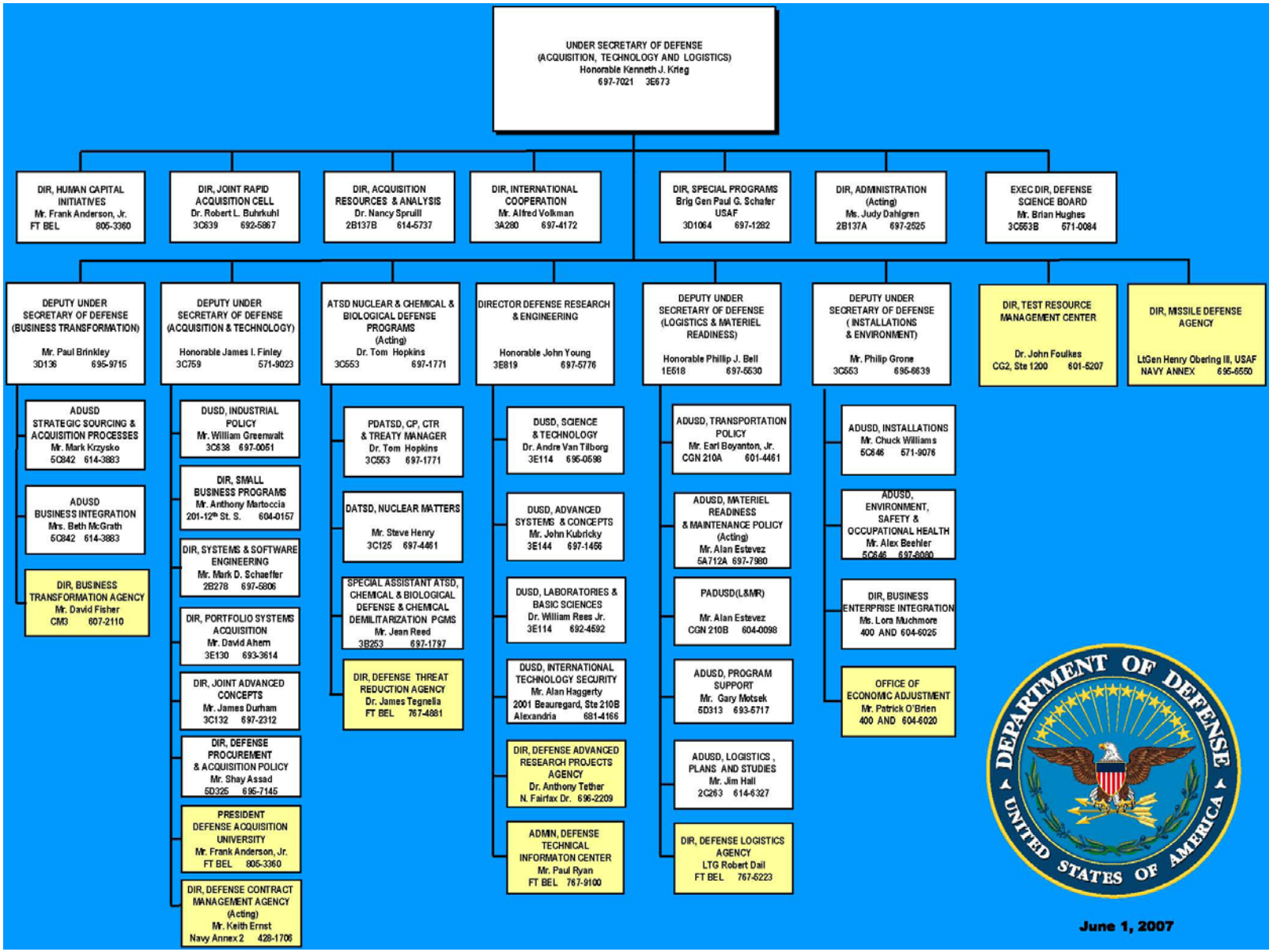
Systems Engineering U.S. Department of Defense Acquisition Perspective

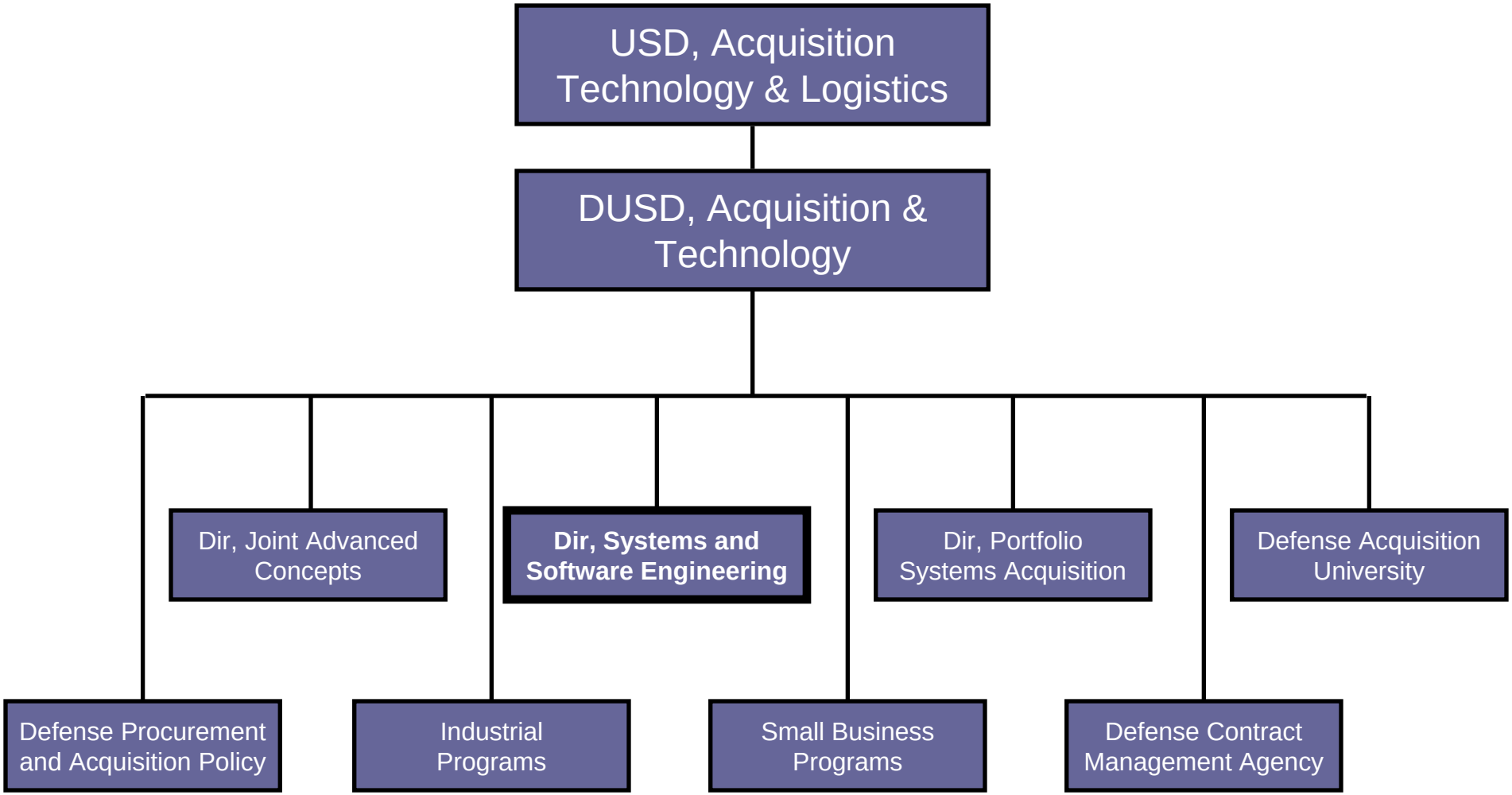
Joint Weapon System Safety Conference
16 August 2007

Chet Bracuto
Systems and Software Engineering
Enterprise Development
Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics

OUSD (AT&L) Organization



OUSD (AT&L) Organization



Systems and Software Engineering Organizational Core Competencies

Director, Systems & Software Engineering

Mark Schaeffer SES

Deputy Director Enterprise Development

Col. Rich Hoeferkamp (Acting)

CORE COMPETENCIES

- SE Policy
- SE Guidance
  - SE in *Defense Acquisition Guidebook*
  - Technical Planning
  - Risk Management
  - Reliability/Maintainability
  - Integrating SE into Systems Acq contracting
  - SoS SE Guide
- SE Education and Training
  - DAU SE Curriculum
  - SPRDE Certification Rqmt
- Corrosion
- R-TOC
- Value Engineering

Deputy Director Developmental Test & Evaluation

Chris DiPetto SES

CORE COMPETENCIES

- DT&E Policy
- DT&E Guidance
  - T&E in *Defense Acquisition Guidebook*
  - TEMP Development Process
- DT&E Education and Training
  - DAU DT&E Curriculum
  - DT&E Certification Rqmt
- Joint Testing, Capabilities & Infrastructure
- Targets Oversight
- Acq Modeling & Simulation
- Energy
- DSOC/Acq Tech Task Force

Deputy Director Software Engineering & System Assurance

Kristen Baldwin SES

CORE COMPETENCIES

- SWE and SA Policy
- SWE and SA Guidance
  - SoS, SA Guides
- SWE and SA Education and Training
  - DAU SW Acq Curriculum
  - Continuous Learning Modules for SWE, SoS, SA
- Software Engineering
  - Acquisition Support
  - Software Engineering Institute (SEI)
- Process Improvement
  - CMMI Sponsor
- DoD/National Software Investment Strategy

Deputy Director Assessments & Support

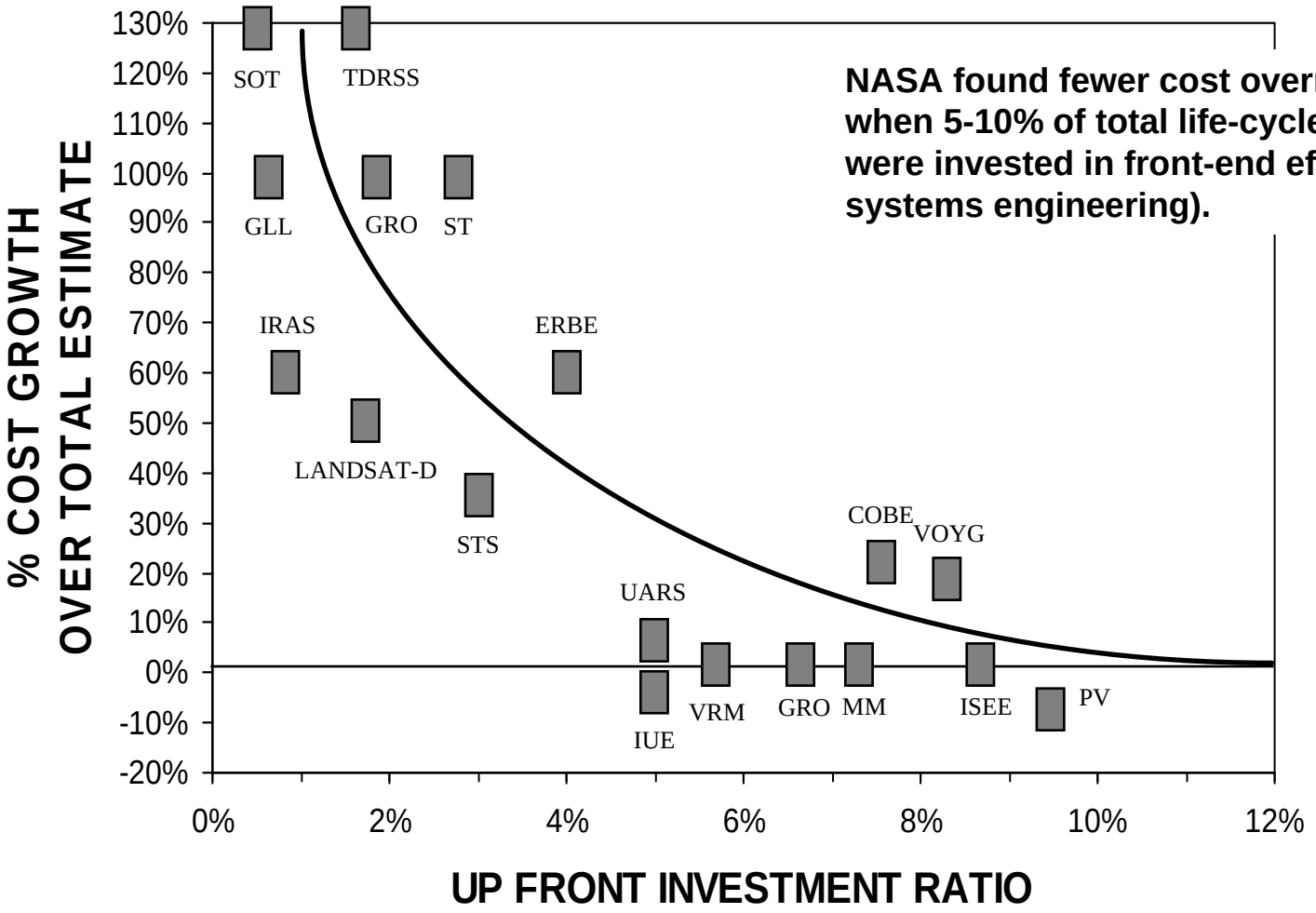
Dave Castellano SES

CORE COMPETENCIES

- Support of ACAT I and Other Special Interest Programs (MDAP, MAIS)
- Assessment Methodology (Program Support Reviews - PSRs)
- T&E Oversight and Assessment of Operational Test Readiness (AOTR)
- Systems Engineering and Developmental Test Planning and Support
- Lean/6-Sigma Training/Cert

Acquisition program excellence through sound systems and software engineering

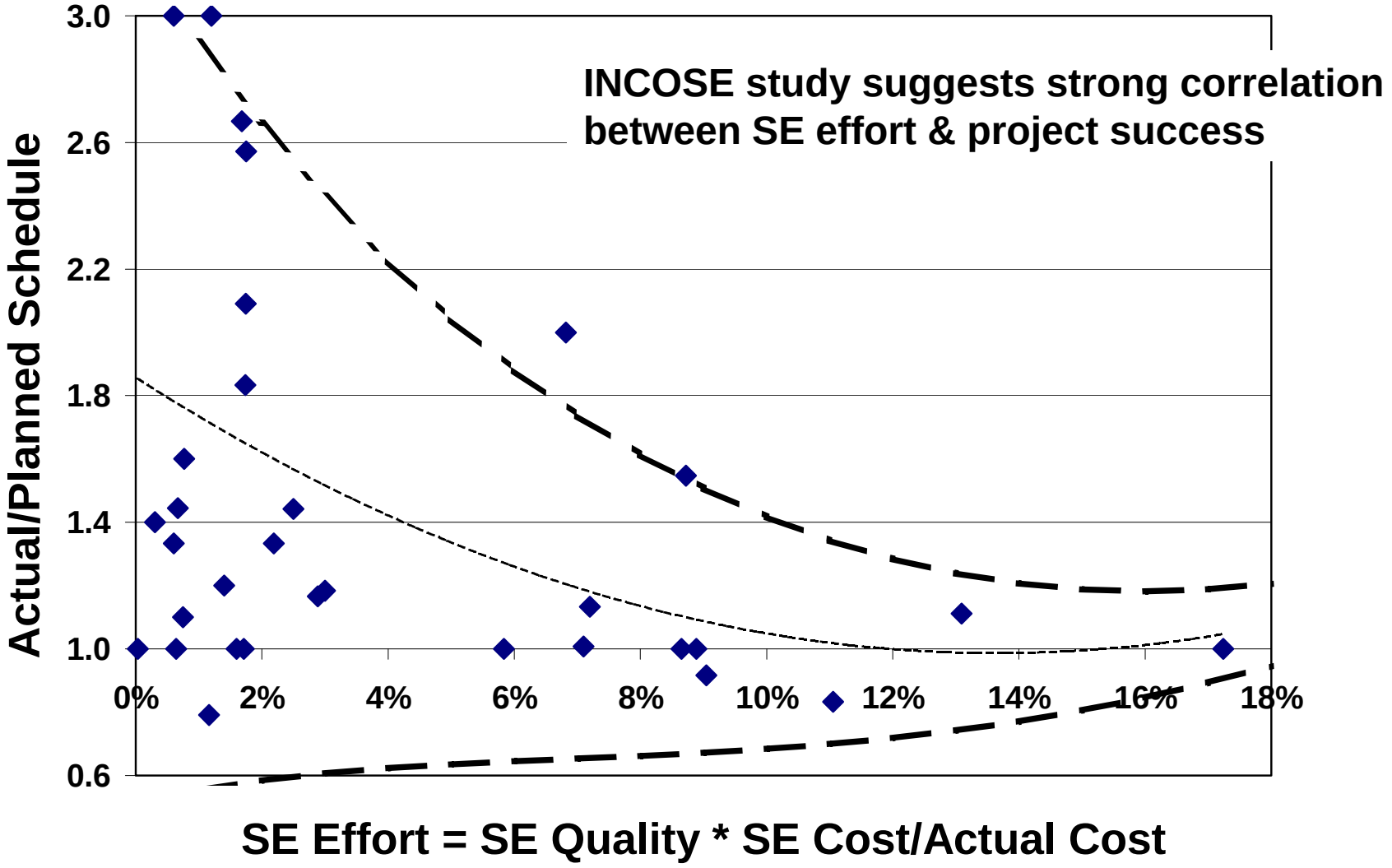
NASA Systems Engineering (SE) Return on Investment



NASA found fewer cost overruns when 5-10% of total life-cycle costs were invested in front-end effort (including systems engineering).

Source: NASA Comptroller's Office, 1985

International Council on Systems Engineering (INCOSE) Study



Source: SECOE 01-03; INCOSE 2002 (Mar and Honour)

SE Agenda

- Overview
- DoD Policy
- Implementation Considerations
- Design Considerations
- DoD Acquisition Framework and “Vee” Model
- SE Across the Life Cycle

SE Agenda

- **Overview**
- DoD Policy
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Some Definitions of SE

Mil-Std 499A [1974]: The application of scientific and engineering efforts to:

(1) transform an operational need into a description of system performance parameters and a system configuration through the use of an iterative process of definition, synthesis, analysis, design, test, and evaluation;

(2) integrate related technical parameters and ensure compatibility of all related, functional, and program interfaces in a manner that optimizes the total system definition and design;

(3) integrate reliability, maintainability, safety, survivability, human, and other such factors into the total technical engineering effort to meet cost, schedule, and technical performance objectives.

INCOSE: SE is an interdisciplinary approach and means to enable the realization of successful systems.

NASA: SE is a robust approach to the design, creation, and operation of systems.

Sage: The design, production, and maintenance of trustworthy systems within cost and time constraints.

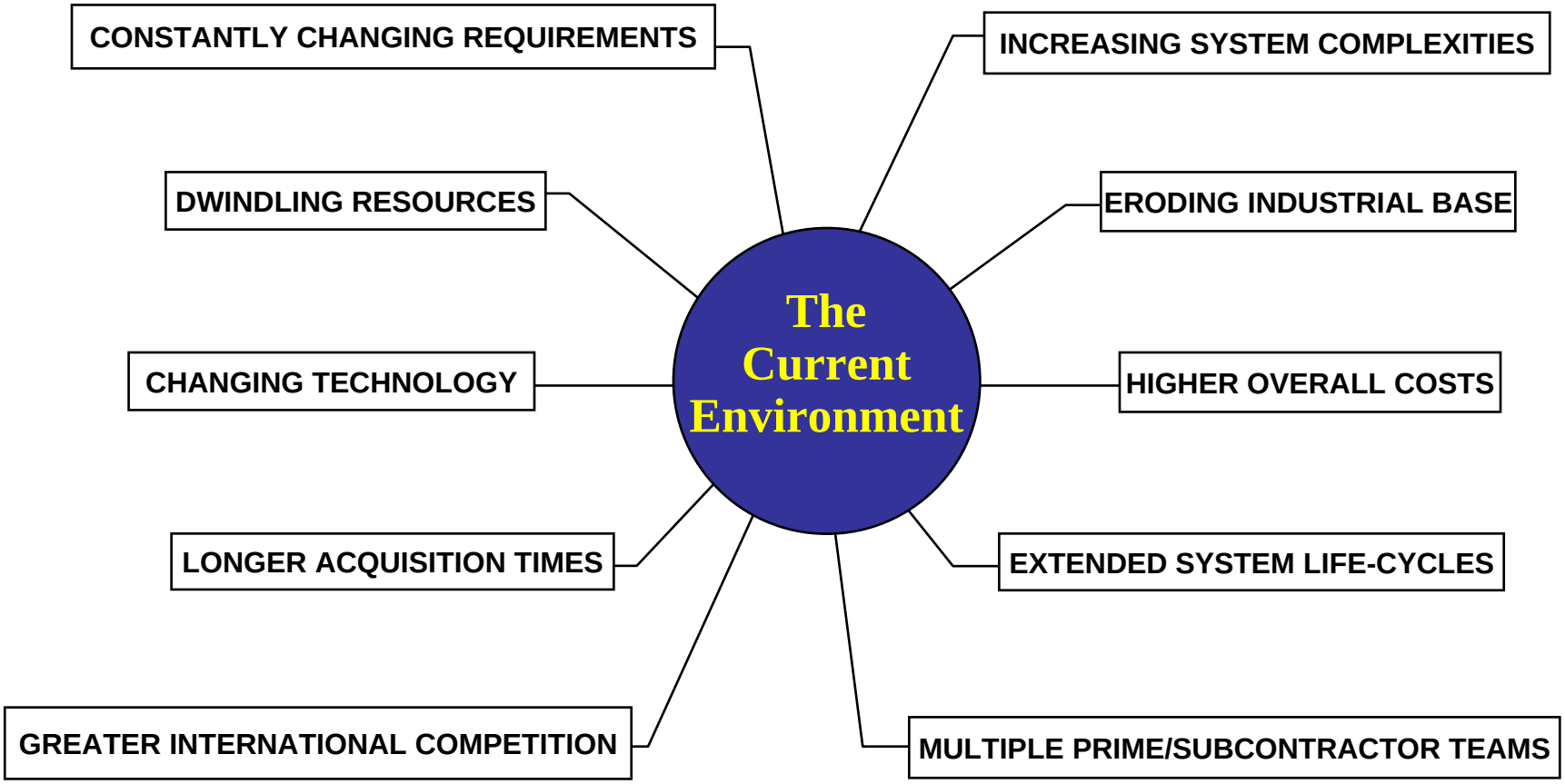
Forsberg & Mooz: The application of the *system analysis and design process* and the *integration and verification process* to the logical sequence of the *technical aspect of the project life cycle*.

DoD has adopted....

*Systems engineering is an **interdisciplinary approach encompassing the entire technical effort to evolve and verify an integrated and total life-cycle balanced set of system, people, and process solutions that satisfy customer needs.** Systems engineering is the **integrating mechanism** across the technical efforts related to the development, manufacturing, verification, deployment, operations, support, disposal of, and user training for systems and their life cycle processes. Systems engineering **develops technical information to support the program management decision-making process**. For example, systems engineers manage and control the definition and management of the system configuration and the translation of the system definition into work breakdown structures.*

Adopted from ANSI/EIA-632, "Processes for Engineering a System"

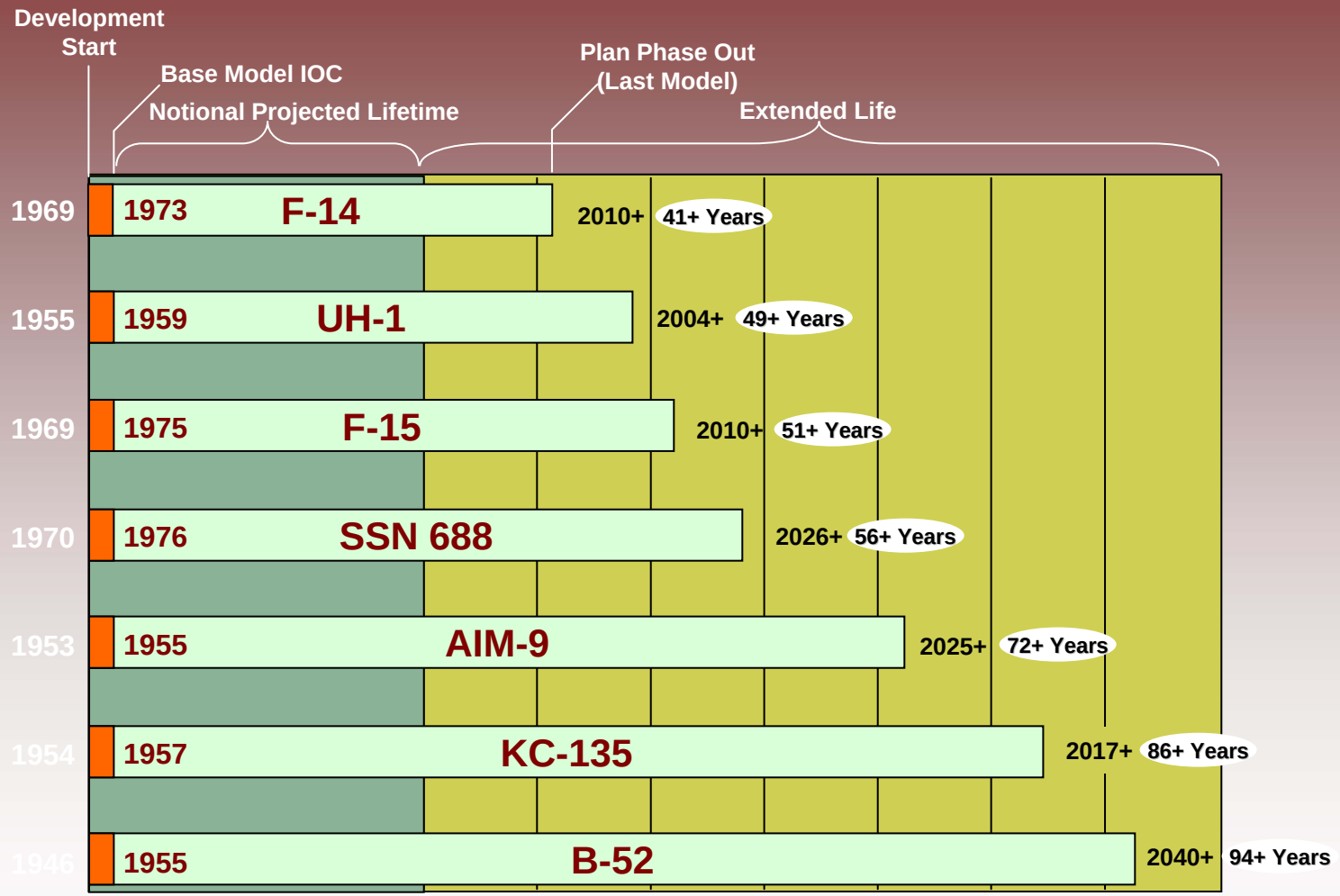
Challenges to Systems Engineers



Current Trends in System Development

- Increasing use of Reusable Parts, Common Platforms, and Commercial Off the Shelf (COTS) system elements
- Increasing emphasis on capabilities that require implementation of “System of Systems” concepts and interoperability
- Increasing emphasis on multiple partner and contractor teams
- Increasingly resource conscious environment
- Evolution towards the “System Integration” business model
- Increasing emphasis on recapitalization of existing systems and assets

Recapitalization of Existing Assets



Similar Reality for Enterprise Level IT Systems - Many Applications Pre-Date the Internet and the Client-Server Architectural Paradigm

LEGACY REVITALIZATION BUSINESS THRUST

Top Five SE Issues:
Based on an NDIA Study in January 2003

- **Lack of awareness of the importance, value, timing, accountability, and organizational structure of SE on programs**
- **Adequate, qualified resources are generally not available within government and industry for allocation on major programs**
- **Insufficient SE tools and environments to effectively execute SE on programs**
- **Requirements definition, development, and management is not applied consistently and effectively**
- **Poor initial program formulation**

System Safety has the same issues

Lack of Uniform Understanding of SE in DoD

- Lack of coherent SE policy
- Lack of effective SE implementation - no “forcing function” for PM or contractor SE activities
- Program teams incentivized by cost and schedule, not execution of disciplined SE
- Products and processes not in balance (emphasis on speed; fix it in the next spiral)
- Inconsistent focus across life-cycle, particularly prior to Milestone B
- SE inadequately considered in program life cycle decisions

System Safety has the same issues

Lack of Uniform Understanding of SE in the Community-at-Large

- No single definition or agreement on the scope of SE
- Lack of common understanding of how SE is implemented on programs
  - Is SE done by the systems engineer?
  - Does the systems engineer lead the SE effort?
- No uniform understanding of what makes a good systems engineer
- No consistent set of metrics or measures to quantify the value of SE
- Cost and schedule estimation and risk management processes inconsistently aligned with SE processes
- Resistance to harmonization of multiple standards and models
- Multiple practitioner communities not aligned

System Safety has the same issues

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DoD Policy

- **Governed by May 2003 DoDD 5000.1 and DoDI 5000.2**
  - **SE approach required**
  - **Knowledge & Performance Based Acquisition**
  - **Performance Based Logistics**
  - **Interoperability**
  - **Total Systems Approach**
  - **Evolutionary Acquisition**
    - **Increased importance of modular and scalable architectures**
      - **Architectures versus design?**
    - **Increased importance of traceability, change management**
    - **Design, development, deployment, and sustainment can become concurrent activities on a program**

DoD Policy

- **DoD Directive 5000.1 requires that:**
  - **Acquisition programs shall be managed through the application of a SE approach that optimizes total system performance and minimizes total ownership costs**
  - **A modular open-systems approach shall be employed, where feasible**
- **DoD Instruction 5000.2 emphasizes that:**
  - **Effective sustainment of weapon systems begins with the design and development of reliable and maintainable systems through the continuous application of a robust SE methodology**

DoD Policy

- **February 2004 SE Policy Memo**
  - **All programs, regardless of ACAT shall:**
    - **Apply an SE approach**
    - **Develop a Systems Engineering Plan (SEP)**
      - **Describe technical approach, including processes, resources, and metrics**
      - **Detail timing and conduct of SE technical reviews**
  - **Systems and Software Engineering Office is tasked to provide SEP guidance for DoDI 5000.2**
    - **Recommend changes in Defense SE**
    - **Establish a senior-level SE forum**
    - **Assess SEP and program readiness to proceed before each major program review**

DoD Policy

- **March 2004 SEP Implementation Guidance Requires SEP to Describe**
  - **SE approach**
    - **Specific processes and their tailoring by phase**
    - **Both Program Office and Contractor processes**
  - **Systems technical baseline approach**
  - **Technical review criteria and outcomes**
    - **Event driven**
    - **Mechanism for assessing technical maturity and risk**
  - **Integration of SE with IPTs and schedules**
    - **Organization, tools, resources, staffing, metrics, mechanisms**
    - **Integrated schedules (e.g., IMP and IMS)**

DoD Policy

- **September 2004 Defense Acquisition System Safety Memo requires Program Managers (PMs) to**
  - **Integrate System Safety into SE**
  - **Use Military Standard (MIL-STD) 882D, DoD Standard Practice for System Safety**
  - **Include System Safety strategy for integrating Environment, Safety, and Occupational Health (ESOH) in the SEP**
  - **Report ESOH hazard risk acceptance status at technical and program reviews**

DoD Policy

- **October 2004 Defense Acquisition Guidebook**
  - **New SE guidance to acquisition community—Chapter 4**
  - **Best practices for "applied" SE**
    - **SE process**
    - **Guide for each acquisition phase, concept refinement through disposal**
  - **Linkage of SE products and processes to acquisition objectives and decision points**

http://akss.dau.mil/dag/welcome.asp

DoD Policy

- **October 2004 SE Policy Addendum Requires**
  - **Each Program Executive Officer (PEO) to have a lead or chief systems engineer**
  - **PEO lead or chief systems engineer shall:**
    - **Review assigned programs' SEPs and oversee their implementation**
    - **Assess the performance of subordinate lead or chief systems engineers**
  - **Technical reviews shall:**
    - **Be event driven (vice schedule driven)**
    - **Conducted when the system under review meets review entrance criteria as documented in the SEP**
    - **Include participation by subject matter experts independent of the program**

SE Agenda

- Overview
- DoD Policy
- **Implementation Considerations**
- Design Considerations
- DoD Acquisition Framework and “Vee” Model
- SE Across the Life Cycle

Implementation Considerations

- **Expectation - successful implementation of proven, disciplined SE processes results in a total system solution that is:**
  - **Robust to changing technical, production, and operating conditions**
  - **Adaptive to the needs of the users**
  - **Balanced among**
    - **Multiple requirements**
    - **Design considerations**
    - **Design constraints**
    - **Program budgets**

Implementation Considerations

- **Participants**
  - **PM**
    - **Implements a robust SE approach to:**
      - **Translate operational needs and capabilities into operationally suitable increments of a system**
      - **Add discipline to the process**
      - **Provide the PM with the information necessary to make trade off decisions**
    - **Exercises leadership, decision making, and oversight throughout the system life cycle**
  - **Multi-Disciplinary IPT**
  - **Chief Engineer or Lead Systems Engineer in the Program Office**
  - **Most program personnel, including System Safety, should consider themselves to be participants in the SE process**

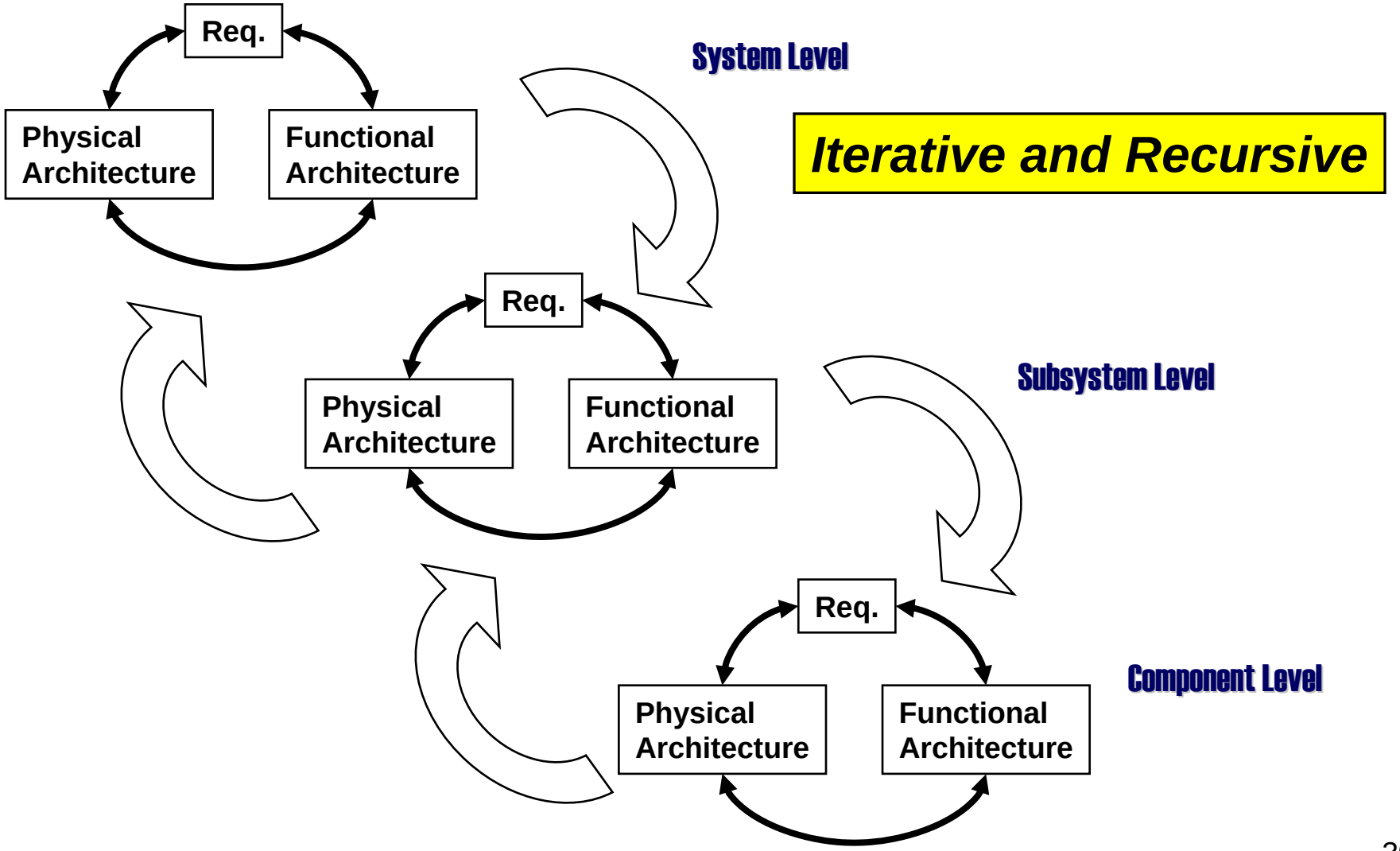
Implementation Considerations

- **Technical Processes**
  - **Requirements Development**
  - **Logical Analysis**
  - **Open Systems Design**
  - **Design Solution**
  - **Implementation**
  - **Integration**
  - **Verification**
  - **Validation**
  - **Transition**

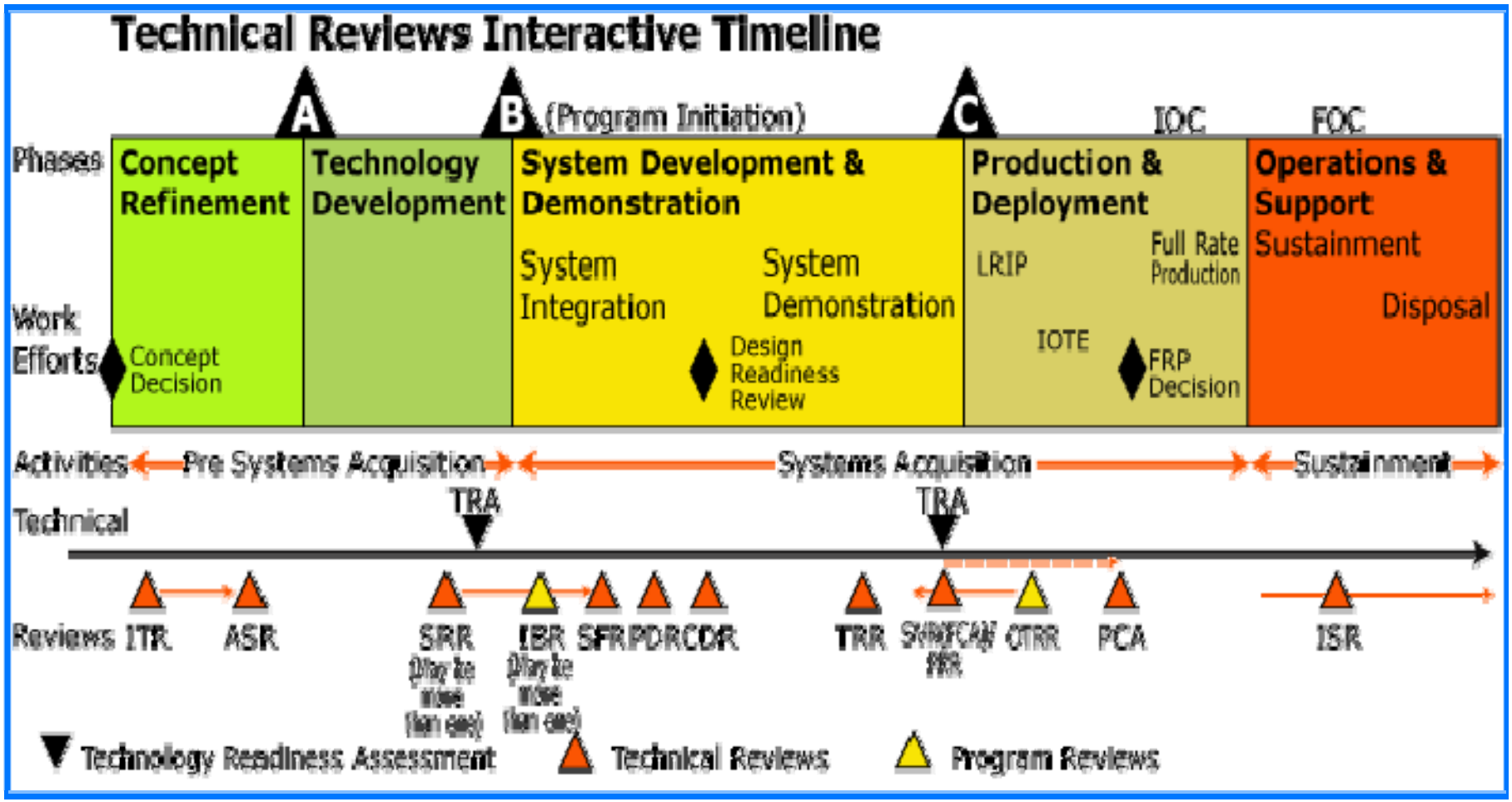
Implementation Considerations

- **Technical Management Processes**
  - **Decision Analysis**
  - **Technical Planning**
  - **Technical Assessment**
  - **Requirements Management**
  - **Risk Management**
  - **System Safety**
  - **Configuration Management**
  - **Data Management**
  - **Interface Management**

Implementation Considerations



Implementation Considerations



Implementation Considerations

- **Technical Reviews Approach and Strategy**
  - **Technical review membership composition, including method for nominating and approving chairperson and membership**
  - **Roles and responsibilities of those involved**
  - **Procedures used in conducting reviews**
  - **Number of technical reviews planned and to what WBS-level**
  - **Entry and exit criteria for each review**
  - **Timing of each review**
  - **How technical reviews are used to manage the technical effort**

Implementation Considerations

- **Implementation and Approach for Trade Studies**
  - **Who is responsible for making trade-off decisions and at what level in the organization does that decision maker reside?**
  - **What studies have been and will be conducted, who did or will conduct them, how they were or are to be conducted to include a discussion of trades as part of a family-of-systems or system-of-systems solution?**
  - **Approach for progressing through the typical systems engineering steps: requirements analysis, decomposition, allocation, and analysis**
  - **Summarize prior trade studies and how they have steered the technical and programmatic changes to the program**

Implementation Considerations

- **Relationship and feedback mechanisms between the SE technical and key program management processes:**
  - **Acquisition strategy**
  - **Risk management**
  - **Program management plan or Integrated Master Plan (IMP)**
  - **Earned Value management system**
  - **Contract management**
  - **Programmatic Environment, Safety and Occupational Health Evaluation (PESHE)**

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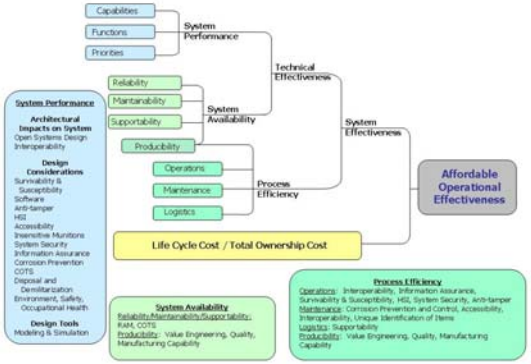
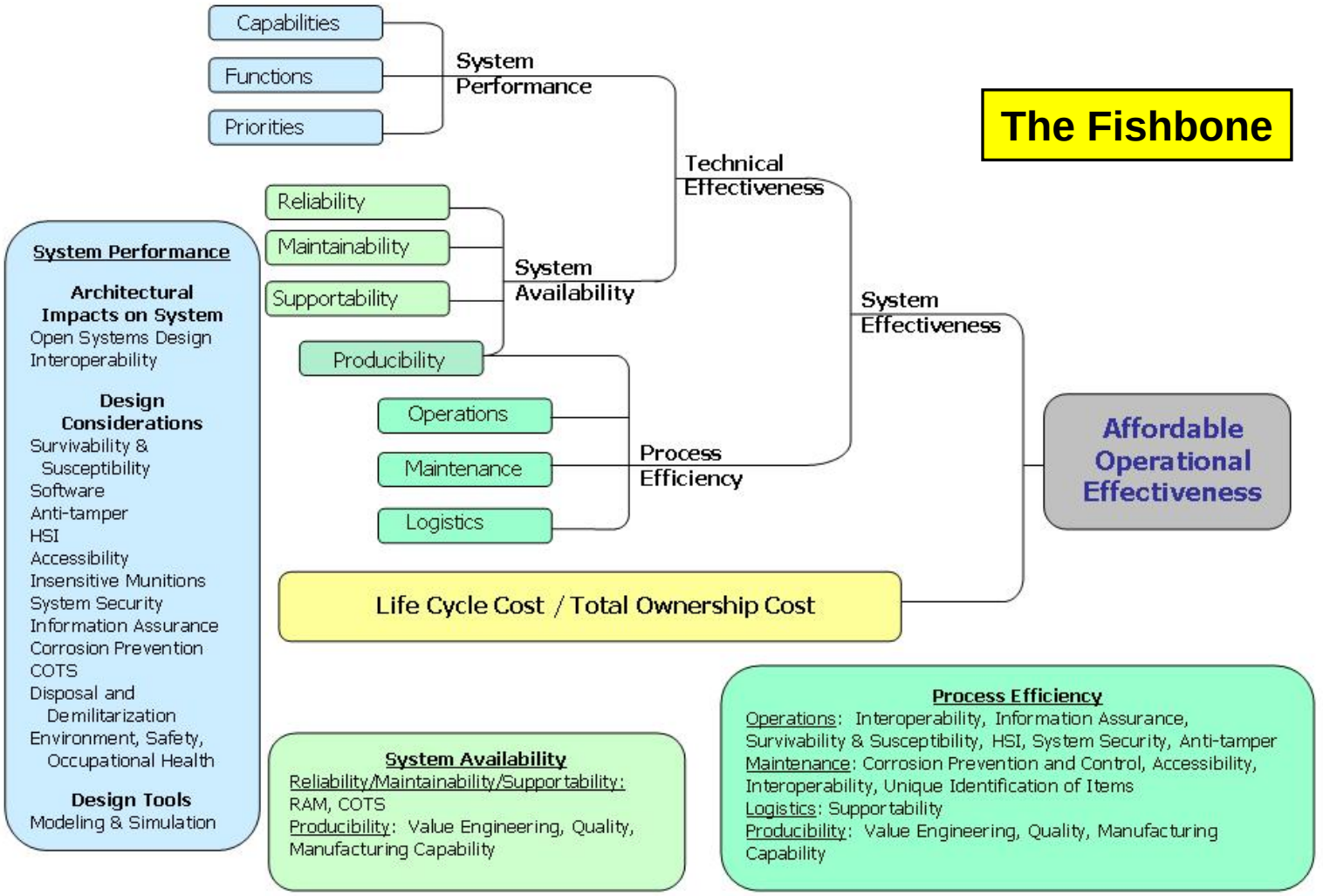
Design Considerations

- **SE must manage all requirements as an integrated set of design constraints**
  - **KPPs**
  - **Statutory**
  - **Regulatory**
  - **Derived performance requirements**
    - **Constraints**
    - **Usage, duty cycle, mission profiles**



- **Decomposition and allocation must address entire set at each level of recursion**
- **Integrated set of requirements and associated stakeholders are a primary driver for program staffing (non-trivial and a major source of program risk)**

Design Considerations



Design Considerations

- **Open Systems Design**
  - **An open system employs modular design tenets, uses widely supported and consensus based standards for its key interfaces, and is subject to validation and verification tests to ensure openness of its key interfaces**
  - **Such an approach should be undertaken after analysis and consideration of required capabilities, technology strategy, and acquisition strategy**
  - **This should be employed within the context of Modular Open Systems Approach (MOSA) implementation:**
    - **Establish an enabling environment**
    - **Employ modular design**
    - **Designate key interfaces**
    - **Use open standards**
    - **Certify conformance**

Design Considerations

- **Interoperability**
- **Standardization**
- **Commercial Off The Shelf**
  - **Adapting to commercial business practices**
  - **COTS evaluation**
  - **Relationship with vendors**
  - **Life Cycle Planning, and**
  - **Test and Evaluation of COTS items**
- **Software**
  - **Software system development should be based on robust systems engineering principles**

Design Considerations

- **Manufacturing Capability**
  - **Producibility**
  - **Manufacturing Readiness Levels**
- **Quality**
- **Reliability, Availability and Maintainability**
- **Supportability**
  - **Supportability Analyses**
  - **Support Concepts**
  - **Support Data**
  - **Support Resources**

Design Considerations

- Human System Integration (HSI)
- ESOH
- Survivability and Susceptibility
- Corrosion Prevention and Control
- Disposal and Demilitarization
- Information Assurance
- Insensitive Munitions
- Anti-Tamper Provisions
- System Security
- Accessibility
- Unique Identification of Items

Design Considerations

- **System of Systems (SoS) Engineering**
  - **Characteristics of SoS**
    - System elements are in themselves independently useful systems with stand alone operational capabilities
    - Integrated into a SoS, the SoS delivers significantly improved capabilities that cannot be achieved by single elements
  - **Factors for particular consideration**
    - Larger scope and greater complexity of integration efforts
    - Collaborative and dynamic engineering
    - Large extent of engineering uncertainty
    - Continuing architectural reconfiguration
    - Simultaneous modeling and simulation of SoS behavior
    - Rigorous interface design and management

Questions?

SE Agenda

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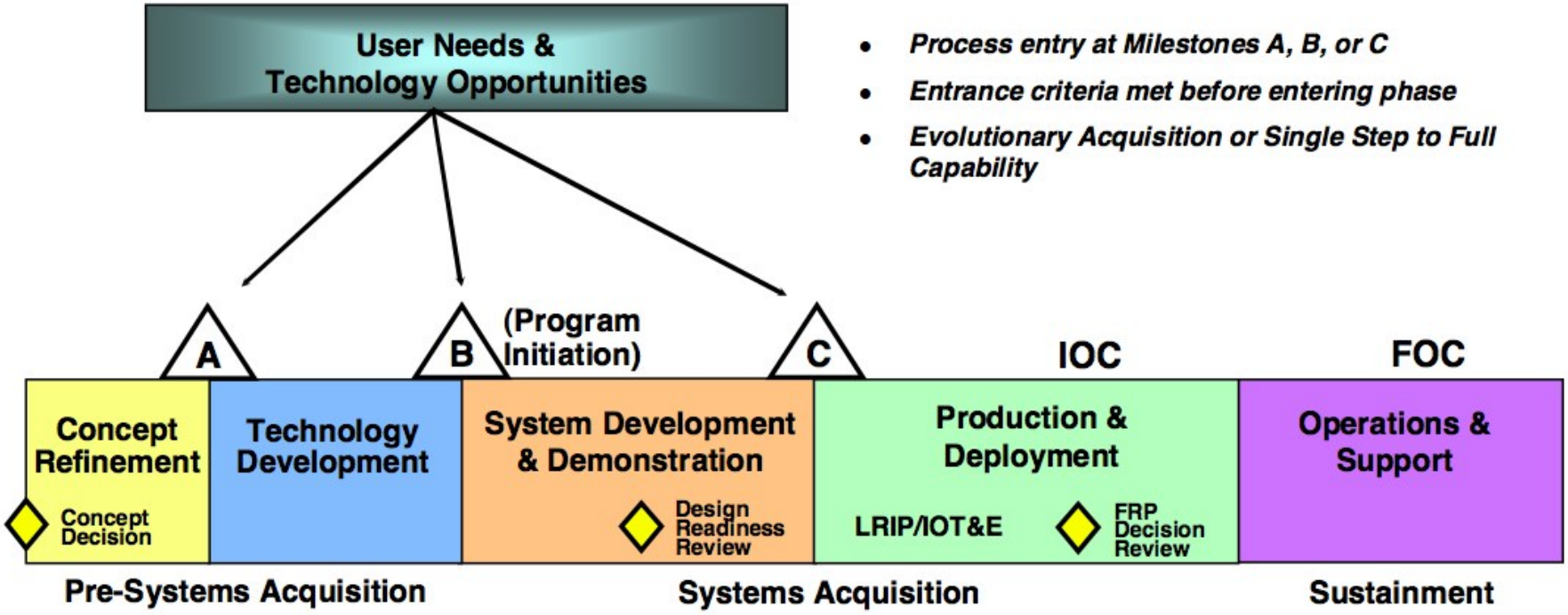
DoD Acquisition Framework

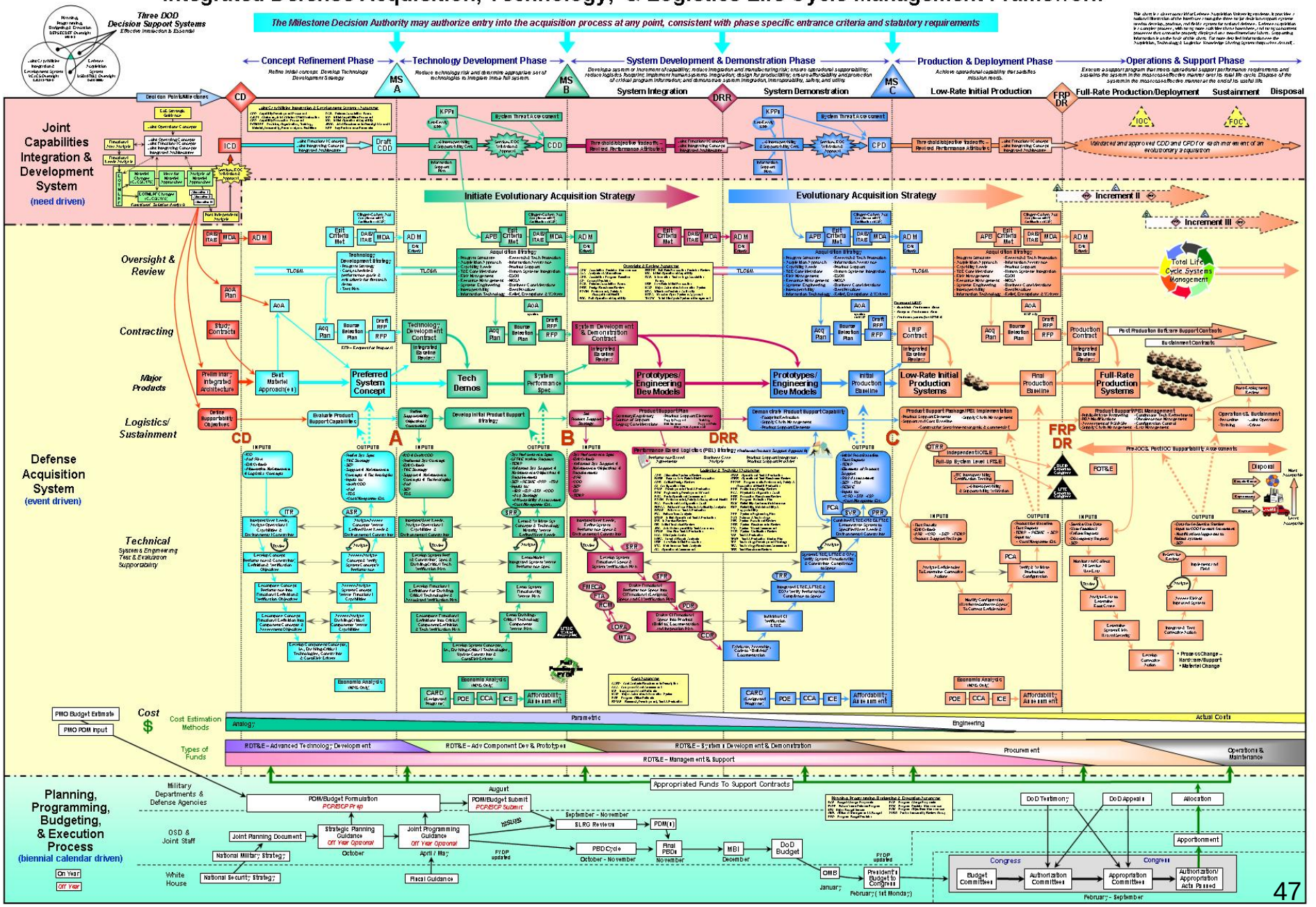


DoD Acquisition Framework

- Each phase builds upon and provides further detail and maturity to the outcomes of the previous phase
- SE processes are iterated in a recursive fashion at each system element level
- Technical Reviews plays an instrumental role to
  - Confirm outcomes of acquisition phases and major technical efforts within the phases
  - Provide the PM with an assessment of technical risk, readiness and maturity
  - Provide input to the continuous evolution of the SEP
- Technical Reviews should be event driven (entry criteria) not schedule driven
- Evolutionary acquisition programs repeat milestones and reviews in accordance with each increment

Integrated Defense Acquisition, Technology, & Logistics Life Cycle Management Framework

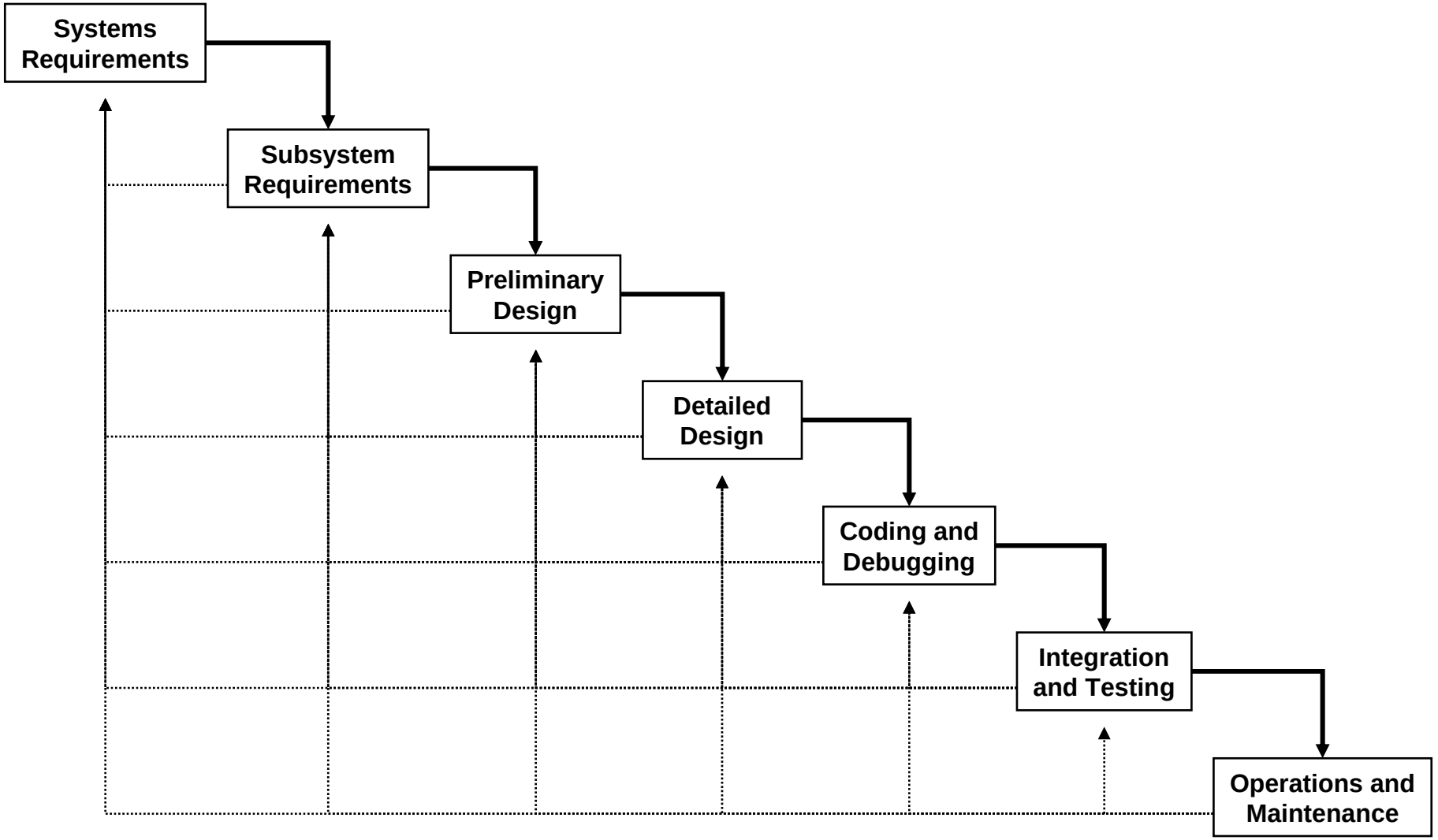
Draft ver. 4.8. September 8, 2004



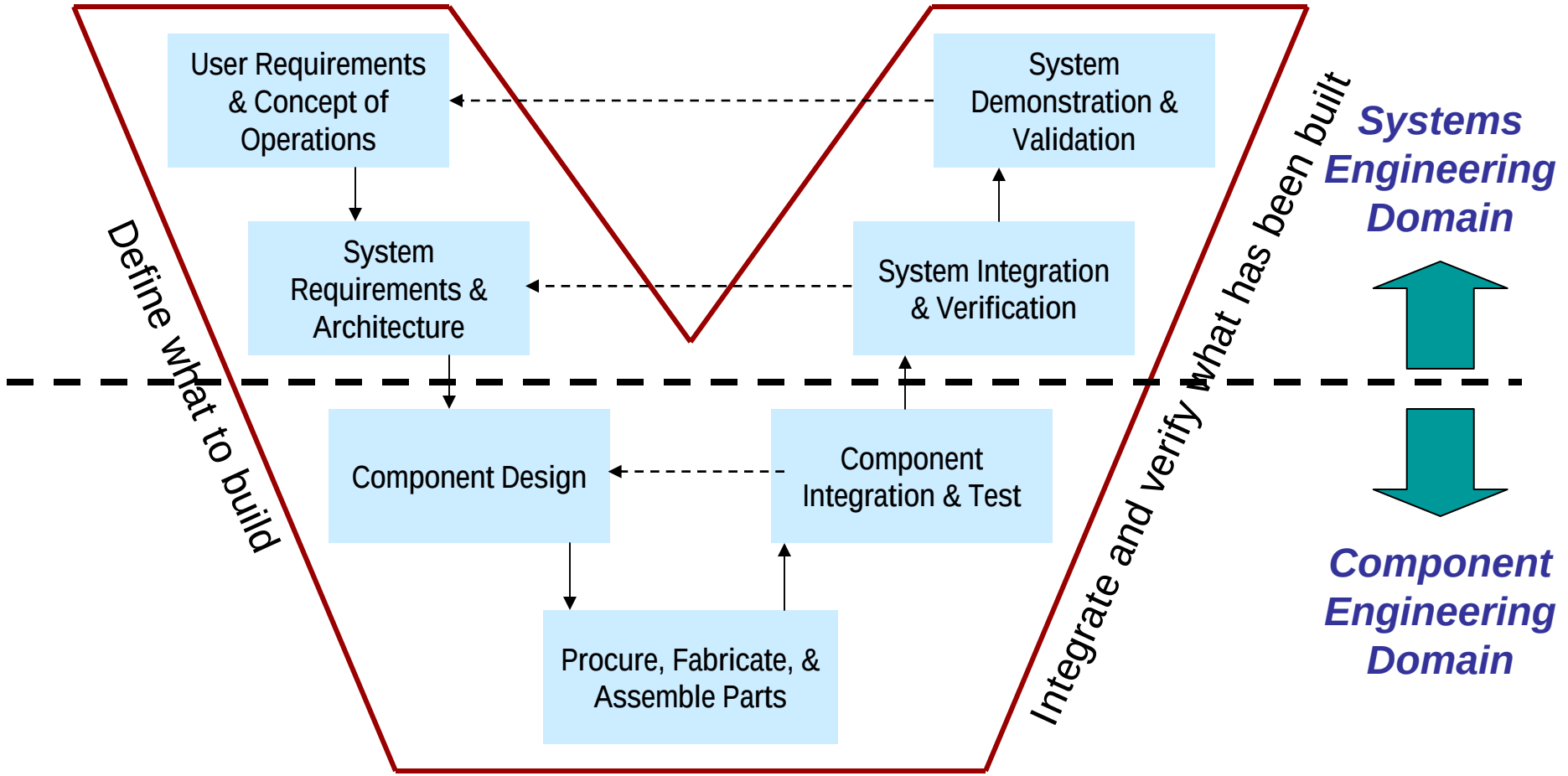
“Vee” Model

- **SE Life Cycle Models**
  - **Waterfall Model**
  - **“Vee” Model**
  - **Spiral Model**

Waterfall Model



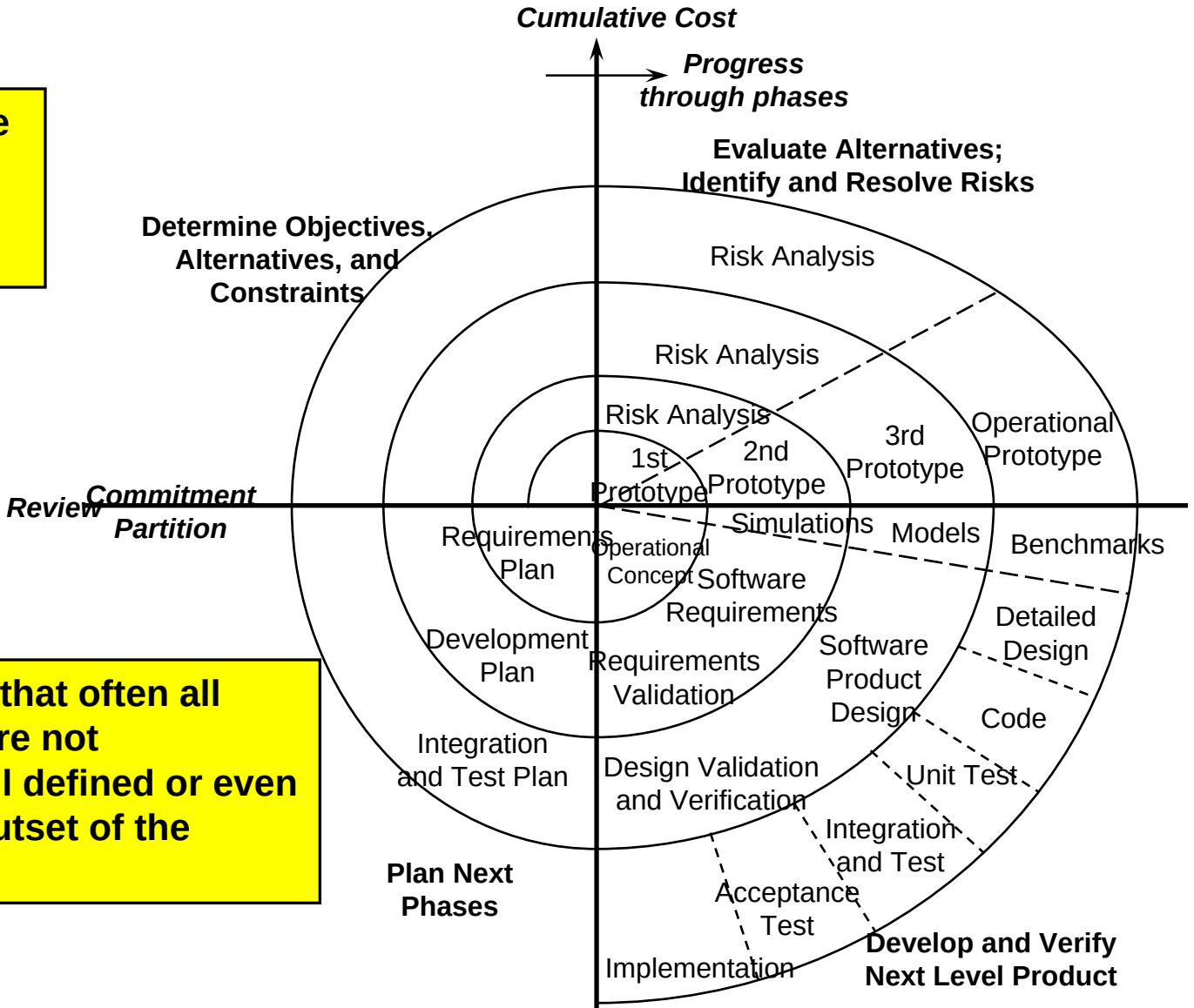
"Vee" Model



Activities "finish", not start, in this order!

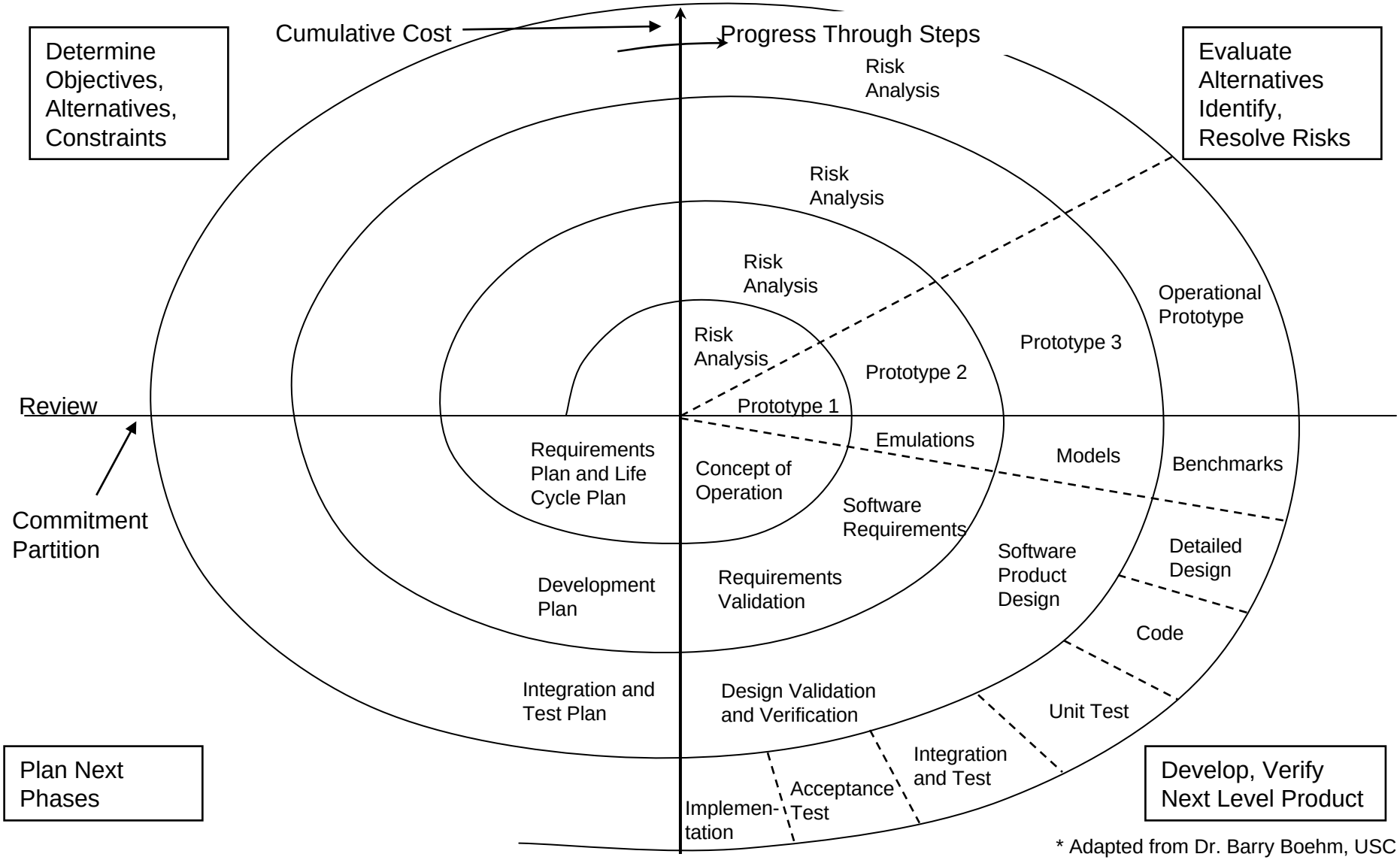
Spiral Model

Emphasizes the iterative nature of systems engineering.



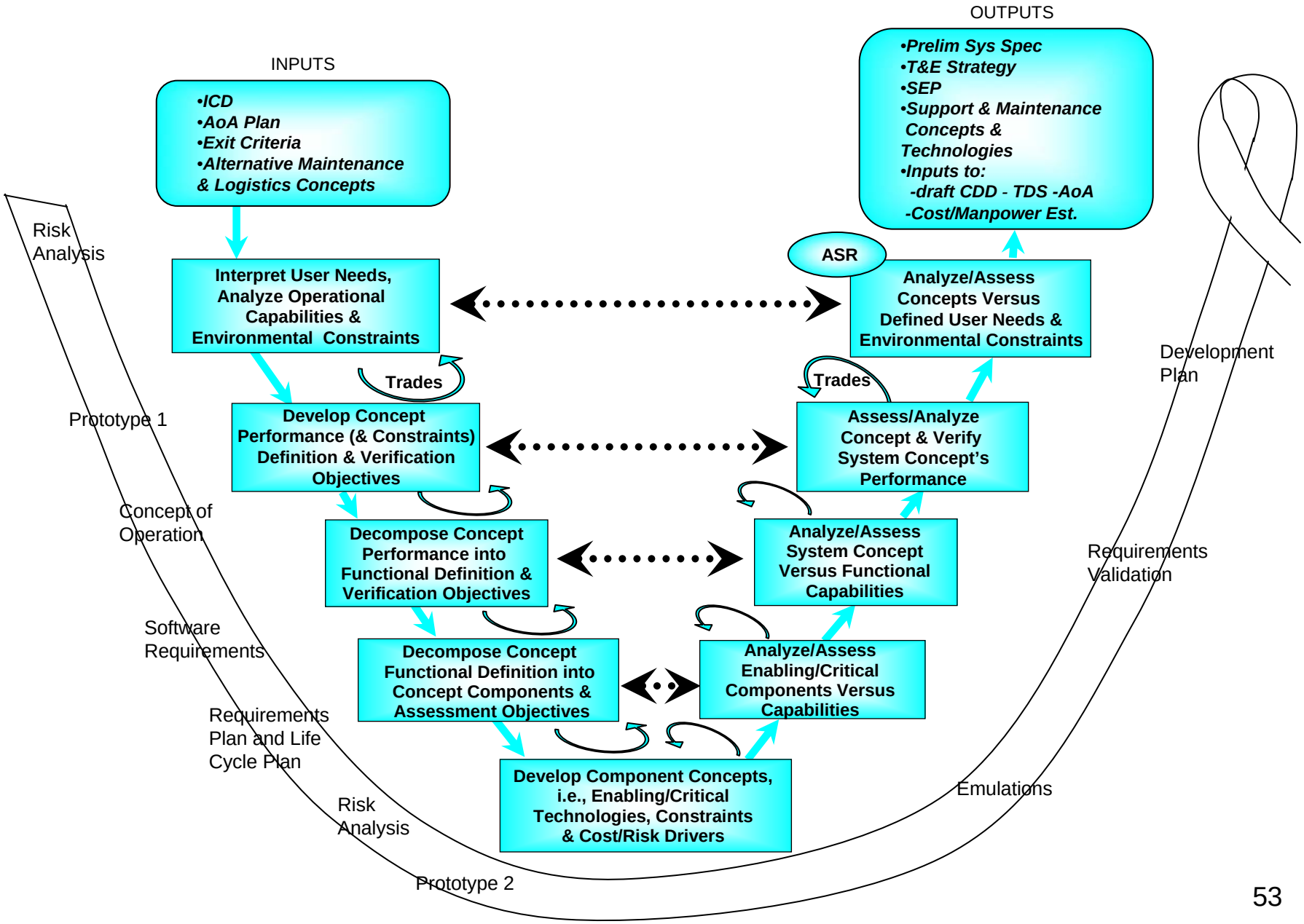
Acknowledges that often all requirements are not necessarily well defined or even known at the outset of the program

Spiral Development*

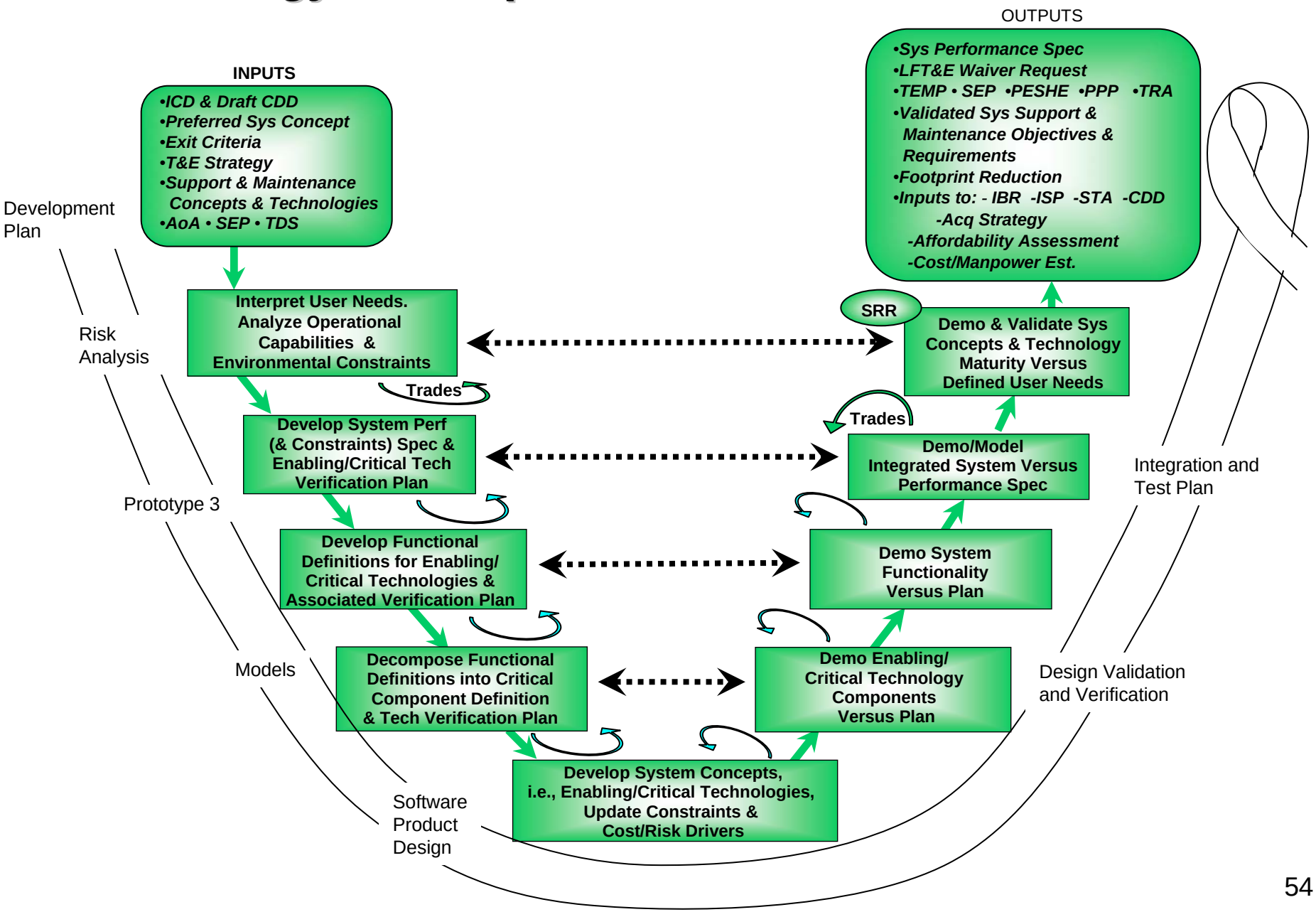


* Adapted from Dr. Barry Boehm, USC

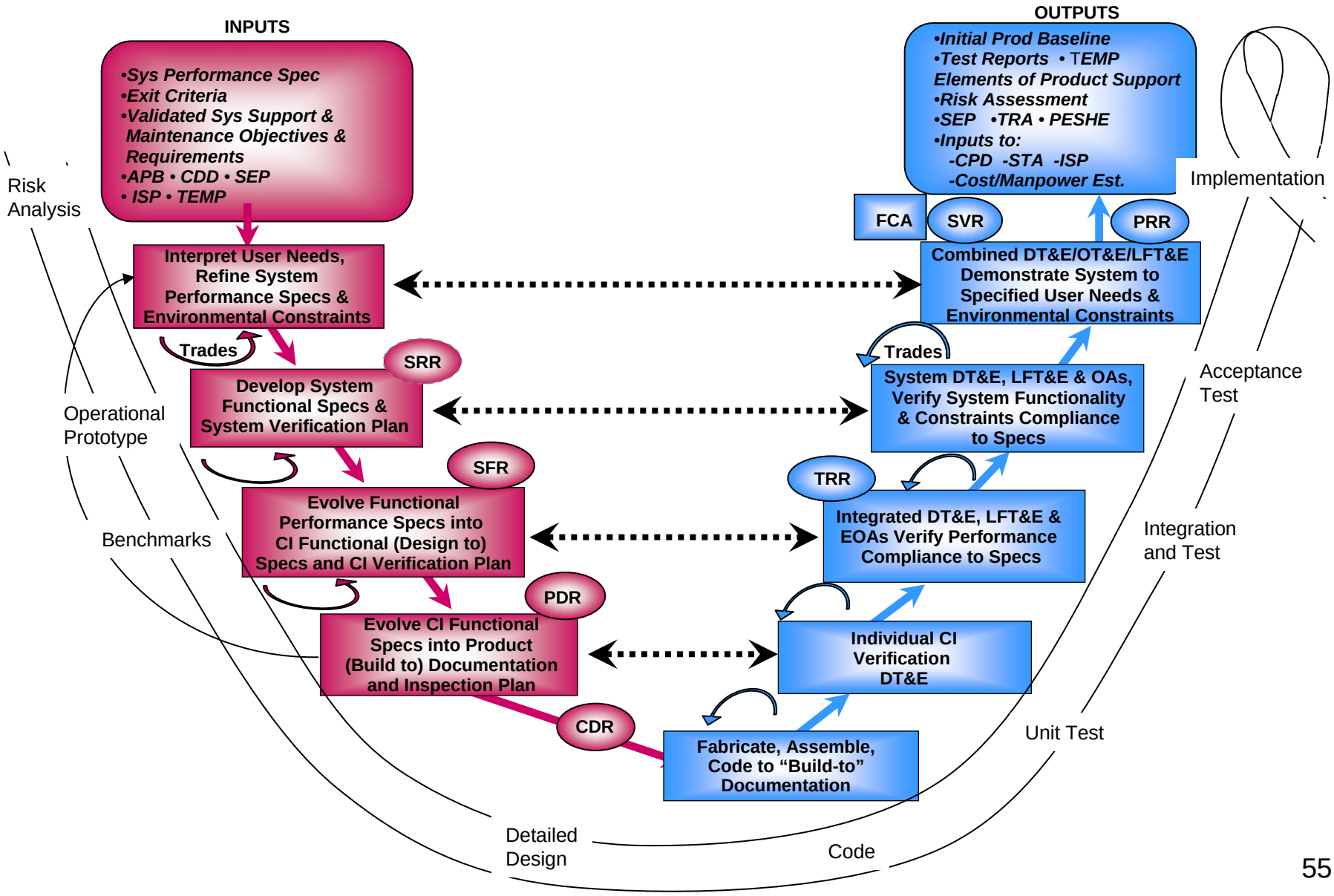
Concept Refinement Phase



Technology Development Phase

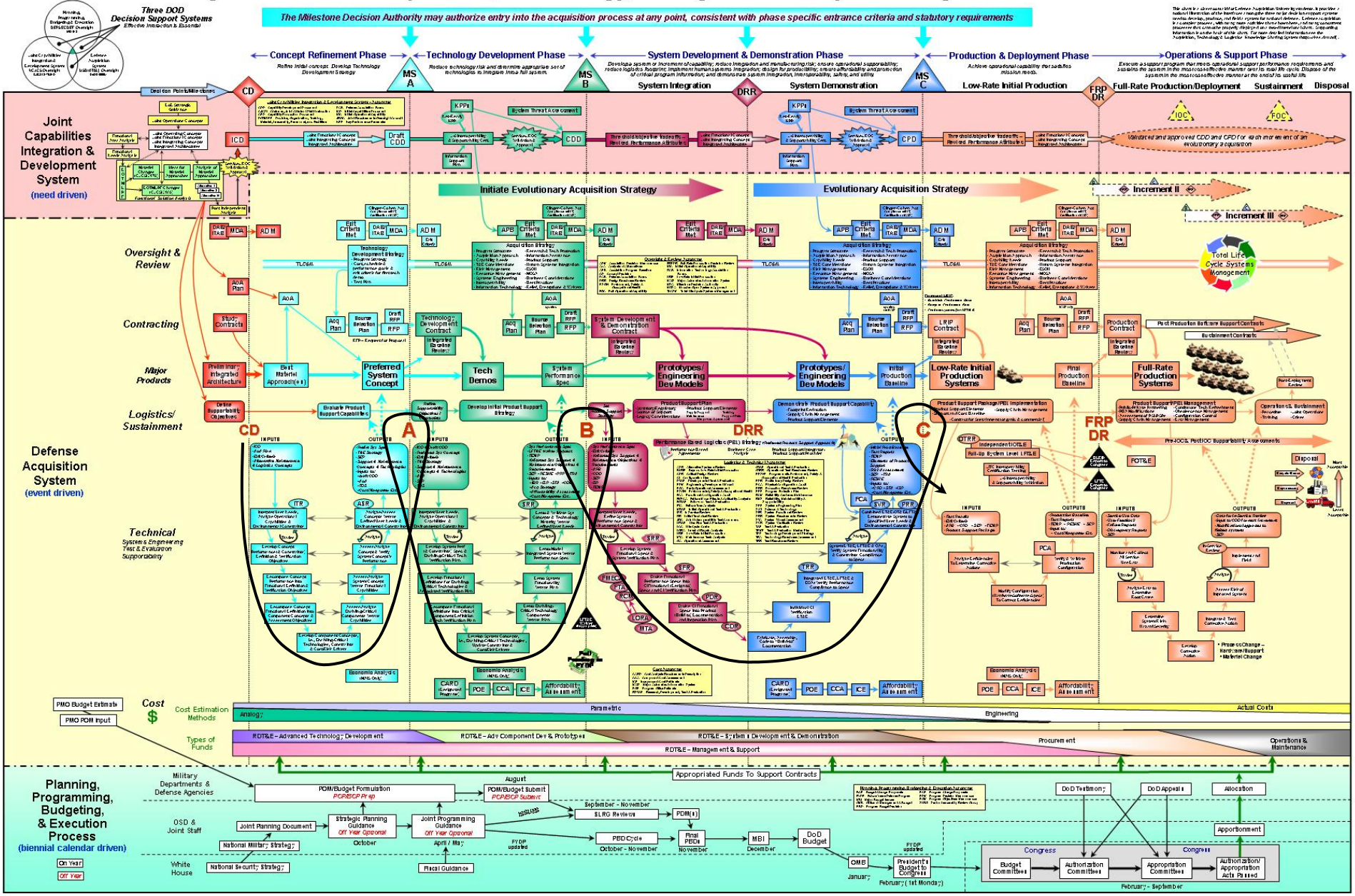


System Development and Demonstration Phase



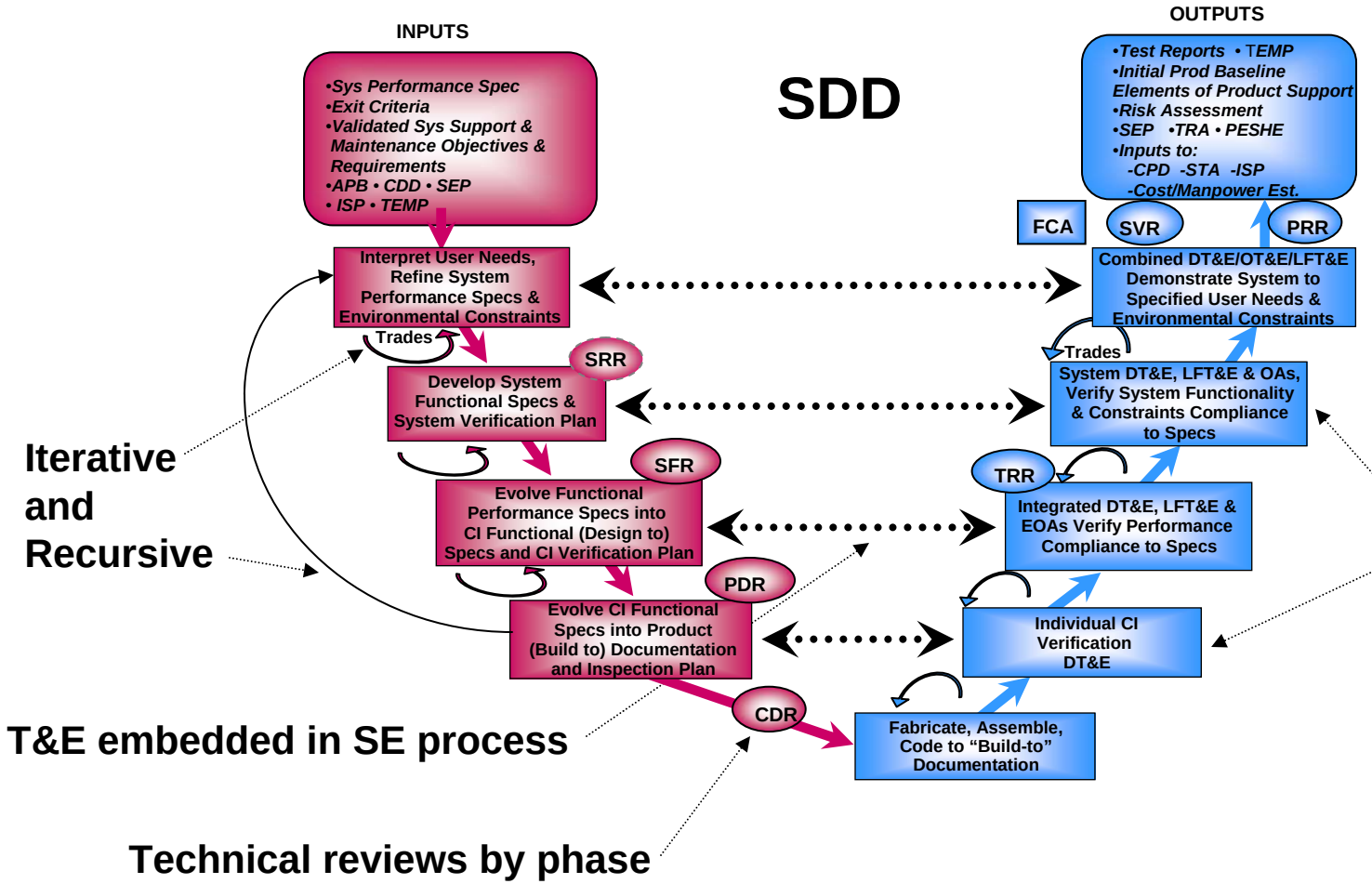
Integrated Defense Acquisition, Technology, & Logistics Life Cycle Management Framework

Draft ver. 4.8 September 8, 2004



DoD "Vee" Model

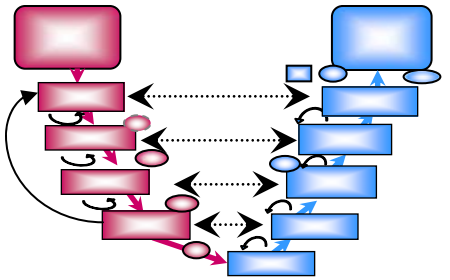
SE Processes directly tied to technical Inputs/Outputs by phase



Understanding Systems Engineering by Phase

DoD "Vee" Model

- **By phase consideration of SE activities**
  - **Purpose of SE in the phase**
  - **Inputs to the SE process**
  - **Key SE activities during the phase**
  - **Technical reviews during the phase**
  - **Outputs of the phase's SE process**



- **Full life cycle coverage, from Concept Refinement through Operations and Support**

DAU Course CLE009 *Systems Safety in SE*

Questions?

Break

Please Return If You Want A Wall Chart

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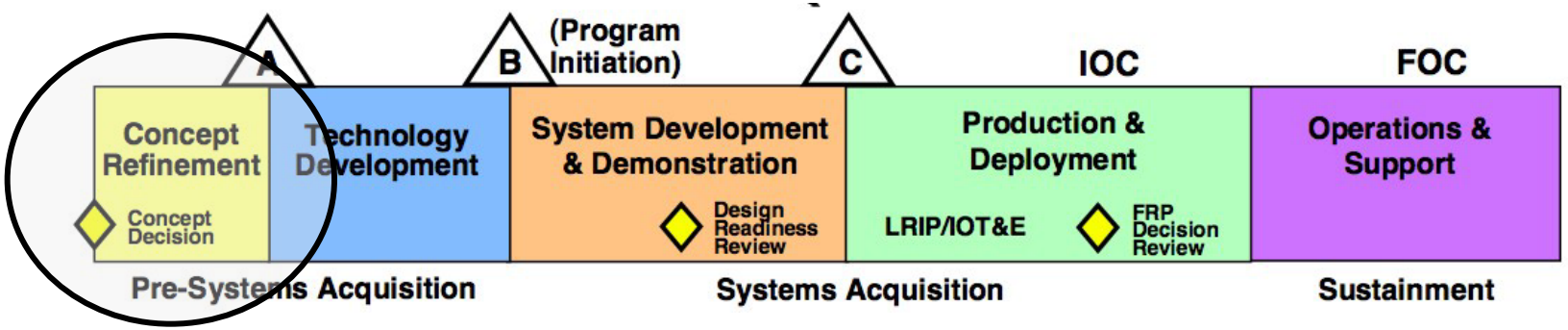
- **SE Across the Life Cycle**

DoD Acquisition Framework: Concept Refinement Phase

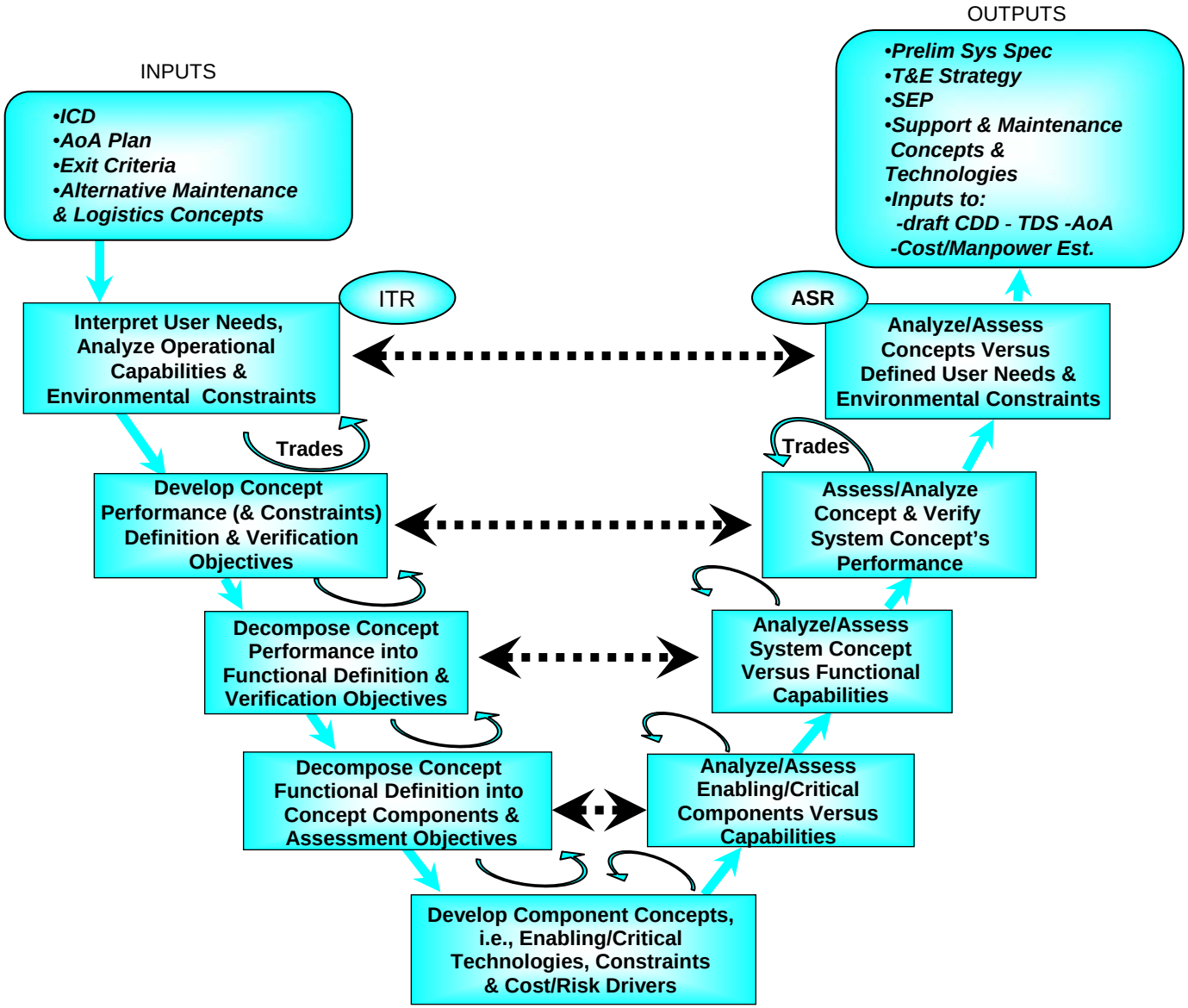


- This phase presents the first substantial opportunity to influence the system design by balancing the operational requirements, technology opportunities, schedule and funding constraints, and performance parameters
- User capabilities, expressed as Key Performance Parameters, should be defined in terms of:
  - Quantifiable metrics (e.g., speed, lethality) of performance to meet mission requirements
  - Full range of operational requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the mission over the long term
- The Concept Refinement Phase refines the initial concept and generates a Technology Development Strategy
  - Inputs to this phase: Successful Concept Decision; Approved Initial Capabilities Document; Analysis of Alternatives Plan
  - Acquisition Decision Memorandum documents Milestone Decision Authority approval of the Analysis of Alternatives Plan and establishes a date for the Milestone A review

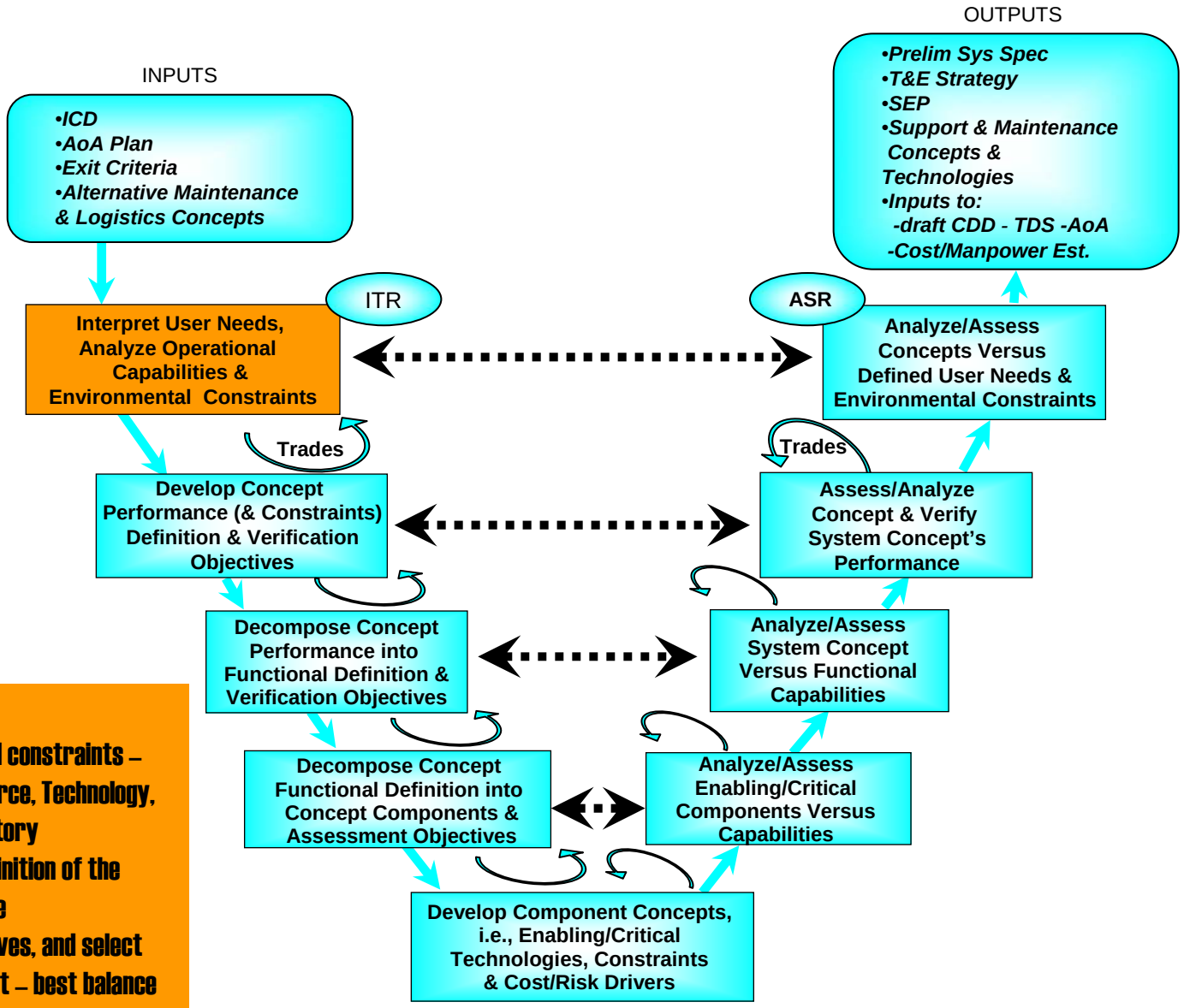
DoD Acquisition Framework: Concept Refinement Phase

- **Purpose of SE in this Phase**
  - **Initiated by an identified materiel need and an affirmative Concept Decision**
  - **SE supports the Analysis of Alternatives (AoA) evaluation and identification of preferred concepts**
    - **Technical evaluation of operational effectiveness**
    - **Cost estimates**
    - **Sensitivity analysis for changes in assumptions and variables**
  - **SE supports the development of the Technology Development Strategy (TDS)**
- **Inputs to the SE Process in this Phase**
  - **Initial Capabilities Document**
  - **AoA Plan**
  - **Exit Criteria for the Concept Refinement Phase**
  - **Alternative Maintenance and Logistics Concepts**

Concept Refinement Phase: Key SE Activities

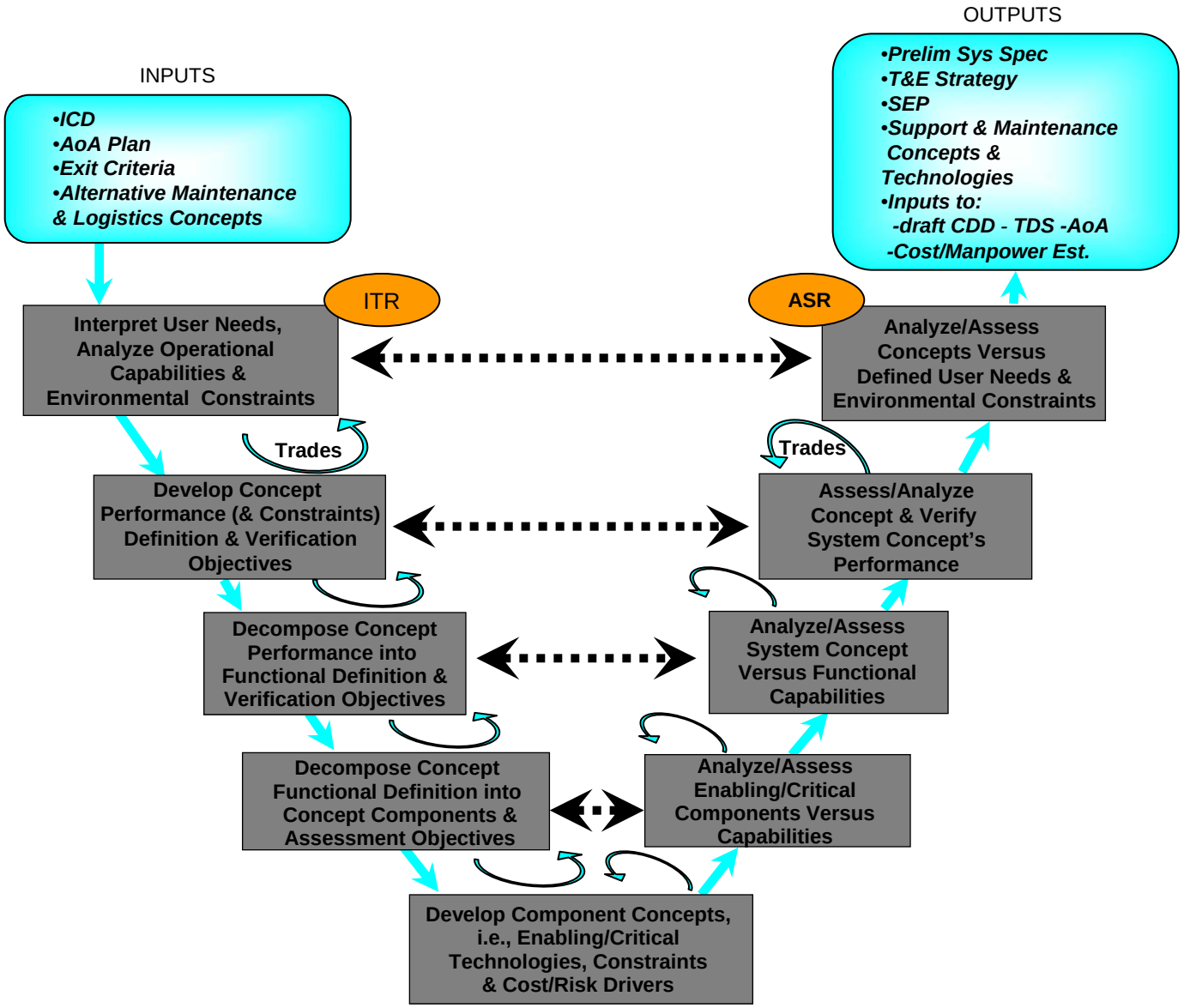


Concept Refinement Phase: Key SE Activities



- Consolidate all inputs
- Ensure clarity wrt all constraints – Environmental, Resource, Technology, statutory and regulatory
- The above ensure definition of the "feasible" trade space
- Analyze the alternatives, and select the preferred concept – best balance between required capabilities and program constraints

Concept Refinement Phase: Key SE Activities



Initial Technical Review (ITR)

- **Purpose**
  - **Assure that the technical baseline is rigorous enough to support a valid cost estimate as well as enable an independent assessment of the estimate by subject matter experts**
- **Provided at completion**
  - **A complete Cost Analysis Requirements Document (CARD) detailing system overview, risk and operational concept**
  - **Assessment of technical and cost risks**
  - **Independent assessment of cost estimate**
- **Typical exit criteria**
  - **Does CARD capture key cost drivers, development costs, production costs, operation and support costs? Is it complete and thorough?**
  - **Are the underlying assumptions technically and programmatically sound and complete?**
  - **Have the appropriate competencies been involved in its development as well as in its independent review?**
  - **Are risks known and manageable within the cost estimate?**
  - **Is the program as captured in the CARD executable?**

Alternative System Review (ASR)

- **Purpose**
  - **Ensure that resulting requirements agree with customer's needs and expectations and that the system under review can proceed into Technology Development (TD)**
  - **Assesses multiple concepts and assures that the preferred one (s) effectively and efficiently meets the need expressed in the ICD**
- **Provided at Completion:**
  - **Agreement on the preferred system concept(s)**
  - **HW and SW architectural constraints/drivers**
  - **Assessment of the full system software concept**
  - **Comprehensive rationale for the preferred concept**
  - **Comprehensive assessment of risks relative to COTS and NDI**
  - **Comprehensive risk assessment for the TD Phase**
  - **Trade studies/Technical Demonstrations for Concept Risk Reduction**
  - **Joint requirements for compatibility, interoperability, and integration**
  - **Translation of MOEs into refined thresholds and objectives**
  - **Planning for the TD phase, and initial planning for the SDD phase**
  - **A draft system requirements document**

SE Outputs from Concept Refinement

- Preliminary System Specification
- T&E Strategy
- SEP
- System Maintenance and Support Concepts and Technologies
- Inputs to draft Capabilities Development Document
- Inputs to Technology Development Strategy
- Inputs to Analysis of Alternatives
- Inputs to Cost and Manpower Estimate

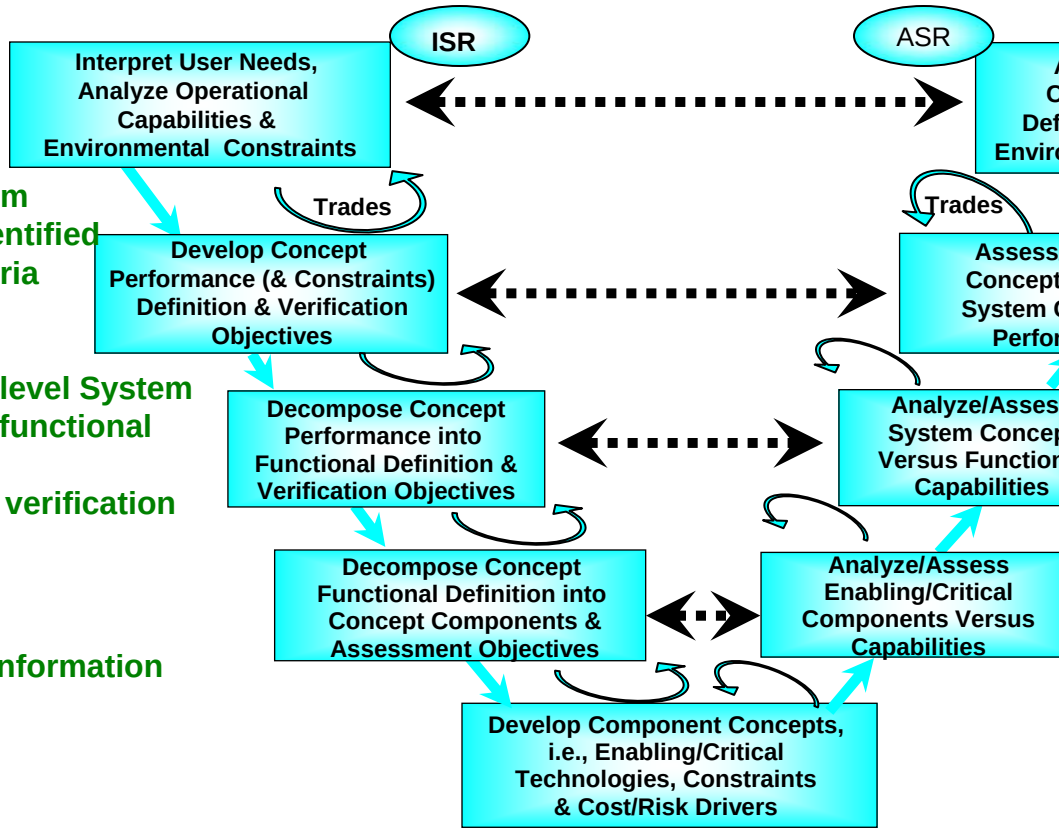
Concept Refinement Phase: Key System Safety Activities

- Review Threat Assessment
- Identify System Safety criteria

- Assess each system concept against identified System Safety criteria

- Translate concept level System Safety Criteria into functional requirements
- Identify applicable verification objectives

- Initiate PHL
- Review historical information



- Finalize PHL
- Recommend preferred system concept

- Evaluate system concept's Ability to meet performance Capability reqt's within identified Constraints.

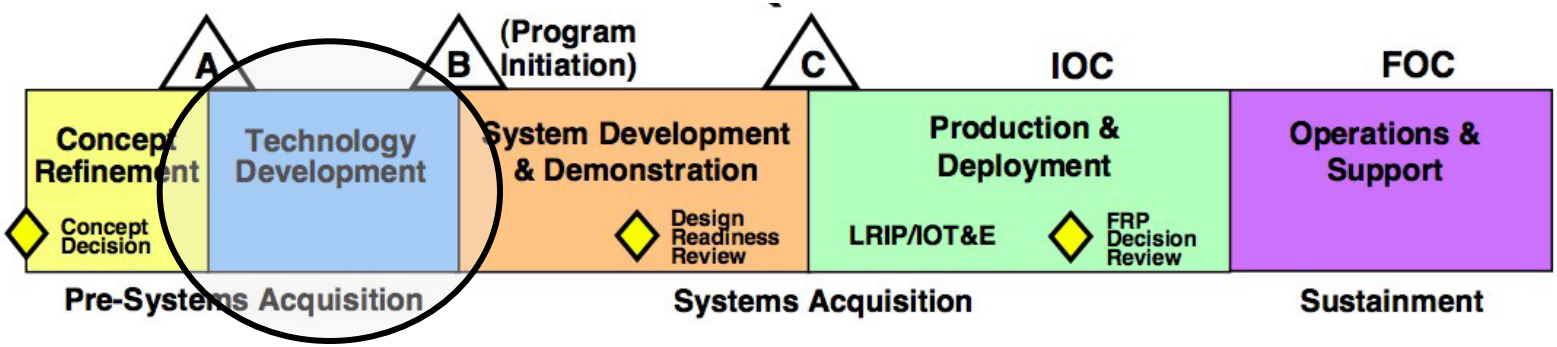
Evaluate system concept based Upon component test results

- Evaluate component test results against Identified constraints

- Update PHL
- Initiate identification of component constraints
- Recommend projected system attrition rates

Questions?

DoD Acquisition Framework: Technology Development Phase

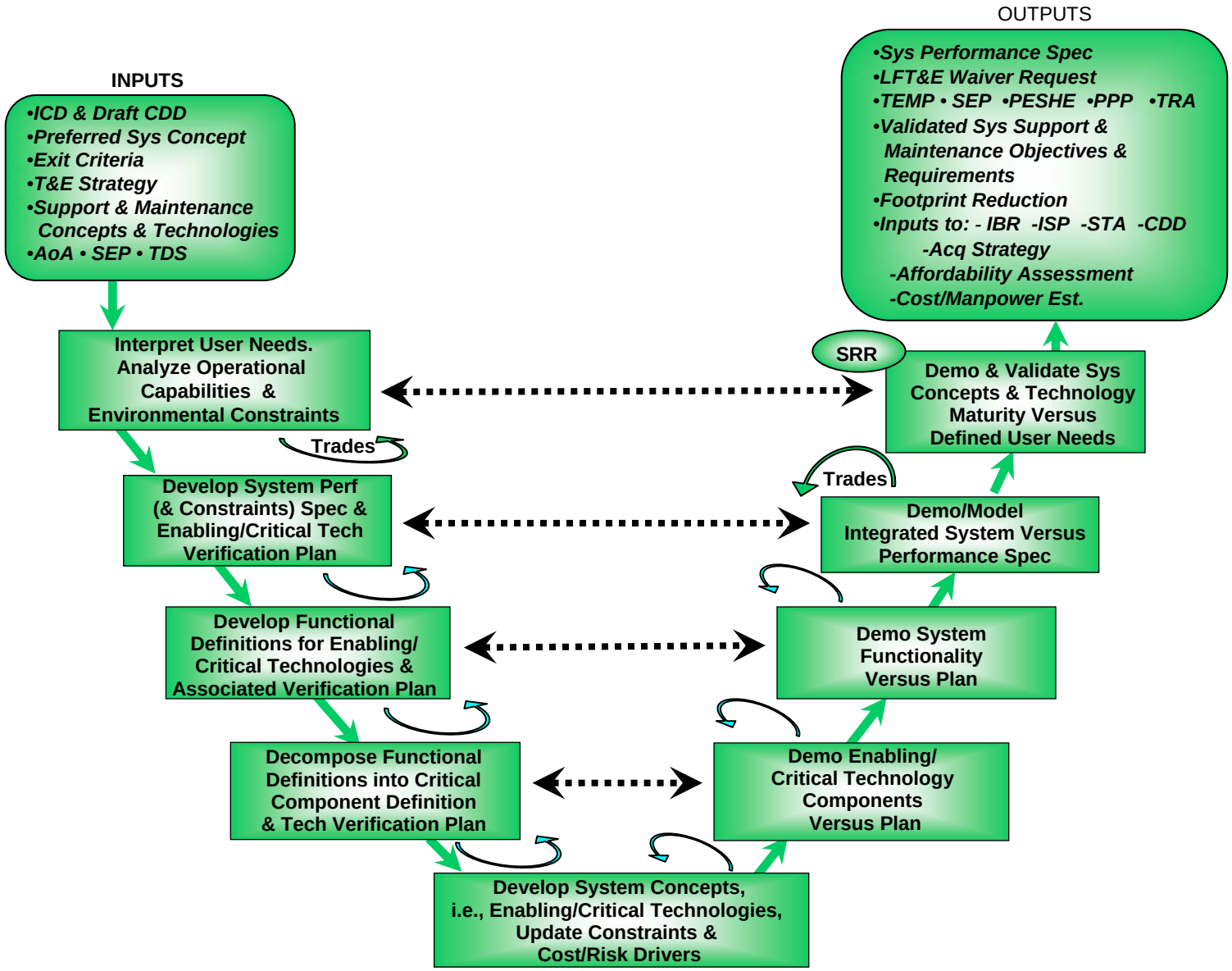


- This phase is focused on reducing technology risk through determining the appropriate set of technologies to be integrated into the full system
- Technology Development is an iterative process to assessing technologies and refining user performance parameters
- Technology Development is a continuous technology discovery and development process reflecting close collaboration between the science and technology community, the user community, and the development community
- This phase is guided by the: Initial Capabilities Document; Technology Development Strategy; and the Draft Capability Development Document
- The final Capability Development Document is the result

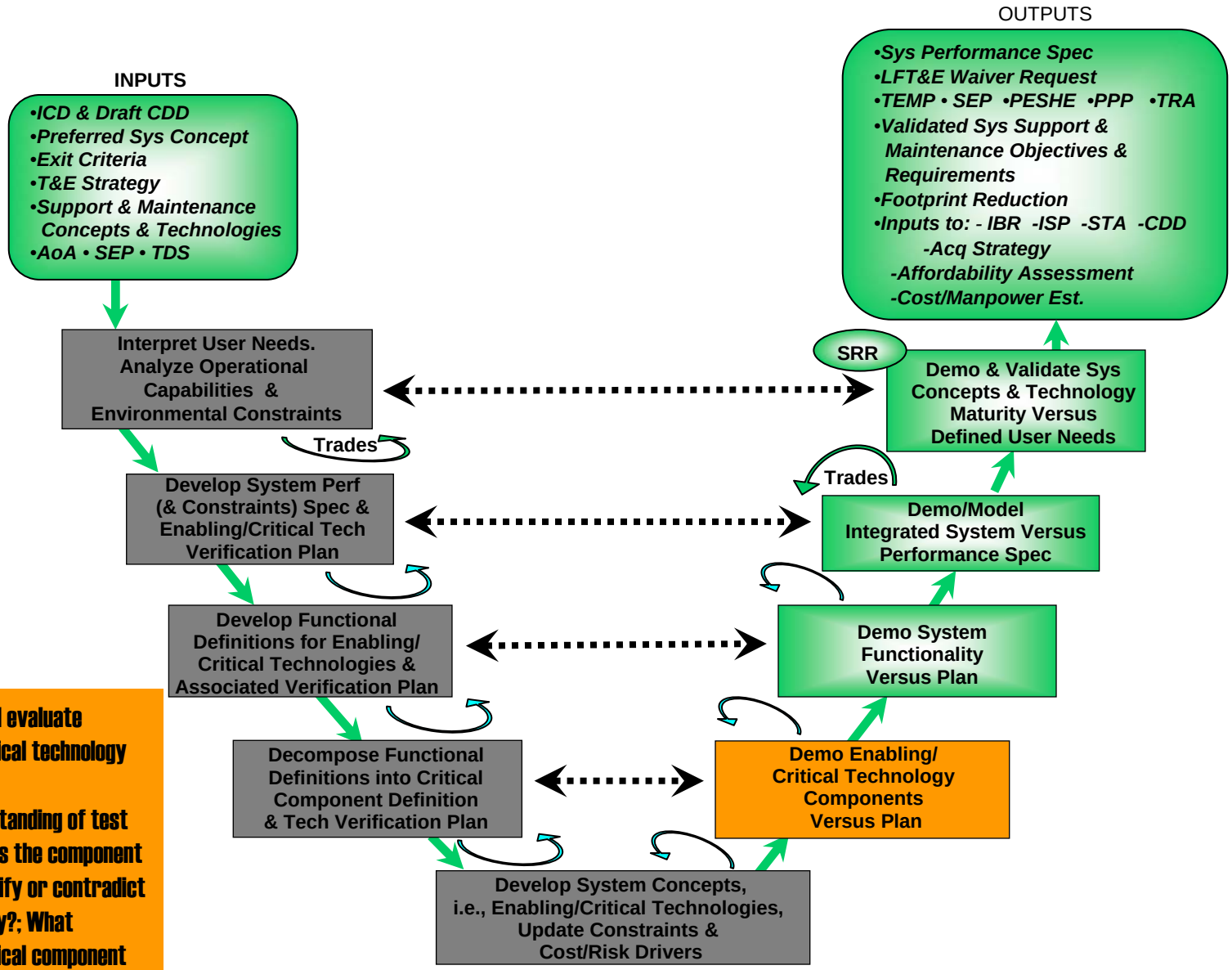
DoD Acquisition Framework: Technology Development Phase

- **Purpose of SE in this Phase**
  - Convert each required capability into a system performance specification
  - Translate user-defined performance parameters into configured systems
  - Integrate the technical inputs of the entire design team
  - Manage interfaces
  - Characterize and manage technical risk
  - Transition technology from the technology base into program specific efforts
  - Verify that designs meet operational needs
- **Inputs to the SE Process in this Phase**
  - Initial Capabilities Document and draft Capability Development Document
  - Preferred System Concept
  - Exit Criteria for the Technology Development Phase
  - Test and Evaluation Strategy
  - Support and Maintenance Concepts and Technologies
  - Analysis of Alternatives
  - Systems Engineering Plan; and
  - Technology Development Strategy

Technology Development Phase: Key SE Activities

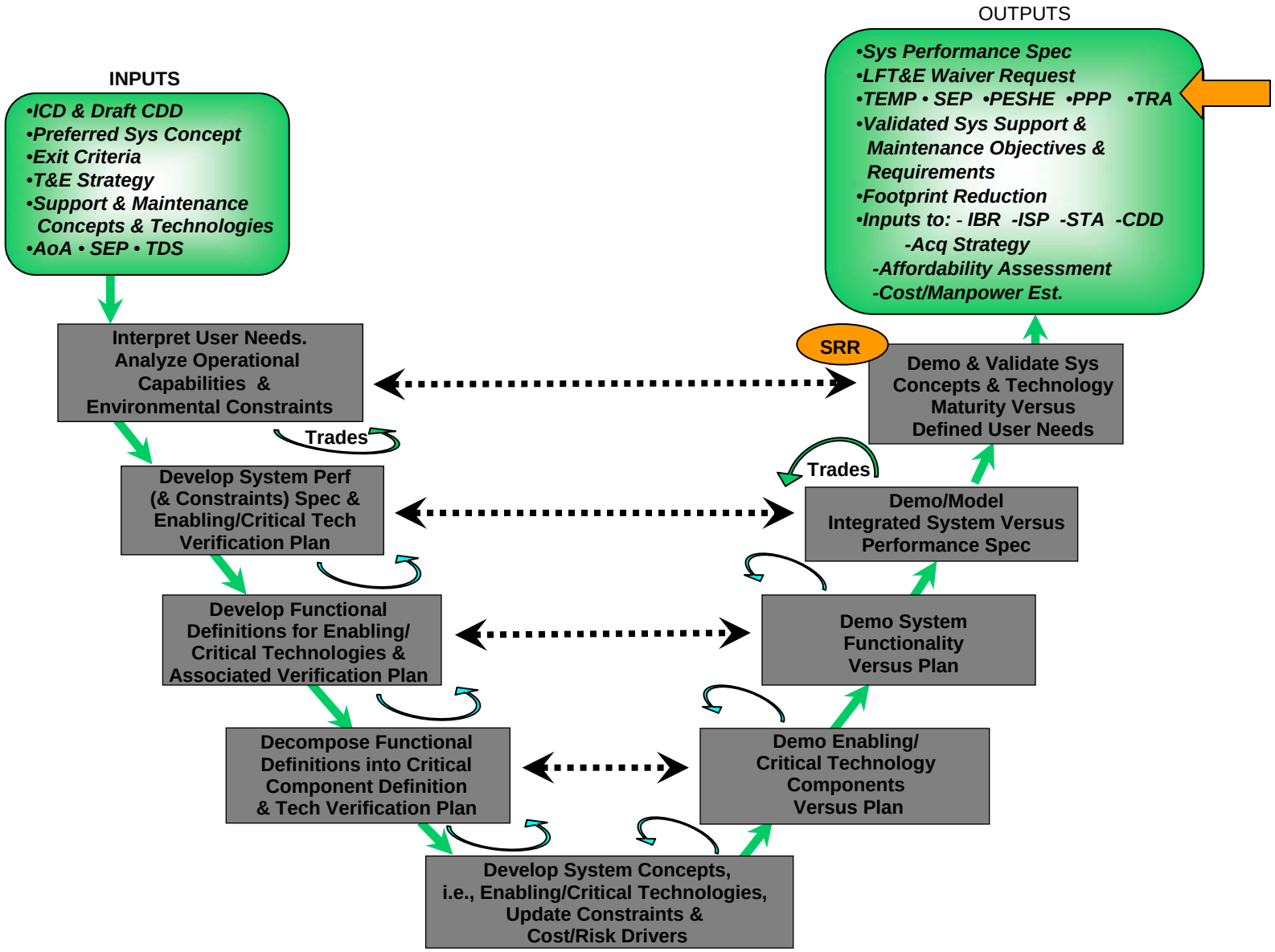


Technology Development Phase: Key SE Activities



- Demonstrate and evaluate enabling and critical technology components
- Critical – Understanding of test results: How does the component functionality verify or contradict desired capability?; What enabling and critical component technologies are required?

Technology Development Phase: Key SE Activities



System Requirements Review (SRR)

- **Purpose and characteristics**
  - **Ascertain progress in defining system technical requirements in accordance with program objectives**
  - **Ensure that system requirements are consistent with preferred solution and available technologies**
  - **Understanding of inherent risk in the system specification as well as an acceptable level of risk is critical to a successful review**
  - **May also be repeated at the start of the SD&D Phase**
- **Provided at completion**
  - **An approved preliminary system performance specification;**
  - **A preliminary allocation of system requirements to hardware, human, and software subsystems**
  - **Identification of all software components (tactical, support, deliverable, non-deliverable, etc.)**
  - **A comprehensive risk assessment for System Development and Demonstration**
  - **An approved System Development and Demonstration Phase Systems Engineering Plan that addresses cost and critical path drivers**
  - **An approved Product Support Plan with updates applicable to this phase**

Technology Readiness Assessment (TRA)

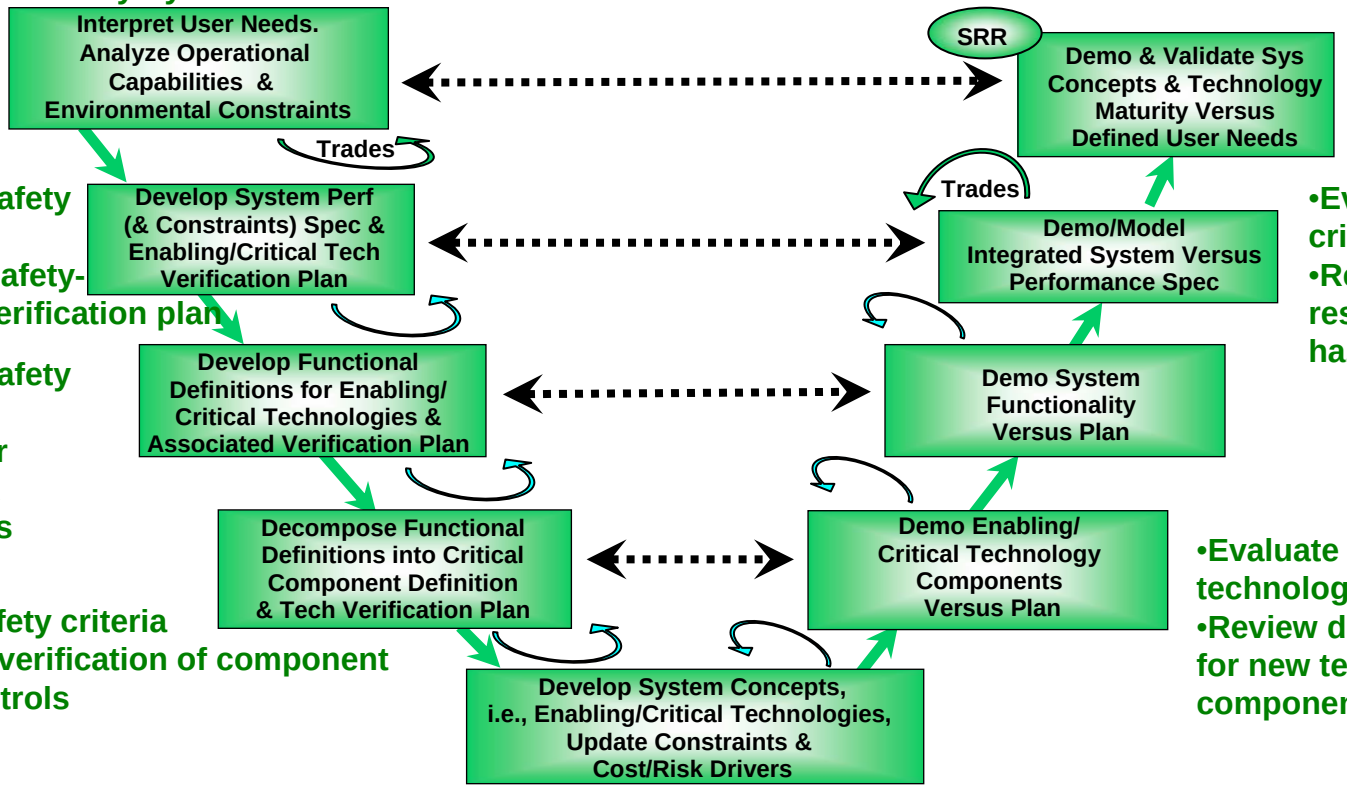
- **Purpose and characteristics**
  - **TRA is a regulatory information requirement for all acquisition programs**
  - **It is a systematic, metrics-based process to assess the maturity of Critical Technology Elements**
  - **It is not considered as risk assessment, but it should be viewed as a tool for assessing program risk and the adequacy of technology maturation planning**
  - **It scores the current readiness level of selected system elements using defined Technology Readiness Levels**
- **Provided at completion**
  - **A comprehensive review of the entire platform or system. This review identifies Critical Technology Elements**
  - **An objective scoring of levels of technological maturity for each Critical Technology Element by subject matter experts**
  - **Maturation plans for achieving acceptable maturity roadmap for Critical Technology Elements prior to critical milestone decision dates**
  - **A final report documenting the findings of the assessment panel**

SE Outputs from Technology Development

- Preliminary System Performance Specification
- Live-Fire T&E Waiver Request
- T&E Master Plan
- SEP
- PESHE
- NEPA Compliance Schedule
- Program Protection Plan
- Technology Readiness Assessment
- Validated System Maintenance and Support Objectives and Requirements
- Footprint Reduction
- Inputs to:
  - Integrated Baseline Review
  - Information Support Plan
  - System Threat Assessment
  - Capability Development Document
  - Acquisition Strategy
  - Affordability Assessment
  - Cost and Manpower Estimate

Technology Development Phase: Key System Safety Activities

- Update identification of System Safety Constraints
- Develop criteria & identify System Safety-critical tech. needs



- Update System Safety criteria
- Include System Safety-critical specs in Verification plan

- Update System Safety criteria
- Develop reqt's for verification of risk mitigation controls

- Update System Safety criteria
- Develop reqt's for verification of component Risk mitigation controls

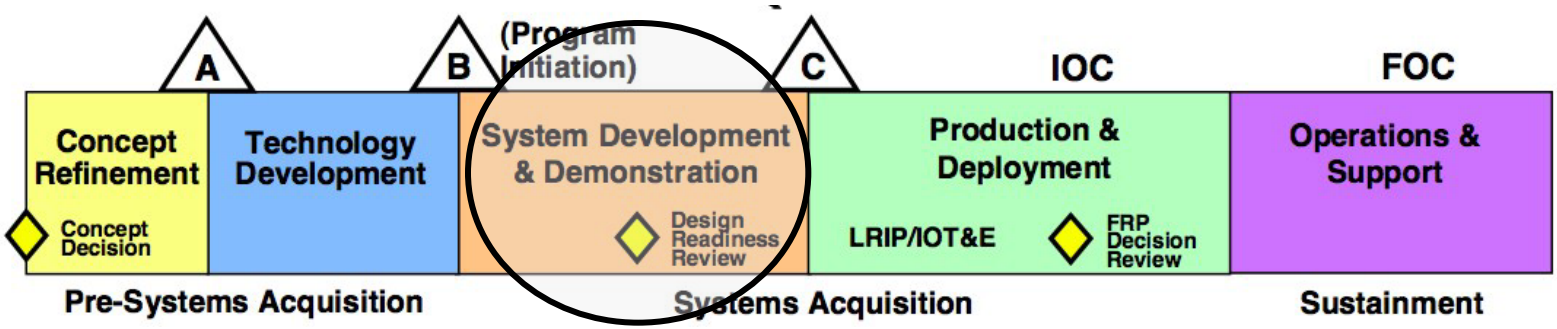
- Evaluate enabling/ critical technologies
- Review demo/model results for new hazards

- Evaluate enabling technologies
- Review demo results for new technology component hazards

- Update PHL
- Update constraints
- Identify potential operational & maintenance training & staffing reqt's
- Estimate system attrition rates

Questions?

DoD Acquisition Framework: System Development & Demonstration Phase



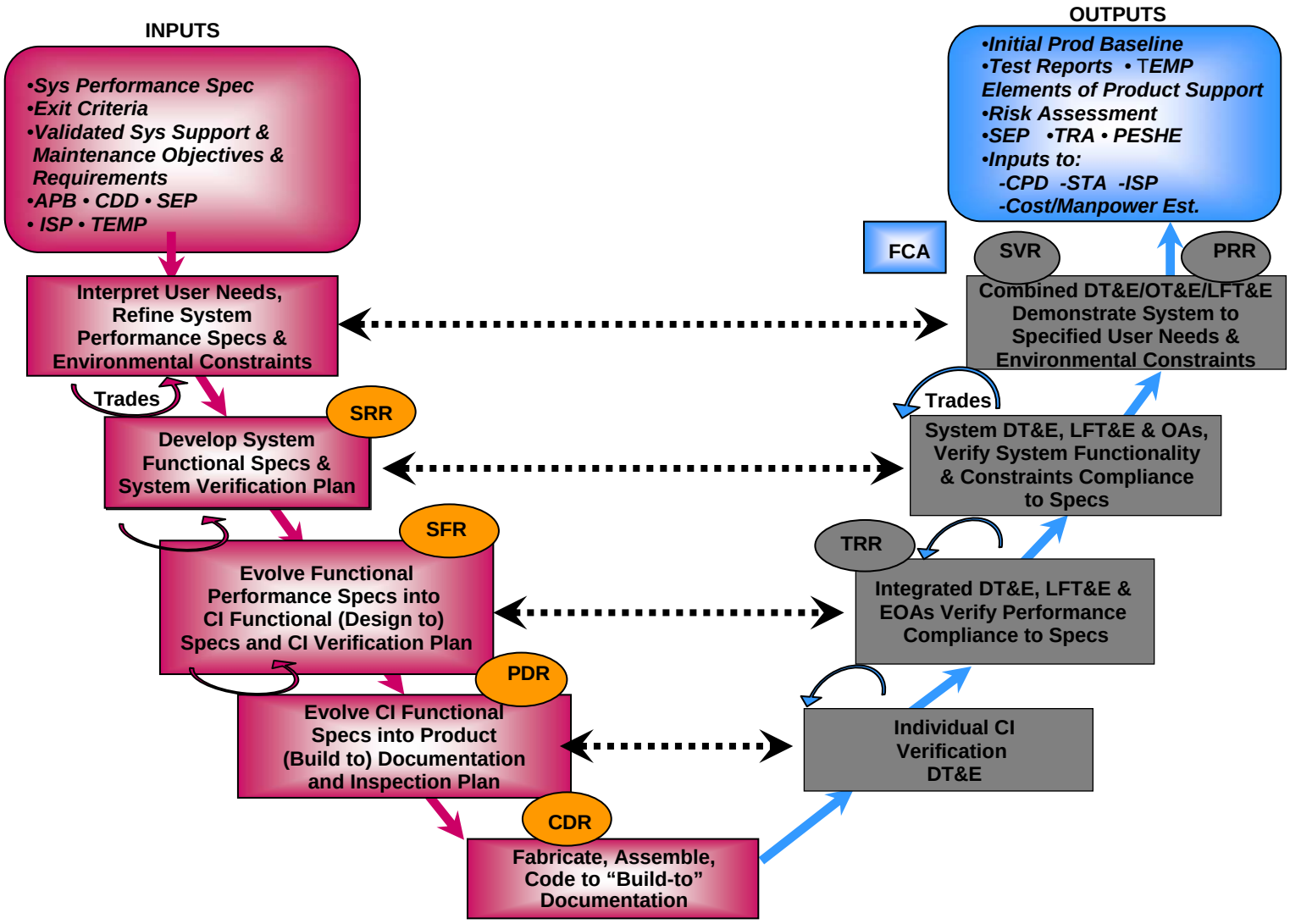
- The program, the system architecture, and system elements down to the configuration item level are defined based upon the mature technology suite selected and integrated during Concept Refinement and Technology Development; System design requirements are allocated down to the major subsystem level; Support concept and strategy are refined during the System Development and Demonstration (SDD) Phase

- The Design Readiness Review separates two work efforts during the SDD: System Integration and System Demonstration

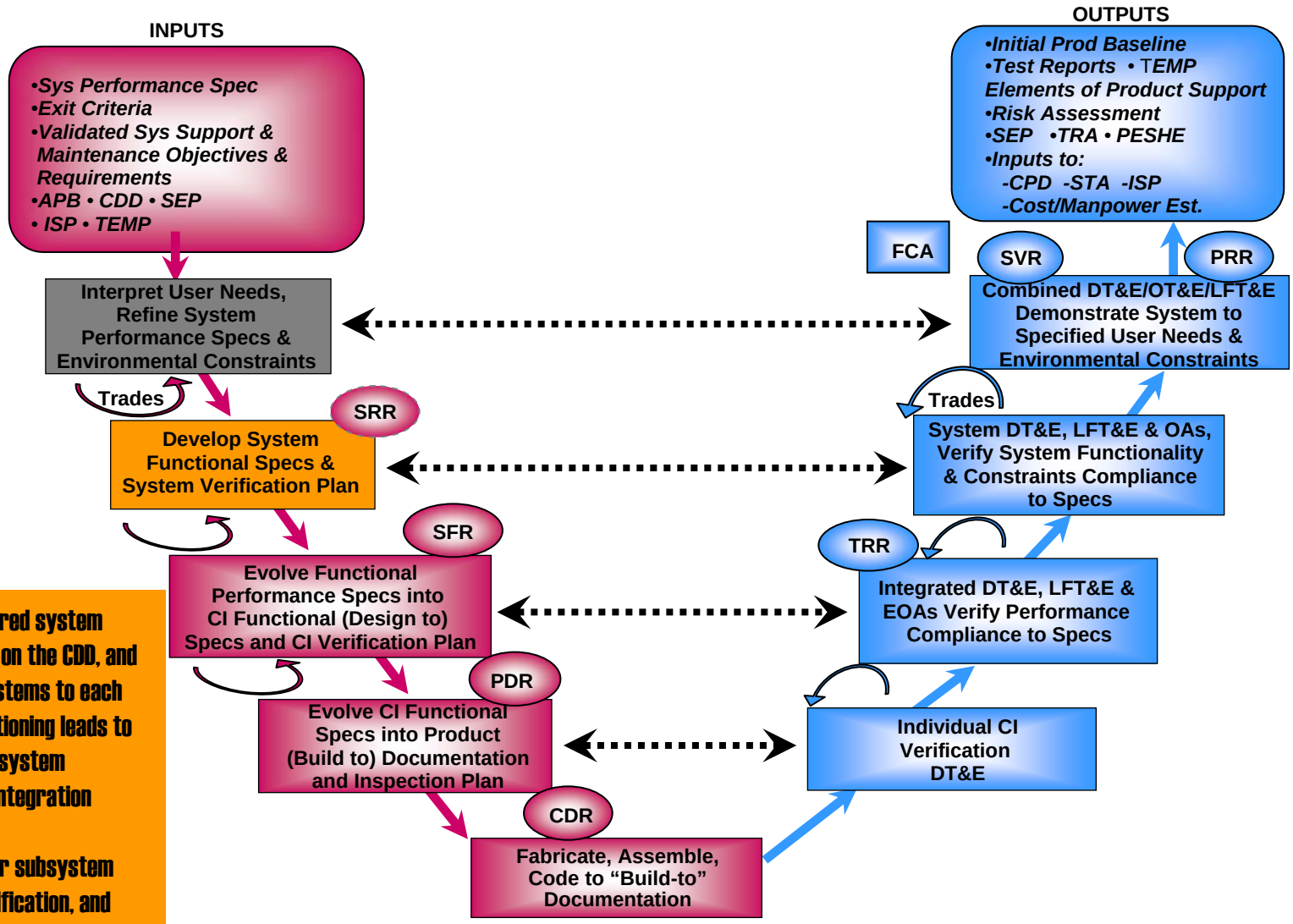
DoD Acquisition Framework: System Development & Demonstration Phase

- **Purpose of SE during System Integration**
  - Develop a system or increment of capability
  - Emphasis on operational supportability to minimize the logistics footprint
  - Reduce integration and manufacturing risk
  - Implement human systems integration
  - Design for producibility
  - Ensure affordability and protection of critical program information
  - Demonstrate system integration, interoperability, safety, and utility
- **Inputs to the SE Process during System Integration**
  - System performance specification
  - Exit criteria for system integration
  - Validated system support and maintenance objectives and requirements
  - Acquisition Program Baseline (APB)
  - Capability Development Document (CDD)
  - SEP
  - Information support plan
  - Test and Evaluation Master Plan (TEMP)
  - Product Support Strategy (PSS)

System Integration: Key SE Activities

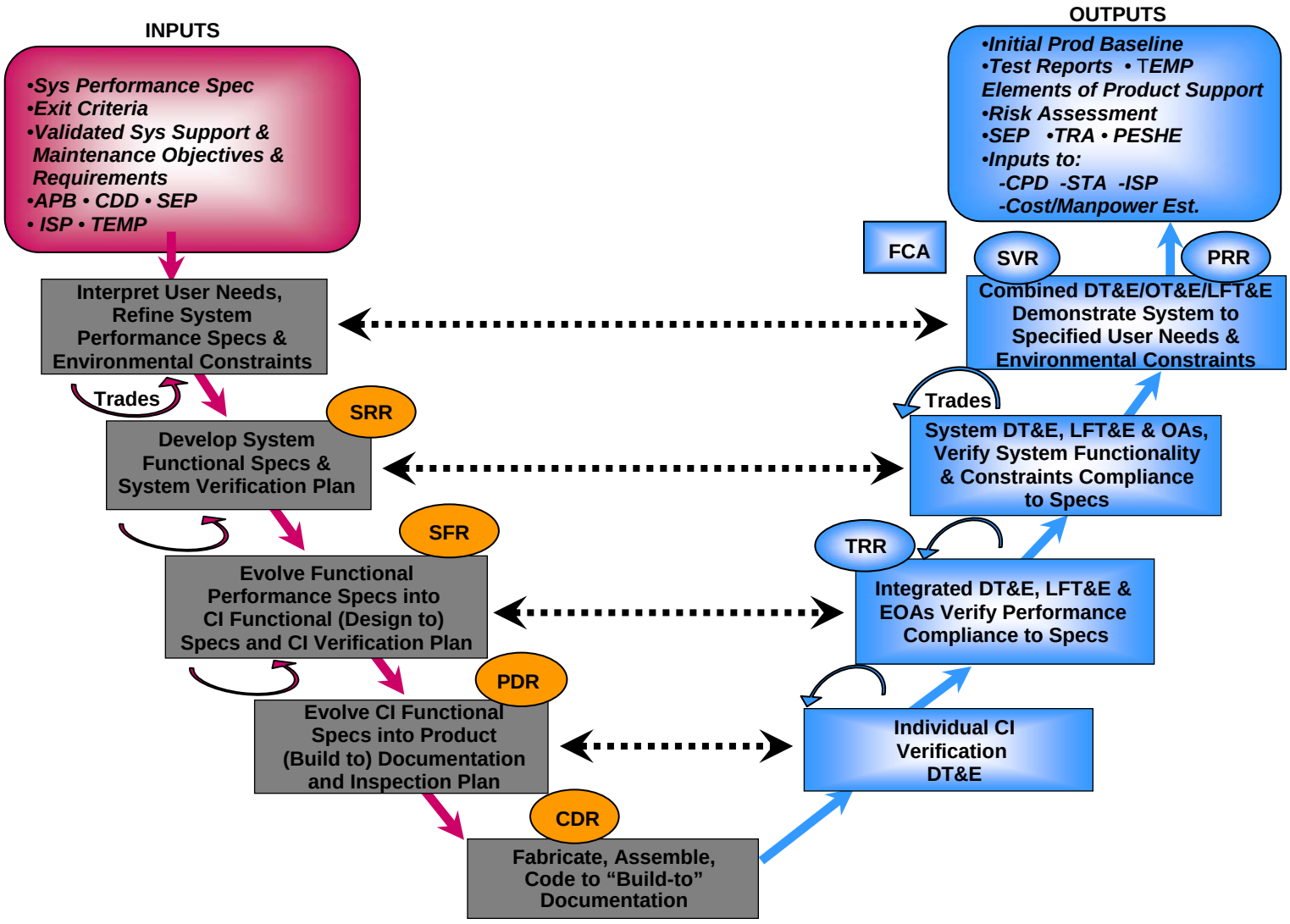


Systems Integration: Key SE Activities



- Determine required system functions based on the CDD, and allocates subsystems to each function – partitioning leads to definition of subsystem interfaces and integration requirements
- Develop plans for subsystem integration, verification, and validation, as well as system verification and validation

Systems Integration: Key SE Activities



System Functional Review (SFR)

- **Purpose and characteristics**
  - **Determine if the functional definition is fully decomposed**
  - **Determine if the Integrated Product Team is prepared to start preliminary design**
  - **Assesses if all performance parameters are fully decomposed into the functional baseline and compliant with the CDD**
- **SFR provides**
  - **An established system functional baseline**
  - **An updated risk assessment for the SDD phase**
  - **An updated Cost Analysis Requirements Description (CARD) or CARD-like document based on the system functional baseline**
  - **An updated program development schedule including system and software critical path drivers**
  - **An approved Product Support Plan (PSP) with updates applicable to this phase**

Preliminary Design Review (PDR)

- **Purpose and characteristics**
  - **Ensure that the system can proceed into detailed design**
  - **Assesses the design as captured in the performance specifications for each configuration item**
  - **Ensures that each functional item of the functional baseline has been allocated to one or more configuration items**
- **PDR provides**
  - **An established system allocated baseline**
  - **An updated risk assessment for SDD**
  - **An updated CARD or CARD-like document based on the system allocated baseline**
  - **An updated program schedule including system and software critical path drivers**
  - **An approved PSP with updates applicable to this phase**

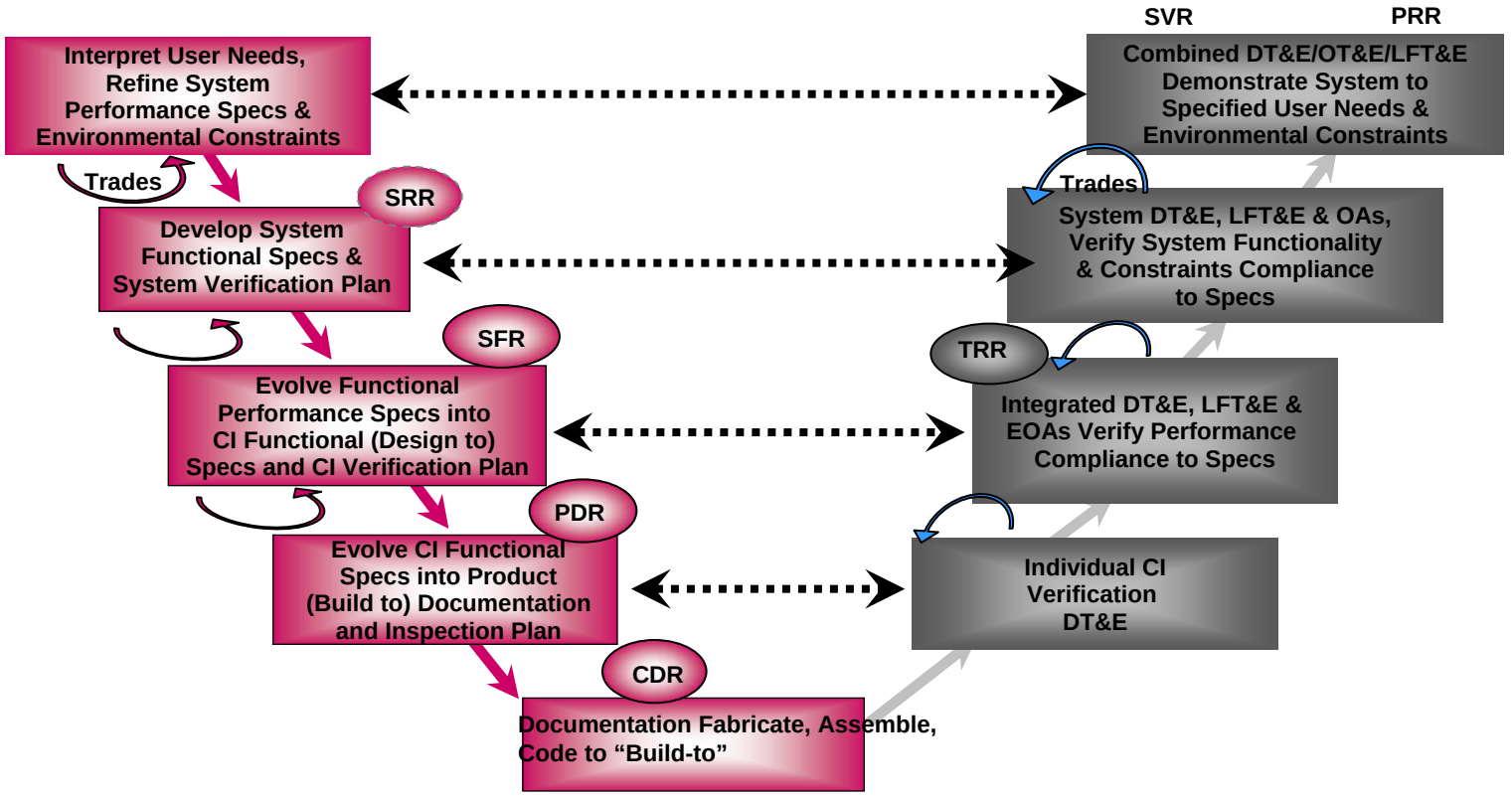
Critical Design Review (CDR)

- **Purpose and Characteristics**
  - **Ensures that the system under review can proceed into fabrication, test and demonstration**
  - **Assess the final design as captured in the product specifications of each configuration item**
    - **Enables fabrication of hardware and coding of software**
  - **For large systems, CDR may be conducted on subsystem or configuration item level**
- **CDR provides**
  - **An established system product baseline**
  - **An updated risk assessment for SDD**
  - **An updated CARD or CARD-like document based on the system product baseline**
  - **An updated program development schedule including fabrication, test, and software coding critical path drivers**
  - **An approved PSP with updates applicable to this phase**

SE Outputs from System Integration

- The number of subsystem and system technical reviews successfully completed
- The percentage of drawings completed
- Planned corrective actions to hardware and software deficiencies
- Adequate development testing
- Assessment of ESOH risks
- Completed FMECA analysis
- Identification of key system characteristics and critical manufacturing processes
- Estimate of system reliability based on demonstrated reliability rates

System Integration: Key System Safety Activities



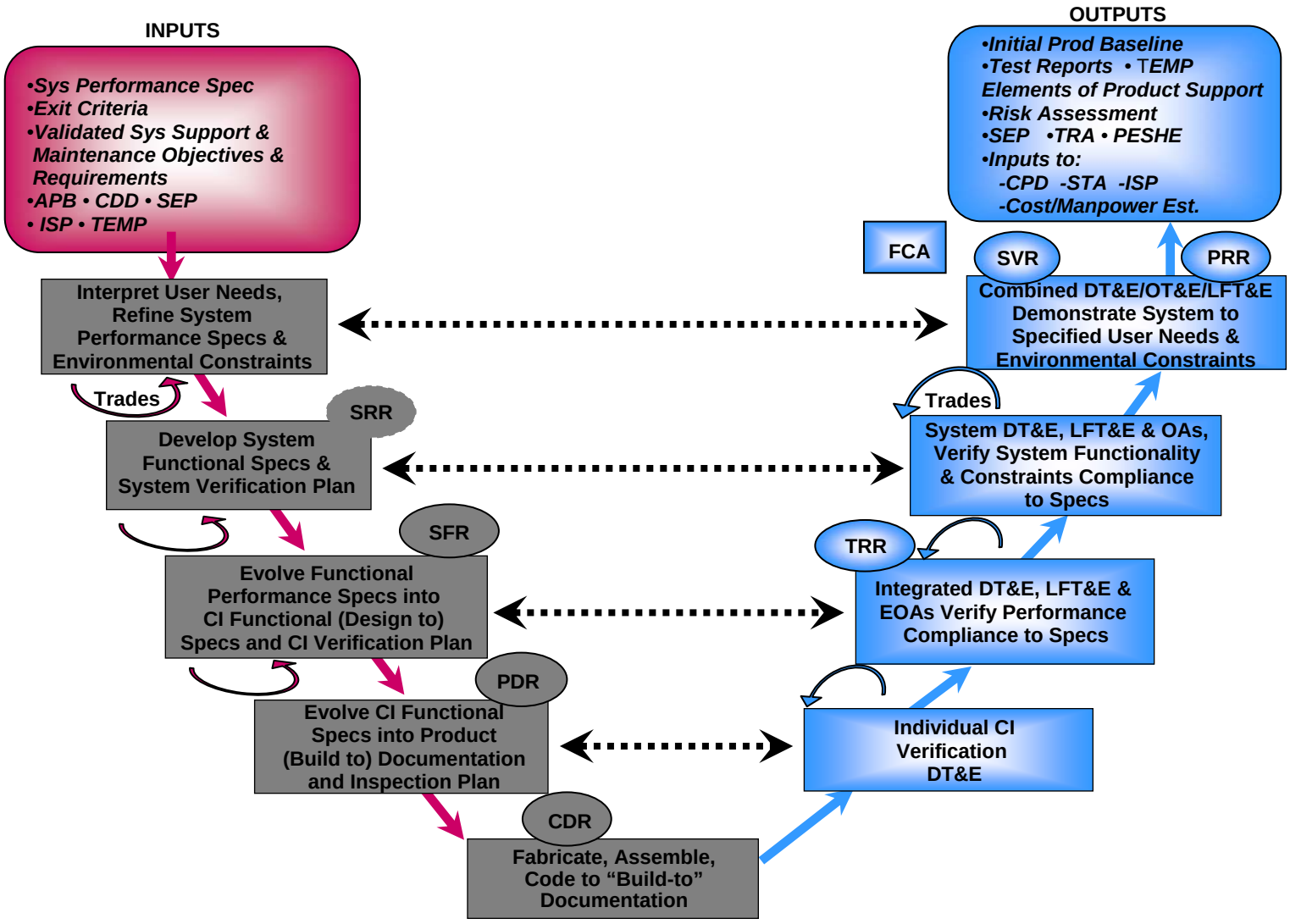
System Integration: Key System Safety Activities

- Include SRCA data
- Require concurrence from applicable safety boards
- Include applicable specs (MIL-STDs)
- Identify hazard mitigation reqt's
- Identify IM reqt's
- Identify mishap reduction reqt's
- Update strategy for integrating ESOH risk management into SE
- Provide guidance on performance feedback and hazard communication
- Identify test reqt's
- Identify requirements for verification of risk mitigation controls
- Identify safety release reqt's, e.g., SAR
- Identify System Safety-critical items and processes
- Identify inspection requirements
- Verify mitigation controls are effective to reduce risk of hazard
- Analyze anomalies, incidents, and mishaps
- Update specific test reqt's
- Provide results of the O&SHA
- Document and report on High and Serious residual risks and risk acceptance
- Document concurrence of applicable safety boards
- Update the mitigation Technology Readiness Levels
- Update hazard database
- Update hazard analyses
- Update preliminary demil/disposal plan

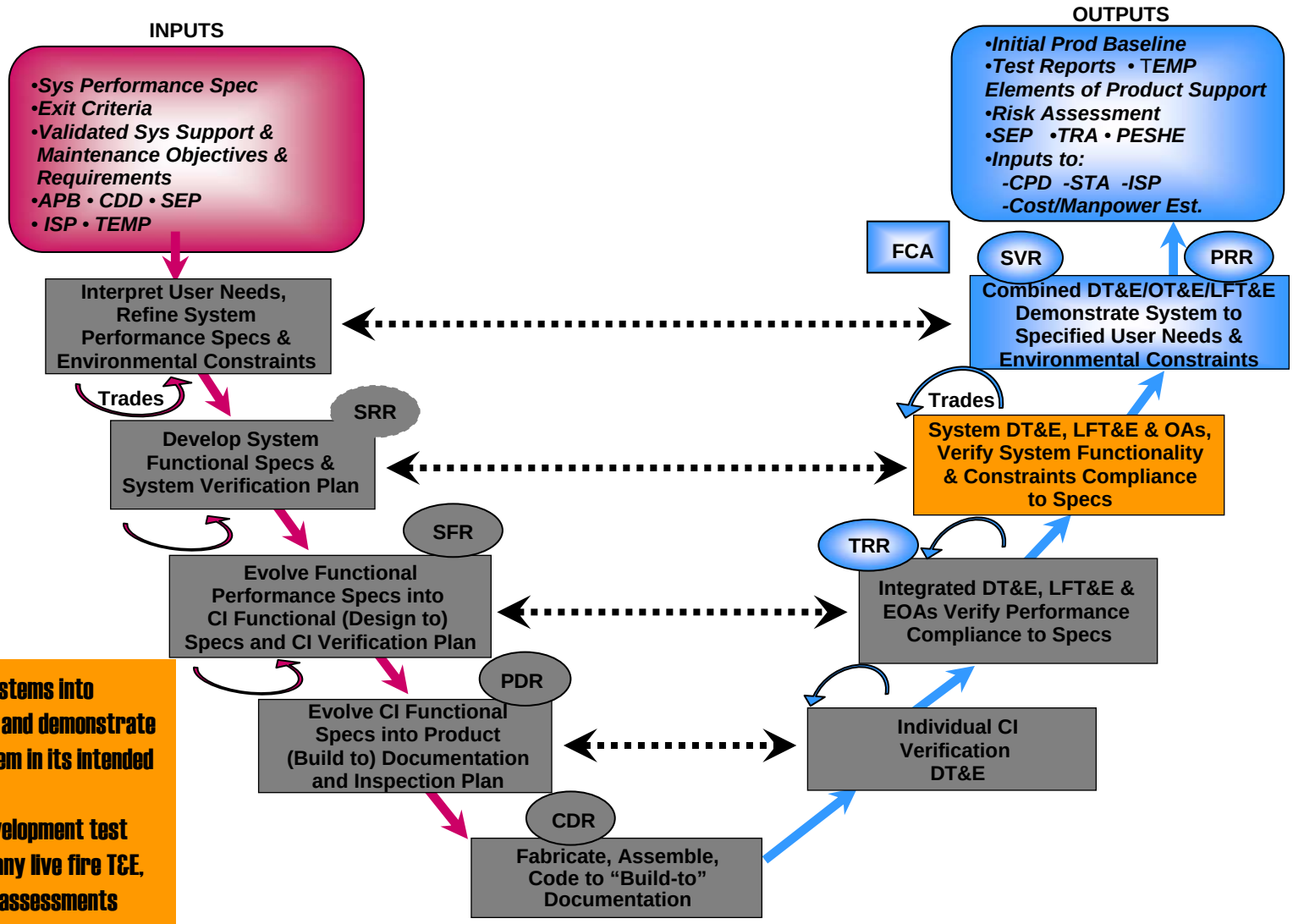
DoD Acquisition Framework: System Development & Demonstration Phase

- **Purpose of SE in System Demonstration**
  - **Successful completion of the CDR and successful demonstration of the system in prototypes or engineering development models end the System Integration work effort**
  - **System Demonstration demonstrates the ability of the system to operate in a useful way consistent with the approved key performance parameters**
    - **A System is demonstrated in its intended environment using selected prototypes**
  - **Key to System Demonstration is acceptable performance in development test and evaluation and early operational assessments, and the use of modeling and simulation to support test design and the demonstration of satisfactory system integration**
- **Inputs to the SE Process in System Demonstration**
  - **Results from the CDR**
  - **The Capability Production Document (CPD), finalized after the CDR**

System Demonstration: Key SE Activities

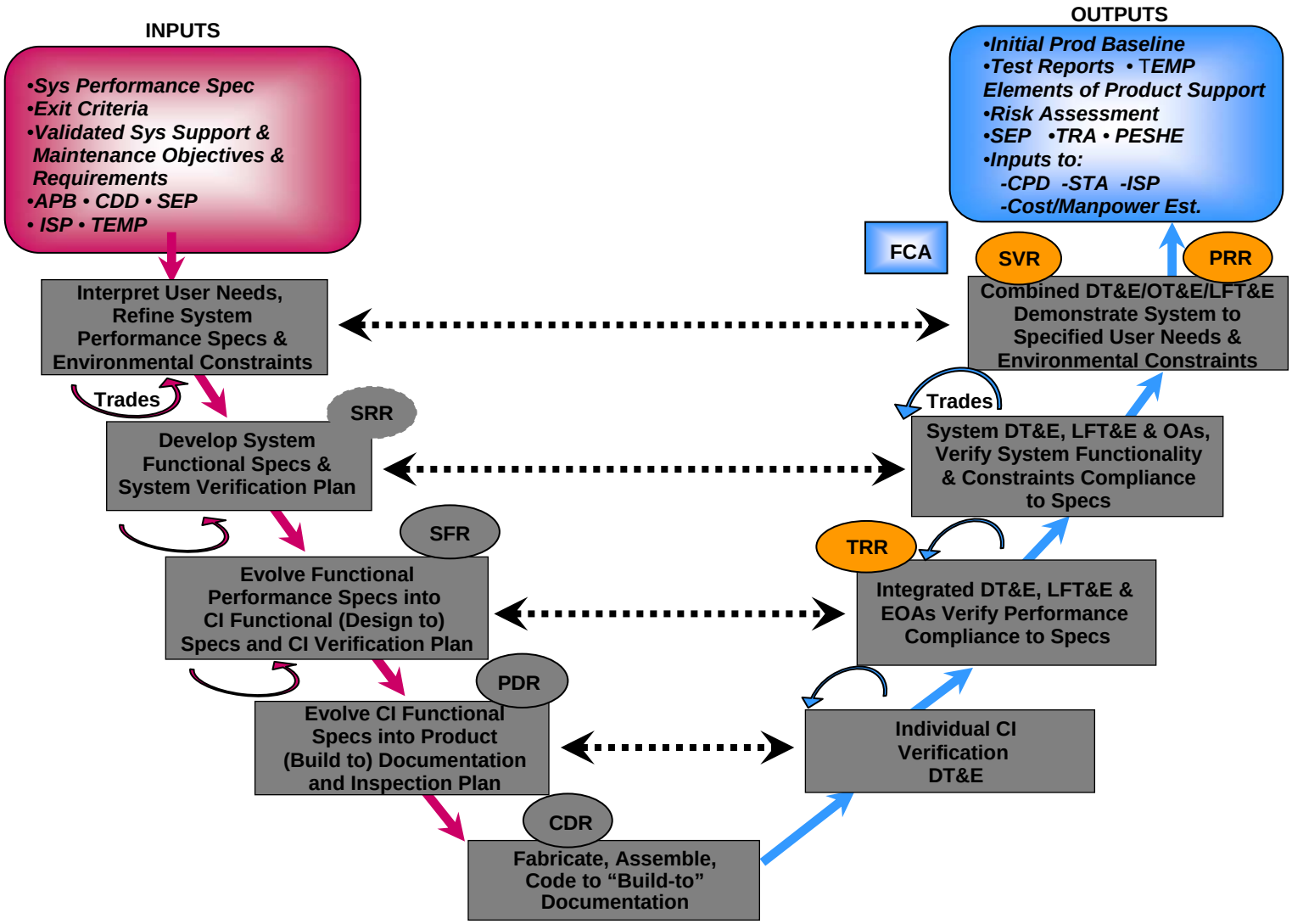


System Demonstration: Key SE Activities



- Integrate subsystems into defined system, and demonstrate integrated system in its intended environment
- Includes any development test and evaluation, any live fire T&E, and operational assessments
- All integration and interface issues must be resolved

System Demonstration: Key SE Activities



Test Readiness Review (TRR)

- **Purpose and characteristics**
  - **Ensures proper technical maturity to initiate formal system-level Developmental Tests**
  - **Assesses test objectives, methods, procedures, scope, resources as well as traceability to requirements and operational needs**
  - **Readiness to convene determined by program manager and test & evaluation IPT based on preliminary testing**
- **TRR provides**
  - **Completed and approved test plans for the system under test;**
  - **Completed identification and coordination of required test resources**
  - **The judgment that previous component, subsystem, and system test results form a satisfactory basis for proceeding into planned tests**
  - **Identified risk level acceptable to the program leadership**

System Verification Review (SVR)

- **Purpose and characteristics**
  - **Ensure that the system under review has the maturity and quality to proceed into production within the program objectives**
  - **Verifies and establishes final product performance**
  - **Constitutes an audit trail from CDR**
  - **Provides inputs to the CPD**

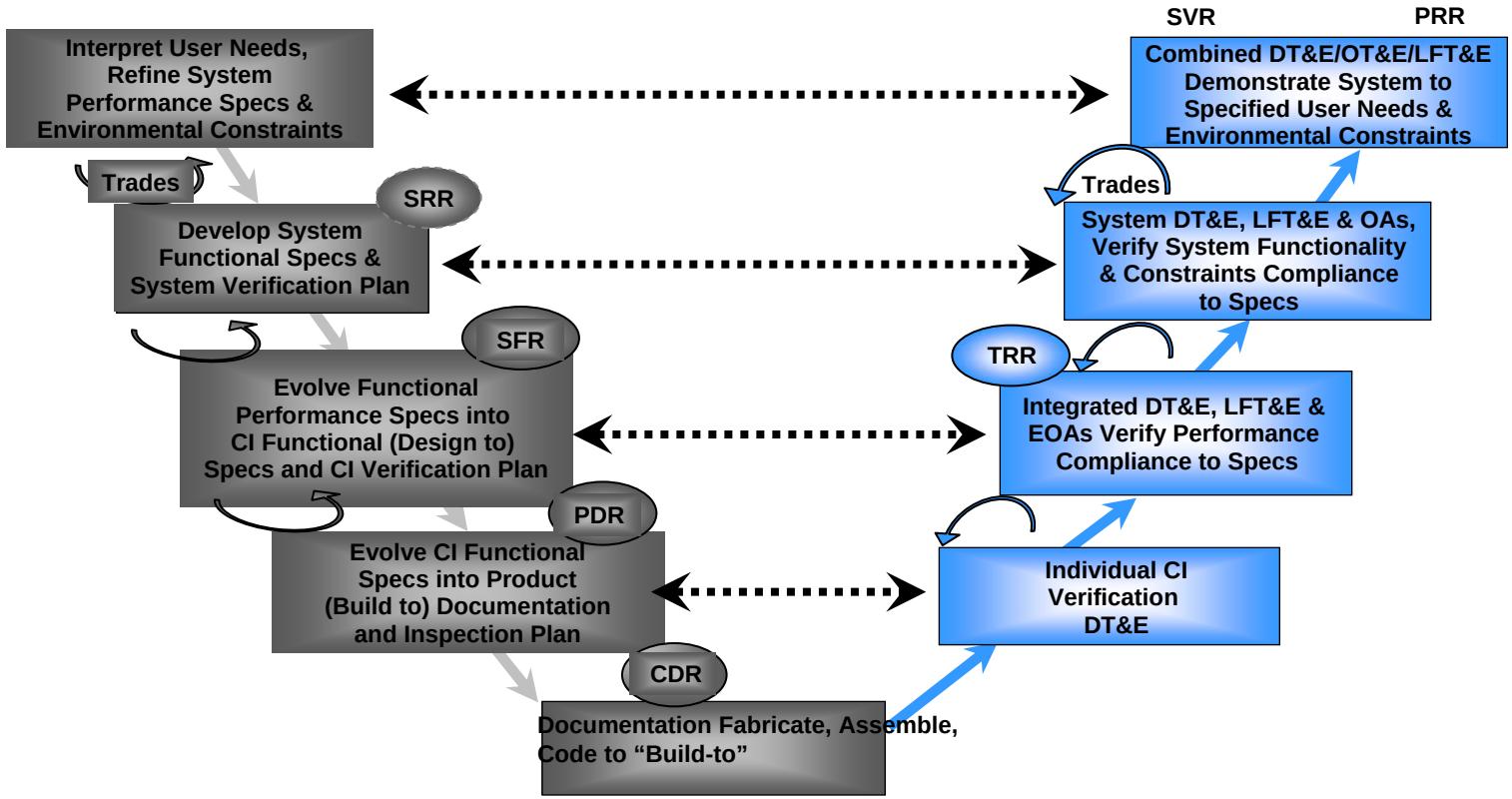
Production Readiness Review (PRR)

- **Purpose and characteristics**
  - **Ensures that the system and enabling systems are ready for production**
  - **Evaluates the full, production-configured system to ensure that all system requirements are implemented**
  - **Evaluates manufacturing processes, quality management system and the complete manufacturing system (facilities, tools....)**
  - **PRR should be conducted in a iterative fashion throughout SDD and include prime and major sub contractors as needed**
  - **“Final” PRR occurs at completion of SDD and should assess manufacturing and quality risks as the program proceeds into Initial and full scale production**

SE Outputs from System Demonstration

- Initial Product Baseline
- Test Reports
- TEMP
- Elements of Product Support
- Risk Assessment
- SEP
- Technology Readiness Assessment
- PESHE
- Inputs to
  - CPD
  - System Threat Assessment
  - Information Support Plan, and
  - Cost and Manpower Estimate

System Demonstration: Key System Safety Activities

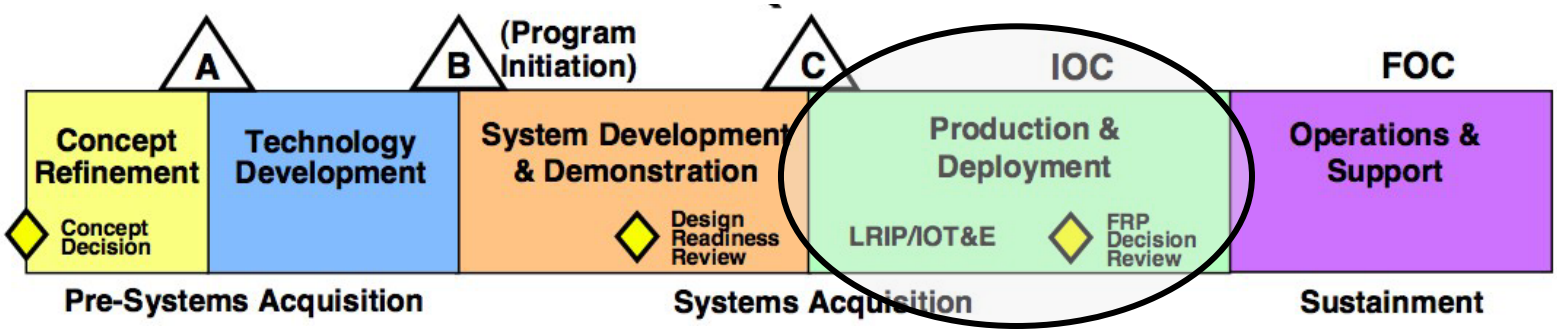


System Demonstration: Key System Safety Activities

- Inputs
  - System Performance Spec
  - Validated Sys Support & Maintenance Obj & Reqt's
  - Acquisition Program Baseline
  - CDD
  - SEP
  - Integrated Support Plan
  - TEMP
- Outputs
  - Initial Production Baseline
  - Test reports
  - TEMP
  - Elements of Product Support
  - Risk assessment
  - SEP
  - TRA
  - PESHE
- Exit Criteria
  - Document formal risk disposition of identified hazards, e.g.. SAR
  - Obtain concurrence from appropriate safety boards
  - Update PESHE

Questions?

DoD Acquisition Framework: Production and Deployment Phase

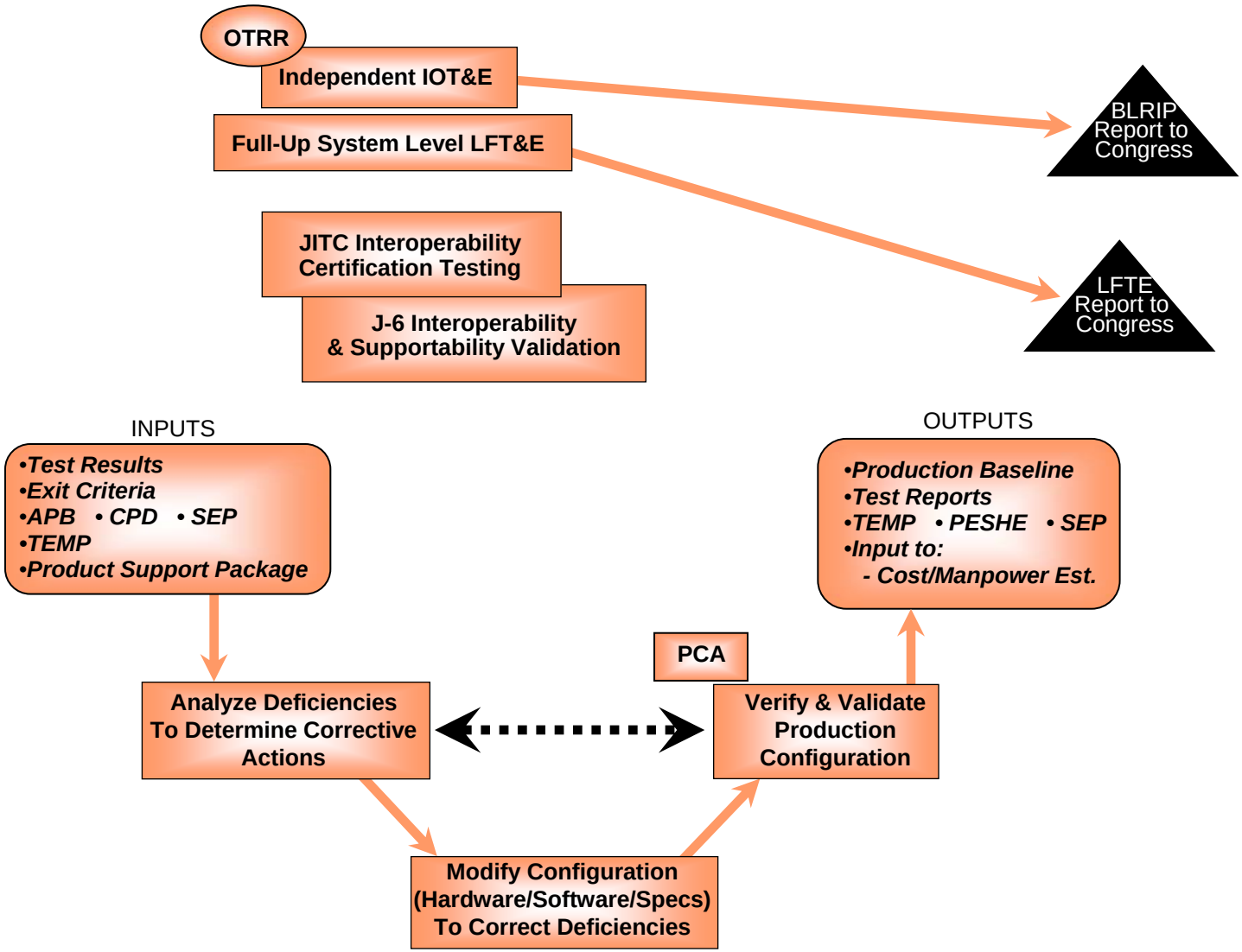


- This phase commences at Milestone C, and encompasses Operations and Support.
- Two work efforts, separated by the Full Rate Production Decision Review, comprise the Production and Deployment Phase
  - Low Rate Initial Production (LRIP)
  - Full Rate Production and Deployment

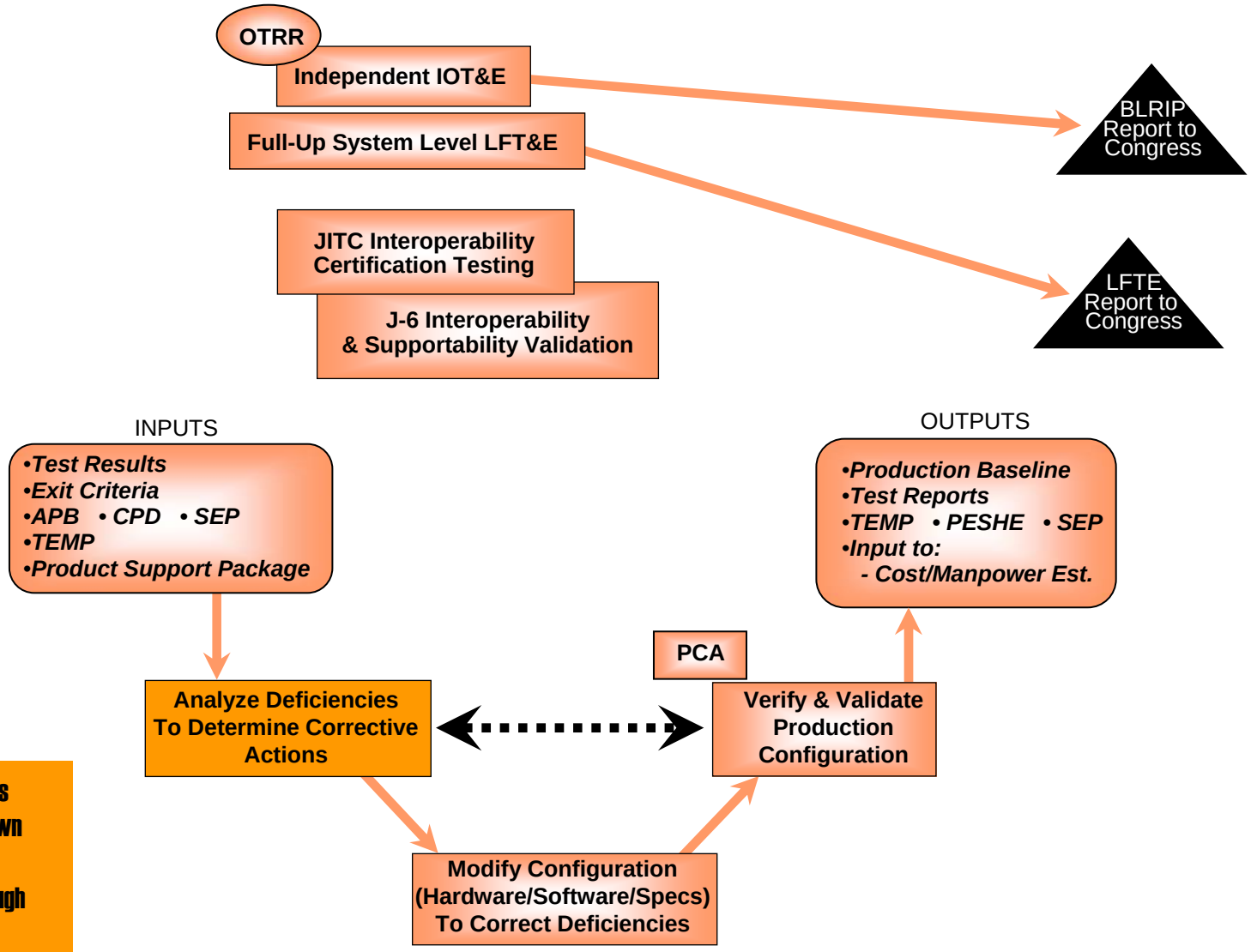
DoD Acquisition Framework: Production and Deployment Phase

- **Purpose of SE in this Phase**
  - **As the integrated components develop into a system, the test and evaluation processes can reveal issues that must be resolved through redesign or improvements**
  - **LRIP should result in completion of manufacturing development**
  - **During Full-Rate Production and Deployment, SE delivers the full funded quantity of systems and supporting materials and services for the program or increment**
  - **During this effort, units attain Initial Operational Capability (IOC)**
- **Inputs to the SE Process in this Phase**
  - **Test results**
  - **Exit criteria to leave production and deployment**
  - **APB**
  - **CDD and CPD**
  - **SEP**
  - **TEMP**
  - **PSP**

Production and Deployment Phase: Key SE Activities

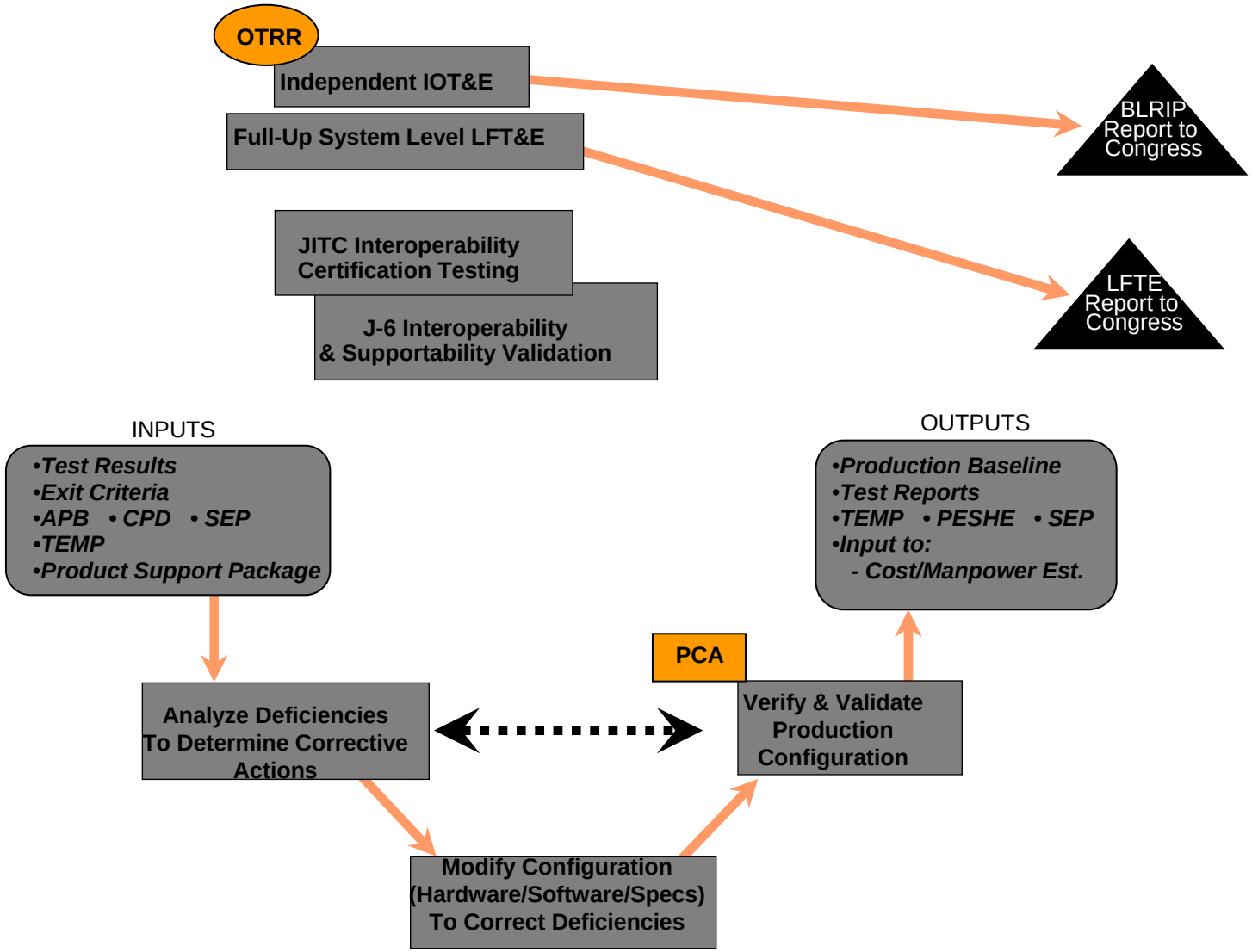


Production and Deployment Phase: Key SE Activities



- Consolidate all input into this phase, and analyze any known deficiencies
- A solution is proposed through use of systems engineering
- A plan to build/modify/verify and test the proposed solution is formulated and approved

Production and Deployment Phase: Key SE Activities



Technical Reviews (OTRR and PCA)

- **Operational Test Readiness Review (OTRR)**
  - An additional TRR may be conducted around MS C
  - Determines if the system can proceed into operational test & evaluation with a high probability of successfully completing the operational testing
  - May be determinant for the decision to enter full-rate production
  - OTRR is complete when Service Acquisition Executive evaluates and determines material readiness for IOT&E
- **Physical Configuration Audit (PCA)**
  - Conducted around the full rate production decision
  - Examines actual configuration of produced items
  - Ensures compliance with specifications and contracts
  - Verifies the manufacturing system
  - Validates supporting processes
  - A PCA is normally conducted when the government plans to control item detail design being acquired via the Technical Data Package. When the government does not plan to exercise such control, the contractor should conduct an internal PCA
  - PCA is complete when the design and manufacturing documentation match the item as specified in the contract

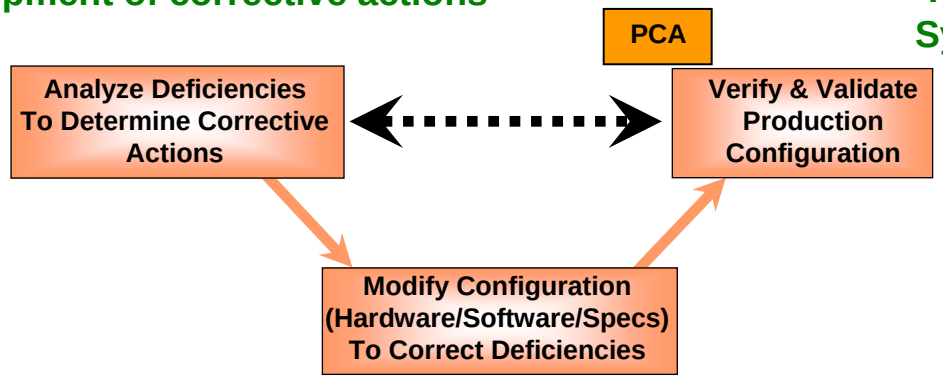
SE Outputs from Production and Deployment

- Production Baseline
- Test Reports
- TEMP
- PESHE
- NEPA Compliance Schedule (As required)
- SEP
- Inputs to Cost and Manpower Estimate

Production and Deployment Phase: Key System Safety Activities

- Review deficiency reports
- Participate in development of corrective actions
- Participate in CCB

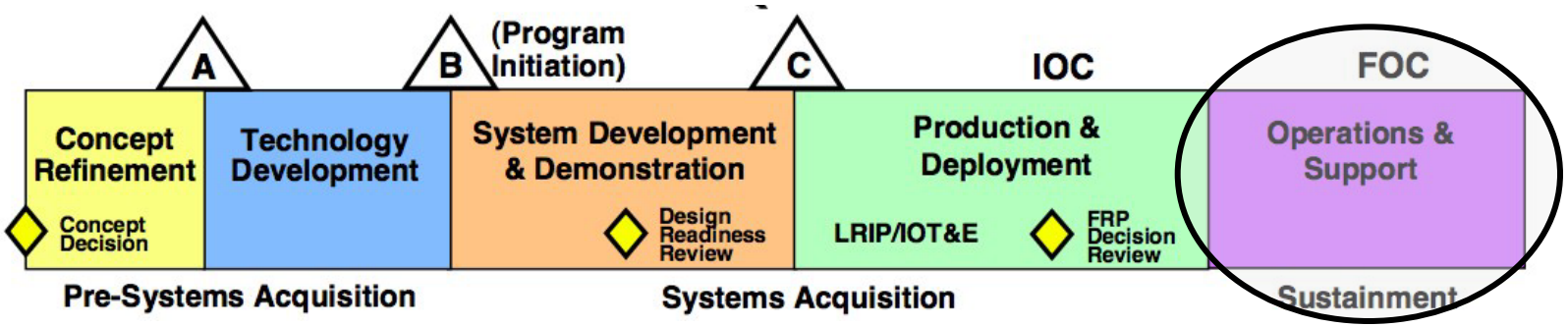
- Verify and validate System Safety item configuration
- Review PCA to identify potential System Safety implications



- Identify System Safety-critical items
- Review and recommend updates to TEMP

Questions?

DoD Acquisition Framework: Operations and Support Phase

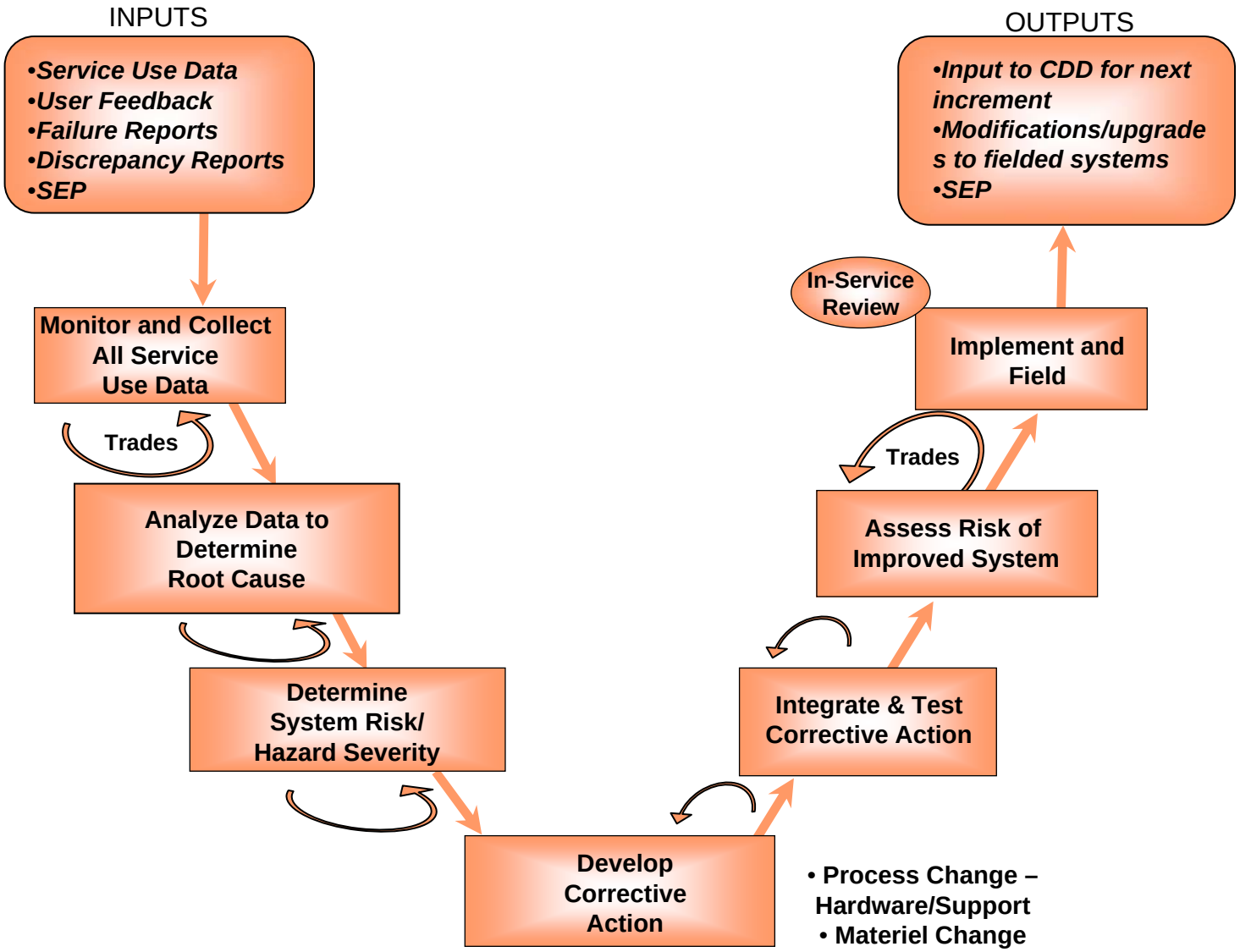


- The objective of this phase is the execution of a support program that meets operational support performance requirements and sustains the system in the most cost effective manner over its life cycle
- Two work efforts, Sustainment and Disposal, comprise this phase

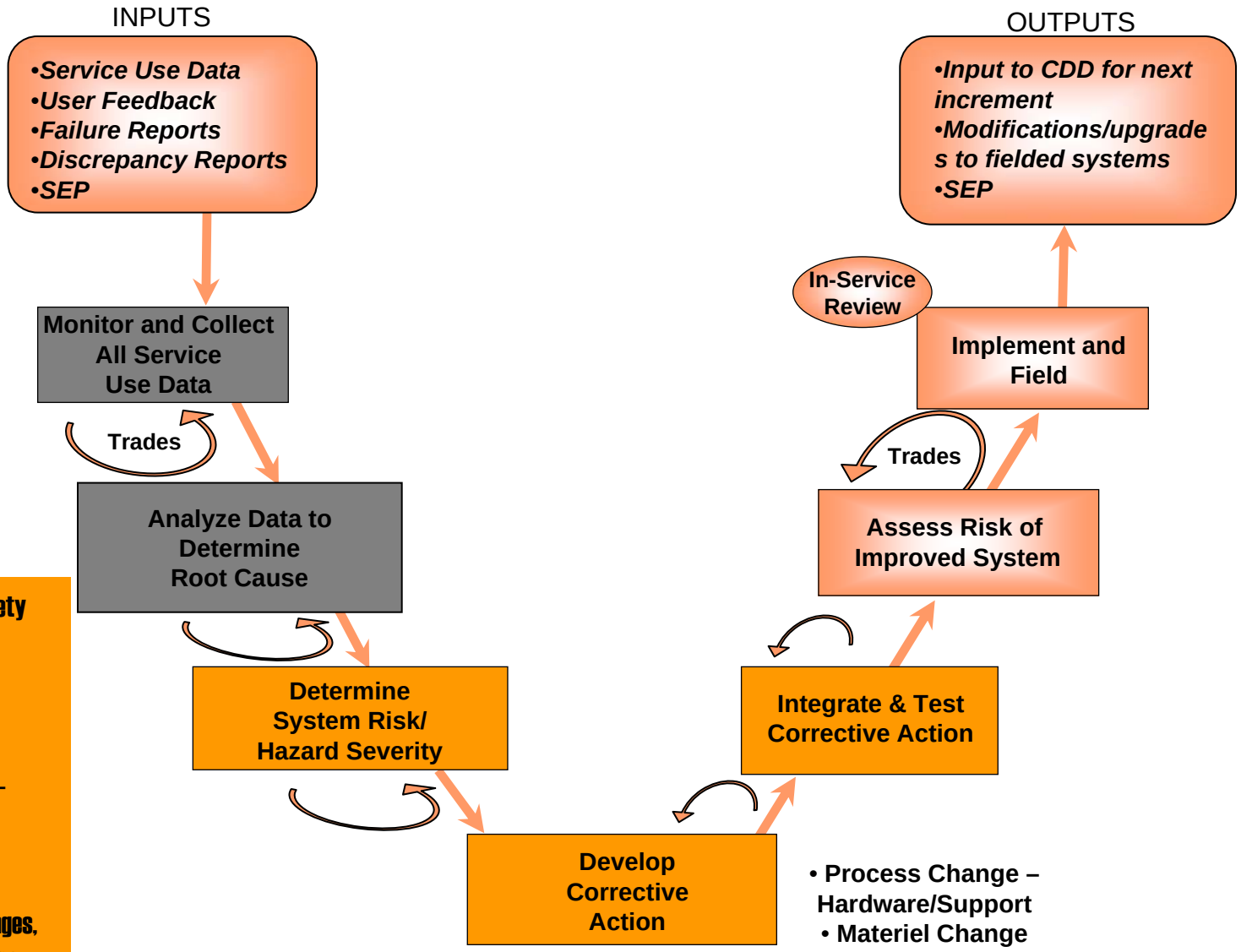
DoD Acquisition Framework: Operations and Support Phase

- **Purpose of SE in this Phase**
  - **Support in service reviews, trade studies, and decision making on modifications, upgrades, and future increments of the system**
  - **SE processes that lead to disposal requirements and considerations impact the "disposal" aspect of this phase**
- **Inputs to the SE Process in this Phase**
  - **Service use data**
  - **User feedback**
  - **Failure reports**
  - **Discrepancy reports, and**
  - **SEP**

Operations and Support Phase: Key SE Activities

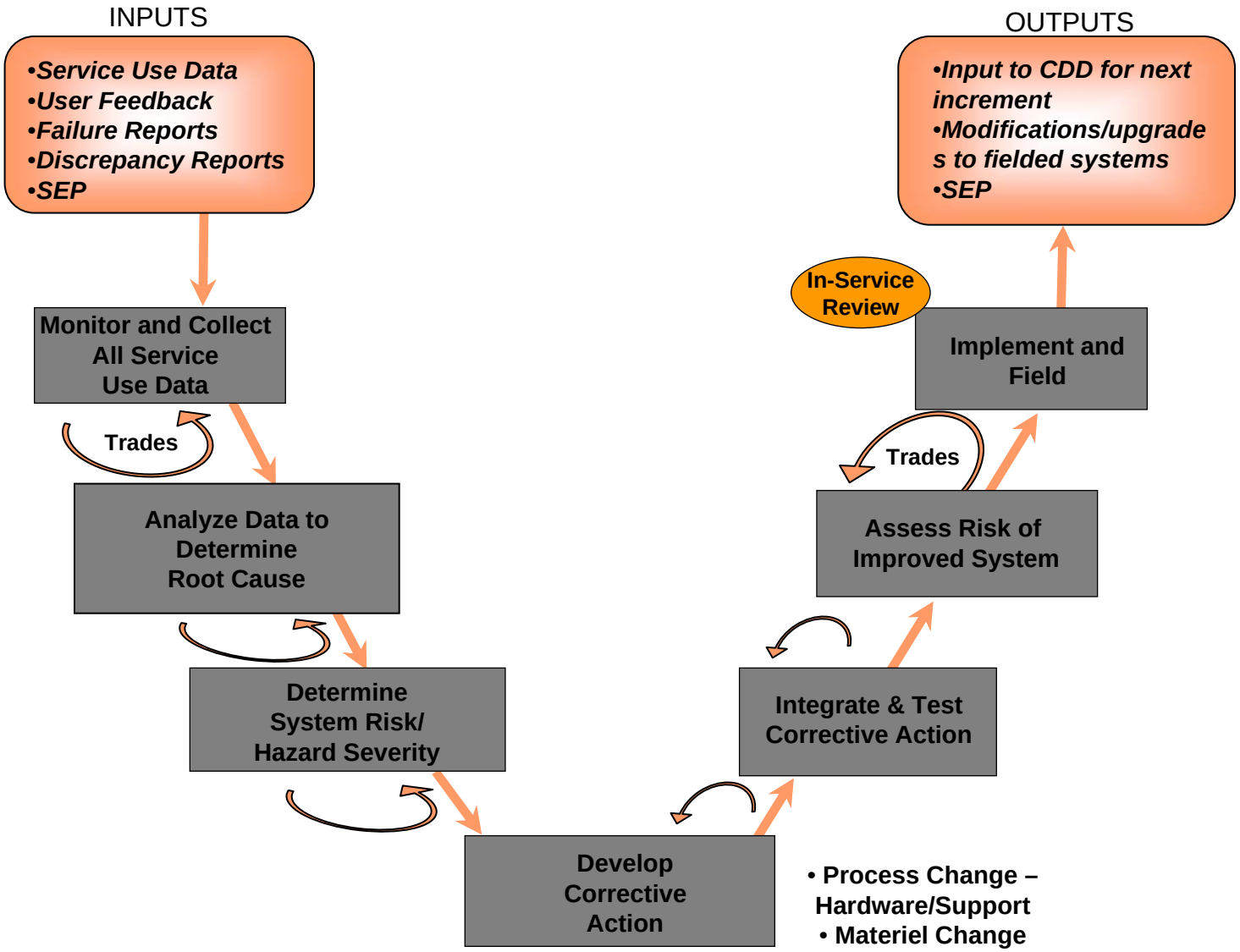


Operations and Support Phase: Key SE Activities



- Determine any HW/SW safety hazards, and identify risks associated with identified deficiencies.
- Develop corrective action – changes to the product or related processes.
- Integrated correction changes, and test resultant prototype – adequate testing should ensure suitability of improvements

Operations and Support Phase: Key SE Activities



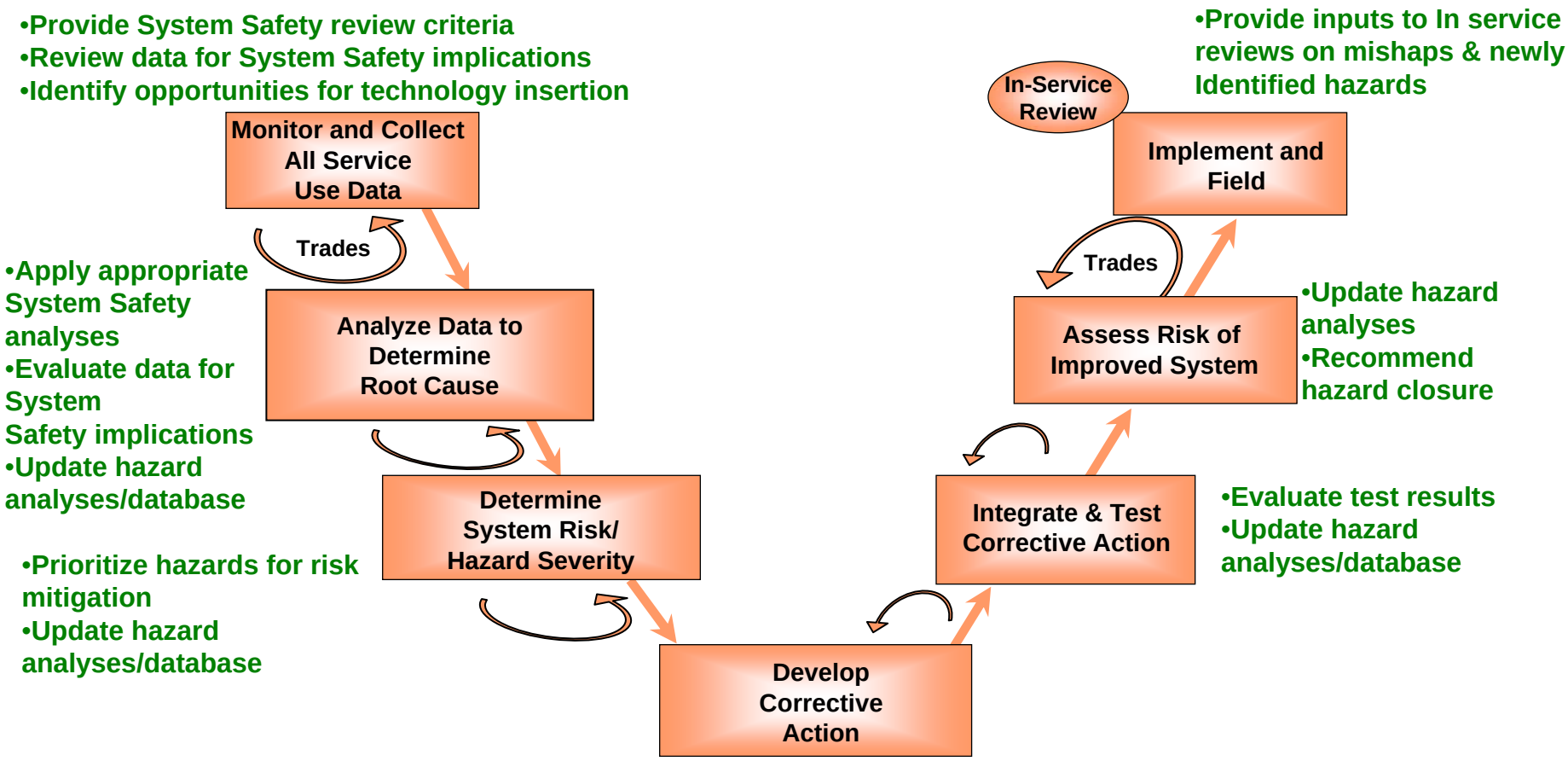
In-Service Review (ISR)

- **Purpose and characteristics**
  - **Ensure that the system under review is operationally employed with well understood and managed risk**
  - **Assesses in-service health, operational risk, readiness and future support requirements**
  - **Substantiates in in-service support budget priorities**
- **ISR provides**
  - **An overall System Hazard Risk Assessment;**
  - **An operational readiness assessment in terms of system problems (hardware, software, and production discrepancies)**
  - **Status of current system problem (discrepancy) report inflow, resolution rate, trends, and updated metrics**
  - **The metrics may be used to prioritize budget requirements**

SE Outputs from Operations and Support

- Input to CDD for next system increment
- Modifications and upgrades to fielded systems
- PESHE
- NEPA Compliance Schedule (as required)
- SEP

Operations Support Phase: Key System Safety Activities



SE Summary

- Overview
- DoD Policy
- Implementation Considerations
- Design Considerations
- DoD Acquisition Framework and “Vee” Model
- SE Across the Life Cycle