Applying the Systems Engineering Method for the Joint Capabilities Integration and Development System (JCIDS)

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The Johns Hopkins University
APPLIED PHYSICS LABORATORY

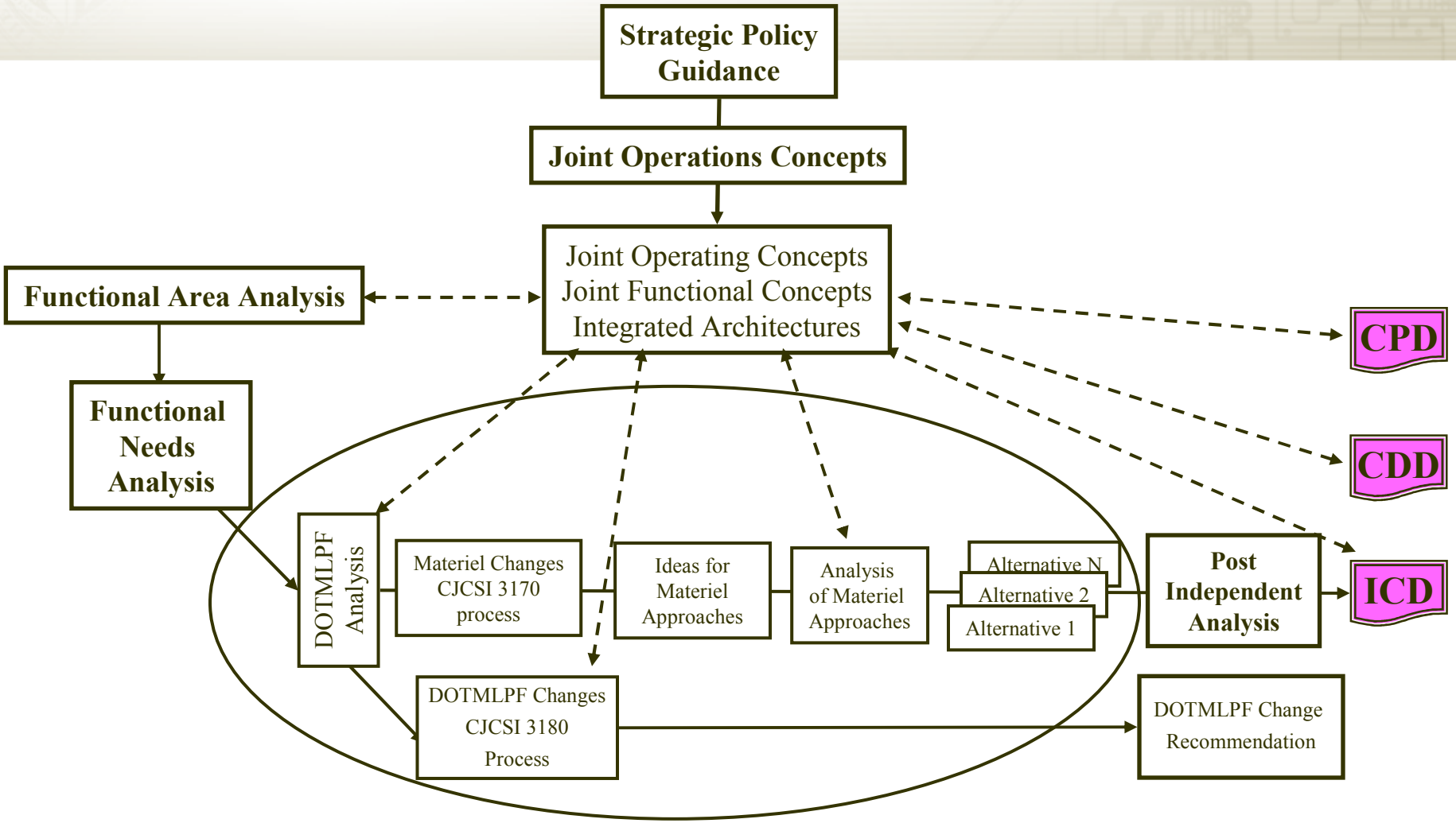
Purpose

- JCIDS prescribes a joint forces approach to identify capability gaps against current force capability needs
- The Systems Engineering (SE) Method applies to each iteration of the systems life-cycle from capability inception through system retirement
- Good systems engineering practice is necessary for successfully implementing JCIDS
- Use of model-driven SE facilitates JCIDS throughout the systems life-cycle

Agenda

- The Joint Capabilities Integration and Development System (JCIDS)
- The Systems Engineering Method
- Model-Driven Systems Engineering for JCIDS
- Why use the Systems Engineering Method JCIDS?

JCIDS Analysis



Functional Solution Analysis

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JCIDS Events

- Functional Area Analysis (FAA)
  - Identify operational task, conditions, and standards needed to accomplish military objectives
  - **Result:** Tasks to be accomplished
- Functional Needs Analysis (FNA)
  - Assess ability of current and programmed capabilities to accomplish the tasks
  - **Result:** List of capability gaps
- Functional Solutions Analysis (FSA)
  - Operational based assessment of DOTMLPF approaches to solving capability gaps
  - **Result:** Potential DOTMLPF approaches to capability gaps
- Post Independent Analysis
  - Independent analysis of approaches to determine best fit
  - **Result:** Initial Capabilities Document

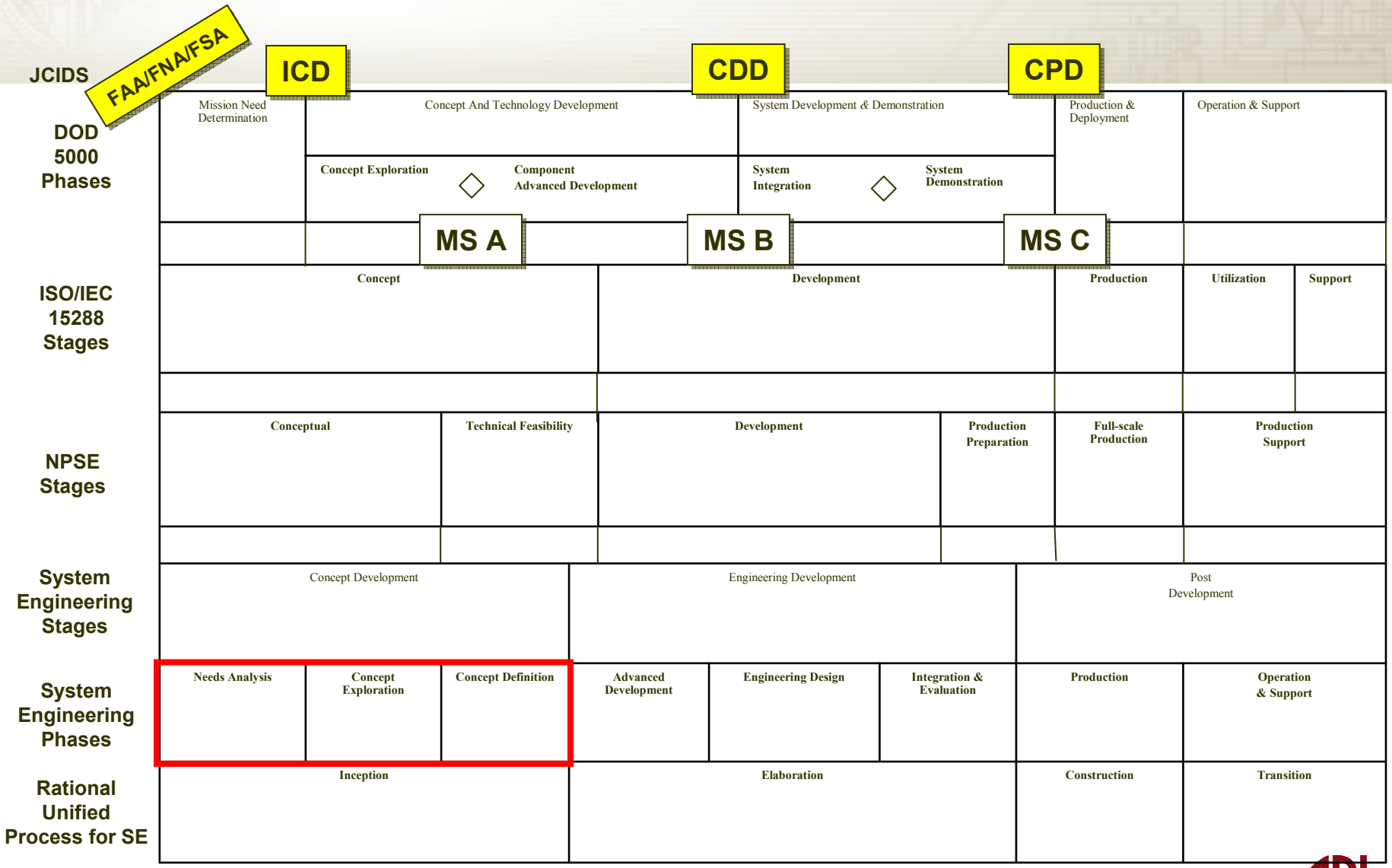
JCIDS

- JCIDS analytical process stresses the fundamentals for applying an effective systems engineering program by any accepted standard
- It guides the "front-end" phases of the SE process for each capability iteration
  - Enterprise (operational) analysis
  - Requirements definition
  - Life-cycle phase
- The analysts must have a thorough understanding of existing capabilities as well as the capability needs
- The JCIDS analysis team eventually determines the optimum combination of material and non-material alternatives to achieve the capability needs to the Battle Force

Systems Engineering Method

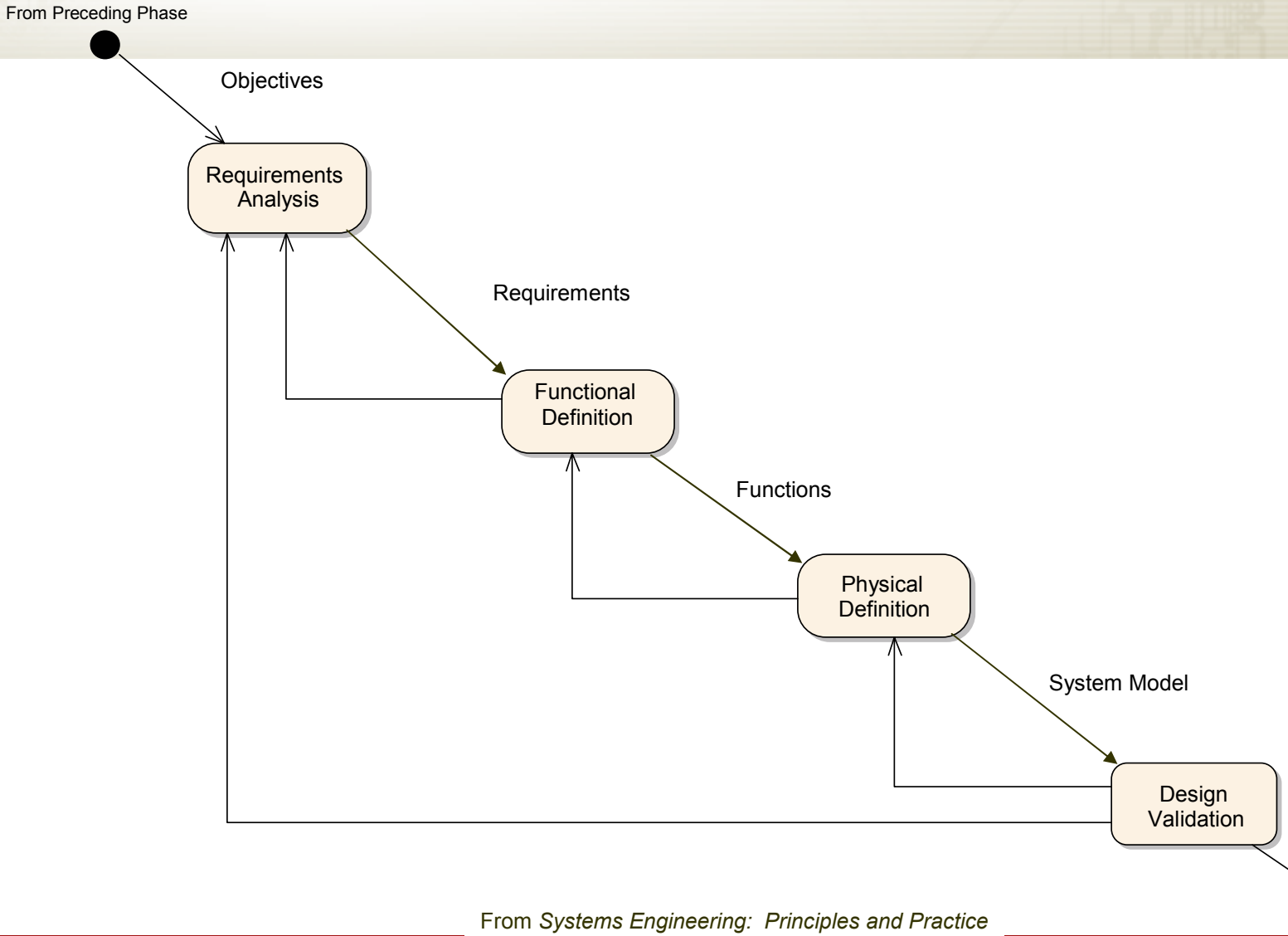
- Regardless of the analytical phase performed by the JCIDS SE team,
  - The basic application of the SE method is constant throughout the process
- Each SE Method activity is performed in some form in each phase of the system life-cycle

Systems Engineering Method Over Life Cycle



From *Systems Engineering: Principles and Practice*
Kossiakoff and Sweet

The Systems Engineering Method



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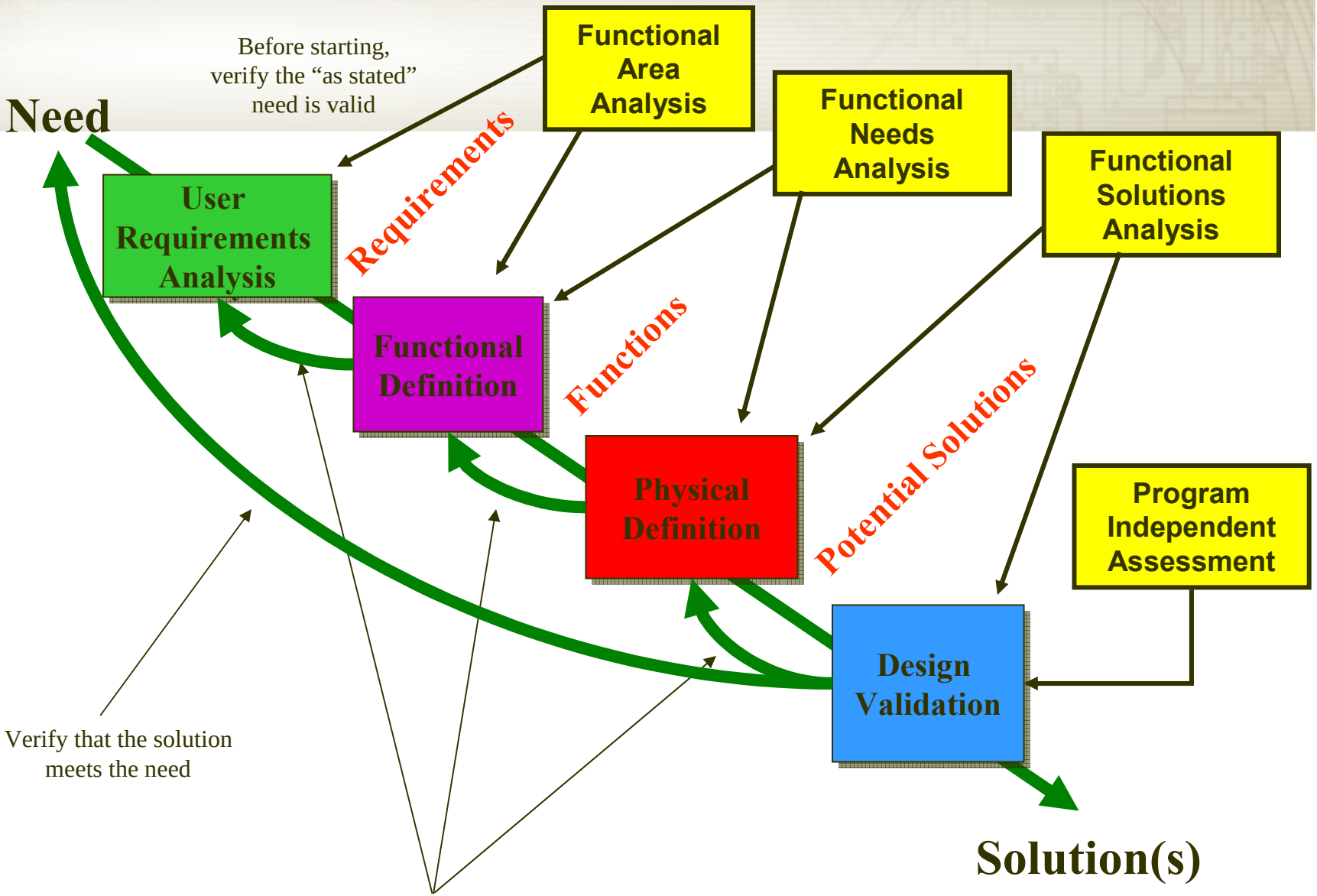
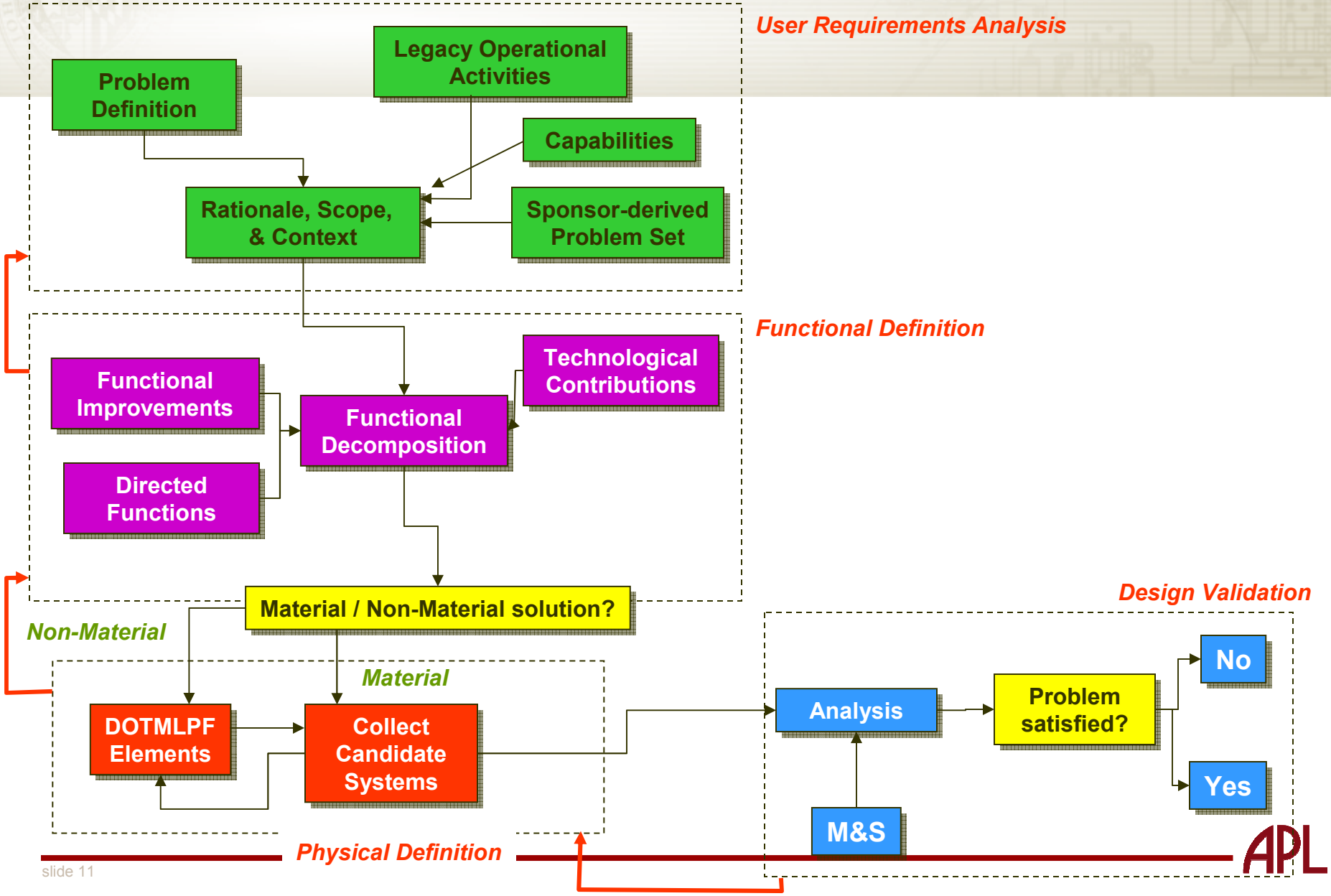
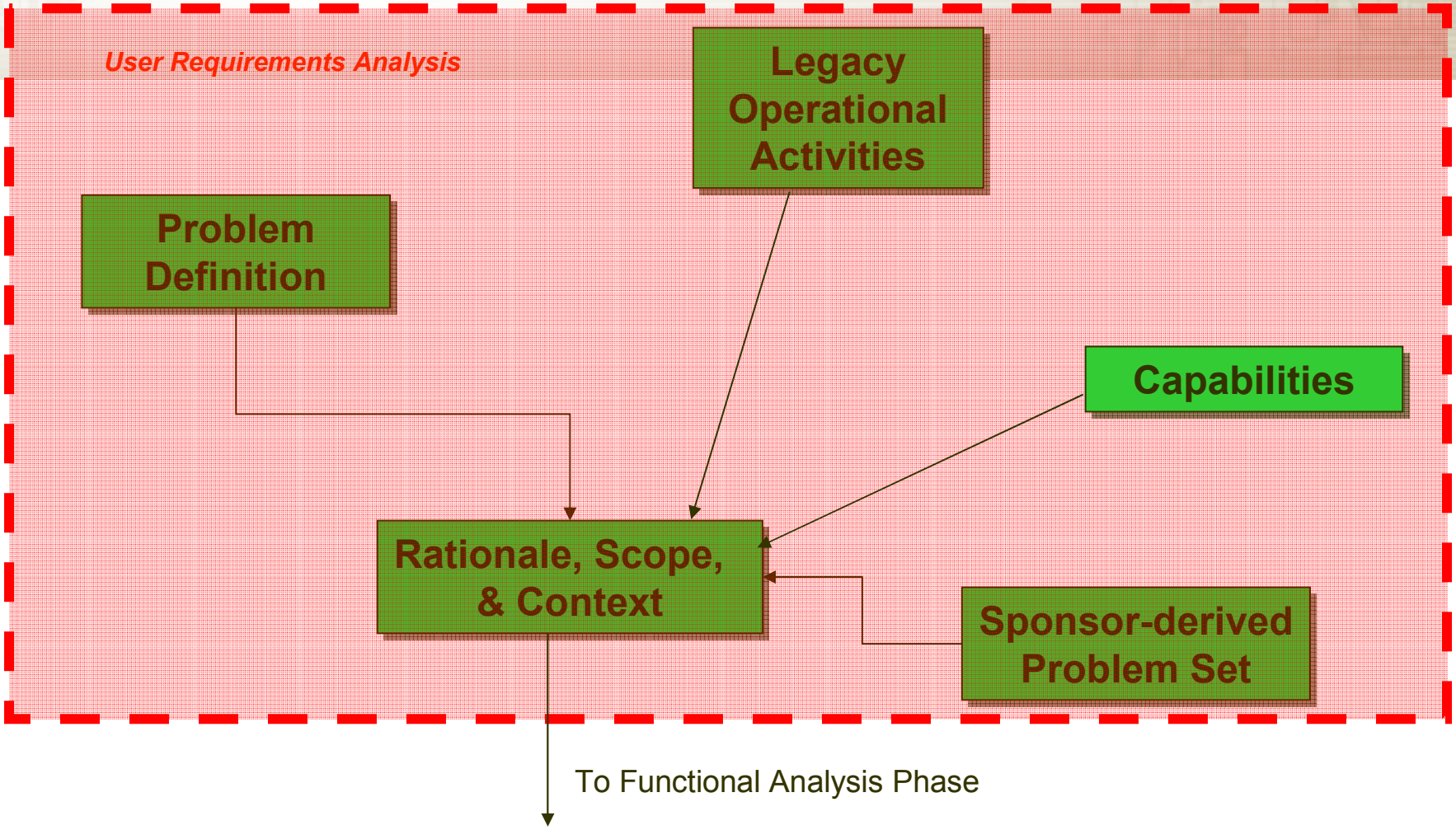
Systems Engineering Method



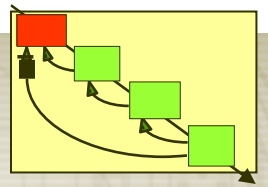
Systems Engineering Method



Systems Engineering Method

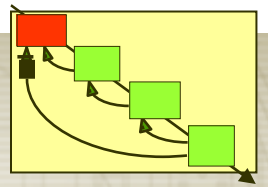


Problem Definition



- At one point in time there is a problem that must be solved due to:
  - Deficient capability with existing systems
  - Desire to improve existing performance
- Need to understand what the objectives are to provide the desired capability
- Define the operational context within the Capability Enterprise!

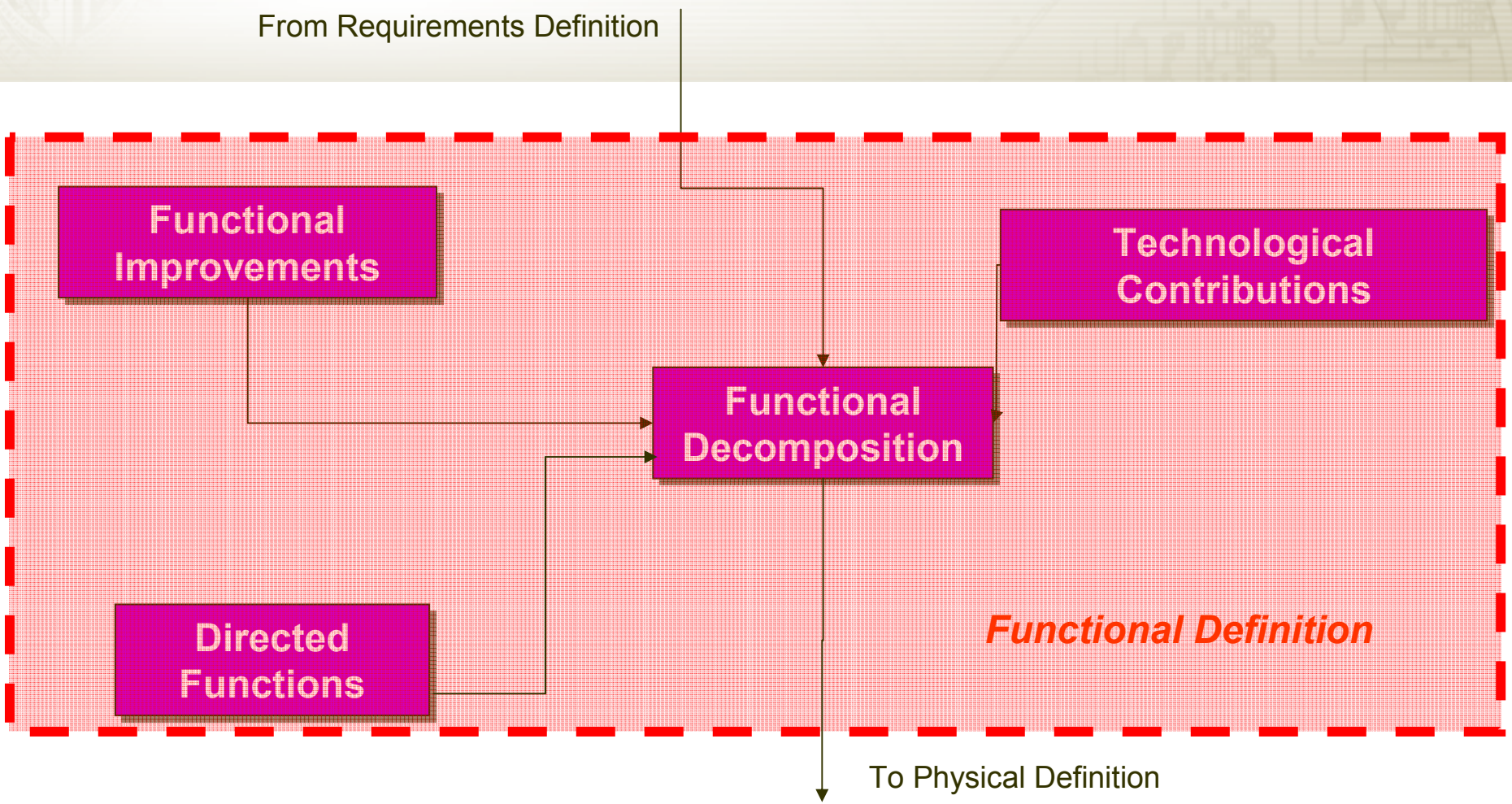
Requirements Analysis Products



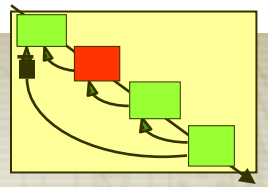
- A clear definition of the problem
- A proper scope of the problem
- Operational context documents and data bases
  - Design Reference Mission
  - Strategy-to-Task Mapping
  - Concept of Operations
  - Physical Environment Database
  - Threat Representation Database
  - Blue Capabilities Database
- Relevant Operational Views

Captured within a SE Requirements Model

Systems Engineering Method



Functional Definition Products



- Functional Decomposition of required activities
  - Functional diagrams (FFBD, UML AD)
- Associated metrics with these functions (threshold / objective?)
- Analysis process that determines if you can solve with a material / non-material / both solution
  - Be able to document and defend this process
- How do we know it's right?
  - The functions are legitimate, correct, and validated by users
- Functional Area Analysis
- Relevant operational views

Functional Analysis Documented in a SE Functional or Logical Model

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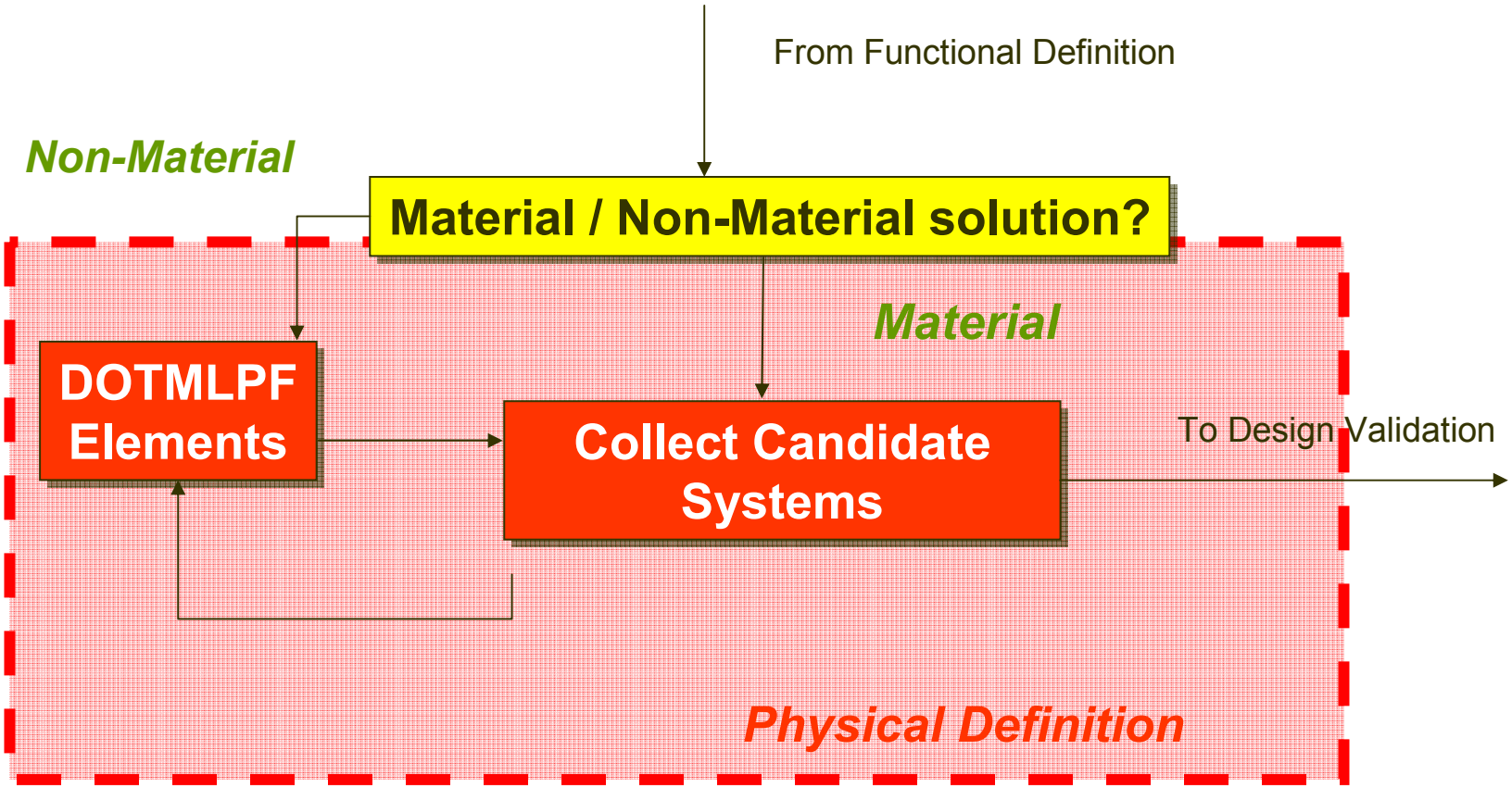
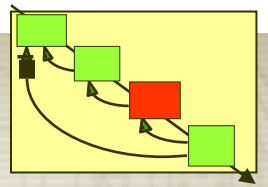
Systems Engineering Method



Physical Definition Products



- Provide system alternatives towards satisfying required functionality
  - Assignment of functions to physical elements
- DOTMLPF analysis products
  - Based on the functional definition phase
- CONOPS changes / recommendations
  - Based on DOTMLPF analysis
- Risk management strategies of the system
- System roadmaps to bridge the gap between the current and future capabilities
- Functional Needs Analysis
- Relevant operational and SYSTEMS views

SE Logical Model with Physical Definition Begins Evolution Toward a Systems Model

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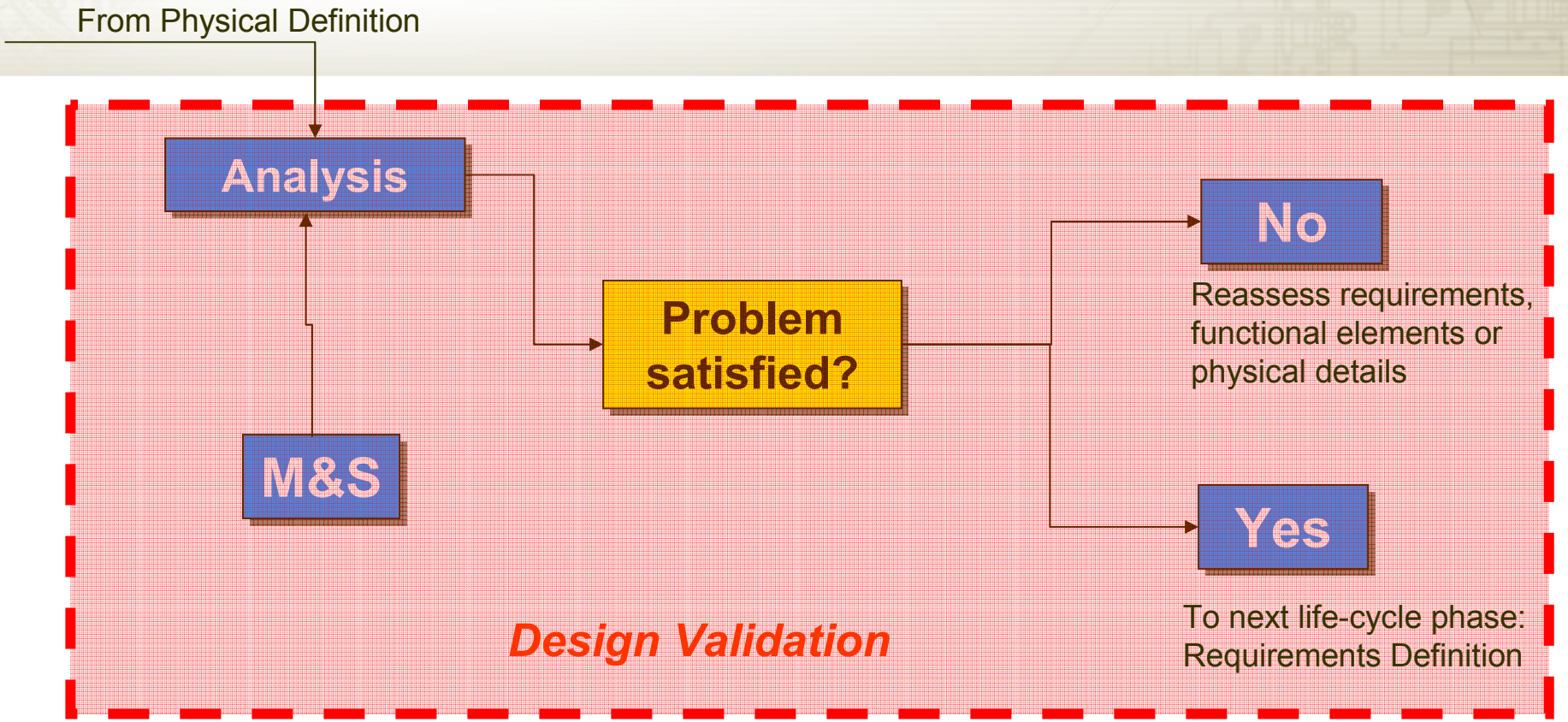
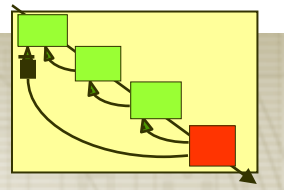
Systems Engineering Method



Design Validation Products



- Demonstrate the analysis documents the assumptions, follows a rigorous process, and arrives at meaningful conclusions that are justifiable
  - There may be multiple processes and products dependent on the sponsor, personnel/time availability, experience
  - This may be an iterative process for ICD, CDD, CPD
- Trade studies
- VV&A
- Risk Management
- Cost Analysis
- Force Allocation
- Functional Solutions Analysis
- Program Independent Assessment

Attain a Fully Validated Systems Engineering Model

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Architectures in JCIDS

- "Integrated Architectures" are a foundation for the analytical process
  - Stated requirements, attributes and measures
- Direct reference to DoD Architecture Framework (DoDAF), however:
  - Architecture is misused term within the realm of SE
- It is important to differentiate "architecture" from "architectural views"
- The JCIDS SE Model is the foundation for the architecture and the architectural views

Systems Engineering Model

- Model is a simplified view of a complex system
  - Assists stakeholders, including engineers, to understand something that is not easily comprehensible
  - Communicates the organization of the system to the stakeholders
- Rechtin
  - "Contributes to the structural stability of a system."
  - Enhances understanding of interfaces, relationships, operations and risk

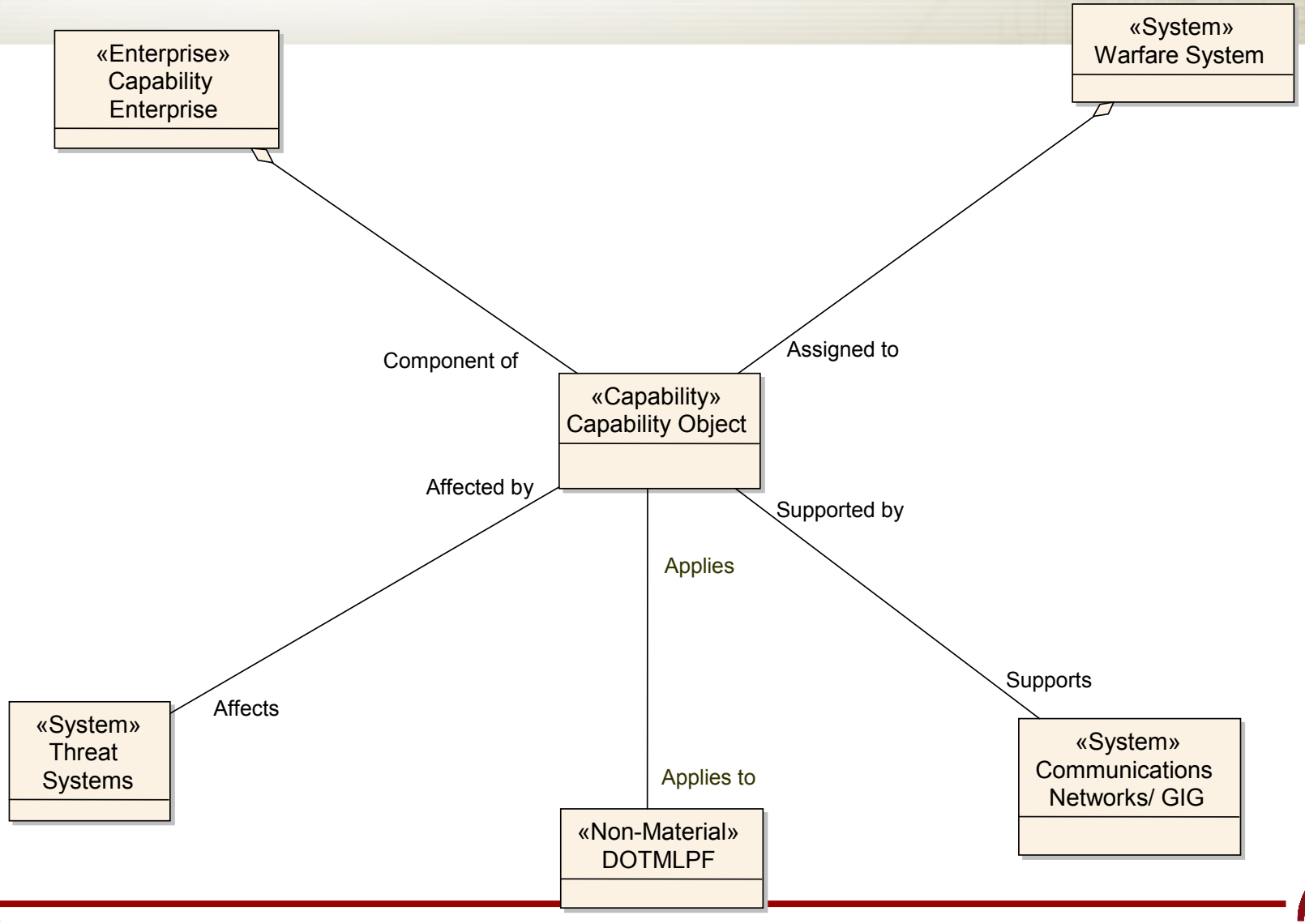
"If you don't model it, you won't understand it."
Ivar Jacobson

Model-Driven SE

- An Systems Engineering model captures the essential elements of the systems engineering life-cycle
- "Dynamic and recursive process" (Bootch, Rumbaugh, Jacobson)
  - Iteratively captures enterprise capabilities and systems requirements
  - Promotes incorporation of technology evolution
- Forms basis for a sound, long-term SE and analysis
  - Fully compliant with precepts of DoDAF and JCIDS

Model-Driven SE in Defense Systems Acquisition becomes Model-Driven JCIDS

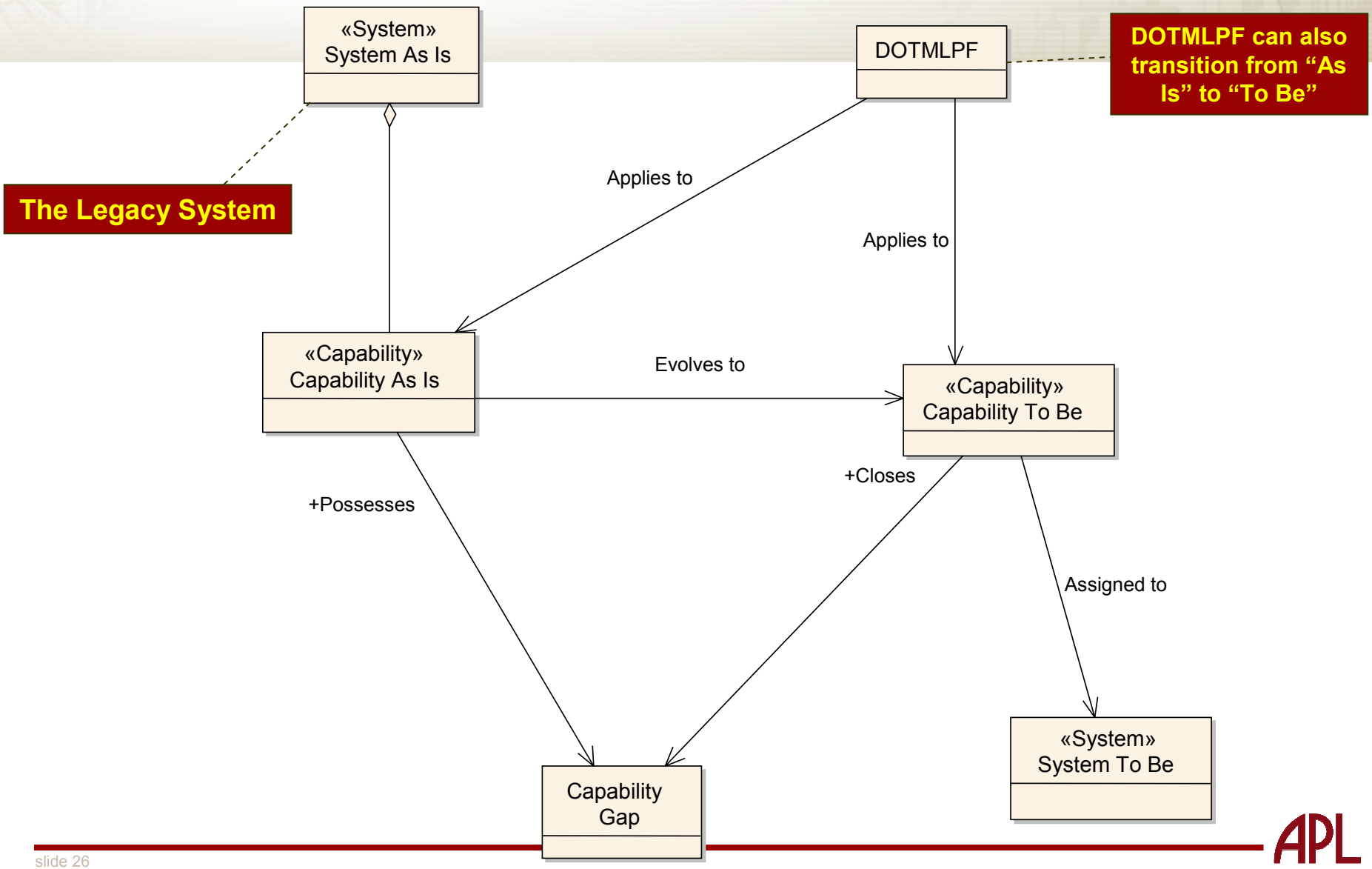
Context of the Capability Enterprise



DOTMLPF

- Dot-mil-pe-ef'
- The "Non-Material" elements of the capability
  - Doctrine
  - Organization
  - Training
  - Material
  - Logistics
  - Personnel
  - Facilities
- Investigate if a modification to any element except the "M" will enhance the Capability Enterprise
  - A far less expensive option

Transition from Capability to System



JHU/APL SE Methodology Linkage to JCIDS

- JHU/APL SE methods can be used to produce JCIDS products/artifacts
- JHU/APL SE methods can iterate throughout the DoD 5000 lifecycle
- Good SE methods can produce JCIDS
- Bad SE methods can produce JCIDS
- Producing JCIDS does not guarantee good SE

Good SE ⟷ Effective JCIDS

Final Thoughts

- JHU/APL has consistently provided SE expertise to numerous programs, following a rigorous and structured SE approach to the problem
  - "It's all about the data"
  - "It's all about the rigor"
- Program Offices have anchored their programs to our approaches and data

Summary

- Description of JHU/APL SE process
- JCIDS is consistent with good systems engineering practices
- JHU/APL SE process is consistent with JCIDS