

# ***Headquarters U.S. Air Force***

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## **The Next Generation of Air Force SE**

**NDIA 9th Annual Systems Engineering  
Conference**

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# Overview

- **Strategic Interests**
- **Life Cycle SE**
  - **SE in Pre-Acquisition (Prior to Milestone / Key Decision Point A)**
  - **Early SE Pilot**
- **SE for Systems of Systems (SoS)**
  - **ROE and Perspectives**
  - **Enabling Capabilities**
  - **Cases and Issues**
- **Focus Areas for SE Planning and Measuring**
- **SE Perspectives**
- **AF SE Vision**



# ***Strategic Interests***

- **Implement a robust engineering vision across the life cycle in all four Air Force product lines (air, space, weapons, command and control)**
- Institutionalize the role of Chief Engineer as the senior technical advisor supporting the Air Force Acquisition Executive
- Grow and mentor the next generation of Air Force technical leaders



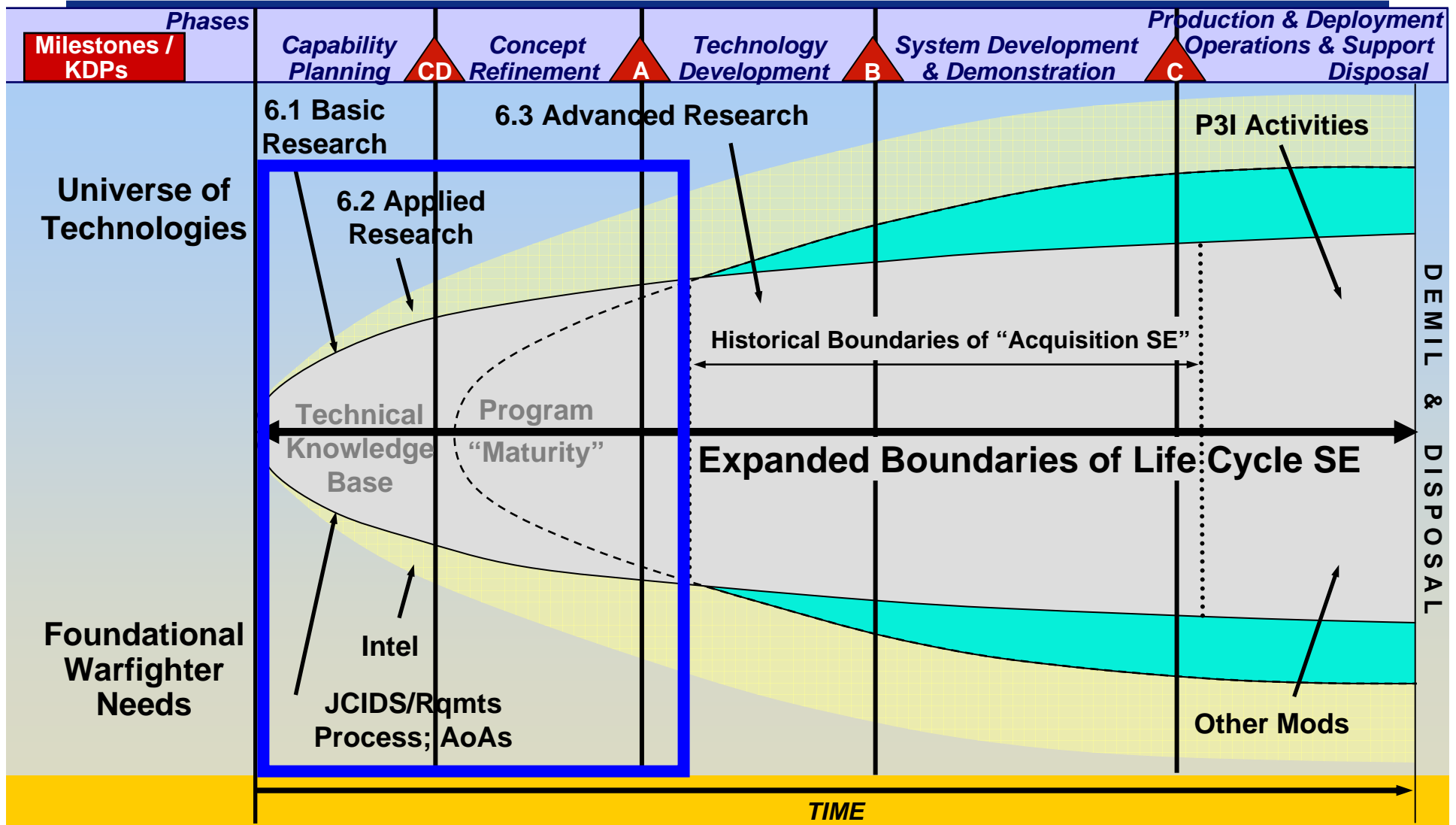
# *Life Cycle SE*

- **“Life Cycle SE”** encompasses the entire set of scientific, technical, and managerial efforts needed to plan, develop, acquire, integrate, verify, field, operate, maintain, improve, and sustain a system to provide a needed capability
  - Core SE Technical Processes
  - Technical Management Processes
  - System-of-Systems (SoS)
  - System Safety and ESOH
  - Software
  - Human Systems Integration
  - Specs and Standards
  - Program Protection
  - Manufacturing Readiness
  - Maintenance Engineering
  - Integrity Programs
  - ... numerous others ...

***OUTCOME: Mission Assurance -- Operational Safety, Suitability, and Effectiveness (OSS&E) -- Throughout the Product / System Life Cycle***



# Life Cycle SE Focus on Pre-Acquisition



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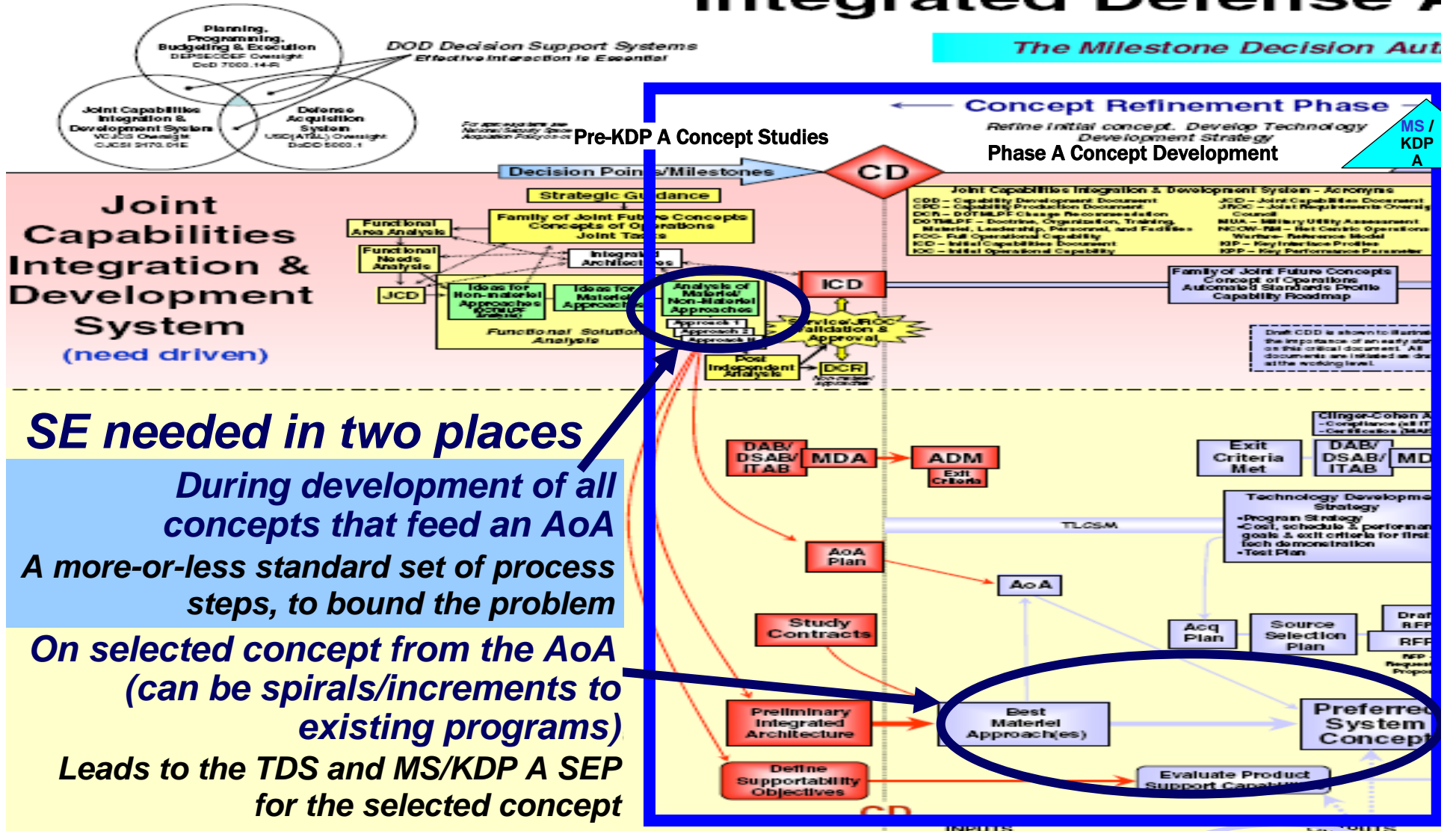


# SE in Pre-Acquisition Disciplined Application Required

r. 5.2. August 2005

## Integrated Defense A

The Milestone Decision Aut



**SE needed in two places**

During development of all concepts that feed an AoA  
 A more-or-less standard set of process steps, to bound the problem

On selected concept from the AoA  
 (can be spirals/increments to existing programs)

Leads to the TDS and MS/KDP A SEP for the selected concept



# ***SE in Pre-Acquisition***

## ■ What it is:

- The tie between JCIDS and the Analysis of Alternatives (AoA)
- A disciplined process to scope capability needs and *develop concepts*
- The process required to do necessary *groundwork for a successful AoA*
- A means to identify candidate technologies and assess their TRLs
- Good SE

## ■ What it is *not*:

- An actual AoA
- "Gaming the system" to favor a solution



# ***SE in Pre-Acquisition Early Documentation***

- **Standard methodology -- “Analysis of Problem” as precursor to formal Analysis of Alternatives**
  - **Describes how SE processes translate capability statements into families of concept designs/approaches**
    - Trade study process
    - Key ground rules/constraints
    - Decision criteria
    - Methodology for populating knowledge base
  - **Describes how operational context (architectures and military utility) drives these translations**
- **Basis for Technology Development Strategy**
  - **TDS should make up ~75% of content of SEP submitted at Milestone / Key Decision Point A for selected concept**





# ***SE in Pre-Acquisition Example***

- **Warfighter needs the capability to cross a body of water**
- **Initial pass through this process yields various methods**
  - Airlift
  - Bridge
  - Catapult
  - Drive around
  - Drive through
  - Ferry
  - Tunnel
  - etc.
- **Further analyses offer parametric trades within a method (e.g., bridge), considering depth, width, current, etc.**
  - "If you build 400 yards upstream where the channel is narrower, you will only need 3 support pilings instead of 4 ..."
  - "If you build 1000 yards downstream where the current is slower, you'll need 5 pilings and 20% more material for the road, but you can finish 10% sooner and the span can take 15% more live load ..."
- **Applying this process, the Acquirer will NOT determine what type of bridge is best -- that comes out of the AoA**

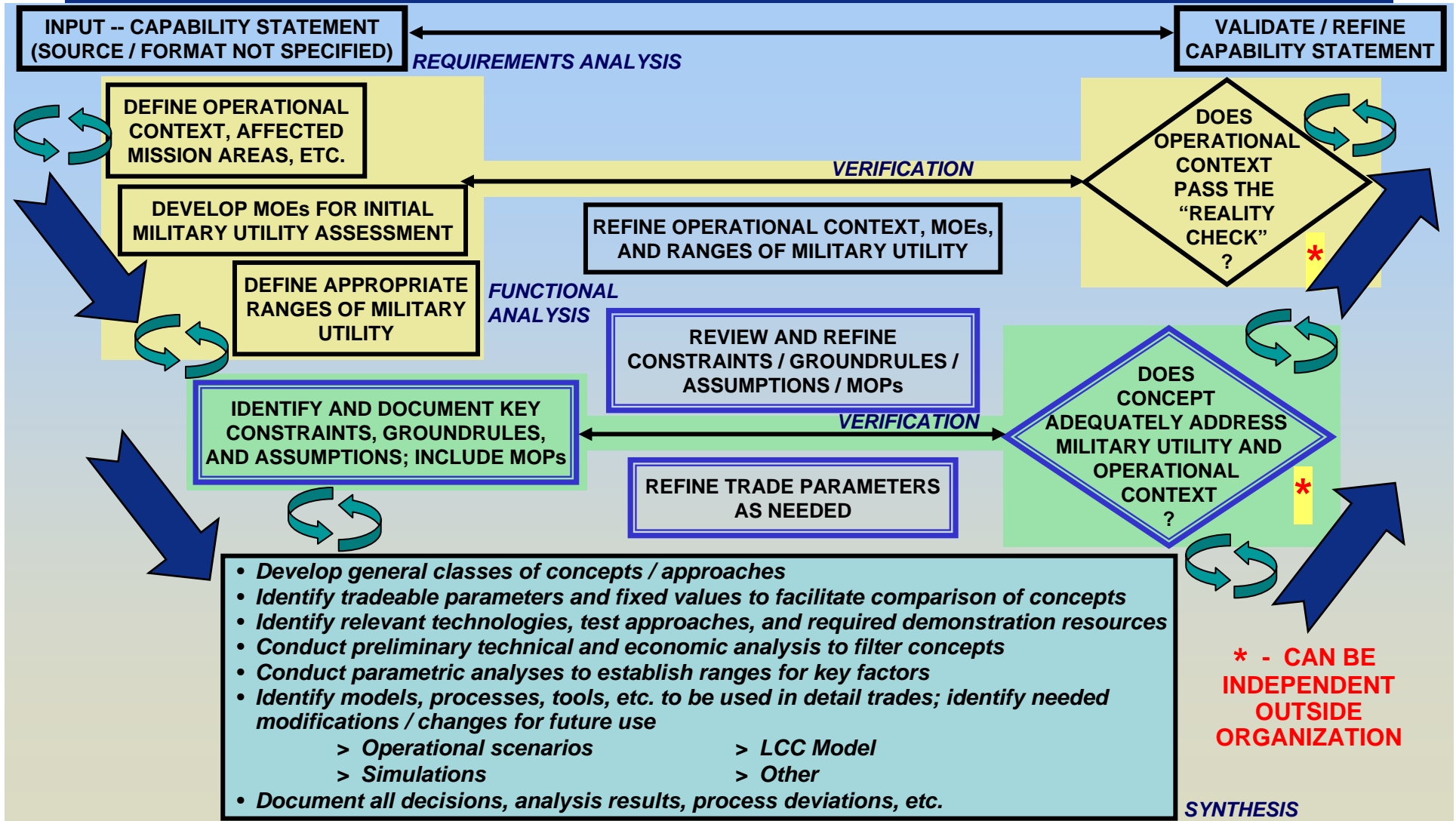


## ***Early SE Pilot***

- **SMC effort began June 06**
  - **SMC/XD to select candidate need from AFSPC Mission Needs Statement library**
  - **Selected needs will be used to validate entire process by developing at least two concepts**
  - **Deliverables include details of each step in process diagram, guide to implementation criteria, and draft SEP for each concept**
  
- **Project will expand to AFMC Product Centers in FY07**
  - **Best Practices and Lessons Learned will shape policy**



# Early SE Pilot Concept Development Process Diagram





# ***SE in Pre-Acquisition Expectations***

- **Disciplined application of Pre-A SE will:**
  - Flow operational needs through concepts into programs
  - Integrate the “illities” up front into concept definition
  - Build a technical knowledge base that migrates with concepts to programs
- **Policy for Pre-A SE will:**
  - Drive linkage of concepts to operational architectures (Air Force, Coalition, and Joint)
  - Facilitate better decision-making at MS/KDP A and B
- **Policy for Pre-A SE will not:**
  - Provide guidance idea generation
  - Direct conduct of AoA or EoA studies
  - Guide overall capabilities integration activities



# ***SE in Pre-Acquisition Summary***

- Aim to institutionalize disciplined and consistent SE application throughout the life cycle, across all AF product lines (air, space, weapons, C2)
  - **MUST** start in the earliest stages of concept development, **BEFORE** formal program initiation
  - Early SE is an **investment to reduce risk** in later program phases
- Pilot project will define rigorous Early SE process
  - Policy will follow validation in FY07

## **ULTIMATE RESULTS**

- Better technical planning, better integrated
- More confidence in programs entering acquisition



# ***SE for Systems of Systems (SoS) Rules of Engagement***

- ***Systems of Systems (SoS) result when independent and useful systems are integrated into a larger system that delivers unique capabilities***
  - **Both the SoS and the constituent systems consist of parts, relationships, and a whole that is greater than the sum of the parts**
  - **While the SoS is a system, all systems are not SoS**
- ***SE for SoS deals with planning, analyzing, organizing, and integrating the capabilities of a mix of existing and new systems into a SoS capability greater than the sum of the capabilities of the constituent parts***

(Defense Acquisition Guidebook, Chapter 4)
- **Keys: Definitions, Development, Acquisition, Operations**

**Guide to Systems of Systems (SoS) Engineering: Considerations for Systems Engineering in a SoS Environment** -- draft OUSD (AT&L) publication; anticipated release Dec 2006



# ***SE for SoS Perspectives - 1***

## ■ **Definitions**

- **System of Systems**
- **Family of Systems**
- **Federation of Systems**
- **Architecture**
- **Enterprise**
- **Others ??**

## ■ **Development**

- **Holistic view**
- **Aggregation of platform-level efforts**
  - **Focus on physical interfaces and functional / information exchanges**
  - **Degree of integration often vague**



# *SE for SoS Perspectives - 2*

## ■ Acquisition

- DoD processes largely specific to each Service/Agency
- Systems acquired independently, even to satisfy similar sets of requirements
- Contractor development processes differ greatly, even for similar systems in similar product areas
- Further cultural differences in AF
  - Space systems       $\longleftrightarrow$       Non-space systems
  - Weapon systems       $\longleftrightarrow$       Business and IT systems
  - Product Centers       $\longleftrightarrow$       Logistics Centers       $\longleftrightarrow$       Test Centers

## ■ Operations / Employment

- Often used in new combinations
  - Near-infinite number of subsets of constituent elements/systems, etc.
  - Near-infinite number of dynamic configurations
- Often used in new environments and operational scenarios
- Often used with new supporting cast



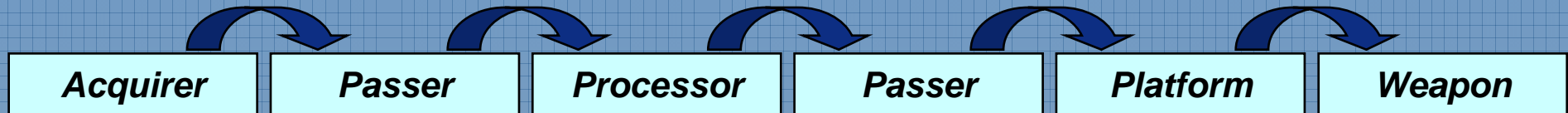


# SE for SoS

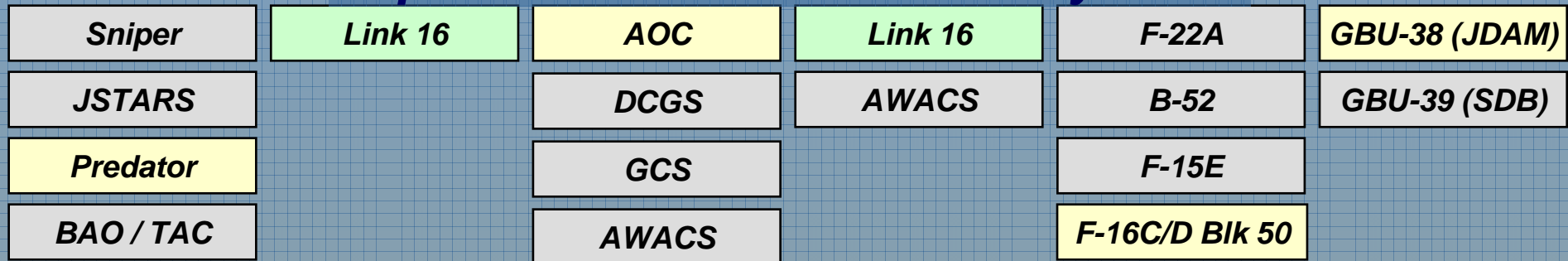
## Enabling Capabilities - Example

**Capability: Targeting of Coordinate-Seeking Weapon (CSW)**  
*(all-weather, air-to-ground, GPS/INS-guided munitions)*

### SoS Architecture



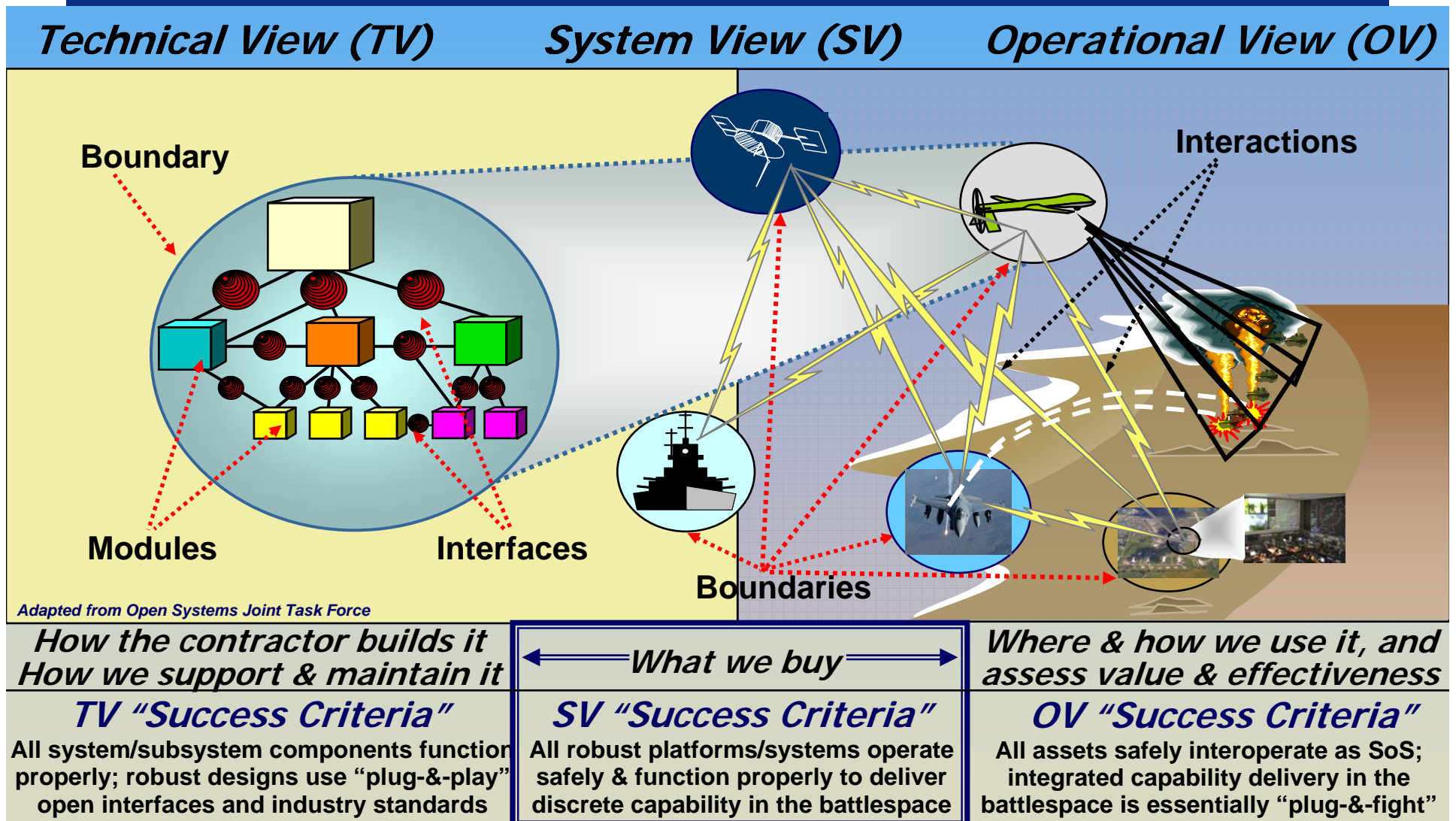
### Representative Constituent Systems



**None of these systems was designed with CSW targeting in mind, and only a few of the systems were designed to interface with each other**



# SoS Enabling Capabilities Defined by Architectural Views



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# ***SE for SoS***

## ***Cases & Issues - 1***

- **New developments**
  - Seen as the exception rather than the rule
  - Affordability constraints
  - Centralized funding and management
  - Role of integrator vs. role(s) of developer(s)
- **Integrated legacy systems for new capability**
  - Will probably be the most common approach
  - Defined in interoperability (“plug-and-fight”) context
  - Discovery of interactions, especially in ad hoc configurations
  - Inconsistent and disparate management of configurations, data, etc.
  - Test / M&S: formal test, verification and validation, experimentation



# ***SE for SoS***

## ***Cases & Issues - 2***

- **Collaboratively developed constituent systems**
  - Defined in terms of a common architecture to guide development of new systems and platforms
  - Greater number of stakeholders, with both parochial and holistic interests
  - Data sharing among multiple contractors
  - Definition and management of common architecture(s)
- **Sustainment of existing systems**
  - Different pace of updates for different systems at different points in their life cycle
  - Increase capabilities by technology refresh / insertion
  - Often with different levels of documentation and data
  - Diminishing (and often volatile) sources of support
  - Local management / funding (particularly true for business and IT systems)



# ***SE for SoS Summary***

- Driven by fiscal and operational realities
- Fundamental SoSE processes (technical & technical management) largely the same as for “classical” SE
  - Greater emphasis on architecting and interfaces
- Integration challenges: test & real-world environments
  - Defining architectures to link systems and platforms
  - Experimentation as a development tool
  - Managing utilization of assets acquired and operated under disparate systems and policies
- Unique management and governance issues

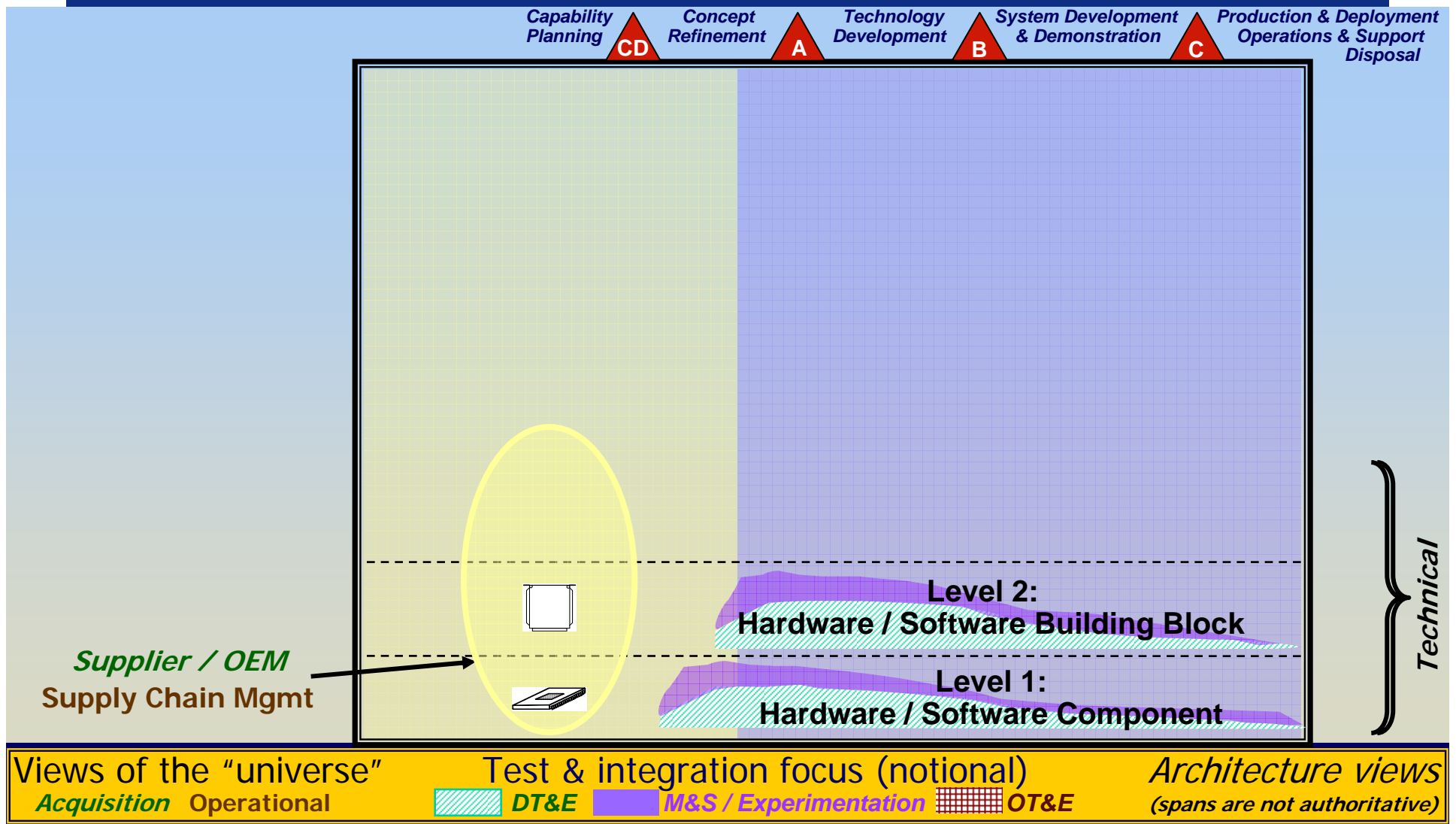
## **ULTIMATE RESULTS**

- Robust, responsive capabilities delivery; better integrated
- More confidence in system performance



# SE Perspectives

## Acquisition, Operations, Integration, Architecture

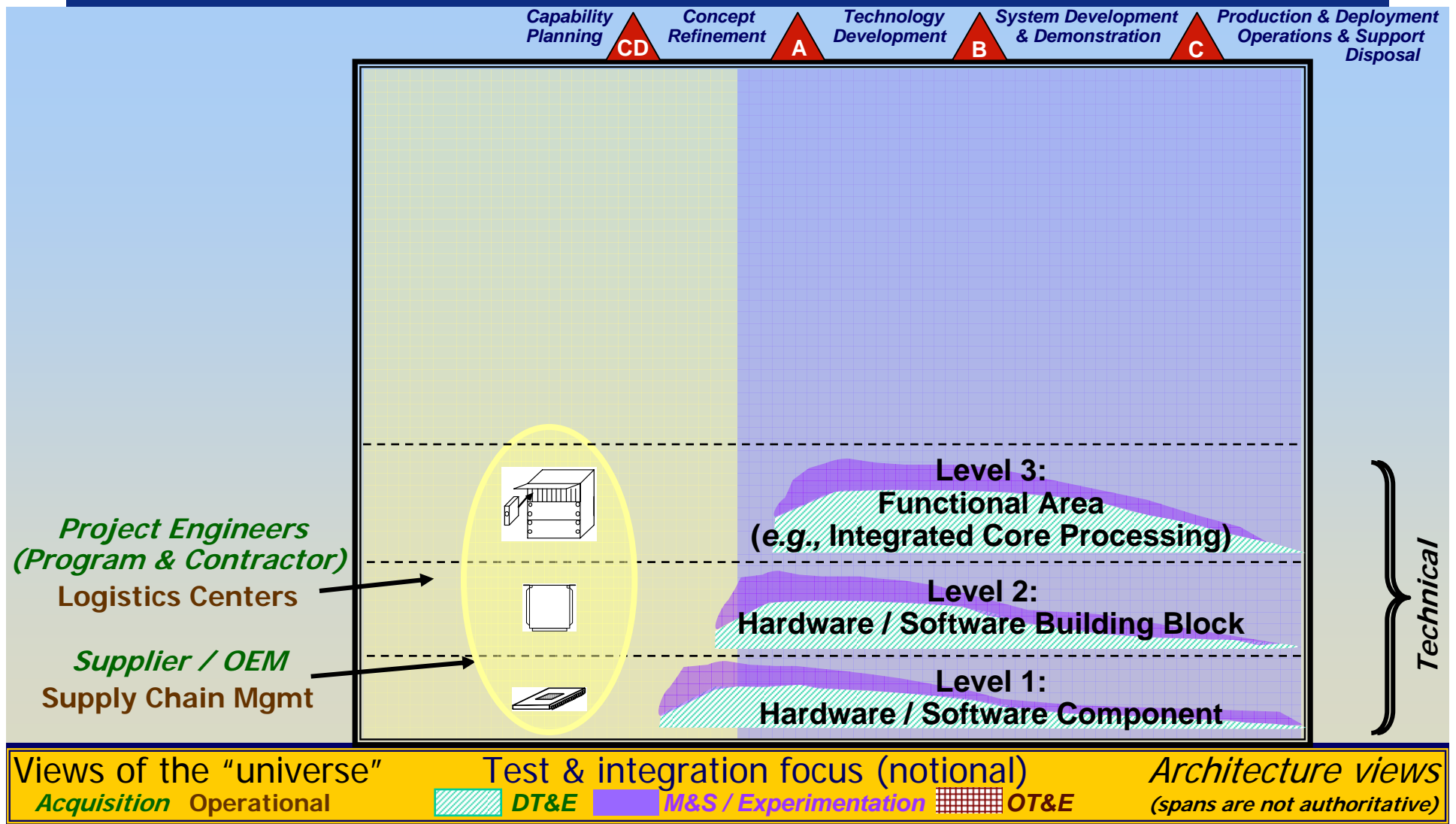


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# SE Perspectives

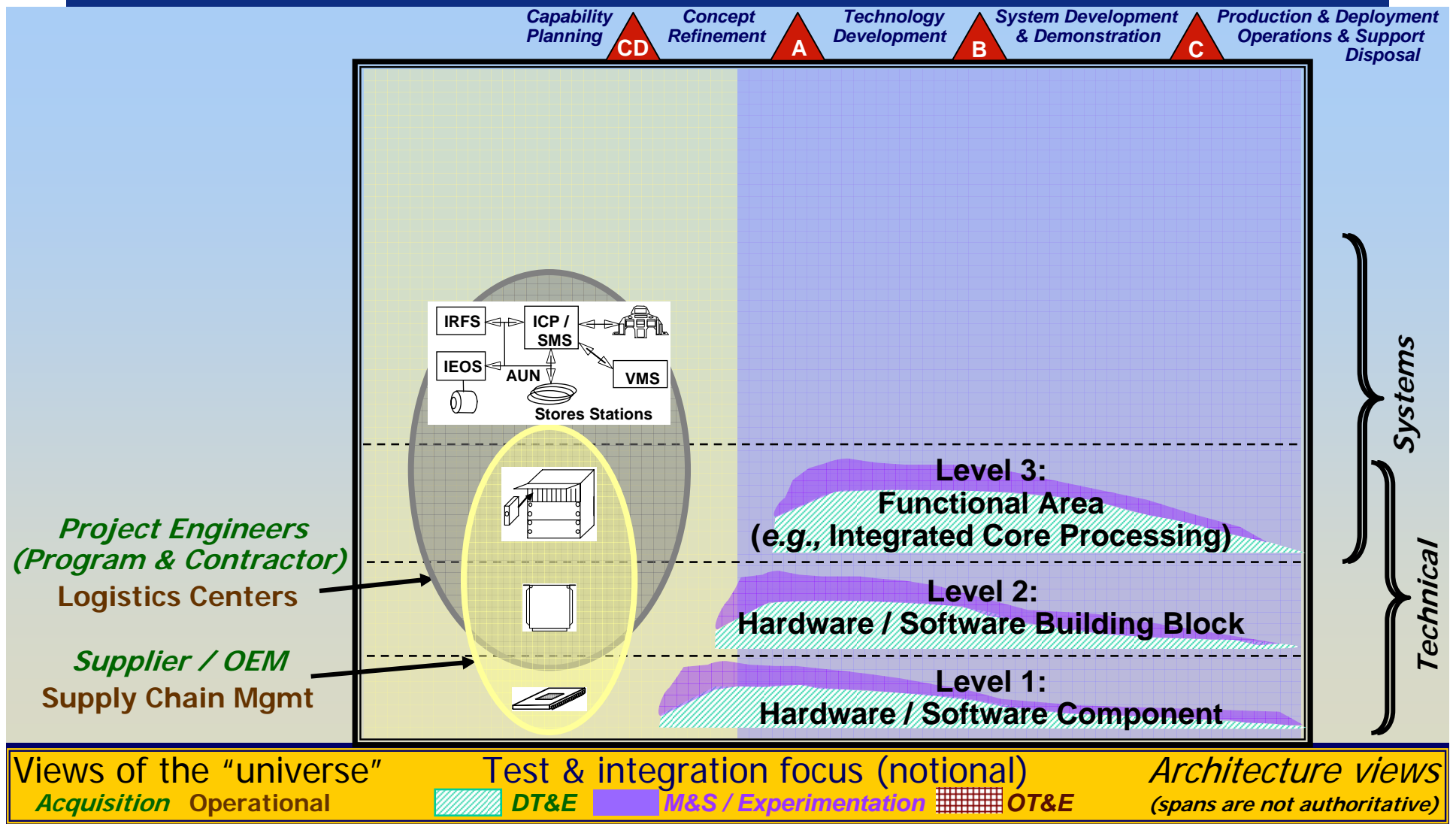
## Acquisition, Operations, Integration, Architecture





# SE Perspectives

## Acquisition, Operations, Integration, Architecture

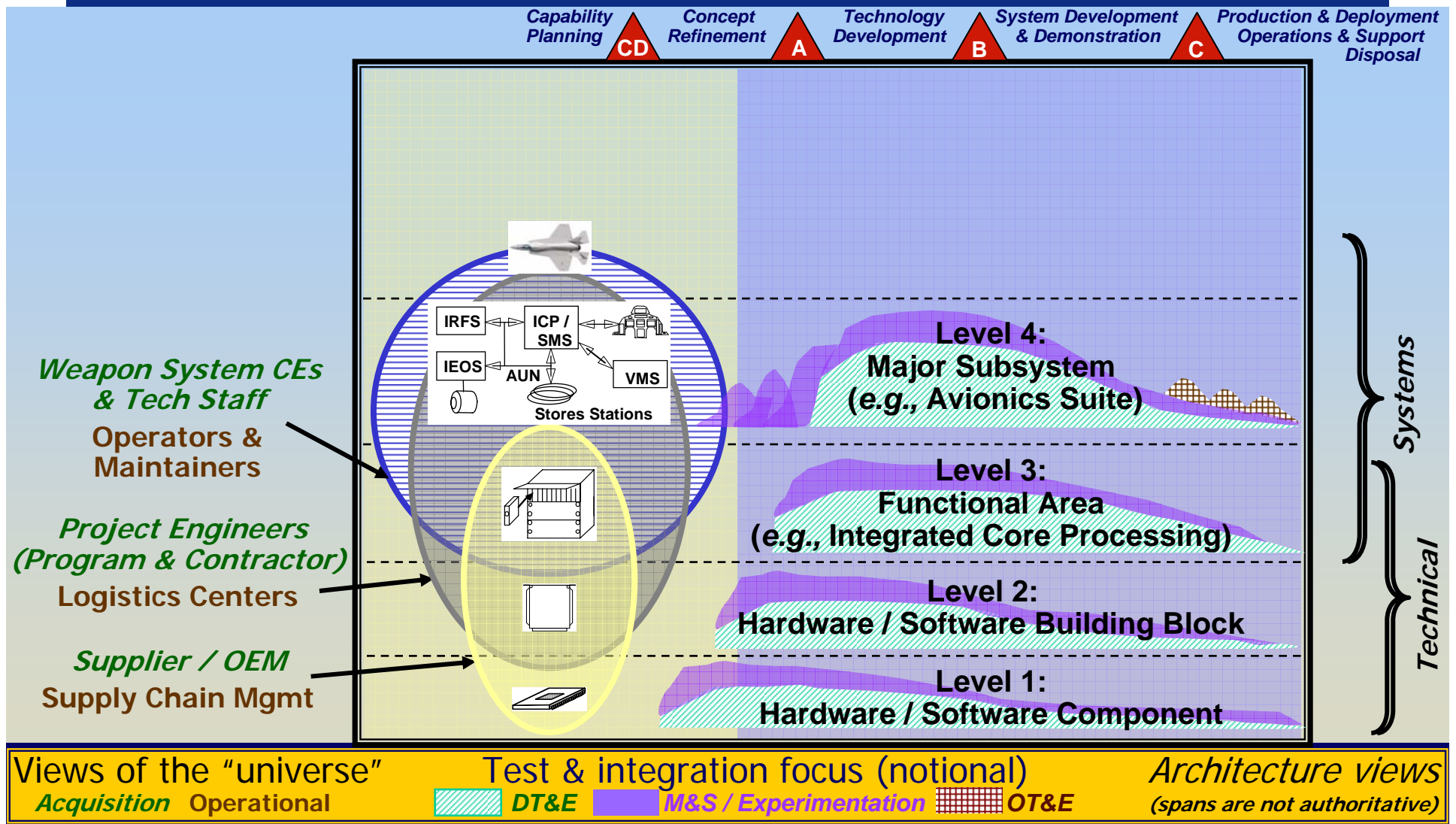






# SE Perspectives

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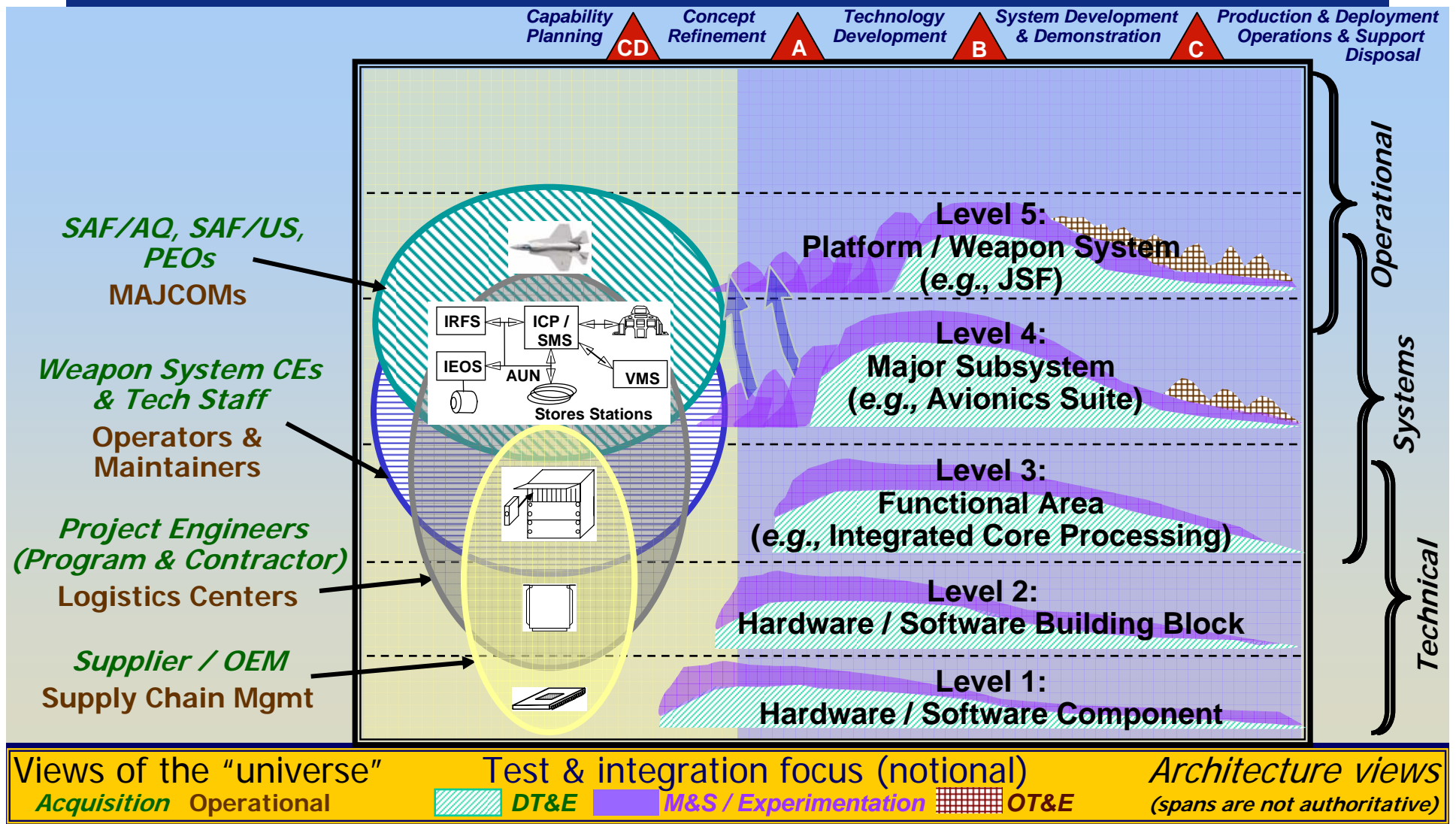


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# SE Perspectives

## Acquisition, Operations, Integration, Architecture

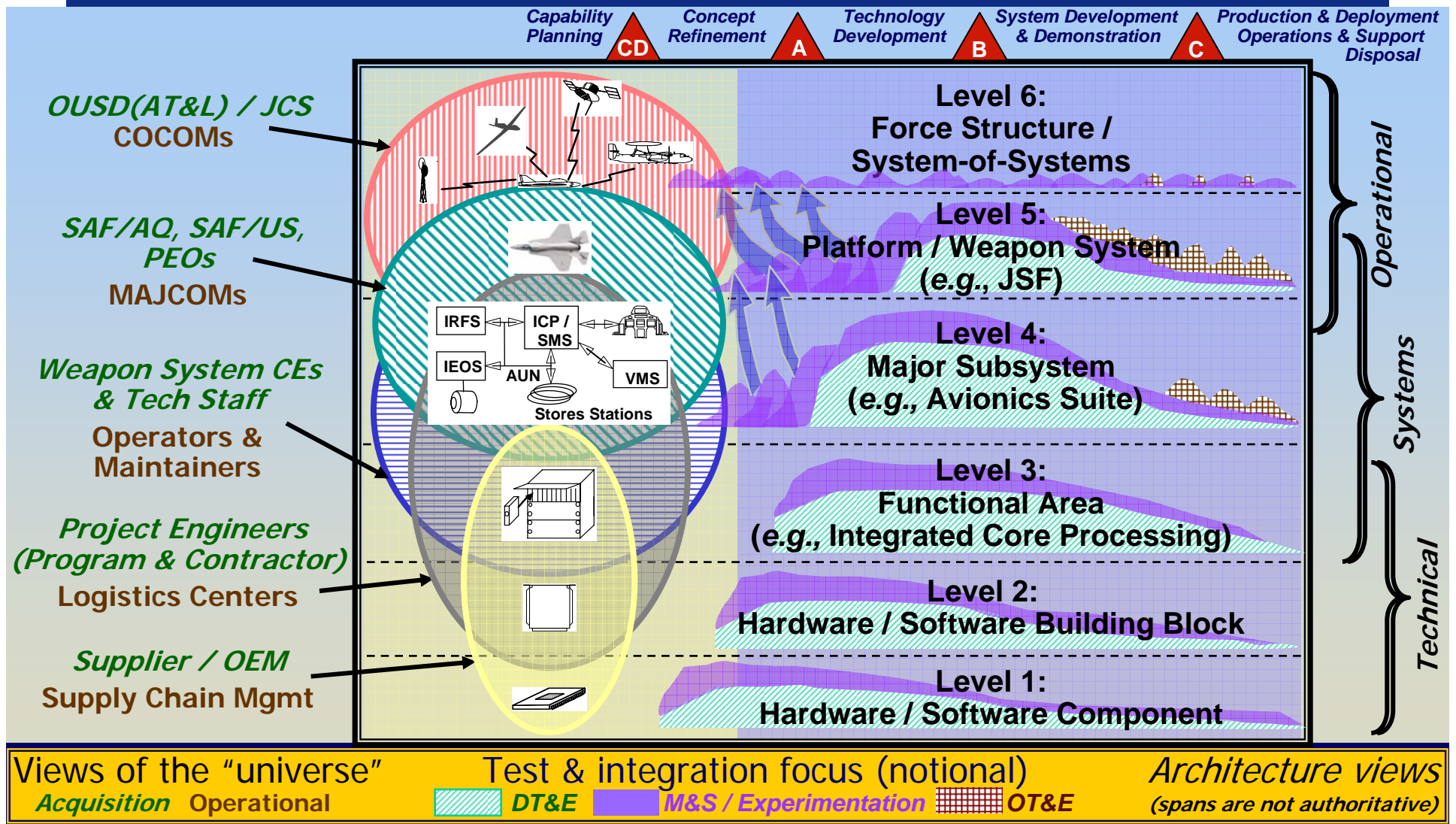


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# SE Perspectives

## Acquisition, Operations, Integration, Architecture



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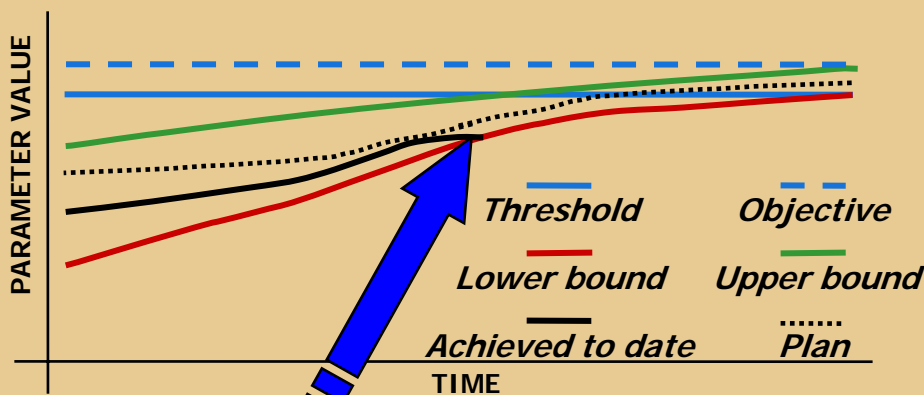
# ***Focus Areas for SE Planning \****

- **Program Requirements**
    - Capabilities, CONOPS, KPPs
    - Statutory / regulatory
    - Specified / derived performance
    - Certifications
    - Design considerations
  - **Technical Staffing / Organization**
    - Technical authority
    - Lead Systems Engineer
    - IPT coordination
    - IPT organization
    - Organizational depth
  - **Systems Engineering Process**
    - Technical Processes
    - Technical Management Processes
    - Process Improvements
    - Key Tools and Resources
    - Trade Studies
    - Linkage to Contractor SE Effort
  - **Technical Baseline Management**
    - Who is responsible
    - Definition of baselines
    - Requirements traceability
    - Specification tree and WBS link
    - Technical maturity and risk
  - **Technical Review Planning**
    - Event-driven reviews
    - Management of reviews
    - Technical authority chair
    - Key stakeholder participation
    - Peer participation
  - **Integration with Overall Management of the Program**
    - Linkage with other program plans
    - Program manager's role in technical reviews
    - Risk management integration
    - Test and logistics integration
    - Contracting considerations
- \* - Based on OSD SEP Preparation Guide

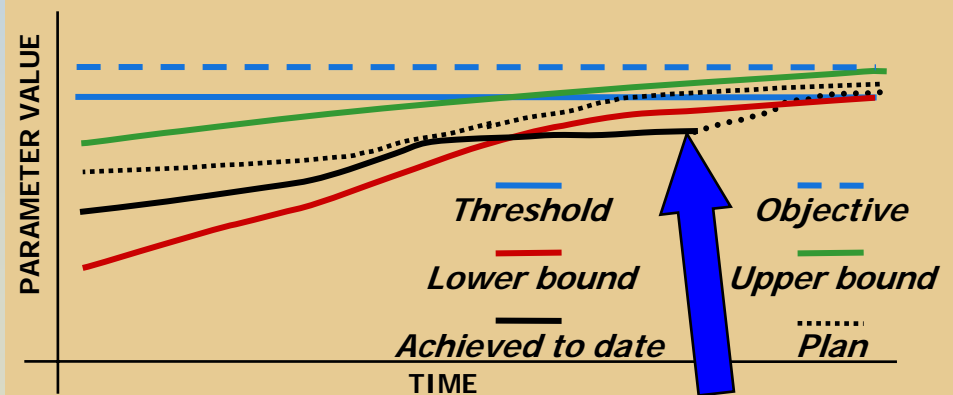


# Focus Areas for Measuring Progress

- Representative Technical Performance Measures (TPM) parameters
  - Hardware – weight, speed, power, cooling, cross-section, bandwidth
  - Software – throughput, lines of code
  - Verification – test asset deliveries, test points completed with valid data
  - Logistics – reliability, maintainability
- Integration – physical and information interface definitions; verification plans
- Earned Value Management System (EVMS) data
  - Cost variances
  - Schedule variances
- Program planning
  - Staffing
  - Subcontracting
  - Specification approvals
  - Closure of review actions



**Monitor trend; take action here**  
*Plan is probably achievable*



**Not here**  
*Overly optimistic "get-well" plan*



# ***Focus Areas -- Emerging***

## **■ Technical**

- Manufacturing Readiness
- Human Systems Integration (AF/SG lead)
- Specifications and Standards

## **■ Governance & Oversight**

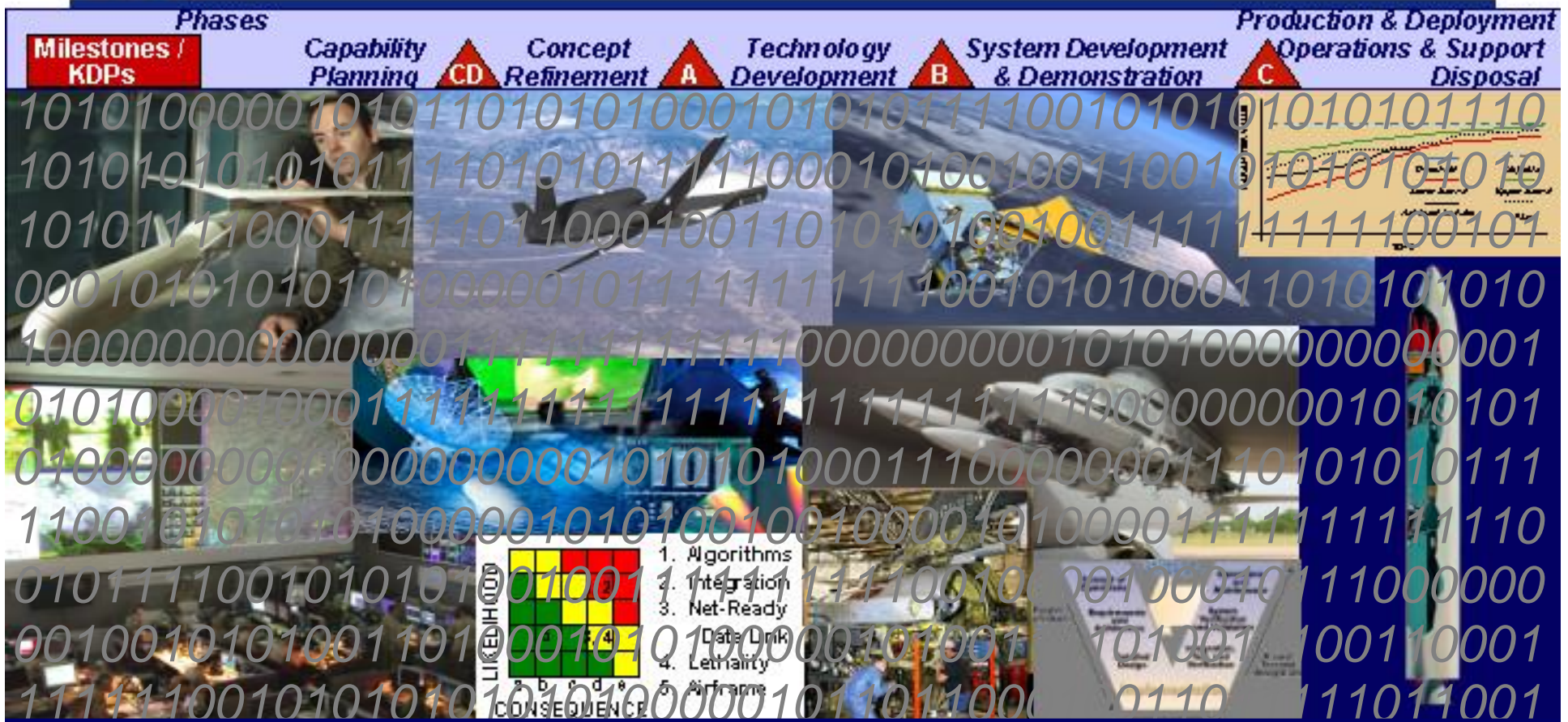
- MDA Certification (Section 801 of National Defense Authorization Act for FY06 [Pub. L. 109-163])
- System & Software Assurance (Security & Program Protection)

## **■ Multi-Faceted**

- Enterprise-level SE
- Industrial Base



# Visions



- **Consistent application of rigorous life cycle SE in all AF product lines, enabled by a skilled workforce and a policy framework with an integrated life cycle perspective**
- **Delivery and support of quality systems/SoS/software, on cost and on schedule**

***“We demand rigidly defined areas  
of doubt and uncertainty!”***

Douglas Adams,  
*The Hitchhiker's Guide to the Galaxy*