Applying Systems Engineering during Pre-Acquisition Activities

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Outline

- Need for Early SE
- Defining Early SE
- SMC Pilot Program
- Policy Initiatives
- Challenges
- Way Forward

Why?

"Systems Engineering is broken; go fix it."

Attributed to SecAF James Roche, spring 2002

Lack of systems engineering has been cited as the cause of major defense acquisition program failures

Cost overruns, schedule slips, mishaps, external criticism, instability in requirements and funding, poor acquisition strategies

The Need

- **RAND Project Air Force study: "Is Weapon System Cost Growth Increasing?"**

  "… despite the many acquisition reforms and other DoD management initiatives over the years, the development cost growth of military systems has not been reduced."*

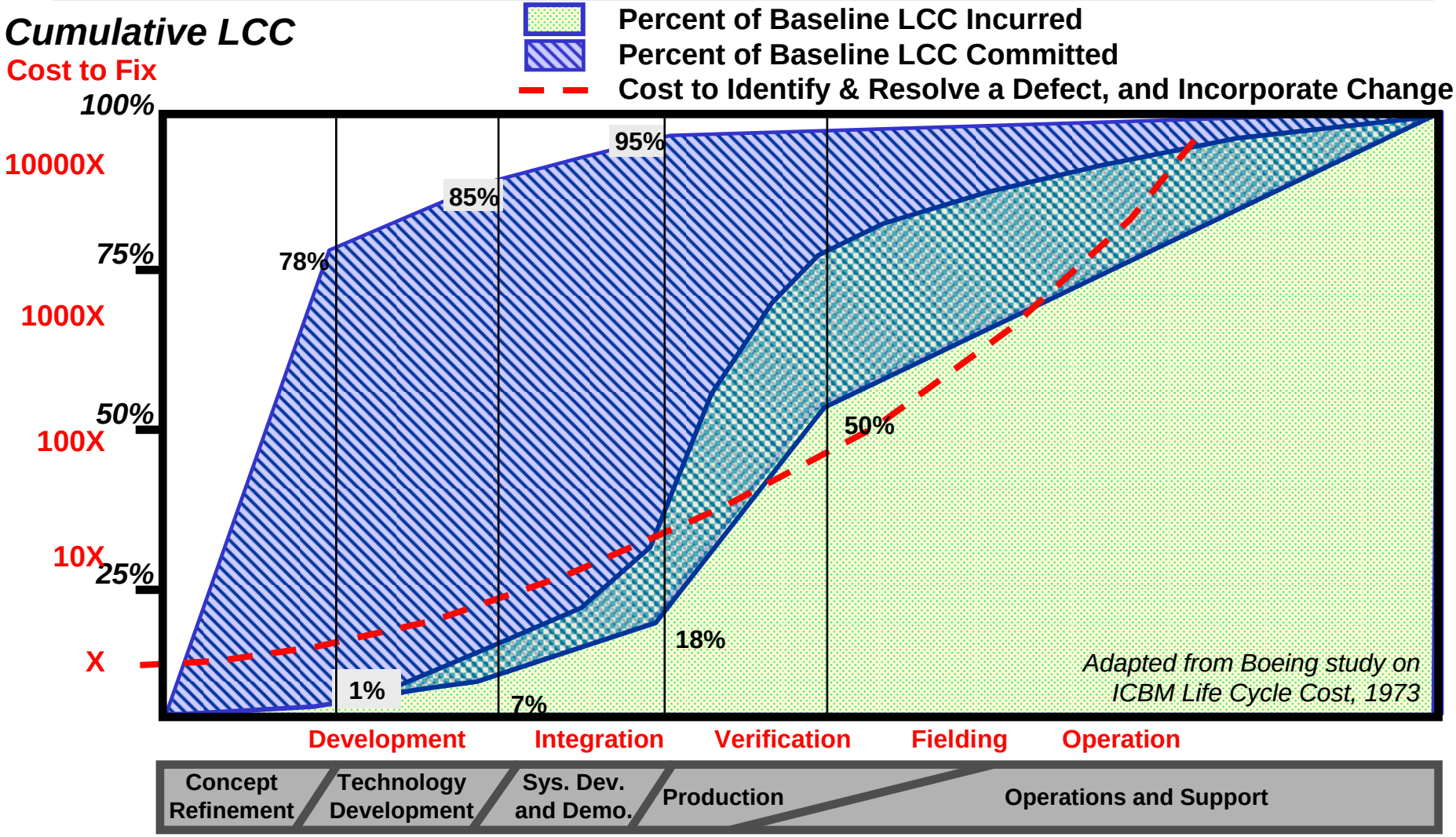
- **This, however, does not indicate we are necessarily doing badly …**

  "There is no doubt that the systems developed in each successive decade are more complex than those of the prior decade. The ever-increasing complexity of technology, software density, system integration complexity, and the like make estimating a total system's development cost … an ever-increasingly challenging endeavor."*

- **Increasing complexity has kept stride with increasingly improved acquisition**

* *Is Weapon System Cost Growth Increasing*, 2007, RAND

Why It's Needed -- Early Decisions Are Key Life Cycle Cost Drivers



Defining Early SE

- **What it is:**
  - **The systems engineering (SE) tie between JCIDS and the AoA … and beyond**
  - **A disciplined process for scoping capability needs and developing concepts**
  - **The process required to do the necessary work for a successful AoA**
  - **A means to identify candidate technologies and assess the realism for transition**
  - **An actual pre-acquisition effort**
- **What it is *not*:**
  - **An AoA**
  - **"Gaming the system" to favor a solution**

Pre-Acquisition "Systems Thinking"
Boundary Conditions

Pre-Acquisition SE efforts, like those throughout the rest of the life cycle, are essentially an "integrating function"

- **Pre-A SE mainly occurs in two domains, each with set boundaries**
  - **The first SE domain spans the period from JCIDS initiation of a need to AoA entrance:**

$$\int_{\text{JCIDS}}^{\text{AoA Entrance}} F_1(SE)\,dSE$$

  - **The second domain continues the SE functions after the AoA until formal program handoff:**

$$\int_{\text{AoA Exit}}^{\text{Program Initiation}} F_2(SE)\,dSE$$

- **The SE functions in both domains are fundamentally similar, but there are attributes unique to each**

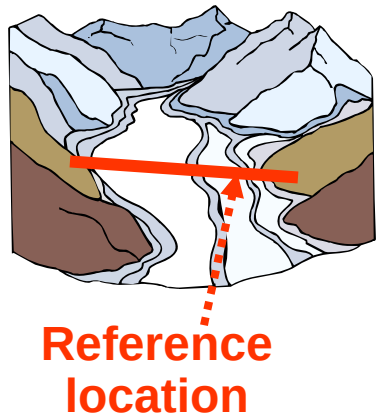
Pre-Acquisition Example

Capability need: "Get people and equipment across a body of water"

- **First pass asks key questions:**
  - **What does "water" mean? (Solution sets will be very different for Piscataway Creek, the Potomac River, and the Pacific Ocean.)**
  - **Are there any obvious constraints? (Sensitivity to water exposure? Time-in-transit limitations?)**
- **Initial analysis should yield various methods, and a cost / risk summary for each**
  - **Airlift**
  - **Bridge**
  - **Catapult (unsuitable for people)**
  - **Drive across (depends on depth, current, etc.)**
  - **Drive around (depends on total distance, thus time)**
  - **Ferry**
  - **Helicopter**
  - **Tunnel**
- **Analysts should also be able to quickly rule out candidates that don't meet constraints**

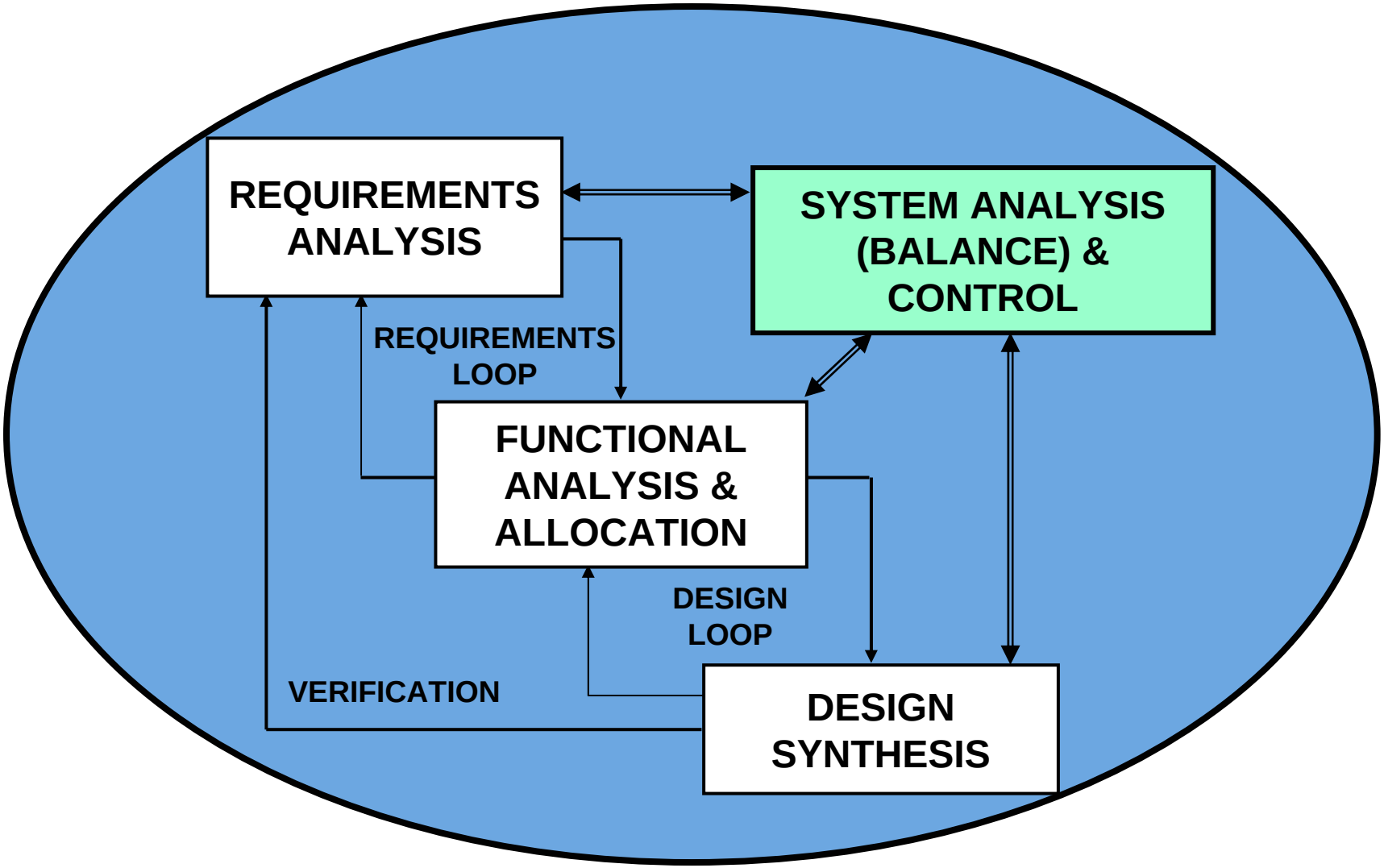
Pre-Acquisition Example (cont)

- Parametric trades within a method (bridge, tunnel, etc.) consider how relevant factors (depth, width, current, etc.) affect a baseline candidate solution
  - "A mile upstream the channel is narrower. The shorter span means ~30% less material cost, but road access and construction staging are difficult."
  - "A mile downstream the current is slower. The longer span means ~20% more material cost, but you can complete construction earlier."

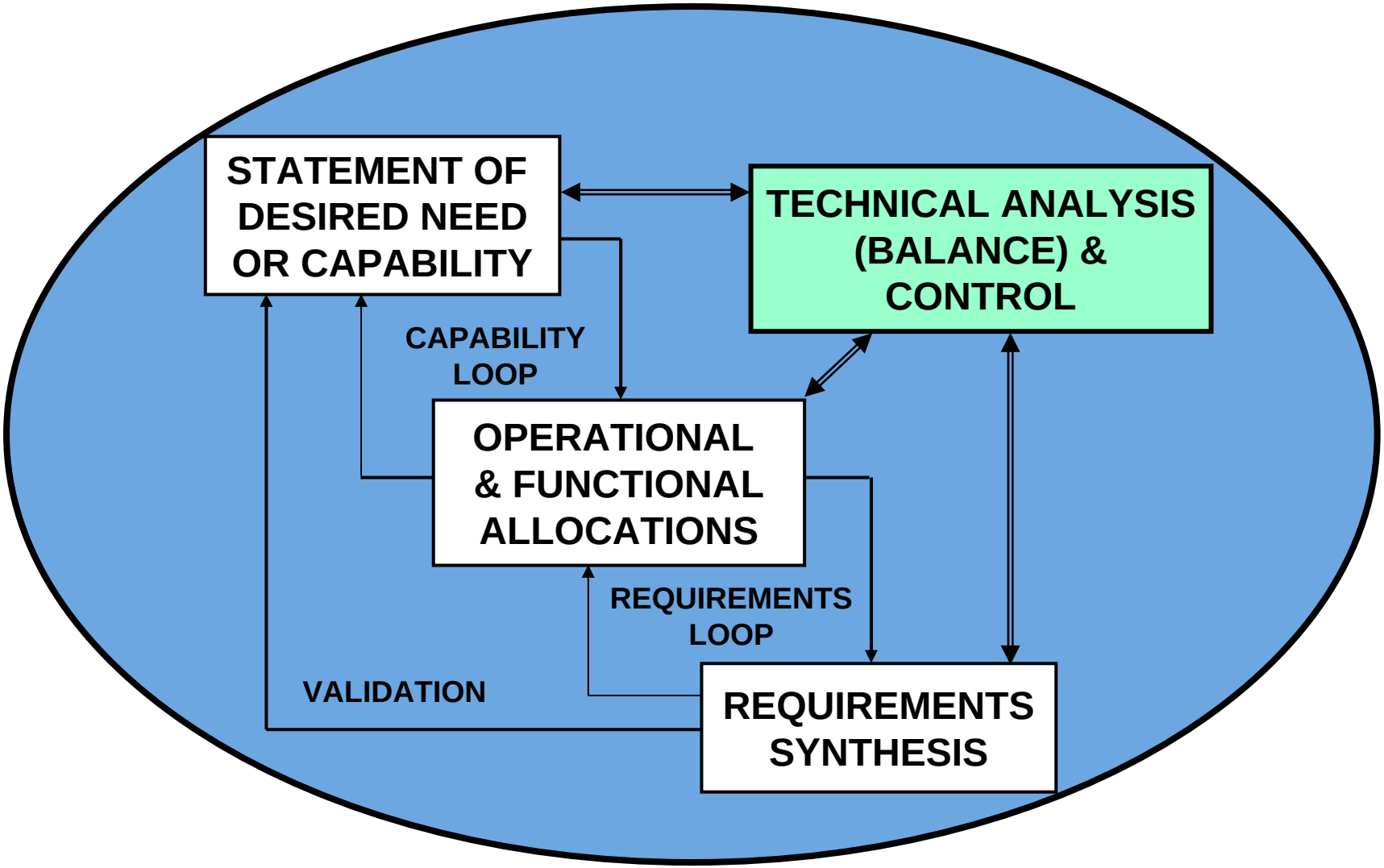


- Once the AoA looks at families of candidates and concludes that a bridge is the best solution, a similar process is employed to determine the optimum type (cantilever, suspension, pontoon, single- or two-span draw, etc.)
- Pre-AoA measures are high-level programmatic / operational parameters (cost, schedule, vehicle capacity, etc.)
- Post-AoA measures have a more traditional design and execution focus (EVM, weight, material durability, etc.)

SE Applied to a Product or System
Transforming Requirements to Design



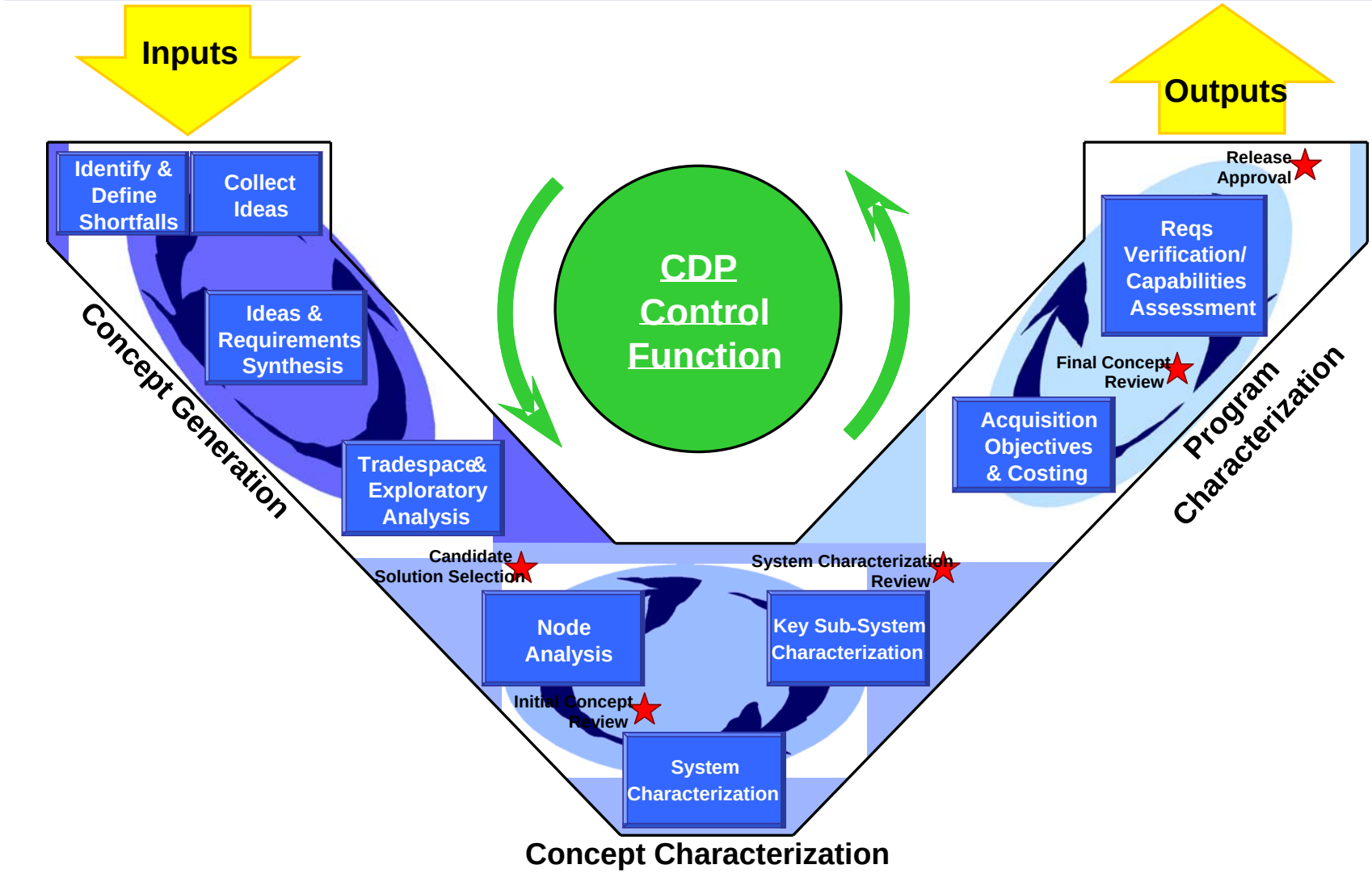
SE Applied to a Capability "Requirements Engineering"



SMC Pilot Program

- Modeled after test case developed for a relatively cheap, ill-defined launcher
- Study commissioned by SAF/AQR
  - Objective: Develop and validate a concept development systems engineering process & guide
  - Identify barriers to success in concept development
- Used standard systems engineering tenets as a baseline
- Modified for future concept development efforts
- Currently validating and documenting

SMC Concept Development Process V-Chart



NRC Pre-A SE Study

Co-Chairs: Dr Kaminski, Gen (ret) Lyles

TASKS

- Assess the contribution of pre-A SE on Air Force programs
- Determine level of pre-A SE required for program success
- Determine current barriers to pre-A implementation, both on concepts leading to an AoA and for the post-AoA selected alternative(s)
- Develop a framework/methodology for developmental organizations to ensure proper pre-A SE is accomplished
- Recommend changes to enable adequate pre-A SE, and the means for seamless transition from need identification through program office standup

STATUS

- Study committee received approx 30 formal briefings
- Committee members currently conducting analyses and writing assigned sections of report
- Anticipate start of peer review Jun 07
- Public release of final report anticipated Nov 07

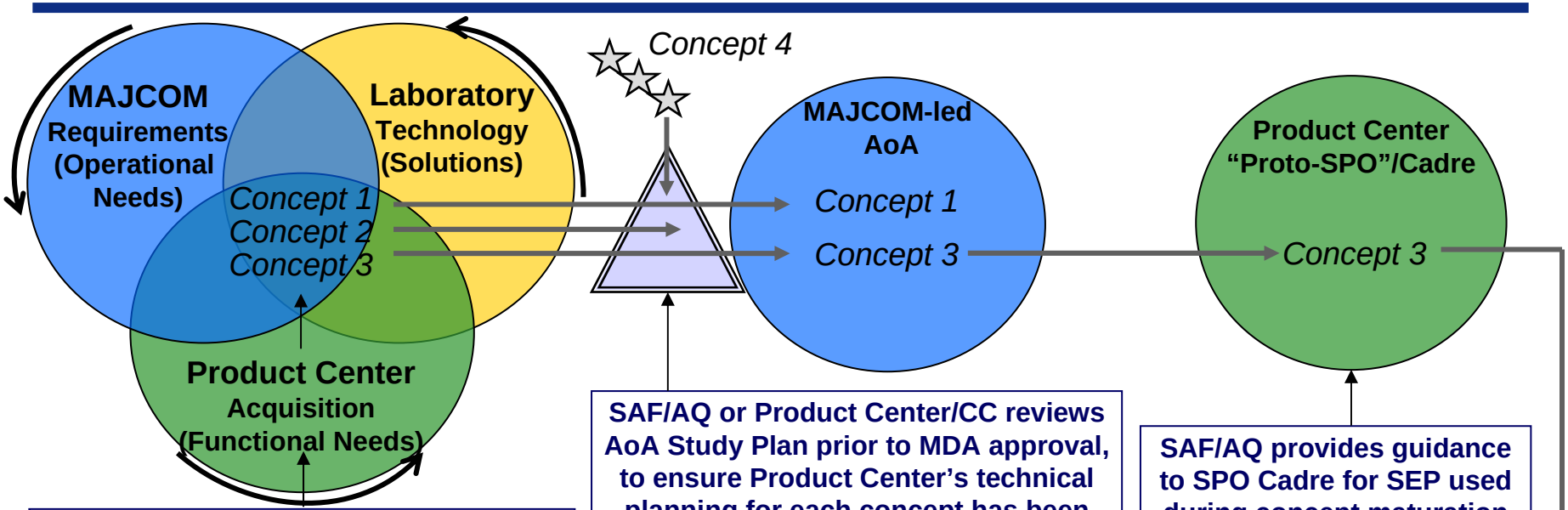
AF Early SE Policy Initiatives

"Nothing in the world is more important than policy!" *

- "Fixing" SE in the pre-Acquisition world requires a two-pronged approach
  - Acquisition policy -- DoD 5000.2, 63 series AFIs
  - Requirements policy -- JCIDS, AFI 10-601
- Current policies *encourage* acquisition and requirements to coordinate, but do not have hooks to *force* working together
- Islands of success exist, but tend to be personality/ experience driven
- Opportunities exist to slip early acquisition community SE involvement into the requirements process

** Lt Col Mark Wilson, Policy Branch Chief, 19 Oct 07*

SE and Technical Planning in Pre-Program Concept Development



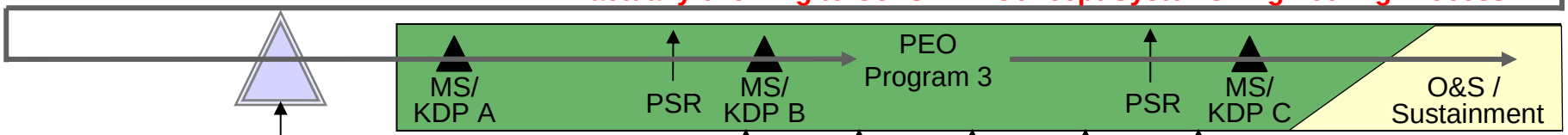
SAF/AQ provides guidance to Product Centers for CDP*, used to decompose needs into requirement sets/concepts

DEFINING THE SOLUTION SPACE

SAF/AQ or Product Center/CC reviews AoA Study Plan prior to MDA approval, to ensure Product Center's technical planning for each concept has been accomplished per their CDP* and documented in a Concept SEP

SAF/AQ provides guidance to SPO Cadre for SEP used during concept maturation

* CDP – ~~Concept Development Process~~
actually evolving to ConSEP – Concept Systems Engineering Process



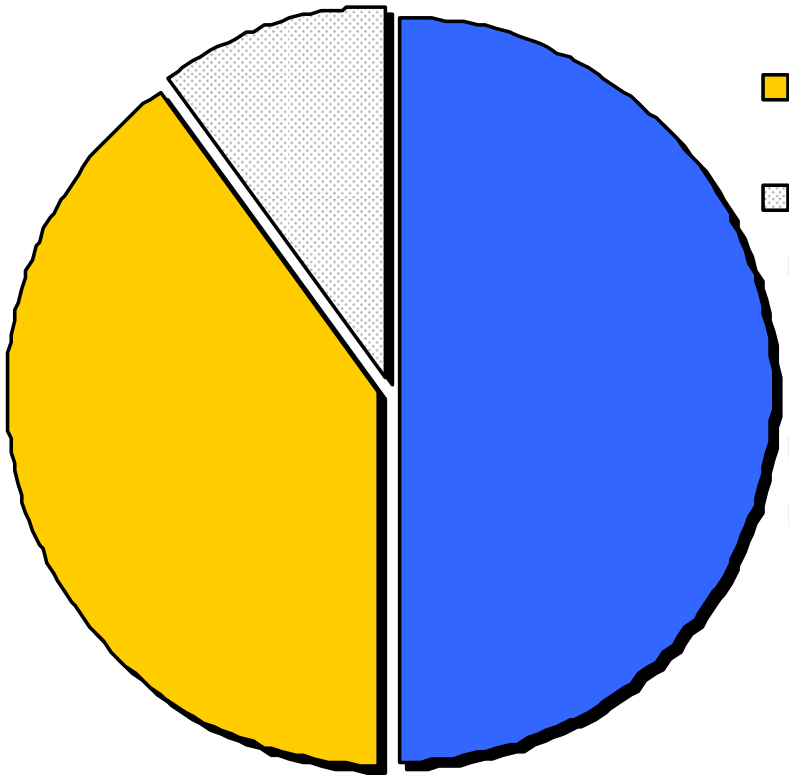
SAF/AQ or Product Center/CC conducts "Concept Technical Review" (~ equivalent to PSR or Sufficiency Review)

SAE provides guidance on SEP and program oversight

Challenges

- Begins with a “R”, rhymes with “forces”
  - Experience “bathtub” (lots of folks with <5 or >20 years, not much in between)
  - Not a very deep bathtub
- Minimize project- and personality-dependent MAJCOM/ COCOM coordination
  - Field users drive most pre-A capability definition efforts in all four domains (air, space, weapons, C2)
  - User community for C2 products is very IT-savvy; things in the IT world tend to happen very quickly
  - Immediate solutions preferred over rigorous process
- Understanding of architecture/SoS concerns
  - Scope is somewhat dependent on domain (more significant for space and C2, less so for aircraft and weapons)
  - Frequent unintended life cycle consequences of “IT now”
- On the plus side, early SE is not broken -- our people are excellent at what they do
  - Above challenges dilute effectiveness

Program Success Factors (it ain't all SE's fault!)



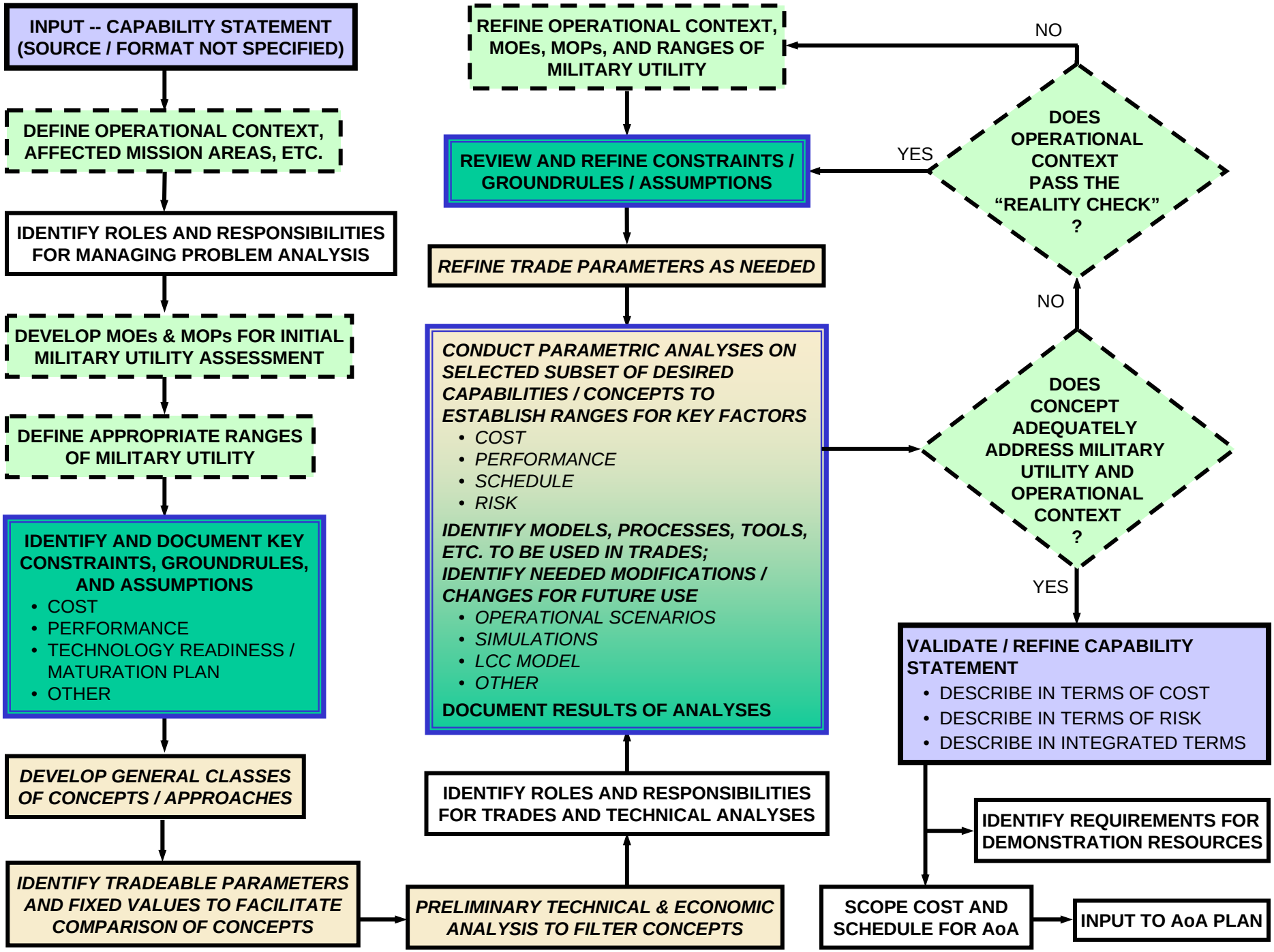
- **"50% Politics" translates to "Nothing happens without an acceptable political compromise"**
- **"40% Budget" … pretty much a fact of life**
- **"10% Technical & Operational Analysis" can appropriately inform (and influence) the other 90% of the trade space**
  - ***If* the right team is engaging with the broader stakeholder community**
  - ***If* those community members are sufficiently objective**
- **Concept Development personnel/ organizations must be politically astute**

Courtesy Chris Leak, ASC/XRS

Way Forward

- Complete SMC, ASC pilot programs
- Socialize draft policy/guidebook throughout AF product centers (in progress)
- Develop forum for 4 product center CD shops to meet/exchange ideas, tools, personnel
- Create more stable funding environment for CD efforts
- Continuing working with OSD and AF Requirements communities on incorporating early SE into broader policy

Backup


INPUT -- CAPABILITY STATEMENT (SOURCE / FORMAT NOT SPECIFIED)
DEFINE OPERATIONAL CONTEXT, AFFECTED MISSION AREAS, ETC.
IDENTIFY ROLES AND RESPONSIBILITIES FOR MANAGING PROBLEM ANALYSIS
DEVELOP MOEs & MOPs FOR INITIAL MILITARY UTILITY ASSESSMENT
DEFINE APPROPRIATE RANGES OF MILITARY UTILITY
IDENTIFY AND DOCUMENT KEY CONSTRAINTS, GROUNDRULES, AND ASSUMPTIONS
• COST
• PERFORMANCE
• TECHNOLOGY READINESS / MATURATION PLAN
• OTHER
DEVELOP GENERAL CLASSES OF CONCEPTS / APPROACHES
IDENTIFY TRADEABLE PARAMETERS AND FIXED VALUES TO FACILITATE COMPARISON OF CONCEPTS
PRELIMINARY TECHNICAL & ECONOMIC ANALYSIS TO FILTER CONCEPTS
IDENTIFY ROLES AND RESPONSIBILITIES FOR TRADES AND TECHNICAL ANALYSES
CONDUCT PARAMETRIC ANALYSES ON SELECTED SUBSET OF DESIRED CAPABILITIES / CONCEPTS TO ESTABLISH RANGES FOR KEY FACTORS
• COST
• PERFORMANCE
• SCHEDULE
• RISK
IDENTIFY MODELS, PROCESSES, TOOLS, ETC. TO BE USED IN TRADES; IDENTIFY NEEDED MODIFICATIONS / CHANGES FOR FUTURE USE
• OPERATIONAL SCENARIOS
• SIMULATIONS
• LCC MODEL
• OTHER
DOCUMENT RESULTS OF ANALYSES
REFINE TRADE PARAMETERS AS NEEDED
REVIEW AND REFINE CONSTRAINTS / GROUNDRULES / ASSUMPTIONS
REFINE OPERATIONAL CONTEXT, MOEs, MOPs, AND RANGES OF MILITARY UTILITY
DOES OPERATIONAL CONTEXT PASS THE "REALITY CHECK" ?
NO
YES
DOES CONCEPT ADEQUATELY ADDRESS MILITARY UTILITY AND OPERATIONAL CONTEXT ?
NO
YES
VALIDATE / REFINE CAPABILITY STATEMENT
• DESCRIBE IN TERMS OF COST
• DESCRIBE IN TERMS OF RISK
• DESCRIBE IN INTEGRATED TERMS
IDENTIFY REQUIREMENTS FOR DEMONSTRATION RESOURCES
SCOPE COST AND SCHEDULE FOR AoA
INPUT TO AoA PLAN