Institute for Defense Analyses
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The Evolving Operational Environment as a Unifying Foundation for Systems Engineering and Acquisition Decision Making

Systemic Approaches to Enhancing SE, DT&E and OT&E in Defense Acquisition

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Context for this Presentation

- Keynote: Lt Gen Scofield , USAF (Ret):
  - Enhancing the Acquisition process:
    - **Adequate understanding of the needed capability**
    - **Foundations for implementation**
    - Clarity in production and sustainment
    - **Enterprise Development Planning**
- Plenary Session 1: Mr. Thompson, DDR&E
  - Two themes:
    - Shorter Timelines
    - **Cognizance of program progress**

•Adequate understanding of the needed capability
•Foundations for implementation
•Enterprise Development Planning
•Cognizance of Program Progress

This Presentation: Systemic Enhancements

This Presentation Objectives and Conditions for Design and Test

Systemic* Categories

*www.ndma.com/resources/ndm1891.htm

Structures: (Organization, Processes & Products)	Culture: (Behavioral Patterns , Habits & Conventions)	Internal Economics:	Methods & Tools:	Metrics & Rewards: (System & Capability Oriented)
Defining **Objectives and Conditions** For SE & T&E	Concepts, Principles & Perspectives for **Objectives and Conditions** For SE & T&E	Facilities (Demand & Supply)	Derivation of **Objectives & Conditions**	Capability (Fielded, OT&E, DT&E & SE Phases)
Design, Test & Evaluation	Education & Training (Design , Test and Evaluation)	Personnel (Demand & Supply)		System Performance & Suitability (Fielded, OT&E, DT&E & SE Phases)
Configuration Management (Test Item)		Services Reimbursement		Design and T&E Processes & Products
Quality Control (Test Item & Test Processes)				
Data (Collection, Reduction & Use)				

Building Effective, Enduring Design and Test Paradigms

Example 1: Anti-ship Cruise Missile (CM) Inadequate SE Conditions

Objective: CM Survives target ship's close-in defensive engagement

Solution: A "Terminal Maneuver" to defeat ship defense system tracking algorithm

Approach to Design & Testing: M&S to support system design changes and to plan test event for terminal "pitch/ roll" maneuver using:

- Detailed, validated model of target ships to determine target RCS aim point
- Validated CM aerodynamics and target tracking/ flight control algorithms (CM designed for long range cruise)

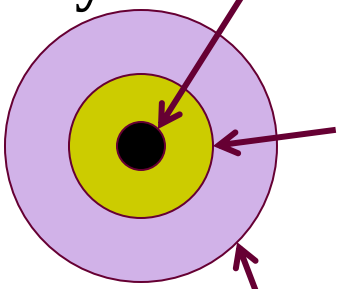
Symptom: CM departed controlled flight in the end-game, missed target, crashed

Cause: **Inadequate derivation of <u>Conditions</u>**: CM target seeker was polarized. *did not consider the*

- Used a two stage design process (culturally motivated)
  - Determine the aim point on the ship, what does the seeker see. Then to the aero-folks for
  - Make the CM maneuver hit the aim point
- **Failed to consider BOTH the "System Design" and Operational kinematics" implications together**
  - *A shift in RCS aim point due to **rolling** polarized seeker's perception of the target.*
  - *while* CM's attempted to maneuver and guide on the shifting RCS aim point => high speed stall

Example 2: Aircraft Self Defense System Design and Test

Desired Capability



Conceptual Depiction

Task Description

•Detect and defend A/C against ground launched IR-guided missiles

Task Performance Standards

•Capable of missile launch identification in any environment
•Low false alarm rate
•Spherical platform coverage
•Capable of jamming all major MANPADS missiles

Conditions: Operational Environment (DOTMLPF)

•Modular LRU configuration
•Capable of installation on nearly all rotary and low- and high-speed fixed-wing aircraft
•All climates, terrains, signature environments

Example 2: Inadequate SE & Test Conditions

- Detection System
  - Design validated (tested) on a **non-moving cable car**
  - Missile detection validated with **missile launches at "one" angle**
  - False alarm rate validated with modeling and simulation (M&S)
    - **Static, unrealistic IR background**

Example 2: Endemic Symptoms Consequences

- Excessive Weight
  - Capable of installation only on **very small number of high value larger rotary-wing platforms**
- Poor Reliability
  - Field revision for **vibration and temperature** variations not previously considered
  - Required substantial number of spares parts to account for **low reliability**
- Inadequate Effectiveness
  - **Limited platform coverage**!
  - **Reduced S/W Threat List to reduce excessive false alarm rate**!

Inadequate Performance and Suitability

Example 3: Endemic Symptoms
It's Not Just a System Problem

Lack of traction in Initiatives intended to enhance effectiveness of T&E

- Testing in Joint Environment (JTEM/CTM)
- VV&A of Test M&S
- Integrated DT/OT
- Design of Experiments (DOE)

SYSTEMICALLY
Why so little traction?
How can it be fixed?

Systemic Concepts: Two Objectives for DT&E

"And Design"

Defense ACQ Guidebook
Sec. 9.3.1
Developmental Test & Evaluation

- "Developmental Test (DT) provides the **verification** and **validation** of the **systems engineering** process and *must **provide confidence that the system design solution is on track to satisfy the desired capabilities**.*"
- "To ensure *that the system engineering verification and validation relates back to user required capabilities*, it is appropriate for government testers to:
- **observe** the contractor testing, conduct additional T&E, and, when appropriate,
- **facilitate early user involvement and contribution in the design and test processes**."

- **Adequate understanding of the needed capability**
- **Foundations for implementation**
- **Enterprise Development Planning**
- **Cognizance of Program Progress**

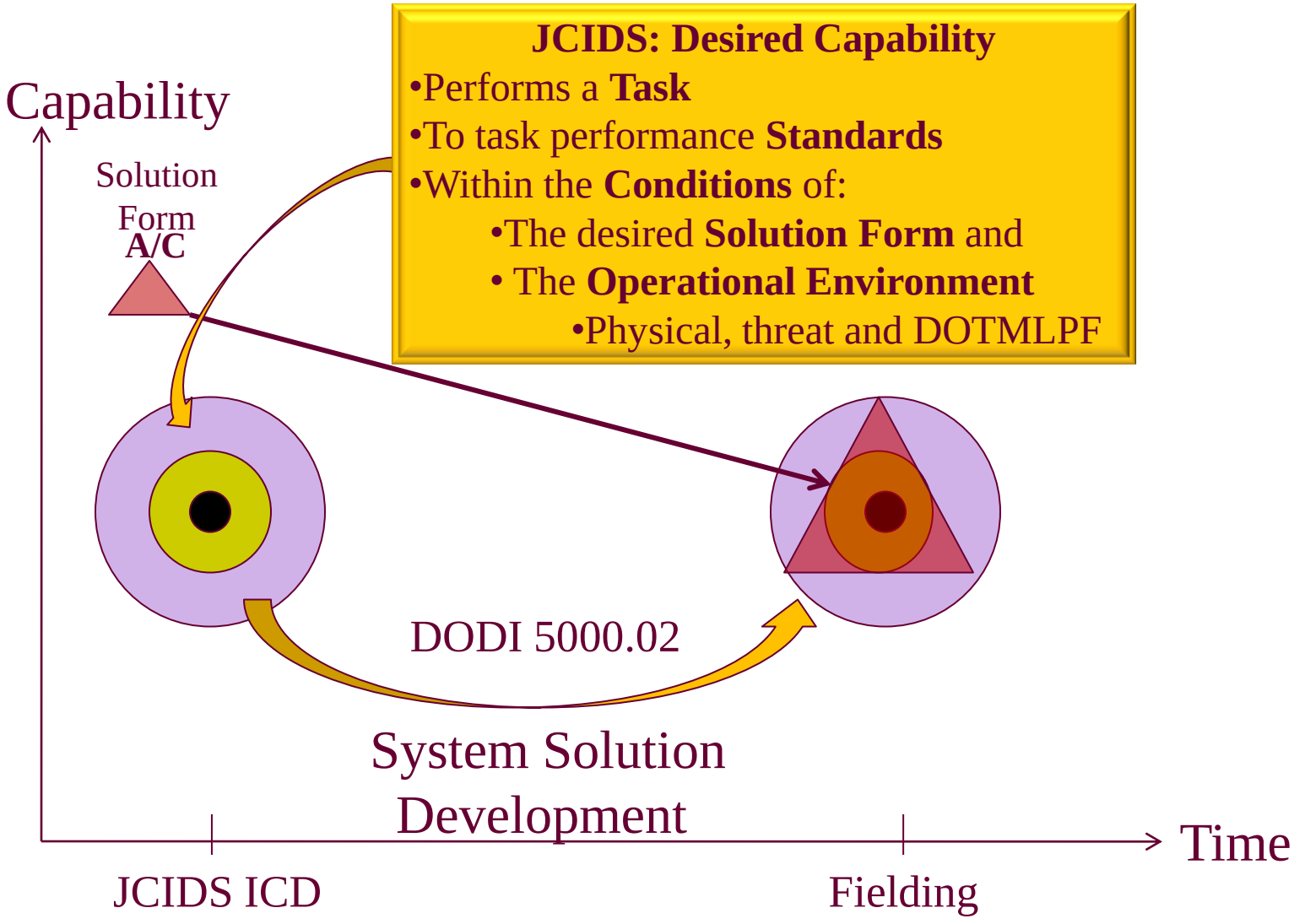
Provide **Verification** of the **systems engineering process** **"System does what it's design intended it to do"**

Test Objectives & Condition relate **performance** to **design** specification

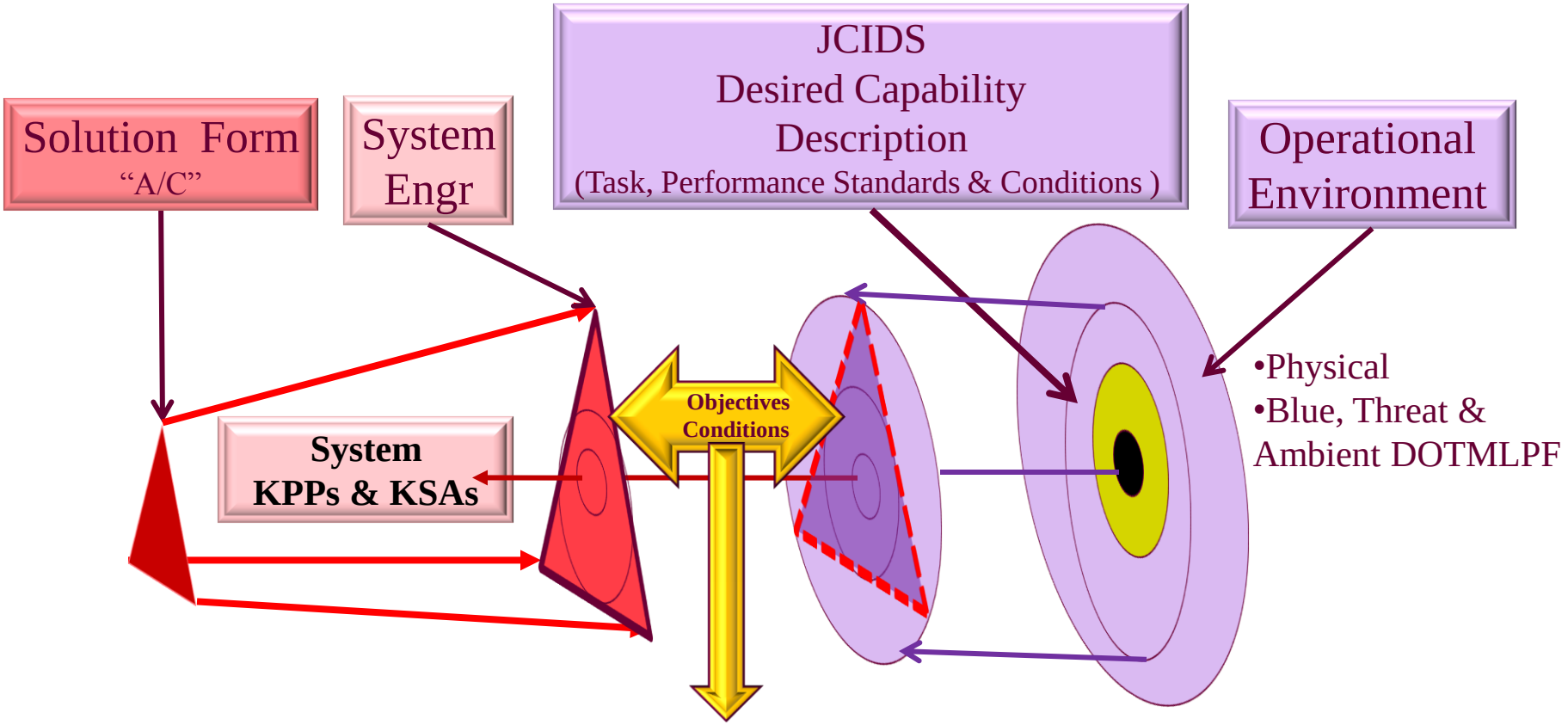
Provide **Validation** of the **systems engineering process** *"provide confidence that the **system design solution is on track to satisfy the desired capabilities"***

Test Objectives & Conditions relate **performance** to the desired **Capability**

Concepts: Solution Design

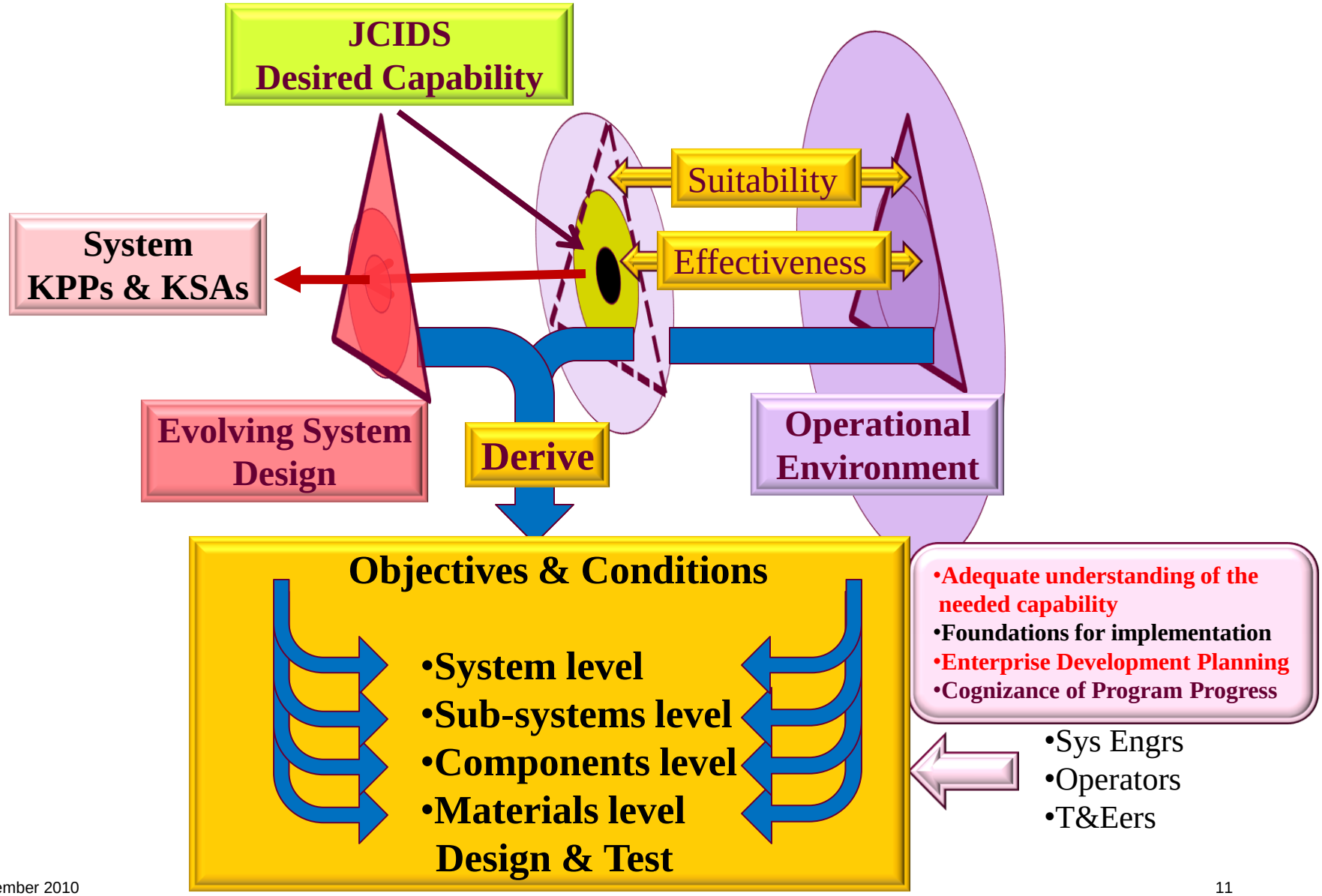


Concepts : Objectives & Conditions for Design and Testing

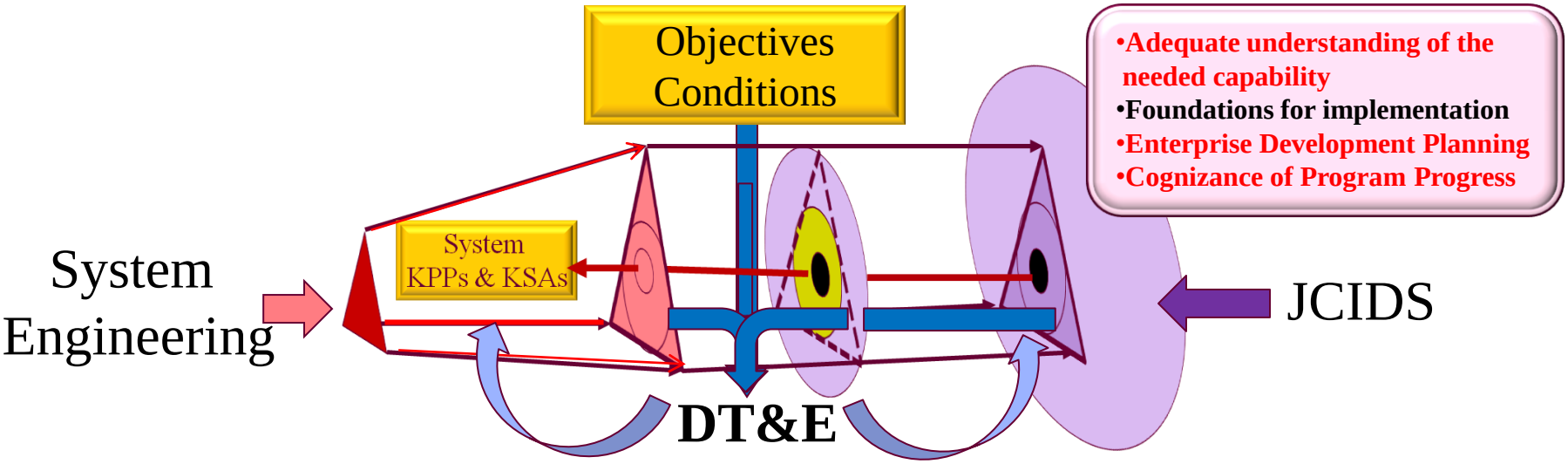


Objectives and Conditions
The devil is in the detail of how the
Design and the **Operational Environment**
interact
to provide the **Desired Capability**

Concept: Deriving Appropriate Test Objectives and Conditions



Concept: Relating System Performance to Desired Capability During Development



Verification
- Of Systems Engineering process
- *"System Works as **designed**"*

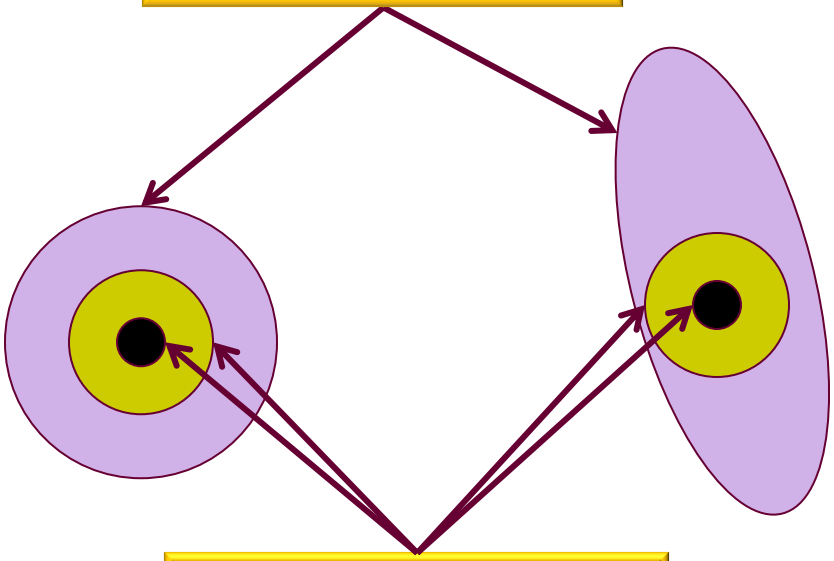
Validation
- Of Systems Engineering process
- *"Provide confidence that the system design solution is on track to satisfy the desired **capabilities**"*

Ensure Test Objectives & Conditions relate system performance to System Engineering **Design**

Ensure Test Objectives & Conditions relate system performance to the **Desired Capability**

Concepts:
The Operational Environment as a Variable

Operational Environment (and perceptions of it) vary and change

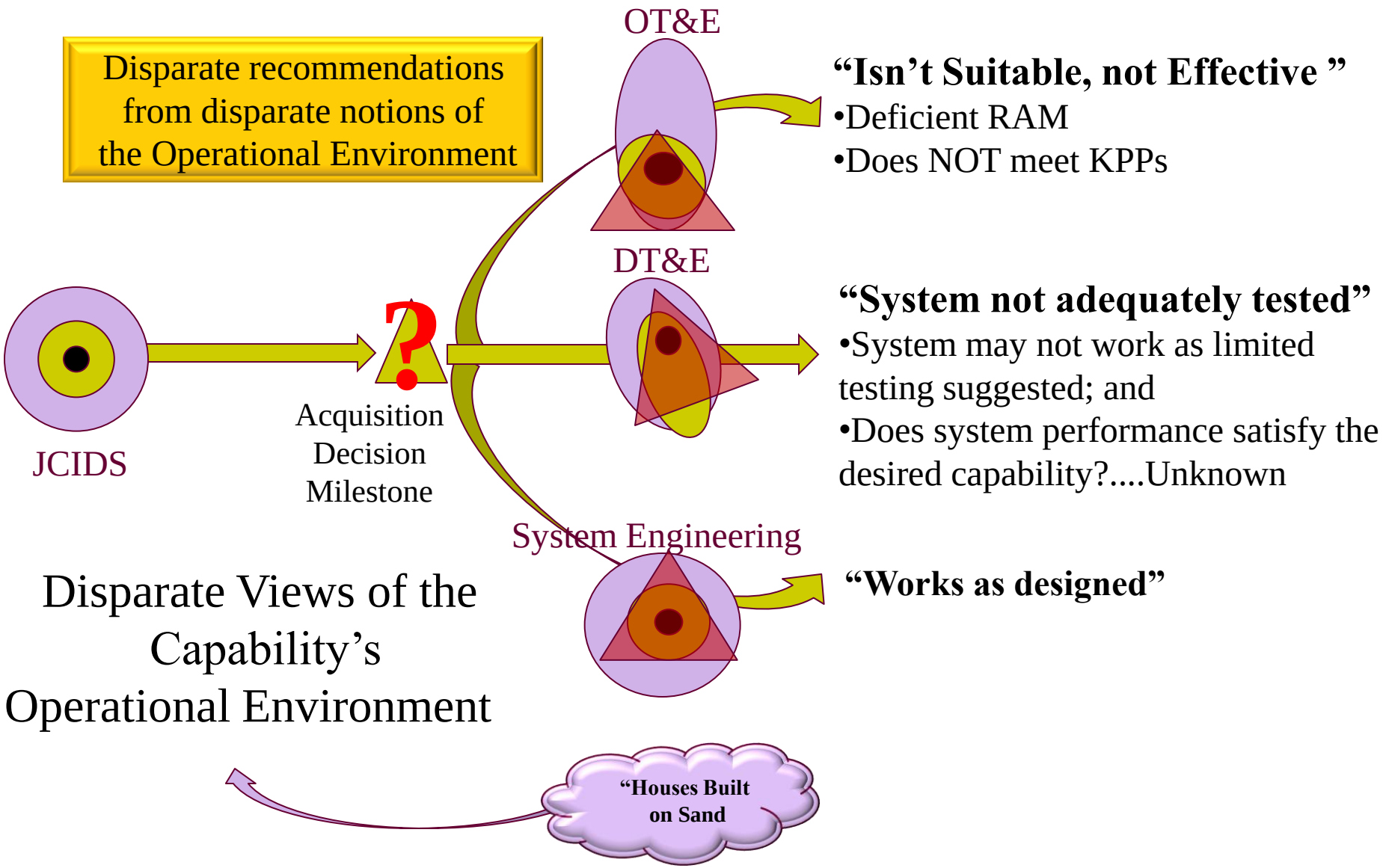


Task and task performance Standards & Conditions may remain unchanged

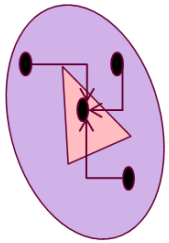
Rationally diverse motivations and perceptions; contribute to **disparate notions** of:
- WHAT in the Operational Environment is important to the design and test of the system, and
- HOW to describe the environment

Disparity in the Objectives and Conditions used for system design, test & evaluation

Symptoms of Systemic Tensions



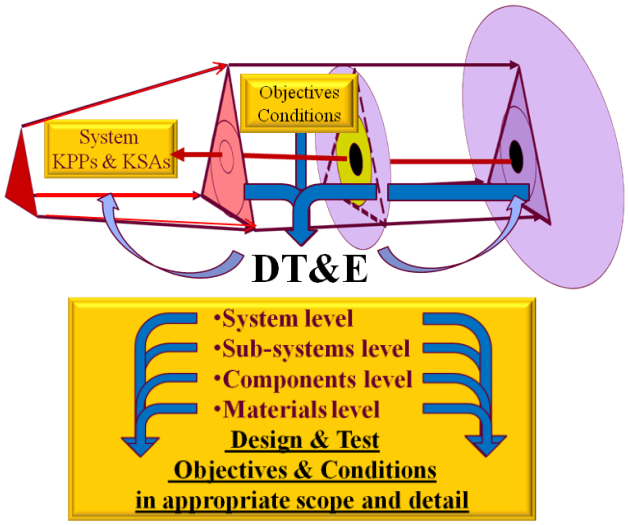
Why No Traction?



OT&E

Testing in Joint Environments (TIJE):

- **Differing perspectives on the Objectives and Conditions appropriate for Testing**
  - **Does not explicitly address the System Design**



M&S: For Acquisition and OT&E

Weak basis for M&S Design, Validation & Accreditation

- M&S tends to depict entities in *the way they would recognize themselves* ***(as blessed by entity owner)***
- Not representing entities in the way *they would interact with the* ***test item***
  - Eg. Model of a Tank signature could be just a *laser spot* –
    - A "valid" representation of the tank---as seen by the the sensor, NOT as the tank PMO sees the tank

Why No Traction?

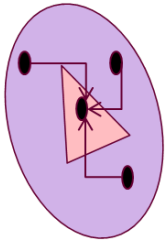
Evaluation-based Testing:

•**No consistent, persistent** analytic **Trade Space in which to** examine alternatives in design, system performance, cost constraints and resulting capability under conditions of the Operational Environment

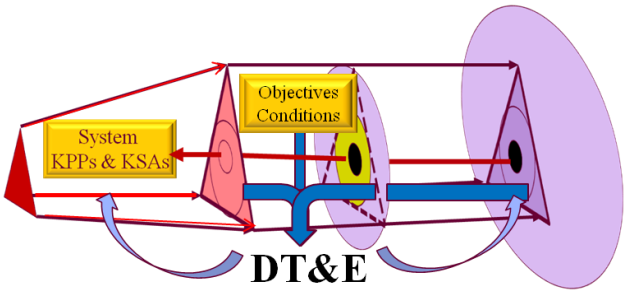
•**No "Baseline" Operational Environment** supporting use or maintenance of a trade space… No common basis for generating or comparing results of alternatives through the evolving development; consequently:

•Failed KPP? –so What?

Why No Traction?



OT&E



DT&E

•System level
•Sub-systems level
•Components level
•Materials level

Design & Test
Objectives & Conditions
in appropriate scope and detail

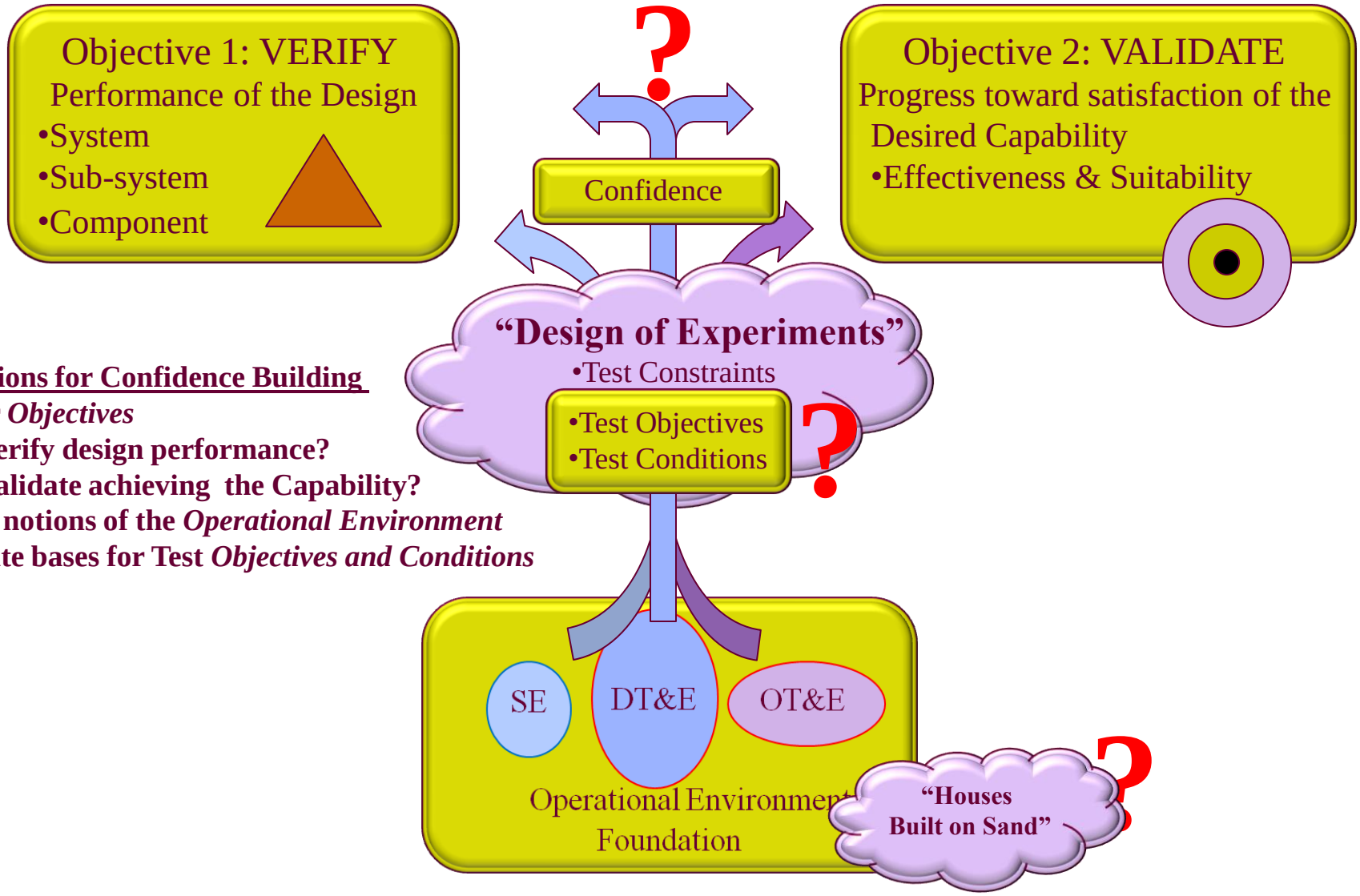
Integrated DT/OT:

Differing perspectives on Objectives and Conditions

- •OT Perspective: Tends to emphasize mission decomposition
  - •The system is a "given"
  - •Ops Environment **imposes** the Test Conditions on the system, sub-systems & components
- •Sys Engr & DT Perspective:
  - •The system Design is a maturing "variable"
  - •Test Objectives and Conditions are derived from the evolving **design's interaction** with the **Ops Environment** to provide the Desired Capability

Integrated DT/OT
A "Realistic" Operational Environment?
•Realistic to whom?
•Realistic for what?

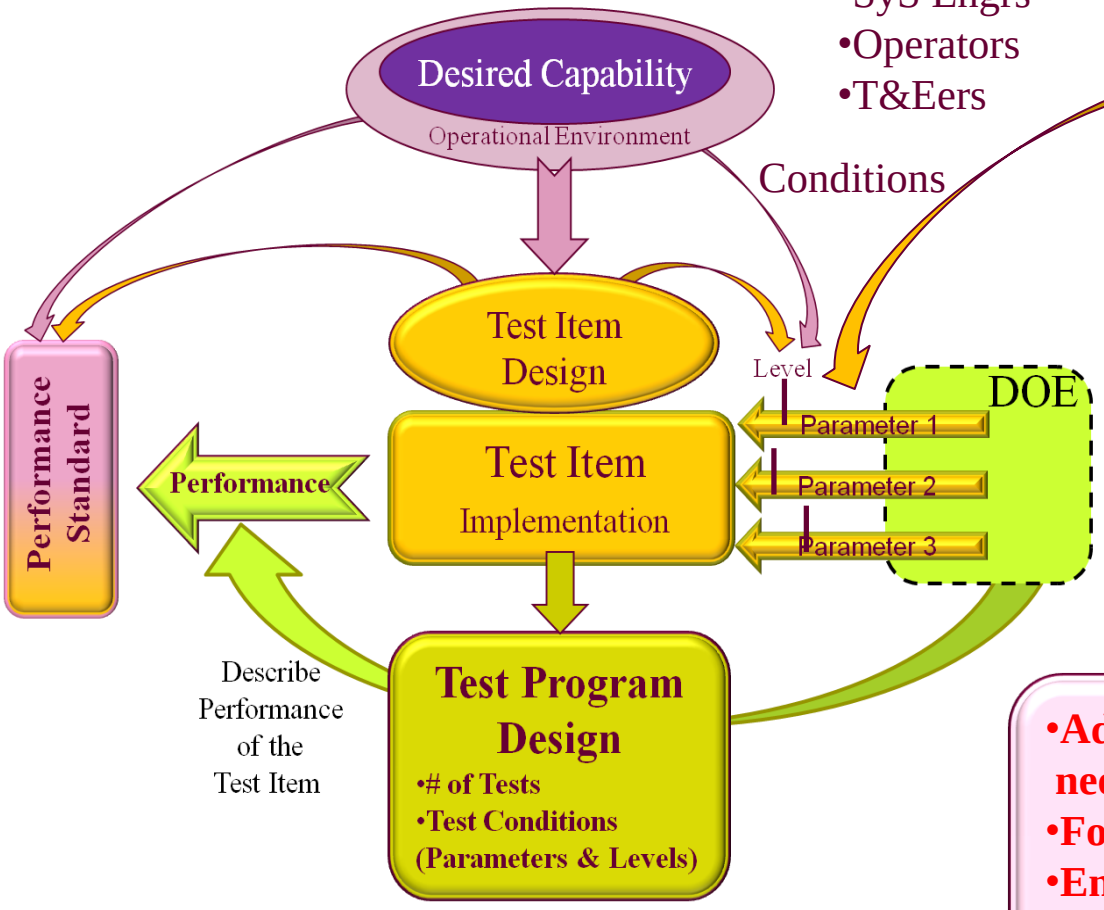
Design of Experiments(?) in Testing
Building Confidence & Understanding Risks



Foundations for Confidence Building

- **Unclear *Objectives***
  - **Verify design performance?**
  - **Validate achieving the Capability?**
- **Diverse notions of the *Operational Environment***
- **Disparate bases for Test *Objectives and Conditions***

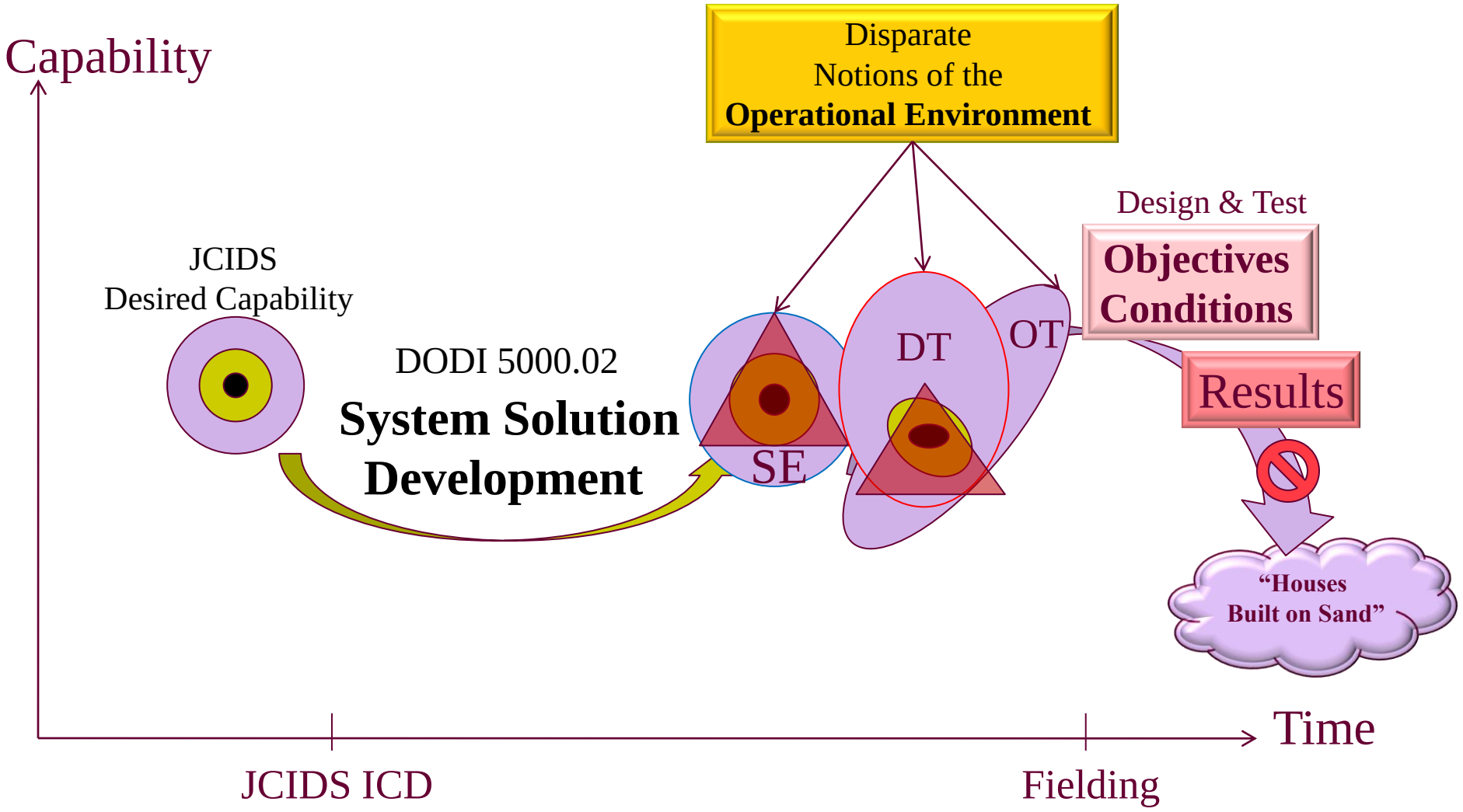
DOE as a "Foundation" for Systems Engineering AND T&E M&S



A Foundation For DOE AND Design and VV&A of M&S Of Conditions For Sys Engr & T&E

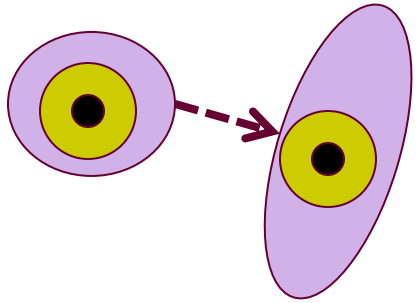
- **Adequate understanding of the needed capability**
- **Foundations for implementation**
- **Enterprise Development Planning**
- **Cognizance of Program Progress**

Foundations: How to Provide A Strong Foundation For Deriving Design and Test Objectives and Conditions?



Systemic Solution Approach: New Guiding Concepts & Processes / New Collaborations

1. Establish an authoritative "Baseline" Operational Environment description for each Capability Solution

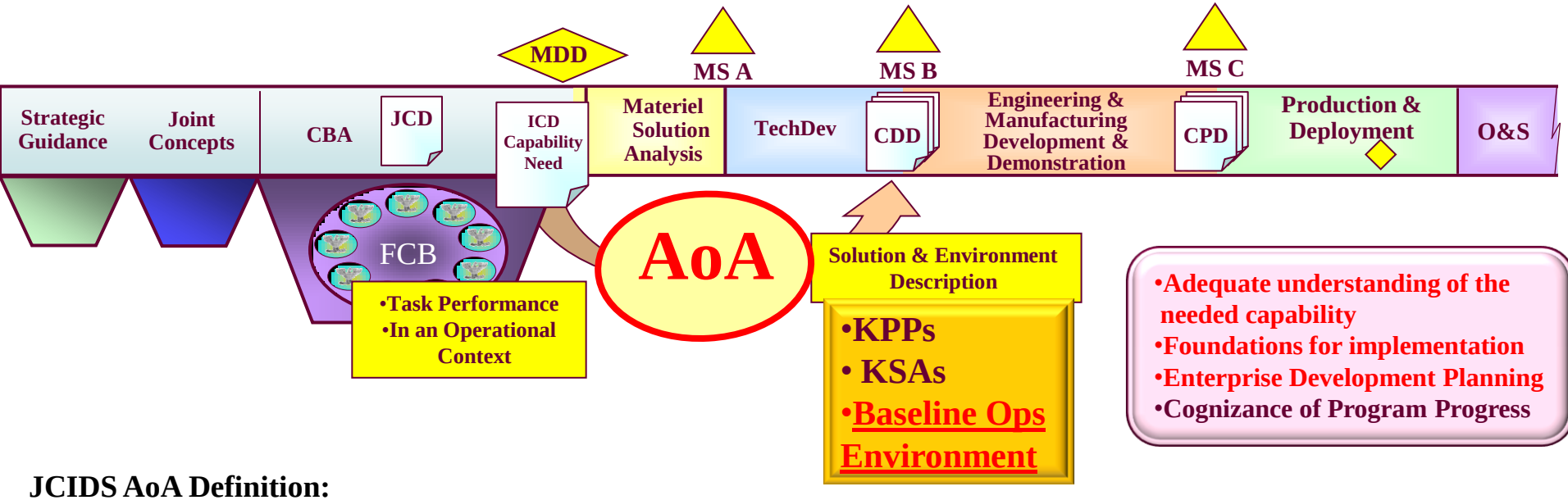


- Speaking with authority for the war fighter
  - Services & COCOM Input (?)
  - JROC Approved (?)
- For use by SE, DT&E, OT&E
  - A common baseline for **deriving** objectives and conditions
    - For use in the SEP, TES, TEMP, Test Plans, System Design, Capability Evaluation, RFPs, Contract Specifications

- **Implementation**
  - Ops Environment is initially in the ICD at the MDD
    - Is already refined and co-evolved with the emerging "Solution Approach" as a component of the AoA and reported in the AoA at MS B
  - Give the AoA Ops Environment description a **Purpose**: "Intended as a foundation for deriving Development Phase Design and Test Objectives and Conditions"
  - Give the AoA Ops Environment description **Authority**: JROC approve the AoA Solution Approach's Description of the Ops Environment with the KPPs and KSAs at MS B
  - Convey the "Baseline" Ops Environment description in System development RFPs
  - **Refine, and JROC approve as appropriate, the Ops Environment description as the System Design matures toward IOT&E and MS C.**

"Baseline" Description of the Capability's Operational Environment

Analysis of Alternatives (AoA)
Translates
A Desired Capability
Into
A "Solution Approach"
(A System Form with Performance Objectives & Conditions)



JCIDS AoA Definition:

"The evaluation of the performance, operational effectiveness, operational suitability, and estimated costs of alternative systems to meet a mission capability. ….The AoA is one of the key inputs to defining the system capabilities in the capability development document"

Systemic Solution Approach: New Oversight/ New Decision Making / New Collaborations

2. Establish oversight to ensure quality of the derivations of KEY Objectives & Conditions from the Capability's baseline Operational Environment

- Ensuring that KEY design and test Objectives and Conditions are appropriately derived "relevant" to:
  - The needed **Capability**
  - The **System Design** and
  - The **Operational Environment**

•SyS Engrs
•Operators
•T&Eers

- **Implementation:**
  - A collaboration among OT&E and AT&L (System Engineering , and DT&E)
  - Revise DODI 5000.02

•Adequate understanding of the needed capability
•Foundations for implementation
•Enterprise Development Planning
•Cognizance of Program Progress

Ensure that Objectives & Conditions are appropriate for KEY system design and testing and ultimately for Satisfying the Desired Capability

Systemic Solution Approach: New Principles, Concepts & Processes

3. <u>Develop Concepts & Guidelines to guide the Derivation of appropriate Objectives & Conditions for system, sub-system, component and materials design & testing</u>

- Relating the **Design**, the desired **Capability** and the **Ops Environment**
- Providing a broader and richer context for deriving appropriate performance Standards and Conditions at all levels of a system's development
- Facilitating effective **verification** of system performance and **validation** of the Systems Engineering process is on track to satisfy the desired capability

- **Implementation:**
  - Defense Acquisition University,
  - Defense Acquisition Guidebook,
  - Others (?)

- **Adequate understanding of the needed capability**
- **Foundations for implementation**
- **Enterprise Development Planning**
- **Cognizance of Program Progress**

4. Provide Methods & Tools for Systems Engineering

- For rapid and agile excursions in the **"Trade Space"** of the ops environment, system **design & engineering**, system **performance**, **suitability,** capability **effectiveness**, and **cost**
- To identify and assess the **implications** of **test results** relative to:
  - System Performance, and
  - Desired Capability
- Answering "So What?" KKP issues
- Supporting Cost driven development of alternative KPPs and KSAs for JROC consideration & approval

•Adequate understanding of the needed capability
•Foundations for implementation
•Enterprise Development Planning
•Cognizance of Program Progress

Systemic Solution Approach: New Principles, Concepts & Processes

5. Provide Methods & Tools for Test & Evaluation

- Identify & explain **Design of Experiments** practices to produce test programs that enhance confidence in test results for use in:
  - **Verification** of system performance & suitability relative to the system Design, and
  - **Validation** that system engineering process is on track to provide the Desired Capability
- Providing a foundation for **VV&A** of M&S
  - For **Sys Engr** and **T&E**

- **Adequate understanding of the needed capability**
- **Foundations for implementation**
- **Enterprise Development Planning**
- **Cognizance of Program Progress**

BACKUP SLIDES

Summary: Systemic Approaches for Enhancing Objectives and Conditions for Design & Testing

APPROACHES

1. Authoritative Operations Environment "Baselines"

2. Appropriate Derivations of Objectives and Conditions that relate Performance to the Desired Capability's Performance Standard for System, Subsystem , and Components for Design, Test and Evaluation

3. SE, DT&E and OT&E Concepts, Guidance, Methods and Tools

ENABLING

Verification of the systems engineering process "System works as designed"

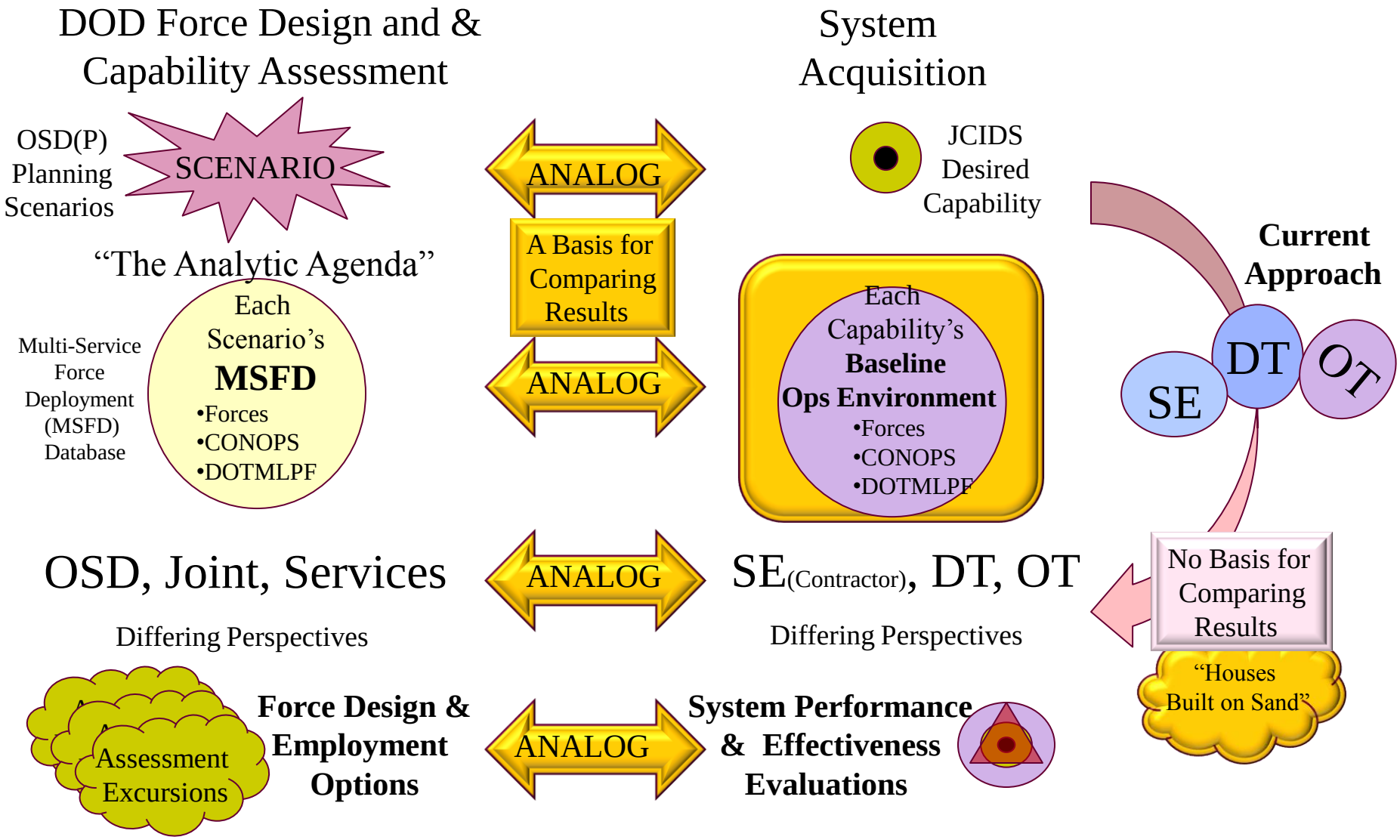
Test Objectives & Condition relate performance to design specifications

Validation of the systems engineering process and *must provide confidence that the system design solution is on track to satisfy the desired capabilities"*

Test Objectives & Conditions relate performance to the desired Capability

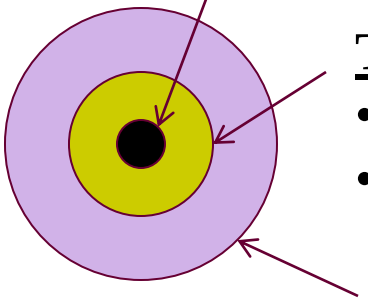
Traction in AT&L Initiatives
- VV&A of M&S
- Testing in Joint Environment
- Evaluation-based Testing
- Integrated DT/OT
- Design of Experiments

An OSD/ Joint Staff Precedent for Baseline Operational Environments



Concepts: A Capability as a Task with Associated Performance Standards & Operational Conditions

Capability = Task + Task Performance Standards + Conditions



Task Description

• Kill a hardened target

Task Performance Standards

•Pk xx%

•All weather, within xx minute of detection

Conditions: Operational Environment

•Threat: Order of Battle and Modes of Operation

•Physical: Climate, Terrain

•DOTMLPF:

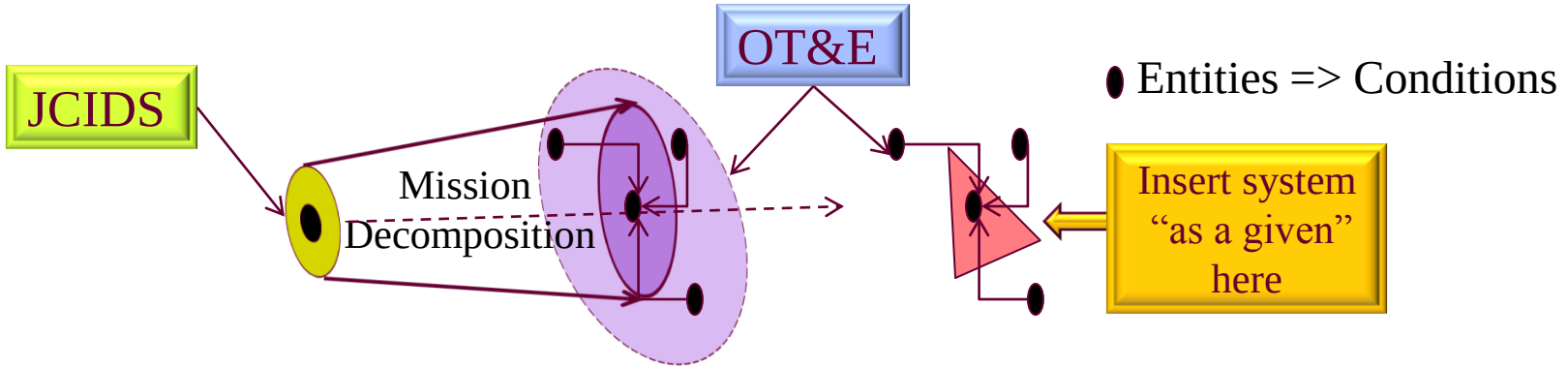
- Forces, Organization & C2 structure
- Logistics process, etc

•Desired "Form" of the Solution (A/C, MSL, truck, etc)

A "Conceptual" Depiction

Concept: Comparison of OT&E and Developmental Perspectives on Test Conditions

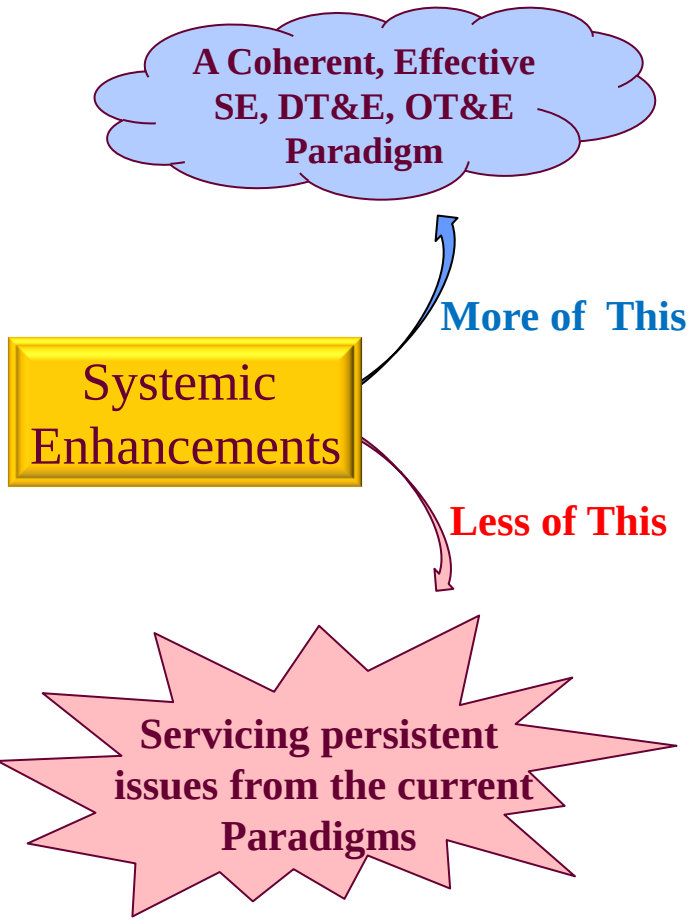
OT&E view for deriving Conditions tends toward a *mission decomposition* perspective which identifies **operational entities** (C2, threat, maintenance, etc) that interact with and affect the system's performance of the Desired Capability



OT&E view is "Necessary" but not "Sufficient" for deriving Effectiveness AND Suitability Objectives and Conditions for the sub-systems or component levels during System development and testing

- Design and Test Objectives and Conditions at those levels can change with the **evolving design**

Systemic v.s. Symptomatic Approaches



Systemic Approaches:

"Correcting conditions that cause persistent issues"

- Cultures, Structures, Internal Economics, Methods & Tools, Metrics & Rewards (www.ndma.com/resources/ndm1891.htm)
- Modes of change:
  - New guiding perspectives, principles, concepts
  - New processes and products
  - New Collaborations with new organizations on new challenges

Symptomatic Approaches:

"Reacting to recurring issues as they emerge"

- Low Reliability, inadequate testing, etc
- Performance arguments among processes
  - Inadequate testing
  - Inventing Requirements
- Routinely broken schedules and resources
  - Nunn-McCurdy cost breaches
  - Delayed Milestone Decisions

Example: A Systemic Challenge

"RAM deficiencies are endemic with big-ticket U.S. weapon systems, a problem that drives up operating and sustaining costs for ships, aircraft, and ground systems"

"Restoring Affordability and Productivity"

DOT&E to DUSD/AT&L: June 2010

Endemic Problem: RAM Deficiencies

Correction: Systemic "Process" Changes

- Implement **Configuration Management** (CM) and **Quality Control** (QC)
  - Provide the processes to identify, understand and resolve the sources of failure in the Reliability, Availability, Maintainability (RAM) relationship