AIA 2007 Spring Product Support Conference

"Systems Engineering for Product Support"

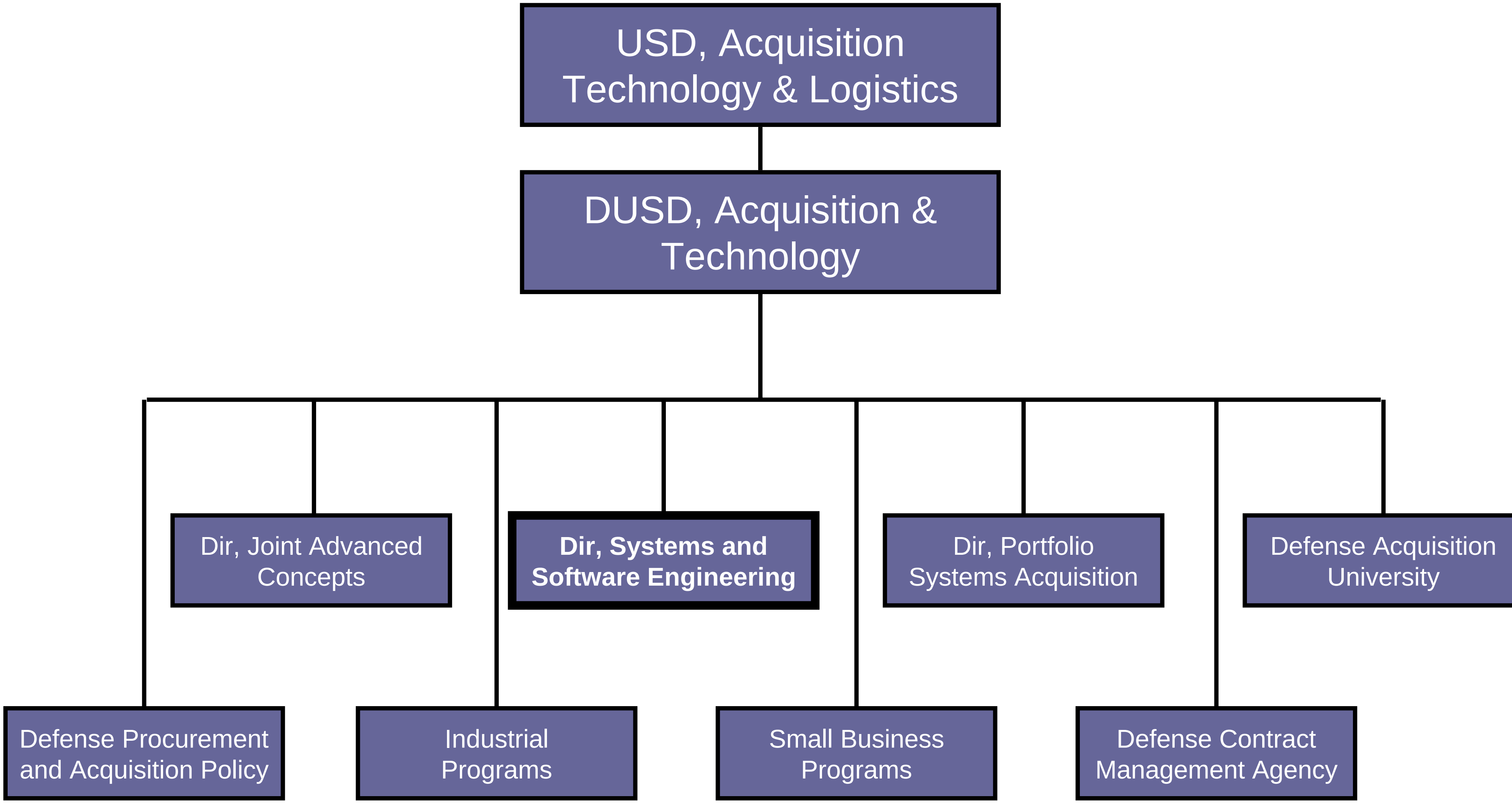
May 8, 2007

Mark D. Schaeffer

Director, Systems and Software Engineering

Office of the Deputy Under Secretary of Defense (A&T)

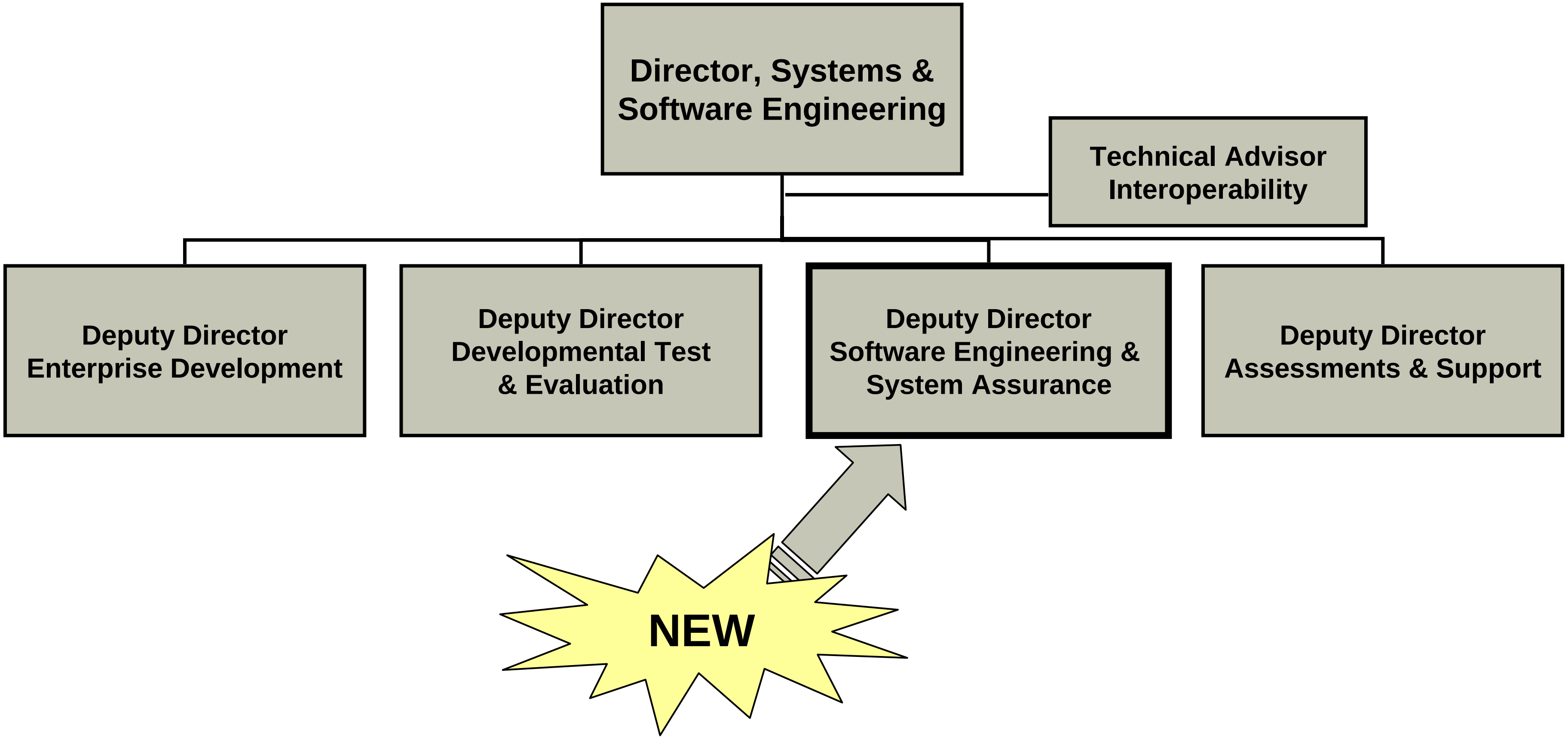
OUSD (AT&L) Organization



Flatter, Leaner, Empowered!

Systems and Software Engineering

An Organizational Construct



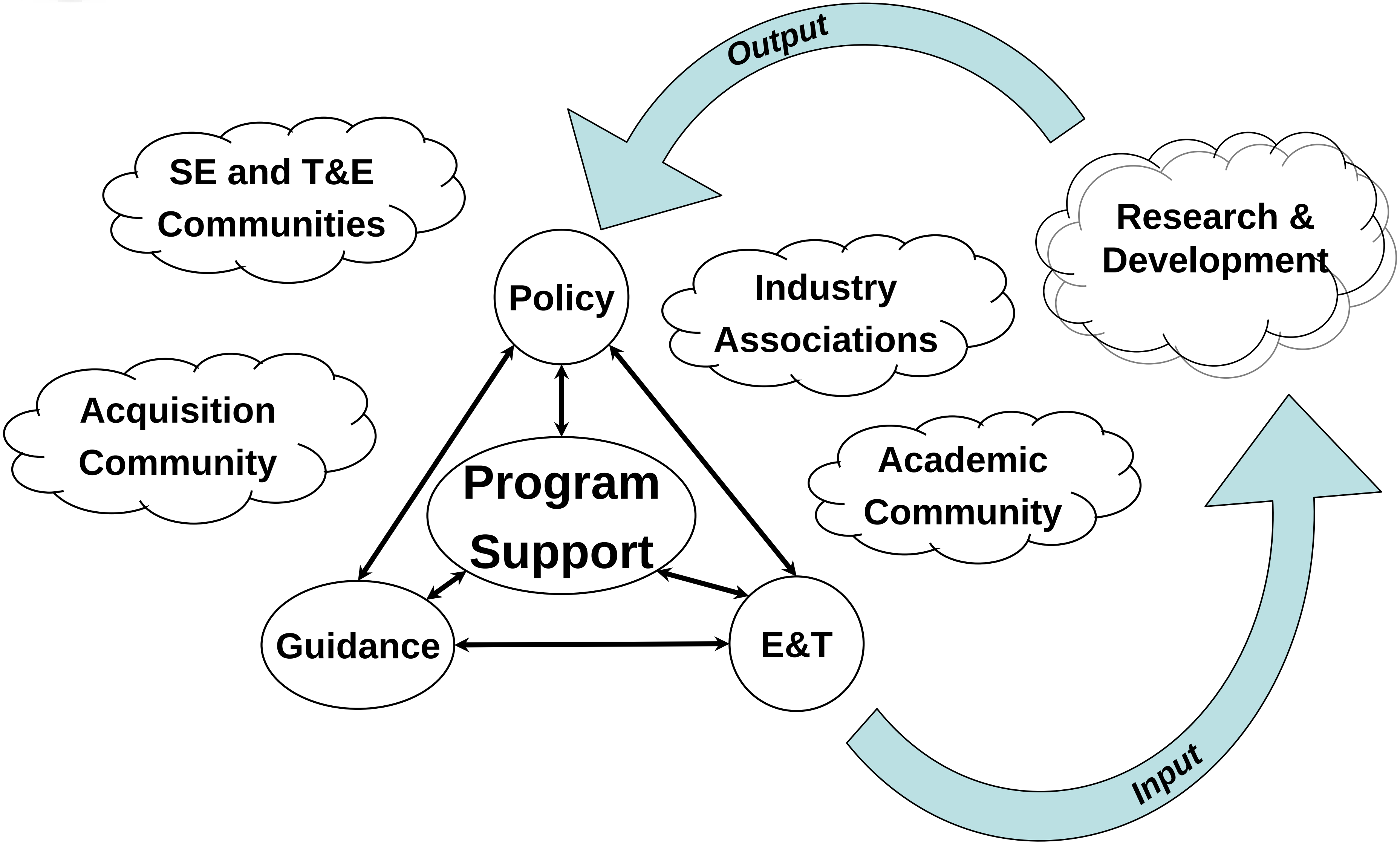
Management Visibility – Best Practices – Acquisition Excellence

Systems and Software Engineering Mission Statement

- Shape acquisition solutions and promote early technical planning
- Promote the application of sound systems and software engineering, developmental test and evaluation, and related technical disciplines across the Department's acquisition community and programs
- Raise awareness of the importance of effective systems engineering and drive the state-of-the-practice into program planning and execution
- Establish policy, guidance, best practices, education, and training in collaboration with academia, industry, and government communities
- Provide technical insight to program managers and leadership to support decision making

Evolving System Engineering Challenges

Systems Engineering Revitalization Cycle



Systems Engineering Revitalization Effort

- Issued Department-wide Systems Engineering (SE) policy
- Integrating developmental testing, software/system assurance and system of systems considerations into SE revitalization efforts—focusing on effective, early engagement of all – sound technical planning
- Instituting a renewed emphasis on modeling & simulation in acquisition
- Working with Defense Acquisition University to revise and update engineering, test curricula and evaluation and software as well as supported disciplines to include technical considerations
- Leverage close working relationships with industry and academia
- Instituted system-level Program Support Reviews in support of executive-level decisions and in support of programs

Much Accomplished – Much to Do!

Driving Technical Rigor Back into Programs "Portfolio Challenge"

- Systems and Software Engineering have been tasked to:
  - Review program's SE Plan (SEP) and T&E Master Plan (TEMP)
  - Conduct PSRs
- Portfolio of major acquisition programs, supporting 10 Domain Areas:
  - Business Systems (3%)
  - Space Systems (7%)
  - C2ISR Systems (10%)
  - Fixed Wing Aircraft (22%)
  - Unmanned Systems (2%)
  - Rotary Wing Aircraft (22%)
  - Land Systems (17%)
  - Ships (7%)
  - Munitions (3%)
  - Missiles (7%)

and Software

Systems Engineering and T&E Support to Over 150 Major Programs in 10 Domain Areas

Driving Technical Rigor Back Into Programs "Program Support Reviews"

- Program Support Reviews (PSR) provide insight into a program's technical execution focusing on:

In RFP and Contract

Adequate Staff and Tools

  - SE as envisioned in program's technical planning
  - T&E as captured in verification and validation strategy
  - Risk management - integrated, effective and resourced
  - Quantifiable milestone exit criteria as captured in Acquisition Decision Memo
  - Acquisition strategy as captured in Acquisition Strategy Report

- Independent, cross-functional view aimed at providing risk-reduction recommendations

The PSR reduces risk in the technical and programmatic execution on a program

Top 10 Emerging Systemic Issues

1. Management	• IPT roles, responsibilities, authority, poor communication • Inexperienced staff, lack of technical expertise
2. Requirements	• Creep/stability • Tangible, measurable, testable
3. Systems Engineering	• Lack of a rigorous approach, technical expertise • Process compliance
4. Staffing	• Inadequate Government program office staff
5. Acquisition Strategy	• Competing budget priorities, schedule-driven • Contracting issues, poor technical assumptions
6. Schedule	• Realism, compression
7. Test Planning	• Breadth, depth, resources
8. Software	• **Architecture, design/development discipline** • **Staffing/skill levels, organizational competency (process)**
9. Maintainability/Logistics	• Sustainment costs not fully considered (short-sighted) • Supportability considerations traded
10. Reliability	• Ambitious growth curves, unrealistic requirements • Inadequate “test time” for statistical calculations

Major contributors to poor program performance

Software Engineering Issues for Consideration

- Requirements growth 10X (% functionality and program content) 1960s – Present*
- Impact of requirements upon software is not consistently quantified and managed in development or sustainment**
- Software life-cycle planning and management by acquirers and suppliers is ineffective**
- Quantity and quality of software engineering expertise is insufficient to meet the demands of government and the defense industry**
- Traditional software verification techniques are costly and ineffective for dealing with the scale and complexity of modern systems**
- Failure to assure correct, predictable, safe, secure execution of complex software in distributed environments**
- Inadequate attention given to total lifecycle issues for COTS/NDI impacts on lifecycle cost and risk**

Effectively Addressing Software Issues Overdue

**** CSIS Software Industrial Base Study***

***** NDIA Top SW Issues meeting, Aug 06***

DoD Software -- What We're Seeing*

- Software systemic issues are significant contributors to poor program execution
  - Software requirements not well defined, traceable, testable
  - Immature architectures, COTS integration, interoperability, obsolescence (electronics/hardware refresh)
  - Software development processes not institutionalized, planning documents missing or incomplete, reuse strategies inconsistent
  - Software test/evaluation lacking rigor and breadth
  - Schedule realism (compressed, overlapping)
  - Lessons learned not incorporated into successive builds
  - Software risks/metrics not well defined, managed

*Based on ~65 program reviews to date

Elements of a DoD Strategy for Software

- Established Directorate focused on software/system assurance
- Support Acquisition Success
  - Ensure effective and efficient software solutions across the acquisition spectrum of systems, SoS and capability portfolios
- Improve the State-of-the-Practice of Software Engineering
  - Advocate and lead software initiatives to improve the state-of-the-practices through transition of tools, techniques, etc.
- Leadership, Outreach and Advocacy
  - Implement at Department and National levels, a strategic plan for meeting Defense software requirements
- Foster Software Resources to meet DoD needs
  - Enable the US and global capability to meet Department software needs, in an assured and responsive manner

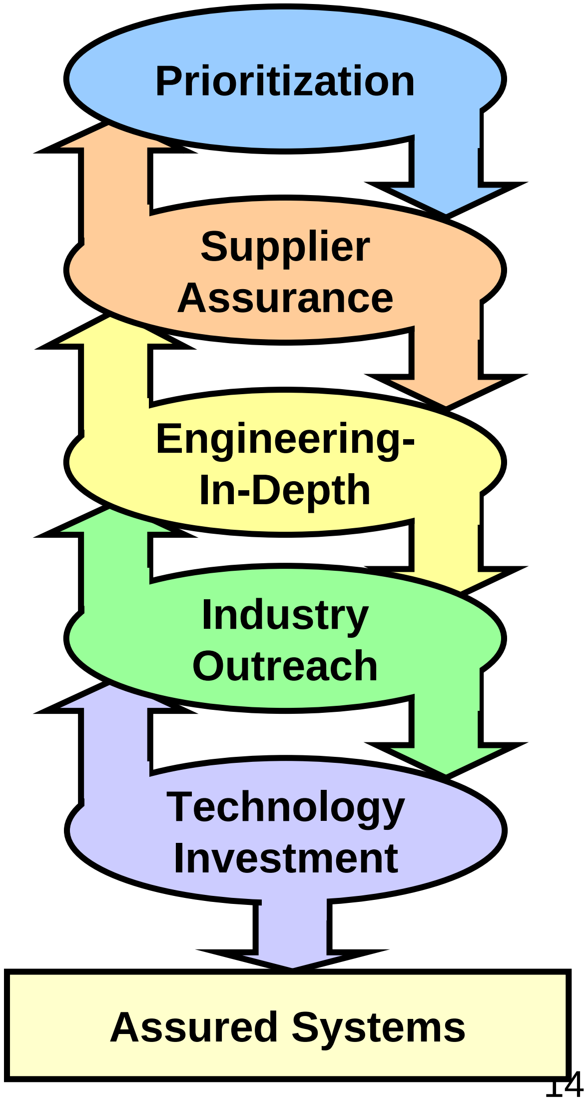
Promote World-Class Leadership for Defense Software Engineering

System Assurance

- Definition: *Level of confidence* that a system functions as intended, is free of exploitable vulnerabilities, and protects critical program information
- The Problem:
  - Growing system complexity makes vulnerabilities* much more difficult to discover and mitigate
    - *Inserted with malicious intent through supply chain opportunity, or
    - *Unintentional vulnerabilities that can be exploited
  - Commercial components are desirable, but
    - Risks inherent due to globalization
    - Difficulty in verification of COTS products
  - Numerous assurance, protection and safety initiatives that are not well aligned
    - Anti-tamper, software & hardware assurance, information assurance…

What Does Success Look Like?

- The requirement for assurance is allocated among the right systems and their critical components
- DoD understands its supply chain risks
- DoD systems are designed and sustained at a known level of assurance
- Commercial sector shares ownership and builds assured products
- Technology investment transforms the ability to detect and mitigate system vulnerabilities



Software Supportability – an Area for Attention

- NDIA Top 7 Software Issues Report (Aug 06) identifies sustainment as an issue
  - Inadequate attention to COTS/NDI sustainment issues impacts lifecycle cost and risk
- We must acquire software with supportability in mind
  - Source code requirements, along with documentation
  - Ensure bi-directional traceability of requirements to design and test documentation
  - Software production baseline (est. by software physical configuration audit)
- Sustainment activity must be subject to equivalent security and assurance practices, and introduce no new vulnerabilities
  - We typically pay attention to the development environment
- Growing complexity of software creates growing requirement for software sustainment
  - We currently cannot support the totality of software sustainment needs
  - How can we quantify the impacts?

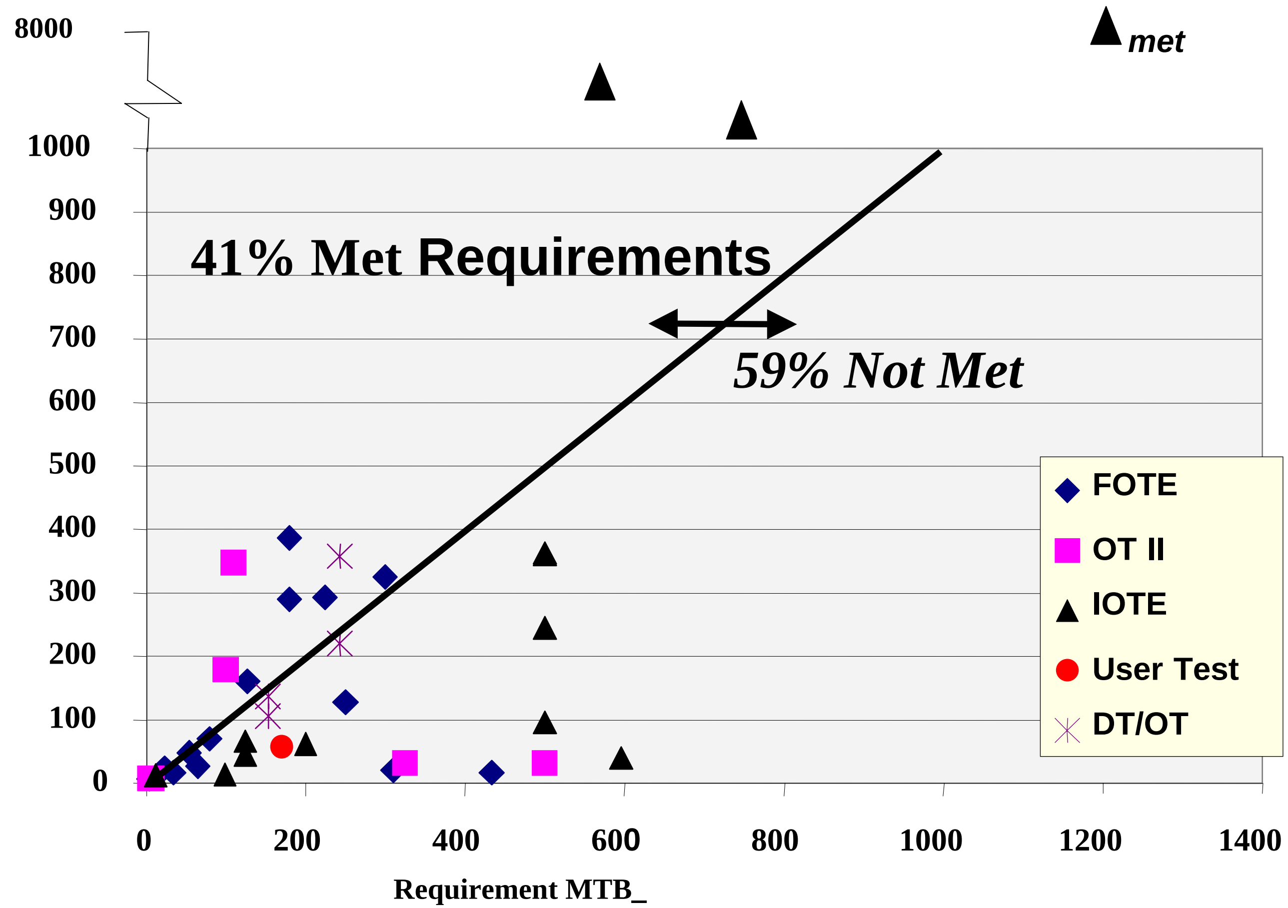
Inadequate attention to software sustainment early in the lifecycle

Top 10 Emerging Systemic Issues

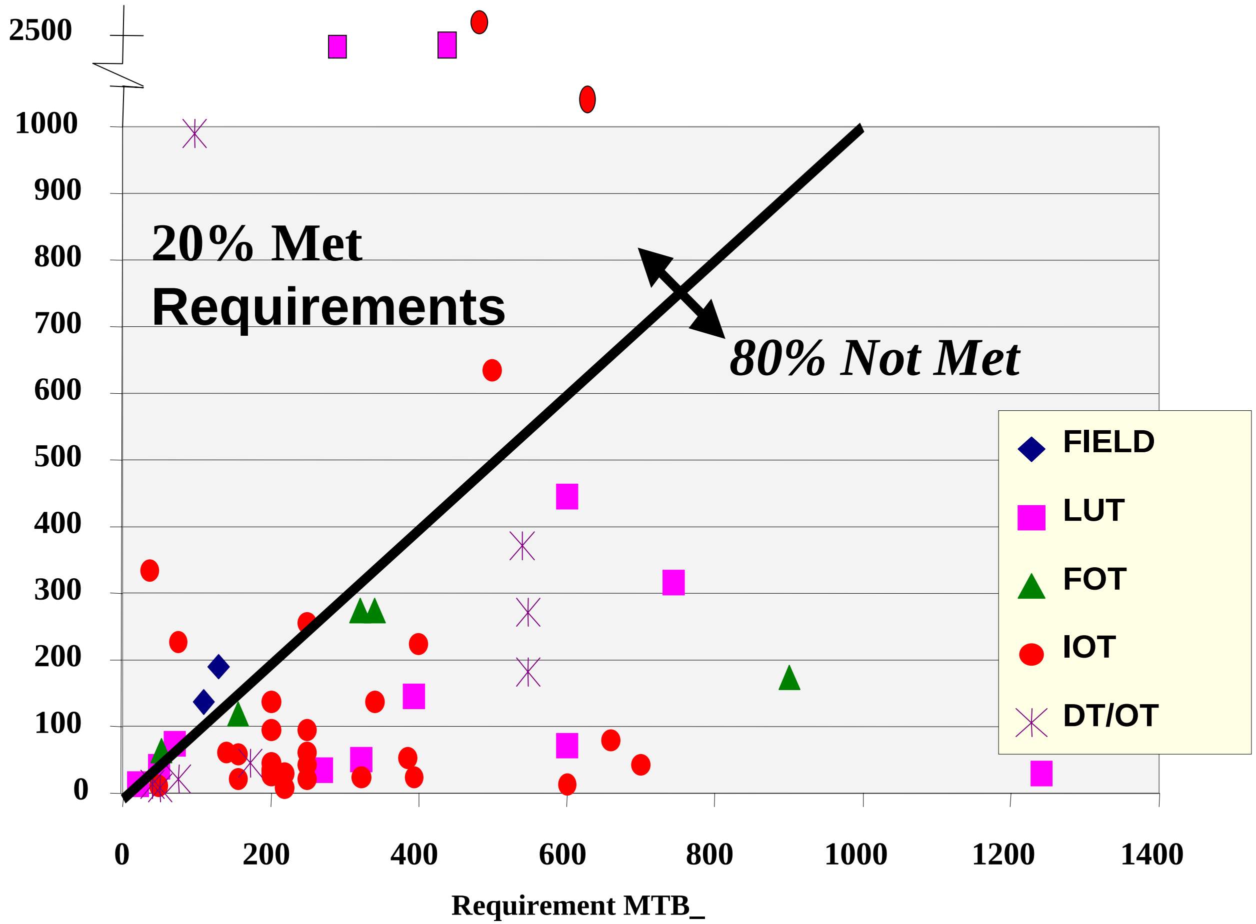
1. Management	• IPT roles, responsibilities, authority, poor communication • Inexperienced staff, lack of technical expertise
2. Requirements	• Creep/stability • Tangible, measurable, testable
3. Systems Engineering	• Lack of a rigorous approach, technical expertise • Process compliance
4. Staffing	• Inadequate Government program office staff
5. Acquisition Strategy	• Competing budget priorities, schedule-driven • Contracting issues, poor technical assumptions
6. Schedule	• Realism, compression
7. Test Planning	• Breadth, depth, resources
8. Software	• Architecture, design/development discipline • Staffing/skill levels, organizational competency (process)
9. Maintainability/Logistics	• **Sustainment costs not fully considered (short-sighted)** • **Supportability considerations traded**
10. Reliability	• **Ambitious growth curves, unrealistic requirements** • **Inadequate “test time” for statistical calculations**

Major contributors to poor program performance

Reliability Trends
1985-1990



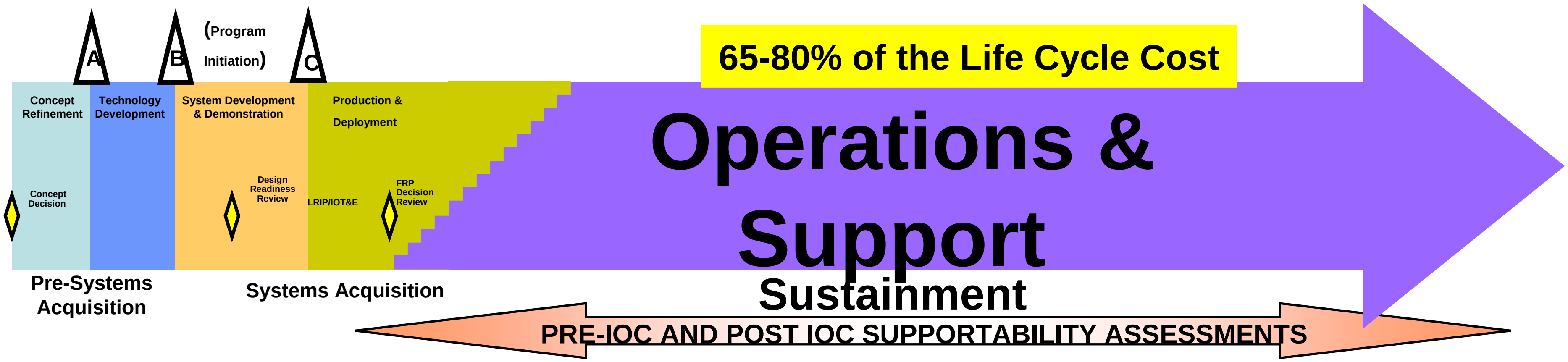
Reliability Trends
1996-2000

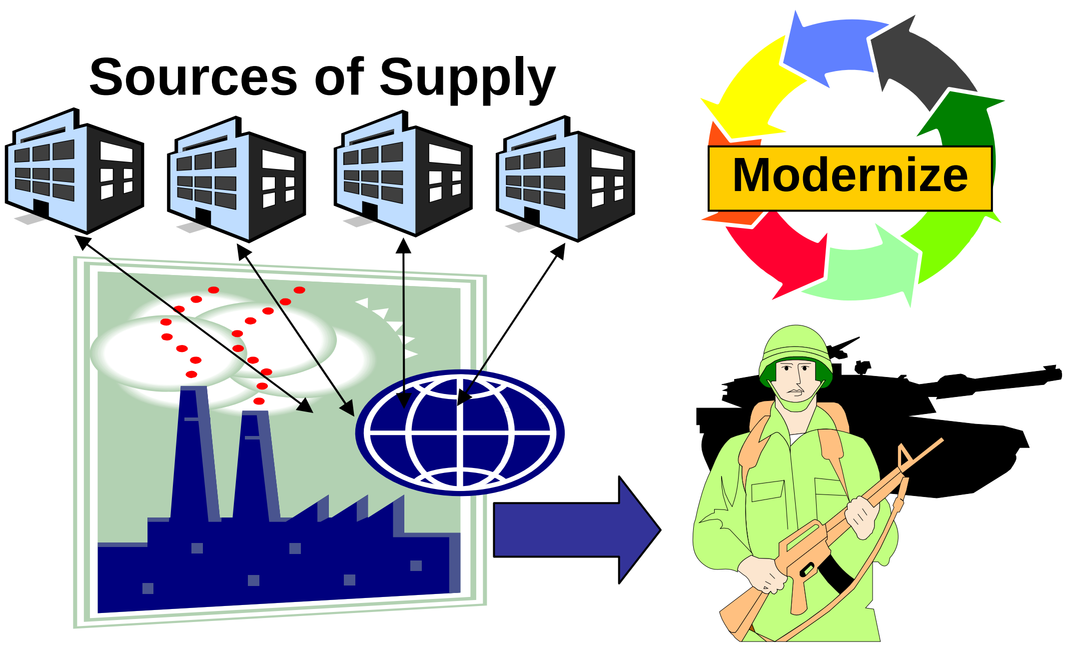


Program Support Reviews
Representative Reliability Issues

- Requirements in ORD/CDD
  - Arbitrary values for Reliability Availability Maintainability (RAM) requirements
  - In some programs, failure to identify mission context or intended use profile
  - Failure to identify when reliability values are required (reliability and availability maturation points)
  - Failure in M&S to ensure harmony between reliability, availability, maintainability, and supportability characteristics
  - Failure to appreciate stochastic character of RAM and hence suitably consider statistical confidence issues
- Reliability Growth Program
  - Underestimating difficulty and resources to achieve/sustain reliability growth
  - Lack of proper planning, managing, and executing reliability growth activities
  - Program test design incompatible with reliability growth program aspects
  - Reliability growth program not funded throughout
  - Failure to consider correct use conditions/environment for reliability test

Materiel Readiness Life Cycle Framework from the Warfighter View





Sustaining the System

- *Ready Available Safe Assets*
  - *24/7 Availability*
- Reliability & Maintainability
- Affordable Weapon Systems
- Obsolescence/Tech Refresh
- Reduced Footprint
- Logistics Chain Reliability
- Logistics Chain Effectiveness
- Logistics Chain Cycle Time
- Retrograde Management
- Production Flexibility

Way Ahead
Policy

- What we've done:
  - Added sustainment as KPP
    - Materiel Availability (KPP): measures percentage of the entire population capable of performing an identified mission
    - Materiel Reliability (KSA): measures confidence an operational, ready end item will successfully complete its mission without a critical failure when tasked
    - Ownership Cost (KSA): measures what it costs to sustain a system after it is placed in service
  - Draft language for DoDI 5000.2 "fact of life" update:
    - Life-Cycle Sustainment (LCS) Plan as part of Acq Strategy (required at MS B/C)
    - Consideration of life-cycle sustainment during Concept Refinement and Technology Development phases
    - Provisions for a data management strategy for re-competition (statute)
    - Requirement for configuration management approach documented in SE Plan
    - Corrosion Prevention Control Plan at MS B and C
    - Consolidation of existing AT&L policy memoranda for AIT, UID, ATS
- What's next:
  - Require a LCS strategy at MS A
  - Consolidate and amplify existing LCS policies into an enclosure during fall 2007 revision of DoDI 5000.2

Way Ahead
Guidance

➢ What we've done:

- Defense Acquisition Guidebook
  - Revised Ch 5 to emphasize LCS by acquisition phase
  - Emphasized LCS and performance-based logistics as part of SE process (Ch 4)
- Reliability, Availability, Maintainability (RAM) Guide
  - Model for improving RAM management and technical processes
  - What can be done to achieve satisfactory levels of RAM and successfully demonstrate RAM levels during test and evaluation

➢ What's next:

- Update Defense Acquisition Guidebook Ch 5 to define contents of new LCS Plan
- Update Defense Acquisition Guidebook Chs 4 and 5 to reflect new SE and LCS policies

Way Ahead
Education & Training

➢ What we've done:

- DAU Continuous Learning Modules
  - Reliability, Availability, Maintainability
  - Diminishing Manufacturing Sources & Material Shortages
  - Designing for Supportability
  - Technical Planning
  - Technical Reviews
- Emphasized early, upfront life-cycle planning in new DAU Systems Engineering courses (SYS 101, 202, 203, 302)

➢ What's next:

- Update DAU LOG and PMT courses to reflect new LCS policies

Need to shift culture towards more upfront, early life-cycle sustainment planning

Initiatives for Strategic & Tactical Excellence

STRATEGIC
"Big A"

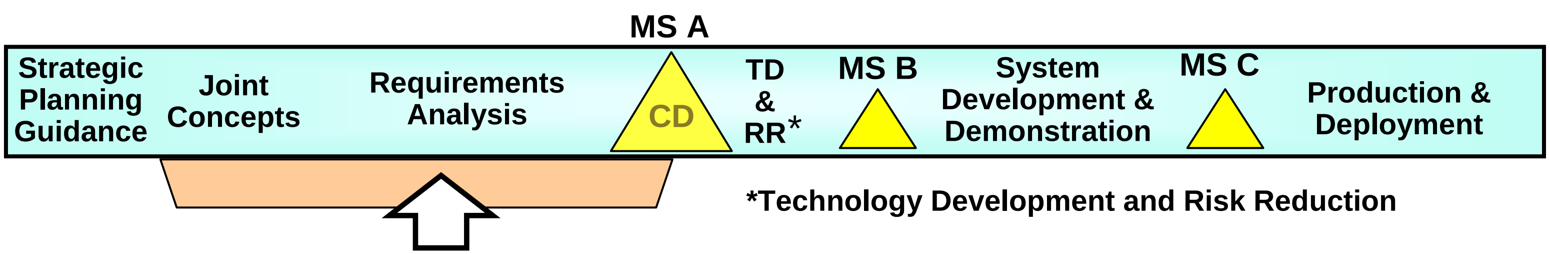
"Little A"
TACTICAL

OBJECTIVES	INITIATIVES
Affordable, Feasible Investments	➢ Concept Decision / Evaluation of Alternatives / Milestone A ➢ Strategic Sourcing (Services)
Making Decisions that Balance the Trade-Space	Tri-Chair Investment Balance Reviews
Starting Programs Right • **Improved, Up-Front Planning** • **Awareness of Risk / Improved Source Selection** • **More Responsive Acquisition Solutions**	➢ **DAB / OIPT Process Optimization** ➢ **Risk-Based Source Selection** ➢ **Time-Defined Acquisition** ➢ **Acquisition of Services Policy** ➢ **Systems Engineering** ➢ **Award Fee and Incentives**
Program Stability • No Downstream Surprises • Issue Awareness	➢ Restructured DAES ➢ Program Baseline Assurance ➢ Capital Accounts

Improving the Full Range of Acquisition Policy

Make Decisions that Balance the Trade Space
Early Lifecycle Planning

- Early lifecycle involvement of Systems Engineering to:
  - Inform evaluation of alternatives with technical insights
  - Ensure solutions balance requirements with technical feasibility
  - Ensure solutions can be validated and verified
  - Use Modeling & Simulation to help refine warfighter concept of operations/system requirements, evaluate design alternatives, and identify potential technology/human interface constraints
- Appropriate resourcing (personnel/funding) required
- Include in requirements, specifications, and contracts



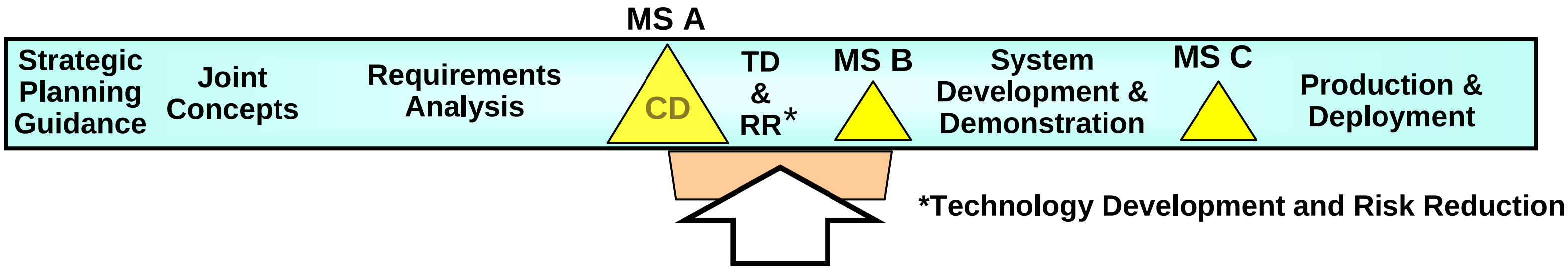
Sustainment must be included up front and early

Structuring Programs Right
Early Lifecycle Planning

Topic	Systems Engineering	Test & Evaluation	Risk Management	Exit Criteria	Acquisition Strategy
Focus Areas	Operational Requirements	V&V Traceability	Risk Drivers	Draft KPPs/KSAs	CONOPS
	Budget/ Schedule Realism	Test Resources	Risk Analysis	ROM Cost & Schedule	Bounded Solution
	Technical Planning &Trades	Parametric Models	Technology Maturity	TRL	Technology Base
	Technical Constraints	M&S	Risk Planning	EOA	Risk Reduction
	System of Systems Integration	Joint/Interop Test Planning	Program/ System Dependency	SoS Architecture	Incremental Strategy
Product	Concept SEP	TES	Risk Mitigation Strategy	Phase Exit Criteria	Draft RFP, ASR

Starting Programs Right – System Level

- System Level
  - Application of System Engineering principles contributes to successful program execution
  - Leverage System Engineering relationship to cost, schedule, and performance
  - Ensure enabling disciplines are in concert with technical planning
- Ensuring program and milestone reviews are informed by technical planning, verification and validation, and complementary business rules



Structuring Programs Right – System Level

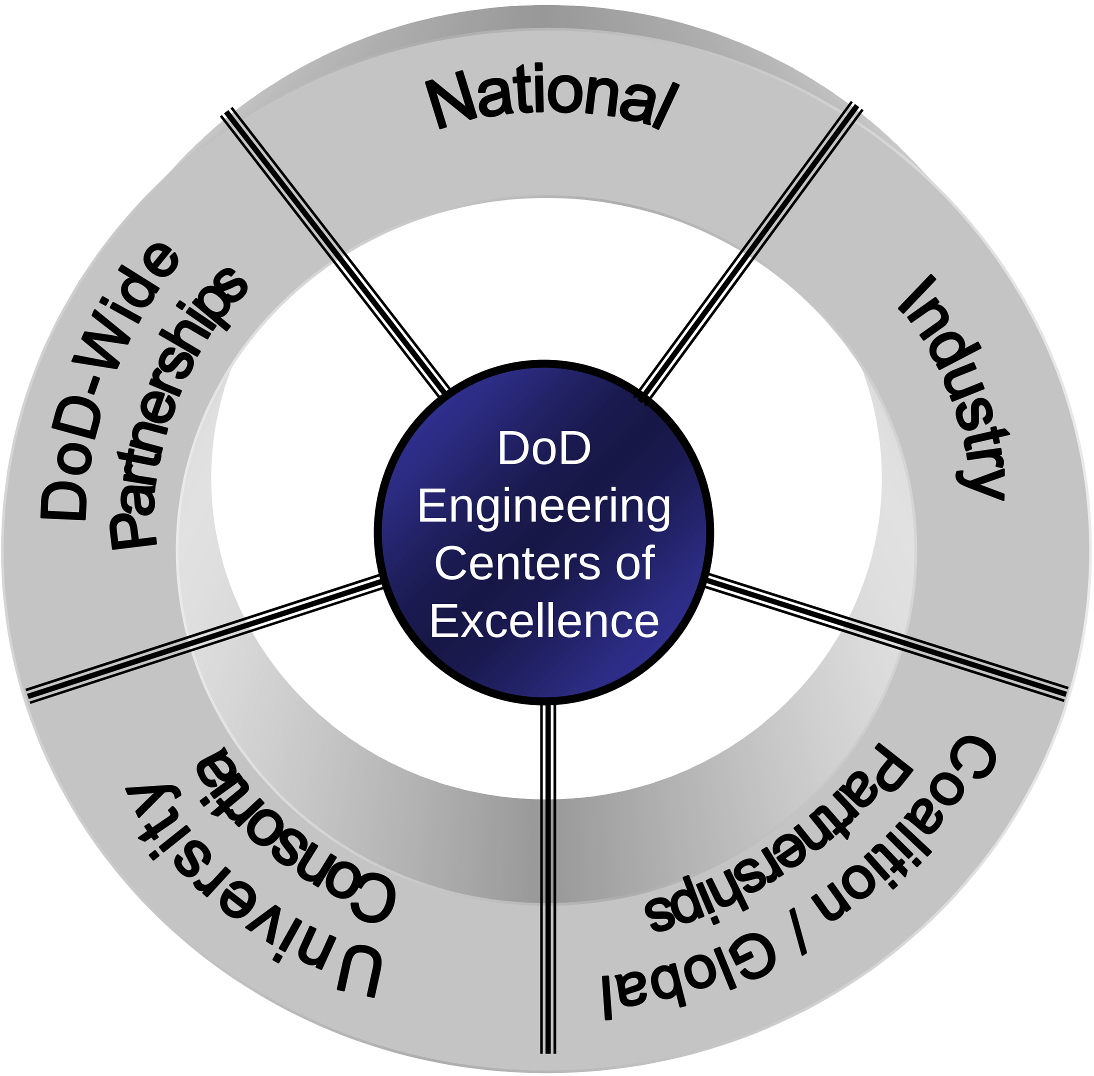
Topic	Systems Engineering	Test & Evaluation	Risk Management	Exit Criteria	Acquisition Strategy
Focus Areas	System Requirements	V&V Traceability	Risk ID	Thresholds & Objectives	KPPs/KSAs
	Organization & Staffing	Test Resources	Risk Analysis	Life Cycle Cost	Defined Budget & Schedule
	Technical Reviews	Test Articles	Risk Mitigation Planning	Technical Maturity Level	Industrial Base
	Technical Baseline	Evaluation	Risk Tracking	Material Readiness	Development & Demonstration
	Linkage w/ Other Program Mgmt & Controls	Linkage w/ Other Program Mgmt & Controls	Program/ System Dependency	Net Centric	Risk-based Source Selection
Product	SEP	TEMP	RM Plan	Phase Exit Criteria	Contract Scope, ASR

Bottom Line

- Reliability, availability, maintainability not insignificant—RAM matters for both hardware and software
  - 60-80% of life-cycle cost is “operations & support”
- Shortsighted sustainment focus--can’t keep trading it away
- Renewed emphasis on life-cycle sustainment pre-Milestone A—start programs right
- Big part of SE revitalization efforts
  - Policy, Guidance, Education & Training
- But SE can’t do it all…L&MR needs to continue to champion sustainment metrics

Can’t afford not to do this!

Many Challenges…
How do we get there?

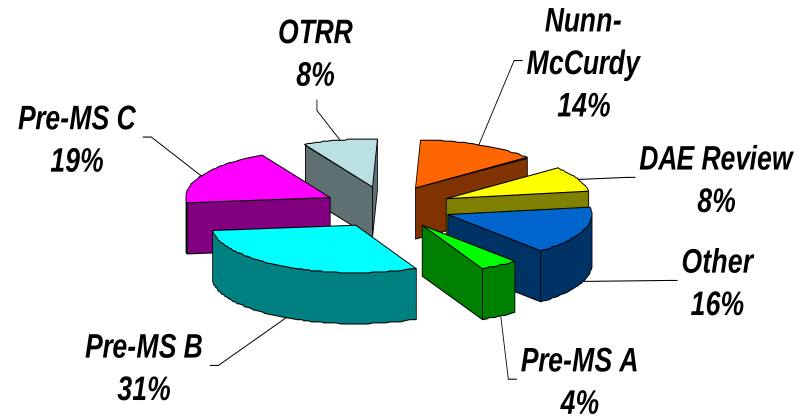


Program Support Review Activity

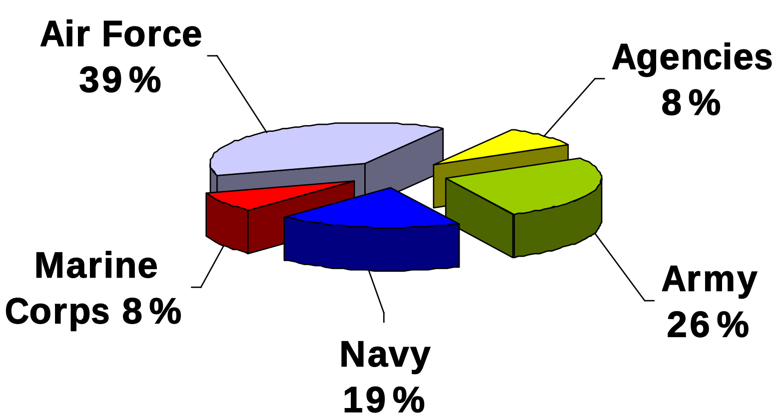
(since March 2004)

- PSRs/NARs completed: 42
- AOTRs completed: 10
- Nunn-McCurdy Certification: 10
- Participation on Service-led IRTs: 2
- Technical Reviews: 9
- Reviews planned for FY07:
  - PSRs/NARs: 10
  - AOTRs: 1
  - Nunn-McCurdy: 6

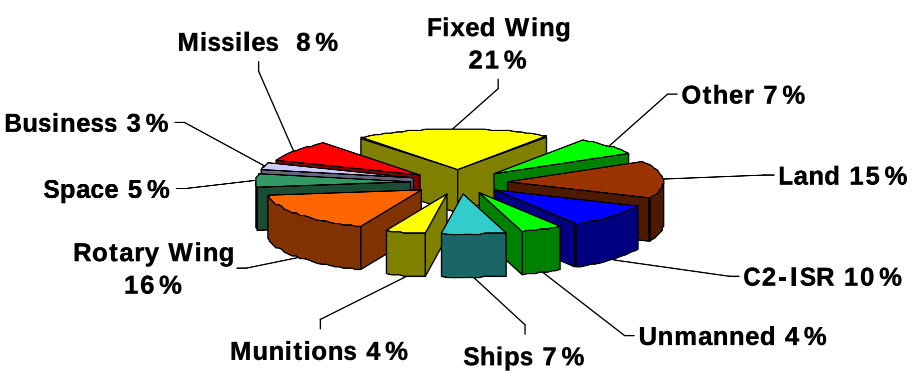
Decision Support Reviews



Service-Managed Acquisitions



Programs by Domain Area



As of 4 May 07

Approved Sustainment KPP and Mandatory KSAs

- Single KPP:
  - <u>Materiel Availability:</u> measures percentage of the entire population capable of performing an identified mission

    Requires both system design and sustainment approach to be addressed: Reliability, Maintainability, Service Life, Sustainment Strategy, Preventative Maintenance, Diagnostics, Supply Chain, Distribution, Transportation
- Mandatory KSAs:
  - <u>Materiel Reliability:</u> measures confidence an operational, ready end item will successfully complete its mission without a critical failure when tasked
  - <u>Ownership Cost:</u> measures what it costs to sustain a system after it is placed in service
- Goals:
  - Correct number of operational end items capable of performing the mission when needed
  - Confidence systems will perform the mission and return home safely without failure
  - Cost balance: solutions cannot result in availability and reliability “at any cost”