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"*The Revitalization of Systems Engineering within DoD*"

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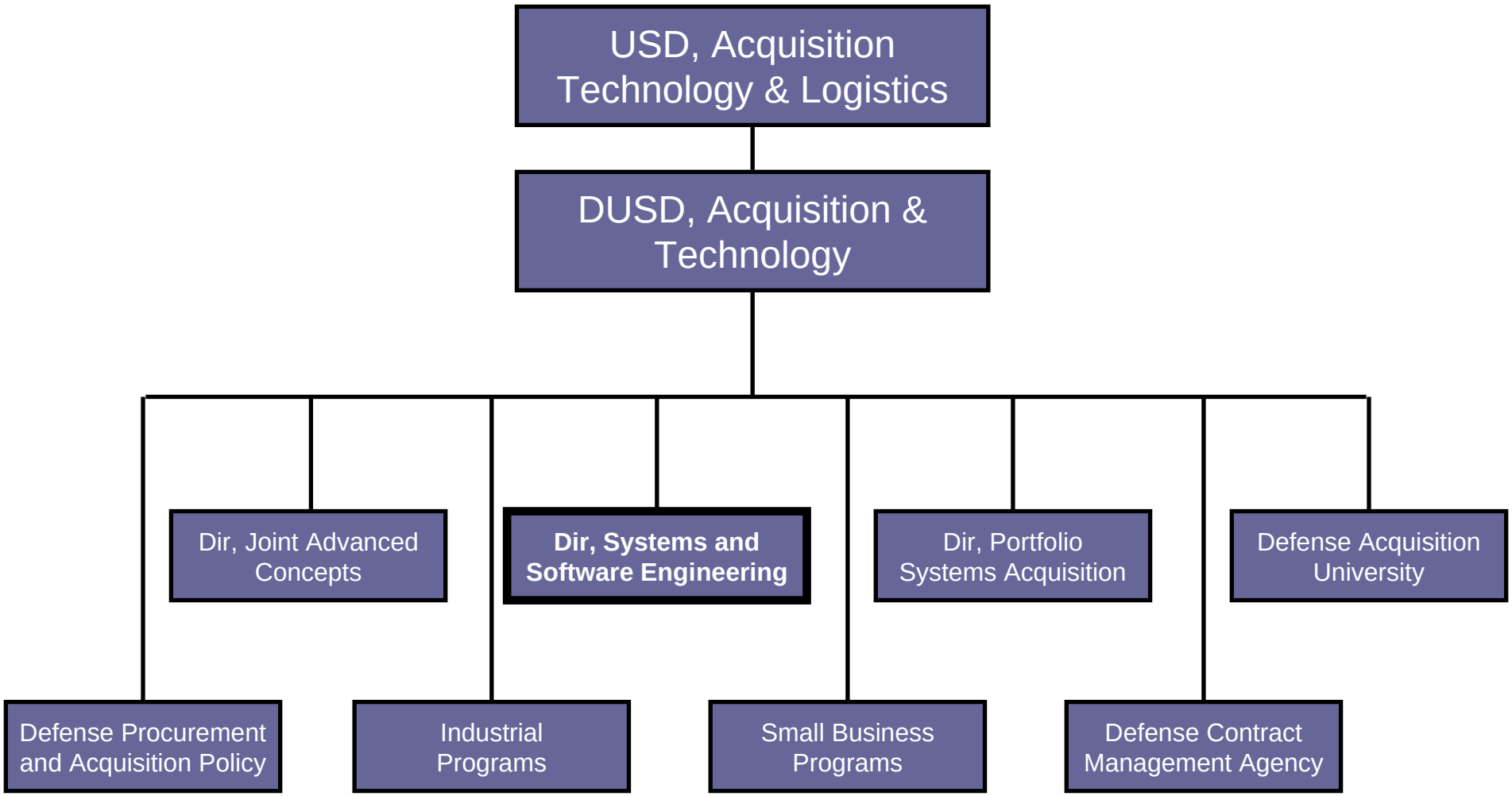
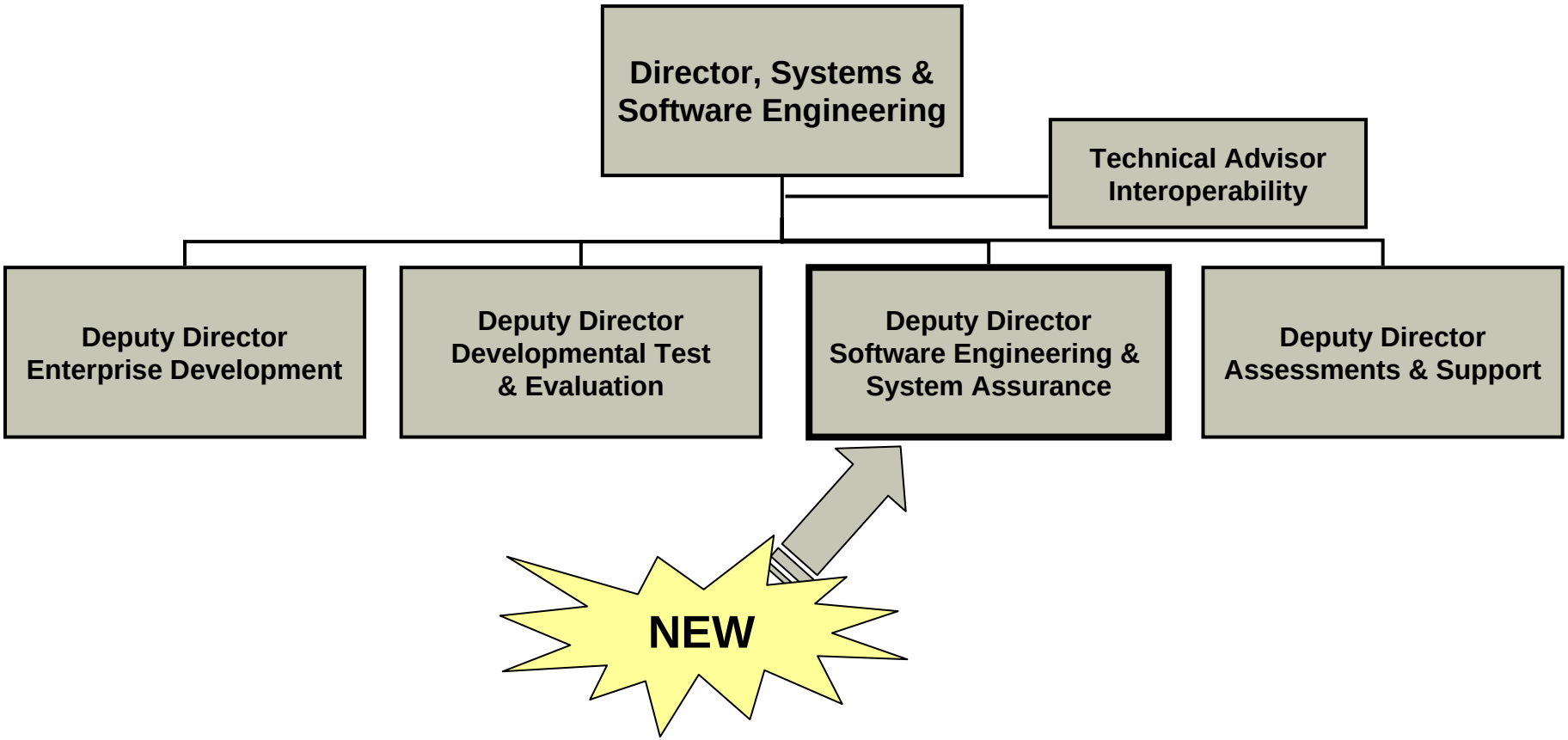


Flatter, Leaner, Empowered!

Systems and Software Engineering

An Organizational Construct



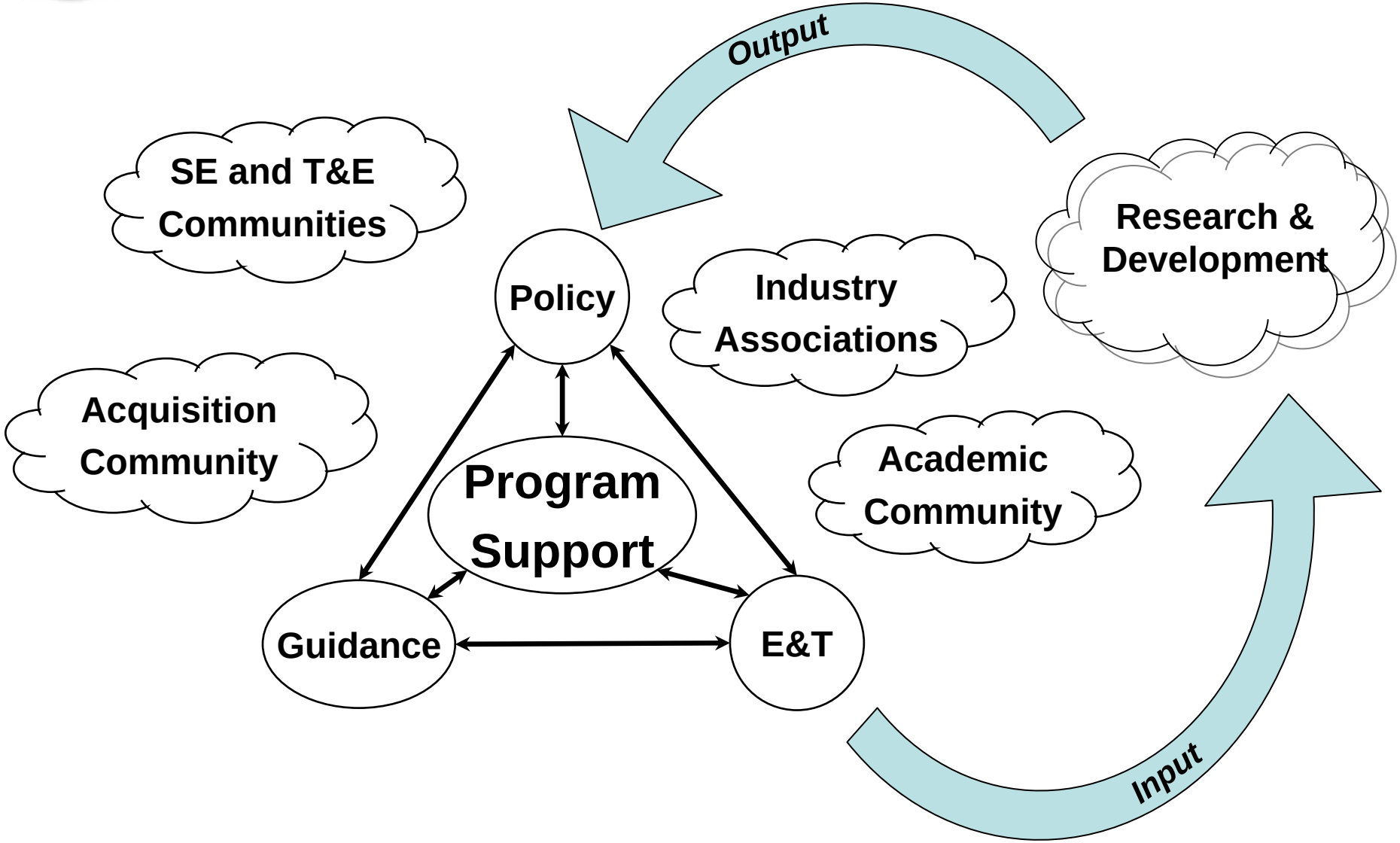
Management Visibility – Best Practices – Acquisition Excellence

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 "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

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 (21%)
  - Unmanned Systems (2%)
  - Rotary Wing Aircraft (21%)
  - Land Systems (16%)
  - Ships (7%)
  - Munitions (3%)
  - Missiles (7%)

and Software

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

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. Reliability	• Ambitious growth curves, unrealistic requirements • Inadequate “test time” for statistical calculations
6. Acquisition Strategy	• Competing budget priorities, schedule-driven • Contracting issues, poor technical assumptions
7. Schedule	• Realism, compression
8. Test Planning	• Breadth, depth, resources
9. Software	• Architecture, design/development discipline • Staffing/skill levels, organizational competency (process)
10. Maintainability/Logistics	• Sustainment costs not fully considered (short-sighted) • Supportability considerations traded

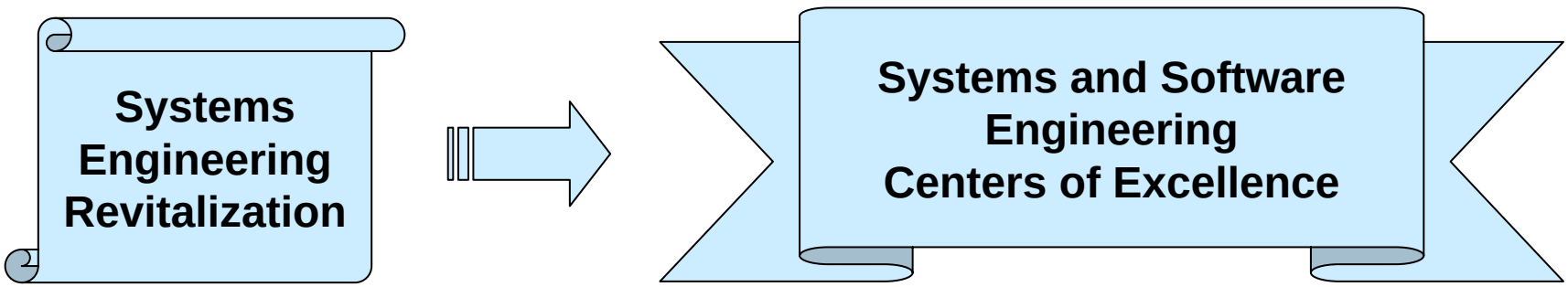
Major contributors to poor program performance

Necessary but not sufficient

now

“Take SE to the Next Level”

Vision for Systems Engineering and Software



- **Competencies Improved**
- **Delivered Product Suite**
  - Policy/Guidance
  - Courseware
  - Program Support methods
- **Elevated Stature**
- **Raised Awareness**
- **Positive Influence**

- **World class leadership**
- **Broaden to Software Engineering, System Assurance, Test & Evaluation**
- **Responsive and agile, technical discipline to shape acquisition solutions**
- **Complex Systems-of- Systems**

. . . the Technical Foundation that Enables Acquisition Excellence

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

- 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

The System Assurance Problem

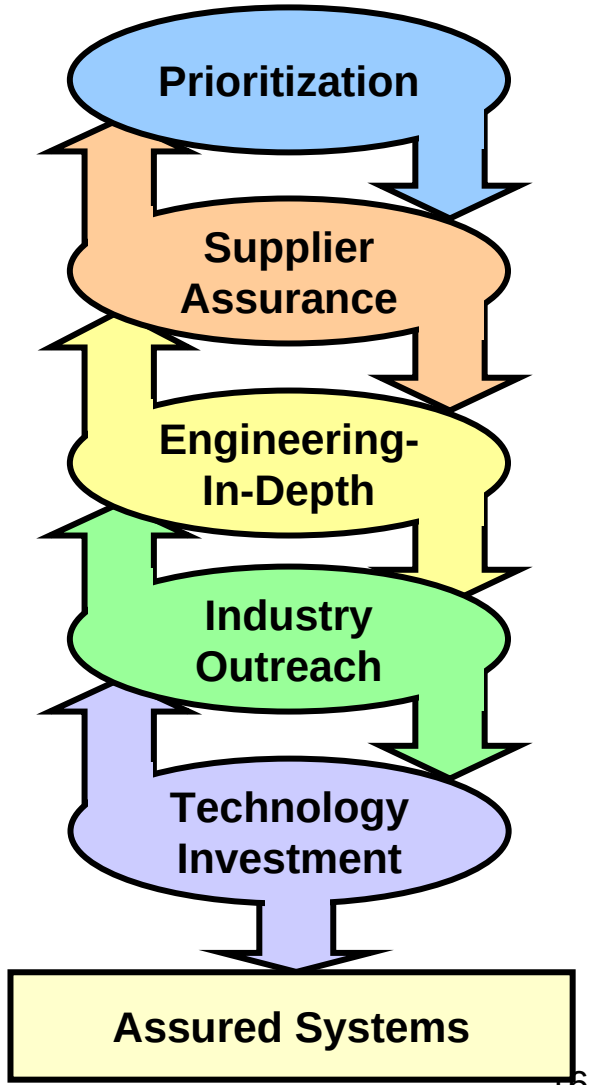
- Growing system complexity makes vulnerabilities* much more difficult to discover and mitigate
  - *Inserted with malicious intent through supply chain opportunity, or
  - *Unintentional vulnerabilities that can be exploited
- Commercial components are desirable, but
  - Risks inherent due to globalization
  - Difficulty in verification of COTS products
- Numerous assurance, protection and safety initiatives that are not well aligned
  - Anti-tamper, software & hardware assurance, information assurance…

System Assurance Definition

Level of confidence that a system functions as intended, is free of exploitable vulnerabilities, and protects critical program information

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



What's Next?

- We have revitalized Systems Engineering Policy, Guidance, Education and Training…
- We have driven good systems engineering practices back into the way the acquisition community does business, and have had a positive impact on programs…
- We have a rigorous process to capture what went wrong...
- We have identified, **but failed to change,** root cause behavior that leads to programs that do not meet cost, schedule, and performance expectations…

Top 10 Emerging Systemic Issues

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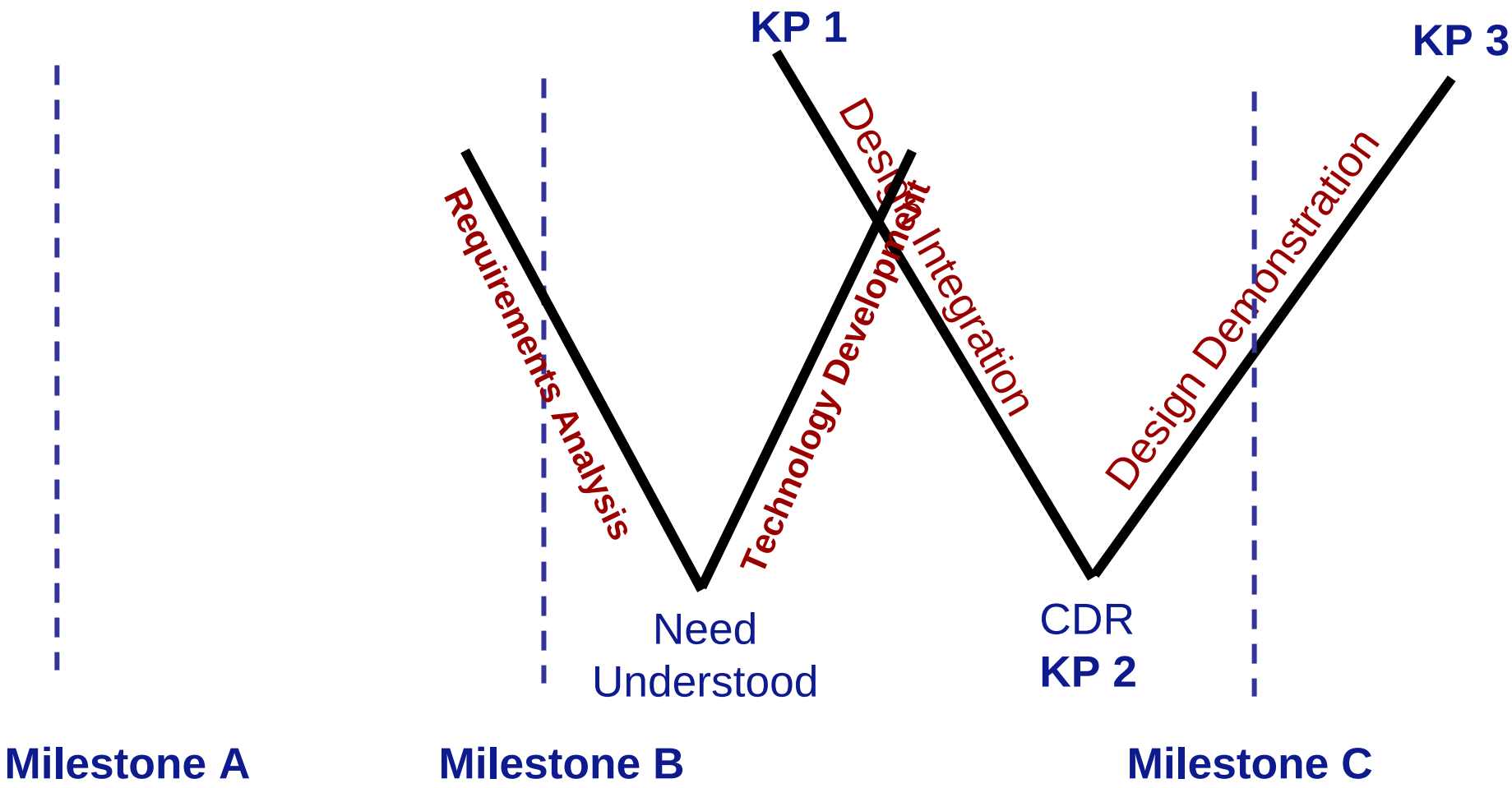
Major contributors to poor program performance

Actual Acquisition Strategies Do Not Align with Systems Engineering



Excerpt – GAO presentation to QDR IPT 5 – 16 Aug 2005

Initiatives For Strategic and Tactical Acquisition Excellence

STRATEGIC
"Big A"

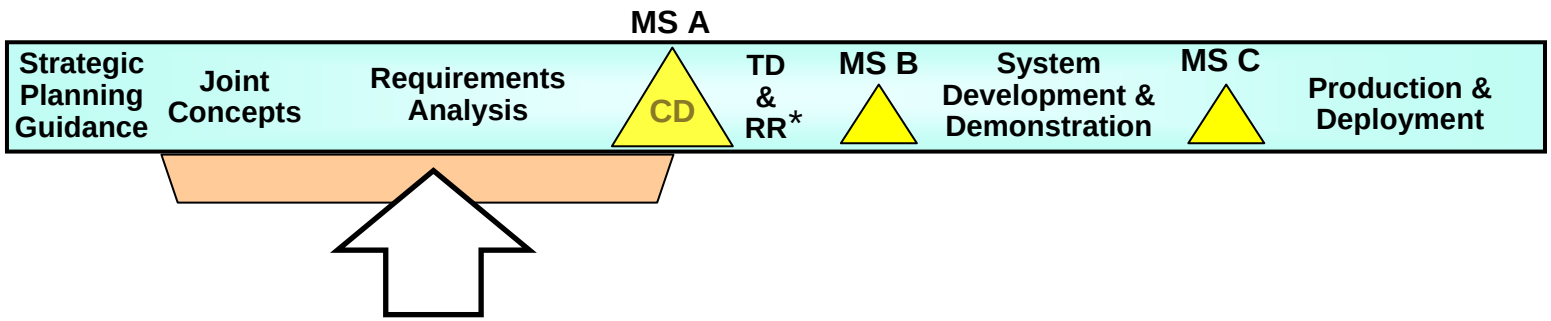
"Little A"
TACTICAL

OBJECTIVES	INITIATIVES
Making Decisions that Balance the Trade-Space • Affordable, Feasible Investments	• Portfolio Management • Tri-Chair Concept Decision / Time-Defined Acquisition • Evaluation of Alternatives • Synchronize Existing Processes • Tri-Chair Investment Balance Reviews
Starting Programs Right • Improved, Up-Front Planning • Awareness of Risk / Improved Source Selection • More Responsive Acquisition Solutions	• Risk-Based Source Selection • Small Business Innovative Research • Acquisition of Services Policy • Systems Engineering Excellence • Award Fee and Incentives
Process efficiency • Tailored, agile, transparent	• DAB / OIPT Process Optimization • Common Data / DAMIR • Restructured DAES
Program Stability • No Downstream Surprises • Issue Awareness	• Program Baseline Assurance • Capital Accounts

Improving the Full Range of Acquisition Execution

Make Decisions that Balance the Trade Space Early Lifecycle Planning

- Early lifecycle involvement of Systems Engineering:
  - 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



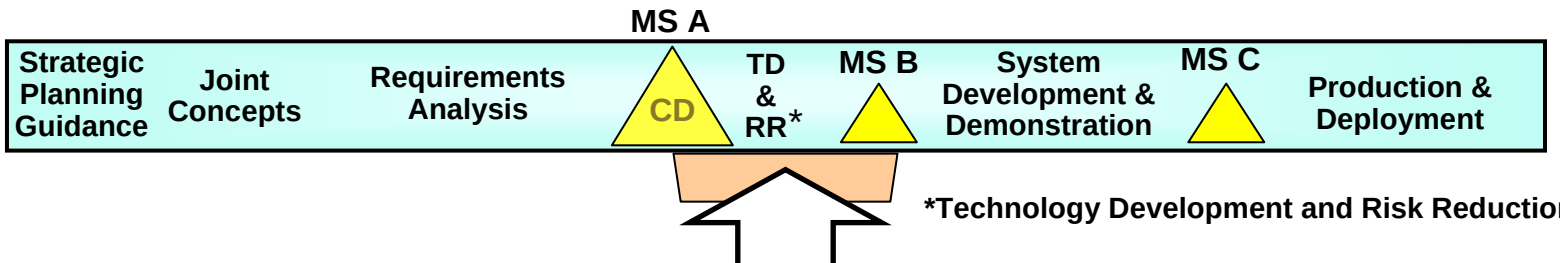
*Technology Development and Risk Reduction

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

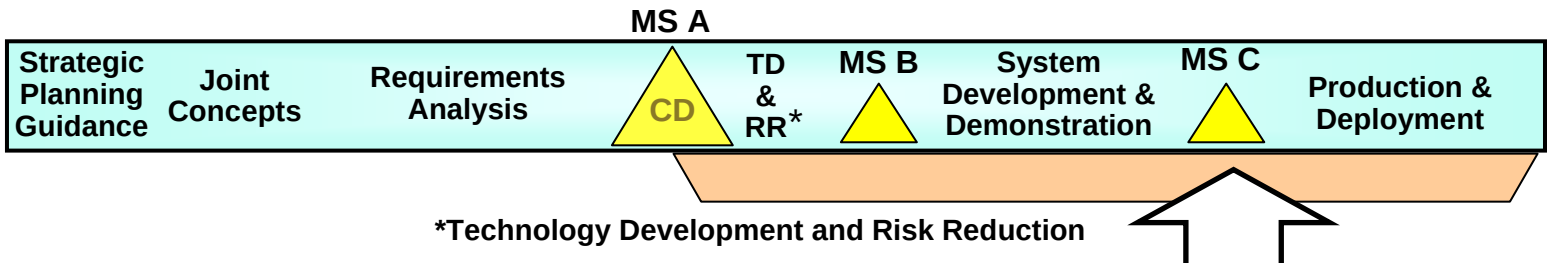


Structuring Programs Right – System Level

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

Starting Programs Right
System of Systems Level

- System-of-Systems Level
  - Needs will be satisfied by groupings of legacy systems, new programs, and technologies
  - Presents additional integration and management issues
  - Success depends heavily upon software interfaces
  - Broad context and knowledge of system interrelationships and CONOPS are critical to decision-making
  - Sound SE practices enable the integration of these SoS solutions



DoD System of Systems SE Guide

SoS Guide Version .9

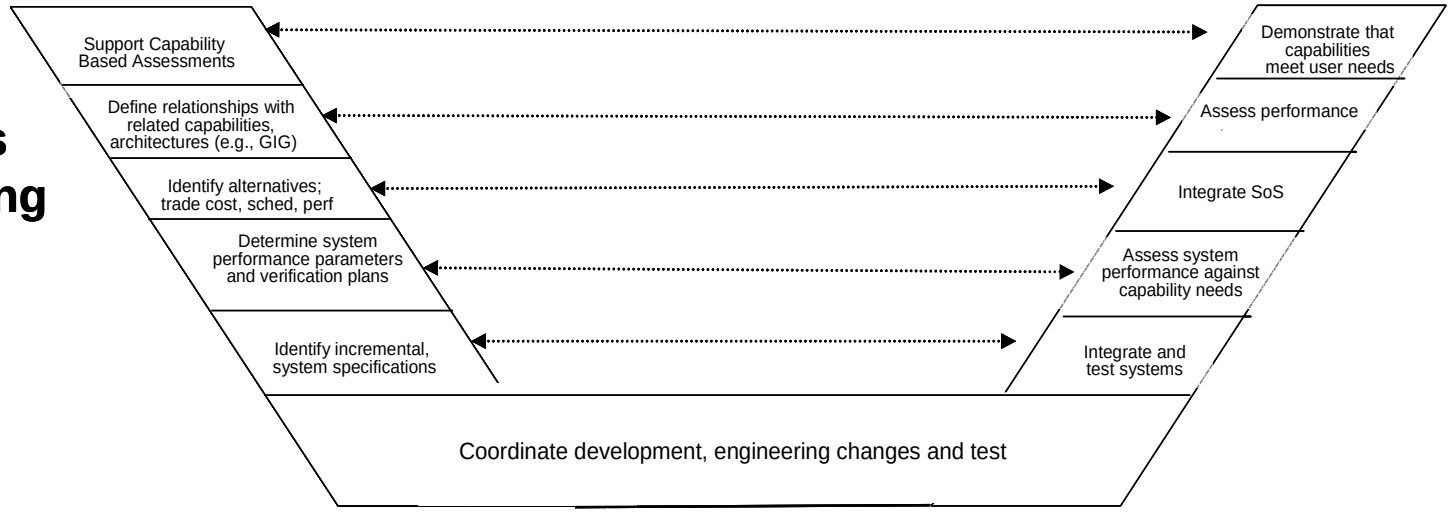
- Effort led by the Office of the Secretary of Defense
- Collaborative Approach with DoD, Industry, Academia
- Purpose
  - 6 month effort addressing areas of agreement across the community
  - Focus on technical aspects of SE applicable across SoS management constructs
  - Vehicle to capture and debate current SoS experience
- Audience
  - Program Managers and Lead/Chief Engineers

Pilot

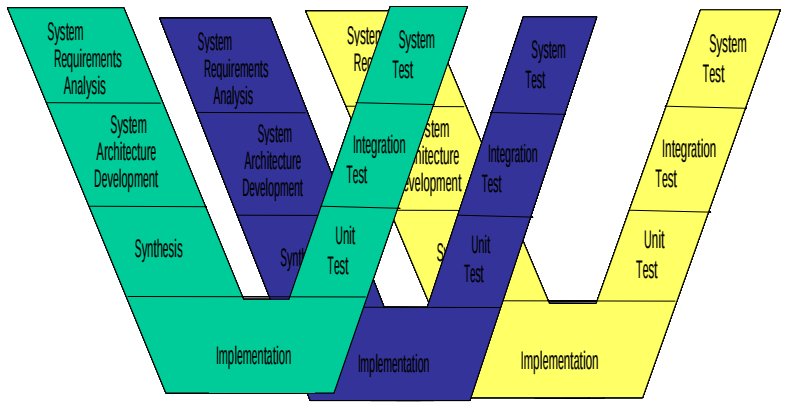
- Pilot effort – "Beta test" the SoS guide
  - Structured walkthroughs with practitioners
  - Refine guide content, identify areas for future study
  - Update findings and release Version 1.0 (Fall 2007)

An “Integrated Vee” for SoS SE*

SoS Systems Engineering



Service/ PEO/PM Program Systems Engineering



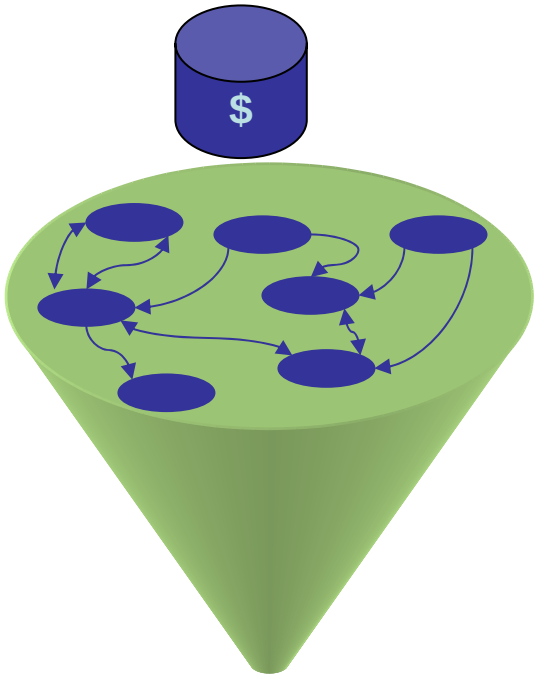
System 1 (Requiring Modification)

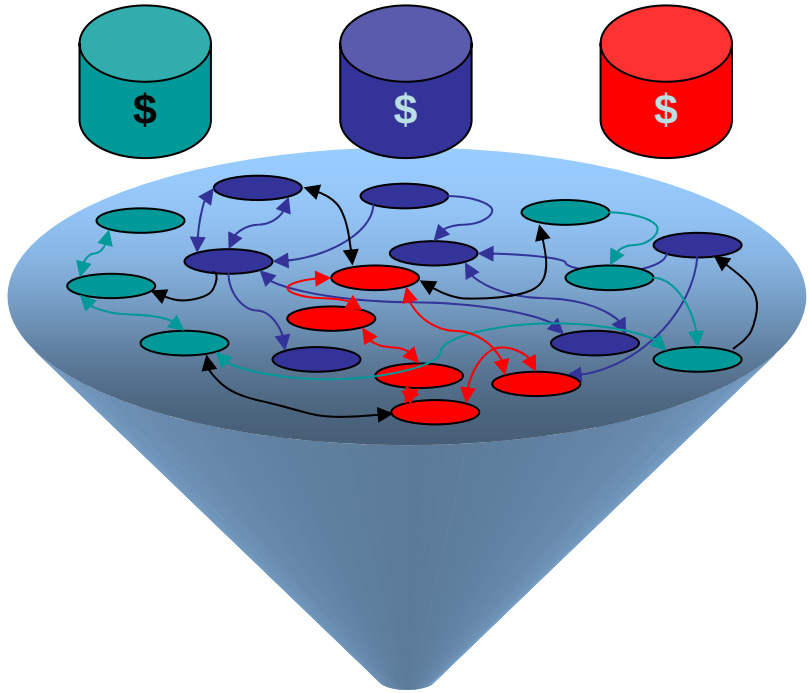
System 2 (New or Early in Development)

System 3 (In production)

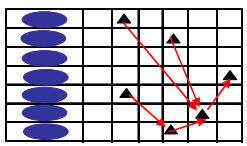
*** From DoD SoS SE Guide v 0.9**

System of Systems
The Management Challenge

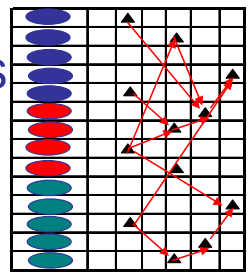




SoS:
Within
Single
Organization

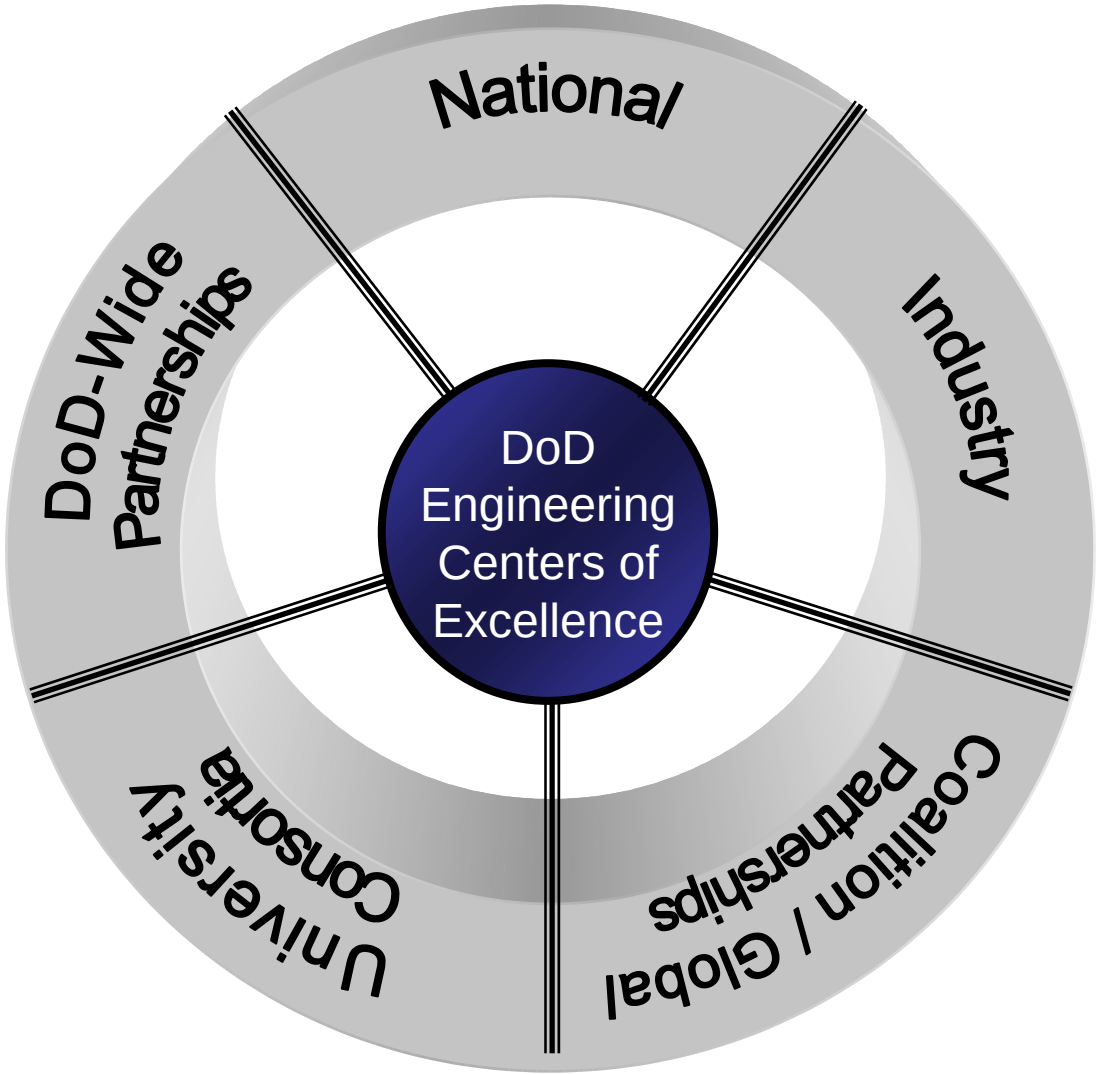


Joint SoS:
Interdependencies
Across
Multiple
Organizations



Political and Cost Considerations impact on Technical Issues

Many Challenges…
How do we get there?



Driving Technical Rigor Back into Programs "Importance and Criticality of the SEP"

- Program's SEP provides insight into every aspect of a program's technical plan, focusing on:
  - What are the program requirements?
  - Who has responsibility and authority for managing technical issues—what is the technical staffing and organization?
  - How will the technical baseline be managed and controlled?
  - What is the technical review process?
  - How is the technical effort linked to overall management of the program?
- Living document with use, application, and updates clearly evident

The SEP is fundamental to technical and programmatic execution on a program

Driving Technical Rigor Back into Programs "Importance of TEMP"

- TEMP provides insight into adequacy of T&E planning:
  - Are the scope and content of planned tests adequate?
  - Is the T&E program structured to support decisions at major milestones? Measure technical progress and maturity?
  - Are the schedule and resource requirements adequate?
  - Is DT&E program structured to achieve successful OT&E?
- Living document that must reflect all major changes to a program

The TEMP is fundamental to validating program maturity

Characterizing the System of Systems Environment

- Community Involvement: Stakeholders, Governance
  - System: stakeholders generally committed only to the one system
  - SoS: stakeholders more diverse; stakeholders from each system involved will have some interest in the other systems comprising the SoS
- Employment Environment: Mission environment, Operational focus
  - System: mission environment is relatively stable, pre-defined, and generally well-known; operational focus is clear
  - SoS: emphasis on multiple missions, integration across missions, need to ad hoc operational capabilities to support rapidly evolving mission objectives
- Implementation: Acquisition/Test and Validation, Engineering
  - System: proceeds through acquisition process as an entity; specified requirements, single DoD program manager, SE with a Systems Engineering Plan, test and validating the system is possible
  - SoS: may be made up of constituent systems in various phases of the acquisition lifecycle, from initial design to sustainment; multiple DoD program managers and operational and support communities; testing is more difficult and test and validation can be distributed and federated

Why System of Systems are important to DoD

- Scale
  - Size of defense enterprise makes a single integrated architecture infeasible
- Ownership/Management
  - Individual systems are owned by the military component or agencies, introducing constraints on management and SE
- Legacy
  - Given defense budget projections, current systems will be part of the defense inventory for the long-term and need to be factored into any approach to SoS
- Changing operations
  - Changing threats and concepts mean that new (ad hoc) SoS configurations will be needed to address changing, unpredictable operational demands
- Criticality of software
  - SoS typically focus on integration across systems through cooperative or distributed software
- Role of network
  - Conceptually DoD SoS will be network-based; budgetary and legacy challenges could lead to uneven implementation

Way Ahead for Systems Engineering

- Continue Systems Engineering Revitalization
  - Policy Guidance, Education, Training, Program and Decision Support, Outreach
  - Continue to positively impact to major programs development
  - Leverage software efforts to support acquisition success and improve State-of-the-Practice of software engineering
  - Focused initiatives on System Assurance, process improvement and System-of-Systems systems engineering
- Taking Systems Engineering to the Next Level
  - Foster early life-cycle involvement key to program success

System of Systems are important to DoD

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  - Size of defense enterprise makes a single integrated architecture challenging
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- Criticality of software
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- Role of network
  - DoD vision: SoS will be network-based

Emerging System of Systems (SoS) Need

- Traditionally, DoD developed single system solutions to satisfy operational needs
  - SE processes applied at system level
- DoD has identified emerging need to develop SoS solutions
  - Example: MDA for ballistic missile threat
  - Department identified potential gap in guidance for programs trying to develop SoS and apply SE processes for SoS solutions

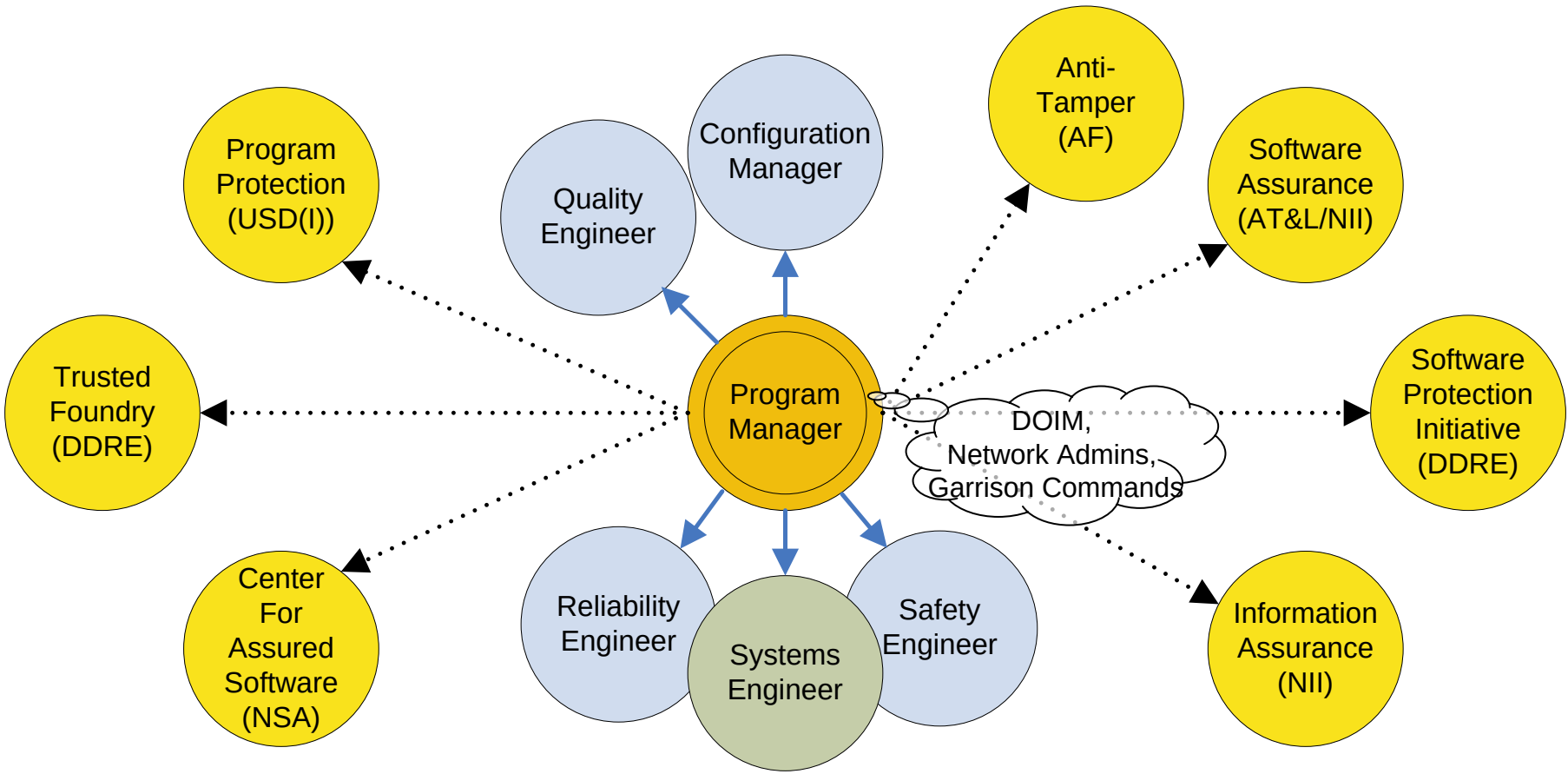
Consequences of Fragmented Systems Assurance Initiatives

- Systems assurance policies are fragmented and confusing for programs to implement
  - Resulting in loss of time and money and lack of focus on applying the most appropriate engineering for systems assurance for each system
  - Resulting in ineffective and inefficient systems assurance for materiel
- Lack of Coherent Direction for PMs, and others acquiring systems
  - Numerous, uncoordinated initiatives
  - Multiple constraints for PMs, sometimes conflicting
- Synergy of Policy – Multiple ownership
  - Failure to capitalize on common methods, instruction among initiatives
- DoD Risk Exposure
  - Lack of total life cycle view
  - Lack of a focal point to endorse system assurance, resolve issues, advocate
    PM attention
  - Lack of system-of-systems, architecture perspective on system assurance
  - Fragmented policies leave gaps in systems assurance protection
  - Policies not net-ready

There is a need to assimilate the multiple security disciplines into a cohesive, overarching Systems Assurance framework

Systems Assurance

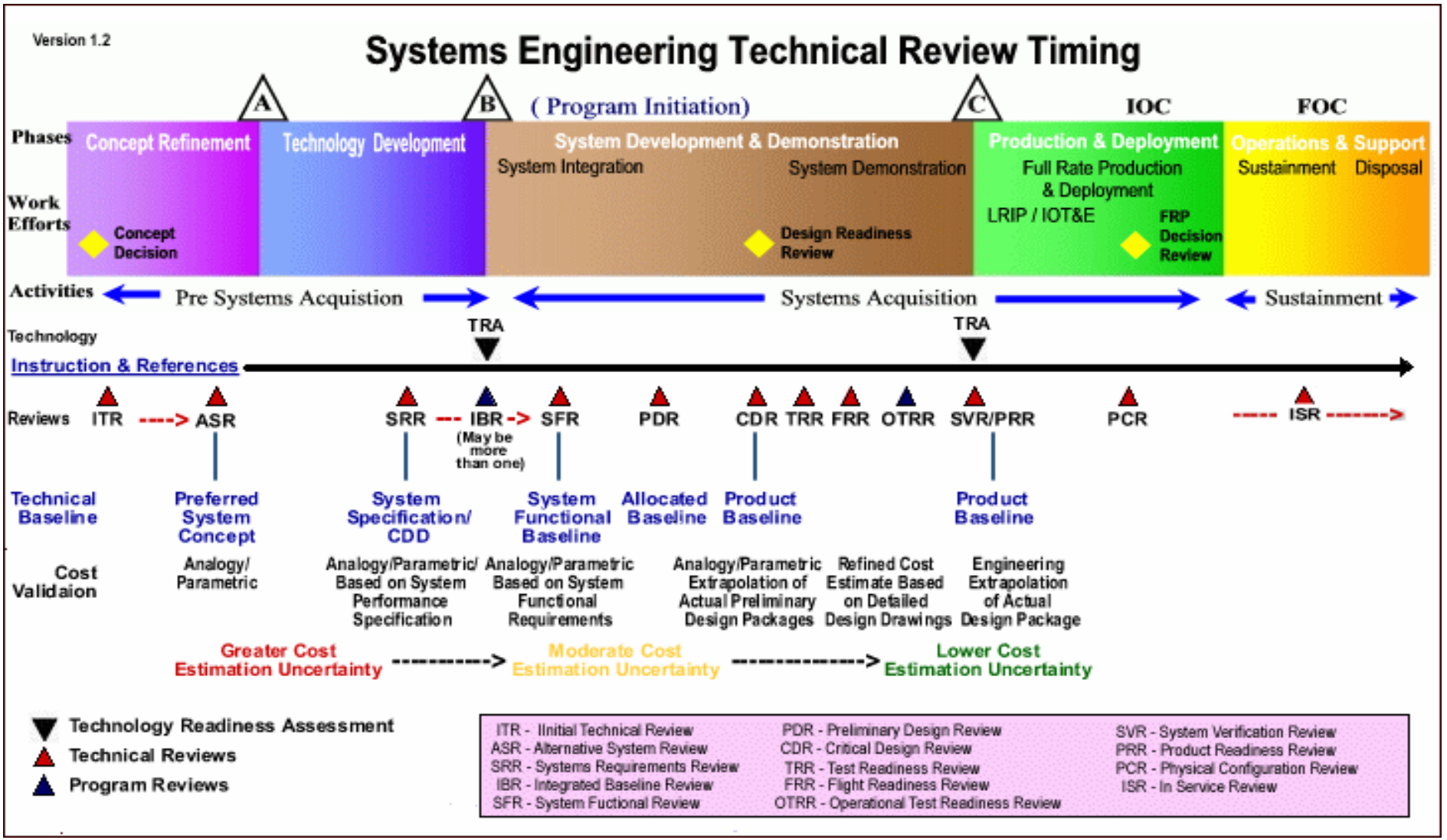
Systems Assurance involves integrating multiple initiatives with multiple owners



Technical Planning
Systems Engineering Plan Trends

- What is working:
  - Programs beginning to establish SE Working IPTs early in the life cycle to develop and document their technical planning
  - Increased Program Executive Office level Lead/Chief Systems Engineers involvement in SEP development
  - Movement to event-driven versus schedule-driven programs
    - More focus on entry and exit criteria for technical reviews
- What needs work:
  - Firming up technical planning prior to RFP release
  - Proposed processes for a program not always tailored to fit program - often appear to be copied from a manual or guide
  - SEP author is someone who is not familiar with the program technical strategy
  - SEPs need to be better aligned with key program documents (RFP, contract, TEMP, etc)
  - Align Program Office and Contractor plans

Technical Reviews Across the Life Cycle



Modeling & Simulation (M&S) in Systems Engineering

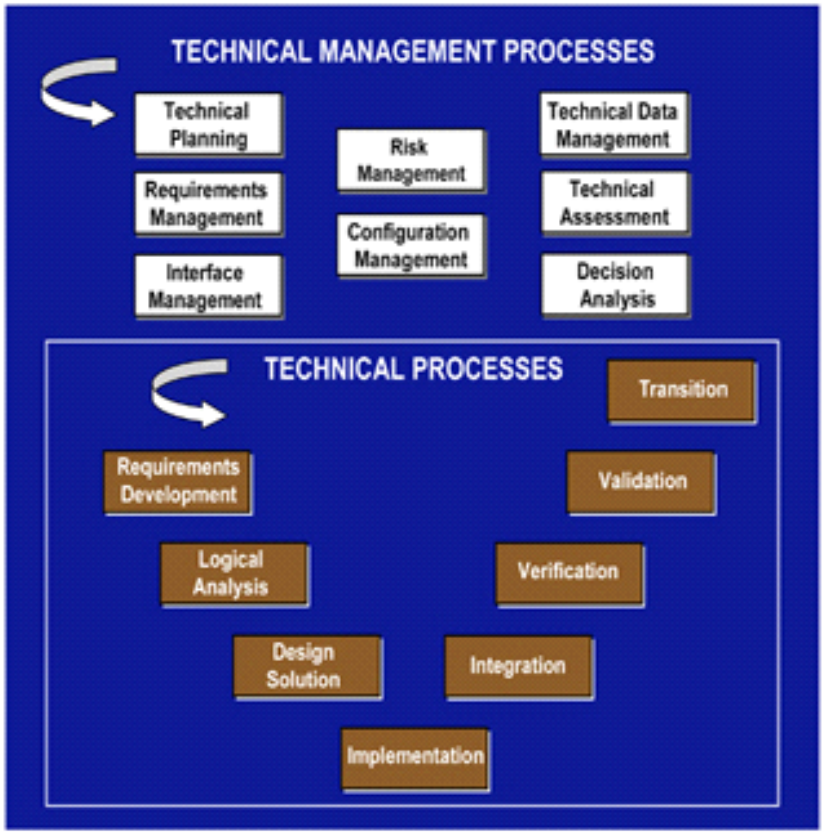
- The Acquisition M&S Working Group – a working group of the SE Forum – is implementing the "Acquisition Modeling and Simulation Master Plan"
  - Plan contains 40 actions to improve effectiveness of M&S in programs
  - 25 of the actions now being worked by Acquisition M&S Working Group
  - Recently began effort to evaluate distributed simulation standards necessary to support integrated Live, Virtual, Constructive (LVC) Architecture
- Developing M&S best practices for use by SE personnel in program offices
  - Developed online continuous learning module "M&S for Systems Engineering"
  - Developing online continuous learning module "M&S for T&E"
  - Updated the M&S section of the Defense Acquisition Program Support (DAPS) to more accurately gauge a program's application of M&S in support of their SEP
  - Offering assist visits for programs needing help with proper planning and use of M&S

Developmental Test & Evaluation

- Strategic View
  - Relevance to T&E community – 5 Vectors
  - Strategic Alliance – Developmental and Operational testing
  - Outreach – industry, joint and coalition
  - T&E Governance
  - Defense Science Board on T&E

- Tactical View – 5 revitalization vectors
  - Support Faster Fielding of Improved Capabilities
  - Reduce Risk of Immature Technology in Systems Development
  - Revitalize T&E Workforce Education
  - Remove Barriers to Efficient Distributed Live-Virtual-Constructive Environments
  - Provide Effective Acquisition Policy and Practices for DT&E

Challenges of SoS for SE Processes



- Technical and Technical Management Processes for SE from Chapter 4 of the Defense Acquisition Guide
  - Identify implications of SoS for each process
  - Challenges these pose
  - Approaches to address the challenges
- Processes apply, but the SoS environment affects approaches, methods and tools needed by SE
  - More collaboration, less top down
  - More complexity to accommodate requirements, approaches and tools used by constituent systems
  - Balance between roles of SoS SE and SE of individual systems
  - More need for experimentation to determine ways to employ existing systems and to discover effects of combined systems