# *Systems Engineering Revitalization Efforts*

***4 September 2007***

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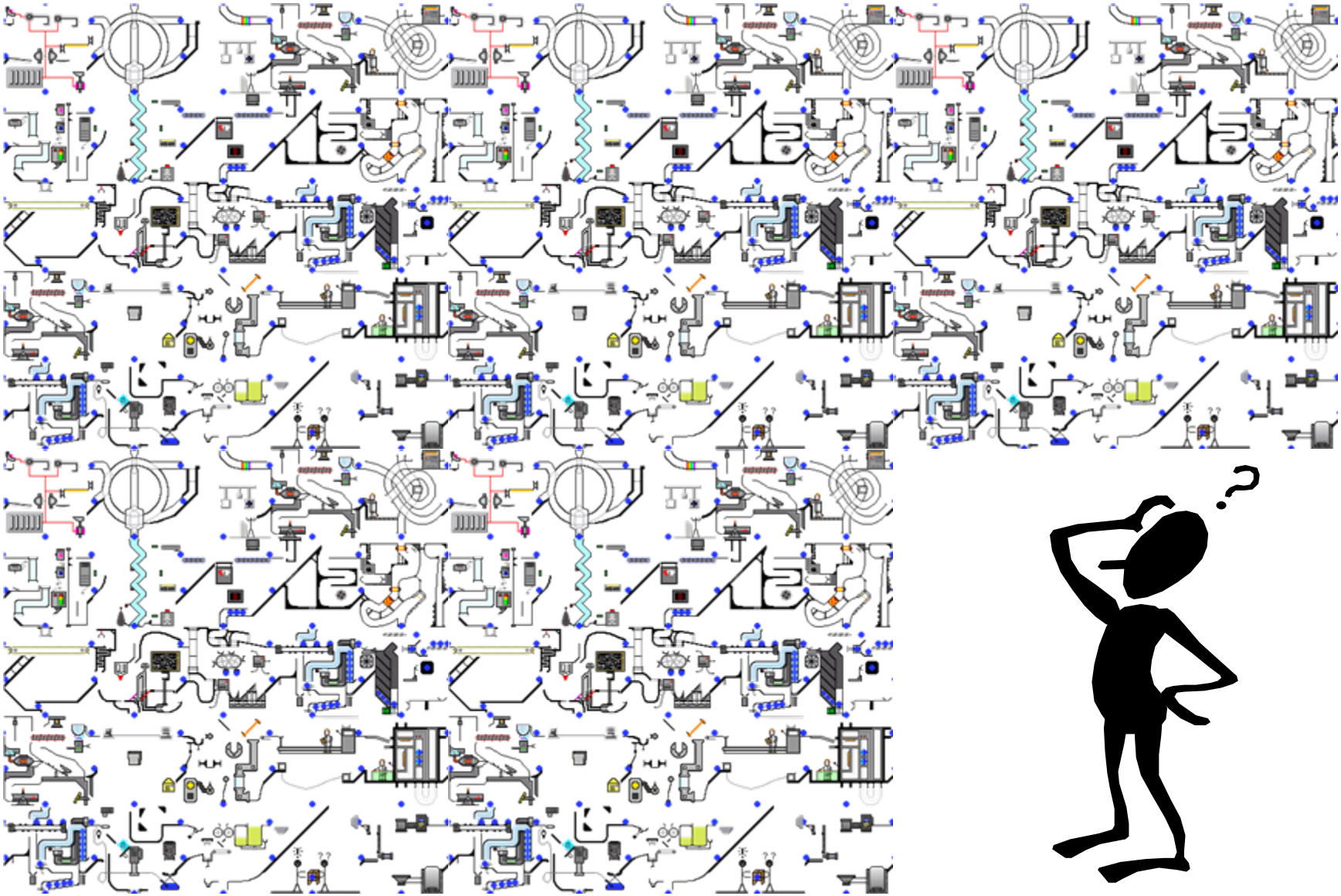
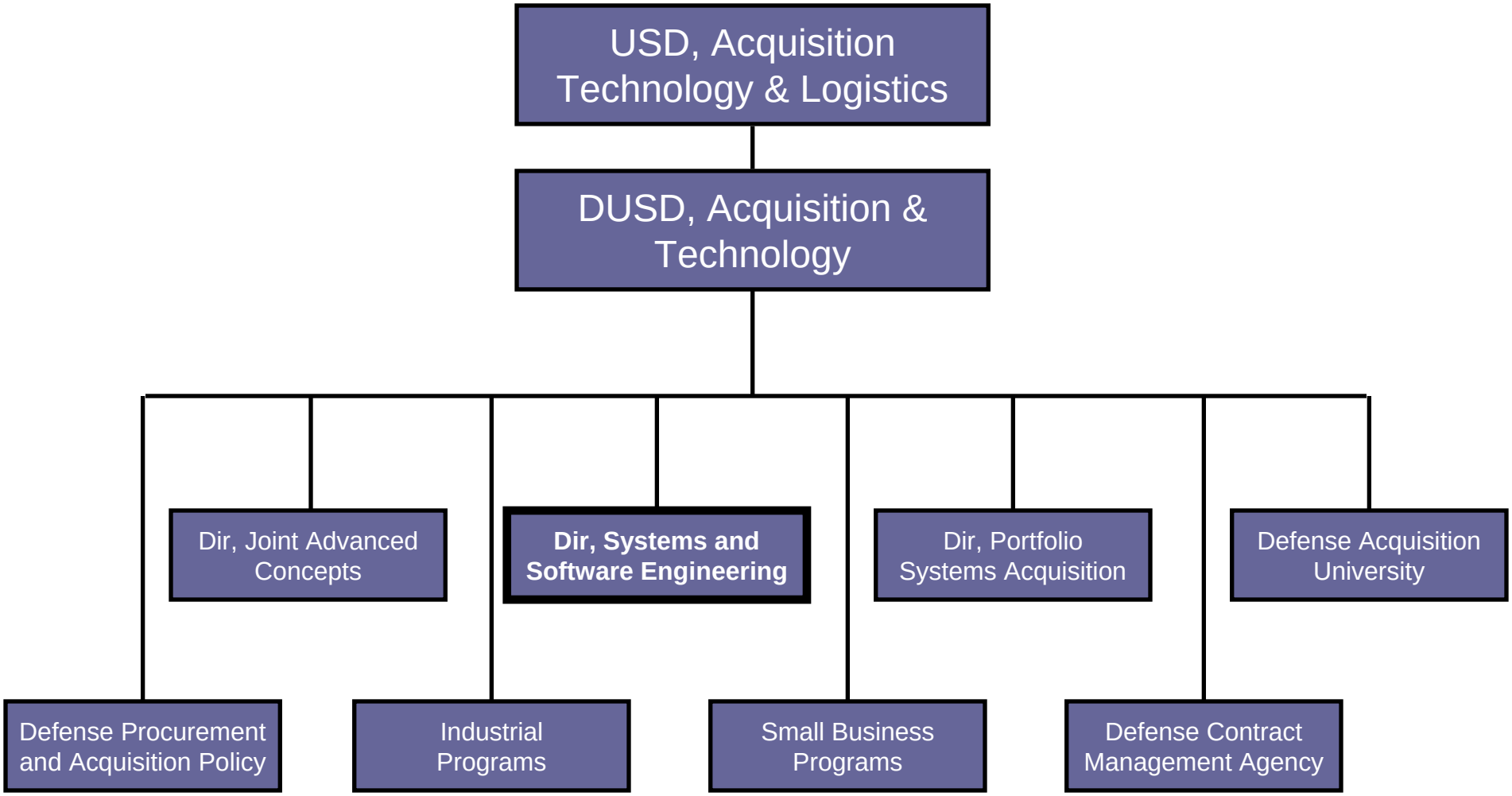
# Systems Engineering…



# General Outline

- What's happening in:
  - Policy
  - Education & Training
  - Guidance
- What we're finding on programs
  - Program Support Reviews
  - System Engineering Plans (SEPs)
- Topics for Discussion

# OUSD (AT&L) Organization



# Systems and Software Engineering
## Organizational Core Competencies

**Director, Systems & Software Engineering**
Mark Schaeffer — SES

### Deputy Director Enterprise Development
Col Rich Hoeferkamp (Acting)

**CORE COMPETENCIES**

- SE Policy
- SE Guidance
  - SE in *Defense Acquisition Guidebook*
  - Technical Planning
  - Risk Management
  - Reliability/Maintainability
  - Integrating SE into Systems Acq contracting
  - SoS SE Guide
- SE Education and Training
  - DAU SE Curriculum
  - SPRDE Certification Rqmt
- Corrosion
- R-TOC
- Value Engineering

### Deputy Director Developmental Test & Evaluation
Chris DiPetto — SES

**CORE COMPETENCIES**

- DT&E Policy
- DT&E Guidance
  - T&E in *Defense Acquisition Guidebook*
  - TEMP Development Process
- DT&E Education and Training
  - DAU DT&E Curriculum
  - DT&E Certification Rqmt
- Joint Testing, Capabilities & Infrastructure
- Targets Oversight
- Acq Modeling & Simulation
- Energy
- DSOC/Acq Tech Task Force

### Deputy Director Software Engineering & System Assurance
Mark Schaeffer (Acting) — SES

**CORE COMPETENCIES**

- SWE and SA Policy
- SWE and SA Guidance
  - SoS, SA Guides
- SWE and SA Education and Training
  - DAU SW Acq Curriculum
  - Continuous Learning Modules for SWE, SoS, SA
- Software Engineering
  - Acquisition Support
  - Software Engineering Institute (SEI)
- Process Improvement
  - CMMI Sponsor
- DoD/National Software Investment Strategy

### Deputy Director Assessments & Support
Dave Castellano — SES

**CORE COMPETENCIES**

- Support of ACAT I and Other Special Interest Programs (MDAP, MAIS)
- Assessment Methodology (Program Support Reviews - PSRs)
- T&E Oversight and Assessment of Operational Test Readiness (AOTR)
- Systems Engineering and Developmental Test Planning and Support
- Lean/6-Sigma Training/Cert

*Acquisition program excellence through sound systems and software engineering*

# System Engineering Policies

**All programs shall develop a SE Plan (SEP)**

**Each PEO shall have a lead or chief systems engineer who monitors SE implementation within program portfolio**

**Event-driven technical reviews with entry criteria and independent subject matter expert participation**

**OSD shall review program's SEP for major acquisition programs (ACAT ID and IAM)**

**Technical Planning**

**Technical Leadership**

**Technical Execution**

**Technical Excellence**

***Technical planning upfront and early***

# What's Coming in Policy

- Codified SE revitalization in DoDI 5000.2
  - Captures previously approved SE and related policies
  - Mandates SEP at Milestones A, B, and C
  - Considers SE during Concept Refinement and Technology Demonstration phases
  - Mandates system-level Critical Design Review, sets CDR exit criteria, requires a CDR report to Milestone Decision Authority
  - Establishes functional, allocated, and product baselines during SDD
  - Mandates Program Support Reviews for all MDAPs
  - Establishes requirement for Configuration Management and Data Management strategies

# Education & Training

## ➢What's available

- On-line Continuous Learning Modules (CLMs):
  - Reliability and Maintainability
  - Technical Reviews
  - Technical Planning
- On-line introductory course SYS 101
- On-line intermediate course SYS 202
- Intermediate classroom course SYS 203
- Advanced classroom course SYS 302
- New "SPRDE/Program Systems Engineer" track

# New SPRDE/PSE & SE Career Path Certification Criteria

## SPRDE-Program Systems Engineer

### LEVEL I (2 Years)

- ACQ 101
- SYS 101
- Two additional Level 100 courses from a variety of disciplines
- XXX 101
- AND
- XXX 101

### LEVEL II (4 Years)

- ACQ 201A/B
- CLM 003
- SYS 202
- SYS 203
- LOG 204 (CM) + one additional Level 100 or 200 course from a variety of disciplines
- LOG 204 (now online)
- XXX 101
- OR
- XXX 201

### LEVEL III (8 Years)

- CLL 008
- SYS 302
- Two additional Level 200 or 300 courses from a variety of disciplines
- XXX 201
- AND
- XXX 301

## SPRDE-Systems Engineering

### LEVEL I (1 Years)

- ACQ 101
- SYS 101

### LEVEL II (2 Years)

- ACQ 201A
- ACQ 201B
- CLM 003
- SYS 202
- SYS 203

### LEVEL III (4 Years)

- CLL 008
- SYS 302

**Legend:**

- Existing
- New
- Additional

# Education & Training
# New SPRDE Key Tenets

- ***Personnel***: those currently certified SPRDE-SE retain their certification

- ***Positions***: those currently coded as “S” (SPRDE-SE) retain that designation—subsequently, Components shall review positions to determine if they should remain coded as SPRDE-SE (“S”) or if they should be recoded as SPRDE-PSE (“Code TBD”)

# Guidance

- What's available:
  - Systems Engineering Plan (SEP) Preparation Guide
  - Risk Management Guide for DoD Acquisition
  - DoD Guide for Achieving Reliability, Availability, and Maintainability
  - Integrated Master Plan/Integrated Master Schedule (IMP/IMS) Guide
  - Guide to Integrating SE into DoD Acquisition Contracts
  - Understanding and Leveraging a Supplier's CMMI Efforts: A Guidebook for Acquirers
- What's coming:
  - Update to SEP Preparation Guide
  - Systems of Systems SE Guide
  - Update to Defense Acquisition Guidebook
    - Chapter 4 -- Systems Engineering
    - Chapter 9 -- Test and Evaluation

# SEP Prep Guide

- Update to be published *soon*

- New guide includes sections by program phase:
  - Technology Development
  - System Development & Demonstration
  - Production & Deployment and Operations & Support

- Each section provides more “food for thought” relative to the technical planning focus areas for that phase
  - Program Requirements
  - Technical Staffing
  - Technical Baseline Management
  - Technical Review Planning
  - Integration with Overall Management of the Program

# Systems Engineering Plan Trends

- What's working:
  - Programs beginning to establish SE WIPTs 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 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 in program office (contractor or junior person) who is not familiar with the technical strategy.
  - SEPs need to be consistent with key program documents

# RISK MANAGEMENT GUIDE FOR DOD ACQUISITION

## Sixth Edition
## (Version 1.0)

**August, 2006**

**Department of Defense**

# Risk

WE'LL NEED A RISK ANALYSIS ON THIS PROJECT BEFORE I CAN APPROVE IT.
www.unitedmedia.com
S. Adams
RISK 1: INDECISIVENESS
RISK 2: OVERANALYSIS
RISK 3: CLUELESSNESS
RISK 4: MICROMANAGE-MENT...
CLICK CLICK CLICK
© 1997 United Feature Syndicate, Inc.
I DON'T UNDERSTAND THESE RISKS.
THAT'S NUMBER THIRTY-SIX.

# Risk Management Guide for DoD Acquisition

- The new *Guide* places emphasis on:
  - The role and management of future root causes
  - Distinguishing between risk management and issue management
  - Tying risk likelihood to the root cause rather than the consequence
  - Tracking the status of risk mitigation implementation vs. risk tracking
  - Event-driven tech reviews to help identify risk areas and assess the effectiveness of mitigation efforts

**Coincides well with the new DAES reporting requirements**

# How Guide Defines Risk

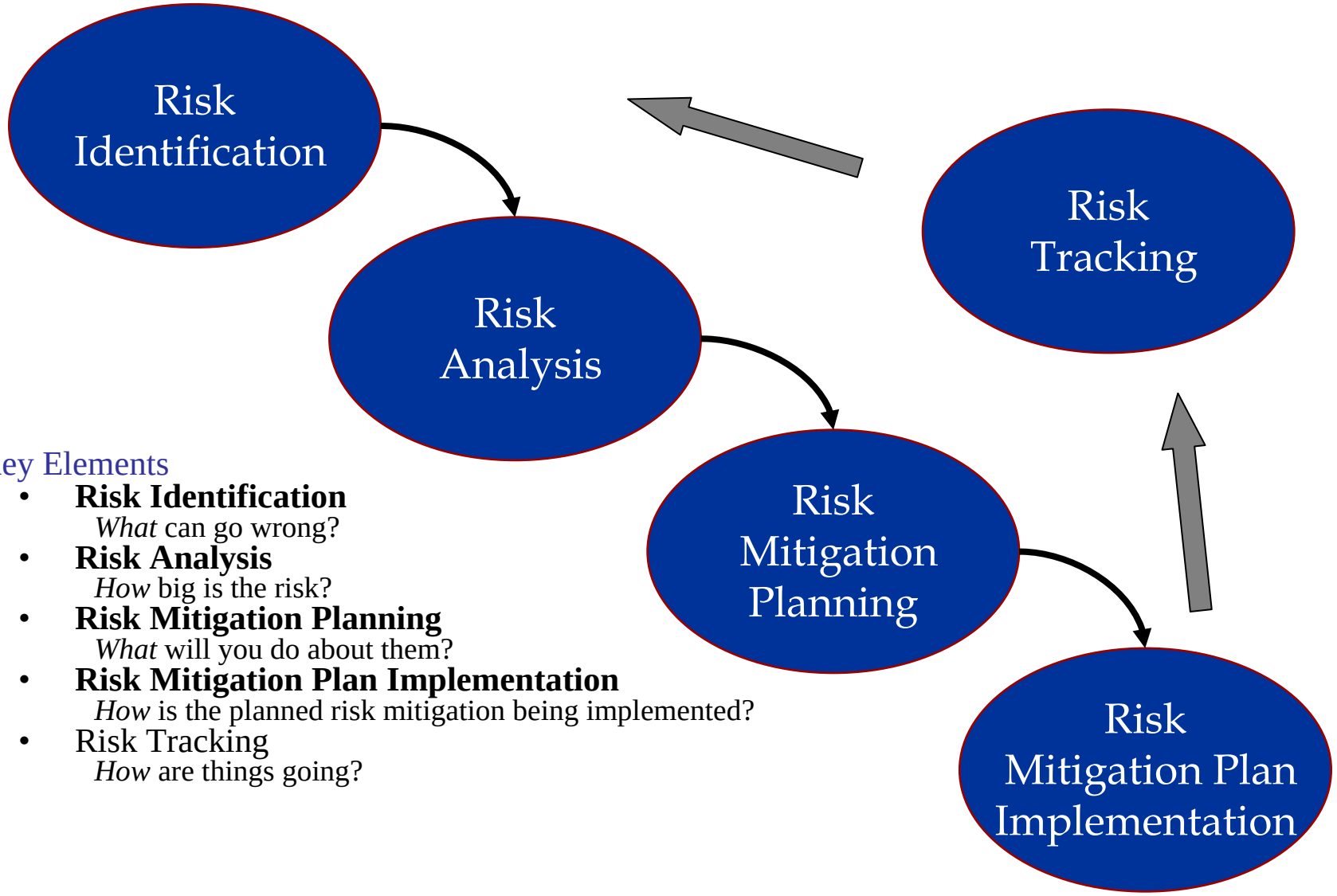
- A measure of future uncertainties in achieving program goals and objectives within defined cost, schedule and performance constraints. *Risk* has three components:
  - A *future root cause*
  - A *likelihood* (or probability) assessed at the present time of a future root cause occurring
  - The *consequence* (or effect) of a future root cause

# Risks vs. Issues

- Risks: *yet to happen*
  - Future consequences
  - Can be closed only after successful mitigation through avoiding, controlling, transferring, or assuming the risk
- Issues: *current* problems and/or challenges
  - Real-time consequences
  - Can be closed within 30-60-90 days windows

**If it's already occurred, it's an issue, not a risk**

# Risk Management Process Model




Key Elements

- **Risk Identification**
  *What* can go wrong?
- **Risk Analysis**
  *How* big is the risk?
- **Risk Mitigation Planning**
  *What* will you do about them?
- **Risk Mitigation Plan Implementation**
  *How* is the planned risk mitigation being implemented?
- Risk Tracking
  *How* are things going?

# Identifying Risk:
# Where to Look for Potential Risks

- Where risks originate
  - Technical
  - Schedule
  - Cost
- Suggestions
  - Examine lessons learned
    - History will repeat itself
  - Study the WBS and SOW
    - Be thorough, but not absurd
    - Take care not to focus all your efforts on highly improbable scenarios
    - Use technical reviews to gauge risks to program
  - Leverage collaboration, particularly with experts

**What has worked for you?**

# Identifying Risk: What Can Go Wrong?

*I cannot imagine any conditions which would cause a ship to founder.*

**Captain E.J. Smith, 1906**

**(Captain of *Titanic* on the evening on 14 April, 1912)**

# Common Risk Pitfalls

- Programs lack properly documented risk management activities
  - No Risk Management Plan that documents an organized, comprehensive and interactive strategy for managing risk
  - Lack of formal documented risk mitigation plans
    - No mitigation plans for all medium / high risks
  - Lack of off-ramps for major program risks
  - Mitigation tasks do not have resources assigned nor due dates nor the status of the task

- Programs lack a mature risk management program
  - Risk avoidance lessons learned are not addressed within risk management approach
  - Risk management by PMO lacks discipline, effectiveness
  - Mixing of issues and risks

# Common Risk Pitfalls

- Tools and methodology supporting risk management are not sufficient
  - Lack of evidence of linkage between TPMs/EVM/Risk Management/WBS/IMS to effectively employ them as management tools that enable risk reduction
  - Risk tool does not map risks to applicable WBS element
  - Government and contractor risk tools are not compatible

- Program management does not have a portfolio view of risk management
  - Enterprises do not have a portfolio view of risk management to prevent one program from being adversely impacted by other acquisition programs or enterprise-wide challenges

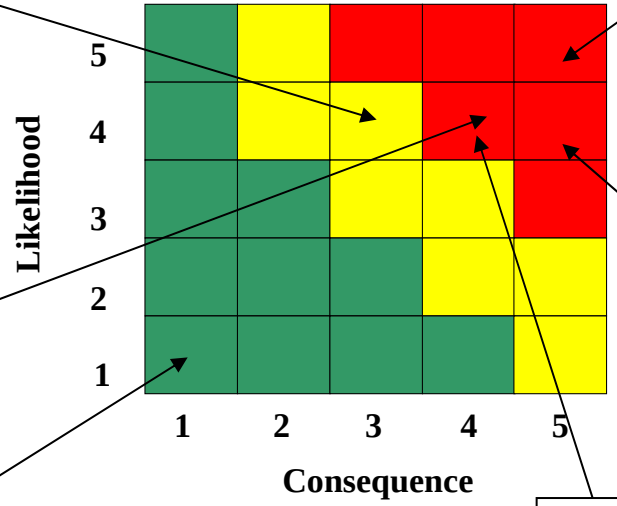
# Risk Reporting 5 X 5 Matrix

**Program Affordability**
Additional scope and EAC growth may grow Costs beyond the program budget
**Mitigation Plan**
1. Identify cost reduction baseline
2. Identify CAIV trade options

**Range Performance**
System weight targets may not be achieved, Causing impacts to system performance and non-compliance requirements
**Mitigation Plan**
1. Establish weight management program
2. Substantiate weight estimates
3. Identify alternative design solutions or trades

**Engine Exhaust**
Current aircraft experiences fuselage heating due to exhaust impingement
**Mitigation Plan**
1. Local thermal blanketing
2. Trade study for redirection of exhaust

ISSUE




**Inspection**
Short Interval (100 hour) inspections for bushing wear and hub cracking will increase overall system down-time and increase spares requirement
**Mitigation Plan**
1. Additional spares
2. Accelerate new development
3. Establish retrofit plan option

ISSUE

**Increment 1 Impact on IOC**
IOC may be delayed beyond Threshold dates
**Mitigation Plan**
1. Mitigate SETR delays through out of station mods
2. Optimize production, missionization and T&E

**Inc 1 & 2 Configuration Differences**
Inc 2 requirements may drive unique differences resulting in Inc 1 structures not being unusable for Inc 2
**Mitigation Plan**
1. Identify structural retrofit requirements
2. Identify potential requirement trades
3. Determine technical, schedule and cost viability of retrofit

# 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

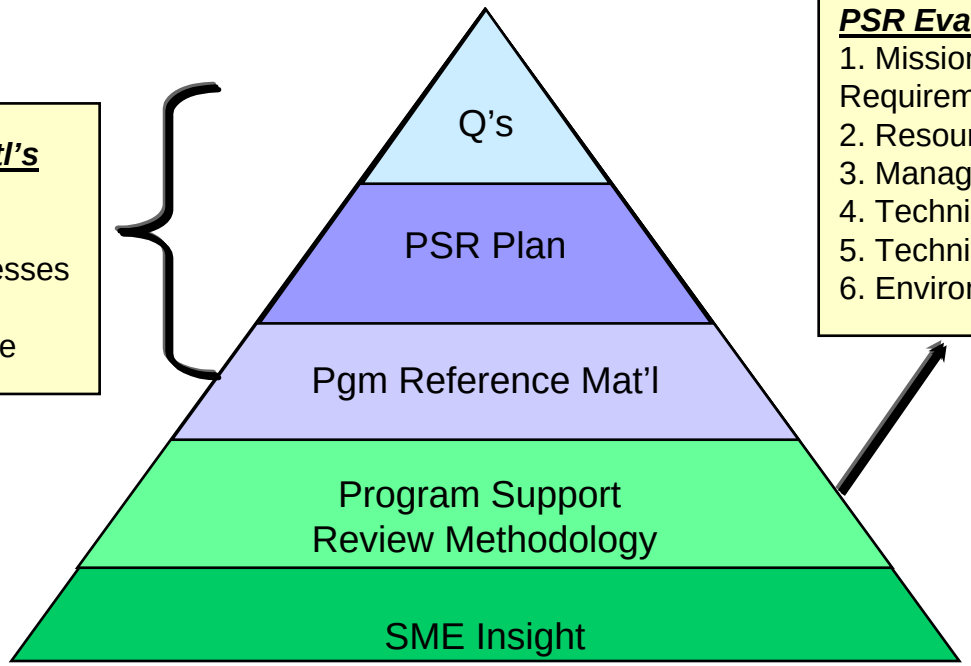
- Independent, cross-functional view aimed at providing risk-reduction recommendations

***Goal: reduce risk in the technical and programmatic execution on a program***

# Program Support Review (PSR)

- DAPS; a repeatable, tailorable, exportable process
- Trained workforce with in-depth understanding of PMs' program issues

***PSR Reference Matl's***
- Templates
- Sample Questions
- Documented Processes
- Training Materials
- Execution Guidance




***PSR Evaluation Areas***
1. Mission Capabilities/ Requirements
2. Resources
3. Management
4. Technical Process
5. Technical Product
6. Environment

**"…PSR team serves as 'disinterested 3rd party' that allows [the PM] to approach leadership armed with powerful program truths, reinforce issues." (PM)**

**PMs Report Process is Insightful, Valuable, and Results Oriented; better than 95% acceptance of recommendations**

# A Tailorable Process Model…

## Pre-MS A (Oct 2004)

Initial Capabilities Documentation (ICD)
Results of system concept studies
Analysis of Alternatives
Technology Development Strategy
Technology Development Planning
Technology Risk Reduction
Systems Engineering planning

## Pre-MS B (Dec 2003)

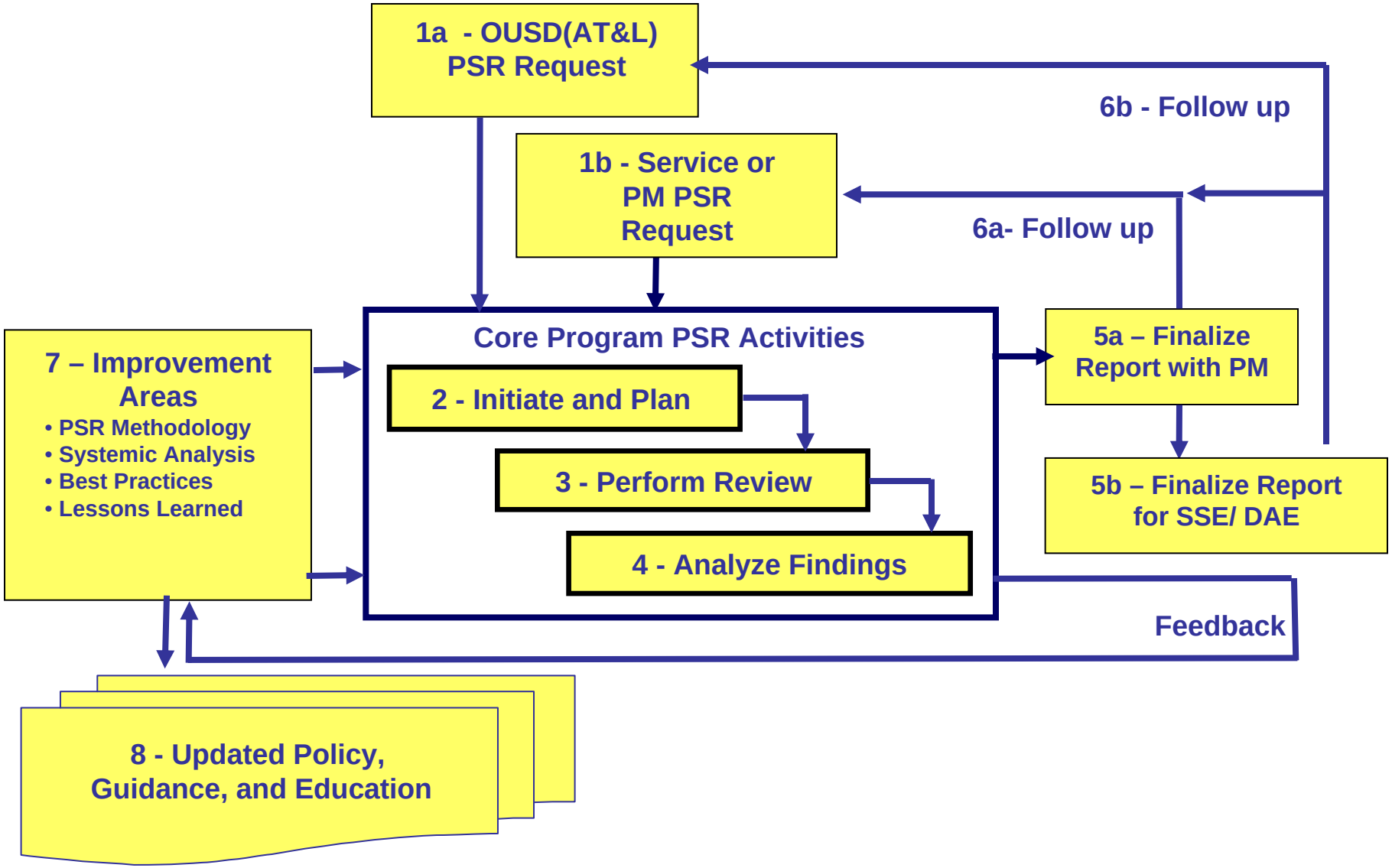
Results of Technology Development and Maturation
Capabilities Development Documentation (CDD)
Feasibility and stability of requirements
Incorporation of MOSA, Net Centric capability
Acquisition Strategy
Test and Evaluation Strategy
Application of systems engineering process in design, test, and verification
Design producibility and transition to production planning
Logistics metrics including supportability, reliability, maintainability

## Pre-MS C (May 2004)

Design Baseline status
Status of system demonstration, test, and evaluation
Execution of systems engineering process
Production metrics and process controls
Transition to production planning
Operational test verification
Logistics metrics verification (maintenance/training)

Defense Acquisition Program Support (DAPS)
Consolidated Web Version – Oct 2005
http://www.acq.osd.mil/se/as/publications.htm

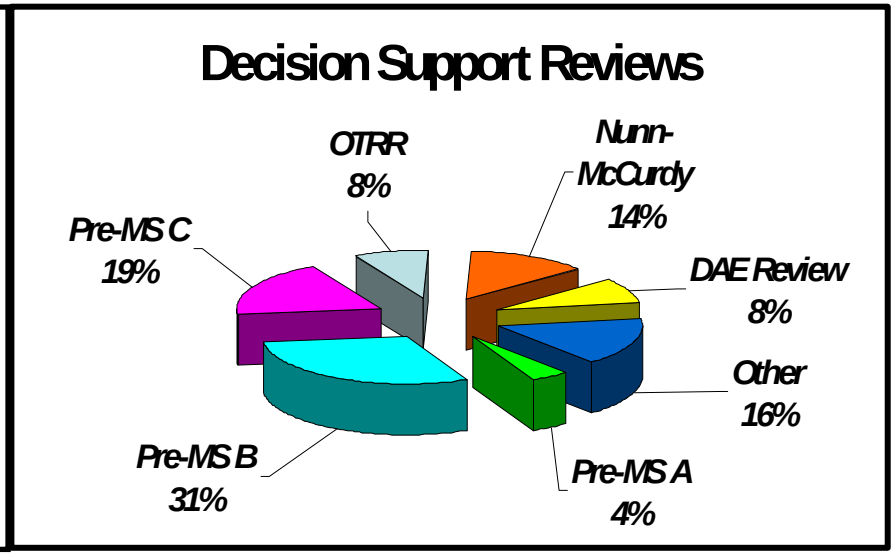
# SSE PSR Process Model

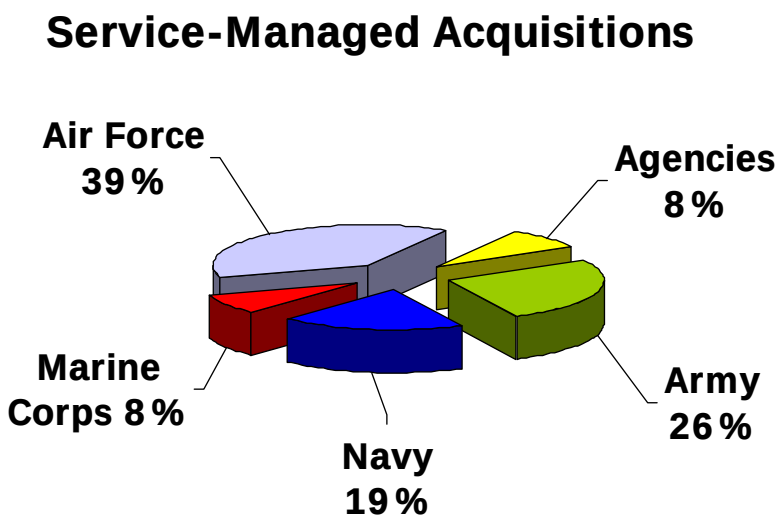


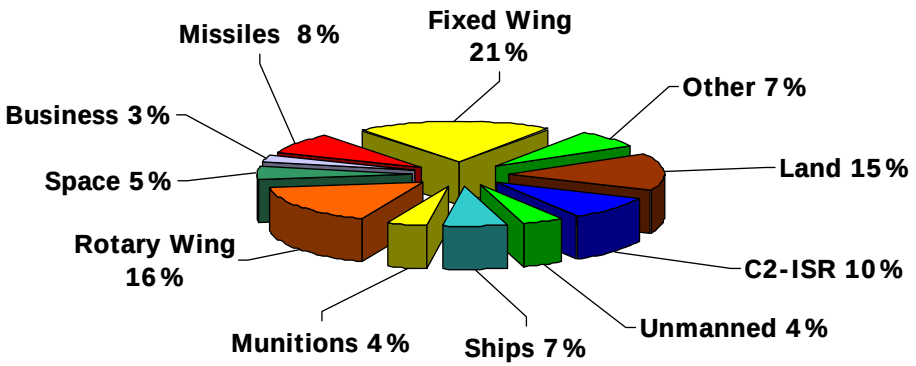
# Program Support Review Activity

(since March 2004)

- PSRs/NARs completed: 42
- AOTRs completed: 10
- Nunn-McCurdy Certifications: 10
- Participation on Service-led IRTs: 2
- Technical Reviews: 9



# Top 10 Emerging Systemic Issues

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

***Major contributors to poor program performance***

# Technical Plan/Risk Management Plan Integration

## Examples

- Program Requirements
  - SEP: describe the critical technologies of the preferred system concept
  - Risk: the critical technologies do not mature by MS B
  - Mitigation: Adjust driving requirement to accommodate more mature technology
- Technical Staffing
  - SEP: describe your system safety certification requirements
  - Risk: the System Safety subject matter expert may retire early
  - Mitigation: identify support contractor; initiate cross-training; multiplex across IPTs
- Technical Baseline Management
  - SEP: describe the approach to requirements traceability and verification
  - Risk: the Modeling & Simulation software (for verification) underperforms
  - Mitigation: plan schedule for regression testing; have provisions to analyze and fix
- Technology Maturation
  - SEP: describe how event-driven Technical Reviews will be conducted
  - Risk: political pressure to stay on schedule regardless of technical maturity
  - Mitigation: plan for early/continuous tracking of product maturity; build in on/off ramps
- Integration with Overall Program
  - SEP: describe integration of technical planning with test & evaluation plans
  - Risk: the window for using the test range is not met
  - Mitigation: line up other ranges in advance; explore opportunities for re-sequencing of testing

**Identify risks as part of the technical planning**

# Topics for Discussion

- What are your thoughts on:
  - The “help” you are getting from OSD (policy, guidance, Education & Training, Programs Support Reviews, SEP reviews, etc.)
    - Have the SE policy memos of 2004 caused you to do anything different?
    - Are you aware of the new DAU SYS 100, 200 and 300 level courses, the new Continuous Learning Modules on Technical Planning and Technical Reviews, and the new Risk Management Plan Guide, and are you using them?
  - What it takes to deploy effective SE across all programs
  - The availability of resources you have to put on SE, and ability to train them
  - The need for independent chair at technical reviews outside of the program
  - Mandating development of the SEP prior to RFP release
  - A unified acquirer/supplier SEP

# Topics for Discussion

- Other questions to consider:
  - How are technical reviews conducted and when are they held? Are they schedule driven or event-based?
  - Do you have “technical baselines”? What process do you use to track and manage them?
  - Who does your planning (e.g. writes your SEP and Risk Plan)? Are these plans used and are they value added?
  - How do the SEP, Risk Plan, TEMP and other technical documents integrate with the acquisition strategy?
  - Will the Redskins win the Super Bowl this year?

# SE links

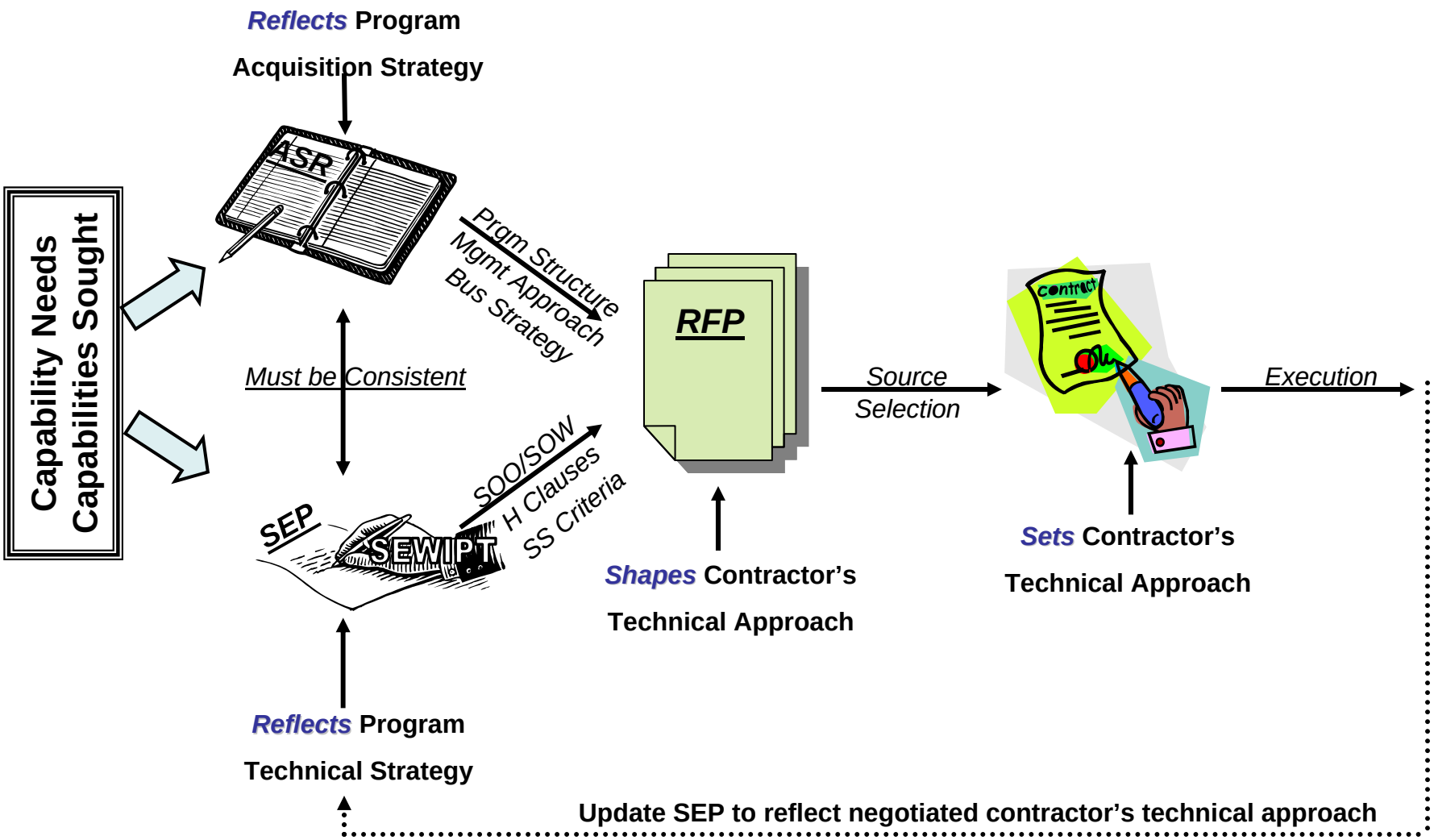
Products:
http://www.acq.osd.mil/se/publications.htm

Education & Training
http://www.dau.mil/basedocs/trainingcourses.asp

OSD SE Webcast (13 Oct 06)
OSD/Tri-Service SE Webcast (23 Feb 07)
http://www.dau.mil

- Backup Slides

# SEP Timing


Reflects Program
Acquisition Strategy
Capability Needs
Capabilities Sought
ASR
Prgm Structure
Mgmt Approach
Bus Strategy
Must be Consistent
SEP
SEWIPT
SOO/SOW
H Clauses
SS Criteria
RFP
Shapes Contractor's
Technical Approach
Source
Selection
contract
Sets Contractor's
Technical Approach
Execution
Reflects Program
Technical Strategy
Update SEP to reflect negotiated contractor's technical approach

# DoD IOT&E Results 1 of 3

| Program | Service | ACAT | IOT&E Result | | Reason |
|---|---|---|---|---|---|
| ***CY 2001*** | | | | | |
| F-15 TEWS | USAF | II | Effective | Not Suitable | Reliability, Maintainability, Availability |
| V-22 Osprey | Navy | 1D | Effective | Not Suitable | Reliability, Availability, Maintainability (RAM), Human Factors, BIT |
| Joint Direct Attack Munitions (JDAM) | USAF | 1C | Effective only with legacy fuses | Not Suitable | Integration with delivery platforms |
| M2A3 Bradley Fighting Vehicle | Army | 1D | Effective | Suitable | |
| ***CY 2002*** | | | | | |
| Joint Primary Aircraft Training System (JPATS) | USAF | 1C | Effective with deficiencies | Not Suitable | RAM, Safety, Human Factors |
| Cooperative Engagement Capability (CEC) | Navy | 1D | Effective | Suitable | |
| Multiple Rocket Launcher System (MLRS) | Army | 1C | Effective | Suitable | |
| MH-60S | Navy | 1C | Effective | Not Suitable | RAM, excessive administrative and logistic repair time impacted RAM |
| ***CY 2003*** | | | | | |
| B-1B Block E Msn Upgrade Program | USAF | 1D | Not Effective | Suitable | 16% decrease in weapons release rate, reduction in accuracy of Mark 82 low drag weapons, 14% hit rate on moving targets |
| Sea wolf Nuclear Attack Submarine | Navy | 1D | Effective | Suitable | Several requirement thresholds were not met but overall system effective and suitable |

# DoD IOT&E Results 2 of 3

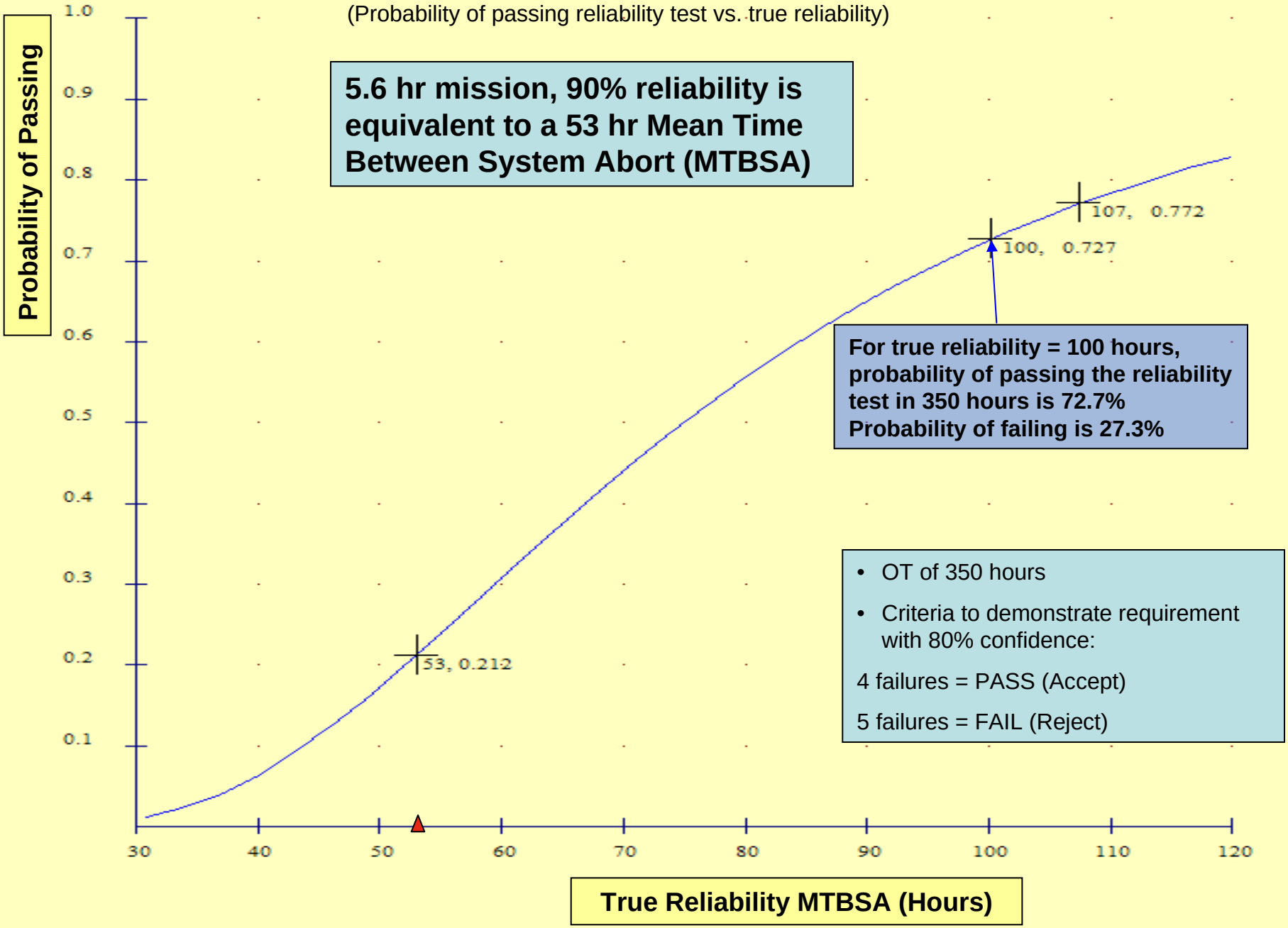
| Program | Service | ACAT | IOT&E Result | | Reason |
|---|---|---|---|---|---|
| | | | ***CY 2004*** | | |
| Evolved Sea sparrow Missile | Navy | II | Effectiveness unresolved | Suitable | Testing was not adequate to determine effectiveness. |
| Stryker | Army | 1D | Effective | Suitable | |
| Advanced SEAL Delivery System (ASDS) | Navy | 1D | Effective with restrictions | Not suitable | Effective for short duration missions; not effective for all missions and profiles.<br>Not suitable due to RAM. |
| Tactical Tomahawk Weapons System | Navy | 1C | Effective | Suitable | |
| Stryker Mortar Carrier-B (MC-B) | Army | 1D | Effective | Not Suitable | RAM and safety concerns. |
| | | | ***CY 2005*** | | |
| CH-47F Block I | Army | 1C | Effective | Not Suitable | RAM; communications system less suitable than CH-47D; did not meet Information Exchange Requirements for Block I. |
| F/A-22 | USAF | 1D | Effective | Not Suitable | RAM; needed more maintenance resources and spare parts; BIT |
| Joint Stand-Off Weapon-C | Navy | 1C | Not Effective | | Not effective against moderately hardened targets; mission planning time was excessive. |
| Guided-MLRS | Army | 1C | Effective | Suitable | |
| High Mobility Attack Rocket System (HMARS) | Army | 1C | Effective | Suitable | |
| V-22 Osprey | Navy | 1D | Effective | Suitable | |
| MH-60R | Navy | 1C | Effective | Suitable | |
| EA-6B (ICAP III) | Navy | II | Effective | Suitable | |

# DoD IOT&E Results 3 of 3

| Program | Service | ACAT | IOT&E Result | | Reason |
|---|---|---|---|---|---|
| | | | ***CY 2006*** | | |
| Common Missile Warning System (CMWS) | Army | 1C | Effective | Suitable | Effective and suitable in the OIF/OEF environment but needs further testing outside of the OIF/OEF environment. |
| Deployable Joint Command and Control (DJC2) | Navy | 1AM | Effective | Not Suitable | Operational Test Agency, COTF, reported effective, not suitable. BLRIP not complete. |
| Integrated Defensive Electronic Countermeasures | Navy | II | | | Test suspended due to reliability problems. |
| Surface Electronic Warfare Improvement Program (SEWIP) Block 1A | Navy | II | Not Effective | Not Suitable | Block 1A Upgrade does not make the AN/SLQ-32 EWS operationally effective and suitable but does enhance ability to protect ships |
| C-130J | USAF | 1C | Effective single ship; Not effective in formation | Suitable with shortfalls | Effective single ship; not effective in formation air land / air drop; not effective in non-permissive threat environment. Shortfalls in suitability due to maintainability issues |
| Small Diameter Bomb (SDB) Increment 1 | USAF | 1D | Effective with limitations | Suitable with limitations | Limited effectiveness and suitability due to bomb rack reliability and deficiencies in software used to predict optimum fuzing solutions. Oct 2006 flight operations suspended |

# Program X Operating Characteristic (OC) Curve

(Probability of passing reliability test vs. true reliability)



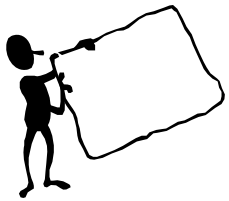

**5.6 hr mission, 90% reliability is equivalent to a 53 hr Mean Time Between System Abort (MTBSA)**

**For true reliability = 100 hours, probability of passing the reliability test in 350 hours is 72.7%**
**Probability of failing is 27.3%**

- OT of 350 hours
- Criteria to demonstrate requirement with 80% confidence:

4 failures = PASS (Accept)

5 failures = FAIL (Reject)

# Systemic Reliability Issues

- Unrealistic reliability requirements
  - Optimistic goals vs. programmatic timelines and allocated resources
  - Failure to document mission context or mission profile
  - Failure to appreciate the stochastic character of RAM and hence suitably statistical confidence issues
- Optimistic growth rate assumptions
  - Inadequate allowance of resources (time, money, people)
  - Over optimistic view of starting reliability (prior to growth)
  - Reliability growth strategy incompatible with demonstration requirements
- Testing Issues
  - Lack of robustness in DT
  - Immaturity of scoring conference and process
  - Arbitrary interpretations of failures during test events
  - Inadequate root cause analysis and corrective actions