DoD Systems Engineering

Government / Boeing Systems Engineering Leadership Meeting
May 10, 2006

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Briefing Topics

<u>Update:</u> *DoD SE Revitalization*

- Policy, Guidance, Education and Training

<u>State of SE:</u> *What we are seeing in programs*

- Findings from our program support reviews

<u>Other SE Initiatives</u>

- Program Protection

- CMMI

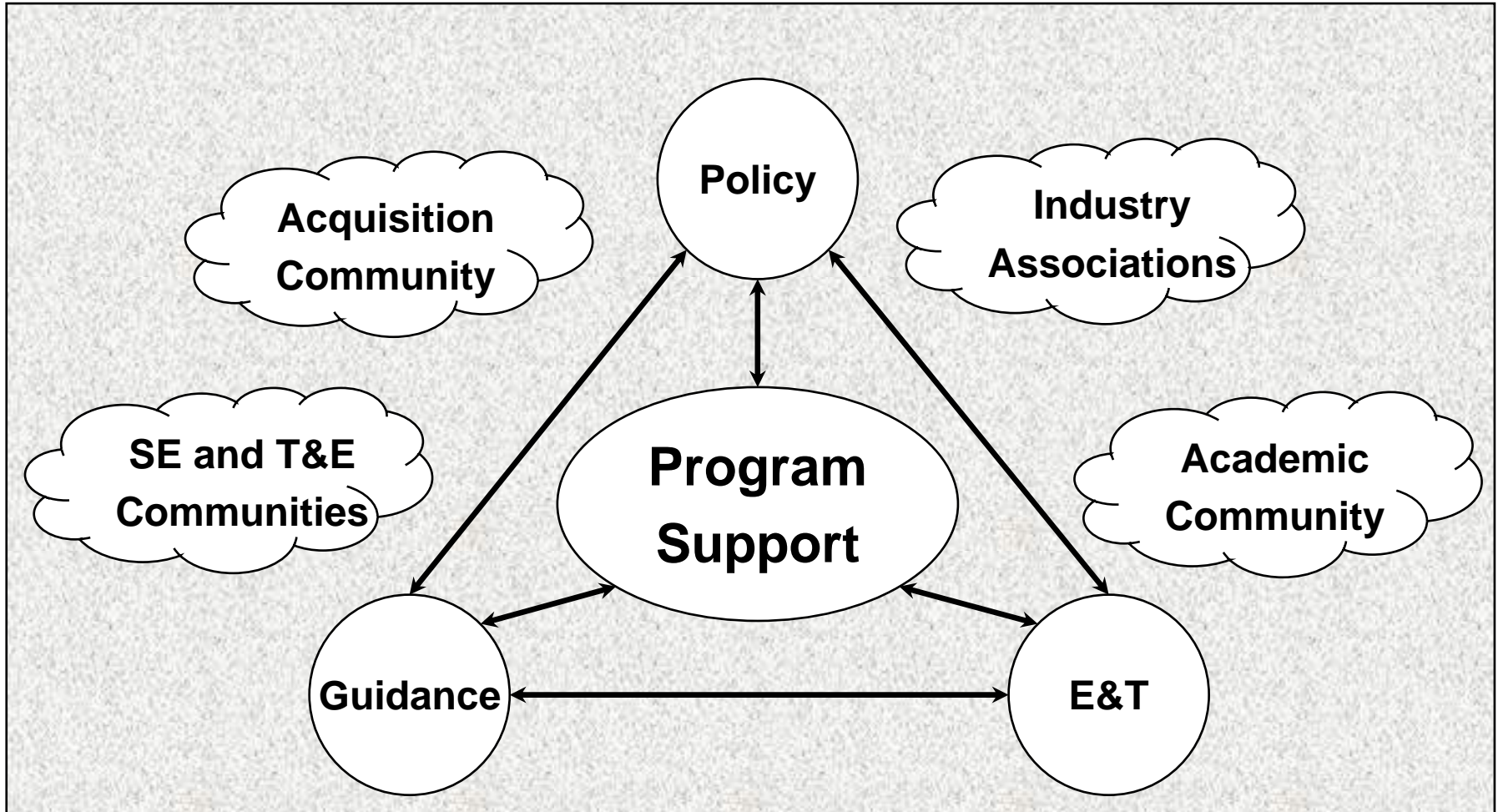- Defense Safety Oversight Council: Acquisition and Technology Programs Task Force

<u>Report on the 2006 QDR:</u> Strategic Acquisition Initiatives

Update:
DoD SE Revitalization

Systems Engineering Revitalization Framework

Driving Technical Excellence into Programs!

Systems Engineering Policy

- Policy Memorandum (February 2004) and Policy Addendum (October 2004)

  – Programs shall apply robust SE approach and develop a SE plan

  – Each PEO shall have a lead or chief systems engineer

  – Event-driven technical reviews with entry criteria and independent SMEs unless waived by MDA

  – OSD shall review program SEPs for ACAT ID and IAM programs

  – Defense Systems shall establish a SE Forum

- DoDD 5000.2 Update

  – Reflect the policy changes of the two memos

Systems Engineering Guidance

- Published Defense Acquisition Guidebook
- Published DoD Guide for Achieving Reliability, Availability, and Maintainability
- Published Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- Published Systems Engineering Plan Preparation Guide
- Upcoming:
  - Update Defense Acquisition Guidebook
  - Update Risk Management Guide
  - Develop Contracting for SE Guide

# Systems Engineering Education, Training, and Outreach

- <u>Updating formal training across key career fields</u>: SE, Acquisition Program Management, Contract Management, Finance, Logistics

- <u>Developing continuous learning, on-line courses</u>: Reliability and Maintainability, Technical Reviews, System Safety, Modeling and Simulation, Technical Planning, Corrosion Prevention and Control, Modular Open Systems Approach

- <u>Engaging universities</u>: Stevens Institute of Technology, University of Southern California, Stanford, Southern Methodist, George Mason, Service Academies and Naval Postgraduate School, AFIT/CSE

State of Systems Engineering:
What we are seeing in programs

Systems Engineering Revitalization Framework
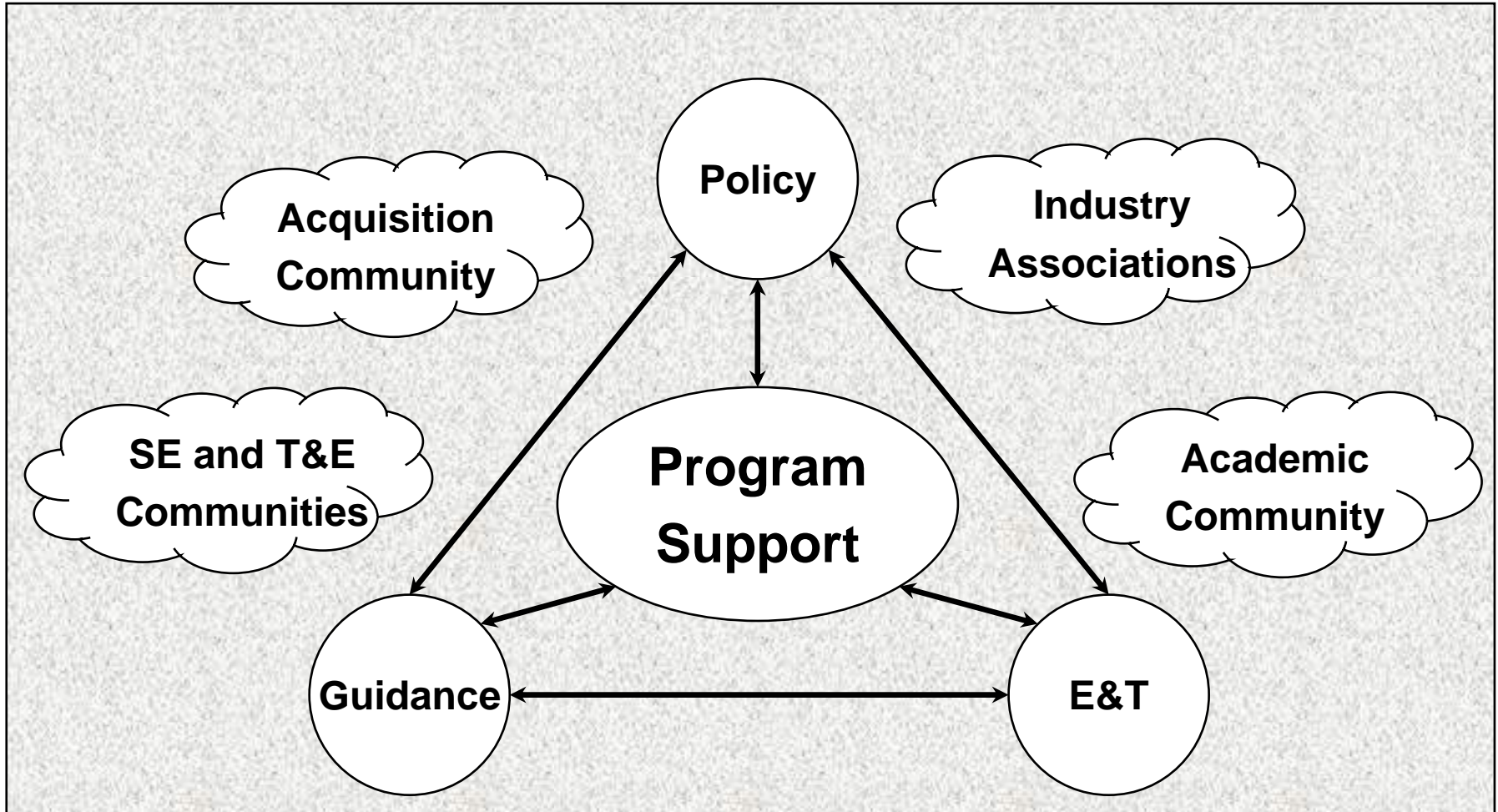
Necessary but not Sufficient

Driving Technical Rigor Back Into Programs
"Program Support Reviews"

- Program Support Reviews provide insight into a program's technical execution focusing on:
  - SE as envisioned in program's technical planning
  - T&E as captured in verification and validation strategy
  - Risk management—integrated, effective and resourced
  - 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
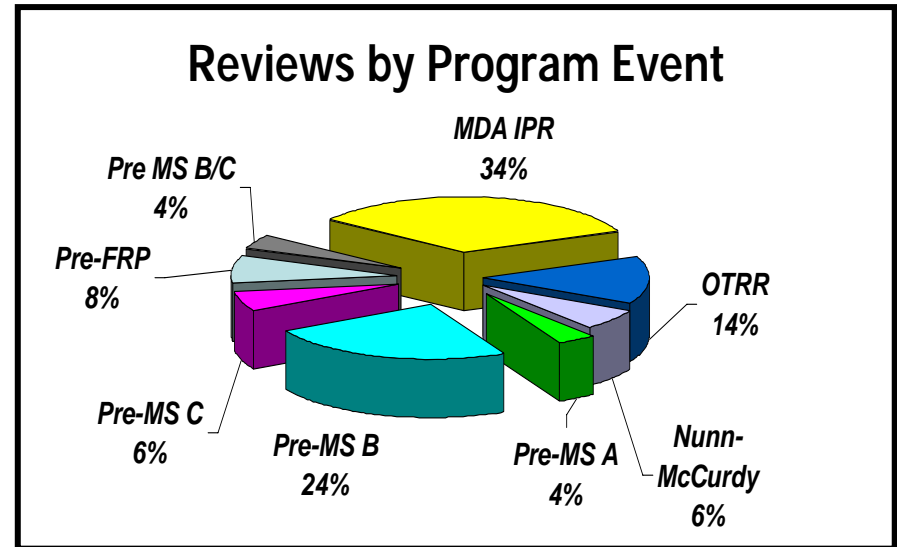
Balancing Key Programmatic Elements

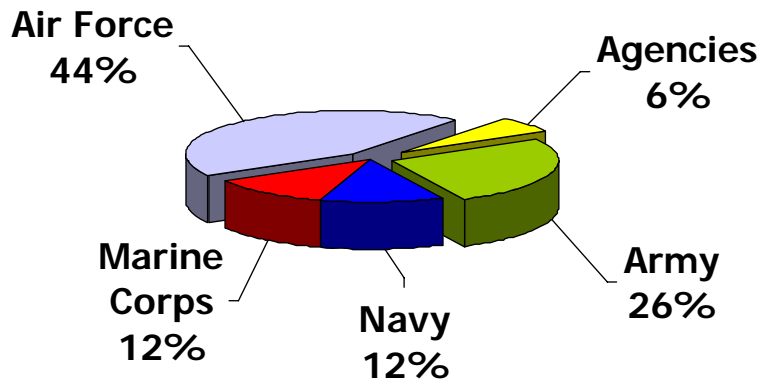| Element	Systems Engineering	Test & Evaluation	Risk Management	Exit Criteria	Acquisition Strategy
Focus Areas	Requirements	V&V Traceability	Risk ID	Mission Systems	Mission Capability
	Organization & Staffing	Test Resources	Risk Analysis	Support	Resources & Management
	Technical Reviews	Test Articles	Risk Mitigation Planning	Manufacturing	Technical Process
	Technical Baseline	Evaluation	Risk Tracking	R & M	Technical Product
	Linkage w/ Other Program Mgmt & Controls	Linkage w/ Other Program Mgmt & Controls	Evidence of Effectiveness	Net Centric	Enterprise Environment
Product	SEP	TEMP	RM Plan	Phase Exit Criteria	ASR/APB

Program Support Review Activity
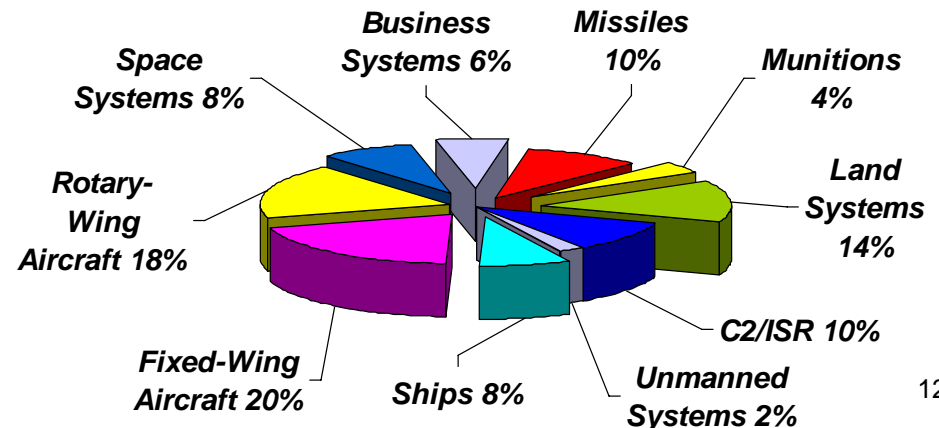## (since March 2004)

- PSRs/NARs completed: 33
- AOTRs completed: 7
- Nunn-McCurdy Certification: 3
- Participation on Service-led IRTs: 4
- Technical Reviews: 3
- Reviews planned for rest of FY06
  - PSRs/NARs: 12+
  - AOTRs: 2
  - Nunn-McCurdy: 2

Reviews by Program Event

- MDA IPR 34%
- Pre MS B/C 4%
- Pre-FRP 8%
- OTRR 14%
- Pre-MS C 6%
- Pre-MS B 24%
- Pre-MS A 4%
- Nunn-McCurdy 6%

Service-Managed Acquisitions

- Air Force 44%
- Agencies 6%
- Marine Corps 12%
- Navy 12%
- Army 26%

Programs by Domain Area

- Business Systems 6%
- Missiles 10%
- Space Systems 8%
- Munitions 4%
- Rotary-Wing Aircraft 18%
- Land Systems 14%
- Fixed-Wing Aircraft 20%
- Ships 8%
- Unmanned Systems 2%
- C2/ISR 10%

12

Program Support Reviews
Representative Issues

- Mission Capabilities

  – Requirements—reasonable, measurable, complete

- Resources/Management

  – Schedule adequacy—success-oriented vice event-driven; schedule realism

  – Risk management—inadequate or not linked to technical effort

- Technical Process

  – Systems Engineering Planning—inadequate technical planning

  – Test & Evaluation—insufficient tests or test articles

- Technical Product

  – Reliability—insufficient reliability growth program

  – Supportability/Maintainability—timing of validation

Other SE Initiatives:
Program Protection

Program Protection

- Expanding Program Protection
  - Horizontally across the full continuum of acquisition
  - In depth to address Software Assurance, Anti-Tamper, Information Assurance, Counter Intelligence, and Commercial and Military Export Control

- NDIA chartered a System Assurance committee to:
  - Enable nationwide collaboration across industry, government
  - Leverage standards activities to address system vulnerabilities
  - Develop a Handbook for Engineering System Assurance

"Effective" system assurance in DoD acquisition must be holistic in its approach and consistently applied by industry and Government alike across the entire acquisition life cycle.

Other SE Initiatives:
CMMI

CMMI: Issues

- Programs execute at lower maturity levels than their organizations have achieved and advertised
- High-maturity practices are not consistently applied at the project level after contract award
- How to ensure new projects will incorporate CMMI processes
- Appraisal sampling procedures – how to ensure adequate coverage of the organizational unit
- Appraiser quality – training, consistency
- Lack of agreement on what constitutes Levels 4 and 5
- Need to converge to a single representation
- Content of appraisal disclosure statements is lacking
- Inadequate training and education for acquirers
- Should CMMI be used for source selection

What is the resolution of these issues?

CMMI: Next Steps

- Implementing changes to the CMMI v1.2 product suite to ensure:

  – Integrity of appraisals

  – Quality of the product suite

  – Education of acquirers

  – Opportunities for streamlining where appropriate

- Developing a CMMI model for Acquirer process improvement

  – Partnership with General Motors

  – Stakeholders cross DoD, Govt Agencies and Industry

CMMI continues to evolve and improve

Defense Safety Oversight Council
Acquisition and Technology Programs (ATP) Task Force

- Joint Weapons
- Unmanned Vehicles

Acquisition and Technology Programs (ATP) Task Force

- Purpose
  - Recommend or implement changes to policies, procedures, initiatives, education and training, and investments to ensure programs address safety throughout the life cycle

- Goals
  - Ensure acquisition policies and procedures for all systems address safety requirements
  - Review and modify, as necessary, relevant DoD standards with respect to safety
  - Recommend ways to ensure acquisition program office decisions consider system hazards
  - Recommend ways to ensure milestone decision reviews and interim progress reviews address safety

Establish dialogue between System Safety and Engineering and Program Management communities

Safety and the Joint Warfighting Environment

- Individual Services have long-standing, rigorous Service-specific weapon safety review processes to meet their unique requirements (philosophies, warfighting needs, definition of what is "safe")

  – Army: Materiel release process, Fuze Safety Review Board, Ignition System Safety Review Board

  – Navy/Marine Corps: Weapon System Explosives Safety Review Board, Laser Safety Review Board

  – Air Force: Non-Nuclear Munitions Safety Board, Laser Safety Review Board

Joint Weapon Safety Review for SOCOM

ISSUE: SOCOM incurs additional cost and schedule time when obtaining concurrences/approvals from multiple service safety boards

Action: OSD and SOCOM jointly tasked Service safety board leaders to develop process to perform collaborative system safety review with goal to:

- Eliminate duplication of testing & analyses
- Decrease costs and time to delivery

Status:

- Pilot process developed
- Process being validated with three SOCOM nominated systems/equipment

Expanded Joint Weapon Safety Review

ISSUE: Joint Program PEOs/PMs incur additional cost & schedule time in obtaining concurrences/approvals from multiple service safety boards

Action: Expand the "SOCOM" process to be utilized on other multi-service weapon systems within DoD.

Status:

- – Framework for process has been developed

- – Working group needs to complete process development and documentation

- – Identify Joint/Multi-Service weapon systems to validate process

Unmanned Systems Safety

- Issue: The Future Combat Systems Board of Directors raised the issue of whether or not proper procedures and processes were in place to ensure weaponized unmanned systems safety in the joint battle space

- ATP TF Goals
  - To determine the maturity of Unmanned Systems development and governance
  - To determine whether or not proper procedures and processes are already in place to ensure vehicle safety
  - To determine if OSD can or should play a role to help ensure DoD puts the necessary procedures and processes in place

Who's in Charge!

Unmanned Systems
QDR Guidance

- The Department will also increase procurement of unmanned aerial vehicles to increase persistent surveillance, nearly doubling today's capacity. It also will begin development of the next generation long-range strike systems, accelerating projected initial operational capability by almost two decades. (pg 6)

- The Air Force has set a goal of increasing its long-range strike capabilities by 50% and the penetrating component of long-range strike by a factor of five by 2025. Approximately 45% of the future long-range strike force will be unmanned. (pg 46)

- Undersea capabilities, both manned and unmanned, will use stealth, survivability, endurance, payload size and flexibility to complicate potential foes' planning efforts and strengthen deterrence. (pg 47)

- The increasing use of robotics has improved U.S. force protection significantly in Operation Iraqi Freedom. (pg 64)

Growth Industry

Unmanned Aircraft (UA) 2006

Theater and Tactical (>10lbs)

- Buster — 20
- Pioneer — 34
- Shadow 200 — 140
- Neptune — 15
- Tern — 15
- Mako — 14
- Tigershark — 6
- SnowGoose — 25
- Hunter — 32
- I-Gnat — 4
- Predator — 70
- Predator B — 6
- Global Hawk(GH) - ACTD — 4
- Global Hawk - Prod — 5
- GH Maritime Demo — 2
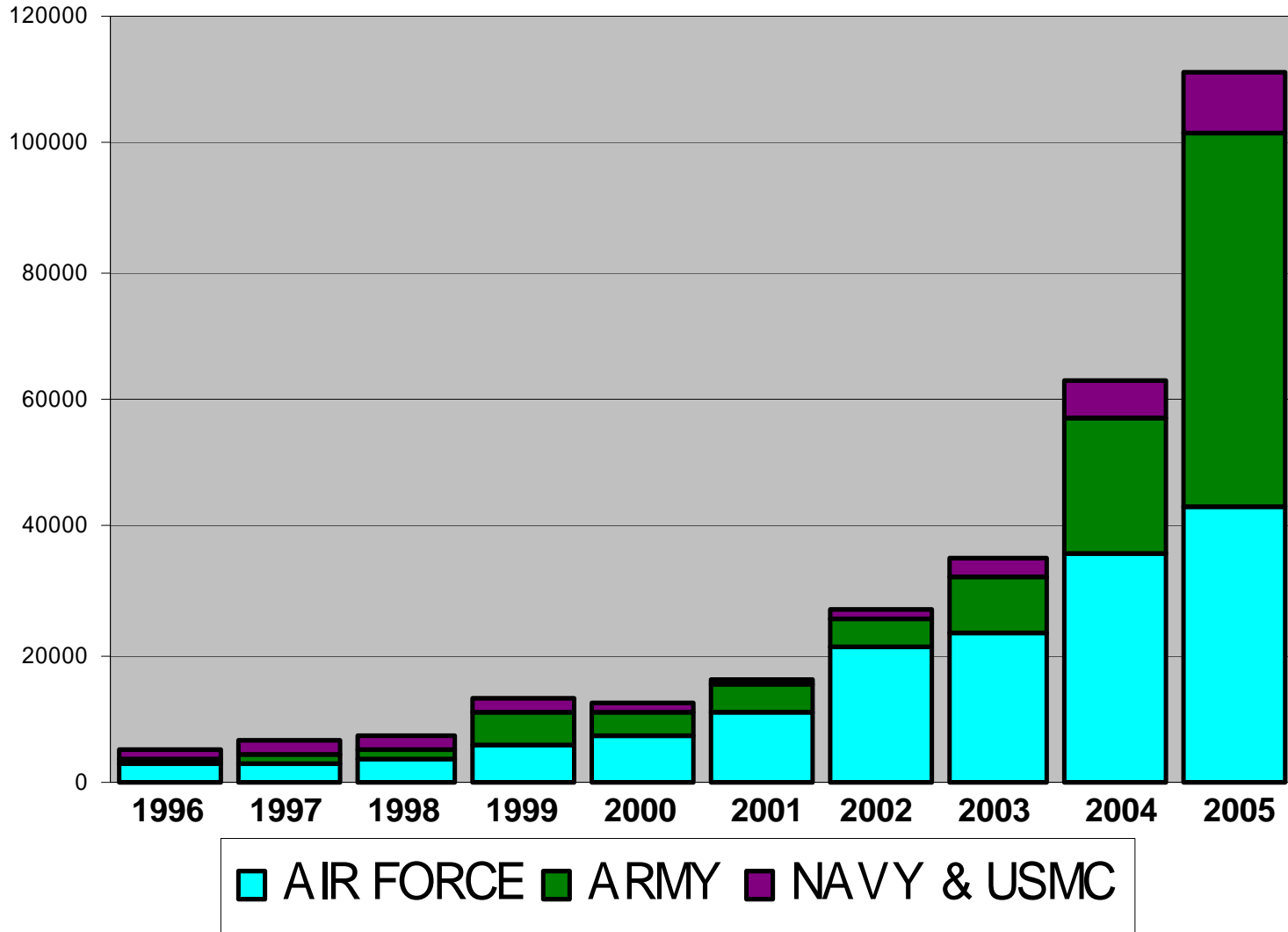- Sub-total — 392

Small (<10lbs)

- Pointer — 126
- Raven — 1776
- Dragon Eye — 402
- Desert Hawk — 126
- BATCAM — 54
- Swift — 212
- Sub-total — 2570

Year	Aircraft	Cost
2002	167 Aircraft	$ 763M
2004	727 Aircraft	$1,631M
2006	2,962 Aircraft	$1,627M

Total R&D and Procurement costs per year

1,674% Increase from 2002

DoD Theater and Tactical UA Flight Hours

Unmanned Ground Systems 2006

EOD/Counter Mine

- Packbot   190
- Talon   172
- Bombot   1000
- MV-4   14
- Sub-total   1376

ISR/Combat

- Dragon Runner   4
- Marcbot   342
- Small Robotic
  Scout System   3700
- Throwbot   30
- Gladiator   1
- Sub-total   4077

2002	15 Systems	$1.0M
2004	162 Systems	$3.5M
2006	4,000 Systems	$89.0M

Total R&D and Procurement costs per year

26,567% Increase from 2002

Unmanned Naval Warfare Systems

Underwater

- MRUUVS   2013 IOC
- SCULPIN   2006 IOC
- BPAUV   2009 IOC
- Surface Mine Countermeasures (SMCM)   2012 IOC

Surface/Semi-submersible

- Mine Sweeping USV   2011 IOC
- Remote Minehunting USV   2007 IOC

2006	6 Systems	$123M
2008	23 Systems	$ 73M
2010	44 Systems	$148M
Total R&D and Procurement costs per year		

633% Increase from 2006

ATP TF Unmanned Systems Findings

- ATP TF brought Unmanned Systems acquisition and operations subject matter experts together to examine and frame the issue and determine possible solutions

- Findings:
  - DoD use of Unmanned Systems will continue to increase substantially over the next decade
  - Mission capability will also increase expanding the range, performance and Joint Service use of Unmanned Systems
  - Unmanned Systems will dramatically reshape doctrine and CONOPS not only for the individual Services but more importantly for the Joint Force Commander
  - Technical pockets of activity but no central leadership
  - Unmanned Aircraft Systems community is further along than Land or Sea communities

> ***Issues are much broader than system safety—weaponized safety, C2, training***

Unmanned Systems Challenges

Airspace	Weapons	Spectrum	Safety	Reliability
Architecture	Payloads	C2	Interoperability	Training
Inter-Agency	Treaty	Data Sharing	Legal	Industrial Base

Inter-Agency Challenges

- Transportation (Federal Aviation Administration)
  - Safety of flight concerns
    - Airspace integration (See & Avoid)
    - Certification / Airworthiness

- Homeland Security
  - Customs and Border Patrol
  - Coast Guard / maritime missions
  - Transportation security
  - Protection of critical infrastructure

- NASA
  - Propulsion
  - Collision avoidance
  - Extremely long endurance aircraft design (HELIOS)
  - Remote sensing

- Commerce
  - Migration of unmanned technology to commercial applications
  - Unmanning cargo / airborne mobile cell phone support

- Agriculture / Interior
  - Unmanned spraying and remote sensing
  - Firefighting support

Training Challenges

- Are we coordinating training for safe operation of unmanned systems?
  - Operator qualification
  - Currency requirements
  - Standardization and evaluation
- Why do pilot and operator requirements differ?
  - Service culture
  - Established operations constructs
  - Capability differences
- Is some standard UAS training appropriate (within UA class)?
  - Entrance requirements appear to be loosening
  - Established career pipelines are being modified
  - Documentation for currency, evaluation, and decertification
- Do the Services have similar specialty codes for the UAS field?
  - Services are creating new manning specialties
  - Maintenance effects on training

> ***Pursuing common solutions to instill safety into unmanned systems operations***

Safety Challenges

- Do we know all the hazards associated with unmanned systems?
    - Airspace deconfliction
    - Perception of friendly / non-combatants in area of operations
    - Inadvertent fire / launch
- What are the safety critical functions of unmanned systems?
    - Firing a weaponized unmanned system
    - Transporting an unmanned system
    - Render safe / render useless / render useful
- What are the risks associated with unmanned systems?
    - Loss of communications
    - Balance between safety in peace time not too constraining for war time
    - Controller / operator "spoofing"
- What technologies can be leveraged to mitigate the hazards / risks?
    - Real-time diagnosis / fault detection
    - Real-time image-processing algorithms
    - Data compression techniques

Take Charge and Be the Leader!

Report on the
2006 Quadrennial Defense Review (QDR)
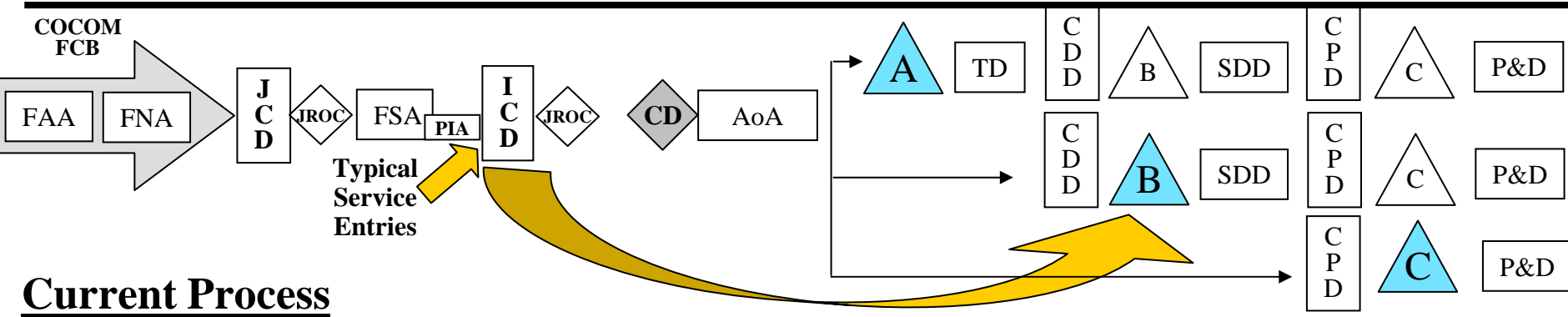## *Strategic Acquisition Initiatives*

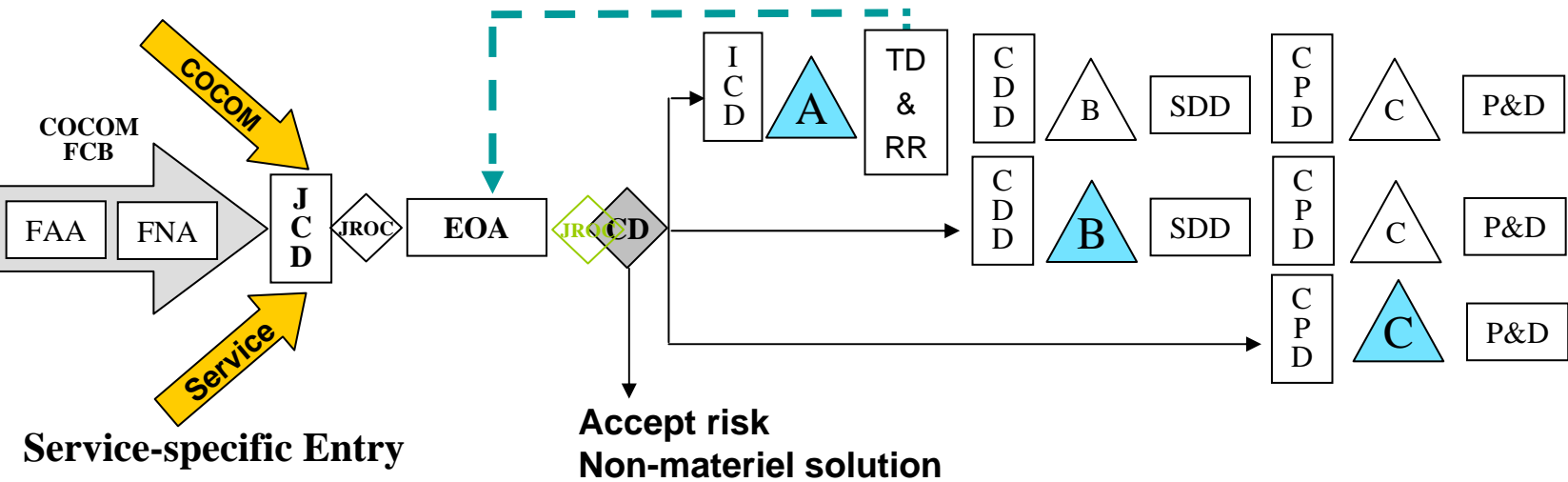# QDR Recommendation:
Improving DoD Investment Decisions

- ## QDR: Investment is not governed by any one DoD process

  - Requirements, Acquisition and Programming interpret strategic guidance independently in making investment decisions

- ## Packard guidance and policy about right

  - Never fully implemented

  - Packard vision needs refinement and disciplined implementation

  - Coordination of Requirements, Acquisition and Programming for Investment Decisions is possible within current Title X authorities

- ## Corporate Concept Decision Review

  - Converge three processes during requirements determination

  - Concept Decision sets conditions for initial phases of acquisition

Concept Decision:
AS IS and TO BE processes

Current Process

COCOM FCB

FAA → FNA → **JCD** → JROC → FSA → PIA → **ICD** → JROC → **CD** → AoA

Typical Service Entries

A → TD → CDD → B → SDD → CPD → C → P&D

CDD → B → SDD → CPD → C → P&D

CPD → C → P&D

Proposed Process

COCOM FCB

COCOM

FAA → FNA → **JCD** → JROC → EOA → JROC **CD**

Service

Service-specific Entry

ICD A → TD & RR → CDD → B → SDD → CPD → C → P&D

CDD → B → SDD → CPD → C → P&D

CPD → C → P&D

Accept risk
Non-materiel solution

QDR Implementation – Next Steps for SE

- Strengthen SE support prior to Concept Decision
  - Solution opportunities
  - Feasibility, life cycle considerations, technical risk
- Enhance early (Pre-Milestone B) SE technical planning and risk reduction
  - Part of DAB/OIPT Streamlining
- SoS Systems Engineering
  - Support capability areas and portfolios
  - Link with broader SE community
    - Leverage OSD SE Forum, NDIA, etc.
    - Continue study and coordination of numerous SoS SE experiences
  - Develop SoS SE Guide
    - Capture knowledge and experience
    - Augment existing policy and processes

USD(AT&L) Goals

Goal 1 - High Performing, Agile and Ethical Workforce

Goal 2 - Strategic and Tactical Acquisition Excellence

Goal 3 - Focused Technology to Meet Warfighting Needs

Goal 4 - Cost-effective Joint Logistics Support for the
Warfighter

Goal 5 - Reliable and Cost-effective Industrial Capabilities
Sufficient to Meet Strategic Objectives

Goal 6 - Improved Governance and Decision Processes

Systems engineering is implemented throughout the AT&L goals