Systems Engineering Overview

Kristen J. Baldwin
Acting Deputy Assistant Secretary of Defense for Systems Engineering (DASD(SE))

Conference for Systems Engineering Research (CSER)
University of Alabama, Huntsville
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Unprecedented Focus on Technical Excellence

“We at the Pentagon must… be open to new ideas and new ways of doing business that can help us operate more efficiently and perform more effectively in an increasingly dynamic and competitive environment.

As DoD counters the very real dangers we face in the world, we will also grab hold of the bright opportunities before us – opportunities to …re-forg[e] our nation’s military and defense establishment into a future force that harnesses and develops the latest, cutting-edge technology, and that remains superior to any potential adversary…”

Secretary of Defense Ash Carter
Submitted Statement, Senate Appropriations Committee-Defense (Budget Request)
May 06, 2015

“...our technological superiority is slipping...we want to achieve an overmatch over any adversary from the operational theater level all the way down to the fighter plane, Navy ship or infantry squad...Battlefield advantages in the future are going to be very short-lived because the amount of technology that is out there right now is unbelievable.”

Honorable Robert Work
Deputy Secretary of Defense
US Army War College, April 2015

“Simply delivering what was initially required on cost and schedule can lead to failure in achieving our evolving national security mission — the reason defense acquisition exists in the first place.”

Honorable Frank Kendall
Under Secretary of Defense (AT&L)
2015 Performance of the Defense Acquisition System
**DoD Research and Engineering Impact**

**Past**
- **Military Capabilities**
  - Communications/Networking
  - IR Night Vision
  - Precision Guidance & Navigation
  - Stealth
  - UAVs

**Enabling Technologies**
- **ARPAnet/Internet Information Technology**: timesharing, client/server, graphics, GUI, RISC, parallel computing, speech recognition
- **Microelectronics**: VLSI, CAD, manufacturing, IR, RF, MEMS
- **Materials Science**: semiconductors, superalloys, carbon fibers, composites, thermoelectrics, ceramics

**Future**
- Directed Energy
- Hypersonics
- Cyber
- Other
Defense Innovation

- **Defense Innovation Initiative (DII):** Identify and invest in innovative ways to sustain and advance our national security into the 21st century

People

New Operational Concepts

Business Practices

Long-Range Research and Development Program Plan (LRRDPP)

“Because, going forward, we need the best people, the best technology, and the best innovation to remain the world’s best fighting force.”

Ash Carter, Secretary of Defense, 9 Sep 2015, DARPA Future Technology Forum
Innovation and Technology Transition Opportunities

- Autonomy & Robotics
- Biomedical
- Electronic Warfare / Cyber
- Future of Computing/ Micro-electronics
- Hypersonics / Directed Energy
- Engineering Complex Systems
  - Manufacturing Innovation Centers
  - Engineered Resilient Systems
Defense Innovation Unit Experimental (DIUx)

Three Year Pilot Project designed to:

- Build new relationships with High-Tech, Non-Traditional firms
- Scout for breakthrough and emerging technologies
- Impedance match the needs of the DoD with the fast-moving commercial innovation
- Highly qualified Civilian and Reserve Military experts with first-hand experience in high-tech start-ups
- Initial operating location: Silicon Valley

“…creating tunnels of ideas into the Department that haven’t existed before...”
- Bob Work, Deputy Secretary of Defense, DSD Editorial Board, 15 September, 2015
Focus on Prototyping

- **Strategic Use of Prototyping**
  - Hedge against technical uncertainty, emerging capabilities, or unanticipated threats
  - Cost-effectively enhance interoperability; reduce lifecycle cost; explore the realm of the possible
  - Forge an effective operating construct to select the most appropriate opportunities/options

- **New approaches**
  - Evaluate new concepts, guide new technology development, demonstrate new capability
  - Sustain unique elements of the defense industrial base
  - Stimulate design teams to advance the state of the practice
  - Improve development methods and manufacturing
  - Promote open standards, and competition throughout the product lifecycle

- **Technology Transition**
  - Accelerate technologies, products, concepts to the warfighter
  - With tested Tactics, Techniques and Procedures; potential operational concepts

*Strategic emphasis on prototyping to address future threats*
Growing Future Engineers

Critical attributes of DoD Systems Engineering:

• Flexible designs that adapt and are resilient to unknown missions and threats
• Ability to quantify cost and affordability attributes of the design trade space
• Systems of Systems, and Enterprise contexts driving requirements from multiple stakeholders
• Responsive, and able to balance agility with rigorous analysis and data
• Safeguarding critical information while designing for interoperability and global markets
• Applied across significantly diverse domains

Balancing these attributes is challenging to SE, drives the state of the practice, and stresses critical workforce capacity

108,000 DoD Military and Civilian Engineers engaged with industry, academia and allied partners
DoD Civilian Engineering Workforce
Geographic Distribution

Data Source: FedScope, 30 September 2015

Population

<table>
<thead>
<tr>
<th>Population</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>5000+</td>
<td>10,832</td>
</tr>
<tr>
<td>1001-5000</td>
<td>688</td>
</tr>
<tr>
<td>501-1000</td>
<td>1,988</td>
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<tr>
<td>101-500</td>
<td>726</td>
</tr>
<tr>
<td>1-100</td>
<td>1,980</td>
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</tbody>
</table>

OCONUS Engineers:

- Suppressed: 2,321
- Foreign Countries: 1,502
- U.S. Territories: 243
- Unspecified: 21

NH: 82
VT: 6
MA: 803
RI: 1,823
CT: 271
NJ: 3,524
DE: 39
MD: 9,616
DC: 2,812
HI: 1,980

Distribution Statement A – Approved for public release by DOPSR. Distribution is unlimited.
Persistent learning organization...talented engineering leadership...advanced tools and methods that enable deep analysis for informed decisions...solutions that are well designed, can adapt, and are secure, sustainable, and affordable
Better Buying Power (BBP)
Continuous Improvement Process

- **Focus of BBP 1.0**: Best Practices and Business Rules; **BBP 2.0**: Critical Thinking, making better business decisions

- **BBP 3.0**: Continues and builds upon prior elements – and takes the focus to our Products
  - **Innovation and Technical Excellence**

- **BBP 3.0 Highlights**:
  - Strengthen **Cybersecurity** throughout the Product Lifecycle
  - Improve **Speed to Market**
  - Remove barriers to **Commercial Technology** Utilization
  - Increase the use of **Prototyping and Experimentation**
  - Use Modular **Open Systems** Architectures to Stimulate Innovation and enable agility
  - Strengthen **Organic Engineering** and **Technical Risk** management
  - Anticipate and plan for responsive and emerging threats by **building stronger partnerships**
Strengthen Organic Engineering Capabilities

- By *broadening implementation of programs* conducting an appropriate level of *early product design and development using technical in-house capabilities*

- Ensure *DoD is a more informed buyer*, allowing for better acquisition strategy, RFP development, and contract control

- *Benefit Industry* with *better requirements definition and information* to improve their ability to plan and execute design and development activities
Engineering Workforce Initiatives

- Managing engineering competencies through the Defense Acquisition Workforce (DAW) competency management framework
- Strengthen organic engineering capabilities
- Establish higher standard for key leadership positions
- Improve our leaders’ ability to understand and mitigate technical risk
- Promoting professionalism through advanced degrees for our engineering workforce
- Seeking continuous learning opportunities to advance our technical edge

Engineering Career Field by Level of Education

- 15897 (39%) - Masters
- 23272 (57%) - Doctorate
- 354 (1%) - Masters
- 93 (0%) - Bachelors
- 1434 (3%) - Unknown

Distribution Statement A – Approved for public release by DOPSR. Distribution is unlimited.
Engineering Workforce Initiatives

• **Systems Engineering Research Center in investments Human Capital Development, include:**
  
  – **Helix:** Understanding key success traits of the successful systems engineers to best leverage/develop future systems engineering talent
  
  – **Systems Engineering Technical Leadership:** Design a leadership development framework, at various responsibility levels, for defense acquisition workforce members conducting technical functions
  
  – **Technical Edge:** Develop an innovative educational curriculum to enable the DoD engineering workforce to grow its technical awareness and edge and enable the U.S. to maintain its technological superiority

• **DoD STEM:**
  
  – **Grow** opportunities to work cutting edge, leap-ahead technologies
  
  – **Promote** diversity and agility of thought
  
  – **Cultivate** a culture of innovation to sustain our competitive edge
Vision of Digital Model-Centric Engineering

Shifting away from a linear, document-centric acquisition process towards a dynamic digital model-centric ecosystem

• Digital Models: Data – or – algorithm – or – process – or – hybrid
• Low fidelity, implicit representations shift to high fidelity, explicit models serving as the “single source of truth” for all stakeholders
• Documents shift from the primary role of specification to the secondary role of communication

Today: Stove-piped data sources

Future: Dynamic Digital Model-Centric Ecosystem
Significant Leverage of DoD S&T Investments to Radically Improve Acquisition

ERS LEVERAGES YEARS OF MAJOR DOD S&T INVESTMENTS

- ADVANCED MODELING
- SIMULATION
- HIGH PERFORMANCE COMPUTING
- MATHEMATICAL OPTIMIZATION
- OPEN & TRUSTED SYSTEMS

ERS INTEGRATED CAPABILITY

- OPEN ARCHITECTURE IMPLEMENTATION
- MODELS
- MULTI-DIMENSIONAL TRADESPACE ANALYTICS
- HIGH PERFORMANCE COMPUTING
- BIG DATA ANALYTICS & VISUALIZATION
- IP PROTECTION
- SECURITY
- KNOWLEDGE MANAGEMENT
- LIFECYCLE INTELLIGENCE & MODELING
- DATA ACCESS & RETENTION

2012

TECHNOLOGIES PROVED TO IMPACT DECISION-MAKING WITHIN CURRENT ACQUISITION PROCESSES

ERS is the first integration of modern computational engineering tools and technologies that directly impact DoD Acquisition environments.
DoD Modular Open Systems Approaches (MOSA)

Goals
- Interoperability
- Tech Refresh
- Competition
- Innovation
- Cost Savings

Approaches
- Modular Design
- Defined Interfaces
- Standards Process
- Accessible Data
- Open Interfaces
- IP Rights

Modular Technical Design Approaches
- Design severable modules
- Define interfaces between modules
- Publish consensus-based standards
- Define, standardize & describe data models
- Perform compliance testing

Open System Business Approaches
- Use open standards & specs for interfaces
- Recognize the relevant technical community
- Acquire necessary data & license rights

Supporting the goals for MOSA implementation are methods, processes and tools which underpin the approach.
The MOSA Technical Standards Working Group (TSWG) was established in late FY14 as an exploratory group by the Defense Standardization Council to assist with the standardization aspects of MOSA.

- Identify the role of standards in enabling adoption of MOSA
  - Determine the criticality of standards to the adoption of MOSA
  - Determine additional domains which would benefit from MOSA standards

- Survey current MOSA efforts within DoD and other agencies
  - Identify common barriers and enablers to effective execution of MOSA that could benefit from implementation or development of standards.
  - Identify opportunities where common standards should be developed

- Outreach
  - Identify initiatives in MOSA standards; and identify 3-4 use cases in DoD and Industry, which detail contributions towards achieving goals of MOSA

DASD(SE) will be leading the creation of a community of practice, leveraging the work done to date, the talent and dedication of the current stakeholders.
Cybersecurity in Acquisition

- Acquisition programs must take responsibility for the cybersecurity of their programs from earliest research and technology development through system concept, design, development, test and evaluation, production, fielding, sustainment, and disposal.

- **Scope of program cybersecurity includes:**
  - **Program information**  Data about acquisition, personnel, planning, requirements, design, test data and support data for the system. Also includes data that alone might not be unclassified or damaging, but in combination with other information could allow an adversary to compromise, counter, clone, or defeat warfighting capability.
  - **Organizations and Personnel**  Government program offices, prime and subcontractors, along with manufacturing, testing, depot and training organizations.
  - **Networks**  Government and Government support activities, unclassified and classified networks, contractor unclassified and classified networks, and interfaces among Government and contractor networks.
  - **Systems and Supporting Systems**  The system being acquired, system interfaces, and associated training, testing, manufacturing, logistics, maintenance and other support systems.

System Security Engineering is the basis for Cybersecurity in Acquisition
SE and SSE Trade-off Analyses

Concept

- System Requirements
  - Complete set of system functional and performance requirements

- Trade-off Analysis
  - Constraints
  - Integrated Requirements

- Systems Engineering Specialties
  - System Performance
  - Reliability and Maintainability
  - Safety
  - System Security
  - Manufacturing
  - Supportability
  - Other SE Specialties

- System Security Engineering Specialties
  - Anti-Tamper
  - Cybersecurity
  - Exportability Features
  - Hardware Assurance
  - Security Specialties
  - Software Assurance
  - Supply Chain Risk Management

Integrated Protection Measures
Constraints on Security
Managing Technical Risk


- Proactively Attack Risks to Maximize Return on Scarce Resources
- Risk management is not a passive activity
- Proactive risk management investments are not free
- It is our job to anticipate surprises, assess consequences and do something either to prevent them or to limit their impacts
- Most decisions to control risk are made in the earliest program stages
  - Branches and Sequels – On/Off-Ramps


- Risk analysis tracking and mitigation techniques
- Planned knowledge points, to inform off-ramp or branch/sequel decisions
- Issue and opportunity management
- Lifecycle focus, with emphasis on the pre-milestone B risk reduction activities
Systems Engineering: Critical to Defense Acquisition

Defense Innovation Marketplace
http://www.defenseinnovationmarketplace.mil

DASD, Systems Engineering
http://www.acq.osd.mil/se

Twitter: @DoDInnovation