Mission Engineering: Evolving Acquisition to Support the Warfighter

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Office of the Under Secretary of Defense for Research and Engineering
October 24, 2018
“Building upon our strengths and pursuing lethality, surprise, and speed will help us become a mission-focused, innovative Department that puts kill chains over systems, heterogeneity over uniformity, and adaptability over doctrine. We will assess capability gaps and needs by missions vs. system or Service, and we will focus on outcome rather than process.”

— USD(R&E) Michael Griffin, June 2018
Shifting Acquisition Concerns – Capability vs. Platform

Requirements-based Acquisition
Lower Threat, Static

Capability-based Acquisition
Higher, Dynamic Threat

Primary Concerns
- Cost
- (Industrial Base)

Primary Concerns
- Schedule
- Performance

Schedule (agility) and performance (innovation) dominate current Defense perspective
Increasingly Complex, Compressing Battlespace

- The complexity of battlespace is increasingly complex:
  - The number of combatants (red, blue and white) and their systems are increasing both in number and sophistication
- “Everything” is networked together to some extent
- The timeline of the battlespace is shrinking:
  - Nano-second decision making is required

Source: https://culturalq.com/
Source: map.norsecorp.com/

The threat is evolving and invalidating our architectures
Key is to recognize these changing factors to better posture material solutions to rapidly/seamlessly enter and exit the battlespace
Current Acquisition is Falling Short

- Acquisition is taking longer
- Acquisition “failures” are increasing (Nunn-McCurdy breaches)
- Acquisition delivery is increasingly irrelevant to current warfighter needs

The causes:
- Increasing complexity – integration and interdependencies
- Immature technology
- Monolithic expectations with unrealistic schedules
- The mission has evolved

We are working harder but achieving less and less must develop capability at the Speed of Relevance
Conway’s Law

“Any organization that designs a system (defined broadly) will produce a design whose structure is a copy of the organization's communication structure...”

~ Melvin Conway, 1967
Department-Wide Realignment / Emphasis

- Acknowledgement that the battlespace is increasingly interconnected, and so should Defense engineering
- Great end-effects can be achieved from less-than-great systems... or even no systems
- Acceptance of judicious risk to make large gains
- Valuation of the speed & relevance of delivery, balancing cost & performance
- Understanding that great engineering cannot correct the shortfalls of an ill-conceived framework architecture

We need to think enterprise-wide not just system-level
Department Re-Alignment / Emphasis

JCIDS Process change
- 2008-Present
- Goal: Synchronize JCIDS – DAS - PPBE

Added:
- Capability analysis
- More coordination steps
- Threat Intel input to Acq.

Redefined Acquisition process goal to better synchronize JCIDS – DAS – PPBE
Department Re-Alignment / Emphasis

JCIDS Process change
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Added:
- Capability analysis
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Improved but didn’t solve means to manage technical tradeoffs and risks
- Short, Med. Long term
- ID areas of divestment

Redefined Acquisition process goal to better synchronize JCIDS – DAS – PPBE
Department Re-Alignment / Emphasis

Mission Engineering
Shift focus to capability implementation & integration

- Integrate engineering as part of Mission Capability Analysis
- Inform of technical/technology tradeoffs more frequently
- Integrate technical assessments to address mission, technology, manufacturing, schedule realism, dynamic threat
- Tightened communications and analysis

Traditional Systems Engineering
- Focused on system implementation

Mission Engineering: Formalizes that engineering rigor and technical insight is key to informing the tradeoffs and risks taken earlier in the Mission-Capability decision
Mission Engineering

Mission Engineering is –

- Disciplined translation of mission needs into a **Enterprise Mission Architecture** providing the foundation to subsequently develop solution architectures and field systems

- **Synchronization** of solution architectures and system dependencies to achieve the enterprise mission architecture and meet the mission need

- Champion **Capability-Enabling Technical Practices** across the department to enable more relevant, timely, and agile solution architectures and systems

- Authoritative identification of **Technical Risk, Opportunities, and Data-driven Insight** to address decisions at all levels: chief engineer, PM, decision authority

**ME focus is: Enterprise-level architectures, interdependencies, enabling practices and authoritative technical insight**
Improve Management of Interdependencies

- Synchronize acquisition program sequencing and timelines
- Synchronize / align shared dependencies and interfaces

Dependencies between programs are not universally tracked and carry hidden risks; improved insight across all ACAT-levels is needed

Operational Capability of M-code PNT

4-year gap between deployed satellite capability and battle-space ability to use M-Code

Shared Dependencies

Improved synchronization and dependency management is critical
Emphasize End-to-End Mission Effects

From Monolithic Kill Chains...
- Risk centralized in monolithic platforms
- Vulnerable to evolving adversary kill-chains
- Difficult to upgrade

To Adaptive Kill Webs...
- Risk distributed across manned/unmanned platforms
- Adapts to evolving adversary kill-chains
- Rapidly upgradable

- In today’s acquisition process, programs are matured independently
- System-of-systems integration occurs when delivered

Optimize enterprise effects vs. platform effects
Practice Systems Engineering Excellence

Extend engineering rigor & analysis to impacts across mission threads

Provides Engineering, Programmatic & Investment Decision Support

- Mission Analysis & Engineering
  - Mission Integration Managers

- Process
  - Concept of Operations
  - Mission Requirements (Supportability); Mission Arch.
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  - Mission Requirements (Supportability); Mission Arch.

- Systems
  - Service-Specific Mission Decomposition
    - Technical Design
      - Derived Platform Requirements
      - Derived System Behaviors
      - Derived Sub-System Requirements
    - Technical Design
      - Derived Platform Requirements
      - Derived System Behaviors
      - Derived Sub-System Requirements
    - Technical Design
      - Derived Platform Requirements
      - Derived System Behaviors
      - Derived Sub-System Requirements
  - Aggregated Platform Validation
  - Aggregated System Validation
  - Sub-System Validation

- Functions
  - Operations Maintenance
    - Mission Level (SoS) Validation
  - Mission Analysis & Engineering
    - Mission Integration Managers

- Reinvigoration of Systems Engineering
  - Extend engineering rigor & analysis to impacts across mission threads

Slide-13
Mission Engineering Enterprise Planning – Multiple Services, Multiple Domains

**Mission Needs**
- Threats
- CONOPs/CONEMPS
- Time-Phased Tasks
- Dependencies
- Cost/Schedule Constraints
- Enterprise Goals

**Needs Decomposed to Time-Phased Functional Model**
- AVs
- CVs
- OVs
- SVs

**Opportunities Analysis & Gap Identification**
- AVs
- CVs
- OVs
- SVs

**Gap Trade-space Analysis & Decision**
- Requirements Refinement
- Rapid Prototype
- Technology Development
- New Procurement

**Reference Mission Enterprise Architecture**
- AVs
- CVs
- OVs
- PVs
- SVs

**Enabling Engineering and Integration**
- Develop Solution Architectures
- Modify Existing Programs
- Rapid Prototypes & Tech Investment
- Start Gap-Filler Programs
- Synchronize Dependencies

**Joint Requirements**
- Legacy Programs
- Technology / Prototypes
- Integration Models
- Enabling Eng. Tools

**Improve velocity through the use of digital models in a digital environment**

**Extend engineering rigor & analysis to impacts across mission threads**
# Value Speed of Delivery at All Levels/Spirals

<table>
<thead>
<tr>
<th>ENGINEERING LEVEL</th>
<th>DESCRIPTOR</th>
<th>TIMELINE</th>
<th>EXAMPLE</th>
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<tbody>
<tr>
<td>COMPONENT</td>
<td>CONTINUOUS DELIVERY of capability developed and acquired in the context of recognized constraints</td>
<td>&lt;1-2 Years</td>
<td>ARCI IV: HF Upgrade, ARCI III: Sphere &amp; Hull Arrays</td>
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<tr>
<td>BLOCK</td>
<td>ITERATIVE DEVELOPMENT delivering “Minimum Viable Product”</td>
<td>~3-4 Years</td>
<td>F-16 Block 25, Block 50 F110; JDAM-LANTIRN Pod</td>
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</table>
| PLATFORM          | RE-STRUCTURE and SEQUENCE platforms to optimize the trades made in the previous two levels ...  
|                   | • Avoid 30-year monolithic acquisitions  
|                   | • Buy 100 before committing to 1000s | ~5-10 Years | MRAP, JLTV, HMMWV |
| EPOCH             | RE-DEFINE THE FRAMEWORK ARCHITECTURE; achieve next level of performance | >10-15 Years | Manned vs. Artificial Intelligence, UCAS |

Next generation – shift from component-block to platform-epoch focus
Research Epoch Changers – Redefine Framework Architecture

- The next *conflict* may be an evolution on our current capability ...
- But the next *war* will be fought in a way just barely considered today

Maintaining relevance by changing the rules of the game, or playing a different game altogether.
Deriving a Reference Enterprise Mission Architecture for the Space Domain

Space Missions’ Reference Architecture(s)

“Space Architecture Study Initiative”
-- ASD(R&E), 2018

- Phase I
  - Real-Time Space Situational Awareness
- Phase II–X
  - The Other Mission Areas

Extend engineering rigor & analysis to impacts across mission threads
### Addressing the Challenge — Acquisition at the Speed of Relevance

Factors impacting ...

<table>
<thead>
<tr>
<th>VELOCITY</th>
<th>RELEVANCE</th>
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<tbody>
<tr>
<td><strong>Continuity Capability Delivery</strong></td>
<td><strong>Architectures</strong></td>
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<tr>
<td>- Sequence – ARCl-Model</td>
<td>- End-to-End Effects</td>
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<tr>
<td>- Appropriate vs. Innovate</td>
<td>- Grand Scales / Unified Architectures = Challenges</td>
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<tr>
<td>- Automation</td>
<td>- Reduce Complexity</td>
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<tr>
<td>- Common Production Environments</td>
<td>- Loosely Coupled / Tightly Integrated, and Vice Versa</td>
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<tr>
<td>- Enterprise Optimization</td>
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<tr>
<th><strong>Minimum Viable Product (MVP)</strong></th>
<th><strong>Preserving Options</strong></th>
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<tr>
<td>- Iterative Development</td>
<td>- Prototyping</td>
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<td>- Pre-Planned Product Improvement</td>
<td>- Manage Acceptable Risk – Failure Tolerance</td>
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<td>- Pre-Planned Obsolescence</td>
<td>- JCTDs</td>
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<td>- Right-Sizing</td>
<td>- Technology Insertion</td>
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<tr>
<td>- Improve Program Scoping and Metrics</td>
<td>- De-couple – Hardware / Software</td>
</tr>
<tr>
<td></td>
<td>- Technical Readiness</td>
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<th><strong>Reducing Latency</strong></th>
<th><strong>Multi-Functionality / Resilience</strong></th>
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<tr>
<td>- Evolve Acquisition Processes</td>
<td>- Interdependencies – Mission Threads</td>
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<tr>
<td>- Data-Driven Decision Making</td>
<td>- Evolve Requirements Processes</td>
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<tr>
<td>- Communities of Practice</td>
<td>- Modularity – Programs, Frameworks, Architectures</td>
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<tr>
<td>- Credibility in Engineering Planning</td>
<td>- Cyber / Security Resiliency</td>
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Key Enabling ME Approaches

Foster Continuous Delivery

Avoid Monolithic Approaches

From

VS.

To

Promote Experimentation / Prototyping

Delivery architecture and prototyping are key to timely, relevant capability delivery
Enabling Processes & Tools

What We Do Now

• Evolve SE practice
• Independent Technical Risk Assessments (ITRA)
• Risk / Opportunity Management
• Modeling & Simulation
• Modularity – MOSA
• Should-Schedule Analysis
• Data Transparency
• Digital Engineering – Model Based Systems Engineering
• Architecture Analysis
• Interdependency / Interface Mgt.
• Measures of Resiliency
• Other tools to abstract the appropriate data to leadership decisions

What We Need to Be Able to Do Better

• Next Generation Threat System (e.g., ONR Strike Group Defender)
• Virtual World Visualization Software
• Architecture Management Integration Environment - open interfaces and integration for simulation models/analysis tools (e.g., Magic Draw Suite, Rational Rhapsody, DOORS)
• Standalone / Networked Tools - DREN/ SDREN, Joint Sim Environment /NSWC Dahlgren Division Ship Labs, Army Labs, etc.
• MBSE and SE integration in SYSML, RSA, etc.
• Improved Data Analytics / Tools
• Robust Cyber Effects (Offensive / Defensive) Modeling

Need academia/industry’s help – improved insights on data-driven capability decisions
Key Enabling ME Processes & Tools

Independent Risk Assessment and Risk & Opportunity Management

Modeling & Simulation

ME Capability Framework

Modular, Open Systems Approach (MOSA)

Refinement of existing tools is needed
Way Ahead: Challenges for DoD and Industry

- How do we accelerate mission need to mission delivery?
- What are the technical measures, metrics, & data to track technical progress toward mission capability vs. traditional specs?
- How do we synchronize interdependent acquisitions regardless of ACAT level? How do we manage dependencies?
- How do we preserve more solution options later in the acquisition cycle?
- How do we set mission performance requirements to promote SoS-centric vs. platform-centric solutions?
- How do you incentivize mission "ilities" – survivability, modularity, adaptability, availability, resiliency, security?
- How do we evaluate candidate solution architectures under a mission reference architecture? What are the models?
- What are industry standards for data/products to improve communication/integration? How do others access that information?
- How do we address IP issues to facilitate collaboration?
- How do we acquire common operating systems and architectures separate from platforms?
- What tools better enable cross-mission dependency and gap analysis?

As a community we need to better address operational mission performance in acquisition
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