USAF Implementation of Recommendations from National Research Council “Pre-Milestone A and Early-Phase Systems Engineering” Study Committee

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“Pre-Milestone A and Early-Phase Systems Engineering: A Retrospective Review and Benefits for Future Air Force Systems Acquisition”

December 2007

http://books.nap.edu/catalog.php?record_id=12065
Findings and Recommendations

■ Finding #1
Attention to a few critical systems engineering processes and functions particularly during preparation for Milestones A and B is essential to ensuring that Air Force acquisition programs deliver products on time and on budget.

■ Recommendation #1
Air Force leadership should require that Milestones A and B be treated as critical milestones in every acquisition program and that … the “Pre-Milestone A/B Checklist” … be used to judge successful completion.
Findings and Recommendations

■ Finding #2

Creating a robust SE process requires experienced SEs with domain knowledge

■ Recommendation #2

Assess career field needs and develop a program to address
Implementation Approach - 2

- Established Program Systems Engineer (PSE) shred under SPRDE
- Active engagement with SPRDE FIPT to influence DAU STM courses
  - Subject matter focus has been realigned
  - Provide additional emphasis on technology transition techniques and tools
- Provided 70+ SMEs to support competency assessments
- “Science, Mathematics, & Research for Transformation” (SMART) –funded by OSD; managed by NPS and ASEE
  - Akin to an undergraduate co-op program
  - Also used to provide opportunities for graduate students
  - Trying to change to automatic hire after award of degree rather than having to compete
Update Apr 01 S&E Strategic Plan

Current & Future Requirements | Goal Areas
--- | ---
Recruitment and retention initiatives | Math
Education and training | Acquisition
Individual growth paths | Test
Awards and recognition | Sustainment

NRC STEM Study (kicked off Aug 08; 15-month duration)
- Determine STEM needs of 26 functionals
- Fold recommended implementation strategy into S&E Strategic Plan update

RAND S&E Study (SAF/AQXD initiated)
- Estimating changes in S&E skills for emerging technical needs
- Two time horizons: near term (5 years), mid-term (10-15+ years)
Findings and Recommendations

■ Finding #3

Government, FFRDCs, and industry all have important roles throughout the life cycle

■ Recommendation #3

Pre-A decisions should be supported by rigorous SE processes and analyses involving teams of acquirers, users, and industry
Implementation Approach – 3
Continuous Capability Planning

- Informed Time-Phased Requirements Development (ITPRD)
  - Identify sponsoring MAJCOM personnel for collaborative requirements development
  - Insert acquisition (AFMC/AFSPC/AFRL) personnel into pre-MS/KDP-A/B process far enough in advance of the HPT to absorb context of program, execute SE processes, and affect content of KPP/KSAs and requirements that go into AoA planning and ICD/CDD/etc.

- Life Cycle Risk Management
  - Comprehensive definition of risk and risk management; should begin at the earliest stages of capability/program planning (pre-MS/KDP-A capability planning effects), and continue throughout the total life cycle of the program

- Modeling, Simulation, and Analysis
Implementation Approach – 3
Life Cycle Management

■ High-Confidence Criteria
  ■ Strategy should document multiple, viable trade space options for cost, schedule, capability-based performance requirements and technology
  ■ Strategy should support proper phasing/synchronization of requirements with on- and off-ramps
  ■ Requirements prioritized and properly time phased (cost/schedule)
  ■ Pre-M/S-B Risk Management plans complete, accurate, current and being followed
Technology Development and Transition Strategy

- Extends the scope of quantitative criteria beyond TRLs
- Includes broader processes and cross-command forums to improve the rigor of early SE and contribute to “doable” requirements
- Increases the probability that highest-priority shortfalls/gaps are addressed
- Results in closer alignment between technology investments and system / capability needs

Transition Stage-Gating

- Provides a CONOPS for total technology insertion into the Acquisition & Sustainment Plan
AF Tech Transition Office (TTO) continues support to JCTD, QRF, TTI and other Tech Transition programs.

Tech Transition Program Initiative funded in FY10 POM ($10M/yr)
- Hardware prototyping
- Bridge funding from Tech Demo to Program POM
- Enterprise interface management / configuration control

Developing R&D Strategic Framework to coordinate AF policy, programs and processes to transition technology through 6.1-6.8 to new program of record or change to existing program.
Findings and Recommendations

Finding #4

The organic development planning function that applied pre-A SE to a number of successful programs was allowed to lapse

Recommendation #4

A development planning function should be established in the military departments to coordinate the concept development and refinement phase of all acquisition programs to ensure that the capabilities ... as a whole are considered and that unifying strategies such as ... interoperability are addressed.
Secured FY10 POM funding ($37M/yr) for new PE for Requirements Analysis & Maturation (RAM) (“Development Planning”)

- Concept Development
- Requirements Analysis Support

- Establishing DP/RAM governance structure; single point of entry for MAJCOM DP requests

- Early SE Guide to be published 4Q CY08

- Institutionalize CCTD and ConSEP in policy
Implementation Approach – 4
RD&E Investment Framework

Transition Assistance -- filling the “Valley of Death”

Corporate S&T

Basic Research

Applied Research

Tech Demo

Rapid Development & Fielding

Programs of Record

Pre-Acquisition Systems Engineering

Technology Development

System Integration

Production

I n t e g r i t y  -  S e r v i c e  -  E x c e l l e n c e
Implementation Approach - 1

- Checklist identifies 20 items in 7 principal areas
- Coverage for 16 of 20 exists in current policy and guidance
- Conducted informal order-of-magnitude assessment of current compliance across practitioner community
- In process of identifying process owners and key linkages for each item needing action
## Checklist – Concept Development

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</table>
| 1 | Have at least two alternative concepts been evaluated? | AoA policy in AFI 10-601 | • PASEP (pre-AoA)  
• ASC process (post-AoA)  
• Early SE Guide | • OAS, A2/5  
• AQR, AFMC/EN | Center XRs | • AoA and DP  
• ESE guide  
• SoS stds / practices |
| 2 | Can an initial capability be achieved within ~5 years from MS/KDP B? If not, can critical subsystems (or a key subset) be demonstrated within that timeframe? | New MAIS programs now require IOC within 5 years of MS A, per FY08 NDAA Section 811. No rqmt for non-MAIS programs. | • Concept SEP (ConSEP)  
• Transition Plan  
• 5000.2 update (PDR ahead of MS B) | A2/5 for DP/RAM and attestation process | Center XRs | • DT&E initiative  
• Risk Assessment  
• Cost estimating  
• Other enduring/ std processes  
• CCP Guide |
| 3 | Will high-risk new technologies have been matured prior to MS/KDP B? If not, is the risk mitigation plan adequate? | 10 USC 2366a requires TRL ~6 (defined by AF Policy Memo) at MS B | • Transition Plan  
• ConSEP  
• Competition & prototyping (Young memo, 5000.2 update) | • A2/5  
• DP efforts and process leading to acq strategies | Center XRs with AFRL | • TD initiatives (RI3, TDTS)  
• CCP Guide |
| 4 | Have external interface complexities (incl. dependencies on other programs) been identified and minimized? Is there a plan to mitigate risks? | Part of JCIDS process; SoS SE guide | • Concept Characterization & Technical Description (CCTD)  
• CCP process for developing options  
• SoS engr (in Early SE Guide) | • AQR Guidance Memo mandates CCTD  
• A2/5 – process for developing option sets  
• AQR, AFMC/EN | Center XRs | • Early SE Guide  
• CCP Guide  
• AFMC/EN SoS eng practices  
• All enduring processes incl analysis  
• TD (RI3) |
### Checklist – KPPs and CONOPS

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| 5 | At MS/KDP A, have KPPs been identified in clear, comprehensive, concise, understandable terms? | AFI 10-601 (JCIDS implementation) (at early stages, MOEs are more appropriate than solution-focused KPPs) | • ConSEP  
• CCTD  
• I-CDD (to support system rqmts refinement and PDR prior to MS B) | • AFMC/CC attestation point  
• DP/RAM process | Center XRs  
• ITPRD initiative  
• Attestation process  
• SE activities  
• LCM |
| 6 | At MS/KDP B, are major system-level requirements (including all KPPs) sufficiently well defined to provide a stable basis for system development? | AFI 10-601 (JCIDS implementation) (at early stages, MOEs are more appropriate than solution-focused KPPs) | • ConSEP  
• CCTD  
• CDD | AFMC/CC atestation process | SPM and center XRs  
• DT&E initiative  
• All enduring processes including analysis  
• LCM |
| 7 | Has a CONOPS been developed showing that system operation can handle expected throughput and meet response time requirements? | | • ConSEP  
• CCTD  
• I-CDD | A2/5 DP/RAM process | SPM and center XRs  
• Analysis framework  
• SoS practices and standards  
• Early SE – all enduring processes |
## Checklist – Cost & Schedule, Performance Assessment

### COST & SCHEDULE SCOPING

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<th>Question</th>
<th>Process/Phase</th>
<th>Documents/Methodology</th>
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<tr>
<td>8</td>
<td>Are major cost and schedule drivers and risks explicitly identified, and is there a plan to track and reduce uncertainty?</td>
<td>Pre-A, Pre-B, SEP, RMP</td>
<td>JROC process per JROCM 06-261, ConSEP, Transition Plan, A2/5 for DP/RAM, RMP, RPX, Acq strategy</td>
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<td></td>
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<td>Risk process (ACE-AFMC/EN), Risk and integrated assessments, SPM and center XRs depending on phase, Risk process, Cost estimating methodology</td>
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### PERFORMANCE ASSESSMENT

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<tbody>
<tr>
<td>9</td>
<td>Have principal stakeholders accepted the confidence level (risk assessment) associated with cost estimates?</td>
<td>CCTD, SEP, RMP</td>
<td>Cost Estimating policy &amp; guidance (POE, ICE, etc.), Risk process, SPM and center XRs depending on effort/phase, Risk process, Cost estimating methodology</td>
</tr>
<tr>
<td>10</td>
<td>Are models and simulations adequate and appropriate to validate the selected concept and CONOPS against the KPPs?</td>
<td>Operational Context rather than “CONOPS” per se, MOEs at earliest “checkpoints”, ConSEP, CCTD, SEP</td>
<td>A2/5 (DP); M&amp;S owner as enabler, A2/5 from attestation perspective, SPM and/or center XRs depending on effort/phase; also need M&amp;S owner, DT&amp;E initiative, Analysis Team products (M&amp;S activity)</td>
</tr>
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<td>11</td>
<td>At MS/KDP B, do the requirements consider likely future mission growth over the life cycle?</td>
<td>SE/SEP guidance (Address in updates), SEP, Transition Plan</td>
<td>AFMC/CC attestation, DP/RAM, SE, SPM with insights from earlier XR efforts, ICD and I-CDD (validation)</td>
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### Checklist – Architecture, Risk

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<tr>
<td>12 <strong>Has the system been partitioned to define segments that can be independently developed and tested?</strong></td>
<td>Architecture views required per JCIDS • ConSEP • CCTD • SEP</td>
<td>SE and DP/RAM</td>
<td>Center XRs and XPM depending on effort/phase</td>
<td>• DT&amp;E initiative • SoS SE • ICD and I-CDD to validate approach • CCP Guide</td>
</tr>
<tr>
<td>13 <strong>By MS/KDP A, is there a plan to have information exchange protocols in place by MS/KDP B?</strong></td>
<td>Architecture views required per JCIDS (OV-3, OV-5 and SV-6 should address) • ConSEP • CCTD • SEP</td>
<td>• A2/5 for DP/RAM process • SE process including SoS</td>
<td>Center XRs and SPM</td>
<td>• SoS practices and standards • early SE • DP/RAM</td>
</tr>
<tr>
<td>14 <strong>At MS/KDP B, is the program plan structured to ensure that the contractor addresses rqmts decomposition / allocation to hardware, software, and human elements sufficiently early in development?</strong></td>
<td>• SE guidance in MS B RFP • WBS</td>
<td>• Acquisition Strategy • IMP/IMS</td>
<td>• SE • AFMC/CC attestation</td>
<td>SPM · Attestation</td>
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# Checklist – Risk Assessment, Program Implementation

## Risk Assessment

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</table>
| 15              | Are all key risk drivers (including but not limited to critical technologies) identified? | 10-6 series? | • ConSEP  
• CCTD  
• SEP  
• TDTS | SoS engr processes; risk process (must begin early) | Center XRs and SPMs depending on effort/phase | • TD initiatives  
• Linkage between risk, SE and SoS eng, Cost |

## Program Implementation

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<th>OPR(S)</th>
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</table>
| 16              | Does the program implementation plan account for necessary and sufficient # and skill levels of organic (military and civilian), FFRDC, and support contractor personnel to manage the program? | • SEP should be a resource-constrained plan  
• LCMP should address. | • Acq strategy  
• Transition Plan | A1 – should be accounted for in Mission Assignment process as well as during transition to a SPO – all functionals (including A2/5 for DP) need to be included in the assessment process | SPO Cadre and SPM (Center XR, EN, other functionals as needed) | In work (HCC definitions) |
| 17              | At MS/KDP A, is there a plan in place that identifies all necessary activities and resources to reach MS/KDP B? | LCMP | Early SE Guide | • A2/5 for DP/RAM  
• SE and SoS processes | Center XRs and SPMs w/resource allocation process | • SoS  
• SE  
• DP/RAM resource allocation  
• All enduring processes |
### Checklist – Program Implementation

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<tr>
<td>18</td>
<td><strong>Is there a top-level system integration and test plan?</strong></td>
<td>SEP and TEMP</td>
<td>A2/5 (DP &amp; attestation), PM, SE, SoS</td>
<td>TE Contractor</td>
<td>DT&amp;E and TD initiatives, SoS practices</td>
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<tr>
<td>19</td>
<td><strong>At MS/KDP B, are the necessary and sufficient program management and systems engineering management personnel in place? Have they been empowered to tailor processes and enforce requirements stability through IOC?</strong></td>
<td>Usually based on PM and CE judgment and then articulated in SEP and LCMP. They are empowered to tailor processes. EMA instituted to add/improve discipline for requirements stability.</td>
<td>A1 (Mission Assignment Process)</td>
<td>SPO Cadre and SPM (Center XR, EN, other functionals as needed)</td>
<td>In work (HCC definitions)</td>
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<tr>
<td>20</td>
<td><strong>Has the government attempted to align the duration of the program manager’s assignment with key milestones and deliverables?</strong></td>
<td>New policy memo forthcoming</td>
<td>Mission assignment process with senior officer moves</td>
<td>OSD</td>
<td>In work (OSD)</td>
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Prototyping and Early SE

- Basic tenets of prototyping can help a program-to-be directly address 10 of the 20 checklist items -- at least one in each of the 7 areas
- A well-crafted prototyping plan can impact most if not all other items

### Prototyping and Early SE Checklist “Box Score”

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<td>Performance Assessment</td>
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*U.S. Air Force*
Concept SE Process

Authorization to Proceed

Trade Space Characterization

Candidate Solution Set Selection

Requirements Exploration & Synthesis

Trade Space & Exploratory Analysis

Capability Decomposition / Analysis

Initial Concept Review

Architecture Characterization

System Characterization

Key Subsystem Characterization

Cost Analysis & Verification

Acquisition Timeline Analysis & Verification

Rqmts Verification/ Capability Assessment

CCTD

Release Approval

Final Concept Review

Concept Characterization Review

Solution Set Technical Analysis

Programmatic Analysis

Integrity - Service - Excellence
# Concept Characterization and Technical Description (CCTD)

for

*Concept Name*

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**DATE**

Prepared by:

*Name of Source (e.g., Concept Development Organization, AFRL, Corporation, etc.)*

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1. Mission / Capability Need Statement / CONOPS
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   3.2 Principal Interfaces
   3.3 Operating Regime
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4. Studies, Analyses, Experiments
   4.1 Parametric Studies (e.g., weight, power, cooling, throughput)
   4.2 Analyses (e.g., HSI, considerations, supportability concepts)
   4.3 Experiments
   4.4 Conclusions
5. Concept Characterization / Design
   5.1 Common Analysis Assumptions
   5.2 Operating Regime
   5.3 Interface / Interoperability / System-of-Systems Approach
   5.4 Critical Subsystem Design and Sizing
   5.5 Supportability / Sustainment Features
   5.6 Configuration Summary
   5.7 Analysis Results
   5.8 Concept Design Conclusions (Capability Performance Description)
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   6.1 Critical Technologies
   6.2 Technology Maturation Approach
   6.3 Test & Evaluation / Verification & Validation Approach
   6.4 Prototyping Approach
   6.5 Manufacturing / Productivity Approach
   6.6 Sustainment / Supportability Approach
   6.7 Schedule Assumptions
   6.8 Cost Analysis Assumptions
   6.9 Cost Estimates
   6.10 Risk Assessment
7. Conclusion
8. Recommendations (if applicable)
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