Reintegration of Sustainment into Systems Engineering During the Department of Defense Acquisition Process

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RMS Partnership Government-Industry Workshop and Symposium
Springfield, VA

Introduction

- **Domain Expert for Reliability, Availability, and Maintainability (RAM) in OSD AT&L Systems Engineering:**
  - Office of the Director, Defense Research and Engineering (ODDR&E), Systems Engineering (SE)
    - MA: Mission Assurance
    - MPS: Major Program Support
- **DoDI 5000.02, dated 8 December 2008, provides for:**
  - Operation of the Defense Acquisition Process including robust Systems Engineering
    - Program Support Reviews
    - Nunn-McCurdy Certifications
    - Senior Management Decision Support, etc.
- **Mandatory Sustainment KPP in CJCSM 3170.01D (March 2009)**
  - Key Performance Parameter (KPP): Availability
    - Key System Attributes (KSA): Reliability and Ownership Cost
- **Operational versus Life-Cycle Based Metrics**
  - Traditional development efforts end at full-rate production decision
  - Costs of sustainment are set by system design
  - Programs have become both unreliable and expensive to sustain
- **Implementation covered in Reliability, Availability, and Maintainability Cost Rationale (RAM-C) Report Manual**

Current Situation
— and How We Got Here

Mistakes have been made!

Background: Report of the Defense Science Board Task Force on Developmental Test & Evaluation (1 of 3)

- **Congressional Testimony (March 3, 2009) by Mr. Pete Adolph (Chairman of DSB Team):**
  - Loss of Core Acquisition Personnel in DoD:
    - 500,000 in 1990
    - 200,000 in 2009
  - "Concurrent with acquisition reform, the general practice of reliability growth during development was de-emphasized and, in most cases, eliminated. This departure from a widely recognized best practice may not have been a direct result of acquisition reform, but may instead be related to the loss of key personnel and experience, **as well as short-sighted attempts to save acquisition funds at the expense of increased sustainment and life cycle costs**."
- **Dr. Paul Kaminski**
  - "…further underscored the importance of early system engineering effort in that, prior to the key Milestone A and B decisions, we find that those decisions **impact somewhere between 75 percent and 85 percent of the total lifecycle costs**. So the time to address those issues is up front before those decisions are made."

Background: Report of the Defense Science Board Task Force on Developmental Test & Evaluation (2 of 3)

- **Acquisition workforce reductions mandated by 1996 thru 1999 Defense Authorization Acts**
  - Loss of experienced management and technical personnel throughout government and industry
  - Service acquisition test organizations were affected:
    - Army essentially eliminated their military DT component and made government DT discretionary
    - Navy reduced DT workforce by 10%
    - Air Force transitioned DT conduct and control to the contractor while significantly reducing test personnel (~15%) and program office engineering support (up to 60%)

continued

Background: Report of the Defense Science Board Task Force on Developmental Test & Evaluation (3 of 3)

- **Programs complexity increasing significantly**
  - Software lines of code increases, off-board sensor data integration, system of systems
- **Elimination or reduction of military standards from contracts**
  - Use of commercial specifications and standards encouraged under acquisition reform
- **De-emphasis of reliability growth**
  - Industry recommendations in the 1970s had caused the Services to implement reliability growth as an integral part of development

"Lack of failure prevention during design leading to low initial MTBF and reduced growth potential are the most significant reasons for systems failing to meet operational reliability requirements."

Background: Other Considerations

- **Performance-based contracts allowed contractors to determine how to reach reliability requirements—often with disastrous results for the warfighter**
- **There is an inherent disincentive for contractors to spend acquisition funds on improving Reliability**
  - Partially due to the lucrative nature of contractor support and sparing
- **Acquisition program managers are not held accountable for post-FRP support costs**
  - But are held accountable for Average Per Unit Cost (APUC)—leading to restricting the expenditure of “discretionary” funds (like those required for Reliability Demonstration and Growth)

IOT&E Results

- **57% (20 of 35) of DoD programs from FY2001 to FY2007 entered IOT&E and failed to meet Operational Effectiveness and/or Suitability requirements**
  - 12 of the 20 (60%) failed to meet Effectiveness requirements
  - 17 of the 20 (85%) were either not Operationally Suitable or Suitability was the cause of test suspension
  - 11 of the 17 (65%) cited Reliability as the cause of failure or suspension

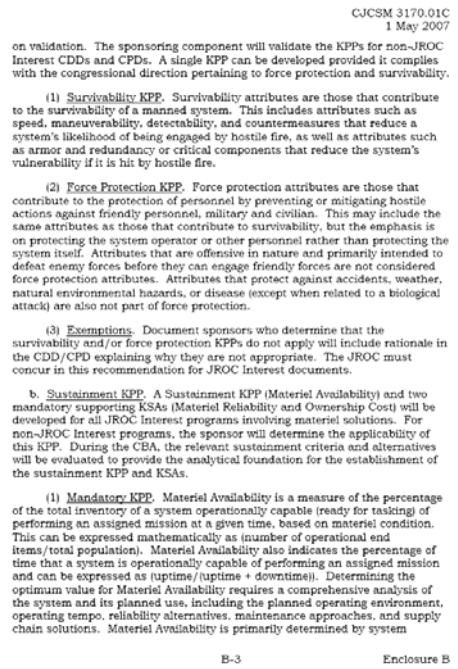
New RAM Policy: Origins of Sustainment Key Performance Parameter (KPP)

- **Joint Capabilities Integration and Development System (JCIDS) Process detailed in CJCSM 3170.01 series in May 2007**
- **Refined in new CJCSM 3170.01 versions in March 2009**
- **Availability KPP**
  - Materiel Availability
  - Operational Availability (Added in March 2009)
    - May require multiple values
- **Reliability Key System Attribute (KSA)**
  - Mission Reliability
    - May require multiple values!
  - Logistics (Basic) Reliability
- **Ownership Cost KSA**

Materiel Availability KPP Established to Relate Logistics Reliability to Ownership Cost

May 2007: CJCSI 3170.01F and CJCSM 3170.01C

- Included Materiel Availability KPP
  - Supported by Materiel Reliability and Ownership Cost KSAs
- Mandatory for JROC Interest Programs



CJCSM 3170.01C
1 May 2007

on validation. The sponsoring component will validate the KPPs for non-JROC Interest CDDs and CPDs. A single KPP can be developed provided it complies with the congressional direction pertaining to force protection and survivability.

(1) Survivability KPP. Survivability attributes are those that contribute to the survivability of a manned system. This includes attributes such as speed, maneuverability, detectability, and countermeasures that reduce a system's likelihood of being engaged by hostile fire, as well as attributes such as armor and redundancy or critical components that reduce the system's vulnerability if it is hit by hostile fire.

(2) Force Protection KPP. Force protection attributes are those that contribute to the protection of personnel by preventing or mitigating hostile actions against friendly personnel, military and civilian. This may include the same attributes as those that contribute to survivability, but the emphasis is on protecting the system operator or other personnel rather than protecting the system itself. Attributes that are offensive in nature and primarily intended to defeat enemy forces before they can engage friendly forces are not considered force protection attributes. Attributes that protect against accidents, weather, natural environmental hazards, or disease (except when related to a biological attack) are also not part of force protection.

(3) Exemptions. Document sponsors who determine that the survivability and/or force protection KPPs do not apply will include rationale in the CDD/CPD explaining why they are not appropriate. The JROC must concur in this recommendation for JROC Interest documents.

b. Sustainment KPP. A Sustainment KPP (Materiel Availability) and two mandatory supporting KSAs (Materiel Reliability and Ownership Cost) will be developed for all JROC Interest programs involving materiel solutions. For non-JROC Interest programs, the sponsor will determine the applicability of this KPP. During the CBA, the relevant sustainment criteria and alternatives will be evaluated to provide the analytical foundation for the establishment of the sustainment KPP and KSAs.

(1) Mandatory KPP. Materiel Availability is a measure of the percentage of the total inventory of a system operationally capable (ready for tasking) of performing an assigned mission at a given time, based on materiel condition. This can be expressed mathematically as (number of operational end items/total population). Materiel Availability also indicates the percentage of time that a system is operationally capable of performing an assigned mission and can be expressed as (uptime/(uptime + downtime)). Determining the optimum value for Materiel Availability requires a comprehensive analysis of the system and its planned use, including the planned operating environment, operating tempo, reliability alternatives, maintenance approaches, and supply chain solutions. Materiel Availability is primarily determined by system

B-3 Enclosure B

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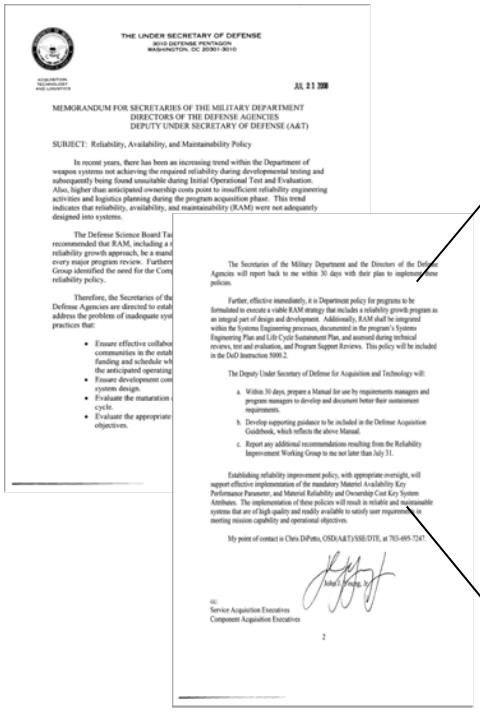
RAM Policy Memo

The July 2008 Reliability, Availability, and Maintainability Policy Requires RAM be integrated into the Systems Engineering process.



THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

JUL 21 2008

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENT
DIRECTORS OF THE DEFENSE AGENCIES
DEPUTY UNDER SECRETARY OF DEFENSE (A&T)

SUBJECT: Reliability, Availability, and Maintainability Policy

In recent years, there has been an increasing trend within the Department of weapon systems not achieving the required reliability during developmental testing and subsequently being found unsuitable during Initial Operational Test and Evaluation. Also, higher than anticipated ownership costs point to insufficient reliability engineering activities and logistics planning during the program acquisition phase. This trend indicates that reliability, availability, and maintainability (RAM) were not adequately designed into systems.

The Defense Science Board Ta recommended that RAM, including a r reliability growth approach, be a mand every major program review. Further Group identified the need for the Com reliability policy.

Therefore, the Secretaries of the Defense Agencies are directed to estab address the problems of inadequate sys practices that:

- Ensure effective collabor communities in the estab funding and schedule wi the anticipated operating
- Ensure development con system design.
- Evaluate the maturation cycle.
- Evaluate the appropriate objectives.

The Secretaries of the Military Department and the Directors of the Defense Agencies will report back to me within 30 days with their plan to implement these policies.

Further, effective immediately, it is Department policy for programs to be formulated to execute a viable RAM strategy that includes a reliability growth program as an integral part of design and development. Additionally, RAM shall be integrated within the Systems Engineering processes, documented in the program's Systems Engineering Plan and Life Cycle Sustainment Plan, and assessed during technical reviews, test and evaluation, and Program Support Reviews. This policy will be included in the DoD Instruction 5000.2.

The Deputy Under Secretary of Defense for Acquisition and Technology will:

a. Within 30 days, prepare a Manual for use by requirements managers and program managers to develop and document better their sustainment requirements.

b. Develop supporting guidance to be included in the Defense Acquisition Guidebook, which reflects the above Manual.

c. Report any additional recommendations resulting from the Reliability Improvement Working Group to me not later than July 31.

Establishing reliability improvement policy, with appropriate oversight, will support effective implementation of the mandatory Materiel Availability Key Performance Parameter, and Materiel Reliability and Ownership Cost Key System Attributes. The implementation of these policies will result in reliable and maintainable systems that are of high quality and readily available to satisfy user requirements in meeting mission capability and operational objectives. My point of contact is Chris DiPetto, OSD/A&T/SSE/DTE, at 703-695-7247.

cc:
Service Acquisition Executives
Component Acquisition Executives

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New RAM Policy: July 21, 2008, RAM Policy Memo

- **ODDR&E SE maintains that a viable RAM strategy requires consideration of sustainment and fielding issues during system design**
  - Mandated in new Weapon Systems Acquisition Reform Act (WSARA)
- **Note the policy intentionally calls for a "…reliability growth program…" and not simply a growth curve**

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Defense Acquisition Guidebook Design Considerations

Achieving the "best value" solution is an iterative task performed within the framework of Systems Engineering.

Sustainment KPP: Materiel Availability

- **Materiel Availability (A_M) is a system design metric**
  - Applies to all items that have been delivered at any point in time—entire inventory (Active + Inactive)
    - A_O applies only to the Active Inventory—and usually to a subset of that!
  - A_M is optimized—not maximized
    - A_O is a direct measure of operational effectiveness and, as such, it is usually best when maximized
    - A_M is a function of how the system is intended to be fielded
      - Proper implementation requires trade-offs between operational AND non-operational factors:
        - » Operational factors include A_O, Mission Reliability, Logistics Reliability, MDT
        - » Non-Operational factors include Total Inventory, Active Inventory, Sustainment Strategy (repair levels, spares availability, delays, etc.), Ownership Cost
- **A_M includes two Key System Attributes (KSAs):**
  - Materiel Reliability
  - Ownership Cost
- **ODDR&E Systems Engineering has developed guidance for implementation of the Sustainment KPP: RAM-C Report Manual**

What is RAM, really?

- **Definitions (Adapted from Reliability Statistics by Dovich):**
  - Reliability:
    1. The duration or probability of failure-free performance under stated conditions.
    2. The probability that a system can perform its intended function for a specified interval under stated conditions.
       - For non-redundant designs, the definitions are equivalent. For designs including redundancy, definition 2 reflects the “mission” reliability.
  - Availability:
    - A measure of the degree to which a system is in the operable and committable state AT THE START of the mission when the mission is called for at an unknown (random) time.

      {Emphasis Added!!!!}
  - Maintainability:
    - The measure of the ability of a system to be retained in, or restored to, a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair.

Reliability, Availability, and Maintainability → RAM

A_O vs. A_M

A_O vs. A_M: What is Materiel Availability? (1 of 4)

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  - A_O applies only to the Active Inventory—and usually to a subset of that!
- **A_M is optimized—not maximized**
  - A_O is a direct measure of operational effectiveness
    - Usually best when maximized
  - A_M is a function of how the system is intended to be fielded
    - Any value is acceptable
      - A missile system where only 5% of the missiles are fielded at any one time might have a valid A_M of 0.05!

A_O vs. A_M: What is Materiel Availability? (2 of 4)

- **Definitions:**
  - For End Items or Assemblies procured with spares (includes one-shot devices) :

$$A_M = \frac{\text{Number Ready for Tasking}}{\text{Total Number Acquired}}$$

  - For Systems procured as part of an end item:

$$A_M = \frac{\text{Uptime}}{\text{Uptime} + \text{Downtime}}$$

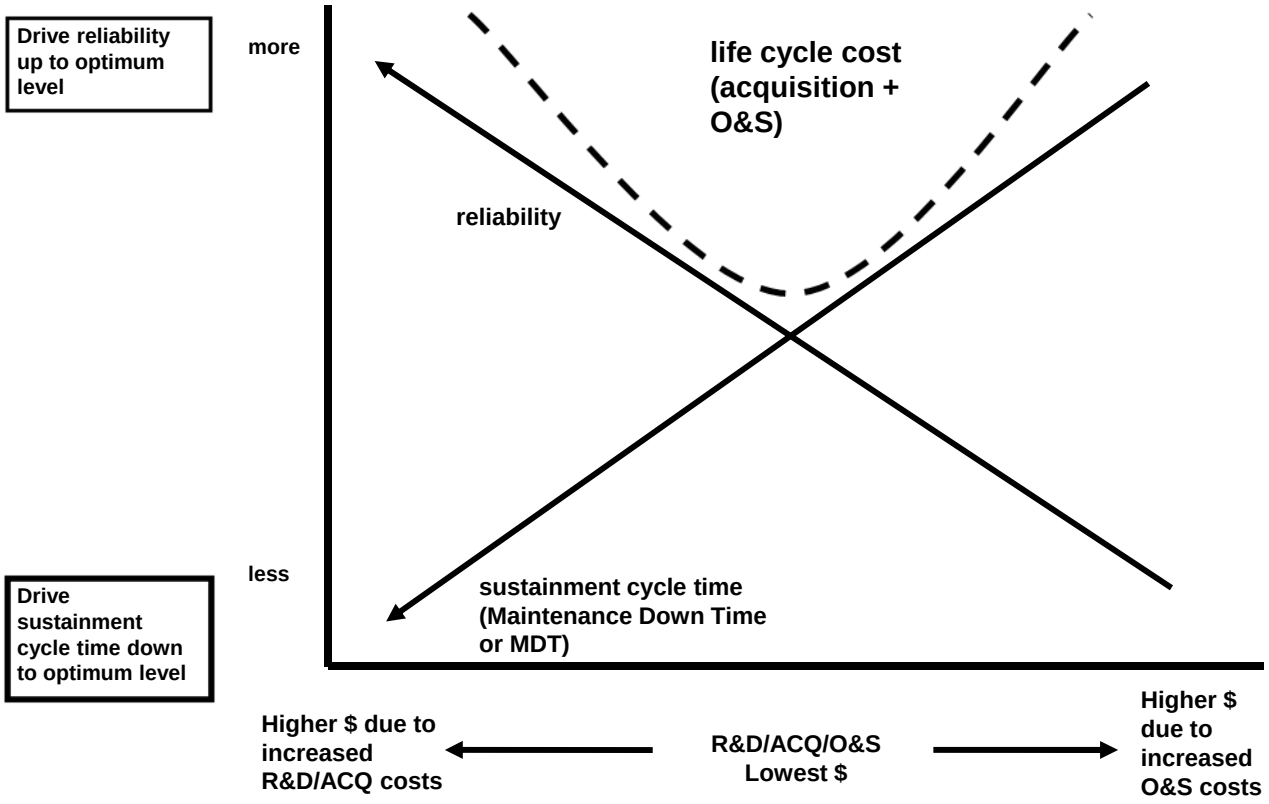
A_O vs. A_M: What is Materiel Availability? (3 of 4)

- **Proper implementation requires trade-offs between operational AND non-operational factors:**
  - Operational factors include:
    - A_O
    - Mission Reliability
    - Logistics Reliability (aka Basic Reliability)
    - Maintenance Down Time (MDT)
  - Non-Operational factors include:
    - Total Inventory
    - Active Inventory
    - Sustainment Strategy (repair levels, spares availability, delays, etc.)
    - Ownership Cost

A_O vs. A_M: What is Materiel Availability? (4 of 4)

- **ODDR&E SE has developed guidance for implementation of the Sustainment KPP**
  - RAM-C Rationale Report Manual
    - Called for in the July 21, 2008, memo
  - Signed May 31, 2009
    - Army non-concurral based on A_M not being immediately under the full control of the combat commander
    - Added A_O as additional consideration in newest version of 3170.01 series manuals

RAM-C Manual: Trade-offs Required for Sustainment KPP



The Sustainment KPP ensures the program considers reliability and O&S costs equally during system design and development.

Summary

- **RAM must return to being a key design consideration during system development—and the new acquisition reform legislation mandates this!**
- **Sustainment costs are mostly set during system design.**
- **The Sustainment KPP is intended to establish necessary trade space.**