National Defense Industrial Association
Systems Engineering Division
Task Group Report
Top Five Systems Engineering Issues
In
Defense Industry
January, 2003

Vers 9, 1/23/03

Background

The Director, Systems Engineering, Office of the Under Secretary of Defense, Acquisition Technology & Logistics, Defense Systems, who serves as the overall OSD sponsor of the NDIA Systems Engineering Division, asked the Division in early January 2003 to identify the Top 5 Issues in Systems Engineering that exist in our defense industry complex, affecting both the industry participants as well as the government participants. A Task Group was formed, inputs were solicited in advance, and a reconciliation meeting with about 18 members was held on January 16, 2003.

Approximately 100 separate issues were raised, and the group found that the bulk of these actually fell into five major issue categories. The detailed results are described below.

Top 5 Systems Engineering Issues

The top five systems engineering issues were deemed to be the following. Please note that these are not listed in any priority:

- **Lack of awareness of the importance, value, timing, accountability, and organizational structure of SE on programs**
- **Adequate, qualified resources are generally not available within Government and industry for allocation on major programs**
- **Insufficient SE tools and environments to effectively execute SE on programs**
- **Requirements definition, development and management is not applied consistently and effectively**
- **Poor initial program formulation**

A discussion of each of these issues, and the Task group recommendations, is described below.

Top 5 Issue Discussion Points and Recommendations

Issue No 1:

Lack of awareness of the importance and value, timing, accountability, and organizational structure of SE on programs

The following main points provide amplification on this issue:

- General awareness of cost benefit and return on investment performance of SE possesses is unknown
- There is a lack of commitment to SE across the life cycle of programs
- There is a lack of understanding on the application of SE principles, content and areas of application to program success, including areas such as risk management, security, COTS integration, architectures, identification of cost drivers, test & evaluation, and supportability/life cycle cost
- Program managers, both industry and government, do not have adequate recognition that SE touches all aspects of the acquisition process, e.g. from up-front requirements, budgeting, to end of life disposition
- Systems Engineering content, when included in proposal costs as a factor versus bottom-up quoting, exacerbates the problem of funding when costs are being evaluated as it is looked at as “overhead” that becomes a prime candidate for cost cutting.
- It would be most helpful to have a “lessons learned” repository

Recommendation

Increase awareness of SE importance within acquisition formulation and decision processes early and consistently over major milestones, and recognize SE authority and responsibility in the ACAT IC/D process present during the acquisition formulation and decision processes, with similar efforts at lower program levels.

Emphasize the following points:

- SE is NOT an option. It is an essential ingredient on all programs and must have adequate funding.
- PMs are accountable and responsible for SE implementation across entire life cycle

NOTE: In order to assist in developing an understanding of the significance of SE to program success, it might be helpful to commission a study of major programs over the past 10 years, comparing the % content of SE in the design / development/EMD phase versus cost and schedule performance (CPI/SPI).

Issue 2:

Adequate, qualified resources are generally not available within Government and industry for allocation on major programs

The following main points provide amplification on this issue:

- An experienced, trained workforce is in short supply. There is sufficient opportunity for systems engineers in Government but inequities in

compensation and incentive versus industry for systems engineers at mid-career (e.g. 10-20 years) encourages migration out of Government service.
- We do not consistently allocate adequate, trained resources on programs
- Program management turnover is an impediment to success
- The DAWIA certification process levies only minimal academic requirements and does not produce adequately trained systems engineers because of inadequate systems engineering experience is required as a qualification.
- Opportunities in industry to gain systems engineering experience are limited by the number of and completeness of systems engineering content on programs
- A limited number of academic and practical sources of systems engineering curricula and a very limited number of graduates are available to either industry or government
- There are inadequate certification methods in both industry and government to insure the quality and competency of systems engineering personnel at all levels, e.g., entry through chief systems engineer.

Recommendation

Establish a program and process for incentivizing career systems engineer positions within the Government.

The following points should also be addressed:
- Require the SEMP to identify the process and qualification requirements for all key personnel proposed for the contract
- Work with major universities to require an introductory course in systems engineering in all undergraduate and graduate level engineering and technical management degree programs.
- Require that program managers receive systems engineering training so they understand the significance that SE plays in assuring program success
- Ensure that DAU SE level 2 and 3 courses address, as a minimum, training on the SE tools processes and documents as defined in SAF AQ memo dated January 06, 2003, "Incentivizing Contractors for Better Systems Engineering".

Issue 3:

Insufficient SE tools and environments to effectively execute SE on programs

The following main points provide amplification on this issue:
- The SE community lacks a set of comprehensive, common and consistent tools, guidance and standards, and metrics, which leads to stovepipes and inadequate data and data transfer
- In terms of the environment definition – there is insufficient understanding of both the individual and System-of-System interdependency of product, process, and people/organization environments. There are insufficient SE tools to properly define the various environments (Modeling and Simulation domain.)
- Substantial data inconsistencies exist – there is no common data dictionary, use of metadata (meaning and definition of data), Configuration Management

of data, and use of common terminology. There is insufficient Validation / Verification and certification of data, resulting in little data sharing and reuse.

- In terms of tools and product environments, there is no overall SE tool system, from a hierarchical standpoint, that corporates the detail design, life cycle cost, and overall performance, including those needed for SOS and Interoperability
- There is little or no integration of Systems Engineering Computer Aided Engineering (CAE) tools with software and hardware design tools, and likewise between the tools and models used by government and Industry
- There is no requirement to use a requirements management s/w tool (such as DOORS, RTM, or SLATE)

Recommendation

Research and identify SE tools for system architecture design and development, and encourage use thereof.

The following points should also be addressed:

- There is need for development of a system architecture framework for particular system in accordance with FEW [federal enterprise architecture / CBA-component based architecture, the DoD-directed Zachman framework, and C4ISR three-schema architecture]
- Efforts should identify all of the program-applicable domains (government, primes and major subcontractors) and environments required for a structured hierarchical decomposition of a weapon or IT system

Issue 4:

Requirements definition, development and management is not applied consistently and effectively

The following main points provide amplification on this issue:

- The Government, for the most part, within the contracting and war fighting / operational communities do not have the Systems Engineering mentality in addressing Mission Needs and requirements and do not follow their requirements process effectively.
- Acquisition and requirements communities follow different directives
- There is often a lack of understanding by contractors / government of true capabilities and requirements needed by the war-fighter, resulting in incomplete or inaccurate Requirements Definition with respect to implications of stated requirements
- There is a serious lack of upfront and continuous requirements development and management, including management of requirements changes
- Determining adequate and correct requirements for software intensive systems that satisfy the overall systems objectives is an elusive task
- We do not adequately plan for systems adaptability / reconfigurability to support rapidly changing requirements, both customer and end-user, (i.e., spiral development and evolutionary acquisition) and technology insertion requirements not generally not defined at program outset

Recommendation:
Synchronize directives used by the acquisition and requirements community to ensure a disciplined and consistent requirements definition and development approach.

The following points provide additional information on this recommendation:

- The education process, both formal and informal, for Government Program Managers and contractors should be sufficient that they mutually understand the necessity of a comprehensive architectural approach and systems engineering focus in applying the complete and managed requirements process on programs
- OSD should link requirements definition, development and management into the program life cycle through defined practice and guidance
- Emphasize process maturity related to requirements for both acquisition and development communities by adoption of maturity models such as CMMI® (Capability Maturity Model Integration®®)
- Involve potential contractors in the requirements definition process early in the acquisition cycle

Issue 5:

Poor initial program formulation practices put successful execution at risk.

Initial Program Formulation begins prior to at Milestone 0 and culminates with Award of SDD Contract. During this timeframe, many critical decisions are made that have potentially profound impact on the program. These include establishing initial cost and schedule baselines, system requirements, and the management approach. The following main points provide amplification on this issue:

- Government & Contractor Program Managers are required to meet predefined baseline cost & schedule. Early estimates of program cost and schedule need to be made based upon a true and valid estimate of the work, not the desired price and timeline. This is at odds with the environment under an evolutionary acquisition approach.
- Moreover, if the attempt is made to make programs more palatable by using optimistic scheduling and cost estimating initially, the program's ability to establish and consistently implement effective systems engineering and associated processes is immediately put at risk
- When the initial funding profile does not address full lifecycle, later attempts to recognize the true implications of the initial program could result in unfunded surprises and the eventual down sizing of the initial program.
- The guidelines used for acquisition are sometimes interpreted as discouraging the telling the real story under the guise of ensuring competition or "keeping the program alive". Clearly exposing the requirements, constraints, ramifications and implications of variants, criteria for decision making, budgetary issues, and customer desires would lead to better

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understanding on the part of the acquisition staff, the PMO, and the bidding contractors and to successful program results.

- Program organizational structures, both government and industry, tend to enable IPTs too early in the execution phase, before system level requirements are firm and able to be allocated to the element/subsystem level. Such strong IPTs and weak Systems Engineering Integrated Teams (SEITs) or Overarching IPTs (OIPTs) foster integration problems at the system level.
- There is inadequate emphasis on architecturally scalable designs and development strategies that can readily accommodate normal requirements growth, especially those programs involving spiral development and evolutionary acquisition.

Recommendation:

Emphasize the use of architecture development and systems engineering practice in the initial program formulation phase including the use of realistic estimates for cost and schedule, risk identification, and clearly defining requirements. Even if the program does not include all life cycle phases, consideration of supportability needs to be included from the outset.

The following points should also be addressed:

- Modify the current acquisition approach to encourage more candid communication of program cost, schedule and risk between Government and Industry
- Encourage that initial engineering go beyond the superficial, either through pre-acquisition activities and funded studies and analysis so that initial program formulation accurately predicts schedule, cost and risk
- Ensure that unrealistic or incompatible cost, schedule, and performance baselines are clearly identified as a risk, so that the situation can be effectively managed.
- Emphasize investigation of the implications of initial requirements statements, not only on design but also on supportability.
- Encourage early and strong government/industry SEIT or OIPT activity prior to formation and chartering of specific IPTs.
- Emphasize process maturity in contractor communities, applicable to all phases of a program, by adoption of maturity models such as CMMI® (Capability Maturity Model Integration®®)

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Summary

The Task Group firmly believes that the issues and rationale presented herein are significant and are having substantial impact on today's programs. The group believes that a great percentage of programmatic problems, while they may manifest themselves as a functional deficiency (i.e. software), are in fact based in ineffective or non-existing systems engineering on the program.

The group also recognizes that not all of the substantive recommendations provided herein are directly within the purview of OUSD(AT&L)DS to address, but to leave out related issues in our discussion and recommendations leads to incompleteness and potential misunderstanding of context. Therefore, from the overall recommendations we have extracted those items that we understand might be directly within the purview of OUSD(AT&L) Director, Defense Systems and Director, Systems Engineering, responsibilities. We ask that the balance of the recommendations be forwarded to the appropriate office for their consideration, with implementation recommendation by the Directors noted, if they are in agreement with the positions put forward.

Summary Recommendations

It is hoped that the Department of Defense will take these recommendations, summarized below, in the spirit of positive actions that the NDIA Systems Engineering Division believes will greatly enhance our collective performance on DoD programs. Those recommendations that directly influenced by OUSD(AT&L) Defense Systems are highlighted in yellow:

- **Increase awareness of SE importance within acquisition formulation and decision processes early and consistently over major milestones, and recognize SE authority and responsibility in the ACAT IC/D process present during the acquisition formulation and decision processes, with similar efforts at lower program levels.**

- **Establish a program and process for incentivizing career systems engineer positions within the Government.**

- **Research and identify SE tools for system architecture design and development, and encourage use thereof.**

- **Synchronize directives used by the acquisition and requirements community to ensure a disciplined and consistent requirements definition and development approach.**

- **Emphasize the use of systems engineering practice in the initial program formulation phase including the use of realistic estimates for cost and schedule, risk identification, and clearly defining requirements. Even if the program does not include all life cycle phases, consideration of supportability needs to be included from the outset.**

Study Participants

The following organizations participated in the generation of the study, by providing input for consideration and/or generating the actual study report.

Raytheon
Northrop Grumman
Boeing
Lockheed Martin
Harris Corp
General Dynamics
Computer Sciences Corp
SAIC
AAI Corporation
Rand Corp
SIMSTRAT, Inc
L3 Communications
DCS Corp
CTC Corp
Veridian

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OUSD(AT&L)DS/SE
Defense Acquisition University
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