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INTEGRATION OF SYSTEMS ENGINEERING BEST PRACTICES WITH DOD ACQUISITION PRACTICES

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ABSTRACT

Technological developments and requirements in a world of rapidly changing innovations and warfare dictate a high level of need for new equipment. The Defense Acquisition System is the management process by which the Department of Defense provides effective, affordable, and timely systems to the users to satisfy capability needs. Currently, this system is managed by DOD Directive 5000.1, entitled the Defense Acquisition System and DOD Instruction 5000.2, Operation of the Defense Acquisition System—which is constantly criticized for its slow, confusing, and bureaucratic nature. For this reason, this project will analyze different systems engineering processes, and compare them to the current Acquisition process, in order to improve the Defense Acquisition System.

1 INTRODUCTION

Changes to the world's political and military landscape since the end of the Cold War have led the industrial-military partnership to develop new technologies for responding to a transforming world order. Results from Operation Desert Storm, the terrorist attack on 9/11 2001, Operation Enduring Freedom and Operation Iraqi Freedom, reveal a need for new equipment and technologies for responding to asymmetric threats. The Department of Defense (DOD) acquisition process is the means by which the branches of military service acquire new or improved technologies, materiel, information systems, or capabilities for responding to operational requirements.[i] This system is explained in DOD Directive 5000.1, *The Defense Acquisition System*, and DOD Instruction 5000.2, *Operation of the Defense Acquisition System*. These two documents describe five overarching policies that the defense acquisition process incorporates and addresses: streamlined and effective management, flexibility, responsiveness, innovation, and discipline.

Many acquisition experts believe that the DOD acquisition life cycle takes too long and is too costly. In light of current world events and how the United States military conducts operations, it is no longer acceptable to take ten to fifteen years to acquire the next generation of weapons and other equipment. For example, it has taken DOD over two years to address the need for armor plating on HMMWVs in Iraq to protect them against improvised explosion devices (IEDs). The threat of these devices to security and stability operations was not anticipated at the end of combat operations. As a result, many soldiers have welded whatever metal was available to the floors and sides of their vehicles. DOD has been frantically developing better suited armor to protect HMMWVs against IED attacks.[ii] Improvements to the acquisition life cycle must ensure that materiel and equipment critical to combat operations is provided to soldiers when needed.

DOD is a large bureaucracy which transforms slowly. Congress controls the direction of the military by approving its budget. Following Congressional approval, new technologies must make their way through a long, complicated acquisition process. The holistic approach of systems engineering is ideally suited for improving all areas of the DOD acquisition process. The *International Council on Systems Engineering* (INCOSE) defines systems engineering as:

> An interdisciplinary approach and means to enable the realization of successful systems focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem.[iii]

We apply this definition of systems engineering, and the associated principles of system decomposition, system design, process improvement, and analysis of alternatives to making recommendations for improving the Defense Acquisition System.

2 PROBLEM STATEMENT

General Problem Statement: To identify where it is most appropriate to introduce systems engineering into the DOD Acquisition Process by identifying specific omissions and redundancies within the DOD Acquisition Process, and aiming to correct them.

Specific Problem Statement: Using comparison and analysis of the SEMP and various other Systems Engineering processes applied to DOD Acquisition, DOD Regulation 5000.2, as well as plans from the Defense Acquisition University, we will identify problems with the current role of Systems Engineering in DOD Acquisition and develop and recommend improvements or suggestions for new methods of approach.

3 STAKEHOLDERS

The stakeholders in our system consist of the users, clients, decision makers, and sponsors:

- Users: all DOD (DA, DON, DAF, NSA, NASA, etc.) agencies and personnel engaged in the acquisition process
- Clients: Dr. Glenn F. Lamartin, Office of the Under Secretary of Defense, Director of Defense Systems; Mr. Mark Schaeffer, Principle to the Assistant Secretary for Acquisition (OUSD (AT&L))
- Decision Makers: Mr. Mark Schaeffer
- Sponsors: Department of Systems Engineering, United States Military Academy
- Others: Dr. Lamartin, Secretary of Defense, Mr. Douglas K. Weltsie, Mr. Bolton

4 PHASES OF WORK

The Benchmark Phase provided the foundation for the project. During this phase, team members researched, studied, and dissected each of the systems engineering processes and extracted key aspects relevant to the project. The first sub-phase involved producing a functional decomposition model of each process. The functional decomposition visually illustrates each function and sub-function found in the process and any prescribed metrics associated with the process. The next sub-phase required a functional flow analysis. The team studied each process and determined the relationship of each function and sub-function, how they interrelated, and how information and products flow from one function to the next. The team gave special attention to feedback, milestones, and repetition within the functional flow diagrams, as these would be key in comparison, the next phase. Finally, the Benchmark Phase concluded with a Functional Flow Narrative, in which the team explained the flows through narration.

The Comparison Phase showed the diversity of the numerous systems engineering processes. During this phase, the team placed each process next to the other and found all common characteristics. The team also found omissions, redundancies, and outlying aspects within each process. Now that this phase is complete, the team is producing an interim report covering all findings to this point.

Follow-on phases include building and testing a model that integrates aspects of each process to create an optimal systems engineering design process. After the testing phase, the team will revise and display this model

5 ENGINEERING PROCESSES REVIEWED

- User Needs & Technology Opportunities 5000-2
  - Current DOD Acquisitions process
- Engineering Design Methods - Nigel Cross
- Defense Acquisition University SEMP – Defense Acquisition University, Fort Belvoir, VA
- Systems Engineering - Andrew Sage
- Engineering Design - Clive L. Dym and Patrick Little
- Systems Engineering and Management Process - Dept of Systems Engineering, USMA, West Point, NY
  - Methodology currently taught within the Systems Engineering Department at USMA. This process is the foundation of numerous courses and large projects.
- Systems 6 Engineering and Design Methodology - COL Mike McGinnis, Department of Systems Engineering, USMA, West Point, NY
  - Methodology personally developed and implemented by COL Mike McGinnis

6 FUNCTIONAL ANALYSIS

For each engineering process, we decomposed them into their functions. After decomposing each process, we organized the functions into hierarchies, which show the top-down relationships between functions and sub-functions (Appendix A). Next, we developed functional flow diagrams. Flowcharts show the sequential transition form phase to phase in each systems engineering process. Like a snapshot, flowcharts provide a glimpse of the system at a point in time. Functional Flow Diagrams are located in Appendix B. Also, written explanations for each functional flow diagram are in Appendix C.

7 COMPARISON

During the Comparative Analysis phase, the group looked at the functional flow diagrams to find similarities, redundancies, and omissions. The purpose was to see which practices respected institutions and individual system engineers believe are the best ways to tackle a problem. Through our analysis, and slight personal bias, we believe that the Systems Engineering Management Process (SEMP) is a creditable baseline of all comparisons. In all other eight systems engineering processes, excluding regulation 5000.1, each phase can be directly related to a phase in the SEMP. Typically, we see a simple change in the choice of words, such as "systems definition," found in Andrew Sage's work, compared to "problem definition" as found in the SEMP. Other times we see the breakdown and increase in specificity of one phase in the SEMP into many in another process. An example is Nigal Cross' process. Cross's method has multiple phases, "clarifying objectives, establishing functions, setting requirements, [and] determining characteristics," that are best represented overall by the "problem definition" phase. We repeated this processes of identifying and establishing relationships between phases with each process. Once completed, we concluded that the SEMP was the most overall encompassing systems engineering process.

DOD Regulation 5000.1 is a systems engineering process of acquisition. One problem with working with DOD Regulation 5000.1 is the increased complexity due to acronyms and references to numerous military terms. We produced a functional flow diagram that we thought best represented the regulation and then proceeded to look for similarities to our baseline process, which is the SEMP. 5000.1 can be looked at in four overall phases just as the SEMP. They are broken up by milestones. Before moving on to the next phase, requirements must be met before each milestone. The phases before milestone A are all problem definition type work. Everything from research, scheduling, budget, and performance goals help define the problem. After the second milestone, milestone B, the phases are shifted towards an optimization focus. The concerns are reductions in the project that will best fit the project's purpose. These phases are an iterative approach to the problem. The major concern we see in Regulation 5000.1 is the lack of decision making. According to the SEMP, once design and analysis has been completed, one must take the results and compare and contrast them through alternative scoring. Instead, 5000.1 jumps directly into the implementation phase producing the product followed by eventually termination. Also, Regulation 5000.1 contains some functions that do not match a phase in the SEMP. For example, "systems development and demonstration," is not involved with design and analysis in the SEMP, or any other phase.

Overall Regulation 5000.1 is well anchored in the systems engineering approach to problem solving. DOD Our primary focus will be in integrating the missing phases of decision making.

8 FUTURE WORK.

Our future work entails building and testing the model as well as the design execution phase. In building and testing a model, we will model a new piece of technology moving through the difference phases of Acquisition. Using information gained from identifying the omissions and redundancies in the functional flows and decompositions of the previously studied systems engineering methods, we will use simulation software to aid in building our model. Testing the model will be done by taking a previous Acquisition project, sending it through our designed system, and comparing our process with the previous one – identifying areas of improvement and areas of weaknesses. The model will continue to be refined and rebuilt until a satisfactory product is made. The recommendations for improvement we glean from this modeling process will be submitted in report form to our stakeholders.

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