NPS-AM-14-C11P12R03-050

PROCEEDINGS
OF THE
ELEVENTH ANNUAL ACQUISITION RESEARCH SYMPOSIUM

THURSDAY SESSIONS
VOLUME II

DoD Lead System Integrator (LSI) Transformation—Creating a Model Based Acquisition Framework (MBAF)

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Published April 30, 2014

The research presented in this report was supported by the Acquisition Research Program of the Graduate School of Business & Public Policy at the Naval Postgraduate School.

Panel 12. Assessing the Role of Public–Private Partnerships in DoD Logistics and Acquisition

Thursday, May 15, 2014	
9:30 a.m. – 11:00 a.m.	**Chair: Lorna B. Estep,** Deputy Director of Logistics, Air Force Materiel Command ***Critical Choices in a Time of Austerity*** Lou Kratz, Lockheed Martin Bradd Buckingham, Lockheed Martin Bernie Kelleher, Lockheed Martin ***Public Private Business Models for Defence Acquisition*** Thomas Ekström, Swedish Defence Research Agency ***DoD Lead System Integrator (LSI) Transformation—Creating a Model Based Acquisition Framework (MBAF)*** Ron Carlson, Naval Postgraduate School Paul Montgomery, Naval Postgraduate School

DoD Lead System Integrator (LSI) Transformation—Creating a Model Based Acquisition Framework (MBAF)

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Abstract

The complexity of designing and acquiring weapons systems continues to increase due to highly integrated system architectures, rapid technology evolution, and emergence of highly diverse warfare missions. The imperatives of system-of-systems (SoS) integration and interoperability (I&I) further complicate the system acquisition process. In order to deliver highly integrated and interoperable systems, the acquisition process itself needs higher levels of integration.

Navy Systems Commands are exploring the need to transform the acquisition process in integrated warfare-driven management, interoperable warfare mission analysis, and complex design-driven engineering workflows. These integrated workflows are embodied in the acquisition roles of a Lead System Integrator (LSI). In our previous papers, we described (1) the roles and attributes of the LSI and, (2) the concept of how System Definition-Enabled Acquisition (SDEA) can support the systems engineering imperatives of acquisition of complex systems.

In this paper, we extend our previous work to discuss emerging concepts being explored in a Navy Systems Command where aggressive transformational goals in *warfare mission-driven acquisition management* processes can be supported by our previously described *design-driven engineering* processes (SDEA). The union of these two process transformations is essential to enabling an environment where the Government acquisition organization can succeed as the LSI to rapidly deliver complex systems while achieving demanding I&I goals and objectives

Introduction

At the 2012 and 2013 acquisition conferences, the authors described (1) the roles and attributes of the LSI (Montgomery, 2012) and, (2) the concept of how System Definition-Enabled Acquisition (SDEA) can support the systems engineering imperatives of acquisition of complex systems (Montgomery, 2013). Since those last two conferences, two significant changes have begun at NAVAIR which has set the stage for the continuation of the application of the previously discussed SDEA principles and practices. The first is that

NAVAIR has started the transition to becoming an LSI as has been proposed by many (Grasso, 2007) over the last several years. One such program is executing Governmental LSI responsibilities by designing, developing, and integrating the mission communication system (MCS) in one of its new helicopter programs. Another program is executing the entire LSI spectrum of responsibilities on a new Unmanned Air Vehicle (UAV) program.

The second key transformation underway at NAVAIR is an aggressive concept of transforming to a mission-driven acquisition management process. In order to deliver the mission capability that is needed in the fleet, an emergent mission-centric approach defining needed operational capability is being pursued. This Integrated Warfare Concept (IWC) is beginning to heavily rely on the understanding and use of Model Based System Engineering (MBSE) methodologies and tools to aide in the accomplishment of this goal. The goal of the IWC is to understand and map all of the systems required to accomplish a specific capability to all of the different platforms and programs of records (PORs) that play a part in it. This requires a thorough understanding of the operational and mission-level requirements to be allocated to the various programs. This IWC process is currently exploring an extensive use of MBSE to accomplish this mission decomposition and allocation to PORs. This creates an urgent need for the PORs to develop a method to directly interface to that model-driven IWC input and map their outputs to it in order to demonstrate that the POR system level requirements can fulfill the IWC mission-level requirements.

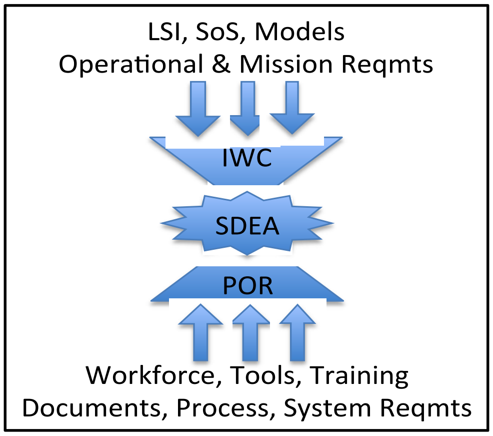

Figure 1. Merger of New Roles and Process With Existing Process

These new concepts are depicted in Figure 1 and are converging and serving as a forcing function for NAVAIR to develop a more robust use of tools that will enable the programs to capture and demonstrate the additional information required to perform in these enhanced roles. The current POR engineering process is a highly document-driven process that relies heavily on teams of seasoned experts to analyze engineering and acquisition documents to determine design readiness. Because of these imperatives to align mission-driven acquisition to design-driven engineering, the authors have been pursuing the further development of the SDEA concept previously introduced. We believe that the use of the SDEA concept will be the conduit which will allow NAVAIR to be successful on both of the above ventures, to become the program LSI, and to demonstrate the ability to integrate with and ultimately acquire the warfighter capabilities dictated from the top down IWC process.

Problem Definition and Research Questions

The imperatives for NAVAIR to perform more of the LSI role (Young, 2010) and the advent of the IWC (Dunaway, 2013) drive the need for a new approach that is less workforce-intensive and less document-driven approach that is in use today. The acquisition of complex system-of-systems (SoS) envisioned in the model-driven IWC process requires revised engineering methods, practices, and principles that ensure capabilities can be met and equip the NAVAIR workforce with the data and knowledge required to perform the acquisition and LSI tasks. This paper will expand the on the concept of SDEA described in earlier conferences and investigate how it could help NAVAIR succeed in performing their new environment.

Problem Statement:

The DoD does not have adequate Systems Engineering (SE) methods, processes, workflows, and/or tools that support the expansive Governmental role of the LSI in major weapons systems acquisitions or the ability to integrate with and develop the programs of record identified through the top-down IWC analysis process.

Research Questions:

- How can the use of MBSE tools be applied to aid the program office in assuming more of the LSI role?
- What are the varied SE methods and practices in use across NAVAIR today.?
- What is a model of the NAVAIR acquisition process in use today?
- What is an integrated framework of tools and MBSE methods that reflects the artifacts needed to integrate with the IWC and perform LSI roles?
- How can this new Model Based Acquisition Framework (MBAF) be applied to simulate or optimize process variations on programs?

LSI Roles and Responsibilities

A review of the roles and responsibilities required of a government LSI was conducted to determine where the application of SDEA and other tools may be most beneficial. The below list of System Engineering and Program Management skills was compiled with the help of several senior leaders from NAVAIR. The bold comments are areas where the increased use of SDEA and other MBSE tools with their data driven definition and the increased visualization should support.

Systems Engineering LSI skills emerging at NAVAIR:

- Conduct **analysis** of broad system **requirements** and identify **inter-dependencies**
- Perform the SoS LSI role and deriving **trade space** to be held at **mission** level
- Ensuring SoS **optimization** and cross platform **interoperability** that provide traceability to mission level requirements.
- Define and control system **interfaces** consistent with the overall systems architecture—both in the SoS operational architecture, and in the related SoS views—to ensure required Mission level capability is delivered through deliberate system development as part of required SoS functionality.
- Develop the **System Architecture** must be developed by the Government (may not be outsourced) and also done without contracting for support with the Prime contractor or any major subsystem vendor. Government ownership

of **system-level architectures** reduces possibility of proprietary or non-compliant contractor-specific architectures

- Control the technical trade space through **preliminary design, to include budget, requirements, and schedule tradeoffs**
- Act as the **LSI role up to Milestone B** to control the trade space with regard to issues impacting the System Architecture.

Program Management LSI skills emerging at NAVAIR:

- Conducting work where precedents are inadequate or controversial.
- Developing project schedules and resource estimates across multi-disciplined technical teams.
- Establishing and managing broad system **processes** that align **requirements** and interdependencies across program boundaries.
- Interacting between disciplines such as contracting, legislative, RDT&E, Logistics, and budgetary processes within the DoD Acquisition Decision Support System
- Navigating a wide range of non-engineering, non-scientific info (FAR, policies, directives, instructions, contracting, admin processes).
- Controlling the **trade space** through preliminary design, to include **budget, requirements, and schedule tradeoffs**
- Maintaining **traceability** of systems integration requirements to higher level mission objectives.
- Representing the system command at national **technical reviews**
- Formalizing Program Management structure for CDD(s) that drive system requirements spanning **multiple PEOs**.
- Exercising technical authority. Government is the **integrator** of major subsystems in the architecture as part of performing the LSI role.

This is a good point to review what is meant by SDEA and what a model based acquisition framework might look like that would help illustrate why the authors believe that this approach is needed to aide NAVAIR or any acquirer to accomplish the SDEA the highlighted areas above.

System Definition Enabled Acquisition

Top-Level Concept

The original SDEA concept has been expanded since we first introduced it (Montgomery, 2012). The Model Based Acquisition Framework (MBAF) description below will demonstrate the process. There are two major pieces to the proposed Model Based Acquisition Framework (MBAF), a System Definition Enabled Acquisition (SDEA) process and a Business Process Model (BPM; see Figure 2).

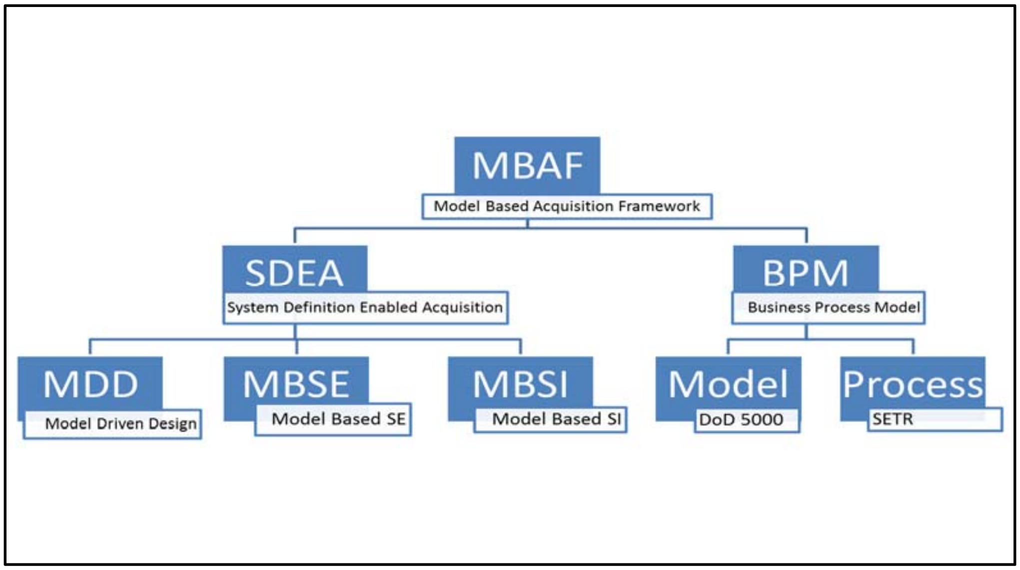

Figure 2. Proposed Model Based Acquisition Framework

System Definition Enabled Acquisition (SDEA)

The SDEA concept starts with a foundational model comprised of a deep understanding of the CONOPS, requirements, and architecture to serve as the basis for understanding and documenting what the system needs to perform. It can be a challenge to describe in just a few scenarios/use-cases and numerous requirements ("shall") statements the entirety of the complex systems that are being developed today. The use of models in the early stages of a program's life could allow for all to get a better mutual understanding of the requirements "shall" statements that are often put out for contractors to bid on. The Chief engineer for the system and software division at the Jet propulsion lab summed it up when he stated that "the benefit of formal modeling is that we can finally stop being ambiguous and say exactly what we mean" (Delp, 2012).

This early foundational, system definition model would serve as the tool from which requirements could be vetted, specifications could be created, and interfaces examined and defined and ultimately would become part of the system proposal from which the rest of the acquisition process would build. This process, shown in Figure 3, would provide much more insight for the designer as they would be able to "see" some of the interaction and obtain a much clearer "picture" of what was required than the normal requirements "shall" statements, use-cases, and CONOPS alone. This triad of integrated, data-driven information forms a strong foundation and platform for the builder to explore the relationships among requirements and to answer the myriad of questions that would not sufficiently or easily be answered using a handful of "shall" statements and walking through use-case/CONOPS, alone.

This system model can look up at the mission-level model and requirements coming down from the IWC process and it can demonstrate that the system design can fulfill those mission requirements. This initial system model could be put in the request for proposal (RFP) and contractors could bid to the model and ultimately be required to demonstrate that their proposal met the requirements by joining with the model. This insight itself has the potential to reduce some of the time that normally takes place when a builder sorts out the true meaning of the proposal they received as they proceed through their requirements derivation and proposal process. This new larger model would continue to grow in detail and design fidelity as the system matured throughout the design cycle and would ultimately become a complete system model that would then include the interfaces and other critical element required for successful system integration.

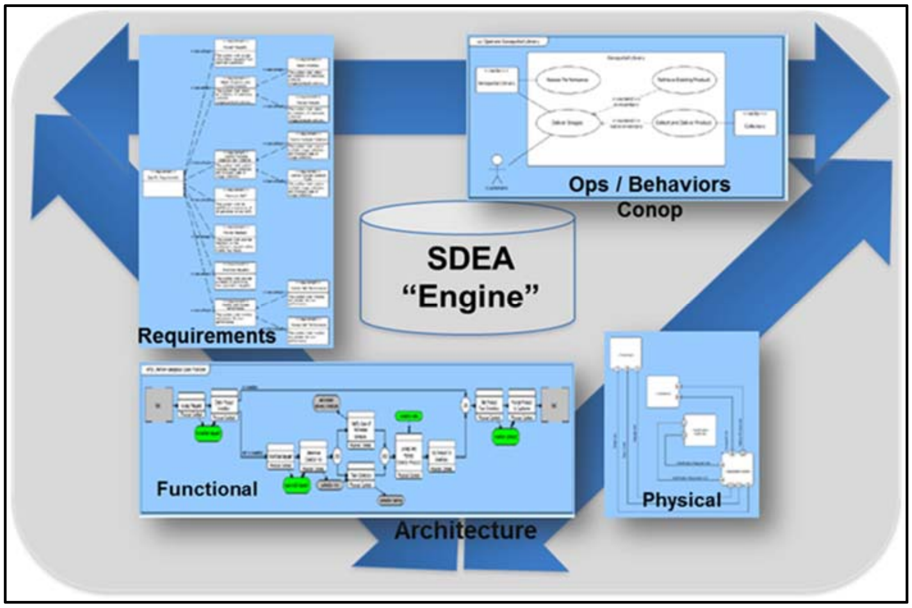

Figure 3. System Definition Enabled Acquisition Overview
(Montgomery, 2013)

SDEA can be visualized in three sections, Model Driven Design (MDD), Model Based System Engineering (MBSE) and finally Model Based System Integration (MBSI). Some may look at these as very similar or even the same, but they are broken out in Figure 4, as they will be referred to in this section.

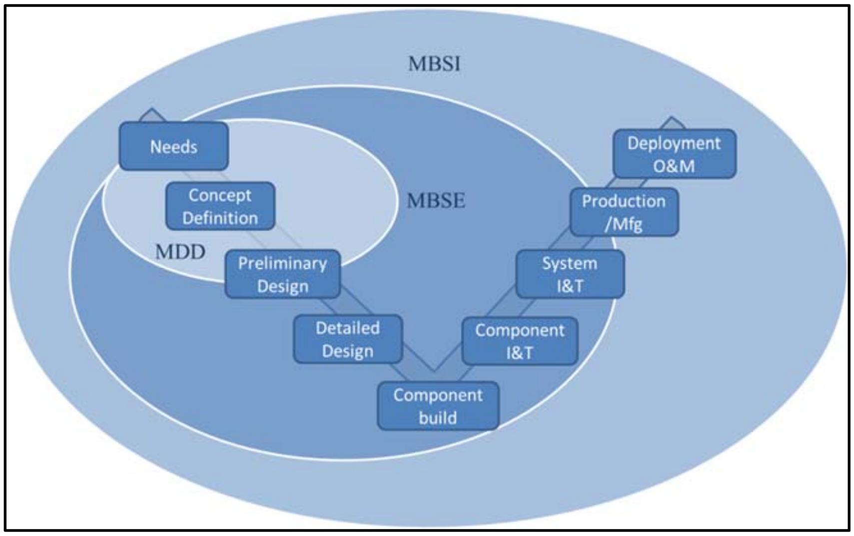

Figure 4. Levels of Model Based Engineering

Model Driven Design (MDD)

The Model Driven Design is the beginning of the SDEA concept. Ultimately, it is the model that is created combining the architecture, both functional and physical, of the system that is captured through decomposing the requirements and fully understanding the

CONOPS of the system. This phase is shown in Figure 4 as continuing through preliminary design as this early model could ultimately be put out for bid. The contractors would add on to this early model to demonstrate that their proposal met the requirements and was able to interact with the proposed concept. This generally gets the program to an early preliminary design review (PDR) just prior to contract award.

Model-Based System Engineering (MBSE)

The MBSE phase as depicted in Figure 4 is the continuation of the original model as the system design is further defined and refined. This is the stage when the addition of some of the other physical models would start be added to the system model that would be utilized as the system matures through the critical design, or "build-to" phase, into the early verification phase. During this phase it is likely that the contractor, or sub-contractors, would be creating or adding on to the base model. The ultimate goal of this approach is to have a full model of the system at the end of design.

Model-Based System Integration (MBSI)

System integration is often thought of at the end of the program but in reality it starts at the beginning. Integrating integration and qualification strategies early in the system design model is the essence of MBSI. How something integrates and how it can be tested should be one of the initial concerns as a program is being built. The use of a model should allow for some early looks across the standard systems engineering process model (SE "V") to see how the concepts are validated down to how individual components can be integrated and validated. In essence, as depicted in Figure 4, this also starts with the initial model created by the government customer. A model that has the fidelity to look across the systems engineering "V" would allow for one to gain confidence in the design, understand or eliminate risks earlier in the program, and lead to some early prototypes when the associated risks become acceptable. The ability to get to production earlier is desired during rapid development initiatives and in general, as time often equals money.

Business Process Model (BPM)

Finally, this model-based acquisition approach needs to be coupled with an appropriate business process that will be able to take full advantage of the new methodology and capture the savings. The authors are seeking to determine if the current acquisition process can be modeled using a data-driven modeling tool such that the major acquisition activities are captured as functions and the major outputs of these activities, the artifacts, are captured as outputs from the functions. Once this model is created and a detailed list of artifacts is produced they can be examined to determine what possible model based tools could or are currently used to produce them, which when combined would form a Model Based Acquisition Framework. There are numerous other potential uses that we will discuss further as we describe the initial steps undertaken on this research. This effort will be described in the remainder of this article.

SE Methods and Practices

Although the DoD 5000.02 has a scripted process or series of events that need to be followed to produce systems it was quickly discovered that the process to perform these steps is far less scripted or documented. The authors have settled in on two main source documents to provide insight into the NAVAIR process, the first being the *International Standard ISO/IEC 15288 Systems and Software Engineering-Systems Life Cycle Processes* and the second being the *Naval Systems Engineering Guide*. From these documents, experience from industry and SMEs at NAVAIR, we are capturing and documenting the NAVAIR process and using it to create the data model. An early observation is that even these documents do not clearly describe a repeatable process that novice engineers could follow without moderate assistance from experienced engineers.

Acquisition Process Model

The process derived from the above documents is then being entered into an MBSE system design modeling tool (Vitech Corporation's CORE®) to form the basis of the data-driven model. Figure 5 shows a representation of the decomposed function Define and Derive Requirements. As mentioned previously, these derived sub-functions are a combination of information from ISO 15288, Navy System Engineering Guide, Industry and NAVAIR SME's. It is crucial in this initial model to accurately capture the NAVAIR process in use today as they would like to use this model to what-if the current process to examine potential areas for efficiencies and policy modifications.

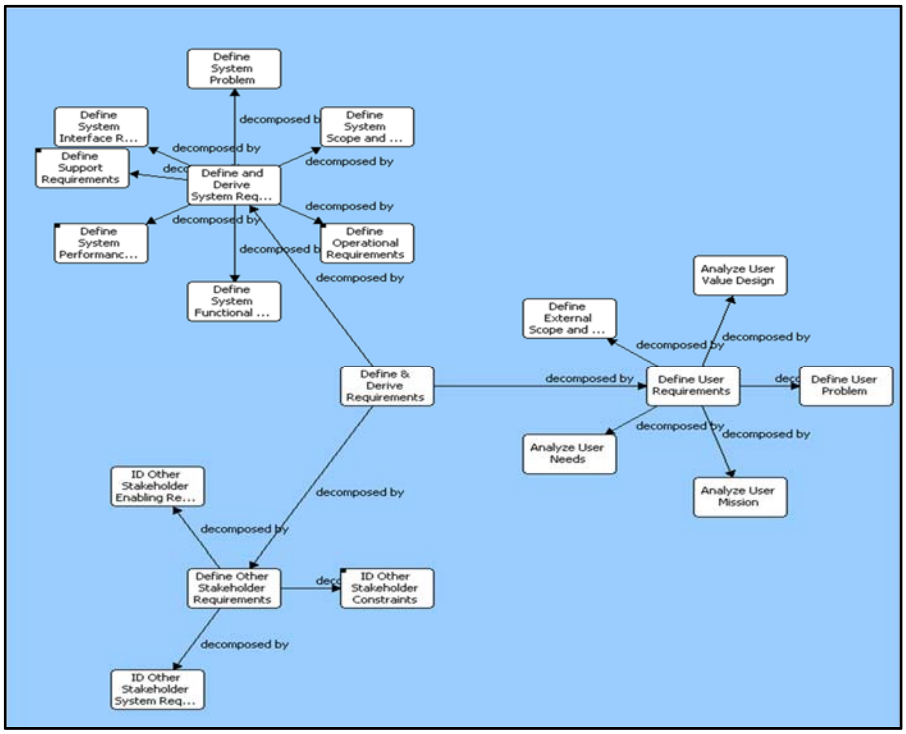

Figure 5. Diagram of Define and Derive Requirements Function

Model Based Acquisition Framework and Products

The artifacts or products that we started mapping were the tier 3 artifacts from NAVAIRs Systems Engineering Technical Review Process (SETR) checklist. These artifacts are the defined products associated with the entry into or exit from a key SETR event. These served as the reference to ensure that the process and artifacts captured aligned as closely as possible with the true as-is process in use today. The original list of tier 3 artifacts contained 326 items, many of which were deemed outside the systems engineering effort and were discarded. After some scrubbing and agreement the final list contained 93 artifacts that were deemed to have a direct or secondary impact on systems engineering. After starting the process mapping and decomposition it quickly became evident that the number of artifacts would increase as some of the artifacts were repeated at different levels of maturity, and some applied to multiple different engineering domains (for example, perform engineering analysis). These needed to be further defined to be specific enough to gain a thorough understanding of the artifacts for further analysis. As mentioned, the artifacts from this model form the requirements or basis for the framework of the MBSE tools and methods. Physical and data models that produce them will be sought to create a Model Based Acquisition Framework (MBAF). With this in mind it was obvious that clarity in these artifacts was very important. Figure 6 is an example of the data flow from the function Define and Derive Requirements.

Another area of interest was to identify the need or specific use of the artifacts produced. Artifacts are produced for several reasons not all are directly related to the design of the system. For example, some are produced for design integrity and flight clearance while others are for statutory or regulatory requirements. The use of these artifacts provides insight into why and whom they are created for and provide NAVAIR with potential areas for process improvements.

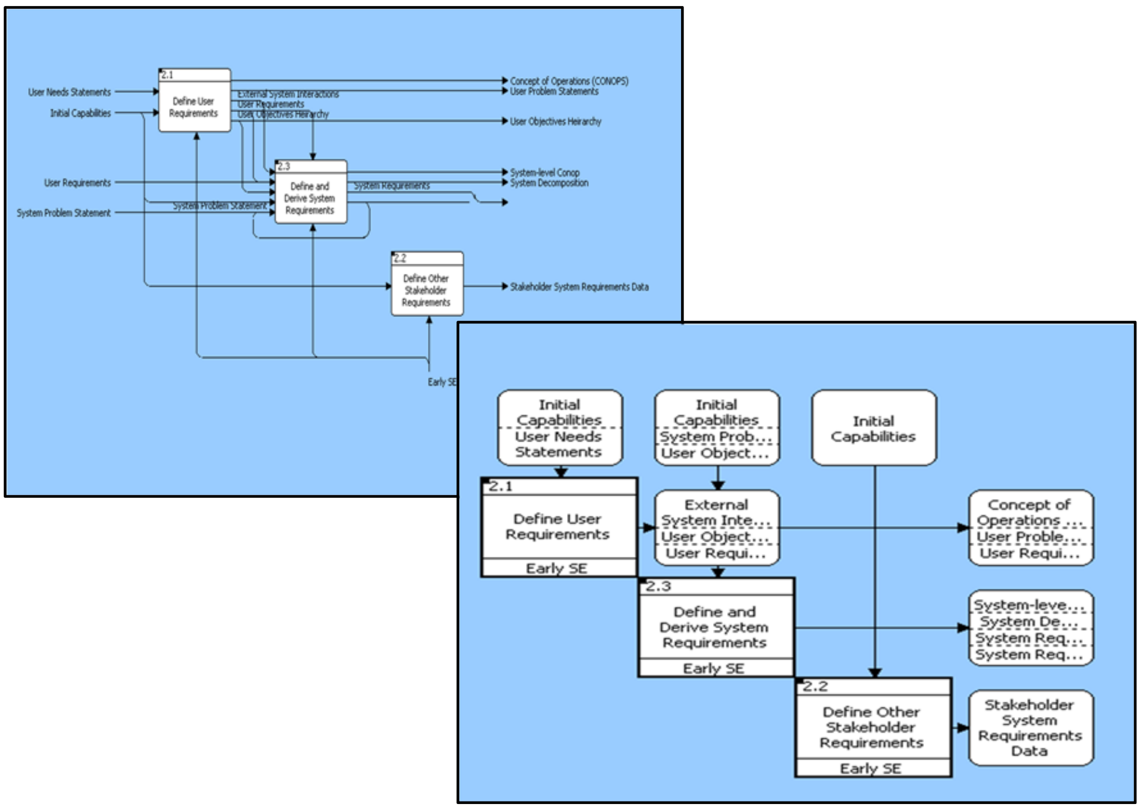

Figure 6. Data Flow Diagrams

Model Validation and Uses

The final phase in the process is to validate the model by using it on a program and then to begin the model/process optimization process. It is the current intent that NAVAIR will use the model to run simulations on process changes in an attempt to make improvements in and optimize their acquisition process. The model should help tailor the process for systems that may not require all of the elements in the acquisition timeline. Currently, all systems, no matter how large or small, start with the same process and have to make determinations on how to tailor the process to fit their program. This detailed model is envisioned to provide insight into that tailoring and also determine the required artifacts. In the realm of IWC and LSI, the system models should provide insight into the capabilities and interfaces of the systems that are not easily captured without a defined modeling environment.

There are multiple other areas that a model with these attributes may provide insights. The model will allow analysis of options related to the elimination of the large event-driven design reviews that are currently part NAVAIRs acquisition process. This alone has the potential to reduce the time and cost to acquire systems as design maturity could be verified incrementally as the system was developed vice waiting for specific large "big bang" technical reviews where the whole system was at the same state of design. This highlights potential sweeping changes to the current business process to capture these types of efficiencies.

Summary

The acquisition process has made changes over the past several years, most notably the implementation of performance based specifications year ago (e.g., JCIDS process). With this came many new considerations for the design review team and the advent of a fairly intrusive overview process. This process was implemented with overdependence upon highly experienced government workforce. As mission interoperability and system complexities have increased, new concepts such as IWC are being introduced. These methods are integration responsibilities of the government workforce, coping with increased complexity, and providing innovative ways to determine design maturity and spec compliance become increasingly important. The numerous changes to the DoD 5000 process have resulted in additional oversight requirements. These oversight mandates have modified design review names and periodicity, however, have not been accompanied with repeatable and quantifiable methods to evaluate design quality and quantifiable engineering risk reduction.

The above changes coupled with the rapidly accelerating decrease in experience in the government workforce and the development of new technologies, computer power, and a workforce that is comfortable in that environment, the time is right to further develop and implement the SDEA concept and create a MBAF that will provide the government team with the ability and design insight that is required to do what they are expected to do. Model-based engineering reviews that provide repeatable, data driven answers will help ensure that the systems the government procures can meet the needs and expectations of the warfighter and, performed correctly with process changes, will be able to acquire faster and utilize fewer human and financial resources. MBAF is a starting point to investigate and create a model-based acquisition system that can make the acquisition process more dynamic and expeditious. The SDEA process will create a system definition model-based start for the program that will enhance the programs ability to communicate with the IWC models and vendors and determine with much more clarity its requirements and interoperability. This model underpins all engineering and management methods and practices, becomes higher fidelity as the acquisition progresses through the MBAF framework, and the technical baseline for the entire lifecycle of the system/program.

The last consideration for implementation of a MBAF is that of adjusting the acquisition process. Currently the DoD 5000.02 prescribes a regimented, document and schedule driven process on which NAVAIR has implemented the SETR process. The SETR process is an event-based review cycle to determine required design maturity levels. As stated earlier, a MBAF should allow for a much more flexible and more dynamic insight and review process that should highlight areas for process changes to capture these efficiencies.

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