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The Making of a Government LSI—From Warfare Capability to Operational System

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The Making of a Government LSI—From Warfare Capability to Operational System

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Abstract

As the government continues to evolve and implement Lead System Integrator (LSI) acquisition strategies, they have started to define numerous program initiatives that employ more integrated engineering and management processes and techniques. These initiatives are developing varying acquisition approaches that define (1) mission-level capability oriented architectures, (2) system-of-system implementation strategies, (3) program of record transition strategies, and (4) system engineering and program management acquisition process transformations. This paper explores these approaches and their progression to the government LSI transformation.

Navy Systems Commands have begun adding a higher level of integration into their acquisition process with the implementation of the design and definition of Integrated Warfare Capability (IWC). This concept integrates the requirements for warfare capabilities and then transitions these well-defined capabilities into programs of records (PORs). This new IWC approach will impact the current technical review process and should enable an enterprise-level approach to the acquisition of capabilities in an interoperable system-of-systems (SoS) environment as well as the PORs that acquire those capabilities.

This paper extends our previous work to discuss how the IWC leads to a POR, as well as an analysis of the various LSI processes being deployed across those programs. Additionally, we will continue to explore how the creation and development of the previously introduced Model Based Acquisition Framework (MBAF), a design-driven engineering process, can help support both the IWC and POR mission-driven acquisition management strategies.

Background

This research is a continuation of research presented at past acquisition conferences. Previously, the authors described (1) the roles and attributes of the Lead System Integrator (LSI; Montgomery et al., 2012) and (2) the concept of how System Definition-Enabled Acquisition (SDEA) can support the systems engineering imperatives of acquisition of complex systems (Montgomery et al., 2013) and the *DoD LSI Transformation—Creating a Model Based Acquisition Framework (MBAF)* (Carlson &

Montgomery, 2014). As mentioned at the last conference, the Naval Air Systems Command (NAVAIR) instituted two significant initiatives that set the stage for continuing the previously discussed SDEA and MBAF principles and practices. They have continued the implementation of LSI, and they now have several programs exercising various levels of attributes of an LSI. To help facilitate and perhaps accelerate the transformation to becoming an LSI, they have also started a Lead System Integrator Certificate program that was designed to explore and examine the attributes of becoming an LSI and educate a cadre of individuals that can help implement the transformation across the organization.

NAVAIR is also enacting a significant organizational structural change and manpower allocation to enable itself to establish a mission-driven acquisition management process. This Integrated Warfare Concept (IWC) is depending upon Model Based System Engineering (MBSE)/System Definition-Enabled Acquisition (SDEA) methodologies and tools to support transition. The goal of the IWC is to understand and map all of the existing and emerging systems required to accomplish a specific capability and align all of the different platforms and programs of records (PORs) that play a part in it. This created a 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 (see Figure 1).

Figure 1. Merger of New Roles and Process With Existing Process
(Carlson & Montgomery, 2014)

This research examines the progress made in furthering the merger of these concepts over that past year.

Problem Definition and Research Questions

Now that NAVAIR has started performing more of the LSI role (Young, 2010) and has supported that LSI role with the implementation of the IWC (Dunaway, 2013) across all of NAVAIR, we can further examine this transition and the processes, methods, practices, and tools that have been adopted in order to implement this radical new process. How have these capability or mission area requirements transitioned into the PORs that NAVAIR is used to performing? Often the start of a transformation also leads to new discoveries, so we examine those as they are discovered as well. This paper explores the progress NAVAIR has made during its implementation of the LSI functions as it goes from warfare capabilities to PORs, as well as how furthering the concept of an SDEA and an MBAF could help NAVAIR succeed in performing in this new environment.

Problem Statement

The DoD's implementation of Lead System Integration roles, processes, methods and practices are not completely defined and developed in existing programs of record (PORs) to ensure that overall warfare capabilities defined by the Integrated Warfare Capability (IWC) analysis process are achieved.

Research Questions

- How are the defined roles of LSI emerging?
- How have these roles manifested or impacted the organization?
- How have these roles and organizational changes impacted the execution of PoRs?
- How can an MBAF support and underpin the efforts of acquiring a system—from capability to PoR?

Emerging Role of LSI

When NAVAIR started down this journey, Stu Young, NAVAIR Director of Systems Engineering, defined LSI as "the assertion and exercise of government controlled trade space" (Carlson & Montgomery, 2014) . With this goal in mind, several programs began exploring and implementing various forms of control such as Presidential Helicopter and its Mission Control System (MCS) and Next Generation Jammer and its contracting strategy. In addition to programs experimenting with various LSI concepts, NAVAIR also formed a Lead System Integrator certificate education program, designed to explore the concepts and application of those concepts on programs as well as creating a definition and lessons learned portfolio for programs to refer to. As part of its research and understanding of LSI, early research from this program defined the following list of LSI attributes:

- Design
    - Primary designer ("design agent") for system and SoS designs
    - Conceptual, architectural design (operational, functional, physical, interface, qualification)
    - Integration and qualification designs
- Control
    - Trade-off studies
    - Analysis of system challenges
    - Risks and opportunities
    - Resources
- System Baseline Management
    - Products (architectures, configurations, drawings, specs)
    - Definition, control, and management of baselines and configurations
    - Capability, operational, performance, functional, allocated, product
- Source Selection
    - Provides solicitation packages
    - Reviews/evaluates proposals
- Vendor Selection
    - Selects/awards contract to component, subsystem, system components or services

- Survey, vetting, and selection of providers of components or services
- Supplier Chain Management
    - Sustain an infrastructure to manage hardware and software configuration item selection, sources of supply, and manufacture
- Qualification (“V & V”)
    - Ultimate responsibility for developmental (verification), operational (validation), at all levels
    - Live, virtual, constructive trades

Organizational Impact of LSI

Reshaping the Engineering Organization

In addition to taking on the role of the LSI, the other major change underway at NAVAIR is the incorporation of the Integrated Warfare Capability (IWC; Figure 2). This concept identifies missing capabilities in various mission areas and determines how to allocate required systems to POR in order to obtain the mission capability.

The mission areas developed are those of Air Warfare (AW), Antisubmarine Warfare (ASW), and Surface Warfare (SUW). These three teams are chartered with the identification and mapping of capabilities and systems required to accomplish them. The NAVAIR technical team is organized in a matrix organization that is allocated to support the various PMAs.

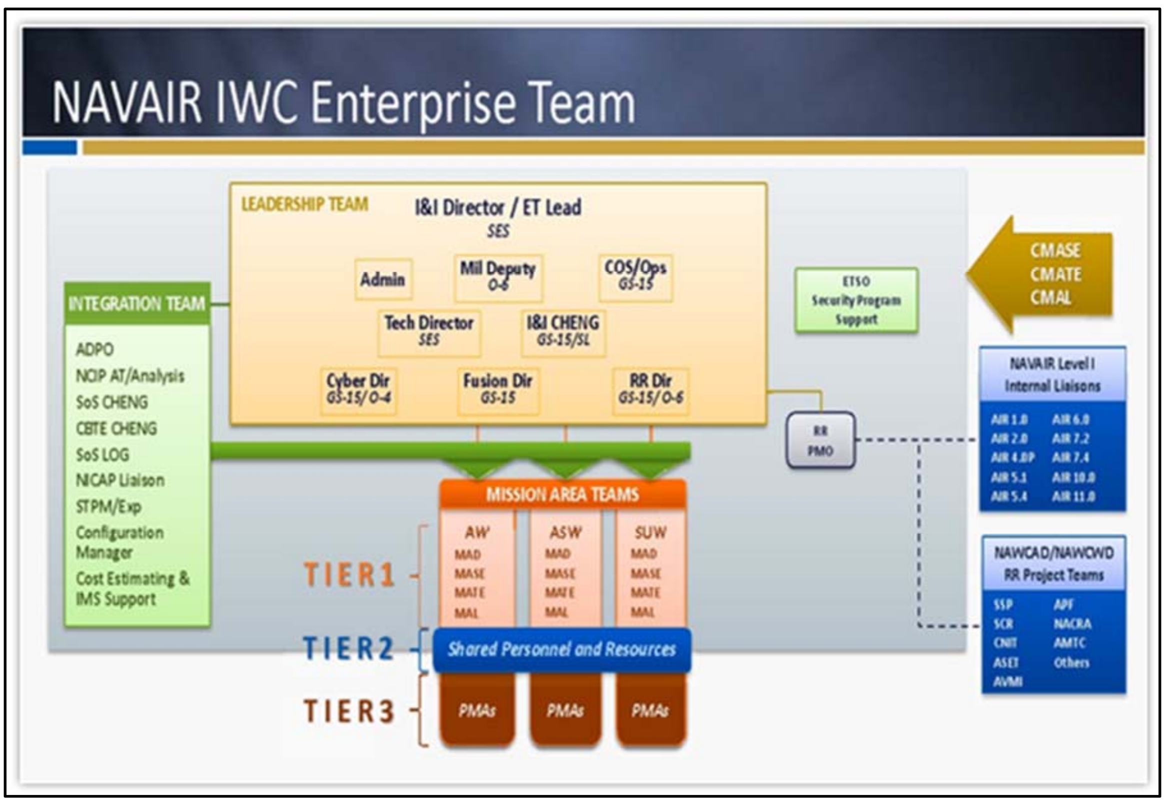

Figure 2. Integrated Warfighter Concept
(Naval Postgraduate School/NAVAIR Cohort #1, 2014)

To help support the mission areas and bridge the gap between them and the PMAs, NAVAIR reorganized its entire technical team (Figure 3) and created an entirely new technical level called 4.0M (Tier 2 in Figure 2). This reorganization has been created to ensure the mission area teams can identify and control the trade space at the capability level and then appropriately assign requirements to the POR where they will gain the most efficiency. This reorganization should also help the PORs better understand their requirements, how they relate to the desired integrated capability, and, finally, to have the ability to control their trade space.

Figure 3. NAVAIR 4.0 Technical Team Reorganization
(Cohen, 2014)

How Have These Roles and Organizational Changes Impacted Execution of PORs?

From Mission Capability to Program of Record

The Mission Area Teams (MATs) determine mission capabilities and their POR allocation of required systems via an Integrated Warfare Capability Package (Figure 4). As can be seen, a capability often involves numerous PORs to make changes to efficiently gain the required capability. The level of change or activity within the PORs varies, as can be seen by the horizontal green and blue bars in Figure 4. Numerous different strategies have been undertaken at the POR level in order to execute the LSI role, the system requirements, as well as the ability to control the trade space within their program. As can be seen in the following POR examples, many of the attributes listed in the first section of this report can be observed.

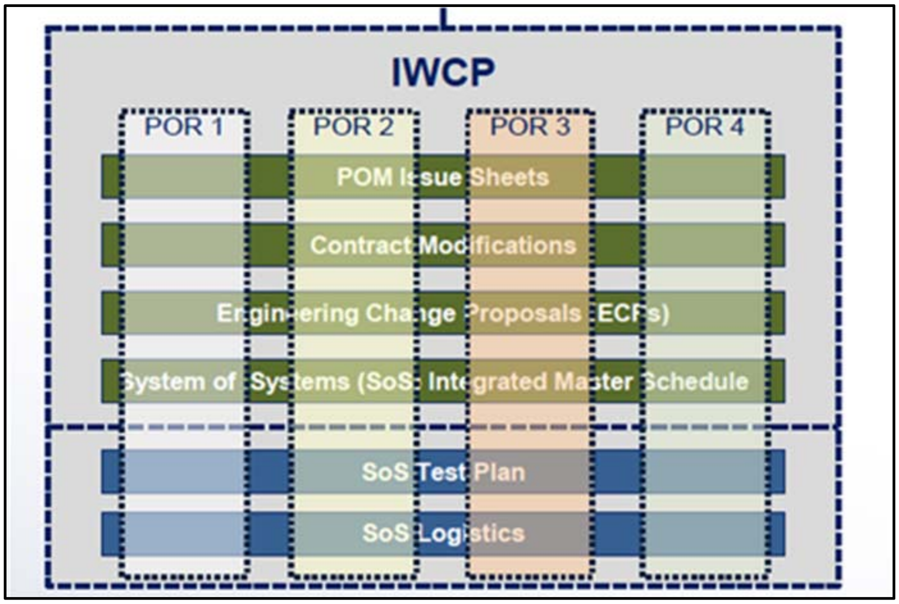

Figure 4. Allocation of PORs From Mission Capabilities
(Cohen, 2014)

PMA-268—Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS)

The UCLASS program is currently pre-contract award, and PMA-268 will operate the program as the LSI. The prime contractor, once selected, will reside primarily under the UCLASS Air Vehicle Segment Integrated Program Team (IPT). To complete the UCLASS system, there are three other government IPTs: CVN Installation, Control Segment and Network, and Program Integration (PI).

The program office is in the process of establishing a Lead Systems Integration team (LSIT) and an LSI board. The LSIT charter is in formation, and will establish the scope of authority that the LSIT will retain. The LSIT will own the trade space between IPTs, including contractual direction for items that affect other IPTs or other organizations. The LSIT will include each Level I IPTL, and functional representation from System Engineering, Test and Evaluation, Logistics, and Special Projects. The Air Vehicle IPTL will represent the prime contractor on the LSIT. Additionally, the LSIT will include associate members acting as non-voting participants for stakeholders that will be affected by LSIT decisions. The LSIT is expected to be chaired by the PI IPT. The LSIT will be responsible for the following:

- Cross segment interface control and architecture
- Anomaly/deficiency adjudication and resource allocation for correction of issues that span multiple IPTs
- Configuration management of hardware and software
- System design trade studies and decisions
- Verification of the total integrated system

PMA-234—Next Generation Jammer (NGJ)

NGJ is the key mission system on the EA-18G to enable an escort role to jam multiple threats and protect other Navy assets as they perform their mission. The NGJ program office will act as the LSI to manage the technical baseline for the Integration of the NGJ onto the EA-18G aircraft. This development effort includes the design and integration of a new electronic jamming pod, modification of aircraft Weapons Replaceable Assemblies (WRAs), and upgraded aircraft software to allow the new pod to function on the aircraft.

The effort is being pursued in an incremental manner with the mid-band being developed first. Future increments will bring in low-band and high-band capability. Raytheon is acting as prime contractor for developing the pods, Boeing will be developing the aircraft ECP, and NAVAIR at Point Mugu will lead development of the required software modifications. The software effort, while being managed through PMA-265, will be placing Boeing on contract for software development support.

The following tasks are a sampling of the activities PMA-234 performs in the LSI role for NGJ:

- Provide clear unambiguous lines of authority in program acquisition governance.
- Allocate work across the contracts to assure integration of products.
- Allocate cost and schedule across the contracts to assure NGJ is developed to meet program timelines.
- Organize the teams to enable collaboration between all contractors and government agencies.
- Manage trade space across the contract boundary to optimize total system performance.
- Develop/maintain system level requirements, architectures, risk management relating to the NGJ system under development.
- Coordinate with key NGJ stakeholders across the interfaces.
- Develop/manage configuration of system technical baselines via centralized databases.
- Integrate the pod and aircraft.

PMA-280—Tomahawk

The Tomahawk program currently spans two program offices: PMA-280 (missile and fire control system) and PMA-281 (mission planning). During Tomahawk development, however, the program spanned seven program offices: Missile; Fire Control System; Mission Planning; Ground Launched Cruise Missile (GLCM—Army version dropped early during development); Box Launcher; Systems Engineering Organization (SEO); and Flight Test. These program offices operated under the oversight of the Navy-led Joint Cruise Missile Project Office (JCMPO) in 1977. One objective of the JCMPO was to maintain a second source for missile production to save cost through competitive procurements. It was believed that competition for production would lower overall costs. To do this, the government needed to own the data package required to produce the missile.

While *LSI* was not a term used at the time, the Tomahawk development program had characteristic elements of an LSI organization. The program had control of the design trade space, and performed detailed engineering work to include design and architecture. Much of this work was accomplished through non-government agencies working under government direction. The program owned the production tooling and test sets, and controlled aspects of the rework and recertification facilities. It owned and managed all internal and external interfaces. The Tomahawk program retained full control of the missile design up through Block III. With introduction of Tomahawk Block IV, however, the government no longer owned the interior design of the missile and there are no longer dual sources for competitive procurement. Under PMA-280 and PMA-281, the government retains control of all the missile exterior interfaces and mission planning.

The following tasks are a sampling of the LSI activities that PMA-280/PMA-281 performs for Tomahawk:

- Weapon control system design management (fire control systems aboard ship)
- Mission planning and distribution system design management
- Management of missile external boundaries
- Control of GFE within the missile (rocket motor, warhead, other components)

VXX ("Presidential Helo") Acquisition Strategy

The acquisition strategy consists of a VXX Prime Contractor that will provide a suitable airworthiness-certified aircraft into which a government-defined Mission Communication System (MCS) and other systems will be integrated. The Prime Contractor will integrate MCS into a suitable air vehicle. The Prime Contractor will also provide an executive cabin interior that meets VXX requirements. The Prime Contractor will be responsible for obtaining an amended airworthiness certification for the VXX aircraft in order to support Interim and Final Flight Clearances.

The VXX Program applied this strategy for risk reduction activities for the MCS ahead of the overall air vehicle acquisition by contracting a government entity (NAVAIR 4.5) to design, build, and test a prototype MCS prior to aircraft integration. These activities are designed to reduce schedule risks associated with the communication subsystem development. It will also support the early definition and refinement of the major subsystem by fostering openness, supportability, and non-developmental solution and by leveraging and expanding the existing In-Service communication suite and using low-risk proven commercial/military solutions.

Since the definition of the communications subsystem necessarily requires interaction with agencies that configure and maintain ground terminals to ensure a functional networking solution, the VXX Program Office contacted the Naval Air Warfare Center Aircraft Division (NAWC-AD) 4.5, St. Inigoes, MD (STI). This team has been supporting the White House Communications Agency for other Senior Leader communications systems and it was well positioned not only to accomplish this coordination but also to design the communication system for the VXX to accomplish the interoperability required.

This strategy was perceived to reduce risk for PMA 274 by having an experienced government team, STI, develop a complex and dynamic mission communication system while holding the Prime Contractor responsible for integration.

How Can an MBAF Support and Underpin the Efforts of Acquiring Systems—From Ops to POR?

MBAF Update

The creation and use of an MBAF can support three different acquisition aspects during POR development:

1. It will serve as a development tool to create the system, including any LSI trade decisions, and allow for an earlier determination of whether the system will perform its requirements and some estimates of attributes, such as time to produce and risk.
2. It will create semantics across the entire acquisition process.
3. It will serve as a way to look back up into the MAT mission-capability model to ensure that the POR meets their needs.

MBAF Development Tool

It is envisioned that the MBAF will consist of design nodes that are relatable to the artifacts and decisions that are required during product development. These various executable nodes, composed of the required data as inputs, will be brought together along the acquisition timeline. Variable or tunable controls such as design maturity and system complexity will be utilized to serve as the inflection points and be manipulated based upon the characteristics of the program. These variable inputs will go through a design node, and the outputs will be the product or artifact of that design mode as well as some indication of time and perhaps risk. Figure 5 depicts the initial vision of what these model nodes might look like and what some of the potential variables and outputs could look like. The variable controls listed could change, but the thought is that if variables such as these are applied, they will affect risk and time.

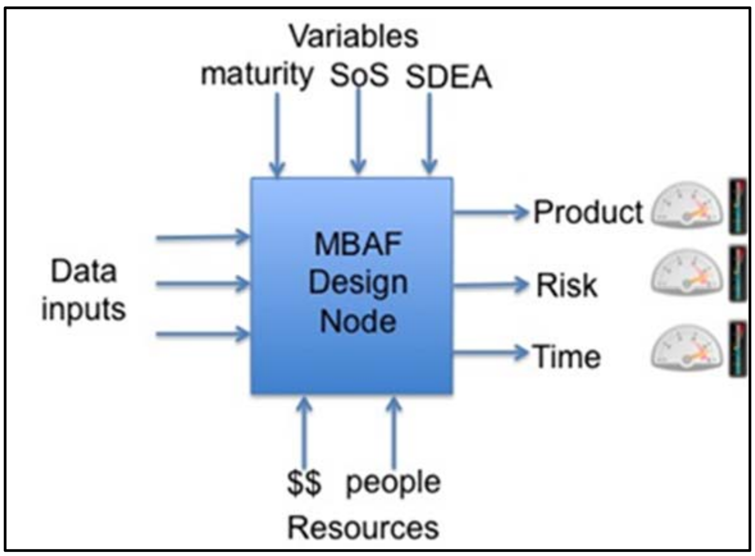

Figure 5. Depiction of an Executable MBAF Design Node

Figure 6 depicts the concept of how these executable nodes could be strung together along the MBAF. This example shows how three other design nodes—requirements, architecture, and risk—could feed the Systems Requirements Review (SRR) decision node.

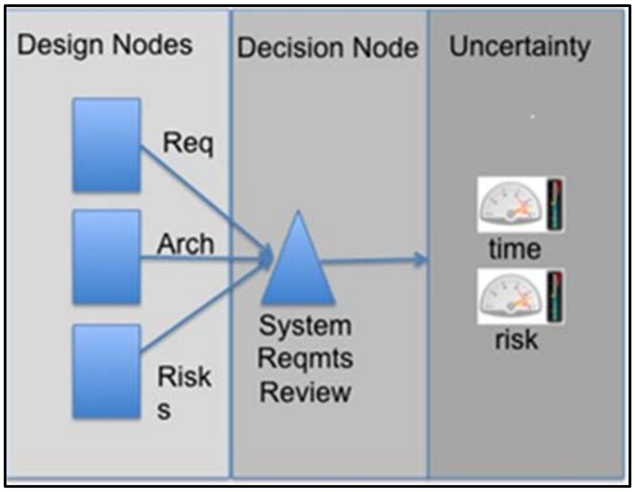

Figure 6. Rollup of Design Nodes Into Decision Nodes

Each of these would have their corresponding assessments and would then feed into the SRR decision node, and the output of this would be a cumulative mix of the outputs of all the design nodes. Ultimately, as depicted in Figure 7, this process would continue throughout the design phase and would produce a cumulative summary of the outputs along the acquisition cycle.

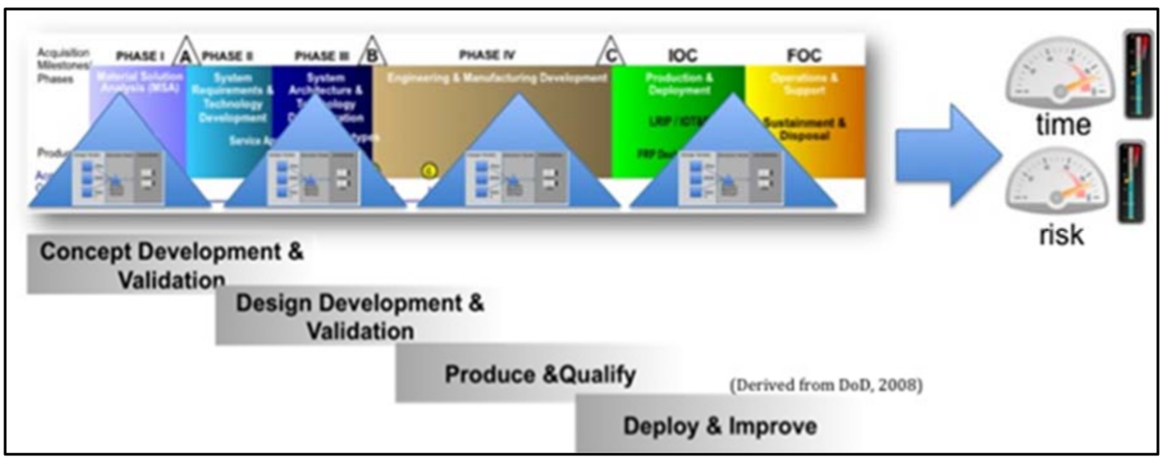

Figure 7. Rollup of Decision Nodes Along Acquisition Timeline

MBAF Semantics

Another benefit of the MBAF is that its set of models and tools will create a common and understood set of semantics for the acquisition process. This currently does not exist, and cannot in the current process, due to much of the information being presented in the form of documents that are evaluated by experts with varying experiences and knowledge. The creation of a known set of tools and models that are used along the acquisition process will create a common meta-data of sorts, which will formalize the data package and allow for a much more common understanding of the data. This common meta-data and understanding will feed into the transformation of the acquisition process from the document-driven, expert-evaluated process in use today (Figure 8) to the data-rich, model-driven approach desired (Figure 9). This will allow for a decision process that relies less on expert opinion to interpret documents, and hence the subjectivity of humans, to one that is more data- and model-centric.

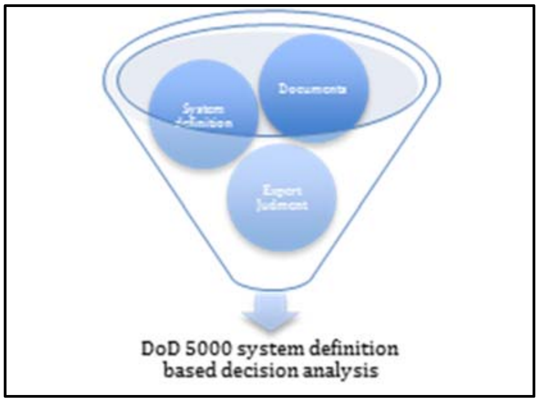

Figure 8. Current DoD 5000–Driven Decision Analysis Process

Written documents contain no known semantic qualities, so the framework or relationships that went into the document are left to the interpretation of the reader and their individual beliefs. When several experts read several documents, with unknown semantics, it is highly improbable that they will all draw the same conclusions based upon their understanding of the written material. This reliance and assumption that every expert and every document writer has the same understanding of the relationships between the information they either create or read, creates additional uncertainty at best, and probable incorrect assumptions and conclusions at worst. This uncertainty and sometimes misinterpretation of documents at the current event-driven technical reviews is what the creation and use of MBAF and the application of known and understood models can help eliminate.

MBAF and its associated models, all with known semantics, will help reduce these uncertainties and misunderstandings. This design-driven process, rich with data from models with known semantics, will establish a well understood baseline for decision-makers to evaluate. Over time, the dependence on experts to interpret documents will diminish and the consistency, richness, and understanding of the data will yield more predictable results. This combination of tools and models, with their semantics, will create in essence the semantics of the acquisition process. These sets of tools and specifically the attributes and data they produce, will become a true representation of the product and lead to informed decisions. There may still be some discussion and disagreement, but at least they will be about well-understood and common data, vice an individual's interpretation of documents and the conclusions they drew from them.

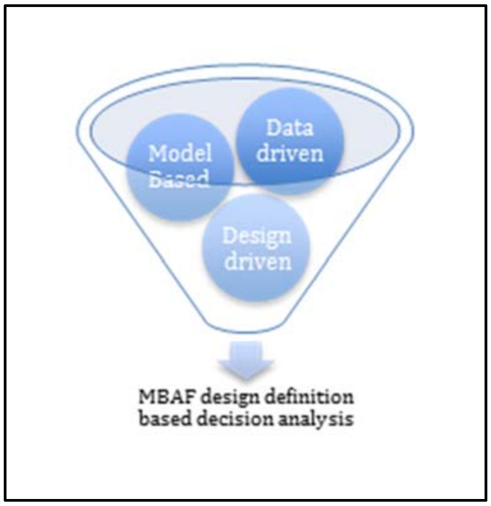

Figure 9. MBAF-Driven Decision Analysis Process

Mission Area Validation

The IWC started creating mission-capability models as a tool to determine what capabilities and systems are required to complete the mission capability. This top-level modeling has created a need or at least provided an opportunity for PORs to create models of the systems that they have under development and use them to determine if what they are developing fulfills the mission capability.

Summary

Many new initiatives have been undertaken at NAVAIR to better support the acquisition of systems to support the warfighter. The creation of the IWC and further pursuit of the government taking on the role of LSI have caused this one SYSCOM to institute transformations ranging from standing up an entirely new organization to a major re-alignment of its technical organization. In order to jump-start and quickly gain an understanding of how to incorporate the role of LSI, it has also instituted a year-long certificate education program to study and help shape NAVAIR's role as an LSI, as well as undertaken several attributes of an LSI in numerous programs.

The creation and use of an MBAF has the potential to be a useful tool that will assist in all of the endeavors that NAVAIR has undertaken. The use of the MBAF and associated tools can serve as a development tool to create the system, including any LSI trade decisions. It will also allow for (1) an early determination of whether the system will perform its requirements, (2) a better estimate of attributes' acquisition cost, schedule, and risk, and (3) establishment of semantics across the entire acquisition process. Finally, it will serve as a way to look back up into the Mission Area Team (MAT) mission-capability model to ensure that the POR meets their needs.

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