Systems Engineering Management in DoD Acquisition

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ABSTRACT:

When purchasing intricate and technologically sophisticated equipment to satisfy the varied demands of the armed services, the Department of Defence (DoD) encounters particular difficulties. In order to assure the successful acquisition, development, and maintenance of these systems throughout their lifespan, effective management of systems engineering procedures is essential. An overview of the main ideas and procedures in systems engineering management within the framework of DoD acquisition is provided in this abstract. Beginning with a discussion of systems engineering's significance in DoD procurement and its role in obtaining targeted operational capabilities, the abstract goes on to summarise its key points. It highlights the need for a methodical and organised strategy to handle the complexity and connectivity of defence systems. The abstract then examines the many phases of the acquisition lifecycle, from the creation of the requirements through the integration and testing of the system, stressing the crucial systems engineering tasks at each level. The paper also goes through the fundamental components of systems engineering management, such as systems thinking, requirements engineering, trade-off analysis, risk management, and configuration management. It investigates how to combine these components into a comprehensive system engineering management framework that complies with DoD acquisition rules and regulations.

KEYWORDS:

Acquisition Process, Dod Acquisition, Operational Requirements, Production Deployment.

I. INTRODUCTION

An essential component of Department of Defence (DoD) acquisition programmes is systems engineering management. It is a methodical technique to manage complex systems' technical components at every stage of their lifespan, from idea creation through retirement. Systems Engineering Management makes ensuring the system is user-friendly, economical, and timely in its delivery. The Defence Acquisition System (DAS), which offers a framework for the acquisition and administration of defence systems, regulates Systems Engineering administration in the DoD acquisition process. The DAS lists the significant checkpoints, judgement calls, and evaluations that must be made during the acquisition process. Understanding operational demands and converting them into system requirements are the first steps in systems engineering management. The functionality, performance, and other qualities that the system must have are captured in these requirements [1], [2].

The system's design and development are under the management of systems engineering. Defining the system architecture, assigning requirements to subsystems, and overseeing component integration are all part of this process. Risk management, trade-off analyses, and assuring compliance with pertinent standards are also included. Through verification and validation procedures, Systems Engineering Management makes sure the system satisfies its requirements. While validation determines if the system satisfies operational requirements, verification verifies that each system component and subsystem operates as intended. Controlling changes to the system's design, documentation, and associated artefacts is a component of configuration management. In order to protect the integrity of the system and limit the risks associated with modifications, systems engineering management develops baseline configurations and guarantees effective version control. Programme managers, engineers, contractors, and users must all work together to effectively manage systems engineering in DoD acquisition programmes. The effective delivery of complex defence systems that satisfy operational requirements while controlling risks, costs, and schedule restrictions is made possible through an iterative and structured methodology [3], [4].

II. DISCUSSION

Federal legislation and public policy serve as the cornerstones of the DoD procurement process. various official DoD directives, instructions, manuals, Service and Component rules, as well as various inter-service and international agreements, regulate the development, procurement, and operation of military systems. Technical management, business management, and contract management are the three fundamental tasks needed to oversee the development and fielding of military equipment. The technical management element of DoD acquisition management is systems engineering management, as it is explained in this book [5], [6].

The planning, programming, and budgeting system's (PPBS) requirements generation and budgeting processes and the acquisition process are simultaneous processes. Threat-driven events often generate user needs. Due to Congressional calendar restrictions, the budgeting process is date-driven. The conflict between event-driven requirements, event-driven technology development, and an event-driven budget must be addressed through Systems Engineering Management, which connects these activities [7], [8].

Information and Advice

Top-level recommendations for planning, budgeting, and purchase are provided by the Office of Management and Budget (OMB) in OMB Circular A-11, Part 3 and the Supplemental Capital Programming Guide: Planning, Budgeting, and purchase of Capital Assets, July 1997. These agreements lay forth the general obligations and guidelines that must be followed when financing and purchasing significant assets. The executive branch's departments are then required to create their own advice in accordance with the specified standards. The DoD 5000 series of directives and regulations serves as the primary reference point for the purchase of defence systems. These publications outline the steps that DoD procurement managers must take to:

1. Transform operational requirements into reliable, reasonably priced programmes,
2. Purchase high-quality goods, and
3. Create an efficient and productive organisation.

The DoD 5000 series papers were updated in 2000 to increase process flexibility, allowing for the quicker and more affordable delivery of cutting-edge technology to warfighters. Depending on the level of development of the core technologies involved, the new approach promotes a variety of entry points and the use of evolutionary methodologies to design and create systems. This promotes a customised approach to engineering management and acquisition, but it leaves the fundamental logic of the underlying systems engineering process alone [9], [10].

ACQUISITION LIFE CYCLE

Figure 1 depicts the updated acquisition procedure for significant defence systems. The process is broken down into a number of stages where technology is created and matured into workable ideas, ready for development and manufacturing. The systems that are then manufactured are then maintained in the field.

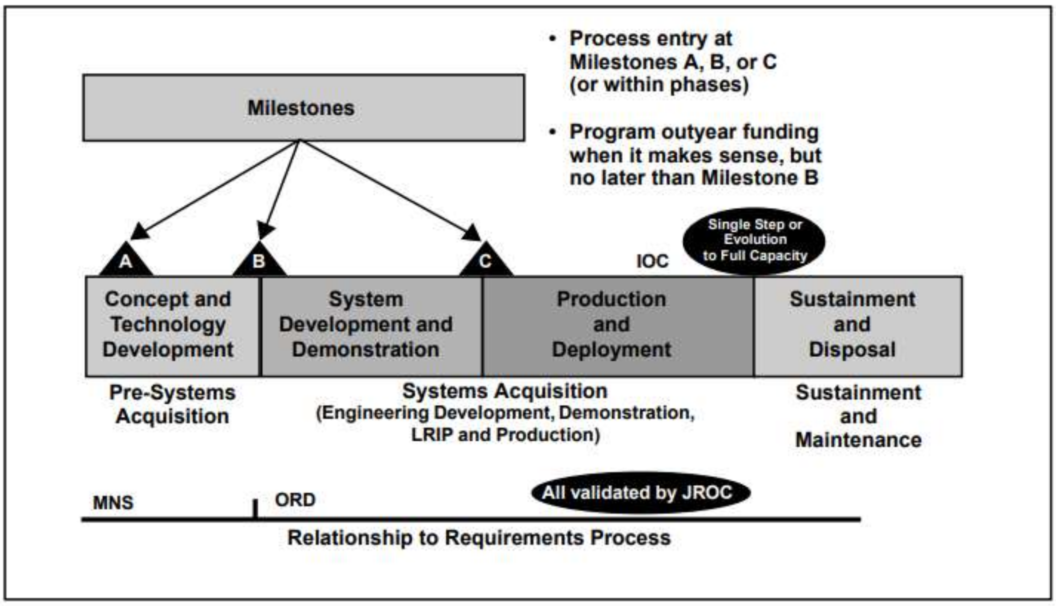

Figure 1: Revised DoD 5000 Acquisition Process.

A specific system may join the process at any stage of development thanks to the procedure. A system based on mature and proven technologies could enter directly into engineering development or, theoretically, even production, whereas a system using unproven technology would enter at the beginning stages of the process and would proceed through a protracted period of technology maturation. Four stages of development are included in the process itself (Figure 1). Concept and technology development, the first, aims to investigate several ideas based on evaluations of operational requirements, technological readiness, risk, and cost. Entry into this phase does not mean that the Department of Defence has committed to a new acquisition programme; rather, it marks the beginning of a process to ascertain whether or not a need (typically outlined in a Mission Need Statement (MNS)) can be satisfied with acceptable levels of technical risk and at reasonable costs. At the Milestone A forum, the decision to begin the Concept and Technology Development phase is officially made.

Concept investigation is the first step in the Concept and Technology Development process. Concept studies are carried out at this stage to establish different ideas and to provide details regarding capacity and risk that would enable an unbiased assessment of competing concepts. Following the conclusion of the idea research activities, a decision review is performed. This evaluation aims to establish if more technological advancement is necessary or whether the system is prepared for system purchase. The Milestone Decision Authority (MDA) may approve to enable the system to progress into system acquisition if the essential technologies involved are sufficiently mature and have previously been proven; if not, the system may be directed into a component advanced development stage. (For a definition of Technology Readiness levels, see Supplement A to this chapter.) System architecture design will continue throughout this phase, and important technologies will be shown to make sure that technical and financial risks are recognised and are at acceptable levels before starting the purchase phase. In any case, the concept and technology development phase are completed with a specified system architecture backed by technologies that have reached a sufficient degree of maturity to allow for the purchase of a system.

A Milestone B choice signals the start of the official system purchase. The choice is based on an integrated evaluation of user needs, technological maturity, and finance. The System Development and Demonstration phase is the next step after Milestone B is successfully completed. This stage might be reached either immediately or after idea and technology development, depending on the technical potential and pressing user demand. System integration and system demonstration are the two steps of development that make up the system development and demonstration phase. It might enter in any stage, or the phases could be blended, depending on the system's degree of development.

This stage sees the integration at the system level, demonstration, and testing of the technologies, components, and subsystems described previously. This stage will be entered by the system during the system integration stage if it has never been integrated into a full system. Following an interim evaluation by the MDA to guarantee preparedness, the programme will typically move onto the system demonstration stage once subsystems have been integrated, prototypes have been demonstrated, and risks are deemed acceptable. The goal of the system demonstration stage is to show that the system satisfies the operational criteria while still being operationally useful. To make sure the system operates as needed, engineering demonstration models are created, and system-level development testing and operational evaluations are carried out. These tests must be carried out under settings that mirror the planned operating settings in the long run. A system may go onto the Production and Deployment phase if it has been proven in a setting that is operationally relevant.

Production preparedness and low rate initial production (LRIP) and rate production and deployment are the two steps that make up the Production and Deployment phase. The Milestone C event serves as the decision-making platform for admission into this phase. Again, technical maturity is the key factor in determining where a programme enters the process, therefore it is possible that a system might enter straight into this phase if it were sufficiently developed, for instance, a commercial product being created for defence uses. The production readiness and LRIP stage is where the first operational test, live fire test, and low rate initial production are carried out, regardless of how the entrance is made directly or via the maturation process mentioned. The system enters the rate production and deployment stage, during which the item is created and distributed to the user, after successfully completing the LRIP stage and receiving a positive Beyond LRIP test result. The third step, Sustainment and Disposal, starts once the system is created and deployed.

The program's Sustainment and Disposal phase is the last and longest one. In order to maintain and support the system in the field in the most cost-effective way feasible, all relevant tasks are completed during this phase. The range of operations is extensive and encompasses everything from supply and maintenance to monitoring of safety, health, and the environment. If necessary, this time frame may also encompass the change from contractor to organic support. As technologies and threat systems advance, alterations and product upgrades are often put into place during this phase to maintain and update the necessary operational capability levels. When a system reaches the end of its useful life, it is disposed of in line with any relevant environmental and classified laws, rules, and directives. Recycling, material recovery, salvaging and reusing, and disposing of development and manufacturing byproducts are further disposal operations.

Programmes may arrive at any point throughout the first three stages, which is the key to this acquisition process approach. Where the programme should enter the process is mostly determined by user wants and the state of technology. For the programme in question, the MDA decides. Programme managers are urged to collaborate with their users to create evolutionary acquisition plans that will enable the delivery of functional capabilities in the shortest amount of time possible, with improvements and enhancements added as necessary through ongoing requirement definition and development activities to support the changing needs.

Engineering for Systems in Acquisition

DoD 5000.2-R stipulates that the systems engineering process must:

1. By concurrently taking into account all lifecycle demands (i.e., development, manufacture, test and evaluation, verification, deployment, operations, support, training, and disposal), operational needs and requirements may be transformed into an integrated system design solution.
2. Ensure that all functional and physical interfaces are compatible, interoperable, and integrated, and that the definition and design of the system take into account the specifications for all system components, including the facilities, people, data, and software.
3. Identify and control technical hazards.
4. Use scientific and technical approaches to locate security flaws and to reduce or eliminate the risks associated with information assurance and force protection.

The management ideas and methods outlined in the next chapters of this book are used to achieve these goals. Acquisition phasing and the use of systems engineering management go hand in hand. Major technical reviews are carried out to assess the maturity of the system design in order to support milestone choices.

Development of Concepts and Technologies

Two pre-acquisition phases of development make up the Concept and Technology Development phase. Concept Exploration is the first and is seen in Figure 2. Usually, a concept's examination is carried out over the course of many brief studies. These studies are anticipated to be developed using a variety of methods, such as the systems engineering process, which transforms inputs into workable concept designs whose functionality may be linked to the requirements. Additionally, the process is supported by market research, BPR initiatives, operational analysis, and trade studies.

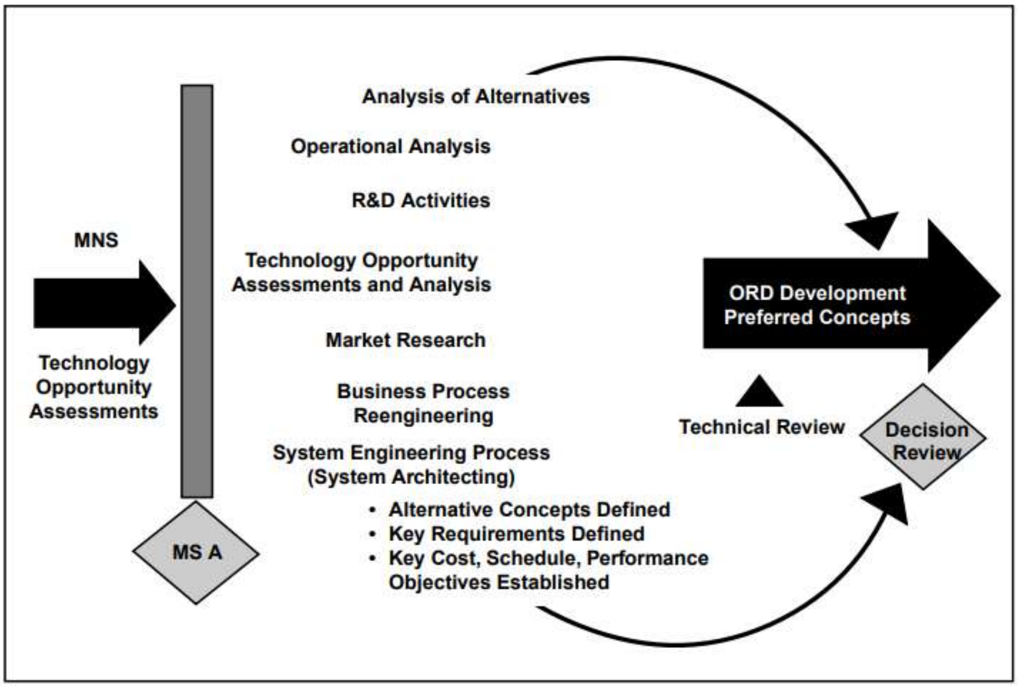

Figure 2: Concept and Technology Development (Concept Exploration Stage) [ocw.mit.edu].

The MNS, which represents needs, evaluations of technological prospects and status, and any efforts made to examine prospective solutions' outcomes are the main inputs to these activities. A single idea is chosen to follow when the contractor studies are finished based on an integrated evaluation of technical performance, technical, schedule, and cost risk, as well as other pertinent criteria. After that, a decision review is conducted to assess both the suggested idea and the technological state on which it is based. The MDA then decides whether the concept development work needs to be extended or redirected or whether the programme can move directly to Mile-stone B (System Development and Demonstration) or Mile-stone C (Production and Deployment) given the technology maturity.

It is likely that the system will move on to the second stage of the Concept and Technology Development phase if the concept's specifics need to be defined, i.e., if it hasn't yet been designed and demonstrated, or if it seems to be based on technologies that pose a significant risk. Figure 3 depicts this level, Component Advanced Development. Additionally, this pre-acquisition stage of development is distinguished by a significant level of DoD Science and Technology (S&T) community engagement. In order to have confidence that the system's building blocks are sufficiently well-defined, tested, and demonstrated to provide confidence that, when integrated into higher level assemblies and subsystems, they will perform dependably, the fundamental goals of this stage of development are to define a system-level architecture and to complete risk-reduction activities as necessary.

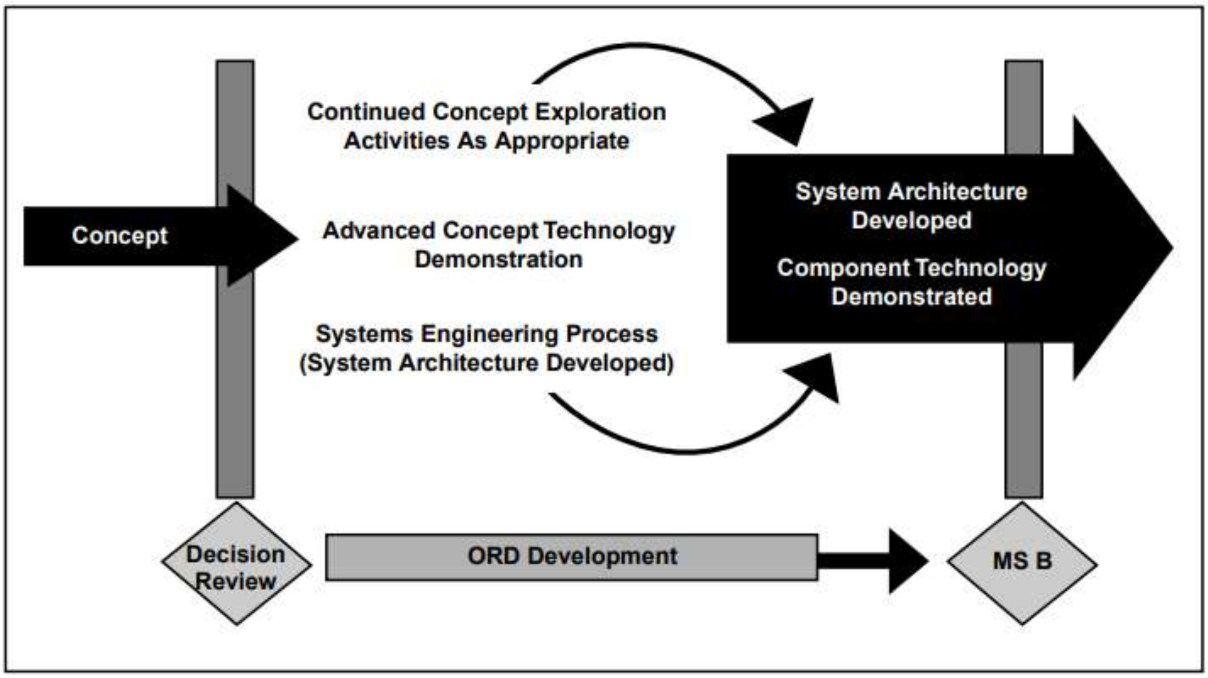

Figure 3: Concept and Technology Development [ocw.mit.edu].

System level needs must be continually refined based on comparison studies of the system ideas being taken into account in order to develop a system-level design. Additionally, the system's place in the system of systems of which it will be a part must be taken into account. Interfaces at the system level must be established. Data flows must be specified, communications and interoperability needs must be developed, and operational ideas must be polished. The tactics that will be used to preserve the system's affordability and supportability over its life cycle, such as the usage of open systems designs and common interface standards, should also be included in top-level planning. At this point of the programme, it is important to address crucial design criteria including interoperability, open systems, and the usage of commercial components.

As choices are made about the many technologies that must be combined to build the system, risk reduction techniques including modelling and simulation, component testing, bench testing, and man-in-the-loop testing are prioritised. Making ensuring that the core technologies that represent the system components (assemblies and sub-systems) are properly understood and sufficiently developed to warrant their usage in a system design and development effort is the main goal at this stage. Engineering development is the following stage of the life cycle, hence research and development (R&D) projects funded by science and technology appropriations should be finished at this time.

III. CONCLUSION

In conclusion, a key component of Department of Defence (DoD) acquisition programmes is systems engineering management. It gives complex systems technical management throughout their lifespan a systematic and methodical approach. The DoD uses Systems Engineering Management to make sure that systems it acquires are functional, economical, and delivered on time. Requirements development, system design and development, verification and validation, configuration management, technical reviews, risk management, systems integration and testing, and transfer to operations are the main components of systems engineering management in DoD acquisition. The Defence Acquisition System (DAS) outlines a number of milestones, decision points, and reviews that are used to deploy these components.

The translation of operational requirements into system requirements, system design and development, and performance verification and validation are all made easier by systems engineering management. Additionally, it handles risk management related to the system's development and operation as well as configuration management to ensure system integrity. Technical reviews are also conducted to evaluate progress and deal with any technical difficulties. The Department of Defence (DoD) seeks to increase acquisition programme success rates, reduce risks, and guarantee that systems are dependable, efficient, and effective via the use of systems engineering management. To successfully deploy Systems Engineering Management in DoD acquisition programmes, stakeholders like as programme managers, engineers, contractors, and users must work together.

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