Introduction to Systems Engineering Management

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ABSTRACT:

For complex systems to be developed and implemented successfully, the discipline of systems engineering management is essential. To guarantee the successful design, development, and operation of big projects, it entails integrating several technical disciplines, project management concepts, and organisational methods. This introduction article gives a general overview of systems engineering management, outlining its core ideas and significance for completing successful projects. Systems thinking, requirements engineering, risk management, and configuration management are some of the main topics covered. Additionally, it emphasises the difficulties and possibilities of systems engineering management while highlighting the need of multidisciplinary cooperation, good communication, and continual development throughout the project lifetime. Stakeholders may improve their capacity to handle complex issues and provide creative, long-lasting solutions by knowing the ideas and practices of systems engineering management.

KEYWORDS:

Configuration Baselines, Subsystem Component, Systems Engineering, Technical Architectures.

I. INTRODUCTION

By combining technical, administrative, and organisational factors, systems engineering management is a crucial discipline that guarantees the effective execution of complex projects. From the creation of the first idea through the delivery of the system and beyond, it entails organising and managing the complete systems engineering process. This introduction gives a summary of systems engineering management while emphasising its main tenets and goals [1], [2]. Planning, organising, coordinating, and regulating the resources, tasks, and stakeholders involved in system development are just a few of the many activities that fall under the umbrella of systems engineering management. The emphasis is on completing the project's goals within the parameters of time, money, and quality while making sure the system fulfils the requirements and expectations of its users.

Systems engineering management's main goal is to efficiently manage the system development lifecycle and make sure that all necessary tasks are carried out in a logical and coordinated way. Clear goals and objectives must be established, system needs must be specified, resources must be allocated, risks must be managed, and stakeholders must maintain good communication [3], [4]. It is important to adhere to a number of fundamental concepts and best practises for effective systems engineering management. Stressing a comprehensive understanding of the system and how it interacts with its surroundings. To comprehend the system's behaviour and performance, systems engineers examine the system's components and their interactions. Integrating diverse engineering disciplines, stakeholders, and project stages via an integrated approach. This encourages a unified and coordinated effort to accomplish the project's goals [4], [5].

System requirements must be developed and managed in a clear, simple, and verifiable manner. In order to gather, assess, and prioritise requirements and maintain their traceability throughout the development process, systems engineers collaborate closely with stakeholders. Risk management is the process of identifying and reducing possible risks and uncertainties during the course of the development lifecycle of a system. To reduce risks' effects on the project's success, systems engineers perform risk assessments, create risk mitigation measures, and keep track of risks. Setting up and maintaining control over the hardware, software, and documentation that make up a system's setup. Configuration management helps with effective change management and keeps the system consistent. Engaging and engaging stakeholders throughout the project to make sure their requirements, expectations, and concerns are recognised and taken into consideration. Successful systems engineering management requires effective stakeholder engagement and communication [6], [7]. Finally, systems engineering management is a crucial subject that guarantees the efficient completion of challenging projects. Systems engineering managers may successfully plan, organise, coordinate, and control system development operations by adhering to fundamental principles and best practices. As a result, high-quality systems that satisfy stakeholder demands and expectations are delivered.

II. DISCUSSION

This text's main structure is explained in the Preface. Some of the fundamental assumptions that are developed throughout the book are established in this chapter. The groundwork for the definitions that follow is laid forth in the chapter's definitions of basic terminology. Starting with a definition of a system, the main concepts and points of view in systems engineering are introduced. A system, said simply, is a grouping of people, things, and procedures that work together to fulfil a specified requirement or goal [8], [9].

Systems Engineering

The technical knowledge area in which the systems engineer works and systems engineering management are two key disciplines that make up systems engineering. The systems engineering management process is the main topic of this book. The most widely used technical standards that pertain to this topic include three definitions of systems engineering that are often utilised. They all have the same subject:

1. A logical flow of actions and choices that converts a functional requirement into a description of the performance characteristics of the system and a recommended system configuration. Engineering Management, MIL-STD499A, 1 May 1974. No longer valid.)
2. An interdisciplinary strategy that integrates the whole technical effort and develops into and validates a set of integrated, life cycle-balanced system solutions including system people, product, and process. (Systems engineering, EIA Standard IS-632, December 1994.)
3. A multidisciplinary, cooperative method that originates, develops, and validates a life-cycle balanced system solution that fulfils public acceptability requirements and customer expectations. Applied and Managed Systems Engineering Process Standard, [Final Draught], IEEE P1220, 26 September 1994.

Systems engineering, to put it briefly, is a multidisciplinary engineering management process that develops and validates a set of integrated, life-cycle-balanced system solutions that meet client demands [10].

Systems Engineering Management

Figure 1 shows how merging three key tasks may be used to manage systems engineering:

1. Development phasing, which manages the design process and offers benchmarks to align design efforts,
2. A system engineering approach that offers a framework for resolving design issues and monitoring requirement flow; and
3. Life cycle integration, which incorporates clients in the design process and guarantees the long-term viability of the created system.

To properly manage a development endeavour, each of these actions is required. Phasing has two main functions: it regulates the design effort and serves as the primary link between the technical management effort and the overall acquisition effort. By creating design baselines that regulate each stage of development, it manages the design effort. In order to analyse design viability, it provides important development process events where acquisition management may be interfaced with. One of the main factors influencing acquisition management Milestone (MS) choices is the viability of the created baselines. As a consequence, it is crucial to time and coordinate technical development phasing with the acquisition plan in order to keep an acquisition programme healthy.

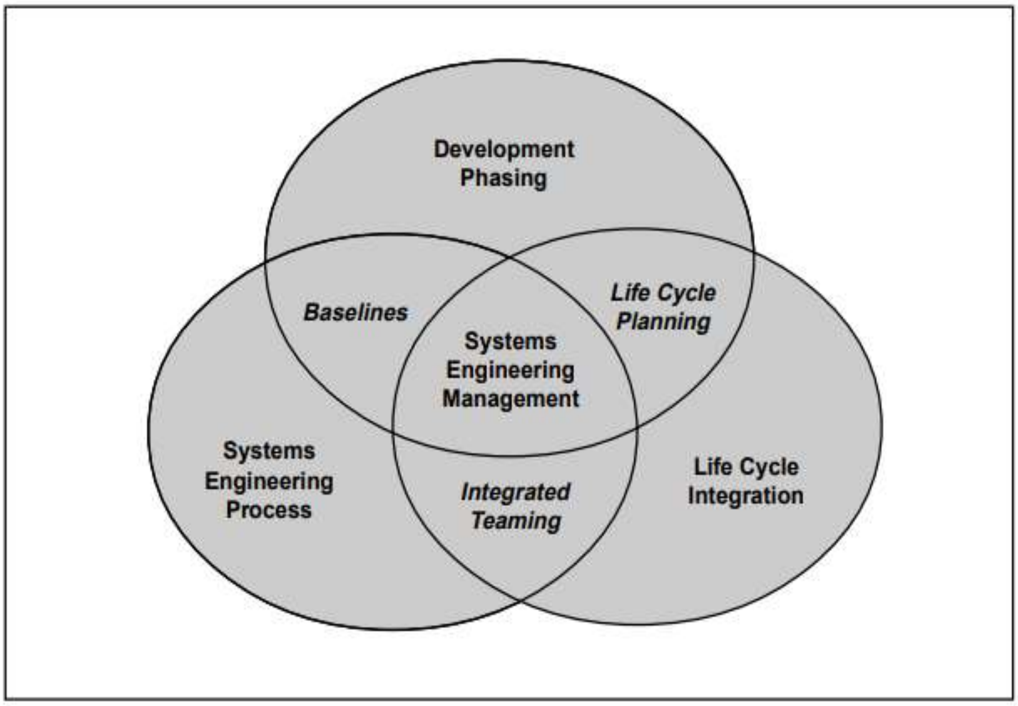

Figure 1: Three Activities of Systems Engineering Management [ocw.mit.edu].

The core of systems engineering management is the systems engineering process. Its goal is to provide a method that converts requirements into specifications, architectures, and configuration baselines in an organised yet adaptable way. The process's structure gives developers the control and traceability they need to create solutions that satisfy customers' expectations. Any stage of the development process allows for one or more iterations of the systems engineering process. To make sure that the design solution is workable throughout the duration of the system, life cycle integration is required. It also involves integrating many functional issues into the design and engineering process, as well as the planning necessary for developing new products and processes. Cycle times for products may be shortened in this way, and redesign and revision are far less necessary.

Development Phasing

Typically, development proceeds via various levels or stages:

1. Idea level, which results in a description of the system idea (often detailed in a concept study);
2. System level, which generates a description of the system in terms of performance requirements; and
3. Subsystem/Component level, which results in the generation of a collection of subsystem and component product performance descriptions first, followed by a set of matching thorough descriptions of the goods' features, which are necessary for their manufacturing.

These descriptions often referred to as configuration baselines—are created by applying the systems engineering process, one level at a time, to the various system development levels. As a consequence, there are many configuration baselines, one for each phase of development. Each step increases the amount of information in these baselines. The functional baseline, allocated baseline, and product baselines are the names given to the configuration baselines in the Department of Defence (DoD) for the system-level description, subsystem/component performance description, and subsystem/component detail description, respectively. The fundamental connections between the baselines are shown in Figure 2. The triangles, which stand for the decision points for baseline controls, are often referred to as technical reviews or audits.

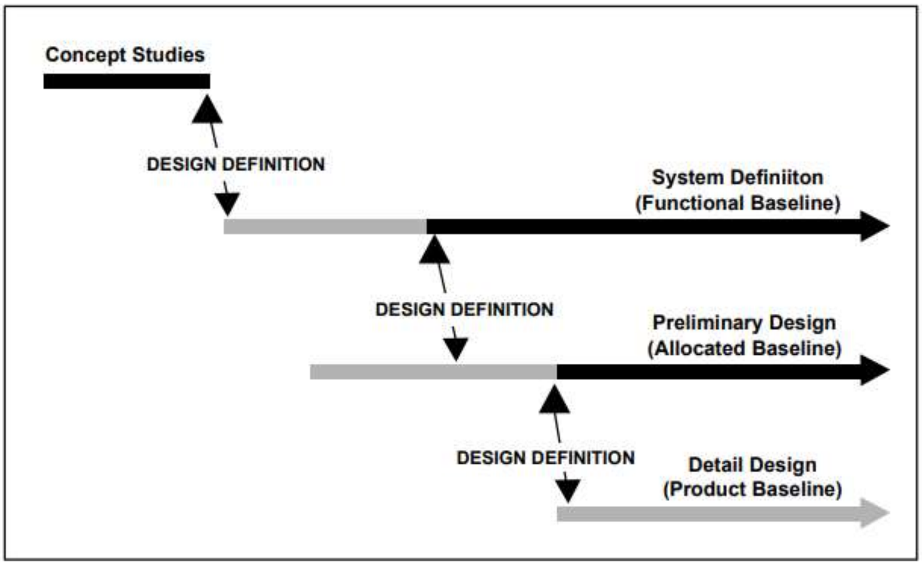

Figure 2: Development Phasing [ocw.mit.edu].

Considerations for Different Development Levels

The system hierarchy should not undergo significant development at any level unless the configuration baselines at the upper levels are deemed full, stable, and controllable. To make sure that the baselines are prepared for the next stage of development, reviews and audits are employed. The review and audit process also offers the essential evaluation of system maturity, which supports the DoD Milestone decision process, as will be shown in the next chapter.

THE PROCESS OF SYSTEMS ENGINEERING

The systems engineering process is a top-down, all-inclusive, iterative, and recursive approach to problem resolution that is utilised progressively through all phases of development to:

1. Convert needs and requirements into a collection of descriptions for system products and processes (adding value and greater specificity with each step of development);
2. Produce data for decision-makers, and
3. Offer suggestions for the next stage of development.

Figure 3 shows that the core systems engineering tasks are requirements analysis, functional analysis and allocation, and design synthesis, which are all balanced by a set of methods and resources known as system analysis and control. Controls in systems engineering are used to monitor choices and requirements, maintain technical baselines, manage interfaces, manage risks, monitor costs and schedules, monitor technical performance, confirm requirements are satisfied, and review/audit the progress.

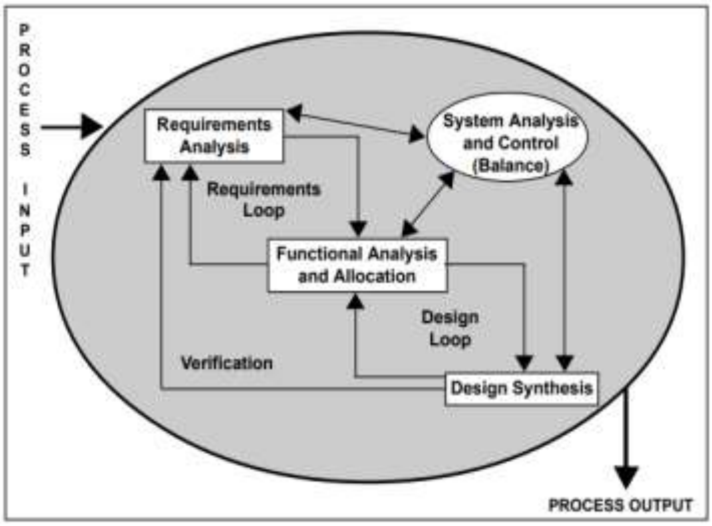

Figure 3: The Systems Engineering Process.

Architectures are created as part of the systems engineering process to help explain and comprehend the system. In the broad subject of engineering, the term "architecture" is used in a variety of settings. It serves as a broad explanation of how the system's subsystems interact with one another. It may also be a thorough explanation of a specific system component, such as the Operational, System, and Technical Architectures used in software-intensive advancements like C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance). However, functional, physical, and system architectures which characterise crucial parts of the system are recognised by Systems Engineering Management as it was created in the DoD. These designs will be the primary subject of this book since they are crucial steps in the systems engineering process.

The functional and performance needs that have been allotted are identified and organised by the functional architecture. The system product is represented by the physical architecture, which demonstrates how it is divided into subsystems and components. The System Architecture describes all the components (including enabling components) required to support the system as well as, implicitly, the procedures required for development, production/construction, deployment, operations, support, disposal, training, and verification.

III. CONCLUSION

A crucial discipline that allows the efficient execution of challenging engineering projects is systems engineering management. The main tenets and guiding principles of systems engineering management have been covered in this abstract, emphasising their importance in attaining project goals and producing high-quality systems. Understanding the project's goals, the demands of the stakeholders, and the overall system architecture are essential for effective systems engineering management. It entails developing effective project management procedures, encouraging cooperation among interdisciplinary teams, and creating clear communication channels. This makes it possible for effective decision-making, risk management, and resource allocation.

Additionally, systems engineering management stresses the need of ongoing oversight and management throughout the course of a project. The project remains on track and achieves its objectives thanks to regular evaluations of project progress, the identification of possible hazards, and prompt modifications to project plans. Additionally, it promotes the use of metrics and performance indicators to assess how well a management strategy is working and to motivate process changes. The benefit of taking into account different viewpoints, such as technical, operational, financial, and organisational issues, is also acknowledged by systems engineering management. Using a comprehensive approach makes it easier to see possible trade-offs, handle competing needs, and match the system design to the expectations of the stakeholders.

In conclusion, successful project execution depends on competent systems engineering management. It offers a well-organized framework for handling complexity, promoting teamwork, and attaining project goals. Organisations may overcome the difficulties of system development and provide top-notch, dependable, and cutting-edge solutions by integrating best practises, constant monitoring, and a multidisciplinary approach.

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