International Journal of Innovative Research in Computer Science & Technology (IJIRCST)
ISSN: 2347-5552, Volume-10, Special Issue-12, December-2022
Innovative Projects 2022
Organized by Presidency University, Bangalore, India

A Brief Discussion on Systems Engineering Planning

Ms. Anandasrinivasan Deviprabha
Assistant Professor, Masters In Business Administration, Presidency University, Bangalore, India,
Email Id-deviprabha@presidencyuniversity.in

ABSTRACT:

A comprehensive and multidisciplinary method called systems engineering assures the effective design, implementation, and operation of complex systems. In systems engineering, the planning stage is crucial for laying the groundwork for a quick and effective system development process. The importance of systems engineering planning in coordinating stakeholder needs with system functionality and performance goals is highlighted in the introduction. The main tasks of systems engineering planning, such as requirements elicitation and analysis, system architecture design, risk assessment, resource allocation, and schedule management, are further discussed in the abstract. The abstract also highlights the iterative nature of systems engineering planning and the need of ongoing review, feedback, and change during the planning process. It emphasises how crucial it is to take into account several system viewpoints, such as technical, operational, economic, and environmental concerns, in order to produce a solid and long-lasting solution. It also emphasises the advantages of using model-based systems engineering (MBSE) strategies, which improve planning operations by using cutting-edge modelling and simulation tools. By giving a visual depiction of the system and its parts, MBSE helps with early design problem discovery, promotes trade-off analysis, and enhances system integration.

KEYWORDS:

Management Concerns, Management Planning, Planning, System Engineers.

I. INTRODUCTION

Engineering of Systems Systems engineering, which focuses on the design and development of complex systems, places a lot of emphasis on planning. It entails taking a methodical and organised approach to identifying, comprehending, and recording the needs, limitations, and goals of a system as well as establishing the procedures and tactics for its effective realisation. Establishing a strong foundation for the whole systems engineering process is the goal of systems engineering planning. It establishes the project's course and offers a framework for organising and controlling all of the steps necessary to build a system that achieves the required goals. Potential problems and dangers may be detected and proactively handled by properly planning the engineering efforts from the outset, resulting in more effective and efficient system development[1], [2].

A thorough grasp of the system's function, stakeholders, and operating environment is built during the Systems Engineering Planning phase. To collect the needs, expectations, and restrictions of stakeholders, such as consumers, users, and subject matter experts, this includes interacting with them. To confirm that the system can be constructed within the available resources and is in line with the project's overall aims, the planning process also include undertaking feasibility studies, risk assessments, and cost-benefit evaluations [3], [4].

The creation of a thorough project plan is a crucial component of systems engineering planning. The system development lifecycle's activities, tasks, milestones, and deliverables are described in this plan. In addition to identifying the necessary resources, such as persons, tools, and equipment, it also entails establishing the system architecture, subsystems, interfaces, and integration techniques. The engineering team uses the project plan as a road map to direct their efforts and make sure the system is created in a logical and methodical way.

Furthermore, risk management and mitigation are included in systems engineering planning. It entails identifying possible hazards and creating plans to lessen their influence on the system development procedure. Contingency planning, alternate strategies, and risk-mitigation techniques may be used to manage technical, scheduling, or financial issues. The overall success of the system development endeavour may be considerably increased by proactively recognising and controlling risks. In conclusion, the Systems Engineering Planning stage of the process is crucial. By determining the system's needs, goals, and limits, creating a thorough project plan, and

addressing possible risks, it lays the groundwork for the productive development of complex systems. System engineers may establish the framework for a smooth and efficient development process, leading to a system that fulfils the intended objectives and satisfies the demands of the stakeholders, by devoting time and effort to good planning [5], [6].

II. DISCUSSION

WHY ENGINEERING PLANS?

Systems engineering planning is a process that determines the practical ways to accomplish the acquisition goals and directly influences acquisition planning choices. Management makes use of it to

1. Ensure that every technical activity is recognised and controlled.
2. Explain the technical strategy to the whole development team,
3. Keep track of choices and technical implementation;
4. Establish the standards for evaluating how effectively the system development effort satisfies management and customer requirements.

Planning for systems engineering takes into account the size of the technical effort needed to create the system. The fundamental inquiries of "who will do what" and "when" are answered. A technical plan should at the very least outline what needs to be done, how systems engineering will be carried out, how the effort will be planned, what resources are required, and how the effort will be monitored and managed. The planning process leads to the creation of a management-focused document that covers the execution of programme requirements for system engineering, including technical management strategies for later life cycle stages. In the DoD, the government does the exercise at the systems level, while contractors perform it at the more specific level [7], [8].

Planning in Technical/Systems Engineering

Technical planning may be included in a comprehensive, integrated programme management plan or detailed in a separate engineering management plan. This plan is first created at the early requirements analysis phase of a project or programme. Technical planning and requirements analysis go hand in hand because requirements study creates a knowledge of what must be given. Having this insight is essential for creating thorough planning. Plans for systems engineering must be revised often in order to be useful. significant upgrades often take place at least immediately before significant management milestone decisions to help management decision-making. The plan must, however, be updated as required in between management milestones in order to be suitably up to date and serve its informational, communicative, and documentational objectives [1], [2].

Technical Plan Elements

Technical plans should have enough details to describe the goal and process of the systems engineering project. The following should be included in plans:

1. A summary of the system being created and an introduction stating the goal of the engineering effort,
2. An explanation of the technical approach connecting the engineering effort to the higher-level management planning,
3. An explanation of how the systems engineering approach will be modified and organised to achieve the strategy's goals,
4. A strategy for organisational structure that outlines how the engineering goals will be achieved;
5. A resource plan including the expected budget and timetable required to implement the approach.

Defining the strategy's scope will help readers understand what area of the overall picture the plan addresses. In the case of a DoD programme office plan, for instance, control over higher-level requirements, the system definition (functional baseline), and all activities required for system development would be emphasised. A contractor's strategy, on the other hand, would place more emphasis on maintaining control over lower-level requirements, preliminary and detailed designs (allocated and product baselines), and activities mandated and constrained by the contract.

System description: The system description should:

1. Be confined to an executive overview highlighting the system's distinguishing characteristics;
2. Talk about the system's operating functions in general.
3. Provide an explanation of what it is and what it will accomplish.

Emphasis: To make the management vision for the development strategy clear, a guiding emphasis should be offered. Lowest cost to meet threshold criteria, for instance, or better performance while staying under budget, superior standardisation for simpler logistics, best usage of the open systems approach to save costs, or something similar. A focal sentence ought to:

1. Have a clear goal to prevent misunderstanding,
2. Be expressed clearly to prevent misunderstandings, and
3. Possess high-level backing.

Purpose: The goal of the engineering effort should be explained in terms of the needed end goods as well as life-cycle enabling products. What must the engineering effort generate should be covered in the stated aim?

Technical Approach

A technical strategy's primary goal is to connect the development process with the procurement or contract management process. It ought to contain:

1. Baselining and related development phasing,
2. Important engineering milestones that support business and risk management objectives;
3. Related parallel innovations or thought-out product improvements, and
4. Additional management-generated restrictions or high-profile actions that could have an impact on the engineering progress.

Milestones and Phasing: The baseline and development phasing sections should outline the strategy for phasing the engineering effort, including how the fundamental procedure outlined in this book was modified and why. The important benchmarks should generally follow the technical review process, but they should be adjusted as necessary to support business management benchmarks and the project/program's development phasing. A description of the transition from design and verification to manufacturing and fielding should be included in the strategy. This section has to explain how production will be introduced gradually (including the use of limited-rate initial production and extended lead-time procurement) and how early support concerns need intensive user and acquisition community collaboration.

Product Improvement and Parallel Developments:

It is important to identify the parallel development programmes required for the system to accomplish its goals and to explain how these programmes relate to one another. Any ideas for product enhancement should be included as well. It is important to outline factors like evolutionary development and planned product enhancement in sufficient depth to indicate how they will fit into the overall effort.

Influences on Strategy

The effect of each condition or restriction that affects the strategy should be determined. Important things to remember are:

1. The development of crucial technologies,
2. Cost as a variable unto itself (CAIV), and
3. Any restriction or action controlled by corporate management that will significantly affect the plan.

Critical Technologies: When talking about critical technologies, you should mention:

a. The risk involved with the development of key technologies and how it affects the strategy,
b. Connection to baseline development, as well as
c. Potential effects on the development endeavour as a whole.

Cost as an Independent Variable: When considering a strategy, it is important to consider how CAIV will be applied and how it will affect the approach. It should go through how the system development is affected by unit cost, development cost, life cycle cost, total ownership cost, and their interrelationships. This part has to be concerned with how these expenses will be managed, how they will be balanced, and how they will affect the strategy and design approach.

Management Concerns: There are many different types of management concerns that might affect the development plan. Typically, management challenges that affect the capacity to support the management strategy are those that are classified as engineering strategy difficulties. Several instances would be:

a. The need of combining developing stages to take into account management-driven schedule or resource constraints,
b. The risk posed by a constrained timetable or financial resources,
c. A contractual strategy that ups the technical risk; and
d. People that have a like mindset.

Technical decisions made by management, such as the usage of M&S, open systems, IPPD, and others, should not be considered a strategy problem until they have an influence on the overall strategy for systems engineering to satisfy management expectations. The plan, how it fits with the management strategy, and how management directives affect it should all be laid out in the strategy discussion.

Processes for Systems Engineering

The system engineering methods that will be used to support the strategy should be the main topic of discussion in this section of the planning. It ought to contain:

a. The phases and loops of the systems engineering process's specific approaches and techniques,
b. Particular system analysis and control tools and their application to step and loop operations;
c. Special design factors that must be taken into account throughout the engineering process.

Loops and Steps The explanation of the systems engineering process should highlight the exact steps and outcomes that will guarantee:

a. Prior to the flow-down and allocation of needs, requirements are understood;
b. Prior to the creation of designs, functional descriptions are developed.
c. Designs that can be traced back to specifications are created,
d. There are ways to go back and review earlier actions, and
e. There are mechanisms in place for verifying that design solutions adhere to demands and specifications.

Each step and loop for each development phase should be included in this planning section, together with identification of the step-specific tools (Functional Flow Block Diagrams, Timeline Analysis, etc.) that will be utilised and the verification strategy. All verification operations, the connection to official developmental T&E efforts, and independent testing activities (including operational testing) should be included in the verification discussion. This area of planning will be heavily influenced by the standards of the specific technical field and the engineering procedures of the command, agency, or corporation doing the activities. However, whatever methods, approaches, analytical tools, or models are used, they must be in line with the fundamentals of systems engineering management as outlined previously in this book.

The requirements analysis carried out during the system definition phase serves as an illustration of the kind of problem this section would tackle. In contrast to subsequent stages, requirements analysis is more crucial and the main emphasis during system definition. To ensure effective development, the right set of client needs must be established at the outset of the project. In order to ensure that the requirements are sufficiently specified before starting the design effort, the system definition phase requirements analysis calls for strict control and an early evaluation. The general process and procedures for requirements analysis should particularly outline the control and verification steps required for the system definition phase.

Analysis and management Planning should specify the analytical methods that will be used to measure effectiveness, analyse, or evaluate alternative approaches, as well as provide a strong mathematical foundation for choosing performance, functional, and design criteria. Trade studies, market surveys, M&S, effectiveness assessments, design analyses, QFD, experiment design, and other procedures are examples of these processes. Planning must include the process for establishing and maintaining control and feedback. Performance-based measurement driven by an event-based timetable is the key to control. The event-driven milestones' entry and exit requirements should be sufficiently defined to show that the required amount of development progress has been made. In a subsequent section of this chapter, we talk more about event-based timetables and departure criteria. The development of techniques for maintaining feedback and control helps track progress towards achieving the exit criterion. The chapters on metrics, risk management, configuration management, and technical reviews previously in this book covered common techniques.

Technical tasks often call for extra care throughout the development of any system. These could result from organisational efforts, legal or regulatory requirements, societal challenges, or management worries. A DoD programme office must, for instance, comply with DoDD 5000.2-R, which outlines a number of technical tasks that must be integrated into the development process. DoD plans must clearly address each problem raised in the

DoD 5000.2-R's Programme Design section. In the case of a contractor, the technical effort may need to solve difficulties that are specified in the contract, promised in the proposal, or defined by management. Each of these challenges has to be addressed in detail in the system engineering planning for the development process [9], [10].

III. CONCLUSION

In conclusion, systems engineering planning is a critical step in the discipline that paves the way for a project's successful completion. It includes defining the system's scope, identifying goals and objectives, and creating a detailed plan to direct the engineering process as a whole. Systems engineering planning's primary goal is to make sure that every component of a system's development and operation is carefully researched and efficiently coordinated. This planning method encourages successful decision-making throughout the project lifetime, creates a shared knowledge of project needs, and promotes good communication among stakeholders. Several important processes are frequently included in systems engineering planning. The system requirements definition, risk and constraint identification, project schedule creation, resource allocation, and system architecture definition are a few examples of these tasks. It also entails developing configuration management procedures, defining verification and validation activities, and deciding on the general strategy for systems integration.

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