A Brief Discussion on Systems Engineering Process Overview

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ABSTRACT:

Systems engineering is a methodical technique to planning and overseeing the lifespan of complex systems. In this abstract, the main stages and activities of the systems engineering process are highlighted. The requirements analysis stage of the systems engineering process is when the system's requirements and goals are established. Gathering feedback from stakeholders, recognizing system limitations, and developing precise, quantifiable criteria are all part of this step. The following step involves developing the system architecture once the requirements have been established. Designing the system's components, interfaces, and structural elements is necessary to make sure it complies with the requirements. The effectiveness and behaviour of the suggested design are often evaluated using tools for system modelling and simulation. The design and execution of the system follow the architectural phase. This entails intricate design tasks including choosing certain components, producing in-depth technical drawings, and manufacturing prototypes. The design process also takes system integration, dependability, and maintainability into account. Construction and testing of the system follow the design phase. Purchasing or creating components, putting together subsystems, and integrating them into the whole system design are all included in this. To ensure that the system works as intended and satisfies all criteria, thorough testing is done.

KEYWORDS:

Components Interfaces, Functional Analysis Allocation, Lifespan Complex Systems, System Integration Testing.

I. INTRODUCTION

Systems engineering is a systematic method used to plan, create, and oversee the lifespan of complex systems. It includes a collection of procedures, guidelines, and techniques that make it possible to successfully implement a system while also maximising its effectiveness, cost, schedule, and other pertinent elements. The systems engineering method offers a well-organized framework for comprehending and resolving complicated issues, integrating multiple subsystems, and guaranteeing the smooth operation of the whole system. It entails an all-encompassing, multidisciplinary approach that takes into account every aspect of the system, including its constituent parts, interactions, interfaces, and operating environment.

The following essential phases are often included in the systems engineering process overview:

System Definition: The first step in the process is to define the goals, specifications, and limitations of the system. Understanding stakeholder requirements and expectations, defining system boundaries, and creating performance standards for the system are all part of this process.

System Analysis: The system requirements are analysed and divided into functional and non-functional needs in this stage. Performing trade-off analyses to uncover the optimum design options include analysing the system's components, interfaces, and interactions [1], [2].

System Design: The system design phase, which is based on the analysis, is concerned with creating a conceptual design that satisfies the specified requirements. It entails determining the system's general structure, interfaces, and behaviour as well as choosing the proper technologies, architectures, and subsystems.

System Implementation: During this stage, the system design is turned into a functional implementation. It entails creating intricate technical plans, acquiring parts or subsystems, and combining them into a functional system. The creation of required components such as software, hardware, and other aspects is also a part of system implementation [3], [4].

System Integration and Testing: After the system components have been created and put together, they are integrated to guarantee optimal operation and compatibility. To ensure that the system satisfies the established criteria and operates as intended, system integration requires thorough testing and verification procedures [5], [6].

System Deployment and Operations: The system is deployed and put into use after a successful testing and integration phase. Installation, training, maintenance, and continuous operations are all part of this phase, which ensures the system runs effectively and dependably.

System assessment and improvement: Throughout the system lifespan, actions are carried out to evaluate the system's performance, pinpoint areas that might need improvement, and take stakeholder comments into account. These actions contribute to the system's and the related processes' ongoing improvement.

The overview of the systems engineering process offers a structured and organised method to direct the creation and administration of complex systems. From the initial requirements study through system deployment and beyond, it makes sure that every component of the system is taken into account. Organisations may successfully manage risks, improve system performance, and produce results that live up to stakeholder expectations by using this procedure.

II. DISCUSSION

THE PROCESS

The Systems Engineering Process (SEP) is a thorough, iterative, and recursive method for problem resolution that is used systematically from the top down by interdisciplinary teams. It generates information for decision makers, turns wants and requirements into a collection of system product and process descriptions, and contributes to the next stage of development. With each level of development, the method is applied progressively, one level at a time, and more depth and clarity are added. Inputs and outputs, requirements analysis, functional analysis and allocation, requirements loop, synthesis, design loop, verification, and system analysis and control are all included in the process, as illustrated by Figure 1.

Inputs to the Systems Engineering Process

Customer demands, goals, requirements, and project limitations make up the majority of the inputs.Missions, effectiveness metrics, environments, the available technological base, output needs from earlier applications of the systems engineering process, programme decision requirements, and requirements based on "corporate knowledge" are just a few examples of the inputs that might be used [7], [8].

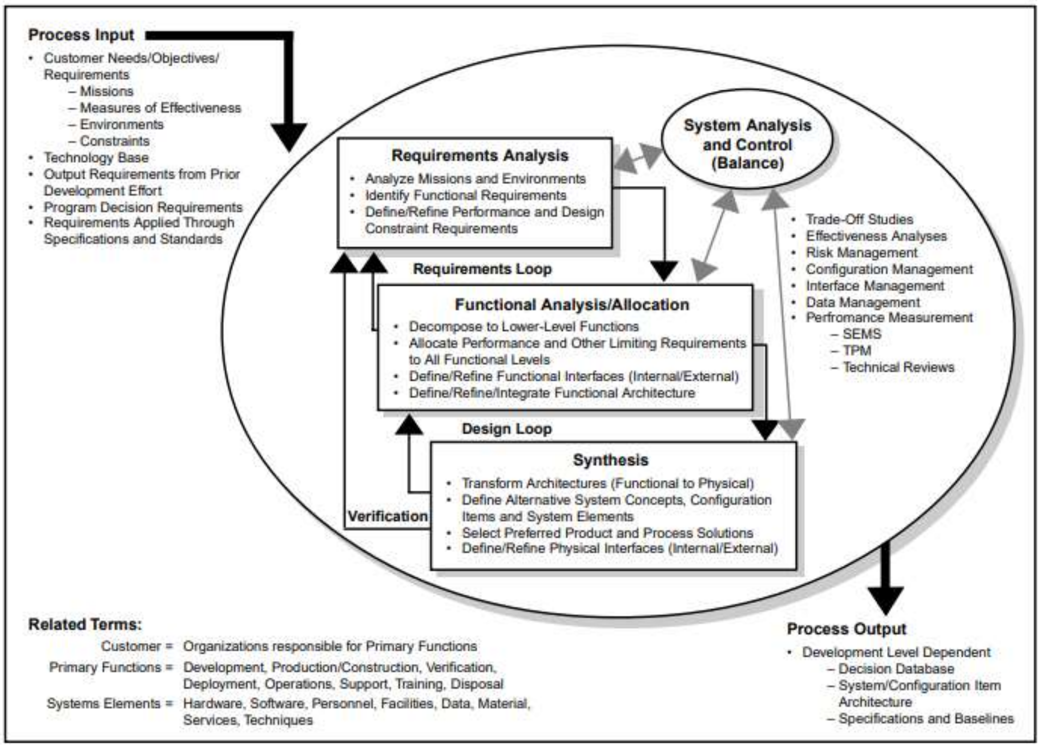

Figure 1: The Systems Engineering Process [ocw.mit.edu].

1. Analysis of Requirements

The analysis of the process inputs is the initial stage in the systems engineering process. The process of translating client needs into a set of requirements that specify what the system must be able to accomplish and how effectively it must perform is known as requirements analysis. The requirements must be clear, simple, thorough, complete, and unambiguous, according to the systems engineer.

Functional requirements and design constraints must be defined and clarified via requirements analysis. Quantity (how many), quality (how excellent), coverage (how far), time frames (when and how long), and availability (how frequently) are all defined by functional requirements. Design constraints are those elements that restrict the flexibility of a design, such as contract, client, or regulatory requirements, environmental conditions or restrictions, and defence against internal or external threats [9], [10].

2. Functional Assessment and Allocation

Decomposing higher-level functions discovered via requirements analysis into lower-level functions allows for the examination of functions. Lower functions are given the performance demands associated with the higher level. As a consequence, the item or product is described in terms of what it logically does as well as the performance necessary. The functional architecture of the product or item is another name for this description. It is possible to better grasp what the system must accomplish, how it can do it, and, to some degree, the priorities and conflicts related to lower-level activities, via the functional analysis and allocation process. It offers knowledge that is crucial for improving physical solutions. Functional Flow Block Diagrams, Time Line Analysis, and the Requirements Allocation Sheet are essential instruments in functional analysis and allocation.

3. Requirements Loop

As a consequence of the functional analysis and allocation, the requirements are better understood, which should lead to a reevaluation of the requirements analysis. Every function that is listed ought to be linked to a need. The requirements loop is the name given to this recurrent process of returning to requirements analysis as a consequence of functional analysis and allocation.

4. Synthesis of Design

Design synthesis is the process of defining a product or item in terms of the software and physical components that together compose and define the product or thing. Physical architecture is a common term used to describe the outcome. Each component must fulfil at least one criteria for functionality, and each component may support many functions. The physical architecture serves as the fundamental framework for creating baselines and specifications.

5. Design Cycle

The design loop is a procedure that, like the requirements loop mentioned above, involves going back through the functional architecture to make sure that the physical design that was synthesised can carry out the needed functions at the appropriate levels of performance. The design loop enables reevaluating how the system will carry out its function, which aids in optimising the synthesised design.

6. Verification

The solution and the requirements for each system engineering application will be compared. The verification loop or, more often, Verification is the name of this step in the process. At every stage of development, every demand must be verified. The baseline documentation created throughout the systems engineering phase needs to specify how each need will be verified.

Examination, demonstration, analysis including modelling and simulation, and testing are appropriate means of verification. System verification relies heavily on formal testing and assessment, both during development and in use.

Systems Control and Analysis

Technical management tasks such as progress measurement, alternative evaluation and selection, and data and decision documentation are included in systems analysis and control. These tasks are relevant at every stage of the systems engineering process. Trade-off analyses, effectiveness assessments, and design analyses are all part of system analysis tasks. They provide a rigorous mathematical foundation for choosing performance, functional, and design criteria and assess different ways to meet technical needs and programme goals. Modelling, simulation, experimentation, and test are examples of tools used to offer input to analytical processes. Risk management, configuration management, data management, and performance-based progress measurement, such as event-based planning, Technical Performance Measurement (TPM), and technical reviews, are all examples of control activities.

Systems Analysis and Control is used to make sure that: Decisions on alternative solutions are only made after considering their effects on system effectiveness, life cycle resources, risk, and customer needs;

a. Traceability from systems engineering process inputs to outputs is maintained;
b. Development and delivery schedules are mutually supportive;
c. Required technical disciplines are integrated into the systems engineering effort;
d. Customer requirements' effects on resulting functional and performance requirements are examined for validity, consistency, desirability, and attitudinal suitability; and

Output of the Systems Engineering Process

The output of a process depends on its state of development. The decision database, the architecture of the system or configuration item, and the baselines, including specifications, relevant to the stage of development will all be included. Generally speaking, it refers to any data that specifies or regulates a product's configuration or the procedures required to create that product.

The engine that propels the balanced development of system products and processes applied to each level of development, one level at a time, is the system engineering process. With each application of the system engineering process, the process gives an increasing amount of descriptive information of the goods and processes. Each application's output serves as the following process application's input.

CONCLUSION

The systems engineering process overview offers a thorough and organised method for creating and overseeing complex systems. It emphasises the need of having a comprehensive grasp of the goals, demands, and limitations of the system during its entire lifespan. Following this procedure enables organisations to reap a number of significant advantages. Additionally, the approach gives system integration and testing a lot of attention. Organisations may find and fix problems, confirm system operation, and make sure the system complies with established criteria via rigorous integration activities and thorough testing. The systems engineering method also acknowledges the need of continuous review and improvement. Organisations may pinpoint areas for improvement, deal with new difficulties, and modify the system to meet changing demands and technological advancements by regularly monitoring and assessing the system's performance. Overall, the overview of the systems engineering process offers a methodical and disciplined approach to creating and overseeing large systems. Organisations may improve system performance, reduce risks, allocate resources optimally, and produce effective results that satisfy stakeholder expectations by adhering to this procedure. For innovation, effectiveness, and the successful implementation of complex systems across multiple disciplines, systems engineering is a crucial facilitator.

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