Meanings of “systems engineering

Oleh : MALABAY

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When people use the phrase “systems engineering,” they have in mind one of the following meanings:

1. The INCOSE definition,
2. A sub-field of electrical engineering,
3. A sub-field of industrial and systems engineering,
4. A sub-field of engineering management or technology management,
5. The information technology definition, or
6. Systems engineering based on systems theory.

1. INCOSE: According to INCOSE (International Council on Systems Engineering),

"Systems Engineering is an interdisciplinary approach and a means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem."

Practitioners of system engineering in this meaning focus on one-time, large projects with a definite start and end, where a new system is to be designed and created to meet customer needs. Practitioners focus on industries such as information technology (IT), aerospace, and defense. On job posting sites (e.g., monster.com), the phrase "systems engineering" almost always describes a job in the INCOSE model, usually in the aerospace or defense industries.

2. Electrical engineering: Within the electrical engineering field, emphasis is attached

to the use of systems theory in applications, e.g., spacecraft manufacture and management. As such, systems engineering within electrical engineering tends to emphasize control techniques which are often software-intensive. It appears that one of the first uses of systems engineering was in Bell Labs

Managing complexity is an important ingredient of many courses taught within these programs. Modeling, simulation, reliability, and safety analysis of complex systems are considered to be essential parts of the training needed for a successful systems engineer.

3 Industrial and systems engineering: This meaning is the hardest to pin down.
Often the phrase "industrial and systems engineering" is used interchangeably with "industrial engineering." Industrial engineers create a new system or improve an

existing system, The word "system" is meant to remind the IE of three key points which IEs emphasize more than other engineering disciplines: (1) components (including machines and people) interact with each other to create the overall behavior of the system; (2) the system being studied is always a subsystem of a larger system and these interactions must also be considered; and (3) systems include humans. The word "system" is a caution against sub-optimization of the larger system through optimization of a subsystem. Because Industrial Engineering academic departments often include a wide range of areas (physical and cognitive human factors, manufacturing processes, operations research, engineering management, etc.),

the word "systems" often appears to be an attempt to be inclusive. Also, some think that the word "industrial" doesn't include the full range of what industrial engineers do. “Industrial and systems engineering” can apply to service companies, hospitals, insurance, etc

4. Technology management or engineering management: In technology management, systems engineering includes taking into consideration all aspects of the life cycle of the system. Thus the systems engineering approach is said to account for manufacturability, installation, operations, maintenance, repair, and disposal of a system. When manufacturing or selling a product, a systems engineer is likely to view the current technological phase of the product as a critical feature. For instance, in the early 1990s, cell phones were in their early technological phases. Designing, manufacturing, and selling cell phones in those years were activities achieved with objectives and mechanisms that were different than those employed in the first decade of this century. A systems engineer is acutely aware of this issue when considering every aspect of managing a business and designing a product.

5. Information technology: A new discipline has emerged in the business schools and computer science departments that goes by the name information systems (which is often a minor in computer science departments) or management of information systems (usually in business schools). This definition of systems engineering tends to focus heavily on the interface of computers with the business world.

While this has emerged as a discipline in its own right, it appears that this definition is also related to the INCOSE definition. Students in this discipline are expected to become experts in database management, computer security, and transaction processing. In this respect, this definition significantly deviates from what is understood as systems engineering in industrial and electrical engineering departments. However, from theperspective of potential employers, this definition seems to be widely used on jobsites.

6. Systems theory and philosophical origins of systems engineering: Various authors have written on the more philosophical roots of systems. Some of them are: Churchman on the systems approach, von Bertalanffy on General System .

System Engineering

- Computer-based system
- System engineering process
- “Business process” engineering
- Product engineering

Computer-based System

Software engineering occurs as a consequence of system engineering

System engineering may take on two different forms depending on the application domain

“Business process” engineering – conducted when the context of the work focuses on a business enterprise
Product engineering – conducted when the context of the work focuses on a product that is to be built
Both forms bring order to the development of computer-based systems
Both forms work to allocate a role for computer software and to establish the links that tie software to other elements of a computer-based system

System (Webster)
A set or arrangement of things so related as to form a unity or organic whole
A set of facts, principles, rules. etc., … to show a logical plan linking the various parts
A method or plan of classification or arrangement
An established way of doing something such as a method or procedure

Defined: A set or arrangement of elements that are organized to accomplish some predefined goal by processing information
The goal may be to support some business function or to develop a product that can be sold to generate business revenue
A computer-based system makes use of system elements
Elements constituting one system may represent one macro element of a still larger system
Example
A factory automation system may consist of a numerical control machine, robots, and data entry devices; each can be its own system
At the next lower hierarchical level, a manufacturing cell is its own computer-based system that may integrate other macro elements
The role of the system engineer is to define the elements of a specific computer-based system in the context of the overall hierarchy of systems

A computer-based system makes use of the following four system elements that combine in a variety of ways to transform information
Software: computer programs, data structures, and related work products that serve to effect the logical method, procedure, or control that is required
Hardware: electronic devices that provide computing capability, interconnectivity devices that enable flow of data, and electromechanical devices that provide external functions
People: Users and operators of hardware and software
Database: A large, organized collection of information that is accessed via software and persists over time
The uses of these elements are described in the following:
Documentation: Descriptive information that portrays the use and operation of the system
Procedures: The steps that define the specific use of each system element or the procedural context in which the system resides

System engineering process

The system engineering process begins with a world view; the business or product domain is examined to ensure that the proper business or technology context can be established

The world view is refined to focus on a specific domain of interest

Within a specific domain, the need for targeted system elements is analyzed

Finally, the analysis, design, and construction of a targeted system element are initiated

At the world view level, a very broad context is established

At the bottom level, detailed technical activities are conducted by the relevant engineering discipline (e.g., software engineering)

System Modeling (at each view level)

Defines the processes (e.g., domain classes in OO terminology) that serve the needs of the view under consideration

Represents the behavior of the processes and the assumptions on which the behavior is based

Explicitly defines intra-level and inter-level input that form links between entities in the model

Represents all linkages (including output) that will enable the engineer to better understand the view

May result in models that call for one of the following

Completely automated solution

A semi-automated solution

A non-automated (i.e., manual) approach

Factors to Consider when Constructing a Model

Assumptions

These reduce the number of possible variations, thus enabling a model to reflect the problem in a reasonable manner

Simplifications

These enable the model to be created in a timely manner

Limitations

These help to bound the maximum and minimum values of the system

Constraints

These guide the manner in which the model is created and the approach taken when the model is implemented

Preferences

These indicate the preferred solution for all data, functions, and behavior

They are driven by customer requirements

System Modeling with UML

The Uniform Modeling Language (UML) provides diagrams for analysis and design at both the system and software levels

Examples

Use case diagrams
Activity diagrams
Class diagrams
State diagrams

Business Process" Engineering

"Business process" engineering defines architectures that will enable a business to use information effectively

It involves the specification of the appropriate computing architecture and the development of the software architecture for the organization's computing resources

Three different architectures must be analyzed and designed within the context of business objectives and goals

The data architecture provides a framework for the information needs of a business (e.g., ERD)

The application architecture encompasses those elements of a system that transform objects within the data architecture for some business purpose

The technology infrastructure provides the foundation for the data and application architectures

It includes the hardware and software that are used to support the applications and data

Product Engineering

Product engineering translates the customer's desire for a set of defined capabilities into a working product

It achieves this goal by establishing a product architecture and a support infrastructure

Product architecture components consist of people, hardware, software, and data

Support infrastructure includes the technology required to tie the components together and the information to support the components

Requirements engineering elicits the requirements from the customer and allocates function and behavior to each of the four components

System component engineering happens next as a set of concurrent activities that address each of the components separately

Each component takes a domain-specific view but maintains communication with the other domains

The actual activities of the engineering discipline takes on an element view

Analysis modeling allocates requirements into function, data, and behavior

Design modeling maps the analysis model into data/class, architectural, interface, and component design

Systems engineering is an interdisciplinary field of engineering and engineering management that focuses on how to design and manage complex systems over their life cycles. At its core, systems engineering utilizes systems thinking principles to organize this body of knowledge. Issues such as requirements engineering, reliability, logistics, coordination of different teams, testing and evaluation, maintainability and many other disciplines necessary for successful system development, design, implementation, and ultimate decommission become more difficult when dealing with large or complex projects. Systems engineering deals with work-processes, optimization methods, and risk management tools in such projects. It overlaps technical and human-centered disciplines such as industrial engineering, mechanical engineering, manufacturing engineering, control engineering, software engineering, electrical engineering, cybernetics, organizational studies, civil engineering and project management. Systems engineering ensures that all likely aspects of a project or system are considered, and integrated into a whole.

The systems engineering process is a discovery process that is quite unlike a manufacturing process. A manufacturing process is focused on repetitive activities that achieve high quality outputs with minimum cost and time. The systems engineering process must begin by discovering the real problems that need to be resolved, and identify the most probable or highest impact failures that can occur – systems engineering involves finding solutions to these problems.

Systems engineering signifies only an approach and, more recently, a discipline in engineering. The aim of education in systems engineering is to formalize various approaches simply and in doing so, identify new methods and research opportunities similar to that which occurs in other fields of engineering. As an approach, systems engineering is holistic and interdisciplinary in flavour.
Origins and traditional scope

The traditional scope of engineering embraces the conception, design, development, production and operation of physical systems. Systems engineering, as originally conceived, falls within this scope. "Systems engineering", in this sense of the term, refers to the distinctive set of concepts, methodologies, organizational structures (and so on) that have been developed to meet the challenges of engineering effective functional systems of unprecedented size and complexity within time, budget, and other constraints. The Apollo program is a leading example of a systems engineering project.
Evolution to broader scope
The use of the term "systems engineer" has evolved over time to embrace a wider, more holistic concept of "systems" and of engineering processes. This evolution of the definition has been a subject of ongoing controversy,[12] and the term continues to apply to both the narrower and broader scope.

Traditional systems engineering was seen as a branch of engineering in the classical sense, that is, as applied only to physical systems, such as spacecraft and aircraft. More recently, systems engineering has evolved to a take on a broader meaning especially when humans were seen as an essential component of a system. Checkland, for example, captures the broader meaning of systems engineering by stating that 'engineering' "can be read in its general sense; you can engineer a meeting or a political agreement."[13]:10

Consistent with the broader scope of systems engineering, the Systems Engineering Body of Knowledge (SEBoK)[14] has defined three types of systems engineering: (1) Product Systems Engineering (PSE) is the traditional systems engineering focused on the design of physical systems consisting of hardware and software. (2) Enterprise Systems Engineering (ESE) pertains to the view of enterprises, that is, organizations or combinations of organizations, as systems. (3) Service Systems Engineering (SSE) has to do with the engineering of service systems. Checkland[13] defines a service system as a system which is conceived as serving another system. Most civil infrastructure systems are service systems.

Holistic view

Systems engineering focuses on analyzing and eliciting customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem, the system lifecycle. This includes fully understanding all of the stakeholders involved. Oliver et al. claim that the systems engineering process can be decomposed into

- a Systems Engineering Technical Process, and
- a Systems Engineering Management Process.

Within Oliver's model, the goal of the Management Process is to organize the technical effort in the lifecycle, while the Technical Process includes assessing available information, defining effectiveness measures, to create a behavior model, create a structure model, perform trade-off analysis, and create sequential build & test plan.[15]

Depending on their application, although there are several models that are used in the industry, all of them aim to identify the relation between the various stages mentioned above and incorporate feedback. Examples of such models include the Waterfall model and the VEE model.[16]

Interdisciplinary field

System development often requires contribution from diverse technical disciplines.[17] By providing a systems (holistic) view of the development effort, systems engineering helps mold all the technical contributors into a unified team effort, forming a structured development process that proceeds from concept to production to operation and, in some cases, to termination and disposal. In an acquisition, the holistic integrative discipline combines contributions and balances tradeoffs among cost, schedule, and performance while maintaining an acceptable level of risk covering the entire life cycle of the item.[18]

This perspective is often replicated in educational programs, in that systems engineering courses are taught by faculty from other engineering departments, which helps create an interdisciplinary environment.[19][20]

Managing complexity

The need for systems engineering arose with the increase in complexity of systems and projects,[21][22] in turn exponentially increasing the possibility of component friction, and therefore the unreliability of the design. When speaking in this context, complexity incorporates not only engineering systems, but also the logical human organization of data. At the same time, a system can become more complex due to an increase in size as well as with an increase in the amount of data, variables, or the number of fields that are involved in the design. The International Space Station is an example of such a system.

The development of smarter control algorithms, microprocessor design, and analysis of environmental systems also come within the purview of systems engineering. Systems engineering encourages the use of tools and methods to better comprehend and manage complexity in systems. Some examples of these tools can be seen here:[

System architecture,
System model, Modeling, and Simulation,
Optimization,
System dynamics,
Systems analysis,
Statistical analysis,
Reliability analysis, and
Decision making

Taking an interdisciplinary approach to engineering systems is inherently complex since the behavior of and interaction among system components is not always immediately well defined or understood. Defining and characterizing such systems and subsystems and the interactions among them is one of the goals of systems engineering. In doing so, the gap that exists between informal requirements from users, operators, marketing organizations, and technical specifications is successfully bridged.

One way to understand the motivation behind systems engineering is to see it as a method, or practice, to identify and improve common rules that exist within a wide variety of systems.[25] Keeping this in mind, the principles of systems engineering – holism, emergent behavior, boundary, et al. – can be applied to any system, complex or otherwise, provided systems thinking is employed at all levels.[26] Besides defense and aerospace, many information and technology based companies, software development firms, and industries in the field of electronics & communications require systems engineers as part of their team.[27]

An analysis by the INCOSE Systems Engineering center of excellence (SECOE) indicates that optimal effort spent on systems engineering is about 15-20% of the total project effort.[28] At the same time, studies have shown that systems engineering essentially leads to reduction in costs among other benefits.[28]

However, no quantitative survey at a larger scale encompassing a wide variety of industries has been conducted until recently. Such studies are underway to determine the effectiveness and quantify the benefits of systems engineering.[29][30]

Systems engineering encourages the use of modeling and simulation to validate assumptions or theories on systems and the interactions within them.[31][32]

Use of methods that allow early detection of possible failures, in safety engineering, are integrated into the design process. At the same time, decisions made at the beginning of a project whose consequences are not clearly understood can have enormous implications later in the life of a system, and it is the task of the modern systems engineer to explore these issues and make critical decisions. No method guarantees today's decisions will still be valid when a system goes into service years or decades after first conceived. However, there are techniques that support the process of systems engineering. Examples include soft systems methodology, Jay Wright Forrester's System dynamics method, and the Unified Modeling Language (UML)—all currently being explored, evaluated, and developed to support the engineering decision process.

Systems engineering tools are strategies, procedures, and techniques that aid in performing systems engineering on a project or product. The purpose of these tools vary from database management, graphical browsing, simulation, and reasoning, to document production, neutral import/export and more.[35]
System

There are many definitions of what a system is in the field of systems engineering. Below are a few authoritative definitions:

ANSI/EIA-632-1999: "An aggregation of end products and enabling products to achieve a given purpose."[36]

DAU Systems Engineering Fundamentals: "an integrated composite of people, products, and processes that provide a capability to satisfy a stated need or objective."

IEEE Std 1220-1998: "A set or arrangement of elements and processes that are related and whose behavior satisfies customer/operational needs and provides for life cycle sustainment of the products."[37]

INCOSE Systems Engineering Handbook: "homogeneous entity that exhibits predefined behavior in the real world and is composed of heterogeneous parts that do not individually exhibit that behavior and an integrated configuration of components and/or subsystems."[38]

INCOSE: "A system is a construct or collection of different elements that together produce results not obtainable by the elements alone. The elements, or parts, can include people, hardware, software, facilities, policies, and documents; that is, all things required to produce systems-level results. The results include system level qualities, properties, characteristics, functions, behavior and performance. The value added by the system as a whole, beyond that contributed independently by the parts, is primarily created by the relationship among the parts; that is, how they are interconnected."[39]

ISO/IEC 15288:2008: "A combination of interacting elements organized to achieve one or more stated purposes."[40]

NASA Systems Engineering Handbook: "(1) The combination of elements that function together to produce the capability to meet a need. The elements include all hardware, software, equipment, facilities, personnel, processes, and procedures needed for this purpose. (2) The end product (which performs operational functions) and enabling products (which provide life-cycle support services to the operational end products) that make up a system."[41]

The systems engineering process

The systems engineering process encompasses all creative, manual and technical activities necessary to define the product and which need to be carried out to convert a system definition to a sufficiently detailed system design specification for product manufacture and deployment. Design and development of a system can be divided into four stages, each with different definitions:[42]

task definition (informative definition),
conceptual stage (cardinal definition),
design stage (formative definition), and
implementation stage (manufacturing definition).

Depending on their application, tools are used for various stages of the systems engineering process:

Using models

Models play important and diverse roles in systems engineering. A model can be defined in several ways, including:[43]

An abstraction of reality designed to answer specific questions about the real world
An imitation, analogue, or representation of a real world process or structure; or
A conceptual, mathematical, or physical tool to assist a decision maker.

Together, these definitions are broad enough to encompass physical engineering models used in the verification of a system design, as well as schematic models like a functional flow block diagram and mathematical (i.e., quantitative) models used in the trade study process. This section focuses on the last.[43]

The main reason for using mathematical models and diagrams in trade studies is to provide estimates of system effectiveness, performance or technical attributes, and cost from a set of known or estimable quantities. Typically, a collection of separate models is needed to provide all of these outcome variables. The heart of any mathematical model is a set of meaningful quantitative relationships among its inputs and outputs. These relationships can be as simple as adding up constituent quantities to obtain a total, or as complex as a set of differential equations describing the trajectory of a spacecraft in a gravitational field. Ideally, the relationships express causality, not just correlation.[43] Furthermore, key to successful systems engineering activities are also the methods with which these models are efficiently and effectively managed and used to simulate the systems. However, diverse domains often present recurring problems of modeling and simulation for systems engineering, and new advancements are aiming to crossfertilize methods among distinct scientific and engineering communities, under the title of 'Modeling & Simulation-based Systems Engineering'.[44]
Modeling formalisms and graphical representations

Initially, when the primary purpose of a systems engineer is to comprehend a complex problem, graphic representations of a system are used to communicate a system's functional and data requirements.[45] Common graphical representations include:

- Functional flow block diagram (FFBD)
- Model-based design
- Data flow diagram (DFD)
- N2 chart
- IDEF0 diagram
- Use case diagram
- Sequence diagram
- Block diagram
- Signal-flow graph
- USL function maps and type maps
- Enterprise architecture frameworks
- Model-based systems engineering

A graphical representation relates the various subsystems or parts of a system through functions, data, or interfaces. Any or each of the above methods are used in an industry based on its requirements. For instance, the N2 chart may be used where interfaces between systems is important. Part of the design phase is to create structural and behavioral models of the system.

Once the requirements are understood, it is now the responsibility of a systems engineer to refine them, and to determine, along with other engineers, the best technology for a job. At this point starting with a trade study, systems engineering encourages the use of weighted choices to determine the best option. A decision matrix, or Pugh method, is one way (QFD is another) to make this choice while considering all criteria that are important. The trade study in turn informs the design, which again affects graphic representations of the system (without changing the requirements). In an SE process, this stage represents the iterative step that is carried out until a feasible solution is found. A decision matrix is often populated using techniques such as statistical analysis, reliability analysis, system dynamics (feedback control), and optimization methods.

Cognitive systems engineering

Cognitive systems engineering (CSE) is a specific approach to the description and analysis of human-machine systems or sociotechnical systems.[48] The three main themes of CSE are how humans cope with complexity, how work is accomplished by the use of artifacts, and how human-machine systems and socio-technical systems can be described as joint cognitive systems. CSE has since its beginning become a recognized scientific discipline, sometimes also referred to as cognitive engineering. The concept of a Joint Cognitive System (JCS) has in particular become widely used as a way of understanding how complex socio-technical systems can be described with varying degrees of resolution. The more than 20 years of experience with CSE has been described extensively.[49][50]

Configuration management

Like systems engineering, configuration management as practiced in the defense and aerospace industry is a broad systems-level practice. The field parallels the taskings of systems engineering; where systems engineering deals with requirements development, allocation to development items and verification, configuration management deals with requirements capture, traceability to the development item, and audit of development item to ensure that it has achieved the desired functionality that systems engineering and/or Test and Verification Engineering have proven out through objective testing.

Control engineering

Control engineering and its design and implementation of control systems, used extensively in nearly every industry, is a large sub-field of systems engineering. The cruise control on an automobile and the guidance system for a ballistic missile are two examples. Control systems theory is an active field of applied mathematics involving the investigation of solution spaces and the development of new methods for the analysis of the control process.

Industrial engineering

Industrial engineering is a branch of engineering that concerns the development, improvement, implementation and evaluation of integrated systems of people, money, knowledge, information, equipment, energy, material and process. Industrial engineering draws upon the principles and methods of engineering analysis and synthesis, as well as mathematical, physical and social sciences together with the principles and methods of engineering analysis and design to specify, predict, and evaluate results obtained from such systems.

Interface design

Interface design and its specification are concerned with assuring that the pieces of a system connect and inter-operate with other parts of the system and with external systems as necessary. Interface design also includes assuring that system interfaces be able to accept new features, including mechanical, electrical and logical interfaces, including reserved wires, plug-space, command codes and bits in communication protocols. This is known as extensibility. Human-Computer Interaction (HCI) or Human-Machine Interface (HMI) is another aspect of interface design, and is a critical aspect of modern systems engineering. Systems engineering principles are applied in the design of network protocols for local-area networks and wide-area networks.

Mechatronic engineering

Mechatronic engineering, like systems engineering, is a multidisciplinary field of engineering that uses dynamical systems modeling to express tangible constructs. In that regard it is almost indistinguishable from Systems Engineering, but what sets it apart is the focus on smaller details rather than larger generalizations and relationships. As such, both fields are distinguished by the scope of their projects rather than the methodology of their practice.

Operations research

Operations research supports systems engineering. The tools of operations research are used in systems analysis, decision making, and trade studies. Several schools teach SE courses within the operations research or industrial engineering department,[25] highlighting the role systems engineering plays in complex projects. Operations research, briefly, is concerned with the optimization of a process under multiple constraints.[51]

Performance engineering

Performance engineering is the discipline of ensuring a system meets customer expectations for performance throughout its life. Performance is usually defined as the speed with which a certain operation is executed, or the capability of executing a number of such operations in a unit of time. Performance may be degraded when operations queued to execute is throttled by limited system capacity. For example, the performance of a packet-switched network is characterized by the end-to-end packet transit delay, or the number of packets switched in an hour. The design of high-performance systems uses analytical or simulation modeling, whereas the delivery of high-performance implementation involves thorough performance testing. Performance engineering relies heavily on statistics, queueing theory and probability theory for its tools and processes.

Program management and project management

Program management (or programme management) has many similarities with systems engineering, but has broader-based origins than the engineering ones of systems engineering. Project management is also closely related to both program management and systems engineering.

Proposal engineering

Proposal engineering is the application of scientific and mathematical principles to design, construct, and operate a cost-effective proposal development system. Basically, proposal engineering uses the "systems engineering process" to create a cost effective proposal and increase the odds of a successful proposal.

Reliability engineering

Reliability engineering is the discipline of ensuring a system meets customer expectations for reliability throughout its life; i.e., it does not fail more frequently than expected. Next to prediction of failure, it is just as much about prevention of failure. Reliability engineering applies to all aspects of the system. It is closely associated with maintainability, availability (dependability or RAMS preferred by some), and logistics engineering. Reliability engineering is always a critical component of safety engineering, as in failure modes and effects analysis (FMEA) and hazard fault tree analysis, and of security engineering.

Risk Management

Risk Management, the practice of assessing and dealing with risk is one of the interdisciplinary parts of Systems Engineering. In development, acquisition, or operational activities, the inclusion of risk in tradeoff with cost, schedule, and performance features, involves the iterative complex configuration management of traceability and evaluation to the scheduling and requirements management across domains and for the system lifecycle that requires the interdisciplinary technical approach of systems engineering. Systems Engineering has Risk Management define, tailor, implement, and monitor a structured process for risk management which is integrated to the overall effort.[52]

Safety engineering

The techniques of safety engineering may be applied by non-specialist engineers in designing complex systems to minimize the probability of safety-critical failures. The "System Safety Engineering" function helps to identify "safety hazards" in emerging designs, and may assist with techniques to "mitigate" the effects of (potentially) hazardous conditions that cannot be designed out of systems.

Scheduling

Scheduling is one of the systems engineering support tools as a practice and item in assessing interdisciplinary concerns under configuration management. In particular the direct relationship of resources, performance features, and risk to duration of a task or the dependency links among tasks and impacts across the system lifecycle are systems engineering concerns.

Security engineering

Security engineering can be viewed as an interdisciplinary field that integrates the community of practice for control systems design, reliability, safety and systems engineering. It may involve such sub-specialties as authentication of system users, system targets and others: people, objects and processes.

Software engineering

From its beginnings, software engineering has helped shape modern systems engineering practice. The techniques used in the handling of the complexities of large software-intensive systems have had a major effect on the shaping and reshaping of the tools, methods and processes of Software Engineering.