

# Enterprise Systems Engineering

From SEBoK

[Enterprise Systems Engineering](#)

[Jump to navigation](#) [Jump to search](#)

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[Enterprise systems engineering](#) Enterprise systems engineering (ESE) is the application of systems engineering principles, concepts, and methods to the planning, design, improvement, and operation of an enterprise.

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## Contents

- [1 Topics](#)
- [2 Introduction](#)
- [3 Key Terms](#)
  - [3.1 Enterprise](#)
  - [3.2 Enterprise vs Organization](#)
  - [3.3 Extended Enterprise](#)
  - [3.4 Enterprise Systems Engineering](#)
- [4 Creating Value](#)
  - [4.1 Resource Optimization](#)
  - [4.2 Enabling Systems Engineering in the Organization](#)
  - [4.3 Kinds of Knowledge Used by the Enterprise](#)
  - [4.4 Projects, Programs & Businesses](#)
- [5 Practical Considerations](#)
- [6 References](#)
  - [6.1 Works Cited](#)
  - [6.2 Primary References](#)
  - [6.3 Additional References](#)

## Topics

Each part of the SEBoK is divided into knowledge areas (KAs), which are groupings of information with a related theme. The KAs in turn are divided into topics. This KA contains the following topics:

- [Enterprise Systems Engineering Background](#)
- [The Enterprise as a System](#)
- [Related Business Activities](#)
- [Enterprise Systems Engineering Key Concepts](#)
- [Enterprise Systems Engineering Process Activities](#)

- [Enterprise Capability Management](#)

## Introduction

This knowledge area provides an introduction to [systems engineering](#) systems engineering (SE) at the [enterprise](#) enterprise level in contrast to “traditional” SE (TSE) (sometimes called “conventional” or “classical” SE) performed in a development [project](#) project or to “product” engineering (often called product development in the SE literature).

The concept of enterprise was instrumental in the great expansion of world trade in the 17th century (see note 1) and again during the Industrial Revolution of the 18th and 19th centuries. The world may be at the cusp of another global revolution enabled by the information age and the technologies and [cultures](#) cultures of the Internet (see note 2). The discipline of SE now has the unique opportunity of providing the tools and methods for the next round of enterprise transformations.

*Note 1. “The Dutch East India Company... was a chartered company established in 1602, when the States-General of the Netherlands granted it a 21-year monopoly to carry out colonial activities in Asia. It was the first multinational corporation in the world and the first company to issue stock. It was also arguably the **world's first mega-corporation**, possessing quasi-governmental powers, including the ability to wage war, negotiate treaties, coin money, and establish colonies.” (emphasis added, National Library of the Netherlands 2010)*

Note 2. This new revolution is being enabled by cheap and easily usable technology, global availability of information and knowledge, and increased mobility and adaptability of human capital. The enterprise level of analysis is only feasible now because [organizations](#) organizations can work together to form enterprises in a much more fluid manner.

ESE is an emerging discipline that focuses on frameworks, tools, and problem-solving approaches for dealing with the inherent [complexities](#) complexities of the enterprise. Furthermore, ESE addresses more than just solving problems; it also deals with the exploitation of opportunities for better ways to achieve the enterprise goals. A good overall description of ESE is provided by in the book by Rebovich and White (2011).

## Key Terms

### Enterprise

An enterprise consists of a purposeful combination (e.g., a [network](#) network) of interdependent resources (e.g., people, [processes](#) processes, organizations, supporting technologies, and funding) that interact with

- each other to coordinate functions, share information, allocate funding, create workflows, and make decisions, etc.; and
- their [environment\(s\)](#) environment(s) to achieve [business](#) business and [operational](#) operational goals through a [complex](#) complex web of interactions distributed across geography and time (Rebovich and White 2011, 4-35).

The term enterprise has been defined as follows:

(1) One or more [organizations](#) organizations sharing a definite [mission](#) mission, goals, and objectives to offer an [output](#) output such as a [product](#) product or [service](#) service. (ISO 2000);

(2) An organization (or cross organizational entity) supporting a defined [business](#) business scope and mission that includes interdependent resources (people, organizations and technologies) that must coordinate their [functions](#) functions and share information in support of a common mission (or set of related missions). (CIO Council 1999);

(3) The term enterprise can be defined in one of two ways. The first is when the entity being considered is tightly bounded and directed by a single executive function. The second is when organizational [boundaries](#) boundaries are less well defined and where there may be multiple owners in terms of direction of the resources being employed. The common factor is that both entities exist to achieve specified outcomes. (MOD 2004); and

(4) A complex, (adaptive) socio-technical system that comprises interdependent resources of people, processes, information, and technology that must interact with each other and their environment in support of a common mission. (Giachetti 2010)

An enterprise must do two things: (1) develop things within the enterprise to serve as either external offerings or as internal mechanisms to enable achievement of enterprise operations, and (2) transform the enterprise itself so that it can most effectively and efficiently perform its operations and survive in its competitive and constrained environment.

## **Enterprise vs Organization**

It is worth noting that an enterprise is not equivalent to an "organization" according to the definition above. This is a frequent misuse of the term enterprise. The figure below shows that an enterprise includes not only the organizations that participate in it, but also people, knowledge, and other assets such as processes, principles, policies, practices, doctrine, theories, beliefs, facilities, land, intellectual property, and so on.

Some enterprises are organizations, but not all enterprises are organizations. Likewise, not all organizations are enterprises. Some enterprises have no readily identifiable "organizations" in them. Some enterprises are self-organizing (i.e., not organized by mandate) in that the sentient beings in the enterprise will find for themselves some way in which they can interact to produce greater results than can be done by the individuals alone. Self-organizing enterprises are often more [flexible](#) flexible and [agile](#) agile than if they were organized from above (Dyer and Ericksen 2009; Stacey 2006).

*One type of enterprise [architecture](#) architecture that supports [agility](#) agility is a non-hierarchical organization without a single point of [control](#) control. Individuals function autonomously, constantly interacting with each other to define the vision and aims,*

*maintain a common understanding of requirements and monitor the work that needs to be done. Roles and responsibilities are not predetermined but rather **emerge** from individuals' self-organizing activities and are constantly in flux. Similarly, projects are generated everywhere in the enterprise, sometimes even from outside affiliates. Key decisions are made collaboratively, on the spot, and on the fly. Because of this, knowledge, power, and intelligence are spread through the enterprise, making it uniquely capable of quickly recovering and adapting to the loss of any key enterprise **component**.* ([http://en.wikipedia.org/wiki/Business\\_agility](http://en.wikipedia.org/wiki/Business_agility))

In spite of this lack of "organization" in some enterprises, SE can still contribute much in the engineering of the enterprise, as described in the articles below. However, SE must be prepared to apply some non-traditional approaches in doing so. Hence the need for embracing the new discipline called enterprise systems engineering (ESE).

Giachetti (2010) distinguishes between enterprise and organization by saying that an organization is a view of the enterprise. The organization view defines the structure and relationships of the organizational units, people, and other actors in an enterprise. Using this definition, we would say that all enterprises have some type of organization, whether formal, informal, hierarchical or self-organizing network.

## **Extended Enterprise**

Sometimes it is prudent to consider a broader scope than merely the "boundaries" of the organizations involved in an enterprise. In some cases, it is necessary (and wise) to consider the "extended enterprise" in modeling, assessment, and decision making. This could include upstream suppliers, downstream consumers, and end **user** organizations, and perhaps even "sidestream" partners and key **stakeholders**. The **extended enterprise** can be defined as:

*Wider organization representing all associated entities - **customers**, employees, suppliers, distributors, etc. - who directly or indirectly, formally or informally, collaborate in the **design**, development, production, and delivery of a product (or **service**) to the end user.* (<http://www.businessdictionary.com>)

## **Enterprise Systems Engineering**

**Enterprise systems engineering** (ESE), for the purpose of this article, is defined as the application of SE principles, concepts, and methods to the planning, design, improvement, and operation of an enterprise (see note 3). To enable more efficient and effective enterprise transformation, the enterprise needs to be looked at "as a **system**," rather than merely as a collection of functions connected solely by information systems and shared facilities (Rouse 2009). While a systems perspective is required for dealing with the enterprise, this is rarely the task or responsibility of people who call themselves systems engineers.

*Note 3. This form of systems engineering (i.e., ESE) includes (1) those traditional principles, concepts, and methods that work well in an enterprise environment, plus (2) an evolving set of newer ideas, precepts, and initiatives derived from **complexity** theory and the behavior of complex systems (such as those observed in nature and human languages).*

# Creating Value

The primary purpose of an enterprise is to create value for society, other stakeholders, and for the organizations that participate in that enterprise. This is illustrated in Figure 1 that shows all the key elements that contribute to this value creation process.

There are three types of organizations of interest: businesses, projects, and [teams](#)teams (see note 4). A typical business participates in multiple enterprises through its [portfolio](#)portfolio of projects. Large SE projects can be enterprises in their own right, with participation by many different businesses, and may be organized as a number of sub-projects.

*Note 4. The use of the word "business" is not intended to mean only for-profit commercial ventures. As used here, it also includes government agencies and not-for-profit organizations, as well as commercial ventures. Business is the activity of providing goods and services involving financial, commercial, and industrial aspects.*



**Figure 1. Organizations Manage Resources to Create Enterprise Value.** (SEBoK Original)

## Resource Optimization

A key choice for businesses that conduct SE is to what extent, if at all, they seek to optimize their use of resources (people, knowledge, assets) across teams, projects, and business units. Optimization of resources is not the goal in itself, but rather a means to achieve the goal of maximizing value for the enterprise and its [stakeholders](#)stakeholders. At one extreme, in a product-oriented organization, projects may be responsible for hiring, training, and firing their own staff, as well as managing all assets required for their delivery of products or services. (The term "product-oriented organization" is not meant in the sense of product-oriented SE, but rather in the sense of this being one of the basic constructs available when formulating organizational strategy.)

At the other extreme, in a functional organization, the projects delegate almost all their work to functional groups. In between these two extremes is a matrix organization that is used to give functional specialists a "home" between project assignments. A full discussion of organizational approaches and situations along with their applicability in enabling SE for the organization is provided in the article called [Systems Engineering Organizational Strategy](#).

The optimization debate can be handled as described in the book called "Enterprise Architecture as Strategy" (Ross, Weill, and Robertson 2006). In other words, an enterprise can choose (or not) to unify its operations and can choose (or not) to unify its information base. There are different strategies the enterprise might adopt to achieve and sustain value creation (and how ESE helps an enterprise to choose). This is further addressed in the section on Enterprise Architecture Formulation & Assessment in the article called [Enterprise Capability Management](#).

## Enabling Systems Engineering in the Organization

SE skills, techniques, and resources are relevant to many enterprise functions, and a well-founded SE [capability](#)capability can make a substantial contribution at the enterprise level, as well as at the project level. The article called [Systems Engineering Organizational Strategy](#) discusses enabling SE in the organization, while the article called [Enabling Businesses and Enterprises](#) focuses on the cross-organizational functions at the business and enterprise levels. The [competence](#)competence of

individuals is discussed in the article called [Enabling Individuals](#).

## Kinds of Knowledge Used by the Enterprise

Knowledge is a key resource for ESE. There are generally two kinds of knowledge: explicit and tacit. Explicit knowledge can be written down or incorporated in computer codes. Much of the relevant knowledge, however, is “tacit knowledge” that only exists within the heads of people and in the context of relationships that people form with each other (e.g., team, project, and business level knowledge). The ability of an organization to create value is critically dependent on the people it employs, on what they know, how they work together, and how well they are organized and motivated to contribute to the organization’s purpose.

## Projects, Programs & Businesses

The term “[program](#)program” is used in various ways in different domains. In some domains a team can be called a program (e.g., a customer support team is their customer relationship “program”). In others, an entire business is called a program (e.g., a wireless communications business unit program), and in others the whole enterprise is called a program (e.g., the Joint Strike Fighter program and the Apollo Space program). And in many cases, the terms [project](#)project and [program](#)program are used interchangeably with no discernible distinction in their meaning or scope. Typically, but not always, there are program managers who have profit and loss (P&L) responsibility and are the ultimate program decision makers. A program manager may have a portfolio of items ([services](#)services, [products](#)products, facilities, intellectual property, etc.) that are usually provided, implemented, or acquired through projects.

The Office of Government Commerce provides a useful distinction between programs and projects:

*The ultimate goal of a Programme is to realise outcomes and benefits of strategic relevance. To achieve this a programme is designed as a temporary flexible organisation structure created to coordinate, direct and oversee the implementation of a set of related projects and activities in order to deliver outcomes and benefits related to the organisation’s strategic objectives...*

*A programme is likely to have a life that spans several years. A Project is usually of shorter duration (a few months perhaps) and will be focussed on the creation of a set of deliverables within agreed cost, time and quality parameters. (OGC 2010)*

## Practical Considerations

When it comes to performing SE at the enterprise level, there are several good practices to keep in mind (Rebovich and White 2011):

- Set enterprise fitness as the key [measure](#)measure of system success. Leverage game theory and ecology, along with the practices of satisfying and governing the commons.
- Deal with uncertainty and conflict in the enterprise through adaptation: variety, selection, exploration, and experimentation.
- Leverage the practice of layered [architectures](#)architectures with [loose coupler](#)loose couplers and the theory of order and [chaos](#)chaos in networks.

Enterprise [governance](#) governance involves shaping the political, operational, economic, and technical (POET) landscape. One should not try to control the enterprise like one would in a TSE effort at the project level.

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[< Previous Article](#) | [Parent Article](#) | [Next Article >](#)

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**Categories:**

- [Part 4](#)



- [Knowledge Area](#)

## Navigation menu

### Personal tools

- [Log in](#)

### Namespaces

- [Page](#)
- [Discussion](#)



### Variants

### Views

- [Read](#)
- [View source](#)
- [View history](#)
- [PDF Export](#)



### More

### Search

### Stewards



- Quicklinks

- [Main Page](#)
- [Letter from the Editor](#)
- [Governance and Editorial Boards](#)

- [SEBoK Sponsors](#)
- [Acknowledgements and Release History](#)
- [FAQs](#)
- Outline
  - [Table of Contents](#)
  - [Part 1: SEBoK Introduction](#)
    - [Introduction to the SEBoK](#)
      - [Scope of the SEBoK](#)
      - [Structure of the SEBoK](#)
    - [Introduction to Systems Engineering](#)
      - [Systems Engineering Overview](#)
      - [Brief History of Systems Engineering](#)
      - [Systems Engineering Principles](#)
      - [Systems Engineering Heuristics](#)
      - [Economic Value of Systems Engineering](#)
      - [Systems Engineering: Historic and Future Challenges](#)
      - [Systems Engineering and Other Disciplines](#)
      - [Systems Engineering Core Concepts](#)
    - [SEBoK Users and Uses](#)
      - [Use Case 0: Systems Engineering Novices](#)
      - [Use Case 1: Practicing Systems Engineers](#)
      - [Use Case 2: Other Engineers](#)
      - [Use Case 3: Customers of Systems Engineering](#)
      - [Use Case 4: Educators and Researchers](#)
      - [Use Case 5: General Managers](#)
  - [Part 2: Foundations of Systems Engineering](#)
    - [Systems Fundamentals](#)
      - [Introduction to System Fundamentals](#)
      - [Types of Systems](#)
      - [Complexity](#)
      - [Emergence](#)
      - [Fundamentals for Future Systems Engineering](#)
    - [Systems Approach Applied to Engineered Systems](#)
      - [Overview of Systems Approaches](#)
      - [Engineered System Context](#)
      - [Identifying and Understanding Problems and Opportunities](#)
      - [Synthesizing Possible Solutions](#)
      - [Analysis and Selection between Alternative Solutions](#)
      - [Implementing and Proving a Solution](#)
      - [Deploying, Using, and Sustaining Systems to Solve Problems](#)
      - [Applying the Systems Approach](#)
    - [Systems Science](#)
      - [History of Systems Science](#)
      - [Cycles and the Cyclic Nature of Systems](#)
      - [Systems Approaches](#)
    - [Systems Thinking](#)
      - [What is Systems Thinking?](#)
      - [Concepts of Systems Thinking](#)
      - [Principles of Systems Thinking](#)

- [Patterns of Systems Thinking](#)
- [Representing Systems with Models](#)
  - [What is a Model?](#)
  - [Why Model?](#)
  - [Types of Models](#)
  - [System Modeling Concepts](#)
  - [Integrating Supporting Aspects into System Models](#)
  - [Modeling Standards](#)
- [Part 3: SE and Management](#)
  - [Introduction to Life Cycle Processes](#)
    - [Generic Life Cycle Model](#)
    - [Applying Life Cycle Processes](#)
    - [Life Cycle Processes and Enterprise Need](#)
  - [Life Cycle Models](#)
    - [Life Cycle Process Drivers and Choices](#)
    - [Life Cycle Process Models: Vee](#)
    - [Life Cycle Process Models: Iterative](#)
    - [Integration of Process](#)
    - [Lean Engineering](#)
  - [Concept Definition](#)
    - [Business or Mission Analysis](#)
    - [Mission Engineering](#)
    - [Stakeholder Needs and Requirements](#)
  - [System Definition](#)
    - [System Requirements](#)
    - [System Architecture](#)
    - [Logical Architecture Model Development](#)
    - [Physical Architecture Model Development](#)
    - [System Design](#)
    - [System Analysis](#)
  - [System Realization](#)
    - [System Implementation](#)
    - [System Integration](#)
    - [System Verification](#)
    - [System Validation](#)
  - [System Deployment and Use](#)
    - [System Deployment](#)
    - [Operation of the System](#)
    - [System Maintenance](#)
    - [Logistics](#)
  - [Systems Engineering Management](#)
    - [Planning](#)
    - [Assessment and Control](#)
    - [Risk Management](#)
    - [Measurement](#)
    - [Decision Management](#)
    - [Configuration Management](#)
    - [Information Management](#)
    - [Quality Management](#)
  - [Product and Service Life Management](#)
    - [Service Life Extension](#)

- [Updates, Upgrades, and Modernization](#)
  - [Disposal and Retirement](#)
- [Systems Engineering Standards](#)
  - [Relevant Standards](#)
  - [Alignment and Comparison](#)
  - [Application](#)
- [Part 4: Applications of Systems Engineering](#)
  - [Product Systems Engineering](#)
    - [Product SE Background](#)
    - [Product as a System Fundamentals](#)
    - [Relate Business Activities](#)
    - [Product SE Key Aspects](#)
    - [Product SE Special Activities](#)
  - [Service Systems Engineering](#)
    - [Service Systems Background](#)
    - [Fundamentals of Services](#)
    - [Properties of Services](#)
    - [Scope of Service Systems Engineering](#)
    - [Value of Service Systems Engineering](#)
    - [Service Systems Engineering Stages](#)
  - [Enterprise Systems Engineering](#)
    - [Enterprise SE Background](#)
    - [The Enterprise as a System](#)
    - [Related Business Activities](#)
    - [Enterprise SE Key Concepts](#)
    - [Enterprise SE Process Activities](#)
    - [Enterprise Capability Management](#)
  - [Systems of Systems \(SoS\)](#)
    - [Architecting Approaches for SoS](#)
    - [Socio-Technical Features of SoS](#)
    - [Capability Engineering](#)
  - [Healthcare Systems Engineering](#)
    - [Overview of the Healthcare Sector](#)
    - [Systems Engineering in Healthcare Delivery](#)
    - [Systems Biology](#)
    - [Lean in Healthcare](#)
- [Part 5: Enabling Systems Engineering](#)
  - [Enabling Businesses and Enterprises](#)
    - [SE Organizational Strategy](#)
    - [Determining Needed Capabilities](#)
    - [Organizing Business to Perform SE](#)
    - [Assessing SE Performance](#)
    - [Developing SE Capabilities](#)
    - [Culture](#)
  - [Enabling Teams](#)
    - [Team Capability](#)
    - [Team Dynamics](#)
    - [Diversity, Equity, and Inclusion](#) **\*\*New Article\*\***
    - [Technical Leadership in SE](#)
  - [Enabling Individuals](#)
    - [Roles and Competencies](#)

- [Assessing Individuals](#)
  - [Developing Individuals](#)
  - [Ethical Behavior](#)
- [Part 6: Related Disciplines](#)
  - [Systems Engineering and Environmental Engineering](#)
  - [Systems Engineering and Geospatial/Geodetic Engineering](#) **\*\*New Article\*\***
    - [Overview of Geospatial/Geodetic Engineering](#) **\*\*New Article\*\***
    - [Relationship between Systems Engineering and Geospatial/Geodetic Engineering](#) **\*\*New Article\*\***
  - [Systems Engineering and Industrial Engineering](#)
  - [Systems Engineering and Project Management](#)
    - [The Nature of Project Management](#)
    - [An Overview of the PMBOK® Guide](#)
    - [Relationships between Systems Engineering and Project Management](#)
    - [The Influence of Project Structure and Governance on Systems Engineering and Project Management Relationships](#)
    - [Procurement and Acquisition](#)
    - [Portfolio Management](#)
  - [Systems Engineering and Software Engineering](#)
    - [Software Engineering in the Systems Engineering Life Cycle](#)
    - [The Nature of Software](#)
    - [An Overview of the SWEBOK Guide](#)
    - [Key Points a Systems Engineer Needs to Know about Software Engineering](#)
    - [Software Engineering Features - Models, Methods, Tools, Standards, and Metrics](#)
  - [Systems Engineering and Quality Attributes](#)
    - [Human Systems Integration](#)
    - [Manufacturability and Producibility](#)
    - [System Affordability](#)
    - [System Hardware Assurance](#) **\*\*New Article\*\***
    - [System Reliability, Availability, and Maintainability](#)
    - [System Resilience](#)
    - [System Resistance to Electromagnetic Interference](#)
    - [System Safety](#)
    - [System Security](#)
- [Part 7: SE Implementation Examples](#)
  - [Matrix of Implementation Examples](#)
  - [Implementation Examples](#)
  - [Defense System Examples](#)
    - [Submarine Warfare Federated Tactical Systems](#)
    - [Virginia Class Submarine](#)
  - [Information System Examples](#)
    - [Complex Adaptive Taxi Service Scheduler](#)
    - [Successful Business Transformation](#)
    - [FBI Virtual Case File System](#)
  - [Management System Examples](#)
    - [Project Management for a Complex Adaptive Operating System](#)
  - [Medical System Examples](#)
    - [Next Generation Medical Infusion Pump](#)
    - [Medical Radiation](#)

- [Design for Maintainability](#)
- Space System Examples
  - [Global Positioning System](#)
  - [Global Positioning System II](#)
  - [Russian Space Agency Project Management Systems](#)
  - [Cassini/Huygens](#)
  - [Hubble Space Telescope](#)
  - [Applying MB Approach for 30 Meter Telescope](#)
  - [MSTI Spacecraft](#)
  - [Apollo 1 Disaster](#)
- Transportation System Examples
  - [Denver Baggage Handling](#)
  - [FAA Advanced Automation System](#)
  - [FAA NextGen](#)
  - [UK Route Modernisation](#)
  - [Korean Light Transit System](#)
- Utilities Examples
  - [Northwest Hydro System](#)
  - [Singapore Water Management](#)
- [Part 8: Emerging Knowledge](#)
  - [Emerging Topics](#)
    - [Socio-technical Systems](#) \*New Article\*
    - [Artificial Intelligence](#) \*New Article\*
    - [Verification and Validation of Systems in Which AI is a Key Element](#) \*New Article\*
    - [Transitioning Systems Engineering to a Model-based Discipline](#)
    - [Model-Based Systems Engineering Adoption Trends 2009-2018](#)
    - [Digital Engineering](#)
    - [Set-Based Design](#)
  - [Emerging Research](#)
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  - [How to Read the SEBoK](#)
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  - [Copyright Information](#)
  - [Cite the SEBoK](#)
  - [About the SEBoK](#)
- Navigation
  - [Knowledge Areas](#)
  - [Topics](#)
  - [Use Cases](#)
  - [Examples](#)
  - [Glossary of Terms](#)
  - [Acronyms](#)
  - [Primary References](#)
- Toolbox
  - [Recent Changes](#)

- [Random Page](#)
- [What Links Here](#)
- [Special Pages](#)

## Quicklinks

- [Main Page](#)
- [Note to Reviewers](#)
- [How to Read the SEBoK](#)
- [Acknowledgements](#)
- [Copyright Information](#)
- [About the SEBoK](#)
- [Download SEBoK PDF](#)

## Outline

- [Table of Contents](#)
- [Part 1: Introduction](#)
- [Part 2: Systems](#)
- [Part 3: SE and Management](#)
- [Part 4: Applications of SE](#)
- [Part 5: Enabling SE](#)
- [Part 6: Related Disciplines](#)
- [Part 7: Examples](#)

## Navigation

- [Knowledge Areas](#)
- [Topics](#)
- [Use Cases](#)
- [Case Studies](#)
- [Vignettes](#)
- [Glossary of Terms](#)
- [Acronyms](#)
- [Primary References](#)

## Tools

- [What links here](#)
- [Related changes](#)
- [Special pages](#)
- [Permanent link](#)
- [Page information](#)
- [Browse properties](#)

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- [Disclaimers](#)

