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The SEBoK provides a widely accepted, community-based, and regularly updated baseline of systems engineering (SE) knowledge. Therefore, it is a curated body of knowledge which is updated on a semi-annual basis. This baseline strengthens the mutual understanding across the many disciplines involved in developing and operating systems.

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Contents

Topics

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

- Scope of the SEBoK
- Structure of the SEBoK

References

Works Cited

None.

Primary References

INCOSE. 2015. *Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities*, Fourth Edition. San Diego, CA, USA: International Council on Systems Engineering (INCOSE). INCOSE-TP-2003-002-004.

INCOSE. 2012. *Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities*, version 3.2.2. San Diego, CA, USA: International Council on Systems Engineering (INCOSE). INCOSE-TP-2003-002-03.2.

Sage, A. and W. Rouse, Eds. 2009. *Handbook of Systems Engineering and Management,* 2nd ed. Hoboken, NJ, USA: John Wiley and Sons, Inc.

Additional References

None.

SEBoK v. 2.9, released 20 November 2023

The primary focus of the SEBoK is on the current baseline of knowledge describing the practice of domain independent systems engineering (SE). This Knowledge Area (KA) contains topic articles which provide an overview of SE practice and discuss its economic value, historic evolution and key relationships.

Topics

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

- Systems Engineering Overview
- Economic Value of Systems Engineering
- Systems Engineering: Historic and Future Challenges
- Systems Engineering and Other Disciplines

Systems Engineering

SE is a transdisciplinary approach and means to enable the realization of successful systems. Successful systems must satisfy the needs of their customers, users and other stakeholders. Some key elements of systems engineering are highlighted in Figure 1 and include:

- The principles and concepts that characterize a system, where a system is an interacting combination of system elements that accomplish a defined objective(s). The system interacts with its environment, which may include other systems, users, and the natural environment. The system elements that compose the system may include hardware, software, firmware, people, information, techniques, facilities, services, and other support elements.
- A systems engineer is a person or role who supports this transdisciplinary approach. In particular, the systems engineer often serves to elicit and translate customer needs into specifications that can be realized by the system development team.
- In order to help realize successful systems, the systems engineer supports a set of life cycle

processes beginning early in conceptual design and continuing throughout the life cycle of the system through its manufacture, deployment, use and disposal. The systems engineer must analyze, specify, design, and verify the system to ensure that its functional, interface, performance, physical, and other quality characteristics, and cost are balanced to meet the needs of the system stakeholders.

- A systems engineer helps ensure the elements of the system fit together to accomplish the objectives of the whole, and ultimately satisfy the needs of the customers and other stakeholders who will acquire and use the system.

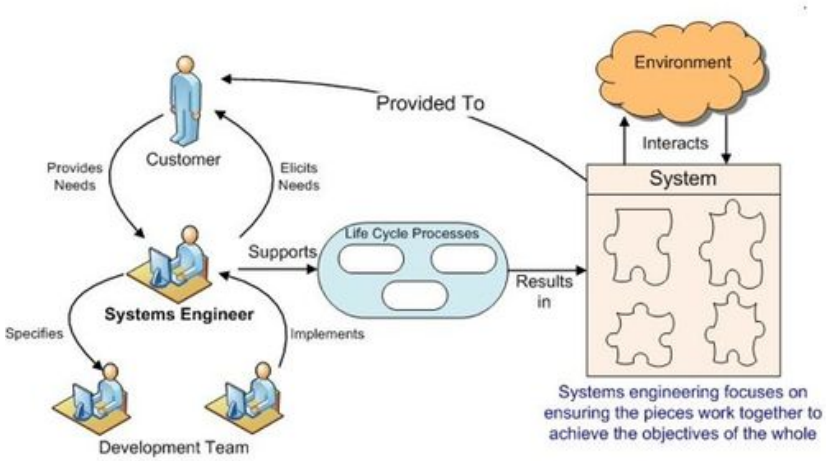

Figure 1. Key Elements of Systems Engineering. (SEBoK Original)

References

None.

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SEBoK v. 2.9, released 20 November 2023

While the primary focus of the SEBoK is on the current practice of domain independent systems engineering, it is also concerned with the future evolution of the discipline.

The topics in this Knowledge Area (KA) summarize SE knowledge which is emerging and transitioning to become part of the practice of systems engineering, such as Model-Based Systems Engineering (MBSE). In general, topics will be introduced here and then expanded into other SEBoK KA's over time.

The knowledge covered in this KA reflects the

transformation and continued evolution of SE. For a summary of the current and future challenges that contribute to this evolution, see Systems Engineering: Historic and Future Challenges. This notion of SE transformation and the other areas of knowledge which it includes are discussed briefly below.

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:

- Transitioning Systems Engineering to a Model-based Discipline
- Digital Engineering
- Set-Based Design
- Model-Based Systems Engineering Adoption Trends 2009-2018
- Systems Engineering Core Concepts

Systems Engineering Transformation

The INCOSE Systems Engineering Vision 2025 (INCOSE 2014) describes the global context for SE, the current state of SE practice and the possible future state of SE. It describes a number of ways in which SE continues to evolve to meet modern system challenges. These are summarized briefly below.

Systems engineering has evolved from a combination of practices used in a number of related industries (particularly aerospace and defense). These have been used as the basis for a standardized approach to the life cycle of any complex system (see Systems Engineering and Management). Hence, SE practices are still largely based on heuristics. Efforts are under-way to evolve a theoretical foundation for systems engineering (see Foundations of Systems Engineering) considering foundational knowledge from a variety of sources.

Systems engineering continues to evolve in response to a long history of increasing system complexity. Much of this evolution is in the models and tools focused on specific aspects of SE, such as understanding stakeholder needs, representing system architectures or modeling specific system properties. The integration

across disciplines, phases of development, and projects continues to represent a key systems engineering challenge.

Systems engineering is gaining recognition across industries, academia and governments. However, SE practice varies across industries, organizations, and system types. Cross fertilization of systems engineering practices across industries has begun slowly but surely; however, the global need for systems capabilities has outpaced the progress in systems engineering.

INCOSE Vision 2025 concludes that SE is poised to play a major role in some of the global challenges of the 21st century, that it has already begun to change to meet these challenges and that it needs to undergo a more significant **transformation** to fully meet these challenges. The following bullet points are taken from the summary section of Vision 2025 and define the attributes of a transformed SE discipline in the future:

- Relevant to a broad range of application domains, well beyond its traditional roots in aerospace and defense, to meeting society's growing quest for sustainable system solutions to providing fundamental needs, in the globally competitive environment.
- Applied more widely to assessments of socio-physical systems in support of policy decisions and other forms of remediation.
- Comprehensively integrating multiple market, social and environmental stakeholder demands against "end-to-end" life-cycle considerations and long-term risks.
- A key integrating role to support collaboration that spans diverse organizational and regional boundaries, and a broad range of disciplines.
- Supported by a more encompassing foundation of theory and sophisticated model-based methods and tools allowing a better understanding of increasingly complex systems and decisions in the face of uncertainty.
- Enhanced by an educational infrastructure that stresses systems thinking and systems analysis at all learning phases.
- Practiced by a growing cadre of professionals who possess not only technical acumen in their domain of application, but who also have mastery of the next generation of tools and methods necessary for the

systems and integration challenges of the times.

Some of these future directions of SE are covered in the SEBoK. Others need to be introduced and fully integrated into the SE knowledge areas as they evolve. This KA will be used to provide an overview of these transforming aspects of SE as they emerge. This transformational knowledge will be integrated into all aspects of the SEBoK as it matures.

References

Works Cited

International Council on Systems Engineering (INCOSE). 2014. *Systems Engineering Vision 2025, July*, 2014; Available at http://www.incose.org/docs/default-source/aboutse/se-vision-2025.pdf?sfvrsn=4. Accessed February 16.

Primary References

None.

Additional References

None.

Relevant Videos

- Leading the Transformation of Model-Based Engineering

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The SEBoK is intended to be a resource that can help anyone understand more about systems engineering. Systems engineers should obviously benefit, but so can undergraduate engineering students, those new to the SE discipline, or people who work with systems engineers and want to understand more about what to expect from systems engineering activities. This article explores a variety of personas. Once you determine which persona best represents you, read on to get practical advice on how to utilize the SEBoK.

Personas

In marketing, "personas" are used to illustrate potential users or customers. Personas are fictional characters that represent a demographic of a target audience. For the SEBoK, we've developed personas that represent different types of people who we anticipate will utilize the SEBoK:

- An engineering undergraduate student
- A new systems engineer
- An experienced systems engineer
- A chief systems engineer
- An organizational manager
- A systems engineering educator or researcher
- A general manager

Note that initial work on personas was published in (Hutchison et al. 2023). The personas published in this reference were built upon and edited to support this article.

An Undergraduate Engineering Student

Stueti is in her final year studying electrical engineering at a private university. In her capstone, she works on a multi-disciplinary team, including students from the mechanical and software engineering departments as well. As the team comes together, each student starts talking about using the most advanced techniques and technologies available in their part of the project. The discussion devolves into an argument about how to do this in the time and budget available. Her faculty advisor says that in order to be successful, they have to work together to create a useful product, which means that they can’t each focus on their own parts in isolation. The advisor suggests that they all need to come to the next team meeting prepared to discuss their project as a system. Stueti Googles "systems" when she gets back to her dorm and stumbles on the SEBoK.

For Stueti, the SEBoK begins to expose her to systems concepts. In particular, Stueti could benefit from reading the articles in Part 2: Foundations of Systems Engineering, particularly The Nature of Systems, which will introduce her to different views on and core definitions of a system. From there, the articles in the Introduction to Systems Engineering knowledge area would be useful. Finally, Stueti reads the article Systems

Engineering and Mechanical Engineering, which relates to this new subject area that she has spent several years learning. In her reading, Stueti finds a few references that she thinks will help her better understand this SE stuff and help her apply it.

This gives Stueti a better understanding of what her professor meant – that all the different elements of the project (or system) must work together to achieve their project goal. As the capstone progresses, Stueti returns to the SEBoK to find additional resources as new issues come up.

If you identify with Stueti, review the recommendation for SE novices.

A New Systems Engineer

Hans completed a master's in computer science three years ago and has since been working for a small company in their IT department. The team he is on has been operating and maintaining the existing customer support system, which has become increasingly cumbersome and costly. Han's manager noticed that he was always asking good questions, and several times Hans's curiosity helped the team uncover the root causes of problems. Hans has also exhibited "out of the box" thinking, which has helped create some novel solutions. Hans's computer science and programming skills are competent. The company creating a new customer support system and, based on his experience with the current system and his inquisitiveness, Hans's manager asks if he would consider taking a role as the software systems engineer. In that role, he would be reporting directly to the chief systems engineer on the project. Hans looks forward to new responsibilities, but other than a few brief interactions with systems engineers, he's not sure what they do. He is enrolled in the company's introductory systems engineering course in a few weeks, but he wants to start understanding more about it now.

Han's manager recommends he take a look at the SEBoK in preparation for his upcoming course. Hans, feeling a bit nervous, decides to search the SEBoK for "computer science" and finds the page, Exploring the Relationship between Systems Engineering and Software Engineering. This is a page about a paper by the same title, which Hans looks up to read later. In the SEBoK, he notices that this is used in something called, Software Engineering in the Systems Engineering Life Cycle.

Hans reads this article and finds a number of related articles on the relationship between systems engineering and software engineering, which highlight the relationships between the two. Hans is now feeling more confident that this “systems stuff” isn’t completely different from what he has learned by applying his computer science degree on the job.

Hans continues to explore the SEBoK, finding a collection of articles about systems thinking, which he finds useful and which leads him to articles about the systems engineering process. He learns about lifecycle approaches and finds an article on agile systems engineering. He is very familiar with agile approaches from his work over the last three years. While reading the SEBoK, Hans looks at the references and identifies 6 articles and 2 books he wants to read to get more familiar with SE. He is feeling much more confident about his ability to tackle the upcoming course and his new role and bookmarks the SEBoK for future reference.

If you identify with Hans, review the recommendations for experienced engineers new to systems engineering.

An Experienced Systems Engineer

Yan has been working in a large company that makes medical devices for the last 10 years, ever since she earned her undergraduate degree in electrical engineering. Within a few years of joining the company, Yan was selected for a "high potential" program to develop new systems talent in the company. As part of the program, Yan completed her graduate degree in systems engineering last year. Currently, she is a lead designer on one of the company’s flagship products. She has taken all the courses her company offers around systems design and engineering and is looking for more resources to continue to develop her skills.

Yan is aware of the SEBoK and has read a few articles but has not used it often. She decides to search the SEBoK for “knowledge skills abilities” (KSA) as her company uses this term when evaluating performance. She finds articles on enabling individuals, ethical behavior, and roles and competencies. She reads the roles and competencies articles and learns about several different competency models. Primary references in these articles point her to these models, and she decides that the NASA's Systems Engineering Competencies model seems to align well with how her company views systems engineering. She decides to look through the

competency model and see what competencies she has and which she might want to work on. She is generally comfortable with the competencies around the systems engineering lifecycle. She has had a few minor leadership roles, but some of the technical management competencies are less familiar. Yan decides that learning more about technical management will improve her skillset and make her more valuable to the company.

She skims the articles on Systems Engineering Management in the SEBoK, and the overview content is pretty familiar. Looking through the works cited and primary references, however, she finds a few really useful references. This leads to the definition of technical management in the SEBoK Glossary of Terms, which points to a joint INCOSE/Project Management Institute (PMI) working group on the subject. Yan reaches out to this group and identifies further resources for self-study. After reviewing these resources, Yan is now more familiar with the vocabulary of technical management and looks for related short courses to help her hone her skills.

If you identify with Yan, review the SEBoK guidance for systems engineers.

A Chief Systems Engineer

Jacquie is a chief systems engineer at a mid-size electronics company. She has led teams to successfully deliver several projects, over the years coordinating hundreds of engineers, project managers, and specialists. Jacquie has recently been asked to step in and support the lead engineers in several smaller projects to resolve some common challenges. She has noted that in almost every case, the issues have two root causes: lack of systems perspective and lack of coordination between teams of different disciplines. Jacquie has seen several initiatives to move the workforce in one direction or another fail over her 18 years with the company, so is wary of top-down mandates saying that everyone needs to become a systems thinker or something similar.

Jacquie is a long-time user of the SEBoK and remembers that there’s a section somewhere about enabling systems engineers. She quickly finds the section in the Outline (Part 5: Enabling Systems Engineering) and she notices a knowledge area on Enabling Businesses and Enterprises and starts reading. The articles on determining what capabilities organizations need and

developing those capabilities are particularly helpful and lead her to a Harvard Business Review article on change management that is really useful.

Armed with this information, Jacquie gets a group of her peers together to discuss the challenges and some potential solutions.

If you identify with Jacquie, review the recommendations for experienced systems engineers.

An Organizational Manager

The primary audience of the SEBoK is individuals working in the SE discipline, but articles are written in a way that should enable non-systems engineers to grasp the basics.

Juan is a mid-level manager at a large firm that makes major weapons systems for his nation’s defense department. The organization is trying to alter the culture toward a more integrative and collaborative model. This includes a focus on systems and systems thinking. Juan's leadership has emphasized that it is critical for all levels of management to show support for this initiative and that, without their support, the initiative cannot be successful. Juan has never heard the term “systems thinking” before and the only connotation he has with “systems” is the company's IT systems that are always causing headaches.

Juan Googles “systems thinking” and is immediately overwhelmed by the search results. Inundated with definitions from companies trying to sell systems thinking services or training, universities advertising their programs, and blog posts, which could be by experts or by people who only think they know what systems thinking is, Juan is quickly overwhelmed. He stumbles upon something that links “systems thinking” to “systems engineering”, which is a term he knows, though he has never been and has no desire to be an “engineer”. He refines his search to include both “systems thinking” and “systems engineering” in Google Scholar to try to find more reputable sources. Again there are tens of thousands of results. He goes to a systems engineer whom he often sees in the break room, and asks him what to do. The systems engineer points him to the SEBoK.

In the SEBoK, Juan quickly finds a knowledge area on systems thinking and several articles and papers that he believes he can trust to give authoritative information.

After reading through the articles and references, Juan now feels he has a basic understanding of what systems thinking is and he now understands why this is such a critical part of the company's strategy for change. Juan now has the vocabulary and knowledge to support the initiative as a member of the management team.

If you identify with Juan, review the guidance for general managers.

References

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Hutchison, N., A. Pyster, and R. Cloutier. 2023. "Using the Systems Engineering Body of Knowledge (SEBoK)." *in* Verma, D. (ed). *Systems Engineering for the Digital Age.* Hoboken, NJ: John Wiley and Sons.

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Hutchison, N., A. Pyster, and R. Cloutier. 2023. "Using the Systems Engineering Body of Knowledge (SEBoK)." *in* Verma, D. (ed). *Systems Engineering for the Digital Age.* Hoboken, NJ: John Wiley and Sons.

Additional References

None.

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