Guidance for Systems Engineers

Both for the entry-level systems engineer learning the discipline of systems engineering (SE), and the more experienced systems engineer seeking the knowledge required to accomplish a work activity, the SEBoK serves as a primary information source and a quick, comprehensive reference for SE information.

What these system engineers find in the SEBoK includes:

- definitions of terms,
- explanations of basic concepts and principles,
- useful discussions of topics,
- references to articles and textbooks that cover topics in-depth, and
- pointers to additional sources.

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Contents

How Systems Engineers Use Topics

Researching SE-related subjects, identifying educational resources, and connecting with individuals or organizations which offer specialized expertise are all part of the job for the practicing systems engineer. The time available to the SE for these activities can be quite limited. The SEBoK is designed to ease the pressure on the systems engineer in this situation, in several ways:

- Because its content is based on research, proven practices, and emerging knowledge, the SEBoK makes high-quality information available to the systems engineer right away.
- Being composed of articles of 2000 words or less in most cases, the SEBoK enables the systems engineer to quickly get an overview of relevant topics.
- By providing primary references, each topic offers a direct route to more detailed information.
- Even greater detail, breadth, and a sense of what's relevant in the SE literature are available through the additional references each topic provides.
- Since the SEBoK sources have been reviewed and vetted by a team of experts, the SEBoK helps the systems engineer avoid less reliable information which can be hard to eliminate within Internet search results.
- The systems engineer who needs to connect with educators and researchers can find relevant names and institutions in SEBoK topics and references.

Systems engineers using the SEBoK may choose one or more of several approaches:

- searching on keywords or article names, using the text field, Search button, and Go button at the top right of each SEBoK page
- scanning the Quick Links, Outline (where the table of contents is located), or Navigation indexes that appear at the left of each SEBoK page, and following links from there to articles that seem likely to be of interest
- searching on keywords using an Internet search engine
- reading through one or more of Parts 1 through 7 in

sequence

Reading the SEBoK in sequence is especially suitable for the practicing engineer who is new to SE or is enrolled in an SE-related training course. For this engineer, SE (or some aspect of it) is a subject to be learned comprehensively. This is made easier by navigation links from each article to the previous, next, and parent articles as found in the Table of Contents.

For practicing systems engineers, having the SEBoK makes it possible to gain knowledge more quickly and reliably than they would otherwise. The goal is to spend less time searching for and compiling new information from disparate sources and more time getting work done.

For a team of practicing engineers, the gap in knowledge between more- and less-experienced engineers can be a major obstacle. The SEBoK serves as a tool for the team to build a framework of agreed-upon definitions and perspectives. The consistency of such a framework enhances communication across the team. New teams, especially, can benefit from bridging the gap between legacy and more-recently-acquired knowledge. For more information, see Enabling Teams in Part 5.

How Systems Engineers Use the Examples

The SEBoK is written, for the most part, independent of any particular domain of practice. By design, parts 1 though 6 focus on the discipline of SE and not the numerous domains where SE can be applied.

This lack of domain-specific content is partly offset by Part 7, Systems Engineering Implementation Examples, which consists of case studies and examples drawn from a number of domains where SE is applied. Each example demonstrates the impact of a particular application domain upon SE activities. Examples are generally most useful to the systems engineer when they are aligned with the domain in which the he or she is working, but sometimes ideas from an example in one domain can be usefully applied to situations in another.

Example: Model-Based Systems Engineering Practitioners

For practitioners of model-based systems engineering

(MBSE), the Representing Systems with Models knowledge area is of central importance within the SEBoK.

Academic faculty who use the SEBoK to support curriculum development and assessment can refer to the same knowledge area to ensure that their curricula accurately cover the languages and/or methodologies such as System Modeling Language (SysML) and Object-Process Methodology (OPM).

SE researchers, too, can adopt an MBSE approach, making their research products more formal and rigorous by basing them on models.

In MBSE, models of systems support system life cycle activities, including requirements engineering, high-level architecture, detailed design, testing, usage, maintenance, and disposal.

Vignette: Systems Engineering for Medical Devices

Tara Washington has worked as a engineer for the HealthTech medical device company for seven years. Besides continuing to improve her strong software skills, she has shown an aptitude for systems thinking. To better understand the products that her software supports, Tara has taken courses in electrical engineering, mechanical engineering, and physiology. The coursework has helped her to perform effectively as a software system analyst on the SE teams of her last two projects.

HealthTech's Research Division proposes a new concept for a highly programmable radiation therapy device that monitors the effects of the radiation on various parts of the body and adjusts the parameters of the radiation dosage to maximize its effectiveness, subject to a number of safety constraints. The software-intensiveness of the device leads Tara's project manager to recommend her as the lead systems engineer for the design and development of the product.

Tara welcomes the opportunity, knowing that she possesses enough domain knowledge to take the lead SE role. Even so, she realizes that she has picked up SE skills mainly by intuition and needs to build them up more systematically. Tara begins to consult some of HealthTech's lead systems engineers, and to study the SEBoK.

After reading the SEBoK Introduction, Tara feels that she has a solid overview of the SEBoK. Tara finds that the next topic, Scope and Context of the SEBoK, outlines the key activities that she expects to lead, along with others which will require her to collaborate with systems developers and project and systems management personnel.

The same topic identifies those parts of the SEBoK that Tara needs to study in preparation for her lead systems engineer role:

- SE concepts, principles, and modeling approaches in Part 2 (Representing Systems with Models knowledge area (KA))
- life cycle processes, management, technical practices, in Part 3 (Systems Engineering and Management KA)
- approaches for specifying, architecting, verifying and validating the hardware, software, and human factors aspects of the product, as well as common pitfalls to avoid and risks to manage, also in Systems Engineering and Management
- guidelines for the systems engineering of products, in Part 4: Applications of Systems Engineering, including references
- SE knowledge, skills, abilities, and attitudes (KSAAs) needed for a project in Part 5: Enabling Systems Engineering including references
- specialty engineering disciplines that may be key to the project's success, in Part 6: Related Disciplines

Tara's awareness of the deaths caused by the Therac-25 radiation therapy device motivates her to study not only the System Safety topic in Part 6, but all of its key references as well.

While reading about SE life cycle process models in Systems Engineering and Management in Part 3, Tara notes the reference to the Next Generation Medical Infusion Pump Case Study in Part 7. This case study strikes Tara as highly relevant to her medical-device work, and she observes that it is organized into phases similar to those used at HealthTech. From the case study, Tara gains understanding of how a project such as hers would progress: by concurrently evaluating technology opportunities, by discovering the needs of various device stakeholders such as patients, nurses, doctors, hospital administrators, and regulatory agencies, and by working through increasingly detailed

prototypes, specifications, designs, plans, business cases, and product safety analyses.

The case study mentions its source: Human-System Integration in the System Development Process (Pew and Mavor 2007), published by the U.S. National Research Council. Tara obtains this book. In it, she finds numerous good practices for human-systems needs analysis, organizational analysis, operations analysis, prototyping, usability criteria formulation, hardware-software-human factors integration, process decision milestone review criteria, and risk management.

As a result of her SEBoK-based study, Tara feels better-qualified to plan, staff, organize, control, and direct the SE portion of the HealthTech radiation therapy device project and to help bring the project to a successful conclusion.

How Systems Engineers Use the Emerging Knowledge

The SE discipline continues to mature and evolve, incorporating new ideas, processes, and technologies. The SEBoK part on Emerging Knowledge describes some of these trends. For example, it currently includes references to the incorporation of artificial intelligence (AI) to support systems engineering.

Summary

In the SEBoK, practicing engineers have an authoritative knowledge resource that can be accessed quickly to gain essential high-level information, and to identify the best references for in-depth study and research into SE topics when an individual's initial level of understanding is not adequate to get the job done.

The SEBoK is also a resource for practicing engineers who teach, as well as those taking training courses.

References

Works Cited

Pew, R. and A. Mavor. 2007. *Human-System Integration in the System Development Process: A New Look*. Washington, DC, USA: The National Academies Press.

Primary References

None.

Additional References

None.

< Previous Article | Parent Article | Next Article >
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