Guide to the Systems Engineering Body of Knowledge (SEBoK) version 0.75

Part 1

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Part 1

From .75 Sebokcase

Part 1 Contents

Part 1: SEBoK 0.75 Introduction

Systems Engineering (SE) (glossary) is essential to the success of many human endeavors. Today, SE is increasingly recognized worldwide for its importance in the development (glossary), deployment (glossary), operation (glossary), and evolution of systems (glossary) with a wide variety of scale, complexity (glossary), and purpose (glossary).

This Guide to the Systems Engineering Body of Knowledge (SEBoK) defines and organizes the knowledge of the SE discipline, including its vocabulary, concepts (glossary), methods, processes (glossary), practices, and tools. It does not attempt to reprint all SE knowledge, which is far too large and dynamic to be captured in any single place. Rather, the SEBoK is a guide for the user in finding and understanding the literature about SE that has been separately published in books, articles, websites, and other generally accessible resources.

All references included in the SEBoK are generally available to any interested reader (i.e., no proprietary information is referenced), but they are not all free (e.g., some books or standards that must be purchased from their publishers). The criterion for including a source is simply that the authors believed it was among the best generally available sources of information on a particular subject.

The SEBoK is one of two products being developed by the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) Project (http://www.bkcase.org/) . The other product, the Graduate Reference Curriculum in Systems Engineering (GRCSE) (http://www.bkcase.org/grcse-05/) uses the content of the SEBoK to define a core Body of Knowledge to be included in graduate SE curricula. The GRCSE is not a standard, but a reference curriculum to be tailored (glossary) and extended to meet the objectives of each university’s graduate program.

Acknowledgements for the many valuable BKCASE collaborators can be found here.

Part 1 Articles

The following articles are discussed in Part 1 and provide an introduction to the tenets of the SEBoK:

- Scope and Context of the SEBoK
- Structure of the SEBoK
- Economic Value of Systems Engineering
- Systems Engineering: Historic and Future Challenges
- Systems Engineering and Other Disciplines
- SEBoK Users and Uses
- SEBoK Evolution
- Acknowledgements

Purpose of the SEBoK

The purpose of the SEBoK is to provide an evolvable community-consensus baseline body of knowledge that can serve as a working set of definitions, principles (glossary), processes, and good practices for the SE field. It is intended to describe the boundaries (glossary), terminology, content, and structure (glossary) of SE that are needed to systematically and consistently support the six broad purposes shown in Table 1.

Table 1. SEBoK Purposes (Table Developed for BKCASE)

Task Name	Task Description
Inform Practice	Inform systems engineers (glossary) about the boundaries, terminology, and structure of their discipline and point them to useful information needed to practice SE in any application domain (glossary).
Inform Research	Inform researchers about the limitations and gaps in current SE knowledge that should help guide their research agenda.
Inform Interactors	Inform performers in interacting disciplines (system implementation, project and enterprise (glossary) management, other disciplines) of the nature and value (glossary) of SE.
Inform Curriculum Developers	Inform organizations defining the content that should be common in undergraduate and graduate programs in SE.
Inform Certifiers	Inform organizations certifying individuals as qualified to practice systems engineering.
Inform SE Staffing	Inform organizations and managers deciding which competencies (glossary) that practicing systems engineers should possess in various roles ranging from apprentice to expert.

The SEBoK is intended to be a guide to the body of knowledge, but does not seek to capture all the knowledge directly. It provides references to more detailed sources of knowledge, and is constructed to facilitate easy update as the field evolves and new sources of knowledge emerge. The SEBoK is also intended to be global in applicability. Despite the challenge that SE is practiced differently from industry to industry and country to country, the SEBoK must be useful to systems engineers around the world. The authors have been chosen from a diverse set of locales and industries to help ensure its broad applicability. With the opening of version 0.75 (the current version) for global review, the authors hope to gain feedback that will enable them to refine the SEBoK into something that is even more universally applicable.

The SEBoK should inform a wide variety of user communities on essential SE concepts and practices, in ways that can be tailored to different enterprises and activities, while retaining more commonality and consistency than is currently possible. The dynamism of the world in which SE is being applied will require continuing update of the SEBoK.

Scope and Context of the SEBoK

The majority of the SEBoK (Parts 2 – 6) focuses on domain-independent information – that which is universal to systems engineering regardless of the domain in which it is applied. Part 7, Systems Engineering Implementation Examples includes examples from real projects, which illustrate the concepts discussed in elsewhere in the SEBoK. As real examples, these include considerations relevant to specific domains, such as aerospace, medical, and transportation. The SEBoK scope is primarily focused on SE in the context of engineered systems (ES) (glossary), including socio-technical systems (glossary), though general systems concepts (glossary) are also discussed in Part 2, Systems. Also, the SEBoK includes considerations for closely-related disciplines (See Part 6, Related Disciplines); i.e., disciplines such as software engineering (See Systems Engineering and Software Engineering) and Project Management (glossary) (See Systems Engineering and Project Management), which are strongly intertwined with the practice of SE.

These are summarized in Part 1 by two diagrams. One summarizes the agent-activity-artifact context diagram summarizes the interactions among systems engineers, systems developers, and an engineered system's environment (glossary) across its life cycle of system definition, development, evolution (production, utilization, and support) and retirement. A second, the agents, activities, and artifacts involved in the SEBoK's definition by an international group of volunteer authors; its review by the SE community at large; its life cycle (glossary) evolution management and support by the two primary international SE-related professional societies, the Institute of Electrical and Electronic Engineers (IEEE) (http://www.ieee.org/index.html) and the International Council on Systems Engineering (INCOSE) (http://www.incose.org) ; and its use in derivative products and services by the community at large. (These figures and more related information can be seen in Scope and Context of the SEBoK.

These are further elaborated in Part 2, Systems on the nature of systems and systems engineering and in the Life Cycle Models topic in Part 3; and then more precisely contextualized in the SEBoK Concept Map. The SEBoK Concept Map, expressed in the Systems Modeling Language (SysML), relates the SEBoK to its environment and shows how the parts of the SEBoK fit together into an integrated whole.

Systems and Systems Engineering

In order to create the SEBoK, the authors began by defining what is meant by the terms "system" and "systems engineering". There is controversy about how these terms should be defined and used within the SE community and as such, there are many different definitions. The SEBoK authors have chosen constructs for "system" and "systems engineering" that are useful, but recognize that they will not be considered "right" by the entire community.

For the purposes of the SEBoK, a system is primarily defined as "a set of related elements that form an integrated whole" (Bertalanffy 1968) and which exists in an environment which contains related systems and conditions. While there are many definitions of the word system, the authors believe that this definition is comprehensive enough to encompass most of those which are relevant to systems engineering. The SEBoK also specifically defines an engineered system as an open, concrete system of technical or sociotechnical elements that exhibits emergent properties not exhibited by its individual elements. Its characteristics include being created by and for people; having a purpose, with multiple views; satisfying key stakeholders' value propositions; having a life cycle and evolution dynamics; having a boundary and an external environment; and being a part of a System of Interest (SoI) hierarchy.

For the purposes of the SEBoK, systems engineering is defined as "an interdisciplinary approach and means to enable the realization of successful systems" (INCOSE 2011). It focuses on [[Holistic (glossary)|holistically] (glossary)] and concurrently understanding stakeholder (glossary) needs; exploring opportunities (glossary); documenting requirements (glossary); and synthesizing (glossary), verifying (glossary), validating (glossary), and evolving solutions (glossary) while considering the complete problem (glossary), from system concept exploration through system disposal (glossary) (See Disposal and Retirement).

These terms can be found in the glossary. Readers should note that in addition to the recommended definition(s) provided, there is also discussion of other existing definitions, how these definitions came about, and where within the community these other definitions are used. For more discussion on the definition of systems, please see the What is a System? article in Part 2; for more on systems engineering, please see Part 3, Systems Engineering and Management.

SEBoK Uses

Early in the BKCASE project, the authors identified potential users of the SEBoK and ways in which these individuals might utilize the information found in the SEBoK. This information was included in version 0.25, which was released for limited review in September 2010. (See "SEBoK Development," below.) Based on this review, the authors refined the list of users and use cases, which can be found in the article SEBoK Users and Uses. This discussion includes consideration of primary users – those who will directly use the SEBoK – and secondary users – those who are expected to require assistance from a systems engineer to utilize the SEBoK. For more information, please see the SEBoK Users and Uses article.

SEBoK Development

The first version of the SEBoK – a prototype labeled Version 0.25 – was released as a PDF document for limited review in September 2010. A total of 3135 comments were received on this document from 114 reviewers across 17 countries. The author team reviewed these comments, paying particular attention to the reviews related to content and highlighting diversity within the community. The second version of the SEBoK – a prototype labeled Version 0.5 – was released on September 19, 2011. This, the third version 0.75 of the SEBoK, was released on March 15, 2011.

In January 2011, the authors agreed to transition from a document-based SEBoK to a wiki-based SEBoK, with the intent to make the information readily accessible worldwide, provide additional methods for searching and navigating the content, and provide a forum for the community to offer feedback while keeping the content of the SEBoK stable between versions. For more information, please see the SEBoK Evolution article.

References

Works Cited

INCOSE. 2011. *INCOSE Systems Engineering Handbook*, version 3.2.1. San Diego, CA, USA: International Council on Systems Engineering (INCOSE). INCOSE-TP-2003-002-03.2.

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SEBoK 0.75 Reviews

Please provide your comments and feedback on SEBoK 0.75 below. You will need to log in to DISQUS using an existing account (e.g. Yahoo, Google, Facebook, Twitter, etc.) or create a DISQUS account (click "DISQUS" button). Please look for the posts by "BKCASE" for specific issues on which the author team would like feedback.

Scope and Context of the SEBoK

The scope of the Guide to the Systems Engineering Body of Knowledge (SEBoK) can be discussed in several dimensions. In general, the SEBoK is bounded by the following:

- The SEBoK is a guide to the body of knowledge versus a stand-alone body of knowledge, providing references to detailed sources for additional information.
- The SEBoK is primarily domain (glossary) independent, with implementation examples providing the domain-specific context (glossary).
- The SEBoK is focused on engineered systems (glossary) (ES) (e.g. products (glossary), services (glossary), Systems of Systems (SoS), and enterprises (glossary)), treating social (glossary) and natural (glossary) systems as relevant and important environmental considerations for ESs (please see “Scope of Systems Engineering within the Systems Domain” below). For additional discussion, please see the Part 2 What is a System? article.
- The SEBoK acknowledges similarities and differences in the application of SE principles to different types of systems (please see Part 4, Applications of Systems Engineering).
- The SEBoK acknowledges and discusses the interaction between systems engineering (glossary) (SE) and other disciplines, highlighting what systems engineers (glossary) need to know about these disciplines (please see Part 6, Related Disciplines).

Each of these considerations is dependent upon the definition and scope of SE. For the SEBoK, the boundaries of SE are defined below. External to the boundaries (glossary) of SE and the SEBoK, the context (glossary) of each is discussed with respect to the agents, activities, and artifacts involved in the SEBoK life cycle (glossary); the life cycle of SE in the context of an ES; and SEBoK externalities with respect to domain-dependent SE.

Scope of Systems Engineering within the Systems Domain

The scope of SE and the SEBoK must ``consider’’ all classes of systems, but ``focuses’’ on the domain of ESs. Socio-technical systems (glossary) are treated as a special form of engineered systems. A convenient way to define the scope of ESs and the SEBoK is to relate it to the two other systems domains, natural systems and social systems, as shown in Figure 1 below.

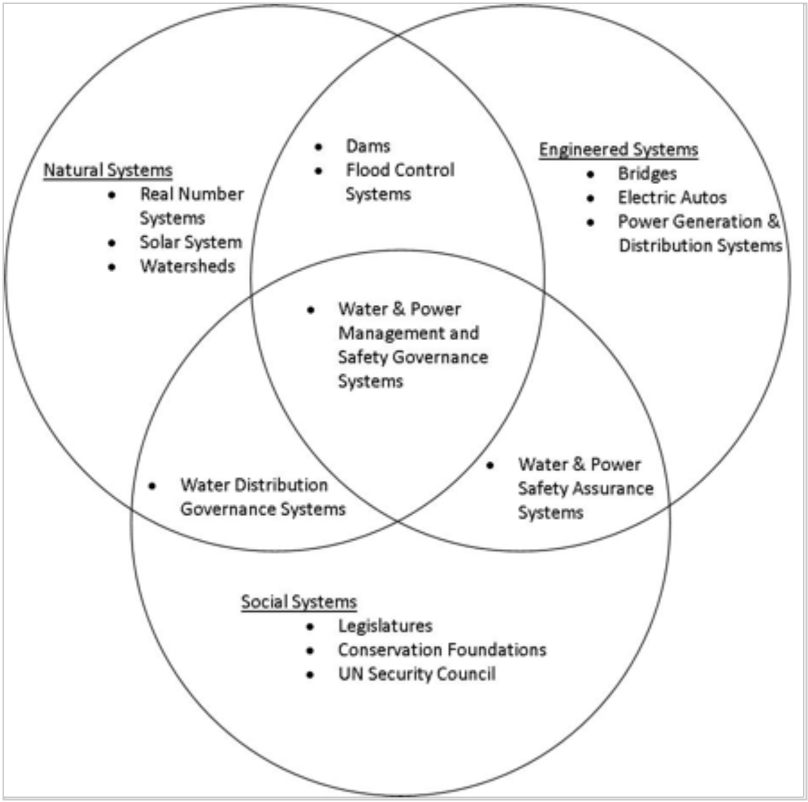

Figure 1. System Boundaries of Engineered Systems, Social Systems, and Natural Systems (Figure Developed for BKCASE)

The nature of and relationships between these system domains is discussed in Part 2, Systems of the SEBoK. Part 2 considers the general nature and purpose (glossary) of systems (glossary) and how these ideas are used to ensure better-ESs. It covers this by considering:

- Systems Thinking (glossary) – a way of understanding complex situations by looking at them as combinations of systems.
- Systems Science (glossary) – a collection of disciplines that have created useful knowledge by applying systems thinking and the scientific method to different aspects of the system domains.
- Systems Approach (glossary) – a way of tackling real world problems (glossary) which makes use of the tools of system science to enable useful systems to be engineered and used.

The systems approach requires understanding of both natural and socio-technical systems to identify and scope the engineering of system problems (glossary) or opportunities (glossary). It is critical to understand each of these system types if ESs are to be deployed into real world situations, achieve their assigned goals, and not adversely impact other outcomes.

The primary focus of the knowledge in Part 3, Systems Engineering and Management and Part 4, Applications of Systems Engineering is on how to create or change ESs to fulfill the goals of all relevant stakeholders within these wider system contexts. The knowledge in Part 5, Enabling Systems Engineering and Part 6, Related Disciplines includes the need for SE itself to be integrated and supported within the human activity systems in which it is performed and the relationships between SE and other engineering and management disciplines.

Scope of Systems Engineering (SE) within the Engineered Systems (ES) Domain

The scope of SE does not include the entire ES domain. Activities such as system construction, manufacturing, funding, and general management are part of the SE environment (glossary), but other than the specific management of the SE function, are not considered as part of SE. This is reflected in the International Council on Systems Engineering (INCOSE (http://www.incose.org)) top-level definition of systems engineering as, “an interdisciplinary approach and means to enable the realization of successful systems.” (INCOSE 2011) For example, SE can enable the realization of successful systems, but cannot ensure a successful realization if the systems’ funding, implementation (glossary), and manufacturing are poorly managed and executed.

Again, a convenient way to define the scope of SE within the ES domain is to develop a Venn diagram showing the relations among SE, system implementation, and project (glossary)/systems management, as shown in Figure 2. Activities, such as analyzing alternative methods for production, testing, and operations, are part of SE planning and analysis functions. Such activities as production line equipment ordering and installation, and its use in manufacturing, are still important SE environment considerations even though they are "outside" the SE boundary (glossary). Note that as defined in Figure 2, system implementation engineering (glossary) also includes the software (glossary) production aspects of system implementation. Software engineering, then, is not considered a subset of SE.

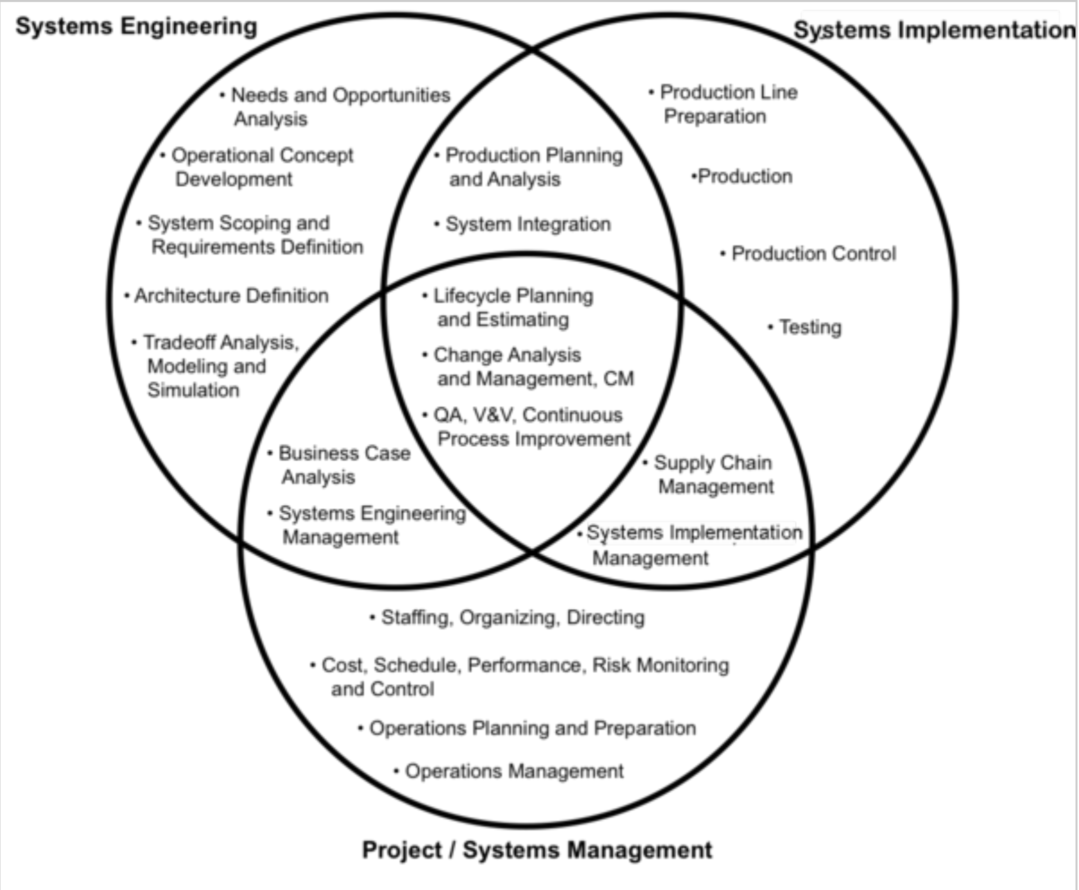

Figure 2. System Boundaries of Systems Engineering, Systems Implementation, and Project/Systems Management (Figure Developed for BKCASE)

Traditional definitions of SE have emphasized sequential performance of SE activities, e.g., "documenting requirements (glossary), then proceeding with design synthesis (glossary)…". (INCOSE 2011) The SEBoK authors have emphasized the inevitable intertwining of system requirements (glossary) definition and system design (glossary) in the following revised definition of SE:

> Systems Engineering (SE) is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on holistically (glossary) and concurrently understanding stakeholder needs; exploring opportunities; documenting requirements; and synthesizing, verifying (glossary), validating (glossary), and evolving solutions (glossary) while considering the complete problem, from system concept (glossary) exploration through system disposal (glossary). (INCOSE 2011, modified)

Part 3, Systems Engineering and Management, elaborates on the definition above and offers additional definitions and constructs, providing further context for the other parts of the SEBoK.

Context of the SEBoK

SEBoK Life Cycle Context

Figure 3 summarizes the main agents, activities, and artifacts involved in the SEBoK life cycle. The SEBoK is one of two primary products of the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) Project [1] (http://www.bkcase.org/) . The other product, the Graduate Reference Curriculum in Systems Engineering (GRCSE) [2] (http://www.bkcase.org/grcse-05/) uses the content of the SEBoK to define a core body of knowledge (CorBoK) to be included in graduate SE curricula. The GRCSE is not a standard, but a reference curriculum to be tailored and extended to meet the objectives of each university's graduate program.

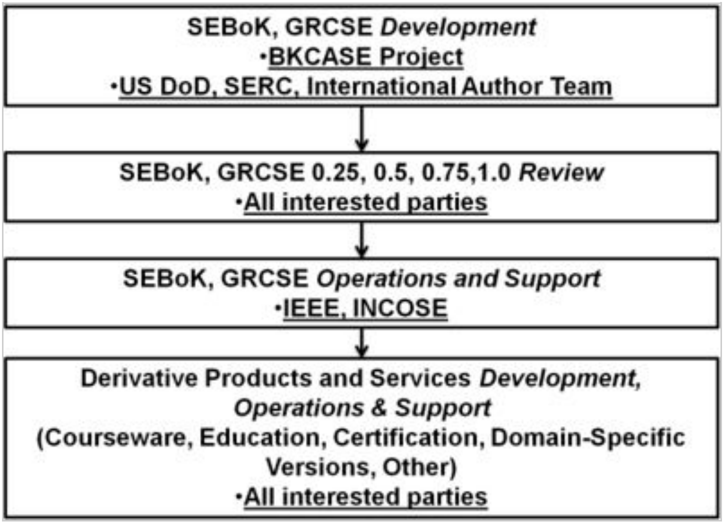

Figure 3. SEBoK Life Cycle and Context: Related Agents, Activities, and Artifacts (Figure Developed for BKCASE)

The BKCASE project, led by Stevens Institute of Technology and the Naval Postgraduate School, has drawn on three primary resources. The U.S. Department of Defense (DoD) [3] (http://www.defense.gov/) has provided the funding and includes a representative, but has not constrained or directed the project's approach and content. The DoD Systems Engineering Research Center (SERC) [4] (http://www.sercuarc.org/) , a DoD university affiliated research center operated by Stevens Institute of Technology [5] (http://www.stevens.edu) , supports BKCASE management and infrastructure and is the means by which DoD funding is delivered to the BKCASE project. The over 70 international author team members have been selected for their expertise in SE and their diversity with respect to home country (authors have come from 15 different countries), economomic sector (government, industry, academia), and SE specialty area. Except for travel support in a few cases, authors have donated their time to the development of the SEBoK content.

The SEBoK content has been incrementally developed. Each of the 0.25, 0.5, and 0.75 versions has undergone an open review by all interested parties. Reviews have involved over 200 reviewers and thousands of comments each of which has been adjudicated. Upon completion of the initial SEBoK and GRCSE development in late 2012, the Institute of Electrical and Electronic Engineers (IEEE) [6] (http://www.ieee.org/index.html) and the International Council on Systems Engineering (INCOSE) [7] (http://www.incose.org/) will likely become the primary stewards for both the SEBoK and GRCSE. The continuing role of Stevens Institute, Naval Postgraduate School, and the SERC in SEBoK and GRCSE operations and maintenance will also be decided in 2012. Interested parties should be able to undertake development, operations, and support of additional derivative products and services, such as courseware, education, certification, and domain-specific versions of the SEBoK and GRCSE.

SE and Engineered Systems Project Life Cycle Context

Figure 4 summarizes the main agents, activities, and artifacts involved in the life cycle of SE, in the context of a project to create and evolve an ES. For each primary project life cycle phase of system definition (glossary), system initial operational capability (IOC) development, and system evolution and retirement, it shows the activities being performed by the primary agents (the systems engineers, the systems developers, and the primary project-external bodies (users (glossary), owners, external systems) constituting the project environment, in creating the evolving states of the ES, which may be a product, service, and/or enterprise.

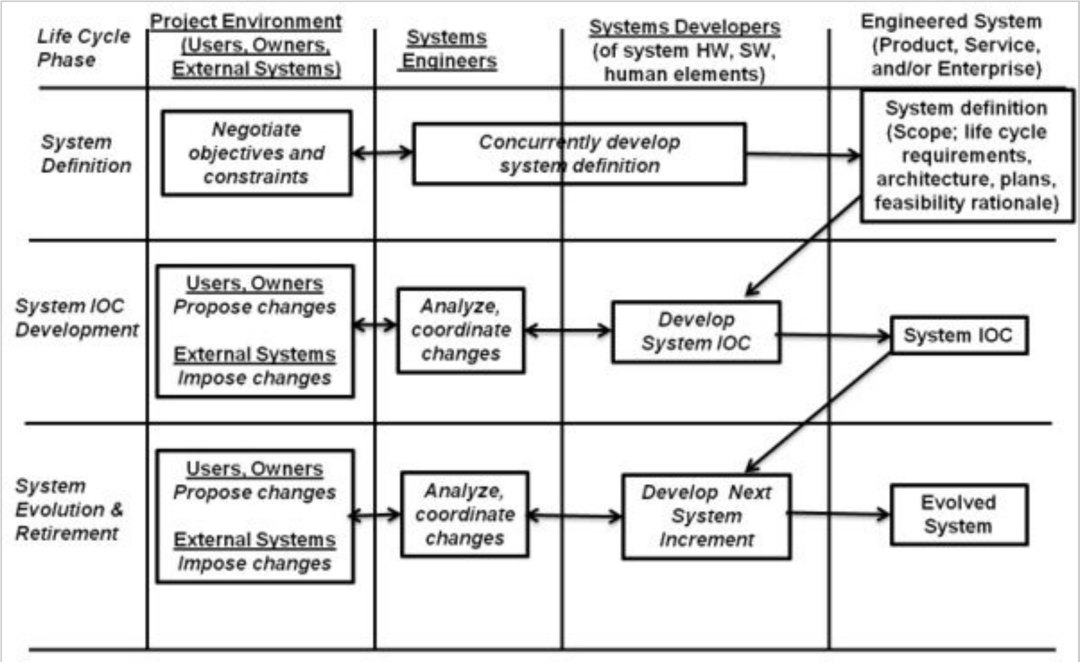

Figure 4. SE and Engineered System Project Life Cycle Context: Related Agents, Activities, and Artifacts(Figure Developed for BKCASE)

The semantics of the boxes and arrows in Figure 4 are that the boxes in the center three columns show activities being performed by the relevant agents in the column, while the boxes in the right-hand column are the resulting artifacts. An arrow going from box A to box B means that the successful outcome of box B depends on the successful outcome of box A. In some cases in Figure 4, there are two-way dependencies, as in the handling of the inevitable changes that arise during system development and evolution.

For example, the system's users and owners may propose changes to respond to competitive threats (glossary) or opportunities (glossary), or to adapt to changes imposed by independently evolving external systems, such as Commercial-off-the-Shelf COTS products, cloud services, or supply chain enablers. These require negotiation among these stakeholders and the system developers, in which the SEs play a key role in analyzing the relative costs (glossary) and benefits of alternative change proposals, and in synthesizing mutually satisfactory solutions.

Domain Independence Context

SE is practiced in numerous domains such as telecommunications, finance, medicine, and aircraft. Each of these domains will have its own specialized vocabulary and key domain concepts. The language and concepts contained in the SEBoK are intended to be what is generally accepted for domain-independent SE. For example, there are domain-independent foundations for SE such as the concepts elaborated in Part 2, Systems of the SEBoK. For the SEBoK, the main body is domain-independent. In order to show how the domain-independent material relates to different domains, several case studies and vignettes demonstrating the effect of domain on the application of SE complement the domain-independent information. Initial versions of the case studies and vignettes are provided in Part 7, Systems Engineering Implementation Examples. The examples demonstrate how a concept would work in a given domain and provide a fair opportunity for reviewers to reflect on whether there are better ways to capture application-dependent aspects of SE knowledge. The authors recognize that including many more case studies would add significantly to the value of the SEBoK, and expect that additional examples will be added during the evolution of the SEBoK.

References

Works Cited

INCOSE. 2011. *Systems Engineering Handbook*, version 3.2.1. San Diego, CA, USA: International Council on Systems Engineering (INCOSE). INCOSE-TP-2003-002-03.2.

Primary References

No primary references have been identified for version 0.75. Please provide any recommendations on primary references in your review.

Additional References

No additional references have been identified for version 0.75. Please provide any recommendations on additional references in your review.

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Comments from SEBoK 0.5 Wiki

Please note that in version 0.5, this article was titled “Scope of the SEBoK”.

SEBoK 0.75 Reviews

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Structure of the SEBoK

As discussed in the Guide to the Systems Engineering Body of Knowledge (SEBoK) SEBoK 0.75 Introduction, the SEBoK is focused primarily on domain-independent knowledge, with one part devoted to implementation examples. The SEBoK is divided into seven parts, as discussed below.

Structure

- Part 1, SEBoK 0.75 Introduction - This part provides the “opening” material to the SEBoK. Primarily, the section introduces the SEBoK (purpose (glossary), scope (glossary), context (glossary), structure (glossary), and economic value (glossary)), the concepts (glossary) of systems (glossary) and systems engineering (glossary) (SE), including an introduction to the history and future challenges of SE, an introduction to the discussion of related disciplines, the use cases (glossary) for the SEBoK, a discussion of SEBoK development and its future evolution, and acknowledgements.

- Part 2, Systems - This part focuses on defining what is created by SE, as well as on providing links to the appropriate aspects of systems science. Specifically, Part 2 provides a discussion of what systems are (including aspects of systems thinking), provides system concepts (truisms about systems which are important for SE), discusses the different types of systems, provides information on different representations of systems (models), and discusses the Systems Approach and Systems Challenges. In particular, the systems approach and SE challenges have strong links to Parts 3, Systems Engineering and Management and 4, Applications of Systems Engineering.

- Part 3, Systems Engineering and Management - This part specifically focuses on how SE is conducted. It includes discussion of the traditional SE processes, such as Concept Definition and System Definition, System Realization, and System Deployment and Use, as well as Systems Engineering Management such as Risk Management, Decision Management, Configuration Management, Information Management, and Quality Management management. Part 3 also includes an overview of life cycles, as well as product and service life management. This part comprises a large portion of the SEBoK and is focused around what has traditionally been viewed by many as SE. It also includes information on Systems Engineering Standards, documented best practices, and common pitfalls for performing SE or systems management activities as appropriate.

- Part 4, Applications of Systems Engineering - focuses on providing guidance on how the processes and methods presented in Part 3, Systems Engineering and Management can, and should, be applied to specific types of systems, specifically Product Systems Engineering, Service Systems Engineering, Enterprise Systems Engineering, and Systems of Systems (SoS).
- Part 5, Enabling Systems Engineering - This part deals with the different ways in which a group can organize to perform SE activities. Specifically, Part 5 discusses strategies for organizing for SE, including value (glossary) propositions, purpose (glossary), and governance (glossary), considerations at the business and enterprise level, and considerations for teams and individuals within an organization (glossary), including competency (glossary), personal SE development, and ethics.
- Part 6, Related Disciplines - This part contains knowledge areas which deal with the intertwining of SE with software engineering (SwE), project management (PM), industrial engineering, procurement and acquisition, and specialty engineering, including discussions of the various system "–ilities" to be balanced and integrated by SE.
- Part 7, Systems Engineering Implementation Examples - This part provides real-world examples of SE activities and links the concepts in those activities to the SEBoK. There are two main types of examples: Case Studies and Vignettes. The case studies included in Part 7 are previously existing case studies that examine the successes and challenges in past SE programs; the Part 7 team connects the case study information to the related SEBoK knowledge areas (KAs) and topics. Vignettes are smaller-scale examples, but are still based on real-world systems. It is important to note that discussion of these examples is centered around links to the SEBoK; it is ''not'' the intention of the SEBoK authors to make value judgments regarding these examples or the systems they describe.

A key activity in the integration of the various parts of the SEBoK has been the development, application, and iteration of a Systems Modeling Language (SysML) concept map. This map shows the relationships among the elements of the SEBoK and its external environment. Two figures have been developed from this concept map, which can be seen in the Scope and Context of the SEBoK section. These figures will be useful in navigating the SEBoK.

References

Works Cited

None.

Primary References

No primary references have been identified for version 0.75. Please provide any recommendations on primary references in your review.

Additional References

No additional references have been identified for version 0.75. Please provide any recommendations on additional references in your review.

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SEBoK 0.75 Reviews

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Economic Value of Systems Engineering

Trends Toward Increasing the Value of Systems Engineering

The systems engineering (glossary) (SE) of traditional artifacts, such as railroads, reservoirs, and refrigerators, could count on having a relatively self-contained system (glossary) to engineer, with relatively stable requirements (glossary), a sound scientific base, and numerous previous precedents. However, more and more systems (glossary) need to be engineered to become parts of several evolving systems of systems (SoS) (glossary) with rapidly increasing scale, dynamism, interdependence, human-intensiveness, sources of vulnerability, and novelty, placing an ever higher economic value (glossary) on the performance of effective SE. This is corroborated by the Case Studies and Vignettes in Part 7. The shortfalls in SE in the United States Federal Aviation Administration (FAA) Advanced Automation System (AAS), United States Federal Bureau of Investigation (FBI) Virtual Case File System, Hubble Space Telescope, and Therac-25 medical linear accelerator, led to either extremely expensive cancelled systems or much more expensive systems in terms of total cost of ownership or loss of human lives. On the other hand, the Global Positioning System (GPS), Miniature Seeker Technology Integration Project (MSTI), and Next Generation Medical Infusion Pump Project, all demonstrated that investment in thorough SE, led to highly cost-effective systems. Figure 1 summarizes the analyses by Werner Gruhl relating investment levels in SE to cost overruns of United States National Aviation Administration (NASA) projects (glossary) (Stutzke 2005).

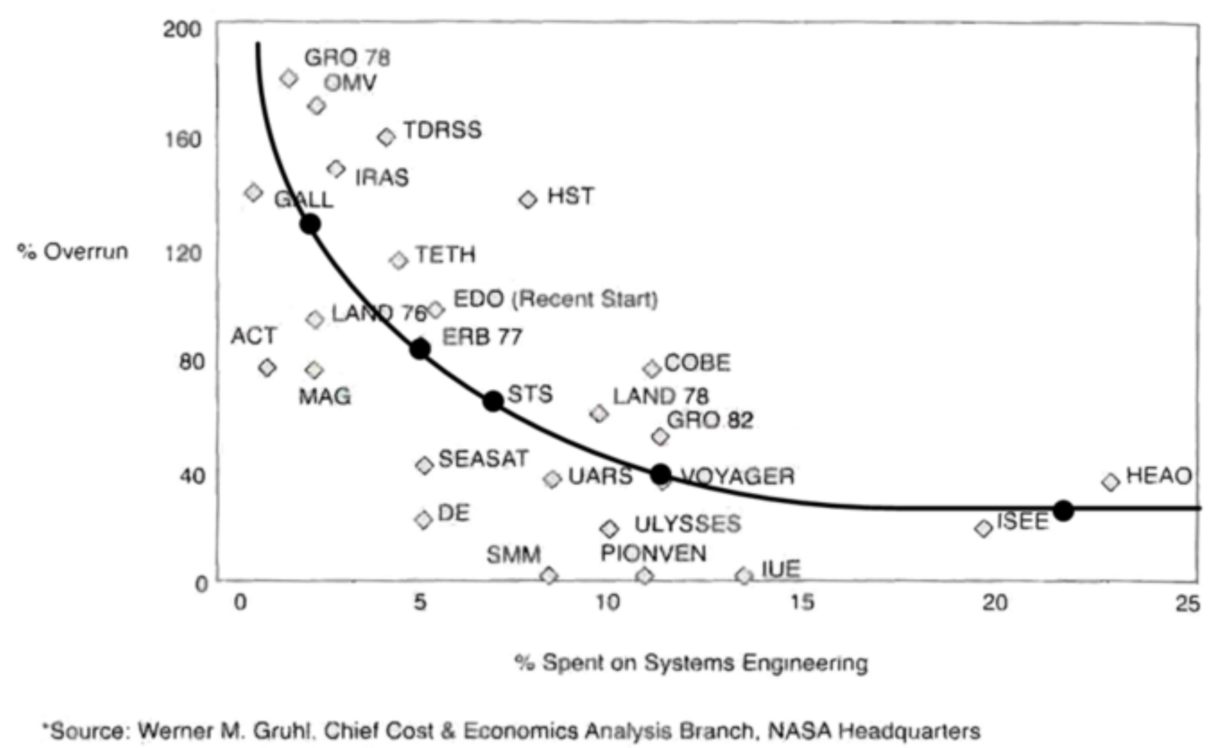

Figure 1. Relation of SE Investments to NASA Program Cost Overruns (Stutzke 2005) Released by NASA HDQRT./Gruhl)

Further Quantitative Evidence of the Value of Systems Engineering

Analysis of the effects of shortfalls in systems architecture (glossary) and risk (glossary) resolution (the results of inadequate SE) for software-intensive systems in the 161-project COnstructive COst MOdel II (COCOMO™ II) [8] (http://sunset.usc.edu/csse/research/COCOMOII/cocomo_main.html) database, showed a statistically-significant increase in rework costs (glossary) as a function of project size: averages of 18% rework for ten thousand source lines of code (SLOC) projects and 91% rework for ten million SLOC projects. This result has been used to help enable major system projects to rectify their initial under investments in SE (e.g., Boehm et al. 2004), and to help determine "how much SE is enough" in general by balancing the risks of SE underinvestment and overinvestment (often called "analysis paralysis"), as shown in Figure 2 (Boehm-Valerdi-Honour 2008).

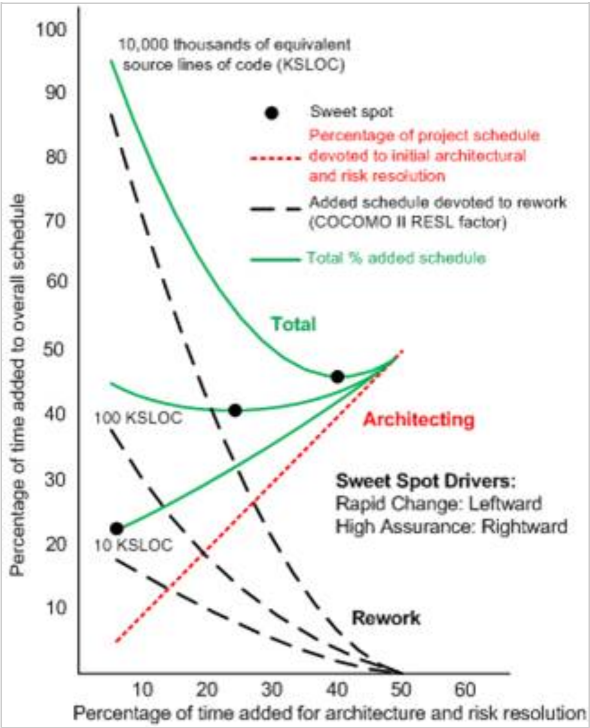

Figure 2. Risk-Balanced "How Much SE Is Enough" (Boehm, Valerdi, Honour 2008) Reprinted with permission of John Wiley & Sons Inc.

In general, small projects can quickly compensate for neglected SE interface (glossary) definition and risk resolution, but as projects get larger, with more independently-developed components (glossary), the late-rework costs rise much more rapidly than the savings in reduced SE effort. Medium-sized projects have relatively flat operating regions, but very large projects pay extremely large penalties for neglecting thorough SE.

A calibrated model (glossary) for further determining "how much SE is enough" has been developed in (Valerdi 2008). It estimates the number of person-months that a project will need for its SE as a function of system size (numbers and complexity (glossary) of requirements (glossary), interfaces, operational (glossary) scenarios, and key algorithms) modified by 14 factors that account for the effects on needed SE effort of requirements, architecture understanding, technology maturity, legacy-system migration, personnel capabilities (glossary), process (glossary) maturity, tool support, etc.

The quantitative effort project-data determined results are corroborated by the results of extensive surveys and case study analyses. Survey data on software cost and schedule overruns in *My Life Is Failure: 100 Things You Should Know to Be a Better Project Leader* (Johnson 2006) indicate that the primary sources of the roughly 50% of the commercial projects with serious "software overruns" were actually due to shortfalls in SE (lack of user input, incomplete requirements, unrealistic expectations, unclear objectives, and unrealistic schedules). The extensive Software Engineering Institute (SEI) [9] (http://www.sei.cmu.edu/) - National Defense Industrial Association (NDIA) [10] (http://www.ndia.org/Pages/Default.aspx) survey of 46 government-contracted industry projects showed a strong correlation between higher project SE capability and higher project performance (Elm et al. 2007). Ongoing research combining project data and survey data reported in "Toward An Understanding of The Value of SE" (Honour 2003) and "Effective Characterization Parameters for Measuring SE" (Honour 2010) provide additional evidence of the economic value of SE, and further insights on SE critical success factors. Further information can be found in the “Value Proposition for SE” article in Part 5, Enabling Systems Engineering.

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SEBoK 0.75 Reviews

Please provide your comments and feedback on SEBoK 0.75 below. You will need to log in to DISQUS using an existing account (e.g. Yahoo, Google, Facebook, Twitter, etc.) or create a DISQUS account (click "DISQUS" button). Please look for the posts by "BKCASE" for specific issues on which the author team would like feedback.

Systems Engineering: Historic and Future Challenges

The evolution of Systems Engineering (glossary) (SE) can be viewed in terms of challenges and responses. Humans have been presented with increasingly complex (glossary) challenges and have had to think systematically and holistically (glossary) in order to produce successful responses. In regards to SE, these efforts were followed by generalists who developed more generic principles (glossary) and practices for repeating past successes.

Historical Perspective

Some of the earliest relevant challenges were in organizing cities, as described in Lewis Mumford's *The City in History* (Mumford 1961). The various functions of emerging cities, such as storing grain and emergency supplies; defending the stores and the city; supporting transportation and trade; accommodating palaces, citadels, temples, and afterlife preparations; providing a water supply; etc. required considerable holistic planning and organizational (glossary) skills. Such skills were independently developed in the Middle East, Egypt, Asia, and Latin America.

The next wave of challenges and responses came with the emergence of megacities and mobile cities for military operations, such as those present in the Roman Empire. These also spawned generalists and their ideological works, such as Vitruvius and his *Ten Books on Architecture* (Vitruvius: Morgan transl. 1960). "Architecture" in Rome not only included buildings, but also aqueducts, surveying, landscaping, central heating, and overall planning of cities.

The next wave of challenges and responses came with the Industrial Revolution. In the nineteenth century, considerable new holistic thinking, planning, and execution were required for the creation and sustainment (glossary) of canal, railroad, and metropolitan transit systems (glossary) to support transportation along with general treatises, such as *The Economic Theory of the Location of Railroads* (Wellington 1887). In the early twentieth century, these involved large-scale industrial enterprise engineering, such as the Ford automotive assembly plants, along with general treatises, such as *The Principles of Scientific Management* (Taylor 1911).

Another wave of challenges and responses came with World War II and the complexities (glossary) of real-time command and control (glossary) of extremely large multinational land, sea, and air forces and their associated logistics (glossary) and intelligence functions (glossary). After the war, and coinciding with the emergence (glossary) of the Cold War and Russian space achievements, considerable investments were made by the U.S. and its allies in researching and developing principles (glossary), methods, processes (glossary), and tools for military defense systems. These were complemented by initiatives addressing industrial and other governmental systems, leading to such landmarks as the codification of operations research and SE in *Introduction to Operations Research* (Churchman et. al 1957), Warfield (1956), and Goode-Machol (1957) and the general Rand Corporation approach to government systems analysis as seen in *Efficiency in Government Through Systems Analysis* (McKean 1958). The late 1940's to 1970's saw the development of general theories of system behavior (glossary) and SE, such as cybernetics (Weiner 1948), system dynamics (Forrester 1961), general systems theory (Bertalanffy 1968), and mathematical systems engineering theory (Wymore 1977).

Beginning in the 1960's, and increasing in the 1970's through 1990's, two further sources of challenge emerged. One was the increasing growth of software (glossary) functionality in systems; e.g., software was responsible for functionality in 8% of military aircraft in 1960, but this number rose to 80% in 2000 (Ferguson 2001). The second source of challenge was the increasing awareness of the criticality of the human element in complex systems. These challenges led to a reorientation from traditional hardware-oriented SE with sequential processes, pre-specified requirements (glossary), and functional-hierarchy (glossary) architectures (glossary) to more "soft" SE approaches with emergent (glossary) requirements, concurrent (glossary) vs. sequential definition of requirements and solutions (glossary), combinations of layered service (glossary)-oriented and functional-hierarchy architectures, heuristic (glossary) vs. pure mathematical solution approaches, and evolutionary vs. single-step system development. Good examples are societal systems (Warfield 1976), soft systems methodology (Checkland 1981) and systems architecting (Rechtin 1991; Rechtin-Maier 1997). As with Vitruvius, architecting (glossary) was not confined to producing blueprints from requirements, but covered concurrent operational (glossary) concept (glossary), requirements, architecture, and life cycle (glossary) plans (glossary) definition.

Evolution of Systems Engineering Challenges

During the 1990's and 2000's, even greater challenges arose in the rapidly increasing scale, dynamism, and sources of vulnerability in the systems needing to be engineered. The Internet has made it possible to benefit from the rapid interoperability (glossary) of net-centric systems of systems (SoS) (glossary), but has also created new sources of system vulnerability and obsolescence as new Internet services (grids, clouds, social networks (glossary), search engines, geolocation services, and recommendation services) proliferate and compete with each other. At the same time, solution approaches have proliferated. Domain (glossary)-specific model (glossary)-based approaches offer significant benefits and are proliferating, carrying with them the challenge of reconciling many different domain assumptions in order to get the domain-specific systems to interoperate (glossary). Similar trends toward increasing rates of change are also continuing to present further SE challenges in such areas as biotechnology, nanotechnology, and massively parallel data processing.

The proliferation of object-oriented methods was partially addressed by the development of the Unified Modeling Language (UML) [11] (http://www.uml.org/) and the Systems Modeling Language (SysML) [12] (http://www.omgsysml.org/) , but there is now a wide variety of tools available to apply UML and SysML, and also a large selection of alternative requirements and architecture representations trying to compensate for the shortfalls of UML and SysML. Similar diversity is seen in various approaches to enterprise architecting (glossary), lean (glossary) and agile (glossary) processes, iterative and evolutionary processes, and methods for simultaneously achieving high-effectiveness, high-assurance, resilient, adaptive, and life cycle affordable systems.

This trend towards diversity has increased awareness that there is no one-size-fits-all product (glossary) or process approach that works best in all situations. Thus, another challenge is to determine which SE approaches work best in which situations in order to determine criteria for the choice of which SE approach to use in a given situation, and to determine how to sustain workable complex systems of systems containing different solution approaches. The SEBoK is organized in an attempt to accommodate this complexity and dynamism by presenting alternative approaches and current knowledge of where they work best. The wiki-based approach to the SEBoK provides a mechanism for allowing easy evolution if desired, while maintaining stability between versions.

Emerging future challenges for SE involve the assessment and integration of new technologies such as nanotechnology, mobile networking, social network technology, cooperative autonomous agent technology, cloud computing and data mining technology, and combinations of physical and biological entities. Ambitious projects are going forward to create smart services, smart hospitals, smart energy grids, and smart cities. These promise improved system capabilities (glossary) and quality of life, but carry serious risks (glossary) of reliance on immature technologies or on combinations of technologies with incompatible objectives or assumptions. The advantages of creating network-centric systems of systems to "see first," "understand first," and "act first" are highly attractive in a globally competitive world, but carry serious challenges of managing complexes of hundreds of independently-evolving systems over which one can have only partial control. The SE field will be increasingly needed, but increasingly challenged, to ensure that future systems will be scalable (glossary), stable, adaptable (glossary), and humane.

A more detailed view of SE challenges is provided in the Systems Challenges knowledge area (KA) within Part 2, Systems.

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Systems Engineering and Other Disciplines

As discussed in the Scope and Context of the SEBoK topic, there are many touch points and overlaps between Systems Engineering (glossary) (SE) and other disciplines. It is important for systems engineers (glossary) to have a basic understanding of the nature of these other disciplines and often there are specific aspects of another discipline that systems engineers need to be aware of. The discussion below provides an overview of the landscape of intertwined disciplines; for more specific information, please see Part 6, Related Disciplines.

Other Engineering Disciplines

The intellectual content of most engineering (glossary) disciplines is largely component (glossary)-oriented and value-neutral (Boehm and Jain 2006). The underlying laws and equations of engineering disciplines, such as Ohm's Law, Hooke's Law, Newton's Laws, Maxwell's equations, the Navier-Stokes equations, Knuth's compendia of sorting and searching algorithms, and Fitts's Law of human movement, deal with aspects of their system of interest's (glossary) performance. But they generally do not address the contributions of this performance to the value (glossary) propositions of the system's (glossary) success-critical stakeholders (glossary), such as funders, owners, users (glossary), operators, maintainers, manufacturers, and safety (glossary) and pollution regulators.

In some cases, such as aeronautical engineering, the engineer is concerned with evaluating and integrating various mechanical, electrical, fluid, combustion-chemical, software, and cockpit design elements into a system that satisfies various proxies of value, such as flight range, payload capacity, fuel consumption, maneuverability, and cost of production and maintenance (glossary). If the system of interest is the aircraft itself, aeronautical engineers are clearly operating as systems engineers as well. However, if aeronautical engineers participate in the engineering of wider systems of interest, such as the various passenger services (glossary), airport configurations, baggage handling, and local surface transportation options and their contribution to the value propositions of the success-critical stakeholders, then they are operating more as systems engineers. Overall, this is to be desired, as they possess key aircraft-domain expertise needed for effective engineering of the wider systems. As discussed in (Guest 1991), most good systems engineers are "T-shaped" people, who have a working knowledge of the wider-system considerations, but who have deep expertise in a relevant domain (glossary), such as aeronautical, manufacturing, software, or human factors (glossary) engineering.

As implicit in the International Council on Systems Engineering (INCOSE) [14] (http://www.incose.org) definition of SE, the intellectual content of realizing successful systems requires reasoning about the relative value of alternative system realizations to success-critical stakeholders, and about the organization of components and people into a system that satisfies the often-conflicting value propositions of the success-critical stakeholders (INCOSE 2011). Thus, compared to other engineering disciplines, the intellectual content of SE is more holistic (glossary) than component-oriented, and more stakeholder value-oriented than value-neutral performance-oriented.

Many systems today have significant software (glossary) content. In fact, most of the functionality of commercial and government systems is now implemented in software, and software plays a prominent, often dominant, role in differentiating competing systems in the marketplace. Software engineering (SwE) is not just an allied discipline, SwE and SE are intimately intertwined (Boehm 1994). Software is usually prominent in modern systems architectures (glossary) and is often the "glue" for integrating complex (glossary) system components. As discussed in the figure "System Boundaries of Systems Engineering, System Implementation, and Project/Systems Management" in Scope and Context of the SEBoK, the scope of SwE includes both software SE and software construction, but does not include hardware SE. Thus neither SwE nor SE is a subset of the other.

The SEBoK explicitly recognizes and embraces the intertwining between SE and SwE, which includes defining the relationship between the SEBoK and the Guide to the Software Engineering Body of Knowledge (SWEBOK) [15] (http://www.computer.org/portal/web/swebok/htmlformat) , which is published by the Institute of Electrical and Electronics Engineers (IEEE) (Abran et al. 2004) and is currently under revision. For more information, please see the topic on Systems Engineering and Software Engineering.

Similarly, the SEBoK explicitly recognizes and embraces the intertwining between SE and human factors engineering, from micro-ergonomics to macro-ergonomics (Booher 2003; Pew-Mavor 2007). These relationships are developed more completely in the topic Human Systems Integration within Systems Engineering and Specialty Engineering in Part 6, Related Disciplines. A further intertwined engineering discipline addressed in Part 6 is Industrial Engineering, which overlaps significantly with SE in the industrial domain, but also includes manufacturing and other implementation activities outside of SE. For more information, please see Systems Engineering and Industrial Engineering.

Finally, there are many specialty fields in engineering, e.g., security, safety, reliability, availability, and maintainability engineering. Most of these are considered professional disciplines in their own right and many have their own bodies of knowledge. However, these disciplines are still critical to the fielding of successful systems. The SEBoK addresses these by providing an overview of and references for the specialty disciplines, and specifically focuses on how each discipline relates to SE. Systems Engineering and Specialty Engineering KA in Part 6 provides an overview for what most systems engineers will need to know about each specialty field, with pointers to the references within each discipline's own Body of Knowledge (glossary).

Non-Engineering Disciplines

Technical management (TM) is often within the purview of a systems engineer. It is very common for SE textbooks, competency (model) models, and university programs to include significant content on TM. SE is intimately intertwined with TM, which itself is a specialization of project management (PM). The SEBoK explicitly defines its relationship to the Guide to the Project Management Body of Knowledge (PMBOK) [[16] (http://www.pmi.org/en/PMBOK-Guide-and-Standards/Standards-Library-of-PMI-Global-Standards.aspx) , which is published by the Project Management Institute (PMI) (PMI 2008). Again, as seen in the figure "System Boundaries of Systems Engineering, System Implementation, and Project/Systems Management" in Scope and Context of the SEBoK, SE and PM have significant common content in TM, but neither is a subset of the other. This relationship is developed more completely in Part 6 in Systems Engineering and Project Management.

Procurement (glossary) and acquisition (glossary) is another non-engineering discipline intertwined with SE. It draws upon SE to determine the scope (glossary) and overall requirements (glossary) of the system to be procured or acquired. It then comprises several specialty disciplines such as preparation of requests for proposals, statements of work, evaluation criteria, and source selection processes (glossary). Once a leading source is selected, it involves various contracting options such as the nature of deliverables, payments, reviews and audits, incentive fees, and acceptance criteria and procedures. Subsequently, it involves monitoring of progress with respect to plans (glossary) (including those for SE), and negotiation and execution of changes and corrective actions. Again, further details are provided in Part 6, Related Disciplines.

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Additional References

No additional references have been identified for version 0.75. However, the references of Part 6 may be helpful in exploring some of the related disciplines. Please provide any recommendations on additional references in your review.

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SEBoK Users and Uses

Based on the six purposes described in SEBoK 0.75 Introduction, the authors created a set of users and uses, as seen in the sections below. The authors have further refined a subset of these uses by creating written use cases, which provide guidance on how to walk through the SEBoK for certain purposes. The primary users for which there are more defined use cases include:

- Use Case 1: Practicing Systems Engineers,
- Use Case 2: Other Engineers,
- Use Case 3: Customers of Systems Engineering,
- Use Case 4: Faculty Members, and
- Use Case 5: General Managers.

Several more use cases are expected for version 1.0.

Primary Users

There are nine types of “primary” SEBoK users along with examples for each their potential uses of the SEBoK, as shown in Table 1. These primary users have the technical skills necessary to access and understand the SEBoK.

Table 1. Primary SEBoK Users and Common Usages (Table Developed for BKCASE)

#	Users	Uses
1	Practicing systems Engineers ranging from novice up through expert	▪ Users are taking on a new SE role in a project and need the best references to help prepare ▪ Users want to expand their areas of SE expertise and specialization and need the best references to read ▪ Users want to understand the principles of SE and find the best references to elaborate on those principles ▪ Users want to understand what best SE practices to look for in a project they are reviewing, or for mentoring a new SE performer ▪ Users want to continue to develop professionally through study of SE topics, including new developments in SE.

2	Process engineers responsible for defining or implementing SE processes	▪ Users are maintaining a library of SE process assets and want to understand which are the most relevant SE process standards ▪ Users are tailoring a process for a specific project and want to find examples in the literature of how others have tailored processes in the past or to find how a specific application domain should affect tailoring ▪ Users wish to measure the effectiveness of their organization's SE processes and want to find examples in the literature of how others have done such measurement ▪ Users are defining standards for a professional society or standards organization.
3	Faculty Members	▪ Users are developing a new graduate program in SE and need to decide the core knowledge that all students in the program should master; users would simultaneously reference GRCSE, which makes extensive reference to the SEBoK ▪ Users are developing a new SE course and need to identify course objectives, topics, and reading assignments ▪ Users in other engineering disciplines want to incorporate SE concepts in their courses or curricula
4	GRCSE authors	▪ Users are members of the GRCSE author team and need to decide what knowledge to expect from all SE graduate students
5	Certifiers	▪ Users are defining a company's in-house SE certification program and want to understand what others have done, how such programs are typically structured, and how to select the knowledge that each person seeking certification should master ▪ Users are defining certification criteria for a professional society or licensure program.
6	General Managers, Other Engineers, developers, testers, researchers	▪ Users want to understand the scope of SE relative to their roles ▪ Users want to understand basic vocabulary, boundaries, and structure of SE and are looking for a few primary references ▪ Users want to understand the role of the systems engineer versus others on a project or in an organization ▪ Users want to effectively perform their roles on a SE integrated product team
7	Customers of Systems Engineering	▪ Users receive artifacts from systems engineers and want to better understand what to ask for, how to request it, and how to judge the quality of what is received
8	SE managers	▪ Users' teams of systems engineers are proposing changes in the teams' processes and tools, and the users want to read independent information to evaluate the proposal ▪ Users need to hire systems engineers and want to develop competency-based job descriptions
9	SE researchers	▪ Users want to understand where the gaps are in SE knowledge to help guide their research agendas ▪ Users want to familiarize themselves with research topics and want to know the best articles to read

Secondary Users

Table 2 shows three types of secondary users – those who lack systems engineering (SE) technical skills and would likely rely on a primary user, such as a practicing systems engineer, to help them access and understand the SEBoK.

Table 2. Secondary SEBoK Users and Common Usages (Table Developed for BKCASE)

#	Users	Uses
1	Human resource development professionals	▪ Users will access SEBoK with the assistance of a direct user in order to support the hiring and professional development of systems engineers
2	Non-technical managers	▪ Users will access SEBoK with the assistance of a direct user in order to find specific information of interest about SE topics central to the managers' concerns; e.g., a contracting manager might want to better understand SE deliverables being called out in a contract
3	Attorneys, policy makers	▪ Users will access SEBoK with the assistance of a direct user in order to understand such legal issues as the liability of a systems engineer for errors in judgment on a project, or to understand the limitations of SE in guaranteeing the success of a project vs. the actions of sponsors, managers, or developers

Please note that the example uses shown in Tables 1 and 2 are intended to be indicative, but are not exhaustive.

References

Works Cited

None.

Primary References

No primary references have been identified for version 0.75. Please provide any recommendations on primary references in your review.

Additional References

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Use Case 1: Practicing Systems Engineers

Entry-level systems engineers (glossary) will use the Systems Engineering Body of Knowledge (SEBoK) as a quick, comprehensive reference for systems engineering (glossary) (SE) topics while they are learning to be systems engineers. The SEBoK will provide a single source with leading references for definition of terms and explanations of basic concepts (glossary) and principles (glossary) associated with SE. More experienced systems engineers will use the SEBoK as a reference to find articles and textbooks that provide more in-depth coverage of topics required to accomplish a work activity. The SEBoK authors have taken the time to identify many valuable assets and sources of knowledge. This will allow practicing systems engineers to reliably gain knowledge more quickly, that will lead to less time spent searching for and learning new information, and more time getting direct work done.

Additionally, the SEBoK will provide a common set of terms, definitions, and concepts to establish a consistent framework for a team of practicing engineers. The framework helps form a bridge across the legacy knowledge of practicing engineers to enhance communication, which is often a major obstacle for new teams. Please see Enabling Teams to Perform Systems Engineering for more information.

Use of Topics

The SEBoK topics provide great value to practicing systems engineers. These engineers have limited time to research topics and find relevant information. Practicing engineers often have limited access to educational resources or to research expertise. The SEBoK provides a compendium of, and references to, some of the best information on SE. This information is based on research, proven practices, and emerging knowledge. The SEBoK helps provide a means of connecting with educators and researchers through the topics and references provided. The primary references will help practicing engineers find reliable, high-quality information more quickly than they would if they had only the internet as a means of searching because the SEBoK sources have been reviewed and vetted by a team of experts.

Having the SEBoK organized by articles that are generally less than 2000 words will help practicing engineers quickly get an overview of relevant topics. The primary references will provide the greater detail that is most relevant to each topic. In cases where the practicing engineer needs additional detail or breadth, the additional references can be consulted.

It is expected that the practicing systems engineer will most often access the SEBoK using a search function with some key words that indicate the topics they are interested in learning. The next most likely access methods would be 1) to check the SEBoK table of contents or an index to find the topics of interest and 2) through the search results of an Internet search engine based on a specific topical search.

Occasionally, practicing engineers who are new to SE and intend on fully learning the subject will read the SEBoK in sequence. This may also be true for practicing engineers in a training course run by their employer. To facilitate in-sequence use, the SEBoK has navigation links in each article, allowing easy access to the previous and next articles in the table of contents, as well as a link to the parent article in the hierarchy.

Implementation Examples

Practicing systems engineers will find the examples useful when these examples are aligned with the domain (glossary) in which the systems engineer is working, though some more general examples will occasionally be useful. Because the SEBoK focuses on the discipline of SE and has minimal coverage of the numerous domains where SE can be applied, the practicing systems engineer will get limited understanding of domain-specific concerns from the discussion in Parts 2 through 6. However, some SE examples within a particular domain are provided in Part 7, Systems Engineering Implementation Examples. Though all relevant domains are not covered, these examples may be useful for understanding how an application domain may impact SE activities. For SEBoK version 1.0, the authors plan to add additional examples.

Model-Based Systems Engineering Practitioners

Practicing systems engineers will use the SEBoK, and in particular its knowledge area on Representing Systems with Models, to practice Model-Based Systems Engineering (MBSE) in order to create models (glossary) of systems (glossary) to support the various system life cycle (glossary) activities, including their requirements (glossary), high-level architecture (glossary), detailed design (glossary), testing, usage, maintenance (glossary), and disposal (glossary).

Faculty members will use the SEBoK to support curriculum development and assessment, and ensure accuracy and completeness of the MBSE part of the curriculum. They will be able to define the modeling methodologies and languages they wish to include in their curriculum, such as System Modeling Language (SysML) and Object-Process Methodology (OPM).

SE researchers will be able to adopt an MBSE approach and base their SE research on models in order to make their research topics more formal and rigorous.

Vignette

Tara Washington has been working as a engineer for the medical device company HealthTech for seven years. Besides continuing to improve her strong software skills, she has shown an aptitude for systems thinking. She has also taken courses in electrical engineering (glossary), mechanical engineering, and physiology to obtain a better understanding of the products (glossary) that her software (glossary) is supporting. This has led her to perform as an effective software system analyst on the SE teams (glossary) of her last two projects (glossary).

HealthTech's Research Division has come up with a new concept (glossary) for a highly programmable radiation therapy device that monitors the effect of the radiation on various parts of the body and adjusts the parameters of the radiation dosage to maximize the effectiveness of the dosage, subject to a number of safety (glossary) constraints (glossary). The software-intensiveness of the device has led Tara's current project manager to recommend her as the lead systems engineer for the design (glossary) and development of the product.

Tara welcomes the opportunity, but realizes that, although she has picked up enough of the domain knowledge that the lead SE role needs, her SE skills have been largely picked up by intuition. In order to build on her SE capabilities (glossary), she consults some of HealthTech's lead systems engineers and studies the SEBoK.

She finds that Part 1, SEBoK 0.75 Introduction, gives her an overview of the SEBoK and the Scope and Context of the SEBoK topic outlines the key activities that she will need to lead, as well as those activities she will need to collaborate on with the systems developers and project/systems management personnel. It also provides her with an overview of the other parts of the SEBoK that will help her understand SE concepts, principles (glossary), and modeling approaches in Representing Systems with Models in Part 2; life cycle (glossary) processes (glossary), management, technical practices, approaches for specifying, architecting (glossary), verifying (glossary) and validating (glossary) the hardware, software, and human factors (glossary) aspects of the product, as well as common pitfalls to avoid and risks (glossary) to manage (Systems Engineering and Management in Part 3); guidelines for the SE of products (Applications of Systems Engineering in Part 4 and its references); required SE Knowledge, Skills, Abilities, and Attitudes (KSAA) needed for a project (Enabling Systems Engineering in Part 5 and its references); and specialty engineering disciplines that may be key to the project's success (Related Disciplines) in Part 6. In particular, as Tara is aware of the deaths caused by the Therac-25 radiation therapy device, she not only reads the Safety Engineering topic in Part 6, but also all of its key references.

While reading about SE life cycle process models in Systems Engineering and Management in Part 3, Tara sees the reference to the Next Generation Medical Infusion Pump Case Study in Systems Engineering Implementation Examples in Part 7. She finds the case study highly relevant to her medical-device situation and organized into phases similar to those used at HealthTech. In particular, it gave Tara a good understanding of how a project such as hers would progress by concurrently evaluating technology opportunities (glossary), understanding the needs of various device stakeholders (glossary) (e.g., patients, nurses, doctors, hospital administrators, and regulatory agencies), and progressing through a succession of increasingly detailed prototypes (glossary), specifications, designs, plans (glossary), business cases, and safety analyses of a product. The case study (glossary) also pointed her toward the U.S. National Research Council book, Human-System Integration in the System Development Process, which was the expanded source of the case study and also provided numerous good practices for human-systems needs analysis, organizational (glossary) analysis, operations analysis, prototyping, usability criteria formulation, hardware-software-human factors integration, process decision milestone review criteria, and risk management (glossary).

As a result, Tara is able to better 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.

Summary

The SEBoK will be viewed by practicing engineers as an authoritative knowledge resource that can be accessed quickly to gain essential high level information. It will be viewed as a quick method for identifying the best references for more in depth study and research into SE topics when an individual's current level of understanding is not enough to get the job done.

The SEBoK will occasionally be used in training courses and as a resource for teaching practicing engineers.

References

Works Cited

None.

Primary References

No primary references have been identified for version 0.75. Please provide any recommendations on primary references in your review.

Additional References

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Use Case 2: Other Engineers

This use case is concerned with the use of the SEBoK by engineers other than systems engineers (glossary), who want to understand the scope of SE relative to their roles in project (glossary) projects and programs that involve systems engineering of products (glossary), services (glossary), enterprises (glossary), or systems of systems (SoS) (glossary). Other kinds of engineers will use the SEBoK to understand how their roles mesh with the roles of systems engineers. The SEBoK will also help them to better understand the relationships between systems engineering and their project or program activities.

Part 1 of the SEBoK, provides an orientation and overview of systems engineering for other kinds of engineers who have an interest in systems engineering. The extensive lists of references in Part 1 and throughout the SEBoK provide a basis for further readings on selected topics in systems engineering.

Part 7 of the SEBoK, provides implementation examples that illustrate the application of systems engineering practices, principles, and concepts in real settings. Some of these may be of direct applicability for engineers who have backgrounds and experiences in those kinds of systems; all of the examples provide concrete examples of the role of systems engineering in various kinds of projects and programs.

Links to glossary terms are embedded throughout the SEBoK; in the upcoming version 1.0 of the SEBoK, each term will include a discussion of its relevance to systems engineering, which will provide further insights into systems engineering for other engineers.

Relevant Parts and Knowledge Areas

Other kinds of engineers will find the following areas of the SEBoK to be relevant to their interests:

Part 2 of the SEBoK provides a guide to those areas of systems knowledge particularly relevant to systems engineering. This provides a foundation for the subsequent elements of the theory and practice of systems engineering in Parts 3, 4 and 5.

In Part 3 of the SEBoK, other engineers will find most of the subjects to be of interest. In particular, the knowledge areas of Life Cycle Models, System Definition, System Realization, and System Deployment and Use will be of value. Although many engineers may be tempted to skip over Systems Engineering Management, most of the topics are relevant for other engineers (e.g., risk management, measurement, configuration management, and quality management).

Reading Part 4 (product, service, enterprise, and systems of systems engineering) will provide other kinds of engineers with an overview of the distinctions among SE activities for these different kinds of engineered systems. Other engineers involved in development or modification of one of these types of systems will benefit from reading the content, primary references, and glossary terms for for the engineering of that type of system.

Other kinds of engineers may be tempted to bypass the knowledge areas in Part 5 of the SEBoK. However, other engineers will benefit from understanding how they and systems engineers fit into the larger picture of enabling individuals and teams to perform systems engineering activities, and how systems engineers fit into the larger picture of systems engineering organizational strategies. In particular, the topic of Organizing Teams to Perform Systems Engineering will be of interest.

The Part 6 knowledge area Systems Engineering and Project Management will be of interest to most other kinds of engineers. Software engineers would benefit from reading the Systems Engineering and Software Engineering knowledge area. Individuals involved in one of the specialty disciplines will benefit from reading the Systems Engineering and Specialty Engineering knowledge area.

Summary

The SEBoK provides insights and guidance concerning systems engineering and systems engineers for other kinds of engineers. These engineers will benefit from the knowledge areas highlighted in this case study.

References

Works Cited

None.

Primary References

No primary references have been identified for version 0.75. Please provide any recommendations on primary references in your review.

Additional References

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Use Case 3: Customers of Systems Engineering

The activities conducted and results achieved by systems engineers (glossary) are done for customers (glossary), and they are the stakeholders (glossary) for a system of interest (glossary). These stakeholders have concerns expressed as needs and expectations in terms of the results that system engineers provide. The systems engineers participate in the realization of engineered systems (glossary) resulting in products (glossary), services (glossary), enterprises (glossary), and systems of systems (glossary). Even though their main activities are related to defining the system, customers must take account of all life cycle aspects. By better understanding the activities that systems engineers perform, customers can know what they should request, how they should request it, and how to judge the quality and value of the results of systems engineering.

The SEBoK assists the customers of systems engineering by providing a broad comprehensive treatment of the concepts, principles, theory, and practice related to systems in general and systems engineering in particular. It cites important references to published books and articles that provide various perspectives on systems and systems engineering.

The Use of Topics

While all topics in the SEBoK are relevant for users of systems engineering and the all knowledge areas should be reviewed, there are topics that provide deeper insight in relationship to customers' specific concerns. Thus, the knowledge area Systems Engineering and Management provides the relevant perspective on what activities systems engineers perform and what results they are expected to achieve.

In particular, customers need to know how to express their concerns in the form of needs, expectations, and requirements in such a manner that the systems engineer can evaluate and use these inputs in establishing the approach to be followed in defining and realizing the SoI. Guidance is provided in the Life Cycle Models and System Definition knowledge areas.

The user should expect that the systems engineer will provide:

- A well-architected product, service, enterprise, or system of systems that will meet their needs and expectations. This depends on high quality input from the stakeholders. Guidance for that input is provided in System Definition.
- A managed life cycle model from the customer need and requirements to the delivered product, service, enterprise or system of systems. Guidance is provided in Life Cycle Models.
- The verification that the SoI will meet the needs and requirements of the stakeholder and the validation that the final result,

when deployed in an operational environment, will provide the value added that was desired are critical to systems engineering (SE). Guidance on these aspects is provided in the System Realization and System Deployment and Use knowledge areas.

Implementation Examples

Good examples provide a basis for deeper understanding. The SEBoK includes Part 7, which contains summaries of and references to full case studies as well as overviews of events (vignettes) related to specific areas of systems engineering. These case studies and vignettes are linked back to the appropriate areas of the SEBoK and a matrix is provided that shows the primary areas of the SEBoK addressed by each case study or vignette. The reader can use the matrix to find case studies and vignettes, along with references, that are related to their particular concerns.

Summary

For the customers of systems engineering, the SEBoK provides both general and specific knowledge that will help users gain important insight in relating to systems engineers. Key to this is learning about life cycles, the definition of SoIs, and how to provide guidance in expressing needs, concerns, and requirements. Further, customers need to know what to expect as a result of SE activities in the form of well-architected products, services, enterprises, or systems of systems and a managed life cycle. The results of verification of stakeholder requirements and the validation of the final result in respect to fulfilling the user needs are vital.

References

Works Cited

None.

Primary References

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Additional References

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Use Case 4: Faculty Members

Faculty members will use the SEBoK to support curriculum development and assessment, especially to ensure accuracy and completeness. The curriculum can be one that is focused on [[Systems Engineering (glossary)|systems engineering (glossary), domain-centric systems engineering, or another engineering discipline that includes some systems engineering topics.

Faculty should also plan to review the Graduate Reference Curriculum for Systems Engineering (GRCSE) companion guide. (Pyster and Olwell et al. 2011) GRCSE provides a summary of which topics should be covered in a systems engineering curriculum, while the SEBoK describes the knowledge that constitutes a topic. (Please note that GRCSE version 0.5 was released in December 2011 and may be downloaded here (http://www.bkcase.org/fileadmin/bkcase/files/GRCSE_0.5/GRCSE_Version0_5_Final.pdf) .)

The Use of Topics

Each topic in the SEBOK identifies a wide range of related concepts and perspectives. A good course requires multiple perspectives on a topic, and the SEBoK provides these various perspectives. As there is a wide diversity in accepted practices across systems engineering, cataloging this diversity for use in courses is important.

The SEBoK also provides a range of references in the citation section and identifies those references that are considered primary references for a particular topic as well as additional references. Faculty can refer to the reference lists at the end of each topic discussion to identify additional content for further curriculum development; to use as reading assignments in a course; or to provide students with additional or supplemental references.

Faculty can also use the concepts, perspectives, and references to develop or refine their course objectives and the techniques for assessing them.

Implementation Examples

Good examples make for good teaching. The SEBoK includes Systems Engineering Implementation Examples, which contains summaries of and references to full case studies and overviews of events (vignettes) related to specific areas of systems engineering. These case studies and vignettes are linked back to the appropriate areas of the SEBoK and a matrix is provided that shows the primary areas of the SEBoK addressed by each case study or vignette. Faculty can use the matrix to find case studies and vignettes, along with additional references, that are related to their areas of study. These examples can be directly used in the curriculum.

Summary

Faculty can check current curriculum against the SEBoK to identify potential gaps in many areas of the curriculum and to support putting a plan in place to address those gaps. They can also use the SEBoK as a framework for determining what subject matter should be included in a new curriculum and as a resource in designing individual courses. Faculty can leverage the case studies and vignettes provided in the SEBoK directly in the classroom. Faculty should use the SEBoK in tandem with GRCSE for development of curricula at the program level. And finally, faculty can use the SEBoK for continuing education and research.

References

Works Cited

Bloom, B.S., M.D. Engelhart, E.J. Furst, W.H. Hill, and D.R. Krathwohl. 1956. *Taxonomy of Educational Objectives the Classification of Educational Goals Handbook I: Cognitive Domain*. London, UK: Longman Group Ltd.

Primary References

Pyster, A., Olwell, D., Squires, A., Hutchison, N., Enck, S., (eds); T. Ferris (lead author). 2011. *Graduate Reference Curriculum for Systems Engineering (GRCSE)*. Version 0.5. Hoboken, NJ, USA: Stevens Institute of Technology. Released for review, December, 2011. Available at http://www.bkcase.org/fileadmin/bkcase/files/GRCSE_0.5/GRCSE_Version0_5_Final.pdf.

Additional References

No additional references have been identified for version 0.75. Please provide any recommendations on additional references in your review.

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Use Case 5: General Managers

This use case concerns those who want to understand the scope of systems engineering (glossary) (SE) relative to their roles in projects and programs that involve systems engineering of products, services, enterprises, or systems of systems. Managers, other kinds of engineers, and all others who are involved in or are affected by a project (glossary) or program (glossary) that involves systems engineering will use the SEBoK to understand how their roles mesh with the roles of systems engineers. The SEBoK will also help them to better understand the relationships between systems engineering and other project or program activities.

Part 1 of the SEBoK provides an orientation and overview of systems engineering for all other stakeholders who have an interest in systems engineering. The extensive lists of references in Part 1 and throughout the SEBoK provide a basis for further readings on selected topics in systems engineering.

Part 7 of the SEBoK provides implementation examples that illustrate the application of systems engineering practices, principles, and concepts in real settings. Some of these may be of direct applicability for some other stakeholders; all of the examples provide concrete examples of the role of systems engineering in various kinds of projects and programs.

Links to glossary terms are embedded throughout the SEBoK; in version 1.0 of the SEBoK, each term will include a discussion of its relevance to systems engineering, which will provide further insights into systems engineering for managers.

The Use of Topics

Managers will find the following topics in the SEBoK to be relevant to their interests:

- In Part 3 of the SEBoK, managers will find the topics of Life Cycle Models, Systems Engineering Management, Product and Service Life Management, and Systems Engineering Standards to be of interest.
- A cursory reading of the Part 4 knowledge areas (products, services, enterprises, and systems of systems) will provide managers with an overview of the distinctions among systems engineering activities for these different kinds of engineered systems. Managers involved in development or modification of one of these types of systems will benefit from detailed reading of the content, primary references, and glossary terms for that topic.
- Managers will benefit from detailed reading of the knowledge areas in Part 5 of the SEBoK. In particular, managers whose project or program includes SE activities will benefit from the following Part 5 knowledge areas: Enabling Teams to Perform Systems Engineering and Enabling Individuals to Perform Systems Engineering. Higher-level managers will gain benefits from the Part 5 knowledge areas: Systems Engineering Organizational Strategy and Enabling Businesses and Enterprises to Perform Systems Engineering.
- The Systems Engineering and Project Management knowledge area in Part 6 will be of interest to project and program managers as well as to higher level managers who manage portfolios of project that involve SE. Those whose projects include SE as well as software engineering (SwE) will benefit from the Systems Engineering and Software Engineering knowledge area.

Summary

The SEBoK provides insights and guidance concerning systems engineering and systems engineers for all stakeholders (glossary) other than systems engineers. Managers, in particular will benefit from the knowledge areas highlighted in this case study. A separate case study includes the relevant parts of the SEBoK for other kinds of engineers.

References

Works Cited

None.

Primary References

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Additional References

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SEBoK Evolution

This article describes the approach used to reach SEBoK version 0.75, the intended way ahead to publication of SEBoK version 1.0, and the anticipated shift in stewardship following the release of 1.0.

SEBoK Background

The Body of Knowledge and Curriculum to Advance Systems Engineering Project (BKCASE) was started in fall 2009 to create a community-based *Guide to the Systems Engineering Body of Knowledge (SEBoK)* and a *Graduate Reference Curriculum for Systems Engineering (GRCSE)*. (Please see http://www.bkcase.org for more information.) Led by the Stevens Institute of Technology and the Naval Postgraduate School, BKCASE is conducted in coordination with many relevant professional societies, and is funded both by the U.S. Department of Defense (DoD) and the generous volunteer efforts of more than 70 authors from dozens of companies, universities, and professional societies across 15 countries. For additional information on the BKCASE authors, please see the Acknowledgements article.

Previous works on developing a guide to the Systems Engineering Body of Knowledge include an International Council on Systems Engineering (INCOSE) sponsored online version of the Guide to the Systems Engineering Body of Knowledge (INCOSE Insight 2002) and the INCOSE Handbook which has continued to evolve and is the de facto community statement of systems engineering (glossary) (SE) knowledge and structure (INCOSE 2011). Systems engineering knowledge has also been documented through the standards bodies, including ISO/IEC/IEEE 15288, *Systems Engineering-System Life Cycle Processes* (2008), IEEE/EIA 12207, *Software Life Cycle Processes* (2008), and ANSI/EIA 632, *Processes for Engineering a System* (1998, 2003). These efforts have provided a foundation for the SEBoK presented here; however, the goal of the SEBoK is to provide a comprehensive view of all SE knowledge and build upon the traditional approach to performing SE.

Around the world, nearly a hundred universities have launched undergraduate and graduate SE programs and numerous companies and government agencies have defined SE competency models and career paths. However, there are many differences in style and substance between university program curricula, career path models and competency models around the world. The SEBoK and GRCSE products will provide a framework for understanding the similarities and differences in these programs.

The SEBoK authors believe that the scale of the effort to create the SEBoK, together with the open collaborative process used to write it, will itself have positive effects on the community. The author team includes official INCOSE representatives and Institute for Electrical and Electronics Engineers (IEEE) Computer Society and Systems Council representatives, and members of other national and international SE bodies. The effort has included extensive awareness initiatives and an open review process. Through these initiatives, the SEBoK is building consensus on the boundaries and context of systems engineering thinking, including its interfaces to three strongly related disciplines – software engineering, project management, and industrial engineering. The SEBoK is intended not only to inform practicing systems engineers, but also also develop a common way to refer to systems engineering knowledge, facilitate communication among systems engineers, and provide a baseline for creating and evolving competency models, certification programs, educational programs, and other workforce development initiatives around the world.

Originally, the BKCASE leadership anticipated three SEBoK releases, each about one year apart (please see Way Ahead to SEBoK 1.0 below for information on updates to this plan):

- Version 0.25 – a prototype that would create the first architecture and early content of the SEBoK for limited review and validation;
- Version 0.5 – a version suitable for early adopters; and
- Version 1.0 – the “final” version to be produced by the BKCASE project.

After version 0.5 was released, it was clear that another intermediate release before version 1.0 was needed - the current release, version 0.75. This is a limited release, with only a third of the content updated or added.

SEBoK version 0.25

The first version of the SEBoK – a prototype labeled version 0.25 – was released as a document for limited review in September 2010. A total of 3135 comments were received on this document from 113 reviewers across 17 countries. The author team reviewed these comments, paying particular attention to the reviews related to content and highlighting diversity within the community. The adjudication of version 0.25 comments may be seen here (http://www.bkcase.org/fileadmin/bkcase/files/Review_Documents/SEBOKVersion0.25AdjudicationReportFINAL1.pdf) .

SEBoK version 0.5

This second version of the SEBoK was released for world-wide comment in September 2011. About 500 comments from approximately 40 reviewers were received. Selected comments were addressed in version 0.75, and others were deferred until the fial version.

Development of SEBoK 0.75

Based on the review comments, the authors first began by reorganizing the SEBoK to better align with the types of information included. The final 0.75 architecture is described in Structure of the SEBoK; to view the full structure, please see SEBoK Table of Contents.

In January 2011, the authors agreed to transition from a document-based SEBoK to a wiki-based SEBoK, with the intent to make the information readily accessible worldwide, provide additional methods for searching and navigating the content, and provide a forum for the community to provide feedback while keeping the content of the SEBoK stable between versions.

Way Ahead to SEBoK 1.0

With the completion of version 0.75, the editors anticipate only minor architectural changes going forward to version 1.0; if the community review indicates otherwise, this will need to be revisited.

Version 1.0 will use the review comments from versions 0.5 and 0.75 to refine the existing articles, continuing to add content, illustrations, and references. Version 1.0 will be released in September 2012.

Ongoing Stewardship

The BKCASE project leadership is working with the leadership of INCOSE and the IEEE Computer Society with the expectation that these organizations will take joint stewardship of the SEBoK after publication of version 1.0. The ongoing role of Stevens Institute, the Naval Postgraduate School, and the Systems Engineering Research Center, which have led the project from inception, is still being defined. A committee with representatives from INCOSE, the IEEE Computer Society, and BKCASE leadership is currently drafting an agreement that specifies governance of both the SEBoK and GRCSE once version 1.0 is published. Version 1.0 of SEBoK itself will include features to facilitate its maintenance and evolution, including the ability for SEBoK users to readily propose new references and evaluate existing references, as well as to readily propose changes to all other aspects of the SEBoK. The recommended frequency of these updates is a point of consideration going forward.

A key principle of the BKCASE project is that all of its products will be available free worldwide in perpetuity – including revisions to those products. That principle will be preserved in any agreement for INCOSE and the IEEE Computer Society to become stewards of the SEBoK and GRCSE.

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Additional References

No additional references have been identified for version 0.75. Please provide any recommendations on additional references in your review.

< Previous Article | Parent Article | Next Article >

Comments from SEBok 0.5 Wiki

No comments were logged for this article in the SEBoK 0.5 wiki. Because of this, it is especially important for reviewers to provide feedback on this article. Please see the discussion prompts below.

SEBoK 0.75 Reviews

Please provide your comments and feedback on SEBoK 0.75 below. You will need to log in to DISQUS using an existing account (e.g. Yahoo, Google, Facebook, Twitter, etc.) or create a DISQUS account (click "DISQUS" button). Please look for the posts by "BKCASE" for specific issues on which the author team would like feedback.

Acknowledgements

The BKCASE project, and the SEBoK in particular, is an immense undertaking. This task could not have been completed without the support and contributions of many individuals and organizations. We could not possibly have gotten this far without those listed below. We sincerely thank our sponsor, authors, partners, and reviewers.

With gratitude,

Art Pyster
Editor in Chief

David H. Olwell
Co-Editor in Chief

James F. Anthony, Jr., Editor
Stephanie Enck, Editor
Devanandham Henry, Editor
Nicole Hutchison, Editor
Alice Squires, Editor

Sponsor

The Department of Defense recognizes the importance of BKCASE to its own workforce development and has offered substantial financial support and partnership to the project. The office of the Deputy Assistant Secretary of Defense for Systems Engineering (DASD/SE) is the primary Department of Defense sponsor for BKCASE. DASD/SE has graciously provided much of the funding for the BKCASE project through their Systems Engineering Research Center (http://www.sercuarc.org) . Those funds primarily pay for the time spent by the BKCASE leadership, enables the many volunteer authors to conduct quarterly physical workshops, and provides for the technical and administrative infrastructure to conduct such a complex distributed project. DASD/SE does not determine the content of the SEBoK, but instead allows the author team and the community to determine what the SEBoK should contain. Without this support, this project would not be possible. Special thanks go to Stephen Welby, Kristen Baldwin, Nicholas Torelli, Don Gelosh, and Scott Lucero.

The remaining two thirds of the project cost were donations in kind by our partners for the labor and travel support of their authors. We gratefully acknowledge their contributions.

Part Team Leads

An individual volunteered to lead a team of authors for each of the Parts identified for the SEBoK (see SEBoK Table of Contents). We would like to thank each of these individuals for their time, dedication, and leadership. In addition, a member of the core team supported each of the part team leads.

- Part 1 - Barry Boehm with support from Art Pyster

- Part 2 - Richard Adcock with support from Nicole Hutchison
- Part 3 - Garry Roedler with support from Jim Anthony
- Part 4 - Harold (Bud) Lawson with support from Dave Olwell
- Part 5 - Art Pyster with support from Alice Squires
- Part 6 - David H. Olwell with support from Art Pyster
- Part 7 - Heidi Davidz with support from Alice Squires

Authors

As a primarily volunteer effort, BKCASE depends on dozens of authors from around the world to provide their own time and expenses. Each of the individuals listed below has worked many hours to develop and improve SEBoK 0.75, and without each of them, it would have been impossible to get this far. Many of them have been supported by their organizations during this effort, including support for travel and labor, and we also gratefully acknowledge the organizational contribution.

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Partners

Partner organizations support BKCASE by providing personnel, opportunities to discuss the SEBoK in open forums such as conferences and workshops, and provide valued feedback on draft SEBoK materials. Some organizations have also chosen to have an official representative(s) participate in BKCASE, as shown below. A special thanks to our partners.

- The International Council on Systems Engineering (INCOSE) (http://www.incose.org) . Official INCOSE representatives: Bill Miller and Kevin Forsberg.
- The Institute of Electrical and Electronics Engineers (IEEE) Computer Society (http://www.computer.org/portal/web/guest/home) . Official IEEE CS representatives are Dick Fairley, Tom Hilburn and Ken Nidiffer.
- The Institute of Electrical and Electronics Engineers (IEEE) Systems Council (http://www.ieeesystemscouncil.org/) . The official IEEE Systems Council representative is Ken Nidiffer.
- The Institute of Industrial Engineers (IIE). (http://iienet.org) The official IIE representative is Johann "Hans" Demmel.
- The Association for Computing Machinery (ACM) (http://www.acm.org) . The official ACM Representative is Andrew McGettrick.
- The National Defense Industrial Association (NDIA) Systems Engineering Division (http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/default.aspx) . The official NDIA Systems Engineering Division representative is Garry Roedler.
- The Systems Engineering Research Center (SERC) (http://www.sercuarc.org) . The official Systems Engineering Research Center representative is Art Pyster.

For more information on potential partner involvement after publication of version 1.0, please see SEBoK Evolution.

Wiki Team

The transition from a tradition document to a wiki-based platform was a long one. We are tremendously grateful to the folks who have helped us install, manage, and update the wiki:

- Nicole Hutchison (team leader), *Stevens Institute of Technology*
- Stephanie Enck (co-lead), *Naval Postgraduate School*
- Hans-Peter de Koning, *European Space Agency*
- Paola Di Maio, *University of Strathclyde*
- Ray Jorgensen, *Rockwell Collins*
- Sanford Friedenthal, *SAF Consulting*
- Steven Mitchell, *Lockheed Martin*

Support for the wiki is provided by Peder Halseide of WikiExpert.

Participants

The following individuals have provided support to the BKCASE team over the course of the project.

- Mike Kreuger
- Richard Frost
- John Baras
- Edward Ghafari
- Richard Gryzbowski

- Ken Kepchar
- Sven-Olaf Schulze
- Greg Mayhew
- Richard Rosenthal
- Mary Jane Willshire
- Peter Jackson

Reviewers

Reviewers are critical to the success and growth of the SEBoK. By providing feedback that represents the diversity of views and opinions on systems engineering, reviewers help the author team identify and describe ground truths for SE as well as areas of contention. The reviewers who provided feedback for version 0.25 are listed in Table 2, below. Many thanks. Many additional reviewers are anticipated for the broad review sought for version 0.5. The adjudication of SEBoK 0.25 review comments can be found here (http://www.bkcase.org/fileadmin/bkcase/files/Review_Documents/SEBOKVersion0.25AdjudicationReportFINAL1.pdf) .

Table 2. SEBoK version 0.25 Reviewers. (Table developed for BKCASE)

Karl Best, *Project Management Institute*	Dr. Stan Rifkin, *Air Force Office of Scientific Research*
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Krister Sutinen, *Siemens Industry Software AB*	Mike Gayle, *Boeing*
Stephanie White, *Long Island University, C.W. Post Campus*	Hans van Vliet, *VU University, Amsterdam*
Kal Toth, *Portland State University*	Gerard Auvray, *Astrium Satellite*
Chia Eng Seng Aaron, *National University of Singapore*	Harold Mooz, *HMA*
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Odile Mornas, *Thales*	Jay Mandelbaum, *Institute for Defense Analyses*
Howard Eisner, *The George Washington University*	Mark Ardis, *Stevens Institute of Technology*
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Dr. Karen J Richter, *Institute for Defense Analyses*	Alan Knott, *Parsons Brinckerhoff*
Mark Maier, *The Aerospace Corporation*	Rolan Mazzella, *THALES*
Andrew Farncombe, *John Boardman Associates*	Dan Dillery
Edmond TONNELLIER, *Thales*	Dahai Liu, *Embry-Riddle Aeronautical University*
Frédéric Autran, *EADS - Cassidian Systems*	Vincenzo Arrichiello, *SELEX Sistemi Integrati SpA*
Jeremy I. Stuart, *The Boeing Company*	Duncan Kemp, *Department for Transport*
Denis Bertrand, *DGMSSC/DMPP 5-2, Ottawa, Canada*	Marcel van de Ven, *Movares Nederland b.v.*
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Nelson Roberts, *Lockheed Martin*	Paul Martellock, *LMT*
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Arnold Neville Pears, *Uppsala University*	Chuck Walrad
Laurie Nasta, *Booz Allen Hamilton*	*IEEE Computer Society (collective review)*

Version 0.5 Review

As version 0.75 was a partial update of the SEBoK, not all review comments were addressed. A complete list of reviewers and the adjudication of comments will be provided for version 1.0.

A summary of the actions taken to address version 0.5 comments can be found in the meantime at Adjudication version 0.5.

References

Works Cited

None.

Primary References

No primary references have been identified for version 0.75. Please provide any recommendations on primary references in your review.

Additional References

No additional references have been identified for version 0.75. Please provide any recommendations on additional references in your review.

< Previous Article | Parent Article | Next Article (Part 2) >

Comments from SEBok 0.5 Wiki

No comments were logged for this article in the SEBoK 0.5 wiki. Because of this, it is especially important for reviewers to provide feedback on this article. Please see the discussion prompts below.

SEBoK 0.75 Reviews

Please provide your comments and feedback on SEBoK 0.75 below. You will need to log in to DISQUS using an existing account (e.g. Yahoo, Google, Facebook, Twitter, etc.) or create a DISQUS account (click "DISQUS" button). Please look for the posts by "BKCASE" for specific issues on which the author team would like feedback.

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