Managing the *Systems Engineering Body of Knowledge*

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The primary challenge for the BKCASE project is to bring together the diverse views of the developing discipline of systems engineering into a coherent guide to a body of knowledge for the benefit of the global community.

What better context for discussing knowledge management with systems engineers than a conversation about managing the information contained within the *Guide to the Systems Engineering Body of Knowledge* (SEBoK)? One of the hallmarks of the maturation of a discipline is an agreement by the professional community regarding what knowledge is included in the discipline and how that knowledge should be captured and organized to facilitate its use by practitioners, researchers, and educators (i.e., a guide to its body of knowledge). With this goal in mind, this article is intended to spur community involvement and support for the SEBoK development currently underway, through constructive and lively conversations about the management of the body of knowledge of systems engineering.

The Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) team has been evolving a body of knowledge for systems engineering since December 2009 (Squires et al. 2009) when the first author workshop was held. At this author workshop, 21 authors and team members developed an initial structure for the SEBoK based on the existing INCOSE *Systems Engineering Handbook* (Haskins 2010) and the ISO/IEC 15288 standard (ISO and IEC 2008); they then subdivided the work and began to write. Other key references for the team's initial efforts included previous work completed by INCOSE members and documented across three editions of **INSIGHT** (Axelband et al. 2006; Friedenthal 2006; Harwell 2006; Leibrandt et al. 2002).

At the second workshop in March 2010, 29 authors and team members expanded the contents of the SEBoK to include applicable knowledge outside of the system life cycle process space, including systems thinking and concepts. The authors organized the SEBoK around knowledge areas, topics, and subtopics, an approach similar to that used by the Software Engineering Body of Knowledge (Abran et al. 2004).

At the third workshop in July 2010, 35 authors and team members agreed on the final content areas for the first draft version 0.25 of the SEBoK (Pyster et al. 2010a). The fourth workshop in October 2010 focused on the finalization of the accompanying *Graduate Reference Curriculum for Systems Engineering* (GRCSE), version 0.25 (Pyster et al. 2010b). The fifth workshop in January 2011 marked the return of the community review comments on SEBoK version 0.25 and the development of a new structure to the SEBoK that was adopted by the 32 author and team members in attendance. In this phase of the evolution, the expansion of knowledge areas that had previously occurred was now reorganized into a higher-level structure, comprised of "parts," with some additional missing pieces identified. This current knowledge structure is outlined next.

Current SEBoK Knowledge Structure

Many SEBoK version 0.25 reviewers recommended changing the overarching structure of the document and in some cases provided suggestions on how to do this. Based on a preliminary review and refinement of one promising recommended approach and the presentation of that approach at the fifth workshop, five overarching parts were defined for the next iteration of the SEBoK material. The authors agreed to a set of guidelines for each of these five parts and allocated chapters of the SEBoK version 0.25 to each part. Nevertheless, the author team assigned to each part will still continue to refine the draft structure and present recommended structures to the entire author team at the next workshop in April 2011. The five parts and their associated version 0.25 chapters and new chapters, as well as the topics that are covered within each chapter in SEBoK version 0.25, are as follows:

- **Part 1: Introduction, Foundations.** This will cover the introduction to and foundations of the discipline, tips for navigating the SEBoK, and an overview of the SEBoK. Version 0.25 chapters and topics include these:
  - *Chapter 1: Introduction.* Topics include overview of systems engineering, value of systems engineering, systems engineering aliases, graphical map of the SEBoK.

- *All chapters*. Topics include overview and introduction to each part and knowledge area.

■ **Part 2: Systems**. This part will discuss what systems are, the basic characteristics of systems, and the languages for discussing and describing systems. This part introduces the basic vocabulary and philosophy of systems but does not address how to build them (for this see part 3). Version 0.25 chapters and topics include these:
  - *Chapter 2* (*first half*): *System Concepts*. Topics include types of systems, system topologies, system-of-interest, system perspectives, complexity, and roles of systems.
  - *Chapter 2* (*second half*): *System Thinking*. Topics include hard and soft systems thinking, paradoxes, models, and languages.
  - *Chapter 3* (*partial*): *Systems Engineering Overview*. Topics include its relationship to other disciplines.
  - *New Chapter: Product Systems*. Topics still to be determined.
  - *Chapter 5: Service Systems*. Topics to be determined.
  - *Chapter 6* (*partial*): *Enterprise Systems*. Topics include the enterprise as a system.

■ **Part 3: Engineering across the Life Cycles**. This part will cover the how and when of systems engineering, the actual engineering of systems, how engineering may be performed, how engineering is managed, and the implications of engineering activities throughout a system's life. This part covers how to build the systems discussed in Part 2. This part will also discuss the different common life cycle models. Version 0.25 chapters and topics include these:
  - *Chapter 3* (*partial*): *Systems Engineering Overview*. Topics include fundamentals of systems engineering, principles of systems engineering as a life cycle approach, principles of systems engineering as a service integration approach, principles of systems engineering as an enterprise approach, sociotechnical issues, and systems engineering standards.
  - *Chapter 4: Life Cycles*. Topics include life cycle characteristics, system life cycle process drivers and choices, and representative system life cycle process models.
  - *Chapter 6 (partial): Enterprise Systems*. Topics include related business activities, enterprise systems engineering (ESE), ESE process activities, and enterprise capability management.
  - *Chapter 8* (*partial*): *Systems Engineering Management* (*from an implementation perspective*). Topics include systems engineering planning, assessment and control, risk management, measurement, decision management, configuration management, and information management.

- *Chapter 9: System Definition*. Topics include stakeholder requirements and mission analysis, system requirements, architectural design, and system analysis.
- *Chapter 10: System Realization*. Topics include implementation, system integration, system verification, and system validation.
- *Chapter 11: System Deployment and Use*. Topics include operation of the system, system maintenance, and logistics.
- *Chapter 12: System Life Management*. Topics include service life extension, capability updates, upgrades, and modernization, and system disposal and retirement.
- *Chapter 14* (*partial*): *Cross Cutting/Specialties* (*from an implementation perspective*). Topics include integration of specialty engineering, affordability and design-to-cost, human system integration, safety, security, spectrum management, electromagnetic interference and TEMPEST, radiation hardness, reliability and maintainability, manufacturing and production, quality, logistics and supportability, occupational health and work environment, disposal, and resilience.

■ **Part 4: Organizing to Perform Systems Engineering.** This part will cover the who and the where of systems engineering, organizational aspects of systems engineering, and who manages and performs systems engineering, as well as organizational considerations such as where systems engineering is housed and competency models for systems engineers. Ethics, roles people play, and professionalism are covered in this part. Version 0.25 chapters and topics include these:
  - *Chapter 7: Enabling Systems Engineering in the Organization*. Topics include managing systems engineering at the business level, and standing-up, improving, and establishing systems engineering in an organization
  - *Chapter 8* (*partial*): *Systems Engineering Management* (*from an organizational perspective*). See part 3 for potential topics.
  - *Chapter 13: Agreement*. Topics include acquisition processes and supplier processes.
  - *Chapter 15: Competency*. Topics include system deployment, application, and future work.
  - *Chapter 14* (*partial*): *Cross-Cutting/Specialties* (*from an organizational perspective*). See part 3 for potential topics.
  - *New Chapter*: Systems engineering in the global context and across different cultures

■ **Part 5: Implementing Systems Engineering.** This part will cover the analysis of existing systems engineering case studies in relation to the SEBoK and how well they address specific SEBoK topics. This part will contrast and compare three

different applications in systems engineering across domains and different-size projects, and bridge terminology and perspectives from the external case studies to the related sections of the SEBoK. This part will also define case-study criteria and discuss case-study development approaches, and serve as guidance for the development of new case studies in systems engineering. Version 0.25 chapters and topics include these:

- *Chapter 16: Applications/Case Studies*. Topics include case-study process and operation of the system.
- *Companion Case-Study Guide* (not yet released for public review). Topics include case-study outline and development, case-study criteria and analysis, domain background, and mapping and relationship to the SEBoK.

Forward Plan for a SEBoK Wiki

As part of the community review cycle for SEBoK version 0.25, reviewers were asked to comment on the integration of the SEBoK information into a wiki format. Responses indicated general support for this strategy. For the SEBoK 0.5 wiki, each topic within a knowledge area or chapter would be considered one "article." Examples of these topics are listed after each chapter in the summary in the preceding section. The current proposed governance model is that of a "static wiki" with periodic updates. In this case, a wiki with static content would be updated periodically en masse, like a traditional document. However, the wiki backbone will provide the ability to capture semantic linkages using a systems engineering ontology as well as community comments related to each individual topic. In addition, all references and glossary terms will be located within their own pages, providing opportunities for annotation and discussion.

This model was chosen in lieu of an open wiki (like Wikipedia) or a traditional document with hyperlinks to key terms or references because the author team believes that this will make the SEBoK easier to navigate and will improve value to the community. The current plan is to use the "static wiki" to first collect
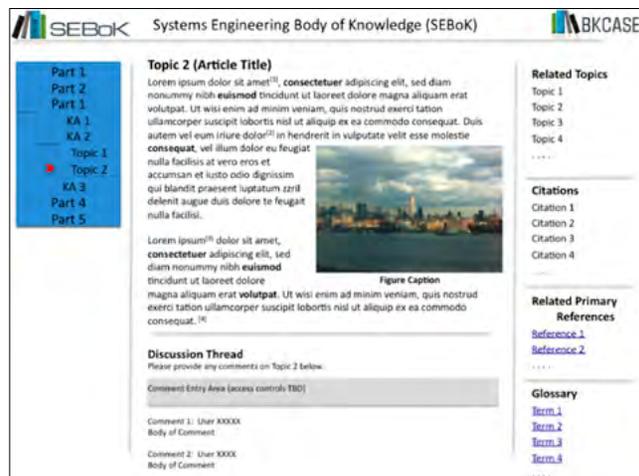

Figure 1. Notional depiction of future wiki page

review comments on SEBoK version 0.5, and next to complete the final delivery of SEBoK version 1.0. A notional depiction of an article within the future wiki is shown in figure 1. Costs, sustainment needs, and specific implementation options for this approach are still being investigated.

In addition to this content wiki, the author team is discussing the possibility of providing a space for discussions on specific issues, such as emerging and ongoing research. This type of "sandbox" may enable consolidated discussion in the community. The author team plans to gather feedback on these options as part of the review of SEBoK version 0.5.

The Challenge

The primary challenge for the BKCASE project is to bring together the diverse views of the developing discipline of systems engineering into a coherent guide to a body of knowledge for the benefit of the global community. A solid knowledge-management strategy is key to the eventual success of this effort. The challenge of developing the SEBoK requires a call to action: to bring the community together to support the successful introduction of SEBoK version 1.0 in the fourth quarter of 2012, through active and constructive reviews and written contributions, and a willingness to reach consensus on the top issues and challenges, in support of this important endeavor. ⓘ

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