2012

Gaps in the body of knowledge of systems

Squires, Alice

INCOSE

22nd Annual INCOSE International Symposium, Rome, Italy, 9-12 July 2012, 11 p.
http://hdl.handle.net/10945/47782

Gaps in the Body of Knowledge of Systems Engineering

Alice Squires
School of Systems and Enterprises
Stevens Institute of Technology
Hoboken, NJ 07030
Email: alice.squires@stevens.edu

Garry Roedler
Lockheed Martin Corporate Engineering
Philadelphia, PA 19101
Email: garry.j.roedler@lmco.com

David Olwell
Naval Postgraduate School, Department of Systems Engineering
Monterey, CA 93943
dholwell@nps.edu

Joseph J. Ekstrom
Fulton College of Engineering and Technology, Brigham Young University
Provo, Utah 84602
jekstrom@byu.edu

Abstract. The boundaries of systems engineering are evolving as system related needs evolve. These 'fuzzy' boundaries result in gaps between what users in the systems engineering community need and what the body of knowledge of systems engineering provides. This paper covers various use cases of the body of knowledge of systems engineering and explores gaps in the existing knowledge base in two areas: 1) related disciplines, and 2) emerging systems engineering topics.

Introduction

The body of knowledge of systems engineering covers the development of engineered systems that are created by and for people. These systems have a purpose within multiple perspectives and satisfy key stakeholder needs. Each system also has a context within which it exists in an external environment, as well as in internal organization that many times determines its level of efficiency and effectiveness. Systems are also typically part of a system-of-interest hierarchy. This paper explores the relationship of a particular body of knowledge, the Guide to the Systems Engineering Body of Knowledge (SEBoK) (Pyster, et. al 2011) and areas where the body of knowledge falls short of meeting the needs of the systems engineering community. These shortfalls have been uncovered through the efforts of both the SEBoK and Graduate Reference Curriculum in System Engineering (GRCSE™) authors (represented by the authors of this paper) and the efforts of reviewers, specifically those who reviewed versions 0.25 and 0.5 of the SEBoK. While this list of shortfalls is not necessarily complete, the list will be modified based on both the efforts of the authors for versions 0.75 (released in March 2012) and 1.0 (to be released in September 2012) based on feedback received from authors and reviewers of these products.

Background

As described in Squires et al. (2009), the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE™) project is a three-year effort initiated in September of 2009 to produce two version 1.0 products: a Guide to the Systems Engineering Body of Knowledge (SEBoK) and a Graduate Reference Curriculum in System Engineering (GRCSE™). The project, primarily funded by the U.S. Department of Defense, is led by a

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **JUL 2012**	2. REPORT TYPE	3. DATES COVERED **00-00-2012 to 00-00-2012**
4. TITLE AND SUBTITLE **Gaps in the Body of Knowledge of Systems Engineering**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Stevens Institute of Technology,School of Systems and Enterprises,Castle Point,Hoboken,NH,07030**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
22nd Annual INCOSE International Symposium, Rome, Italy, 9-12 July 2012.

14. ABSTRACT
The boundaries of systems engineering are evolving as system related needs evolve. These ?fuzzy? boundaries result in gaps between what users in the systems engineering community need and what the body of knowledge of systems engineering provides. This paper covers various use cases of the body of knowledge of systems engineering and explores gaps in the existing knowledge base in two areas: 1) related disciplines, and 2) emerging systems engineering topics.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**10**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

university partnership between the Stevens Institute of Technology and the U.S. Naval Postgraduate School (NPS) with support from various professional societies, especially the International Council on Systems Engineering (INCOSE) and the Institute of Electrical and Electronics Engineers (IEEE), along with other universities and companies who provide and support about 70 BKCASE authors from around the globe. A series of articles updating the status of the project from 2009 through 2011 are available from Olwell et al. (2010), Squires et al. (2010), Roussel et al, (2011) and Squires et al. (2011).

Adcock et al (2011) focused on research gaps in the initial version 0.25 of the SEBoK. This paper expands that gap analysis using the perspective of interrelationships with related disciplines and emerging systems engineering topics. The most current SEBoK version 0.75 can be found at sebokwiki.org (Pyster, et. al., 2011); however, this analysis began with version 0.5, and the most current available version 0.75 addresses some of these findings. The goal is to address additional areas in the final version 1.0 to be released in September.

Use Cases

The SEBoK is intended to inform systems engineering practice, research, curriculum development, certification, organizational strategy, and related disciplines. Users of the SEBoK include practicing systems engineers, process engineers, faculty members and curriculum developers, systems engineering trainers and certifiers, engineering managers, hardware engineers, software engineers, project managers, and customers of systems engineering products and services. The SEBoK currently describes use cases for several types of users; however, these are high-level descriptions that will need to evolve into detailed roadmaps that can be used to quickly navigate the SEBoK based on immediate and longer-term needs. As these use cases evolve, the gaps in the body of knowledge will become more apparent. In the meantime, the two main areas of focus are related disciplines and emerging topics, each of which are addressed in the next two main sections.

Related Disciplines

The SEBoK represents the best efforts of a large community of systems engineers to define the topics that comprise the discipline of systems engineering. As part of that definition, the authors struggled with the relationship of systems engineering to related disciplines such as hardware engineering, software engineering, project management and engineering management. The team discovered that stakeholders from the systems engineering and related communities draw the boundaries between these disciplines differently. In addition, there was a disagreement among systems engineering experts as to which related disciplines were of key importance versus those that were not. Topics often were included in two or more of these overlapping disciplines, and the boundaries were fuzzy.

The SEBoK authors decided to limit the number of duplicate topics in bodies of knowledge developed by other disciplines, notably the Project Management Body of Knowledge (PMBoK) (PMI, 2008) and the Software Engineering Body of Knowledge (SWEBoK) (Abran and Moore, 2004). This led to some difficulty, as the approach and content of an article on software engineering written for a software engineer, for example, may be substantially different in scope and depth from an article written for a systems engineer on the same topic, which might have a much greater management and integration emphasis. Thus, in some parts of the SEBoK it was necessary to include knowledge areas and topics that have duplicate topical coverage, but present the information from a systems engineering perspective. Relationships of systems engineering to other disciplines is also addressed in Part 1 of the SEBoK in a general way. However, there are some gaps in the areas of the SEBoK related to other disciplines, in general. Areas of interest to systems engineers in hardware and software engineering, project management, as well as industrial engineering, procurement and acquisition, and emerging specialty disciplines are explored specifically in the following sections.

Hardware and Software Engineering

The relationship of systems engineering to hardware engineering is a classical relationship that has stood the test of time. In this way, systems engineering has supported the integration of the traditional engineering disciplines of electrical, mechanical, civil, aeronautical and others, that have historically been based in hardware. The relationship of systems engineering to these disciplines is so ingrained that many believe systems engineering to be the actual integration of these disciplines – or multidisciplinary in nature and definition. In this way a multidisciplinary engineer is synonymous with systems engineer.

The argument has been made that software is no different than any other discipline relative to systems engineering. However, as more and more of the control functions of systems is embodied in software, systems engineers are required to interact with more software oriented team members and understand systems that are more and more software intensive in their development. There are two distinct perspectives that need to be well understood by systems engineers. First there are the aspects of software as a component of systems that are simply different than other types of components. Just as mechanical systems requirements have physical vibration and load requirements, software requires treatment specific to software such as platform and operation execution time. System engineers need to know about managing and interacting with software teams.

For hardware and software Engineering, there are fundamental concepts of design development and architecture that every SE involved with systems should understand in order to function in these environments. In particular, a systems engineer should understand common architectures and design patterns. A system engineer should have a basic understanding of the tools and models used to design and develop systems. Many projects have failed due to systems integration issues associated with underestimating the complexity of defining and managing interfaces. These interfaces are also one of the areas where security vulnerabilities are most common. Since hardware and software must often be developed and tested in simulated environments a systems engineer must understand the limitations of such testing. Knowledge areas with which a systems engineer should be at least conversant include:

- Architectures and design patterns, and their implications for the system life cycle
    - Open architecture: issues, strategies, risks, costs, benefits.
    - Interfaces and interface management
- Cyber security issues, assurance, strategies, and costs
- Hardware and software development methodologies and tools
    - Model driven software development
    - Resilient SW
    - Agile SW

- Information management and modeling concepts and tools
  - Data rights
  - Data modeling
- Hardware and software deployment platforms and issues
  - Real time embedded systems
  - Standards based Operating Systems
  - Standards based Data Management Systems
  - Standards based Middleware
- Maturity models
  - CMMI
- Verification and Validation of hardware and software
  - Simulation of performance
  - Benchmarks
- Systems of systems environment: issues and strategies.
- Current issues and advances in engineering

Project Management

The Systems Engineering Management Knowledge Area of the SEBoK addressed Planning, Assessment and Control, Risk Management, Configuration Management, Measurement, Quality Management, and Information Management. The Knowledge Area explores the topics from a systems engineering technical perspective and from the systems engineer's responsibility to supplement and collaborate with PM. The SEBoK version 0.5 also address the relationship between systems engineering and project management through the Systems Engineering Management Plan (SEMP). However, there has been an extensive amount of research documented about the importance of the chief systems engineer and the project manager to be 'joined at the hip'. From a high level perspective, the project manager and the chief engineer share many of the same responsibilities around planning, estimating, risk management, leading and directing, and measuring and controlling. Both are responsible for cost, schedule and the technical success of the project. The main difference is typically viewed as the project manager's focus is on cost and schedule where the chief systems engineer's focus is on technical. Yet, project success requires the success of all three project attributes. Also, on smaller projects the same person may carry out the role of project manager and systems engineer. On large complex projects, a team may be needed to support each role. From a body of knowledge perspective, it is important to provide the systems engineering community with common practices in these areas related to roles and responsibility expectations and accountability demands. Systems engineers need to be accountable not only for the technical system solution but also for the total ownership cost of the system. Understanding technical management, risk analysis, decision-making, configuration management, and many other areas that also fall into the realm of the project manager are important areas needed to support high quality systems engineering.

Other Specialty Disciplines

Other obvious disciplines to include in the discussion of systems engineering is industrial engineering and procurement and acquisition. Clear distinction between emerging characteristics of systems (see Emerging Topics), including many of the more recent specialty engineering topics. Until recently, the specialty engineering topics were hand-picked for inclusion in the SEBoK. As characteristics emerge or become more prominent, we need to identify and define the set of key design/decision characteristics/criteria currently of greatest concern (e.g., resilience, robustness, trusted systems, system assurance, adaptability, flexibility, etc..). However, it is not enough to define each from only its own perspective. We need to define the relationships between the characteristics and their level of independence. And then provide guidance on their priorities under which system/operating conditions.

Emerging Topics

The SEBoK has primarily focused on the portion of the body of knowledge that has solid roots in theory and application. However there are many emerging topics in systems engineering. Many of these are seen today in the university and industry research, advances in technology and tools, and further integration with related disciplines. The following provides a set of topics that fit into the Emerging SE area that reflect to some extent gaps in the SEBoK. Whereas, a few of these topics are covered in the SEBoK, they are topics that are still developing, but have a solid foundation with reasonable application. These can be divided into the areas of:

1. SE Efficiency and Responsiveness
2. Architecture Reuse and Efficiency
3. Model-based SE
4. Complex systems and System-of-Systems (SoS) Analysis
5. System Affordability
6. SE Measurement Evolution
7. Total system solution perspective
8. Advanced Methods of Understanding Stakeholder Needs

Each of these is explored in more detail in the following sections.

SE Efficiency and Responsiveness

SE Efficiency and Responsiveness involves the "right-sizing" and work-flow planning of systems engineering based on the characteristics and risks of the project and the timing requirements to get the capabilities to the user. These approaches incorporate principles of lean practices, agile development, Kanban, risk management, and decision management. This focus is being driven by the need to reduce time for delivery of key capabilities to customers and are being developed to address the following situations:.

Expedited SE. Expedited SE covers situations where SE is focused on full-scale life cycle needs, but emphasizes cost effectiveness and efficiency to decrease the time without sacrificing the necessary level of rigor. Expedited SE needs to be able to address changing operational needs/threats and innovation/advances in technology across the life cycle through a risk managed approach. There is research currently being performed under the SE Research Center (SERC) on this topic, as well as a means to incorporate Kanban approaches to scheduling the SE activities based on value.

Rapid Fielding. In this situation, there is a short time to market requirement for first delivery of the most critical or desired capability. That is, the developed system must meet a short timeline to field the capability, and the resulting system may be a one-time implementation or an evolutionary and ongoing development.

Rapid Response. In this case the situation requires systems engineering as a service in a rapid response to provide systems engineering services as needed.

Architecture Related Topics

In too many new systems, the architecture development starts from scratch without consideration for previous architecture definitions. Although this allows for incorporation of new technology, it ignores the efficiencies of reuse and the maturity of proven architectures. In many cases the system is a variant within a product line. In these cases, there are significant efficiencies to be gained by recognizing the potential variants and designing in the right adaptability. The following are key elements that allow the Systems Engineers and Architects to better leverage reusable architectural elements for both efficiency and effectiveness. These should also help in the SE responsiveness discussed above

Platform based engineering. This considers how to provide adaptability through the use of flexible platforms that can account for variations and evolution of mission needs. This can include the use of Product Line Architectures (PLAs) that are created with a range of potential variations in mind.

Reuse of system definition elements. This employs the identification and definition of architecture patterns, reference architectures, and architecture frameworks to allow leverage of proven architecture elements in order to reduce effort while improving quality and consistency.

Addressing architecture from both top down and bottom up. This includes the use of building block concept, i.e., integration of well-designed, configurable system elements within an architecture framework.

Pattern Based Architecture. This addresses the use of proven architecture, architectural elements, or patterns to streamline the development of new architectures.

Model-Based SE

The true power of modeling and simulation to support SE across the life cycle is still emerging. Model-based SE is addressed in the SEBoK, but is still very early in its application, especially to address full life cycle needs. When the data integration needs can be adequately addressed, the application of Model-Based SE will likely become more widespread and mature. The SEBoK addresses some aspects of models and modeling, but does not reveal the full potential of Model-based SE as discussed in the Final Report of the Model Based Engineering Subcommittee of the National Defense Industrial Association (NDIA) (NDIA, February 2011).

Complex Systems and SoS Analysis

Complex systems and SoS analysis are covered to some extent in the SEBoK, but are still emerging with respect to the application and knowledge. The analysis and management necessary for such complex systems and systems-of-systems are also still emerging (see

ODUSD(A&T)SSE, 2008). The analysis and management of these systems are being considered for exploration in the SEBoK per the items listed below.

Multivariate analysis. These systems have many variables to balance and needs the development of cost-effective and efficient means to perform multivariate analysis to support trades for the growing array of key characteristics.

SoS Portfolio Management. As the SoS evolves, it becomes more important to establish some management of the portfolio of systems that compose it. This is often a challenge due to the independent governance of those systems. The management of the portfolio of systems in a SoS requires cooperative governance to evolve capabilities most efficiently – e.g., evolve capabilities across the set of systems versus creating a new system and managing the interface and interoperating functions that may involve multiple systems.

Emergent properties. One of the challenges in managing the Complex System/SoS is the high likelihood of emergent properties. It is essential to develop effective practices for the management of emergent properties/requirements to ensure acceptable and useful evolution of the Complex System/SoS and the relevance of the solution.

System Affordability

There is a growing emphasis on system affordability (i.e., value across the life cycle). The SEBoK does not currently provide a recognizable thread regarding affordability through the set of Knowledge Areas and Topics. With the increasing focus on the cost and value of the system across the total life cycle, new activities or changes to existing activities need to be identified and defined to ensure affordability becomes part of the mindset. Operability and supportability are becoming more important in the government arena – changing analysis and decision models.

SE Measurement Evolution

Measurement for SE has been evolving significantly over the past several years (NDIA, October 2011). While SE Measurement is a topic in the SEBoK, this topic will continue to evolve with the emerging topics of SE and lessons are learned from the application of recent developments. New measures and measurement analysis for emerging areas and key characteristics are needed and currently being explored. SE leading indicators have been defined and are being leveraged for greater insight. Yet, there is a need to link cost and schedule in EVM to technical performance, including 1) work products passing reviews, 2) accomplishments of TPM milestones, 3) verification of system requirements, and 4) validation of stakeholder needs. Additionally, advancements in SE measurement are needed to provide necessary insight for affordability, as well as some of the other topics discussed above.

Total System Solutions

Related to the total system solution perspective, there is an increasing realization that system solutions need to consider much more than the system-of-interest itself. Concurrent engineering of the system-of-interest, enabling systems (new or modified to support SOI), and interfaces/interoperability with known and potential systems in the operating environment comprise the scope for the total system solution (ISO/IEC/IEEE 15288:2008(E). 2008; ISO/IEC/IEEE 24748-1, 2010).

Advanced Methods of Gathering Stakeholder Needs

Recent research in the area of advanced methods of understanding stakeholder needs is very promising and includes areas such as one in concept engineering that explores graphical or virtual ConOps and OpsCons and allows interactive involvement of stakeholders in a fully immersive environment where the stakeholders can explore concepts and their feasibility

Forward Plan

Based on ongoing gap analyses such as this paper and the previous work by Adcock et al. (2011), the BKCASE team plans to continue to expand on the topics covered in the SEBoK for the final version 1.0 release in September 2012. Following this, two professional societies, the International Council on Systems Engineering (INCOSE) and Institute of Electrical and Electronics Engineers (IEEE), have agreed to become joint stewards of the BKCASE products once they are released in 2012. Both INCOSE and the IEEE are partners in the current project and have provided observers and authors to the BKCASE team. Other partners and sponsoring organizations include the Association for Computing Machinery (ACM) and the Systems Engineering Division (SED) of the National Defense Industrial Organization. Plans are underway to continue to identify and address gaps in the SEBoK through the stewardship of these organizations.

Summary

In this paper we have examined the gaps between community needs and the SEBoK version 0.5 knowledge base. In particular we have explored unmet needs in 1) related disciplines and 2) emerging systems engineering topics. Although there is no consensus on what knowledge from related disciplines should be included in the SEBoK, it is clear that a systems engineering specific treatment of certain areas of knowledge in some adjacent disciplines would be useful to the SE community. We have described a set of topics in Software Engineering, Project Management, and Specialty disciplines that are currently missing but that would provide conceptual bridges for SE's in multidisciplinary teams. We do not suggest that these are the only areas in which such SE specific treatments could be useful, however, we have provided examples that illustrate topics for which bridging articles could be integrated into the SEBoK.

Acknowledgements

The authors are indebted to the entire BKCASE team.

References

Abran, A. and J.W. Moore (exec. eds); P. Borque and R. Dupuis (eds.). 2004. SWEBOK: Guide to the Software Engineering Body of Knowledge. Piscataway, NJ, USA: The Institute of Electrical and Electronic Engineers, Inc. (IEEE). Available at: http://www.computer.org/portal/web/swebok

Adcock, R., A. Squires, D. Olwell, N. Hutchison, 2011. "Research Issues Raised by the Guide to the Systems Engineering Body of Knowledge", Proceedings from the Ninth Annual Conference on Systems Engineering Research (CSER), Redondo Beach, CA, April 14-16, 2011.

ISO/IEC/IEEE 15288:2008(E). (2008). Systems and software engineering — system life cycle processes, ieeestd 15288-2008, second edition

ISO/IEC/IEEE 24748-1, 2010. Guide to Life Cycle Management.

NDIA, February 2011. Final Report of the Model Based Engineering Subcommittee of the National Defense Industrial Association (NDIA).

NDIA, October 2011. System Development Performance Measurement Working Group Report NDIA Systems Engineering Division, SE Effectiveness Committee, in conjunction with Practical Software and System Measurement

ODUSD(A&T)SSE, 2008. Office of the Deputy Under Secretary of Defense for Acquisition and Technology, Systems and Software Engineering. Systems Engineering Guide for Systems of Systems, Version 1.0. Washington, DC.

Olwell, D., Pyster, A., Squires, A., Gelosh, D., Enck, S., & Anthony, J. (2010). "The Systems Engineering Body of Knowledge and Graduate Reference Curriculum", Proceedings of the European Systems Engineering Conference 2010, Stockholm, Sweden, May 23-26, 2010.

PMI. 2008. A Guide to the Project Management Body of Knowledge (PMBOK guide). 4th ed. Newtown Square, PA, USA: Project Management Institute (PMI).

Pyster, A., D. Olwell, A. Squires, N. Hutchison, S. Enck, J. Anthony, Eds. (2011) "A Guide to the Systems Engineering Body of Knowledge (SEBoK). Version 0.5." Stevens Institute of Technology, Hoboken, NJ, USA. Released for public review, September, 2011. See sebokwiki.org.

Roussel, J-C., A. Squires, T.L.J. Ferris, G.R. Freeman, 2011. "Status of the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE™) Project, Proceedings of the 5th Asia-Pacific Conference on Systems Engineering (APCOSE 2011), Seoul, Korea, October 19-21, 2011.

Squires, A., A. Pyster, D. Olwell, S. Few, and D. Gelosh, 2009. "Announcing BKCASE: Body of knowledge and curriculum to advance systems engineering." INCOSE Insight 12 (4): p 69-70.

Squires, A., A. Pyster, B. Sauser, D. Olwell, S. Enck, D. Gelosh, J. Anthony, 2010. "Applying Systems Thinking via Systemigrams for Defining the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) Project", Proceedings of the 20th Annual International Symposium, INCOSE 2010, Chicago, Illinois, July 12-15, 2010.

Squires, A., N. Hutchison, A. Pyster, D. Olwell, 2011. "Managing the Systems Engineering Body of Knowledge." INCOSE Insight, 14(1), pp. 37-39.

Biographies

Alice Squires has nearly 30 years of professional experience and is a faculty at the School of System and Enterprises, Stevens Institute of Technology. She is a senior researcher for the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) and Systems Engineering Experience Accelerator (SEEA) projects. Alice is INCOSE CSEP and CSEP-Acq certified with a BSEE, MBA and doctorate in systems engineering. Alice is Past Chair of the Systems Engineering Division of ASEE and received the Stevens Institute of Technology Provost's Online Teaching Excellence Award in 2007.

Garry Roedler is a Fellow and the Engineering Outreach Program Manager for Lockheed Martin. His systems engineering experience spans the full life cycle and includes technical leadership roles in both programs and systems engineering business functions. He holds the Expert Systems Engineering Professional (ESEP) certification from INCOSE and serves as the INCOSE Corporate Advisory Board chair. Garry is the author of numerous publications and editor of several key standards, including ISO/IEC/IEEE 15288, System Life Cycle Processes. The INCOSE Founders Award, Best SE Journal Paper, and selection for the IEEE Golden Core are among the many awards Garry has received for his work.

David H. Olwell is Professor of Systems Engineering at the Naval Postgraduate School. Dr. Olwell holds a Ph.D. in Statistics and an M.S. in Mathematics and in Statistics from the University of Minnesota and is a 2011-2012 American Council on Education (ACE) Fellow placed at the University of Hawaii. He is also the co-Principal Investigator of the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) project.

Joseph J. Ekstrom spent 30 years as a software developer, system integrator, manager, and executive. In 2001 he joined the faculty of the Information Technology program in the Fulton College of Engineering and Technology at Brigham Young University and currently serves as Program Chair. His interests include IT curriculum, Software and Systems Engineering curriculum, IT as a profession, Network and systems administration and management, Cyber-security, and how all of the above should inform each other.