The Body of Knowledge and Curriculum to Advance Systems Engineering

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Agenda

1. BKCASE background and objectives
2. Systems Engineering Body of Knowledge status and plans
3. Graduate Reference Curriculum on Systems Engineering status and plans
4. Questions

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How We Got Here

In Spring 2007, 3 phase effort was proposed:

1. A reference curriculum* for graduate software engineering with the “right” amount of systems engineering
2. A reference curriculum for graduate systems engineering with the “right” amount of software engineering
3. A fully interdisciplinary reference curriculum for systems and software engineering

*A reference curriculum offers recommendations on longer-term objectives for students, outcomes at graduation, entrance expectations, curriculum architecture, and required knowledge. Recommendations will be tailored. They do not specify course offerings or packaging except as examples.

You Are Here…

DONE

Phase 1. A reference curriculum for graduate software engineering with the "right" amount of systems engineering

NOW

Phase 2. A reference curriculum for graduate systems engineering with the "right" amount of software engineering

FUTURE

Phase 3. A fully interdisciplinary reference curriculum for systems and software engineering

Phase 1 Primary Products

- Graduate Software Engineering 2009 (GSwE2009): Curriculum Guidelines for Graduate Degree Programs in Software Engineering
- GSwE2009 Companion Document: Comparisons of GSwE2009 to Current Master's Programs in Software Engineering
- GSwE2009 Companion Document: Frequently Asked Questions on Implementing GSwE2009


iSSEc

Integrated Software & Systems Engineering Curriculum (iSSEc) Project

Graduate Software Engineering 2009(GSwE2009)

Curriculum Guidelines for
Graduate Degree Programs in Software Engineering

GSwE 2009

Version 1.0

September 30, 2009

Unlimited Global Distribution

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Endorsed by INCOSE, NDIA SE Division, Brazilian Computer Society

Originally sponsored by DoD. **Now sponsored by the IEEE Computer Society and ACM**

www.GSwE2009.org

What is BKCASE?

- Project to create:
  - Systems Engineering Body of Knowledge
  - Graduate Reference Curriculum in Systems Engineering (GRCSE™ – pronounced “Gracie”)
- Started in September 2009 by Stevens Institute of Technology and Naval Postgraduate School with primary support from Department of Defense
- Project will run through 2012
- Intended for world-wide use

What is in the SEBoK?

Describes the boundaries, terminology, content, and structure of SE that are needed to systematically and consistently ***support and enable***:

Task Name	Task Description
Inform Practice	Inform systems engineers about the boundaries, terminology, and structure of their discipline and point them to useful information needed to practice SE in any application domain
Inform Research	Inform researchers about the limitations and gaps in current SE knowledge that should help guide their research agenda
Define Curricula	Define the content that should be common in undergraduate and graduate programs in SE
Certify Professionals	Certify individuals as qualified to practice systems engineering
Decide Competencies	Decide which competencies practicing systems engineers should possess in various roles ranging from apprentice to expert

Guide to the literature, not all the content of the literature

What is in GRCSE?

- ***Guidance for Constructing and Maintaining the Reference Curriculum:*** the fundamental principles, assumptions, and context for the reference curriculum authors
- ***Entrance Expectations:*** what students should be capable of and have experienced before they enter a graduate program
- ***Objectives:*** what students should be able to achieve 3 to 5 years after graduation based on what they learn in program
- ***Outcomes:*** what students should achieve by graduation
- ***Architecture:*** the structure of a curriculum to accommodate core material, university-specific material, and elective material
- ***Core Body of Knowledge:*** material that all students should master in a graduate SE program

Not specific courses. Not specific packaging. Adaption and selective adoption expected and encouraged.

BKCASE Vision and Objectives

Vision

"Systems Engineering competency models, certification programs, textbooks, graduate programs, and related workforce development initiatives around the world align with BKCASE."

Objectives

1. Create the SEBoK and have it be globally recognized by the SE community as the authoritative guide to the body of knowledge for the SE discipline.
2. Create GRCSE and have it be globally recognized by the SE community as the authoritative guidance for graduate programs in SE.
3. Facilitate the global alignment of related workforce development initiatives with SEBoK and GRCSE.
4. Transfer stewardship of SEBoK and GRCSE to INCOSE and the IEEE after BKCASE publishes version 1.0 of those products, including possible integration into their certification, accreditation, and other workforce development and education initiatives.

BKCASE™

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1. Products generated by the authors, not the sponsor or supporters
2. Even though the Department of Defense is the sponsor, it does not have any authority over the content of the products, nor are the products slanted towards defense systems development and acquisition
3. Volunteer authors do the bulk of the writing
4. Core Team from Stevens and Naval Postgraduate School provides stable labor and direction
5. Core Team responsible for final integration, technical editing, and clean up of products

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2. ***Systems Engineering Body of Knowledge status and plans***
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Natural and Engineered Systems

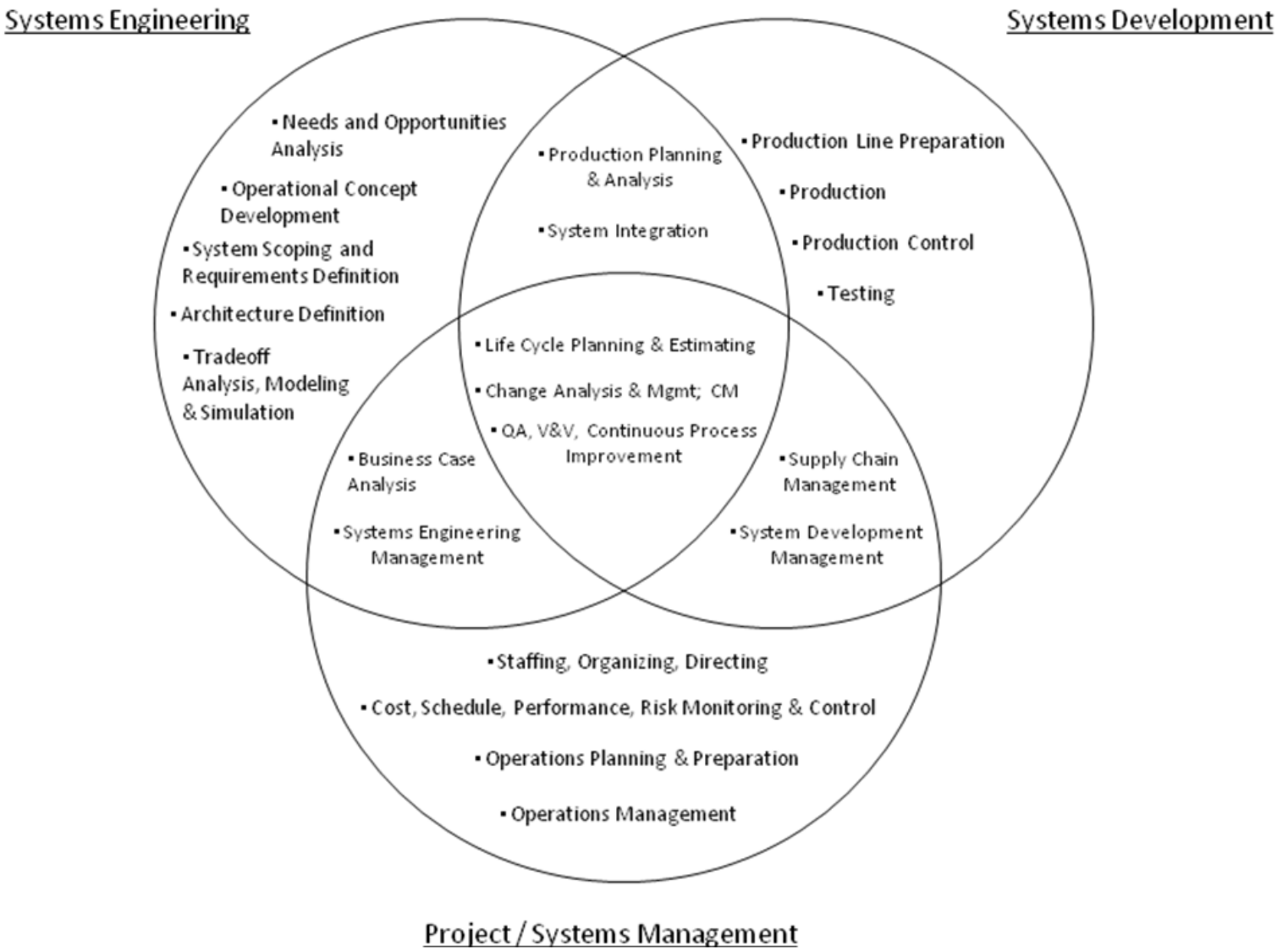
- Natural systems: Solar system, real number system
  - Not a concern of SEBoK, other than being external environments
- Engineered systems: Technical or sociotechnical aggregations of physical, informational, and human elements that exhibit emergent properties not exhibited by the individual elements
  - Created by and for people
  - Have a purpose, with multiple views
  - Satisfy key stakeholders' value propositions
  - Have a life cycle and evolution dynamics
  - Have a boundary and an external environment
  - Are part of a system-of-interest hierarchy

Systems Engineering Defined

- INCOSE
  - Interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, **then** proceeding with design synthesis and system validation while considering the complete problem

- Possible Alternative
  - Interdisciplinary approach and means to enable the realization of successful systems. It focuses on holistically and concurrently understanding stakeholder needs, exploring opportunities, documenting requirements, and synthesizing, verifying, and validating solutions

SE, Development, Management



SEBoK 0.25 Table of Contents

1. Introduction
2. System Concepts and Systems Thinking
3. SE Overview
4. Generic Life Cycle Stages
5. Service SE
6. Enterprise SE
7. Enabling SE in the Organization
8. SE Management
9. System Definition
10. System Realization Fundamentals
11. System Deployment and Use
12. System Life Management
13. SE Agreement
14. Cross-Cutting Knowledge
15. SE Competencies
16. SE Applications/Case Studies
17. References
18. Glossary

State of SEBoK 0.25

1. Version 0.25 released for limited review on September 15, 2010
   - 0.25 is prototype; 0.5 for early adopters; 1.0 for everyone
2. 656 pages long, 15 out of 16 chapters drafted, lots of very good material – more than expected at this point
3. Pointers to more than 700 books, articles, and websites divided into two broad categories: primary references and additional references/ readings.
4. Uneven maturity, too aerospace/defense, too process-oriented
5. More than 3000 comments from more than 100 reviewers

Review Questions

1. Is stated purpose of the SEBoK correct?
2. Is intended audience of the SEBoK correct?
3. Is scope of the SEBoK correct; i.e., does SEBoK cover the right topics?
4. How would you improve the writing about any specific topic? Did we leave off an important concept or discuss a concept poorly?

Review Questions

5. Did we properly identify all the primary references for a topic? The additional references and readings? Are there references or readings missing? If so, please identify them.

6. Did we properly identify all the correct glossary terms? Were important terms left out or are the definitions incorrect or incomplete?

7. How well does the SEBoK currently satisfy its stated purpose?

8. The BKCASE Team plans to convert the SEBoK into a wiki-based format. What are the considerations for this format? What capabilities should be expected from this structure?

SEBoK 0.5 Anticipated TOC

Part I: A guide to the SEBoK itself – Why does it exist? What is in it? How will different people use it?

Part II: A guide to knowledge about systems – What types of systems exist? What fundamental principles help explain systems?

Part III: A guide to knowledge about SE practice – How is SE performed? What are typical SE activities?

Part IV: A guide to knowledge about SE deployment and sustainment – When is SE performed? Who performs it? How is it enabled by an organization?

Part V: Implementation Examples – What do existing case studies reveal about SE knowledge and practice? How does SE practice vary by domain and system type?

Wiki Planned for SEBoK 0.5

Part 1
Part 2
Part 1
KA 1

SEBoK Map: Generated from TOC

Part 4
Part 5

Topic 2 (Article Title)

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Figure Caption

Discussion Thread

Please provide any comments on Topic 2 below.

Comment Ent

Comment 1:
Body of Com

Comment 2: User XXXX
Body of Comment
. . . .

Community Involvement & Conversation: Specific aspect of wiki development

Related Topics

Topic 1

Guidance Materials

Citations, Glossary, and primary references – Generated from 0.5 materials

Related Primary References and Related topics: New efforts unique to Wiki discussion

Glossary

Term 1
Term 2
Term 3
. . . .

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GRCSE Value Proposition

1. There is no authoritative source to guide universities in establishing the outcomes graduating students should achieve with a master's degree in SE, nor guidance on reasonable entrance expectations, curriculum architecture, or curriculum content.

2. This gap in guidance creates unnecessary inconsistency in student proficiency at graduation, makes it harder for students to select where to attend, and makes it harder for employers to evaluate prospective new graduates.

3. GRCSE will fill that gap, becoming the "go to" reference to develop, modify, and evaluate graduate programs in SE.

GRCSE used GSwE2009 as starting point and made many improvements

Version 0.25 released for limited review on December 17, 2010

GRCSE 0.25 Contents

Title - Chapters
1. Introduction
2. Context and Guidance for the Construction and Maintenance of GRCSE
3. Expected Student Background When Entering A Master's Program
4. Expected objectives
5. Expected outcomes when a student graduates
6. Curriculum architecture
7. Core body of knowledge (CorBOK)
8. Assessment
9. Anticipated GRCSE evolution

Title - Appendices
Glossary
References
App A. Summary of graduate SE-centric SE programs in 2010
App B. Bloom's taxonomy of educational outcomes
App C. GRCSE outcomes to CorBOK mapping
App D. Assessment and achievement of learning outcomes
App E. Competency-based curriculum development approach
App F. Discussion of program emphasis

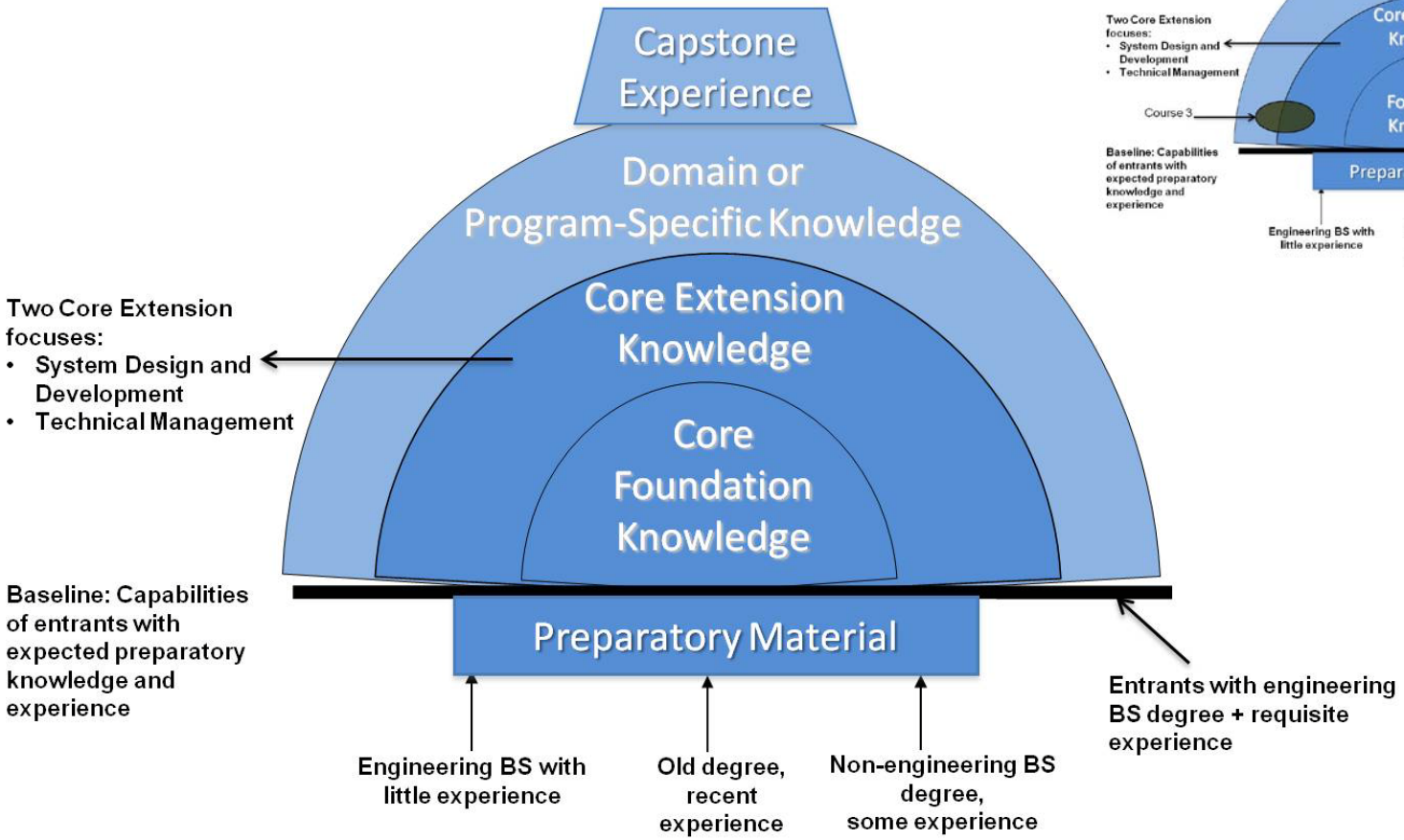
Some Key Decisions

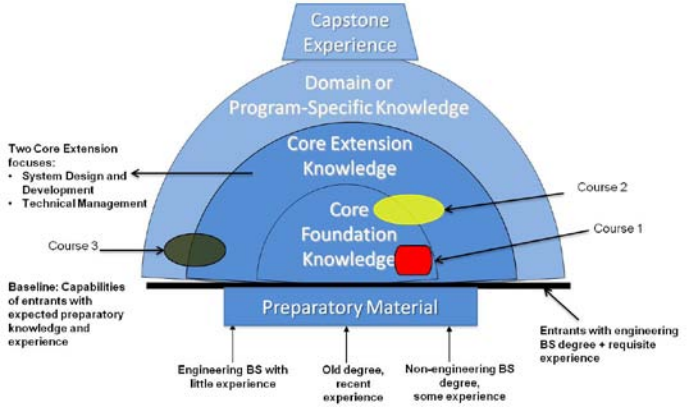
Question	Decision for GRCSE 0.25
Focus on Domain-Centric SE programs or just Systems-Centric programs?	Systems-Centric only
What type of undergraduate degree should be expected?	Engineering, science, math, or computing
How much experience should be expected of program entrants?	At least 2 years of practical experience in some aspect of SE
Focus on traditional product SE or on services and enterprise SE as well?	All 3 – product, services, and enterprise SE
One set of outcomes and objectives or several sets, reflecting the range of SE educational practice?	One set

Some More Decisions…

Question	Decision for GRCSE 0.25
Any communication abilities expected?	Effective technical communication in the language of instruction
How much content should be standardized?	No more than 50%
Learn SE abstractly or in the context of an application domain	In context of application domain
How much software engineering expected at graduation?	Mastery of specific elements of SWEBOK to specified Bloom's levels

Curriculum Architecture





Core Body of Knowledge

SEBoK Chapter SWEBoK Chapter	Topic	Core Foundation	Core Extension: System Design and Development (SDD)	Core Extension: Technical Management (TM)
Used for cross-reference to SEBoK/SWEBOK	Name of topic	Bloom level to be attained	Bloom level to be attained in SDD focus area	Bloom level to be attained in the TM focus area

CorBOK Content

SEBoK Chapter	Topic	Core	SDD	TM
2.4	Systems Thinking	X	X	X
3.2	Fundamentals of Systems Engineering	X		
6.2	Fundamentals of Enterprise SE	X		
7.2	Fundamentals of Enabling SE in the Organization			X
8.1	Systems Engineering Management Fundamentals	X		X
9.3	Stakeholders Requirements and Mission Analysis	X	X	
9.4	System Requirements	X	X	
9.5	Architectural Design	X	X	
9.6	System Analysis	X	X	
10.3	System Implementation	X	X	
10.4	System Integration	X	X	
10.5	System Verification	X	X	
10.6	System Validation	X	X	
11.3	System Deployment	X	X	X
11.4	Operation of the System	X	X	X
11.5	System Maintenance	X	X	X
11.6	Logistics	X	X	X
12.3	Service Life Extension	X		
12.4	Capability Updates, Upgrades, and Modernization	X	X	X
12.5	System Disposal and Retirement	X	X	X
13.3	Acquisition Process			X
13.4	Supplier Processes			X
14.3	Integration of Specialty Engineering	X		
14.4	Affordability/Design to Cost	X	X	X
14.5	Human System Integration	X		
14.6	Safety	X	X	X
14.7	Security	X	X	X
14.11	Reliability and Maintainability	X	X	
14.12	Manufacturing and Production	X	X	
14.13	Quality	X	X	X
14.14	Logistics/Supportability	X	X	X
14.15	Occupational Health/ Work Environment	X	X	X
14.16	Disposal	X		
14.17	Resilience	X		

If We Are Successful…

SEBoK will strongly influence the INCOSE SE Handbook Version 4, the INCOSE SE Professional Certification Program, many industry and governmental SE competency efforts, will highlight places where research is needed, become a standard reference for practitioners, and improve the quality and richness of communication among systems engineers worldwide.

GRCSE will clearly distinguish between graduate and undergraduate education in SE and influence the content of both undergraduate and graduate SE programs worldwide.

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