

# BKCASE: Body of Knowledge and Curriculum to Advance Systems Engineering

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Distinguished Research Professor

October 13, 2009

## Can You Spot the Systems Engineer?



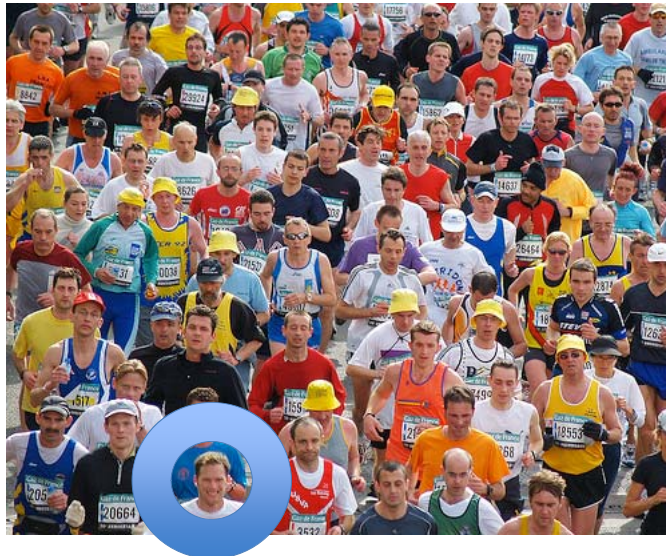
## Leading the Pack and Smiling



10/13/09

3

## Why Is He Smiling?



10/13/09

4

The screenshot shows the Stevens Institute of Technology website with a Yahoo! Finance overlay. The main content includes several articles: 'Dest Jobs in America' by Tom Ichniowski, 'Money on Money.com's list of great careers', 'Systems Engineer' by Michael Wang, 'The Death of the PC' by Andrew H. Lee, and 'Physician Assistant' by Michael Wang. A market data table is also visible, showing various indices like the S&P 500, Dow Jones, and NASDAQ.

10/13/09 5

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- Stevens has begun a 3-year project to create a robust body of knowledge and a reference curriculum to advance systems engineering. Naval Postgraduate School is co-lead.
- DoD recognizes that their own SE success depends on having a well-accepted robust SE BoK on which standard practice, certification, and workforce competency and education can be based. They are providing substantial funding for effort.
- BKCASE will likely follow similar approach as did SWEBOK and GSWE2009, two analogous projects for software engineering and leverage other efforts such as NPS Modeling and Simulation Acquisition Curriculum
- INCOSE and IEEE Systems Council have agreed to participate
- IEEE Computer Society and ACM invited to participate

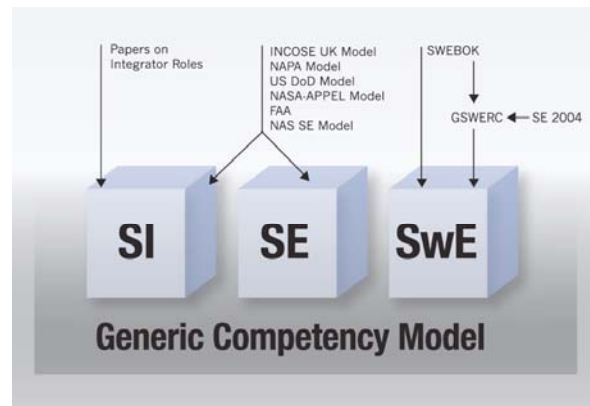
10/13/09 6


- There are many Systems Engineering (SE) workforce development initiatives that rely on a clear understanding of the knowledge that is included in SE and on how that information is organized – but there is no authoritative body of knowledge on which to rely
  - INCOSE SE Handbook
  - FAA SE competency model
  - DoD SE competency model
  - UK INCOSE SE framework
  - INCOSE SE reference curriculum framework
  - NASA SE Handbook
  - etc



Everyone is forced to invent their own or rely on references to other non-authoritative sources

Sources used to create a generic SE, systems integration, and software engineering competency model for the U.S. Federal Aviation Administration





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## INCOSE UK Chapter Framework

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“An issue identified by the INCOSE UK Advisory Board (UKAB) was the inability of individuals and enterprises to identify the competencies that are required to conduct good systems engineering. Some enterprises found that they *“did not know what it is they did not know”* about systems engineering and that individuals did not have a clear career path to become a “chartered systems engineer”.

Objective was to “have a measurable set of competencies for systems engineering which will achieve national recognition and will be useful to the enterprises represented by the UKAB”

Created a framework based on:

- ISO 15288, CMMI, EIA 731, INCOSE SE BoK and Handbook,
- NASA Handbook, IEE/BCS Safety Competency Guidelines

10/13/09
9



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## DoD Competency Model


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Model created to support workforce improvement. Specifically, to determine

1. The current SE competencies of the SPRDE-SE/PSE workforce
2. How these SE competencies are distributed across DoD organizations and acquisition programs
3. How these SE competencies will be affected in the next 5 years by people departing the SPRDE-SE/PSE workforce; and
4. The potential for the current SPRDE-SE/PSE workforce to increase its competency

<i>Unit of Competence: Analytical</i>		
#	Competency	Element Description
5	Requirements Analysis	Element 5. Ensure the requirements derived from the customer-designated capabilities are analyzed, decomposed, functionally detailed across the entire system, feasible and effective.


10/13/09
10



## INCOSE Professional Certification


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- Certification “provides formal recognition that a person has achieved competency in specific areas (demonstrated by education, experience, and knowledge)”.
- Stevens Institute is collaborating with INCOSE to encourage and enable the granting of SE professional certification to appropriately qualified Stevens’ graduate students.
- Exam is based on INCOSE SE Handbook



ESEP	Expert Systems Engineering Professional
CSEP-Acq	CSEP w/ US DoD Acquisition
CSEP	Certified Systems Engineering Professional
ASEP	Associate Systems Engineering Professional

10/13/09
11



## BKCASE Vision and Objectives

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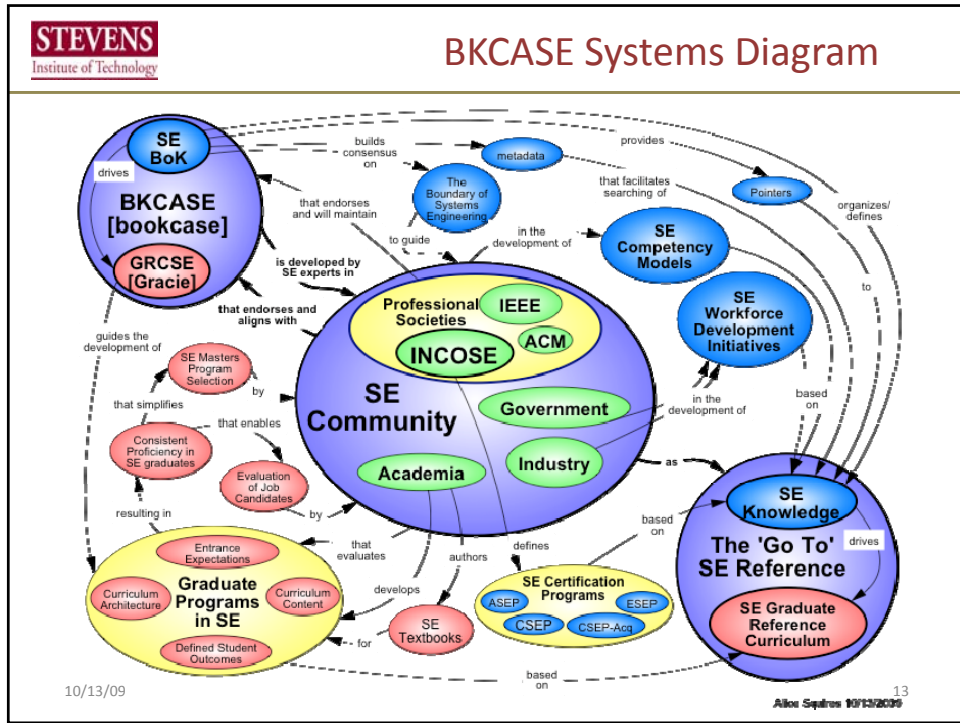
**Vision**

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

**Objectives**

1. Create a SE BoK that is globally recognized by the SE community as the authoritative BoK for the SE discipline.
2. Create a graduate reference curriculum for SE (GRCSE – pronounced “Gracie”) that is 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 SE BoK and GRCSE.
4. Transfer stewardship of SE BoK and GRCSE to INCOSE and other suitable professional societies after BKCASE releases version 1.0 of those products.

10/13/09
12




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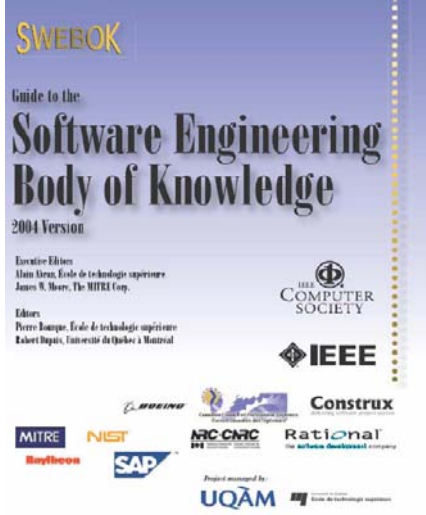
## What Has Software Engineering Done to Address Similar Challenges?


10/13/09

14



## SWEBOK and GSwE2009






Integrated Software & System Engineering Curriculum (ISSEc) Project

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**Graduate Software Engineering 2009(GSwE2009)**  
Curriculum Guidelines for  
Graduate Degree Programs in Software Engineering




Version 1.0


September 30, 2009

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10/13/09
15



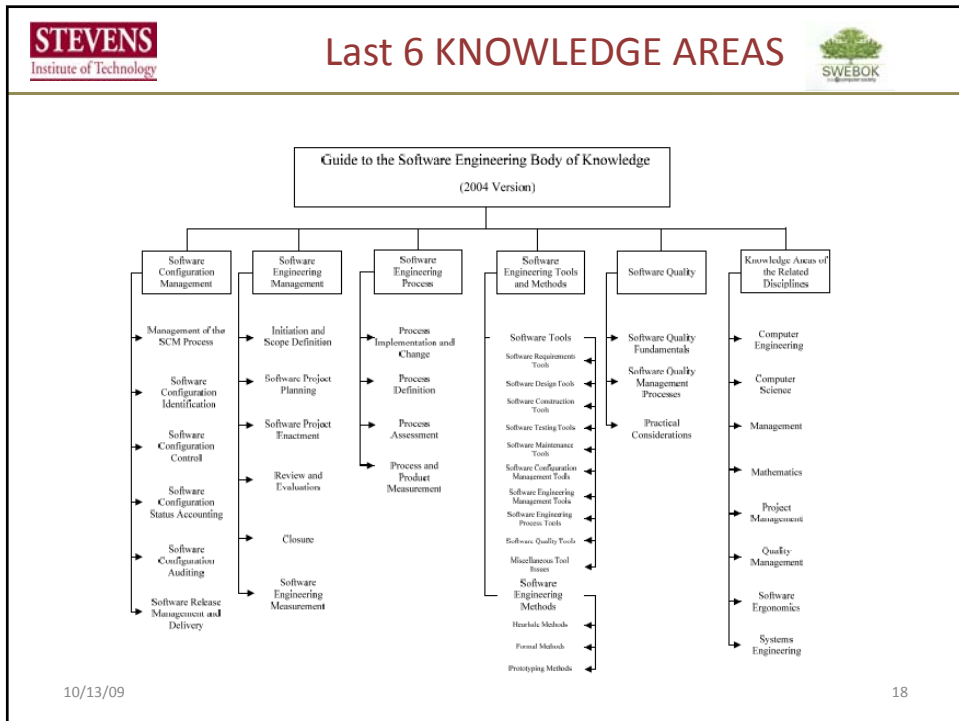
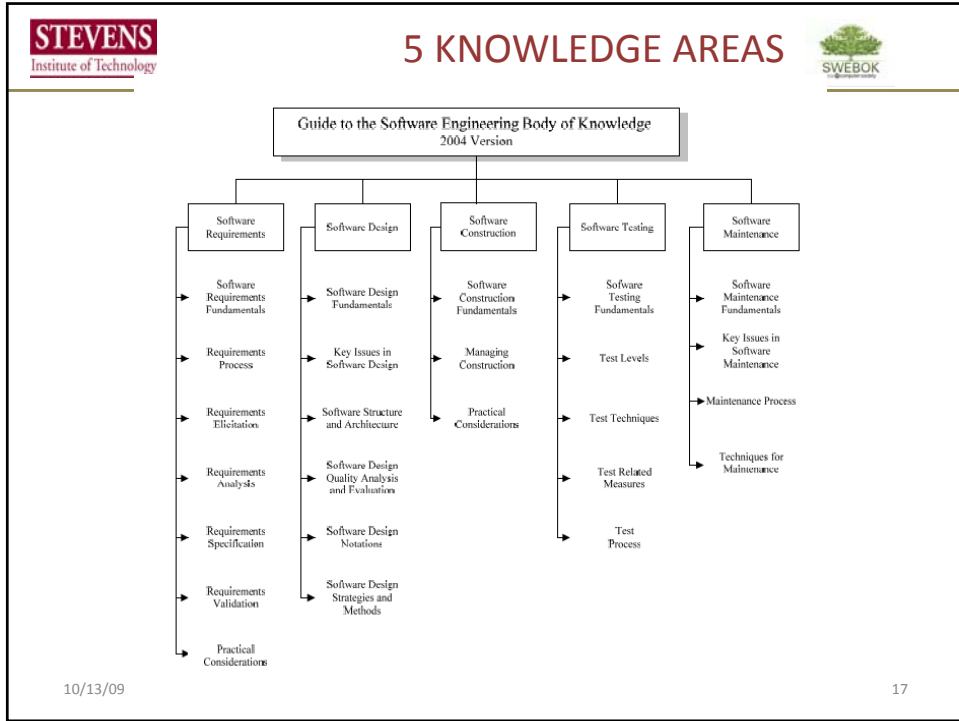
## SWEBOK



- SWEBOK is a way of organizing all the knowledge that is within the software engineering (SwE) discipline
- It is a hierarchical structure for the knowledge and references to key documents stating the knowledge as of 2004
- It was developed by a community of authors and reviewers from around the world
- It is static – it has not changed since it was published
- A refresh project is underway to produce a new version in 2010

[www.SWEBOK.org](http://www.SWEBOK.org)

10/13/09
16



6.1. *Requirements Reviews*  
[Kot00; Som05; Tha97]

Perhaps the most common means of validation is by inspection or reviews of the requirements document(s). A group of reviewers is assigned a brief to look for errors, mistaken assumptions, lack of clarity, and deviation from standard practice. The composition of the group that conducts the review is important (at least one representative of the customer should be included for a customer-driven project, for example), and it may help to provide guidance on what to look for in the form of checklists.

Reviews may be constituted on completion of the system definition document, the system specification document, the software requirements specification document, the baseline specification for a new release, or at any other step in the process. IEEE Std 1028 provides guidance on conducting such reviews. (IEEE1028-97) Reviews are also covered in the Software Quality KA, topic 2.3 *Reviews and Audits*.

- Static hierarchical structure
- No way to keep fresh with new references as new knowledge emerges (new ways to perform requirements analysis or prototype)
- No way to update hierarchy as SwE discipline evolves (reflect highly distributed software development projects)
- BKCASE must do better

**Proposed Supplemental Knowledge Areas (KAs)**


Supplemental KAs are works in progress. Qualified practitioners are invited to draft a document that describes generally accepted knowledge in a new area. The Professional Activities Board reviews the document, then it is posted here for informal review and comment. Eventually, the document may undergo a full review and rewrite, before it undergoes the full SWEBOK review to become a full SWEBOK knowledge area.

Meanwhile, these drafts provide the basis for ongoing discussion of these areas and useful pointers in emerging areas. Supplemental KAs include

1. Measurement
2. Security


In addition, the 2010 refresh of SWEBOK will be using and refining a list of suggested point-wise security updates to the 2004 SWEBOK Guide:

1. "Security-oriented Point-wise Changes to SWEBOK" (suggested point-wise security-related changes to the 2004 SWEBOK Guide)



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**GSwE2009**




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- GSwE2009 is a set of recommendations for faculty who are creating or updating a graduate program in software engineering (SwE)
- Secondly, it could be used by
  - employers in selecting new SwE graduates, and
  - students in selecting graduate programs
- GSwE2009 is intended for world-wide use
- GSwE2009 is *not* intended to be used directly for accreditation

[www.GSwE2009.org](http://www.GSwE2009.org)


10/13/09

21



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**GSwE2009 Structure**



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- **Guidance for Constructing and Maintaining GSwE2009:** the fundamental principles, assumptions, and context for the GSwE2009 authors
- **Outcomes:** what students should have achieved when they graduate
- **Entrance Expectations:** what students should be capable of and have experienced when they enter a graduate program
- **Architecture:** the structure of a curriculum to accommodate core material, university-specific material, and elective material
- **Core Body of Knowledge (CBOK):** material that all students should master in a graduate SwE program

10/13/09

22

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## GSwE2009 Operational Concept

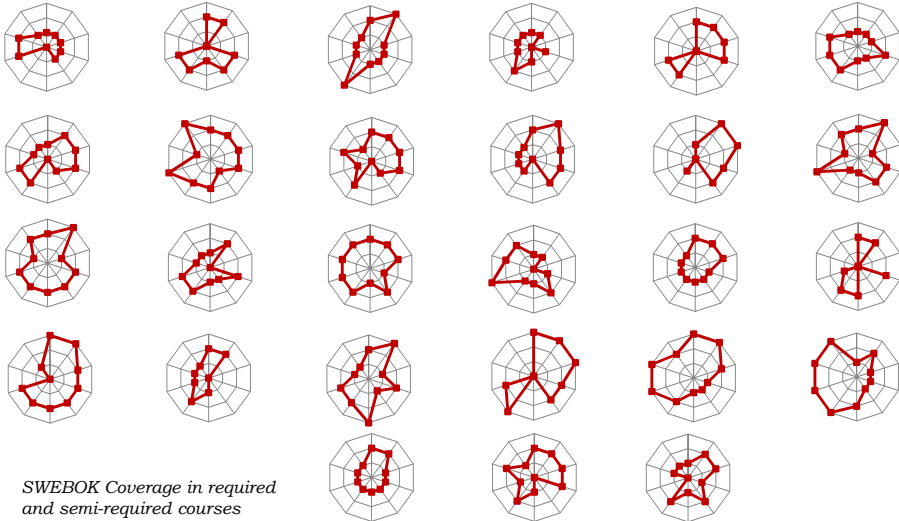



- For a program that fully satisfies the GSwE2009 recommendations:  
*Each student should arrive meeting all entrance expectations, participate in a program that follows the architecture, master the entire CBOK, and achieve all the outcomes*
- HOWEVER, because this is *a reference curriculum*, actual programs will likely choose to deviate from some GSwE2009 recommendations – *this is both expected and reasonable*

10/13/09 23


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## Extreme Diversity in SwE Programs




*SWEBOOK Coverage in required and semi-required courses*

10/13/09 24



## Project History and Process



1. Project to create Graduate Software Engineering Reference Curriculum (GSwERC) started in July 2007 at Stevens Institute of Technology with Department of Defense funding (GSwERC renamed in August to GSwE2009)
2. DoD agreed at beginning of project to take a “hands off” approach to technical content – critical to achieving primary objective
3. Formed Early Start Team of about 15 authors who met in August 2007 to shape project
4. Early Start Team gradually expanded and became Curriculum Author Team (CAT)
5. Workshop held every 3 months to synchronize work, adjust plan, and approve interim products – workshop minutes posted on website
6. Email, WebEx, and teleconferences to conduct business between workshops
7. Teams formed to work on specific sections of GSwE2009
8. Open and transparent operations at all times

10/13/09
25




## Author Team




<ul style="list-style-type: none"> <li>• Rick Adcock, <i>Cranfield University and INCOSE</i></li> <li>• Edward Alef, <i>General Motors</i></li> <li>• Bruce Amato, <i>Department of Defense</i></li> <li>• Mark Ardis, <i>Stevens Institute of Technology</i></li> <li>• Larry Bernstein, <i>Stevens Institute of Technology</i></li> <li>• Barry Boehm, <i>University of Southern California</i></li> <li>• Pierre Bourque, <i>École de technologie supérieure and SWEBOK</i></li> <li>• John Bracket, <i>Boston University</i></li> <li>• Murray Cantor, <i>IBM</i></li> <li>• Lillian Cassel, <i>Villanova and ACM</i></li> <li>• Robert Edson, <i>ANSER</i></li> <li>• Richard Fairley, <i>Colorado Technical University</i></li> <li>• Dennis Frailey, <i>Raytheon &amp; Southern Methodist University</i></li> <li>• Gary Hafen, <i>Lockheed Martin and NDIA SE</i></li> <li>• Thomas Hilburn, <i>Embry-Riddle Aeronautical University</i></li> <li>• Greg Hislop, <i>Drexel University and IEEE Computer Society</i></li> <li>• David Klappholz, <i>Stevens Institute of Technology</i></li> <li>• Philippe Kruchten, <i>University of British Columbia</i></li> <li>• Phil Laplante, <i>Pennsylvania State University, Great Valley</i></li> <li>• Qiaoyun (Liz) Li, <i>Wuhan University, China</i></li> </ul>	<ul style="list-style-type: none"> <li>• Scott Lucero, <i>Department of Defense</i></li> <li>• John McDermid, <i>University of York, UK</i></li> <li>• James McDonald, <i>Monmouth University</i></li> <li>• Ernest McDuffie, <i>National Coordination Office for NITRD</i></li> <li>• Bret Michael, <i>Naval Postgraduate School</i></li> <li>• William Milam, <i>Ford</i></li> <li>• Ken Nidiffer, <i>Software Engineering Institute</i></li> <li>• Art Pyster, <i>Stevens Institute of Technology</i></li> <li>• Paul Robitaille, <i>Lockheed Martin and INCOSE</i></li> <li>• Mary Shaw, <i>Carnegie Mellon University</i></li> <li>• Sarah Sheard, <i>Third Millennium Systems</i></li> <li>• Robert Suritis, <i>IBM</i></li> <li>• Richard Thayer, <i>California State University at Sacramento</i></li> <li>• Barrie Thompson, <i>Sunderland University, UK</i></li> <li>• Massood Towhidnejad, <i>Embry-Riddle Aeronautical University</i></li> <li>• Guilherme Travassos, <i>Brazilian Computer Society, Brazil</i></li> <li>• Richard Turner, <i>Stevens Institute of Technology</i></li> <li>• Joseph Urban, <i>Texas Technical University</i></li> <li>• Ricardo Valerdi, <i>MIT &amp; INCOSE participant</i></li> <li>• Osmo Vikman, <i>Nokia</i></li> <li>• David Weiss, <i>Avaya</i></li> <li>• Mary Jane Willshire, <i>Colorado Technical University</i></li> </ul>
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10/13/09
26



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## Project History & Process -Part II



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9. Built GSwE2009 on foundation documents, primarily SWEBOK, SE2004, and INCOSE Handbook
10. Created GSwE2009 incrementally and iteratively – Version 0.25 in February 2008, Version 0.5 in October 2008, Version 1.0 in September 2009
11. Invited reviewers for Version 0.25, unlimited review for Version 0.5
12. More than 100 reviewers from 23 countries: Australia, Brazil, Canada, China, Egypt, France, Germany, Greece, India, Israel, Italy, Japan, Latvia, Mexico, Netherlands, Poland, Portugal, Russia, Singapore, Sweden, Thailand, UK, US
13. About 800 review comments for Version 0.5, each adjudicated
14. Numerous presentations and workshops to obtain feedback, and to generate awareness and demand:
  - CSEET 2009, ICSE 2009, SIGCSE 2008 and 2009; NDIA Systems Engineering Conferences 2007, 2008, and 2009; INCOSE International Symposium 2008 and 2009; ASEE 2008; Asian-Pacific INCOSE Conference 2008; ...

10/13/09
27



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## Expectations at Program Entry



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**DEGREE:**

The equivalent of an undergraduate degree in computing, or an undergraduate degree in an engineering or scientific field and a minor in computing


**SWE COURSE:**

The equivalent of an introductory course in software engineering


**EXPERIENCE:**

At least two years of practical experience in some aspect of software engineering or software development. This experience should include participation in teams, development of a program or component that has been successfully delivered, and an update or repair to an existing program or component.

10/13/09
28



## Sample Outcomes at Graduation




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**CBOK:**  
Master the Core Body of Knowledge


**DOMAIN:**  
Master software engineering in at least one application domain, such as finance, medical, transportation, or telecommunications, and in one application type, such as real-time, embedded, safety-critical, or highly distributed systems. That mastery includes understanding how differences in domain and type manifest themselves in both the software itself and in their engineering, and includes understanding how to learn a new application domain or type.

**DEPTH:**  
Master at least one knowledge area or sub-area from the Core Body of Knowledge to at least the Bloom Synthesis level.

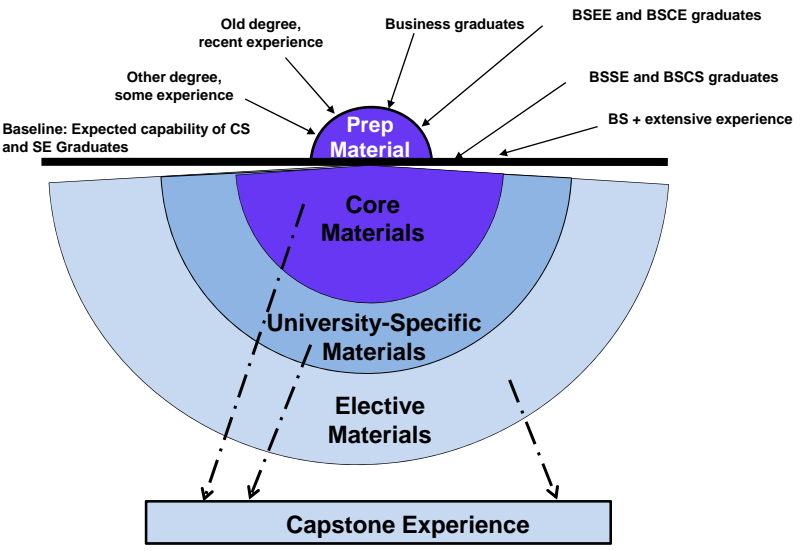
10/13/09
29



## Curriculum Architecture

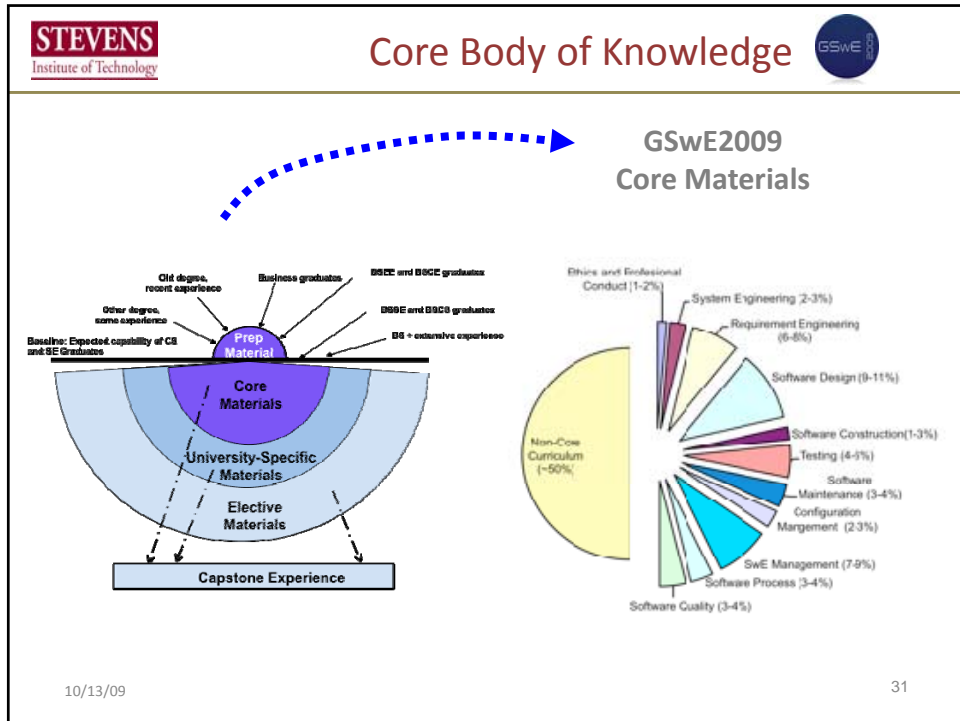


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The diagram illustrates the Curriculum Architecture as a funnel-shaped structure. At the top, a horizontal line represents the 'Baseline: Expected capability of CS and SE Graduates'. Above this line, several categories of graduates are listed with arrows pointing to a central purple circle labeled 'Prep Material': 'Old degree, recent experience', 'Other degree, some experience', 'Business graduates', 'BSEE and BSCE graduates', 'BSSE and BSCS graduates', and 'BS + extensive experience'. Below the 'Prep Material' circle, the funnel widens into three layers: 'Core Materials' (purple), 'University-Specific Materials' (light blue), and 'Elective Materials' (light blue). Dashed lines connect these three layers to a rectangular box at the bottom labeled 'Capstone Experience'.

10/13/09
30



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- Future**
- DoD, Stevens, and author team always wanted professional societies to participate and eventually become “stewards” of GSWE2009 – but word “steward” was vague
  - Early agreement by INCOSE and NDIA to participate and provide authors
  - ACM and IEEE Computer Society provided authors and now considering proposal to become *sponsors* of GSWE2009 – their term for stewards. Expect agreement by end of 2009.
- 10/13/09 32

## Some Lessons Learned from GSWE2009

1. Involve professional societies from the very beginning
2. Build a highly diverse author team early on
3. Create a sense of camaraderie among the author team
4. Actively seek reviews from global stakeholders
5. Hold face-to-face workshops at least once every 3 months
6. Establish a project plan early but expect it to evolve – most of the labor is voluntary and reviewers will throw curve balls

10/13/09

33

## BKCASE Revisited

- Stevens has begun a 3-year project to create a robust body of knowledge and a reference curriculum to advance systems engineering. Naval Postgraduate School is co-lead.
- DoD recognizes that their own SE success depends on having a well-accepted robust SE BoK on which standard practice, certification, and workforce competency and education can be based. They are providing substantial funding for effort.
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- INCOSE and IEEE Systems Council have agreed to participate
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10/13/09

34

1. BKCASE will be an open, collaborative project with international participation sought from academia, industry, government, related projects, and professional societies.
2. Art Pyster (Stevens) is Principal Investigator (PI); Dave Olwell (NPS) is Co-Principal Investigator. Alice Squires and Stephanie Few are key researchers.
3. BKCASE is seeking 30-40 active volunteer authors + several hundred volunteer reviewers. About a dozen already signed up.

10/13/09

35

4. Each participating professional society will provide at least one active author. (INCOSE has agreed to participate and fund 3 authors.)
5. Authors are invited onto the project by the Principal Investigator (PI); anyone is welcome to be a reviewer.
6. BKCASE will pay for authors to attend workshops to the extent possible, analogous to GSwE2009. First workshop scheduled for December 8-9 at Naval Postgraduate School.
7. BKCASE will generally not pay for the labor of authors or reviewers.

10/13/09

36

## BKCASE Products

1. BKCASE will iteratively deliver a SE BoK and a reference curriculum for a master's degree in SE together with supplementary material to facilitate their dissemination and adoption.
2. Products freely available without charge provided credit is given.
3. Ideally, any other SE BoK or curriculum effort would merge with BKCASE and efforts to create or evolve SE competency models and certification programs would closely coordinate with BKCASE.
4. Nominal schedule is:
  - a. SE BoK: Version 0.25 June 2010, Version 0.5 June 2011, Version 1.0 June 2012
  - b. Reference Curriculum: Version 0.25 September 2010, Version 0.5 September 2011, Version 1.0 September 2012

10/13/09

37

## Looking for authors, reviewers, source material, ...

Anyone interested in participating or having source material to offer, please send contact information to [art.pyster@stevens.edu](mailto:art.pyster@stevens.edu).

10/13/09

38