Project BKCASE
Body of Knowledge and Curriculum for Advanced Systems Engineering

NDIA Dinner
26 October 2009
Agenda

• Welcome and Introduction
• Overview of the BKCASE Project
• Discussion of exemplars and lessons learned
• Discussion
• Invitation to workshop in Monterey 8-9 December
Overview

• Stevens and NPS have begun a 3-year project to create a robust body of knowledge and a reference curriculum to advance systems engineering.
• 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
Babel

- 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
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 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.
Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE)

BKCASE Project

SE Certification Programs
- ASEP
- CSEP
- CSEP-Acq
- ESEP

SE Competency Models

SE Workforce Development Initiatives

SE Body of Knowledge (SEBoK)

Graduate Reference Curriculum in SE (GRCSE)

INCOSE

IEEE

ACM

Professional Societies

SE Community

Government

Academia

Industry

Consortiums and Competency Models

SE Masters Program Selection
- Consistent Proficiency in SE graduates

Evaluation of Job Candidates
- Resulting in SE Body of Knowledge (SEBoK)

Graduate Programs in SE
- Defined Student Outcomes
- Curriculum Architecture
- Curriculum Content

Entrance Expectations

SE Textbooks

drives

organized/defines

builds consensus on

that facilitates searching of

metadata

provides

Pointers

that together create

for use by

that will maintain

for

by

to develop

to author

to develop

to guide

to guide

to guide

to develop

to develop

to define

used to certify

is supported by SE experts in

that shapes and endorses

by

that simplifies

that enables

 Alice Squires 10/25/09
Strategy

- Publish incrementally/iteratively with SE curriculum reference trailing SE BoK
- Involve professional societies from the beginning
- Build early consensus and maintain throughout
- Rely on and include academia, industry, and government
- Leverage volunteer labor for both authoring and editorial review
- Rely on existing source material wherever possible and involve principals from efforts that created source material wherever possible
- Use GSwERC and NPS M&S process as foundations
- Keep completely open and collaborative at a global level
- Use workshops every 3 months to sync up teams and build team relationships – rely on virtual and electronic communication at other times
- Keep team focused on value proposition when conflicts arise.
Exemplars and lessons learned

- SWEBOK
- GSwE2009
- M&S for Acquisition project
CH 2 Example from SWEBOK

BREAKDOWN OF TOPICS FOR SOFTWARE

Software Requirements

- Software Requirements Fundamentals
  - Definition of a Software Requirement
  - Product and Process Requirements
  - Functional and Non-functional Requirements
  - Emergent Properties
- Requirements Process
  - Process Models
  - Process Actors
  - Process Support and Management
  - Process Quality and Improvement
- Requirements Elicitation
  - Requirements Sources
  - Elicitation Techniques
- Requirements Analysis
  - Requirements Classification
  - Conceptual Modeling
  - Architectural Design and Requirements Allocation
  - Requirements Negotiation
- Requirements Specification
  - System Definition Document
  - Systems Requirements Specification
  - Software Requirements Specification
- Requirements Validation
  - Requirements Reviews
  - Prototyping
  - Model Validation
  - Acceptance Tests
- Practical Considerations
  - Iterative Nature of Requirements Process
  - Change Management
  - Requirements Attributes
  - Requirements Tracing
  - Measuring Requirements
1. Software Requirements Fundamentals

1.1. Definition of a Software Requirement

At its most basic, a software requirement is a property which must be exhibited in order to solve some problem in the real world. The Guide refers to requirements on "software" because it is concerned with problems to be addressed by software. Hence, a software requirement is a property which must be exhibited by software developed or adapted to solve a particular problem. The problem may be to automate part of a task of someone who will use the software, to support the business processes of the organization that has commissioned the software, to correct shortcomings of existing software, to control a device, and many more. The functioning of users, business processes, and devices is typically complex. By extension, therefore, the requirements on particular software are typically a complex combination of requirements from different people at different levels of an organization and from the environment in which the software will operate.

An essential property of all software requirements is that they be verifiable. It may be difficult or costly to verify certain software requirements. For example, verification of the throughput requirement on the call center may necessitate the development of simulation software. Both the software requirements and software quality personnel must ensure that the requirements can be verified within the available resource constraints.

Requirements have other attributes in addition to the behavioral properties that they express. Common examples include a priority rating to enable trade-offs in the face of finite resources and a status value to enable project progress to be monitored. Typically, software requirements are uniquely identified so that they can be over the entire software life cycle. [Ku93; MI91; Suri95; Tha97]

1.2. Product and Process Requirements

A distinction can be drawn between product parameters and process parameters. Product parameters are requirements on software to be developed (for example, "The software shall verify that a student meets all prerequisites before he or she registers for a course.").

A process parameter is essentially a constraint on the development of the software (for example, "The software shall be written in Ada."). These are sometimes known as process requirements.

Some software requirements generate implicit process requirements. The choice of verification technique is one example. Another might be the use of particularly rigorous analysis techniques (such as formal specification methods) to reduce faults which can lead to inadequate reliability. Process requirements may also be imposed directly by the development organization, their customer, or a third party such as a safety regulator [Ku93; Suri95].
Graduate Software Engineering 2009 (GSwE2009)

Curriculum Guidelines for
Graduate Degree Programs in Software Engineering

Version 1.0

September 30, 2009
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GSwE2009 includes the following:

- A set of outcomes to be fulfilled by a student who successfully completes a graduate program based on the curriculum (see summary below)
- A set of student skills, knowledge, and experience assumed by the curriculum, not intended as entrance requirements for a specific program, but as the starting point for the curriculum’s outcomes (see summary below)
- An architectural framework to support implementation of the curriculum
- A description of the fundamental or core skills, knowledge, and experience to be taught in the curriculum to achieve the outcomes. This is termed a Core Body of Knowledge (CBOK) and includes topic areas and the depth of understanding a student should achieve.

Additional materials included in this document:

- The fundamental philosophy for GSwE2009 development as described in a set of guiding principles (see summary below)
- A discussion of how GSwE2009 will evolve to remain effective
- A mapping of expected outcomes to the CBOK and to the total GSwE2009 program recommendations
- A description of Knowledge Areas (KAs) discussed in GSwE2009 that are not yet fully integrated into the current version of the Software Engineering Body of Knowledge (SWEBOK)
- Glossary, references, and other supporting material.
Modeling and Simulation
Educating the DoD Communities and Services

UCF
Old Dominion University
UCSD
George Mason University
UAHuntsville
NPS
Johns Hopkins University

Acquisition; Test and Evaluation
NPS Engineering Case Studies

- Supplemental program material for courses.
- Case studies developed primarily for acquisition professionals who do not possess engineering degrees.
- Case study content focuses on describing underlying engineering concepts.

8 Case Studies Available Online at www.nps.edu/msacq
Coming to a University Near You January 2009

FULL ACADEMIC COURSES
SHORT ACADEMIC COURSES
WEB-BASED MODULES

16 NEW COURSES
M&S in the Acquisition Life Cycle, Parts 1 and 2
M&S Strategy and Support Plans
M&S Requirements and Evaluating M&S Proposals
Contracting for M&S
Best Practices in M&S
M&S in Decision Risk Analysis and Mitigation
M&S Environments
M&S Data Strategies
M&S for Test and Evaluation, Introduction and Advanced
Introduction to Engineering M&S Applications
Physics-based M&S
Basic Engineering Concepts in M&S, Parts 1 and 2
Topics in the Application of Engineering M&S
Sample Certificate Program

Proposed Certificate Program

FOUR CERTIFICATE PROGRAMS

M&S MANAGEMENT
- Intro to DoD M&S
- M&S in the Acquisition Life Cycle, Parts 1 and 2
- Best Practices in M&S

M&S ACQUISITION
- M&S Strategy and Support Plans
- M&S Requirements & Evaluating Proposals
- Contracting for M&S
- M&S in Decision Risk Analysis

M&S TEST AND EVALUATION
- M&S for Test and Evaluation, Introduction and Advanced
- M&S Environments
- M&S Data Strategies

M&S ENGINEERING INTEGRATION
- Physics-based M&S
- Basic Engineering Concepts in M&S, Parts 1 and 2
- Selected Topics in the Application Engineering M&S

Certificates can be credited toward resident and non-resident NPS degree programs.
2008 Development: Sample Material

Modeling & Simulation for Shelf Design Analysis

Here we see a "finite element analysis" simulation of the static loading of the shelf. Our two design criteria of deflection and stress are determined by the simulation, for the given loading.

The System Design Process

Once a preliminary design has been established, the various subsystems and components are then designed, in a similar process to that described earlier.

Statically Determinate and Indeterminate Structures

- Statically indeterminate Structure
  - Let’s see some statically indeterminate structures

Physics based M&S and Basic Engineering Concepts in M&S

Acquisition applications [NRC, 2002]

- System design
  - Simulate alternative system designs to assess capability and reliability ("Engineering" level)
- System selection
  - Compare combat effectiveness of alternative notional weapons systems

Acquisition example: FCS

Future Combat System

- Concept for future Army fighting vehicle
- "System-of-Systems" linking different domains
- Concept to be refined using simulations
- Janus and CASTFOREM used for co-simulation

M&S Environments and M&S T&E

9/17/08    Modeling and Simulation Education for the Acquisition and T&E Workforce
Authors as of 10/24/09

1. **John Baras** from University of Maryland and IEEE Systems Council
2. **Barry Boehm** from University of Southern California and fellow of INCOSE, ACM, IEEE. Member of National Academy.
3. **Tim Ferris** from Defence and Systems Institute at University of South Australia and Director of Technical Operations for INCOSE
4. **Kevin Forsberg** is co-inventor of ‘Vee’ model and fellow of INCOSE. Runs CSM training company.
5. **Sandy Friedenthal** is one of the inventors of SYSML, INCOSE fellow, with Lockheed Martin
6. **Bud Lawson** runs his own consulting company, credited with the ‘Pointer’ concept in programming languages and an INCOSE fellow.
7. **Alex Lee** is Deputy Director of the DSTA College in Singapore and one of the leaders of the INCOSE Singapore Chapter
8. **David Olwell** Naval Postgraduate School Systems Engineering Department
9. **Art Pyster** Stevens Institute of Technology
10. **Garry Roedler** is a senior SE employee at Lockheed Martin and written extensively on systems measurement
11. **Bill Rouse** is from GA Tech, INCOSE and IEEE fellow, member of National Academy among other organizations.
12. **Alice Squires** Stevens Institute of Technology
13. **Massood Towhidnejad** is from Embry-Riddle Aeronautical University
Discussion
Kick-off meeting

• 8-9 December in Monterey, CA
• By invitation
• Contact Art Pyster or Dave Olwell to join us
Backups
FAA Model

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

“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
DoD Competency Model

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

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<thead>
<tr>
<th>#</th>
<th>Competency</th>
<th>Element Description</th>
</tr>
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<tbody>
<tr>
<td>5</td>
<td>Requirements Analysis</td>
<td>Element 3. Ensure the requirements derived from the customer-designated capabilities are analyzed, decomposed, functionally detailed across the entire system, feasible and effective.</td>
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INCOSE Professional Certification

• 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