The Emerging Consensus on the Software Engineering Body of Knowledge & Software Quality

A. Abran,
P. Bourque, R. Dupuis, J. W. Moore, L. Tripp
American Society for Quality
Ottawa, Oct 29, 2002
Presentation Plan

- **Project background**
  - Project objectives, audiences and plan
  - Content of the Guide
  - Current Uses
  - Next step
A Key Issue: Quality

- **Quality** of the software is now a key issue for software:
  - Users
  - Purchasers
  - Producers
  - National competitiveness
  - Global economics progress
Software Quality

- How to address the issue at the:
  - Individual level?
  - Organisational level?
  - National level?
  - International level?

- What infrastructure must be set up to tackle all levels across the board?
Context

Increased interest in the establishment of the **software engineering** profession but up until the early 2000’s…

- **Groups and individuals:**
  - Different views of software engineering

- **Universities:**
  - Offering undergraduate degrees in *Software* Engineering, within & outside of traditional Engineering Departments
  - Limited consistency across curriculum
A Trend Setter….

Texas Board of Engineers:

- Decision to license software engineers

- A strategy with significant impact on:
  - individuals
  - industry (e.g. mobility of staff & training)
  - universities
  - policy bodies

(+ engineering boards and universities)
Software Engineering

- What is it?
- Is it ‘engineering’?
- It is mature?
What is Software Engineering?

- IEEE 610.12:
  - “(1) The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software.
  - (2) The study of approaches as in (1).”
Recognized Profession?

  - Knowledge and competence validated by the community of peers
  - Consensually validated knowledge rests on rational, scientific grounds
  - Judgment and advice oriented toward a set of substantive values
Model of the Maturity of a Profession

Ford and Gibbs:
- Education
- Accreditation
- Skills development
- Licensing/certification
- Professional development
- Code of ethics
- Professional society or societies

Professional Development

- Initial professional education
- Skills Development
- One or both Certification and Licensing
- Full Professional Status
- Accreditation
- Professional development
- Code of ethics
- Professional societies

Adapted from Steve McConnell, *After the Gold Rush*, Microsoft Press, 1999, p. 93
Professional Development

Initial professional education

Professional Development

Skills Development

One or both
Certification Licensing

Full Professional Status

Infrastructure Support for the Profession

Accreditation

Professional Society Influences

Professional societies

Professional development

Code of ethics

Adapted from Steve McConnell, *After the Gold Rush*, Microsoft Press, 1999, p. 93
Presentation Plan

- Project background
- **Project objectives, audiences and plan**
  - Content of the Guide
  - Next steps
  - Research issues
Project Objectives

- Promote a consistent view of software engineering worldwide
- Clarify the place of, and set the boundary of, software engineering with respect to other disciplines
- Characterize the contents of the Software Engineering Body of Knowledge - SWEBOK
- Provide a topical access to the Software Engineering Body of Knowledge
- Provide a foundation for curriculum development and individual certification and licensing material
Strategy: Build a consensus on a Core Body of Knowledge

- Development of Software Engineering Curricula
- Consensus on a Core Body of Knowledge
- Development of Certification / Licensing Criteria and Exams
- Development of University Program Accreditation Criteria

Influences:

- Development of Software Engineering Curricula
- Consensus on a Core Body of Knowledge
- Development of University Program Accreditation Criteria
Intended Audiences

- Public and private organizations
- Practicing software engineers
- Makers of public policy
- Professional societies
- Software engineering students
- Educators and trainers
What Are we Not Trying to Accomplish?

- Not an all-inclusive description of the sum of knowledge in the field
- Not all categories of knowledge
- Not a curriculum development effort
Knowledge of a Software Engineer

- Application domain knowledge
- Advanced SE Knowledge
- Specialized SE Knowledge
- Guide to the SWEBOK Stoneman
- C.S.
- Maths
- ...
# Categories of Knowledge in the SWEBOK

<table>
<thead>
<tr>
<th>Specialized</th>
<th>Generally Accepted</th>
<th>Advanced and Research</th>
</tr>
</thead>
</table>

Focus of the SWEBOK Guide
Generally Accepted

- «Applies to most projects, most of the time, and widespread consensus validates its value and effectiveness»
  - Project Management Institute - PMI

- Bachelor + 4 years of experience
IEEE and ACM strategies

- **IEEE-CS:**
  - initial focus on generally accepted
  - strategy with intermediate deliverables
  - contributions to the maturation and consensus building

- **ACM:**
  - opposition to licensing
    - withdrawal from joint efforts with IEEE-CS
    - concerns limited to specialized knowledge
Three Underlying Principles of the Project

- **Transparency**: the development process is itself published and fully documented

- **Consensus-building**: the development process is designed to build, over time, consensus:
  - In industry, among professional societies and standards-setting bodies and in academia
  - Consensus does not equal Unanimity
  - Consensus does not equal an expert opinion which is not yet generally accepted

- Available **free** on the web
A Three-Phase Approach for Developing the Guide to the SWEBOK

- Straw Man Version
- Stone Man Version
- Iron Man Version (Sub-phase 1)
- Iron Man Version (Sub-phase 2)

1998 1999 2000 2001 2002 2003
Project Team

- Editorial team
- Industrial Advisory Board
- Knowledge Area Specialists
- A very large international group of Reviewers
Editorial Team

○ Project “Champion”:
  ➢ Leonard Tripp, 1999 President, IEEE Computer Society

○ Executive Editors:
  ➢ Alain Abran, École de Technologie Supérieure
  ➢ James W. Moore, The MITRE Corp.

○ Editors:
  ➢ Pierre Bourque, École de Technologie Supérieure
  ➢ Robert Dupuis, UQAM
A Three-Phase Approach for Developing the Guide to the SWEBOK

- Straw Man Version
- Stone Man Version
- Iron Man Version (Sub-phase 1)
- Iron Man Version (Sub-phase 2)
Strawman: Process

Undergrad. SE curricula
Graduate Admission Criteria
Graduate SE Curricula
SE Textbooks

Preliminary list of related disciplines
ISO/IEC 12207

Proposed SE Knowledge Areas
List of related disciplines
Proposed related disciplines and SE KAs

Body of SE Standards

Must be discussed in general SE textbooks
Must be specifically adapted to SE
Knowledge Area Specialists

- Bertolino, Istituto Elaborazione Informazione, CNR, Italy
- Bollinger, MITRE, USA, Martin & Gabrini, UQAM
- Carrington, Queensland University, Australia
- El Emam, National Research Council, Canada
- MacDonell, University of Otago, New-Zealand
- Sawyer & Kotonya, Lancaster University, UK
- Scott, Lawrence Livermore National Lab., USA
- Tremblay, UQAM, Canada
- Pigoski, USA
- Wallace & Reeker, NIST, USA
A Three-Phase Approach for Developing the Guide to the SWEBOK
Phase 2: Stone Man Review Process

Version 0.1

Limited number of domain experts

Review Cycle 1

Version 0.5

Selected users

Review cycle 2

Version 0.7

Community

Review Cycle 3

Version 0.9
Stone Man Review Process

- Transparency and consensus-building
  - All intermediate versions of documents are published and archived on www.swebok.org
  - All comments are made public as well as the identity of the reviewers
  - Detailed comment disposition reports are produced for Review Cycle 2 and 3
Data on reviewers

- Version 0.1: 33
- Version 0.5: 195
- Version 0.7: 378
  - + ISO reviews from 5 countries
Geographic Distribution of Reviewers

- USA: 55%
- Europe: 18%
  - 90 reviewers from 25 countries
- Canada: 10%
- Australia: 5%
- Asia: 5%
- Latin America: 4%
Education of Reviewers

- Doctorate: 34%
- Master: 39%
- Bachelor: 24%
- Other: 3%

© IEEE-Computer Society  www.swebok.org
Organizations of Reviewers (no. of employees)

- 0-50: 37%
- 50-500: 32%
- 500 more: 31%
Project Overview
Presentation Plan

- Project background
- Project scope, objectives, audience and plan

Contents of the Guide

- How you can leverage the Guide within your organization
- Conclusion
Stone Man Deliverables:

- **Consensus** on a list of Knowledge Areas
- **Consensus** on a list of *topics and relevant reference materials* for each Knowledge Area
- **Consensus** on a list of Related Disciplines
Software Requirements

- Requirements Engineering 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
- Requirement Specification
  - Requirements Definition Document
  - Software Requirements Specification (SRS)
  - Document Structure and Standards
  - Document Quality
- Conduct of Requirements Reviews
- Prototyping
- Model Validation
- Acceptance tests
- Requirements Validation
- Change Management
- Requirements Attributes
- Requirements Tracing

© IEEE-Computer Society
Bloom’s Taxonomy

- What level of “knowledge”?
  - Knowledge,
  - Comprehension,
  - Application,
  - Analysis,
  - Synthesis and
  - Evaluation
Knowledge Area Description

Classification of Topics

Matrix of Topics & References

References

Topic Descriptions

Classification by Vincenti’s Taxonomy

Classification by Bloom’s Taxonomy

References to Related Disciplines

Not implemented in Stoneman
Related Disciplines

- Software Requirements
- Software Design
- Software Construction
- Software Testing
- Software Maintenance
- Software Configuration Management
- Software Eng. Management
- Software Eng. Tools & Methods
- Software Engineering Process
- Software Quality

Related Disciplines

- Computer Science (CC2001)
- Mathematics (CC2001)
- Project Management (PMBOK)
- Computer Engineering
- Cognitive Sciences and Human Factors
- Systems Engineering
- Management and Management Science
Project Overview

Presentation Plan

- Project background
- Project scope, objectives, audience and plan
- Contents of the Guide
- Current Use
- Next steps
Current Use

- Interim versions on the web since 1999

- Stoneman version:
  - Web version: May 2001
  - ISO version: End of 2002
  - CD-ROM version: in progress

- Current Use:
  - Who, where and for what?
Initial web survey

- Summer 2002 = + 1,000 SWEBOK references
  - University
    - Software Engineering curriculum
    - University lectures
    - Research Papers
  - Professional development
    - Conferences & Workshops
    - Certification & Licensing
    - Government & Policy organizations
  - Individuals
# University S.E. Curriculum

| USA                          | National Technical University - NTU:  
|------------------------------|--------------------------------------  
|                              | ❖ Distance teaching with a network of 24 US Universities.  
|                              | Kent State U.  
|                              | U. Central Florida  
|                              | Florida Institute of Technology  
|                              | Washington  
| Canada                      | U. Ottawa  
|                              | Université du Québec à Montréal - UQAM  
|                              | École de technologie supérieure (Engineering University)  
|                              | U. Waterloo  

## University Curriculum

<table>
<thead>
<tr>
<th>Location</th>
<th>Institutions</th>
</tr>
</thead>
</table>
| Spain    | U. Polytechnica Madrid  
|          | U. Pais Basco |
| Switzerland | U. St-Gallen  
|          | SWEED Curriculum initiative |
| Australia | Monash U.  
|          | Swinburne U.  
|          | Murdoch U. |
| France   | Paris VI |
| UK       | U. of Scranton |
## University Course Material - USA

<table>
<thead>
<tr>
<th>U. Massasschuset</th>
<th>Clarkson U.</th>
<th>Walla Walla College</th>
</tr>
</thead>
<tbody>
<tr>
<td>U. Maryland</td>
<td>Oregon U.</td>
<td>PACE</td>
</tr>
<tr>
<td>Milwaukee School Eng.</td>
<td>U. Omaha</td>
<td>Nova Southern U.</td>
</tr>
<tr>
<td>Kansas State U.</td>
<td>U. Texas</td>
<td>U.A.</td>
</tr>
<tr>
<td>Mississippi State U.</td>
<td>Drexel U.</td>
<td>U. Oklahoma</td>
</tr>
<tr>
<td>Stanford U.</td>
<td>Bucknell U.</td>
<td>Texas Wesleyan</td>
</tr>
<tr>
<td>Rochester Institute Tech.</td>
<td></td>
<td>Knox</td>
</tr>
<tr>
<td>Southern Polytechnic State</td>
<td></td>
<td>M.S. State</td>
</tr>
</tbody>
</table>
# University Course Material - Canada

<table>
<thead>
<tr>
<th>University</th>
<th>University</th>
</tr>
</thead>
<tbody>
<tr>
<td>U. Ottawa</td>
<td>U. Western</td>
</tr>
<tr>
<td>U. Calgary</td>
<td>Guelph U.</td>
</tr>
<tr>
<td>U. Montréal</td>
<td>UQAM</td>
</tr>
<tr>
<td>U. Alberta</td>
<td></td>
</tr>
<tr>
<td>U. Sherbrooke</td>
<td></td>
</tr>
<tr>
<td>École de technologie supérieure</td>
<td></td>
</tr>
<tr>
<td>Augustana College</td>
<td></td>
</tr>
</tbody>
</table>
# University Course Material - Germany

<table>
<thead>
<tr>
<th>Germany</th>
<th>Technical U. Berlin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U. Frankfurt</td>
</tr>
<tr>
<td></td>
<td>U. Stuttgart</td>
</tr>
<tr>
<td></td>
<td>U. Postdam</td>
</tr>
<tr>
<td></td>
<td>Technical U. Chemnitz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spain</th>
<th>U. Valladolid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U.C.L.M.</td>
</tr>
<tr>
<td></td>
<td>U. San Sebastian</td>
</tr>
<tr>
<td></td>
<td>Escuela Superior Informatica</td>
</tr>
</tbody>
</table>
### University Course Material - Others

<table>
<thead>
<tr>
<th>Country</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>U. Zagreb</td>
</tr>
<tr>
<td>Ireland</td>
<td>U. Ulster</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Victoria U.</td>
</tr>
<tr>
<td>Denmark</td>
<td>Aalborg U.</td>
</tr>
<tr>
<td>Colombia</td>
<td>U. AEFIT</td>
</tr>
<tr>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>Scotland</td>
<td>Edinburg</td>
</tr>
<tr>
<td>Brazil</td>
<td>Unicam</td>
</tr>
<tr>
<td></td>
<td>Federal U. Goias</td>
</tr>
</tbody>
</table>
## University Course Material - Others

<table>
<thead>
<tr>
<th>Country</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>K.A.I.S.T, C.A.U AC</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Vrieje U., Nejmess U.</td>
</tr>
<tr>
<td>Austria</td>
<td>Vienna U. Technology</td>
</tr>
<tr>
<td>Finland</td>
<td>Joensu U., Oulu U., Tempere U.</td>
</tr>
<tr>
<td>South Africa</td>
<td>Pretoria U.</td>
</tr>
<tr>
<td>Sweden</td>
<td>Swedish School Economics</td>
</tr>
<tr>
<td>Slovakia</td>
<td>Stuba U.</td>
</tr>
</tbody>
</table>
Conferences & Workshops

- 1999-2002: 32 conferences and workshops:
  - North America
  - Europe
  - Australia, New-Zealand, Argentina, ..

- Editorial team presentations:
  - USA, Canada, Spain, Brazil, Japan, China, ..
Quality Related Issues

- Learning Tree (USA, Sweeden)
- Quality sources (Finland)
- Software Quality Management Center (Japan)
- Software Validation Accreditation lab.
  - (American Association for Accrediting Lab. Ref. 291)
- Certification, Licensing, Ethics & standards:
  - + 25 entries
Government related

- **China:**
  - ‘We are planning to introduce some worldwide recognized certification program... Eg. SWEBOK, PMBOK, ..’
  - Ref. 317

- **Saudi Arabia:**
  - ‘An integrated professional software engineering study program based on international standards’
  - Ref. 375
Web site references = ??

- Japan: 26
- Turkey: 10
- China = 7, including government
- Finland = 7
- Korea = 5
- Others: Germany, Netherlands, Croatia, Brazil, Vietnam, Norway, Czechia, Greece, Argentina, Russia
A Three-Phase Approach for Developing the Guide to the SWEBOK

Straw Man Version

Stone Man Version

Iron Man Version (Sub-phase 1)

Iron Man Version (Sub-phase 2)
Collection of feedback from:

- Education:
  - Curriculum design/evaluation
  - Program accreditation
  - Course design/evaluation
  - Internal training, corporate universities
Collection of feedback from:

- Industry & Government
  - job description
  - hiring
  - staffing of projects
  - career planning
  - contracting
Collection of feedback from:

- Policy organisations
  - Licensing & Certification
    - licensing exam questions
    - study material
    - in software engineering and other IT fields
    - could be on subsets of Knowledge Areas
Collection of feedback from:

ASQ – Software Division and its specialized expertise on software quality

- Quality Body of Knowledge:
  - Across the 9 SWEBOK Knowledge Areas
  - Within the **Quality** Knowledge Area
A Three-Phase Approach for Developing the Guide to the SWEBOK

- Straw Man Version
- Stone Man Version
- Iron Man Version (Sub-phase 1)
- Iron Man Version (Sub-phase 2)
Professional Development

Professional Development

Infrastructure Support for the Profession

Professional Society Influences

Initial professional education

Skills Development

One or both

Certification

Licensing

Full Professional Status

Accreditation

Professional development

Code of ethics

Adapted from Steve McConnell, After the Gold Rush, Microsoft Press, 1999, p. 93
Concluding Remarks

- Software Engineering: The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software
  - IEEE 610.12

- Strengthening the Engineering Knowledge within this new discipline is required for a rapid maturation, and significant contribution to the global software industry
www.swebok.org
I. Software Design Basic Concepts
   - General design concepts
   - The context of software design
   - The software design process
   - Enabling techniques for software design

II. Key Issues in Software Design
   - Concurrency
   - Control and handling of events
   - Distribution
   - Exception handling
   - Interactive systems
   - Persistence

III. Software Structure and Architecture
   - Architectural structures and viewpoints
   - Architectural styles and patterns (macro-architecture)
   - Design patterns (micro-architecture)
   - Design of families of programs and frameworks

IV. Software Design Quality Analysis and Evaluation
   - Quality attributes
   - Quality analysis and evaluation tools
   - Software design reviews
   - Static analysis
   - Simulation and prototyping
   - Measures
     - Function-oriented (structured) design measures
     - Object-oriented design measures

V. Design Notations
   - Structural descriptions (static view)
   - Behavior descriptions (dynamic view)

VI. Software Design Strategies and Methods
   - General Strategies
   - Function-oriented design
   - Object-oriented design
   - Data-structure centered design
   - Other methods
# University Curriculum

<table>
<thead>
<tr>
<th>Country</th>
<th>University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithuania</td>
<td>Kaumo Tech. U.</td>
</tr>
<tr>
<td>Japan</td>
<td>Gunma U.</td>
</tr>
<tr>
<td>Iceland</td>
<td></td>
</tr>
<tr>
<td>Bangladesh</td>
<td></td>
</tr>
</tbody>
</table>
The Engineering of:

- Software Requirements
- Software Design
- Software Construction
- Software Testing
- Software Maintenance
- Software Quality
- Software Eng. Management
- Software Eng. Tools & Methods
- Software Engineering Process
- Software Configuration Management
## Research References - Papers

<table>
<thead>
<tr>
<th>Country</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>U. California, Clamson U., Kentucky U., Denver U., Alabama U.</td>
</tr>
<tr>
<td>UK &amp; Scotland</td>
<td>Sutherland, Brighton, Aberdeen, Sheffield</td>
</tr>
<tr>
<td>Netherlands</td>
<td>T. U. Delf, T.U. Eindhoven, Twente U.</td>
</tr>
<tr>
<td>Spain</td>
<td>U. Polytechnica Catalunya</td>
</tr>
<tr>
<td>Germany</td>
<td>T.U Chemnitz, U. Hannover</td>
</tr>
<tr>
<td>Dubai, Finland, New Zealand, Canada</td>
<td></td>
</tr>
</tbody>
</table>
30 distincts groups
- Including 2 in China
- Project Management related
- Brazil, Finland, Greece
- Software Quality related