A Baseline for a List Related Disciplines for the Stone Man Version of the Guide to the Software Engineering Body of Knowledge

Approved by the Industrial Advisory Board

Guide to the Software Engineering Body of Knowledge Project

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It was agreed by the Industrial Advisory Board that the Stone Man version of the Guide to the SWEBOK would present the core Body of Knowledge, i.e. the generally accepted knowledge in the field expected from a graduate with four years of experience. It was also agreed in Mont-Tremblant that expected knowledge of other Related Disciplines would only be referenced in the Guide to the SWEBOK. Additionally, these references will be more oriented towards definitions and basic concepts than to content material *per se*.

On January 19, it was decided that, according to the suggestions made by Dennis Fraily in the January 6 'white paper':

The SWEBOK project team is fully responsible for "identifying other disciplines that contain knowledge areas that are important to a software engineer",

The SWEBOK project and the Education project accepts joint responsibility for "identifying those Knowledge Areas within other disciplines ... that are necessary for software engineers",

The lists of knowledge Areas for each Related Discipline in this document are lists of *potential* Knowledge Areas from which knowledge will be considered necessary for the software engineers. They are not by themselves the complete list of such knowledge areas. The SWEBOK Knowledge Area Specialists and the reviewers will establish which of those are considered necessary knowledge for the software engineers. The level of knowledge necessary for each will also be determined at later stages of the process.

Based on the Straw Man report, on the discussions of the Industrial Advisory Board at the Mont-Tremblant kick-off meeting and on subsequent works and discussions, the proposed list of Related Disciplines is:

Computer Science

- It was agreed in Mont-Tremblant that the reference for this Related Discipline would be obtained through an initiative called the IEEE Computer Society and ACM Joint Task Force on "Year 2001 Model Curricula for Computing: CC-2001". To ensure proper coordination with this initiative, Carl Chang, Joint Task Force Co-Chair is a member of the Industrial Advisory Board and was present in Mont-Tremblant. Appendix A lists the preliminary Knowledge Areas of Computer Science as determined by the CC-2001 group.

Mathematics

- It was agreed in Mont-Tremblant that the Computing Curricula 2001 initiative would be the "conduit" to mathematics. So far, we have not received such a list of Knowledge Areas (Knowledge Units in the CC-2001

vocabulary), for Mathematics but it is expected that CC-2001 will provide it. In the mean time, the Editorial Team recommends referring to the list defined by the Computing Curriculum 1991[1] initiative and found in Appendix B.

Project Management

- The reference for this Related Discipline will be "A Guide to the Project Management Body of Knowledge"[2] published by the Project Management Institute. This document is currently being adopted as an IEEE software engineering standard. The list of Knowledge Areas for project management can be found in Appendix C.

Computer Engineering

A list of Knowledge Areas for Computer Engineering and found in Appendix D was compiled from the integration of:

- The syllabus for the British licensing exam for the field of Computer Systems Engineering[3].

- The Principles and Practice of Engineering Examination - Guide for Writers and Reviewers in Electrical Engineering of the National Council of Examiners for Engineering and Surveying (USA). An appendix listed Computer Engineering Knowledge Areas for which questions should be put to the candidates.

- The Computer Engineering undergraduate program at the Milwaukee School of Engineering[4]. This program is considered to be a typical example of an American accredited program by the director of the Computer Engineering and Computer Science Department at MSOE.

Systems Engineering

Appendix E contains a proposed list of Knowledge Areas for Systems Engineering. The list was compiled from:

- The EIA 632 and IEEE 1220 (Trial-Use) standards;

- the Andriole and Freeman paper[5];

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[1] See http://computer.org/educate/cc1991/

[2] See www.pmi.org to download this report.

[3] See http://www.engc.org.uk

[4] See http://www.msoe.edu/eecs/ce/index.htm

[5] Stephen J. Andriole and Peter A. Freeman, *Software systems engineering: the case for a new discipline*, System Engineering Journal, Vol. 8, No. 3, May 1993, pp. 165-179.

- the material available on the INCOSE (International Council on Systems Engineering) website[6];

- a curriculum for a graduate degree in Systems Engineering at the University of Maryland[7];

Three experts in the field were also consulted, John Harauz, from Ontario Hydro, John Kellogg from Lockheed Martin, and Claude Laporte consultant, previously with the Armed Forces of Canada and Oerlikon Aerospace.

We recommend adopting Appendix E as a baseline list of Knowledge Areas of Systems Engineering and to continue improving it notably as the INCOSE results are made available.

Management and Management Science

No definitive source has been identified so far for a list of Management and Management Science Knowledge Areas relevant to software engineering. A list was therefore compiled from

- the Technology Management Handbook[8] which contains many relevant chapters;

- the Engineering Handbook[9] which contains a section on Engineering Economics and Management covering many of the relevant topics;

- an article by Henri Barki and Suzanne "Rivard titled A Keyword Classification Scheme for IS Research Literature: An Update"[10].

The proposed list of knowledge areas for Management and Management Science can be found in Appendix F.

Cognitive Sciences and Human Factors

Appendix G contains a list of proposed Knowledge Areas for Cognitive Sciences and Human Factors. The was compiled from the list of courses offered at the John Hopkins University Department of Cognitive Sciences[11] and from the ACM SIGCHI Curricula for Human-Computer Interaction[12].

The list was then refined by three experts in the field: two from UQAM and W. W. McMillan, from Eastern Michigan University. They were asked to indicate which of

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[6] See www.incose.org

[7] See http://www.isr.umd.edu/ISR/education/msse/

[8] See CRC Press

[9] See Crc Press

[10] See MIS Quaterly, June 1993, pp. 209-226

[11] See http://www.cogsci.jhu.edu/

[12] See TABLE 1. Content of HCI athttp://www.acm.org/sigchi/cdg/cdg2.html

these topics should be known by a software engineer. The topics that were rejected by two of the three respondents were removed from the original list.

It was also decided at the Mont-Tremblant meeting that the following Related Disciplines proposed in the Straw Man report be removed from the list. However, the Knowledge Area Specialists will be free to put forward any Discipline that, in their view, “contains Knowledge Areas that are important to a software engineer”.

The three removed disciplines are:

- Telecommunications/Networks
- Science
- Other Engineering Disciplines

Appendix A. Knowledge Areas of Computer Science.

On January 21, we received the following list of Knowledge of Focus Areas from Mr. Chang for the CC-2001 initiative:

0. [MP] **Mathematics and Physical Sciences**

1. [FO] **Foundations**
   - Complexity analysis
   - Complexity classes
   - Computability and undecidability
   - Discrete mathematics (logic, combinatorics, probability)
   - Proof techniques
   - Automata (regular expressions, context-free grammars, FSMs/PDAs/TMs)
   - Formal specifications
   - Program semantics

2. [AL] **Algorithms and Data Structures**
   - Basic data structures
   - Abstract data types
   - Sorting and searching
   - parallel and distributed algorithms

3. [AR] **Computer Architecture**
   - Digital logic
   - Digital systems
   - Machine level representation of data
   - Number representations
   - Assembly level machine organization
   - Memory system organization and architecture
   - Interfacing and communication
   - Alternative architectures
   - Digital signal processing
   - Performance

4. [IS**] Intelligence Systems** (IS)
   - Artificial intelligence
   - Robotics
   - Agents

Pattern Recognition
Soft computing (neural networks, genetic algorithms, fuzzy logic)

5. [IM] **Information Management**
   Database models
   Search Engines
   Data mining/warehousing
   Digital libraries
   Transaction processing
   Data compression

6. [CI] **Computing at the Interface**
   Human-computer interaction (usability design, human factors)
   Graphics
   Vision
   Visualization
   Multimedia
   PDAs and other new hardware
   User-level application generators

7. [OS] **Operating Systems**
   Tasks, processes and threads
   Process coordination and synchronization
   Scheduling and dispatching
   Physical and virtual memory organizations
   File systems
   Networking fundamentals (protocols, RPC, sockets)
   Security
   Protection
   Distributed systems
   Real-time computing
   Embedded systems
   Mobile computing infrastructure

8. [PF] **Programming Fundamentals and Skills**
   Introduction to programming languages
   Recursive algorithms/programming
   Programming paradigms

Program-solving strategies
Compilers/translation
Code Generation

9. [SE] **Software Engineering**

Software Engineering will not be a related discipline to Software Engineering...

This focus group will be coordinated with the SWEBOK project in order to avoid double definitions of the field.

10. [NC] **Net-centric Computing**

Computer-supported cooperative work
Collaboration Technology
Distributed objects computing (DOC/CORBA/DCOM/JVM)
E-Commerce
Enterprise computing
Network-level security

11. [CN] **Computational Science**

Numerical analysis
Scientific computing
Parallel algorithms
Supercomputing
Modeling and simulation

12. [SP] **Social, Ethical, Legal and Professional Issues**

Historical and social context of computing
Philosophical ethics
Intellectual property
Copyrights, patents, and trade secrets
Risks and liabilities
Responsibilities of computing professionals
Computer crime

Appendix B. Knowledge Areas of Mathematics

Discrete Mathematics: sets, functions, elementary propositional and predicate logic, Boolean algebra, elementary graph theory, matrices, proof techniques (including induction and contradiction), combinatorics, probability, and random numbers.

Calculus: differential and integral calculus, including sequences and series and an introduction to differential equations.

Probability: discrete and continuous, including combinatorics and elementary statistics.

Linear Algebra: elementary, including matrices, vectors, and linear transformations.

Mathematical Logic: propositional and functional calculi, completeness, validity, proof, and decision

Appendix C. Knowledge Areas of Project Management

The list of Knowledge Areas defined by the Project Management Institute for project management is:

- Project Integration Management
- Project Scope Management
- Project Time Management
- Project Cost Management
- Project Quality Management
- Project Human Resource Management
- Project Communications Management
- Project Risk Management
- Project Procurement Management

Appendix D. Knowledge Areas of Computer Engineering.

Digital Data Manipulation
Processor Design
Digital Systems Design
Computer Organization
Storage Devices and Systems
Peripherals and Communication
High Performance Systems
System Design
Measurement and Instrumentation
Codes and Standards
Circuit Theory
Electronics
Controls
Combinational and Sequential Logic
Embedded Systems Software
Engineering Systems Analysis with Numerical Methods
Computer Modeling and Simulation

Appendix E. Knowledge Areas of Systems Engineering

PROCESS
- Need Analysis
- Behavioral Analysis
- Enterprise Analysis
- Prototyping
- Project Planning
- Acquisition
- Requirements Definition
- System definition
- Specification trees
- System breakdown structure
- Design
- Effectiveness Analysis
- Component specification
- Integration
- Maintenance & Operations
- Configuration Management
- Documentation
- Systems Quality Analysis and Management
- Systems V & V
- System Evaluation
- Systems Lifecycle Cost Estimation
- Design of Human-Machine Systems
- Fractals and self-similarities

ESSENTIAL FUNCTIONAL PROCESSES: (IEEE 1220)
- Development
- Manufacturing
- Test
- Distribution
- Operations
- Support
- Training
- Disposal

TECHNIQUES & TOOLS (IEEE 1220)

Metrics
Privacy
Process Improvement
Reliability
Safety
Security
Vocabulary
Effectiveness Assessment

Appendix F. Knowledge Areas of Management and Management Science

- BUSINESS STRATEGY
- FINANCE
- EXTERNAL ENVIRONMENT
  - Economic Environment
  - Legal Environment
  - Regulation processes
- ORGANIZATIONAL ENVIRONMENT
  - Organizational Characteristics
  - Organizational Functions
  - Organizational Dynamics
- INFORMATION SYSTEMS MANAGEMENT
  - Data Resource Management
  - Information Resource Management
  - Personnel Resource Management
  - IS Staffing
- INNOVATION AND CHANGE
- ACCOUNTING
- TRAINING

- MANAGEMENT SCIENCE
  - Models
    - Financial Models
    - Planning Models
  - Optimization
    - Optimization methods
    - Heuristics
    - Linear Programming
    - Goal Programming
    - Mathematical Programming
  - Statistics
  - Simulation

Appendix G. Knowledge Areas of Cognitive Sciences and Human Factors

Cognition
Cognitive AI I: Reasoning
Machine Learning and Grammar Induction
Formal Methods in Cognitive Science: Language
Formal Methods in Cognitive Science: Reasoning
Formal Methods in Cognitive Science: Cognitive Architecture
Cognitive AI II: Learning
Foundations of Cognitive Science
Information Extraction from Speech and Text
Lexical Processing
Computational Language Acquisition

The Nature of HCI
    (Meta-)Models of HCI
Use and Context of Computers
    Human Social Organization and Work
    Application Areas
    Human-Machine Fit and Adaptation
Human Characteristics
    Human Information Processing
    Language, Communication, Interaction
    Ergonomics
Computer System and Interface Architecture
    Input and Output Devices
    Dialogue Techniques
    Dialogue Genre
    Computer Graphics
    Dialogue Architecture
Development Process
    Design Approaches
    Implementation Techniques
    Evaluation Techniques
    Example Systems and Case Studies