
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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2. See [www.pmi.org](http://www.pmi.org) to download this report.
4. See [http://www.msoe.edu/eecs/ce/index.htm](http://www.msoe.edu/eecs/ce/index.htm)
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

\(^{6}\) 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 Quartery, 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