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1. Introduction

JTC1/SC7 Resolution 794 established a Study Group to consider the subject of standards and/or technical reports for professional certifications of software engineers.

The resolution instructs the Study Group to consider the following issues:

(I1) a "task analysis", referenced to ISO/IEC 12207, describing the work activities that software engineers should be qualified to perform

(I2) a "test specification", referenced to ISO/IEC TR 19759, describing the knowledge that software engineers should master

(I3) harmonization with any existing ISO standards concerning personnel certification

(I4) coordinated development with the IEEE Computer Society under the terms of SC7 N2860

(I5) provisions enabling nations to write culturally appropriate examinations and operate culturally appropriate certification programs

(I6) provisions providing for "portability" of certifications across national boundaries and mechanisms for mutual recognition

(I7) provisions respecting the status of individuals recognized by governments as "software engineers" or the equivalent

(I8) the criteria and operation of existing schemes in various nations

2. Relevant Standards

Two recent international standards[1] (ISO/DIS 9712, ISO/DIS 18436) define requirements for bodies that operate systems for certifying personnel in the areas of non-destructive testing and machinery condition monitoring, respectively. Both standards call such bodies *certification bodies*, and both reference a standard (ISO/IEC 17024) that specifies requirements for certification bodies that are independent of any particular area of expertise. Note that the European standardization body CEN has replaced the previous European standard on this topic (EN 45013) with EN-ISO/IEC 17024: 2003, which adopts ISO/IEC 17024 as a whole.

In the United States, the National Organization for Competency Assurance has created a set of standards and an accreditation process for certification programs that has been operating since the late 1970s.

3. Fundamental Principles of Certification

The principles described in the following paragraphs are summarized from the text of ISO/IEC 17024. They are reasonably consistent with the National Commission for Certifying Agencies (NCCA) standards commonly used in the United States.

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[1] All international standards cited in this document are listed in Appendix 1.

The primary characteristic of a certification body is that it will define policies and procedures for granting, maintaining, renewing, expanding, and reducing the scope of the desired certification, and suspending or withdrawing the certification.

A certification body must define, develop, and maintain the methods and mechanisms (*certification schemes*) to be used to evaluate the competence of candidates. Certification schemes should only be established in response to government requirements or market needs/desires. A certification scheme should include the following elements:

- Interested parties should be consulted to elicit a description of the field for which persons will be certified and a description of the competence and evaluation requirements and procedures and to determine the organization, body, or person who will be responsible for developing the proposed certification scheme.

- A job/practice analysis should be conducted periodically, to produce a description of the target population, a list of the important tasks performed by people working in the profession, a list of the certification requirements, and a specification for the certification examination (content outline, types of questions, cognitive levels, time length of the examination, method for determining acceptance level, and methods for marking).

A certification body must establish, implement, and maintain a management system that ensures the application of the relevant standards. It must maintain appropriate records in such a way as to ensure the integrity of the certification process. Security and confidentiality must be ensured throughout the process.

A certification body may subcontract aspects of its work (e.g. administering the examination) to an external agency. Employees or persons working under contract must commit themselves to the rules defined by the certification body. In particular, examiners must be familiar with the certification scheme; they must have appropriate competence and a thorough knowledge of the examination methods and documents, and they must be able to demonstrate that they can be impartial.

A certification body must be able to provide a detailed description of the certification process along with application materials and any other relevant documents. The certification body must review a candidate’s application, accommodate any special needs, examine the candidate’s competence, and make a decision on certification of the candidate. If the candidate is certified, an appropriate certificate must be issued.

A certification body must establish procedures and conditions for the maintenance of certification. It must define a surveillance process to monitor certificate holders’ compliance with these procedures and conditions.

A certification body must define recertification requirements and establish procedures and conditions for enforcing these requirements.

If a certification body provides a certification mark or logo, it must document the conditions for use and appropriately manage usage rights.

4. Approaches to the Certification of Software Engineers

A professional certification effort has three relatively independent dimensions: (1) a characterization of the professional role that is to be certified, (2) a list of the abilities and skills needed by a professional in that role, and (3) a description of the certification process and its organization. Explicitly recognizing these certification dimensions helps to clarify the differences between various national approaches to the certification of software engineers.

In some nations, candidates achieve certification by passing one or more examinations. In this case, the first certification dimension is often represented by the prerequisites that must be met by a candidate. For example, a candidate for IEEE Computer Society's Certified Software Development Professional (CSDP) certification must hold a baccalaureate or equivalent university degree and have had a minimum of two years of recent software engineering experience in at least six of eleven specified knowledge areas (see www.computer.org/certification/education.htm). The second certification dimension is represented by a specification of the job tasks and knowledge and skill items considered relevant to certification. For the CSDP certification examination, an Excel spreadsheet containing a list of task and knowledge statements is given in an appendix to this document. The Japanese government's Information Technology Engineers Examination (ITEE) program provides an IT body of knowledge and IT engineers' skill standards for this purpose. The third certification dimension corresponds reasonably closely to the requirements of ISO/IEC 17024.

In other nations, candidates are certified only after a peer review of credentials and experience, possibly including a face-to-face interview. Peer-based certification processes are sometimes associated with national efforts to classify the skills and experience of software and information professionals. In this case, the first certification dimension is derived from a common understanding or model of professional engineering performance. This dimension always contains both implicit and explicit components. The implicit components correspond to the performance expectations that are generally shared by professional engineers. Examples of explicit components can be found in the responsibility levels of the skills frameworks recently developed in the United Kingdom (Skills Framework for the Information Age, or SFIA) and Japan (Information Technology Skill Standard, or ITSS). The second dimension of a peer-based certification process can also be explicit or implicit. The knowledge elements found in the SFIA and ITSS frameworks constitute an explicit second dimension. The more informal expectations used in the peer-based chartered engineer process in the UK and Australia would correspond to an implicit second dimension. The third dimension is set out explicitly in the documents describing these certification schemes. It corresponds well to ISO/IEC 17024, with the exception that references to examinations must be replaced by references to the peer review process.

The implicit aspects of a national peer-based software engineering certification process are inseparable from the expectations of the communities of practice represented by the software engineers in that nation. An international standard for the certification of software engineers that included peer-based certifications would therefore have to develop a useful set of features common to professional-community expectations in different nations. The dimensional approach outlined above is a good place to start.

Examination-based certification processes are built around explicit artifacts, including examinations, specifications, international standards, and bodies of knowledge. It is relatively straightforward to use these explicit artifacts to identify commonalities between different national examination-based certification processes. The existence and role of these artifacts makes it possible to identify a common substrate that could serve as the basis for international standards for certification. Current international standards (ISO/IEC 12207, ISO/IEC TR 19759) could form part of that substrate.

The next section of this document shows how a common substrate built around ISO/IEC 12207 and ISO/IEC TR 19759 can be used to construct guidelines for examination-based certification of software engineers.

5. Initial Guidelines for the Examination-Based Certification of Software Engineers

These guidelines should be regarded as a reference model for examination-based certification of software engineers. Items in brackets are links to elements of the charge to the study group or to existing standards.

(a) Responsibility for all certification activities must rest with a professional organization, a government body, or an academic consortium. This entity may establish a subordinate body and assign the certification activities to it. The aforementioned entity or its subordinate body will be called the *certification body* [17024: 4.1]. It will have an appropriate organizational structure [17024: 4.2].

(b) The certification body will develop and maintain a certification scheme. It will consult with a broad-based group of software engineering professionals, representing academia, industry, and government, to establish support for the proposed scheme and lay the groundwork for a job and task analysis. [17024: A.2]

(c) The certification body will perform a job and task analysis with the following goals:

(i) Identify the important and critical tasks and work activities performed by competent software engineers. This effort will include consideration of the systems engineering context of software engineering.

(ii) Map these tasks and work activities to the relevant standards, including ISO/IEC 12207. [I1]. In this regard, it is important to note that ISO/IEC 15288 provides a systems engineering context for 12207.

(iii) Determine a specification for the examination: a list of topic areas to be tested, the number of questions and their distribution across the topic areas, the goals for the cognitive levels of the questions, and the cut score for certification. The test specification should be referenced to the relevant standards, including ISO/IEC TR 19759. [I2]

(iii) The job and task analysis should be culturally appropriate. [I5]

(d) The certification body will create and approve a culturally appropriate examination that conforms to the specification. The examination may include multiple-choice items, case studies, short essays, as well as other question formats. [I5]

(e) The certification body will establish a management system for its certification activities. Management activities must include the creation and maintenance of a record-keeping system and providing assurance of confidentiality and security. It may include managing the subcontracting of work related to certification. The decision on certification may not be subcontracted. [17024: 4.4-4.8]

(f) The certification body will provide on request a current detailed description of the requirements for certification and the certification process. [17024: 6.1.1]

(g) The certification body will administer an application process that includes the completion and evaluation of a formal application. [17024: 6.1.2, 6.2]

(h) The certification body will make the decision on certification of a candidate. Appropriate certificates will be issued to all certified persons. [17024: 6.3]

(i) The certification body will establish a process to monitor the maintenance of certification. This will include the surveillance of certificate holders to assure compliance with appropriate requirements and the recertification of individuals holding certificates. [17024: 6.4]

(j) Using this reference model, the certification body would work with analogous bodies in other countries to develop mechanisms for mutual recognition of software engineering professional certification and to assure the "portability" of such certification across national boundaries. This effort must take account of the criteria and operation of existing certification schemes in various nations. In particular, it must take account of current European efforts to develop tools that support transfer and transparency of qualifications and competences. [I6, I8] Currently, "professional recognition" in the European Union is governed by a set of directives that specify the rights of individual citizens with respect to qualifications. This set of directives will in the near future be replaced by one single directive covering all regulated professions (see europa.eu.int/comm/education/policies/rec_qual/rec_qual_en.html).

(k) The certification body would develop procedures for granting certification to individuals recognized by governments as professional software engineers. This category will include software engineers holding chartered or licensed status. [I7]

6. Examples of Examination-Based Software Engineering Certification Processes

(a) The IEEE Computer Society's Certified Software Development Professional (CSDP) Program

In 1998, the IEEE Computer Society began a discussion of the feasibility of certifying software engineering professionals. The Society then decided to initiate a formal investigation of this possibility; the first step in this process was to gather input from the professional community, as required by 5(b). In 1999, the Society conducted a study that included surveys and discussions with potential certificate holders and with industry representatives. In 2001, the Society surveyed a sample of its members. The results of both efforts indicated a strong interest in certification.

In February 1999, the Computer Society contracted with Chauncey Group International (CGI) for test development. CGI, a subsidiary of the US-based Educational Testing Service, is a leading consultant in the development of certification examinations. Later that year, a group of software engineers met under the guidance of CGI to review and revise a draft listing of task and knowledge statements, as required by 5(c)(i). CGI's involvement ensured that the job and task analysis was culturally appropriate [5(c)(iii))]. The set of task and knowledge statements was then distributed for validation to a group of software engineers selected to satisfy explicit educational and geographic criteria. The comments of these engineers were used to produce a final version of the task and knowledge statements. The knowledge statements have been mapped to SWEBOK 2004, and the task statements have been mapped to ISO/IEC 12207. An Excel spreadsheet containing the list of task and knowledge statements and the task statement mappings is given in Appendix 2. A file containing the spreadsheet has also been distributed with the file containing this document.

In October 1999, test specifications were developed from information derived from the job analysis, as required by 5(c)(ii). The specifications became the blueprint for defining the final content of the examination. A group of software engineers met to decide the examination content weights.

In Spring 2000, test questions (items), were written, edited and approved by groups of software engineers trained in item development by CGI, who then edited the items for style, format, logic and grammar before classifying and banking them. A separate group of software engineers evaluated the items to ensure that each item was clear and concise, and measured the content to check that it conformed to the test specifications. CGI ensured that the examination was psychometrically valid and culturally appropriate [(5(d))].

Later that year, approved items were assembled into two examination forms, in accordance with the test specifications. The assembled forms were reviewed by a test developer and by a group of software engineers, who reviewed potential problem items and made substitutions were necessary.

In the spring and summer of 2001, the approved test forms were pilot-tested by a group of software engineers selected to match the targets for education and experience. A preliminary item analysis was done on the pilot-test data, detecting any errors in the key and any potentially flawed items. These errors were reviewed and corrected. A cut-score workshop was then conducted; a group of software engineers took the exam and rated the difficulty level of each item and a range of scores for the exam that would determine whether a candidate would be certified. The IEEE Computer Society Professional Practices Committee (acting as the CSDP oversight committee) formally accepted one of the cut-score recommendations. The second form of the exam was then statistically equated to the first. At this time, the examination was officially ready for release.

Testing windows were held in the spring of 2002, 2003, and 2004. In May 2004, an item-writing workshop was held to begin the development of items for the planned examination revision in 2005. This ongoing effort will also harmonize the examination specification with SWEBOK 2.0 (ISO/IEC TR 19759).

The IEEE Computer Society has assigned responsibility for the CSDP certification effort to its Professional Practices Committee (PPC). This committee has established a Certification Committee to manage the CSDP effort and any future software engineering certifications. Responsibility for supervising training for individuals intending to apply for certification has been assigned to the CSDP Training Committee, which reports to the Computer Society's Educational Activities Board. [5(a)]

The IEEE Computer Society has assigned the responsibility of managing all aspects of the certification process to a staff member. This includes responding to questions, distributing informational and application materials, processing applications, organizing and coordinating training activities, administering the examination (via a contract with a test administration firm), certifying successful applicants using the examination cut score, and administering the recertification process. [(5(e-i))]

There are currently more than 450 CSDP certificate holders. These individuals reside in many countries, located in all parts of the world. The IEEE Computer Society's Professional Practices Committee is very interested in establishing relationships with software engineering certification bodies in other countries that will lead to mechanisms for mutual recognition of certification and that will help to assure the "portability" of certifications across national boundaries. The move toward mutual recognition and portability must take account of the criteria and operation of existing national certification schemes. [5(j)] The Professional Practices Committee has worked closely with professional engineering associations in the United States and Canada to develop a relationship between software engineering certification and professional licensure. The PPC anticipates that this and other similar relationships will lead to the development of procedures for granting certification to individuals recognized by governments as "software engineers" or the equivalent. [5(k)]

(b) The Japanese Government's Information Technology Engineers Examination (ITEE) Program

In 1969, Japan's Ministry of Economy, Trade and Industry (then called the Ministry of International Trade and Industry) established the Information Technology Engineers Examination as a national examination. In 1984, the Japan Information Processing Development Corporation (JIPDEC) was designated as the official examination administrator by METI, and the Japan Information Technology Engineers Examination Center (JITEC) was established to carry out the details of the administration [5(a)]. The JITEC has responsibility for all certification activities, from acceptance of applications to maintenance of certification [5(e-i)]. In 2004, examination administration was transferred to the Information-technology Promotion Agency, JAPAN (IPA) in accordance with amendments to the Promotion of Information Processing Act, the law establishing the examination. The first examinations offered were Class I Information Technology Engineer and Class II Information Technology Engineer. During its 35 years of operation, the examination has undergone numerous changes and revisions. In 1994, a major revision introduced many new examination categories. The most recent revision was made in 2001, which resulted in the examination categories shown in Figure 1.

Some of the examination categories correspond to engineers who play primary roles in software development: system analyst, application systems engineer, software design and development engineer, and fundamental information technology engineer. Although the organization of the examinations was not based on the waterfall development model, the resulting categories for these engineers can be mapped to ISO/IEC 12207. [5(c)(i)]

The scope and skill standards for the examination are based on the opinions of experts from industry and academia, as required by 5(b). These standards are continuously reviewed to keep them consistent with changes in the information technology and information industries. At the same time, the examination categories are reviewed for their relevance to current trends in information technology as well as for consistency with past examinations.

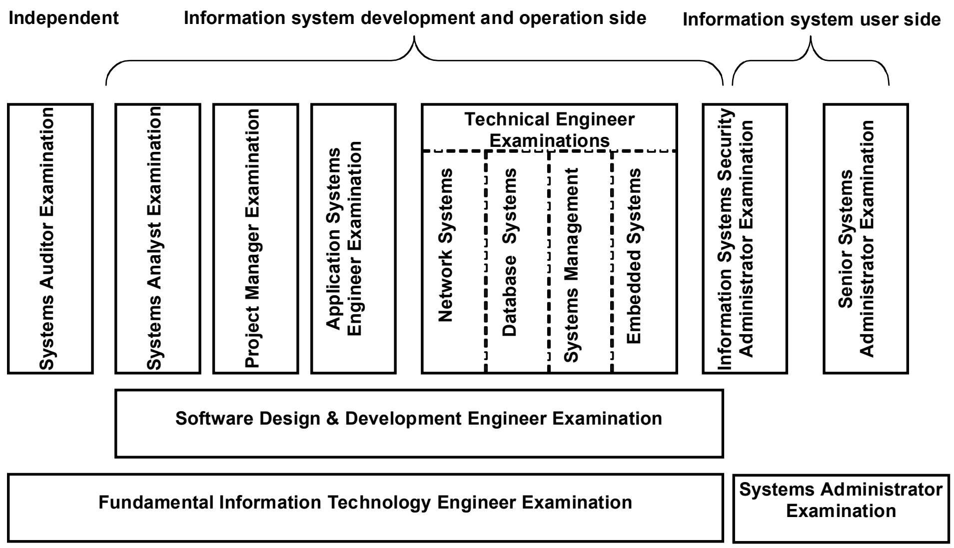

Figure 1. ITEE examination categories

The scope of an examination includes the test specification and a blueprint for the exam. The skill standard for an examination provides context [5(c)(iii)]. It describes the activities and tasks of engineers employed in the relevant examination category, as well as outlining the underlying knowledge needed in this category. The activities and tasks are based on ISO/IEC12207. [5(c)(i)] The body of knowledge for each category includes material from software engineering, information systems, and computer science. It corresponds well to ISO/IEC 19759. [5(c)(ii)]

There are no specific eligibility criteria for the examinations. The duration of each examination is one day. A morning session uses multiple-choice questions to test a candidate's familiarity with the required knowledge. An afternoon session uses case studies and essay questions to test a candidate's ability to apply and practice the knowledge. The case study and essay questions also serve as a way of assessing a candidate's past experience.

The examination questions are developed by an examination committee, which comprises about 400 experts from industry and academia. [5(d)] Subcommittees are charged with question development, checking, and selection. Each subcommittee has independent authority to construct appropriate questions. In general, new questions are produced for each examination, but some knowledge questions may be reused with modification.

After the examination, candidates can bring question papers home to use for self-study and further education. The correct answers for some questions are made available, and examinees can obtain their scores on the examination. Transparency of the examination is therefore ensured in several ways: scope of examination, production of examination questions, availability of examination scores and sample question answers.

Certificates are issued to successful examinees under the name of the Minister of Economy, Trade and Industry. The certificates show the date of certification. They do not have an expiration date, though this has been under discussion.

Table 1 shows the numbers of applicants and successful candidates accumulated up to the spring of 2004 for the various examinations.

Category	No. of applicants	No. of successful candidates
System Analist	71,353	2,888
System Auditor	153,619	5,440
Project Manager	125,425	4,996
Senior Systems Administrator	70,276	2,992
Application Systems Engineer	580,803	22,814
Technical Engineer (Systems Management)	79,499	2,940
Technical Engineer (Network)	783,433	26,041
Technical Engineer (Database)	167,267	7,430
Tecinical Engineer (Embedded)	28,588	2,172
Information Systems Security Administrator	152,028	12,222
Software Design & Development Engineer	1,945,172	160,523
Fundamental Information Technology Engineer	6,464,857	669,577
Systems Administrator	1,698,148	400,513
Production Engineer	84,245	4,321
Total	**12,404,713**	**1,324,869**

Table 1. Numbers of ITEE Applicants and Successful Candidates

Japan has promoted mutual certification of examinations with Asian nations, and Memorandum of Understanding regarding Mutual Certification have been concluded with ten countries: India, Singapore, Korea, China, Philippines, Thailand, Vietnam, Myanmar, Malaysia, and Taiwan. Many other countries have expressed interest in mutual certification. The mutual certification of qualification has increased the professional mobility of engineers. [5(j)]

During its 35 years of existence, the Information Technology Engineers Examination has been able to adapt to the rapidly changing information technology environment. Its adaptability to the demands of the times has been a major factor in its success.

(c) Examinations offered by the British Computer Society (BCS)

The British Computer Society offers two independent families of professional examinations. The Information Systems Examination Board (ISEB) offers examinations in many areas, including some that are relevant to software engineering. Examples include project management, business systems development, data protection, and software testing. The BCS also offers professional examinations at three levels that provide the equivalent of academic qualifications. The highest-level examination is regarded as equivalent to a university honors degree. Software engineering appears as an optional module at the second and third examination levels.

(d) Examinations of the International Software Quality Institute (iSQI)

The International Software Quality Institute (iSQI) is an independent nonprofit organization in Germany (with support from German national and state governments) that provides comprehensive services in the field of software quality. Its primary mission is to coordinate industry and professional efforts to develop and implement software quality standards.

Certification of software engineering professionals is an important part of iSQI's activities. Individual examinations are offered in several software engineering professional specialties: software architecture, project management, requirements engineering, software quality, process engineering, and software testing. Each iSQI examination is administered by an examination board. The iSQI software testing examinations are currently being harmonized with the software testing examinations offered by the BCS ISEB.

All examinations are offered at foundation levels, while the testing examination is also offered at advanced level. Advanced-level examinations are anticipated for the other specialties as well. The foundation-level examinations are 90-minute multiple-choice examinations. The advanced-level testing examination consists of three 90-minute multiple-choice parts (Test Manager, Functional Tester, Technical Tester). The examinations are offered frequently at two sites in Germany (Erlangen, Berlin).

Training courses for prospective examination takers are provided by a number of organizations. The appropriate examination boards accredit organizations that provide training courses. The underlying bodies of knowledge and examination specifications can be inferred from the training course outlines found on the iSQI website.

7. Conclusions

There are significant commonalities shared by the many national perspectives on software engineering professional certification. For example, approaches to certification tend to be based either on examinations or on peer evaluation, and certification examinations generally reference either a body of knowledge or a specific skill set. These commonalities suggest that it would be useful and feasible to think about standardizing these approaches to certification.

An international standard for the professional software engineering certification process would make mutual recognition of professional credentials much easier, enabling professionals to move easily within an increasingly global software industry. So far, such recognition can only be achieved by bilateral negotiations, as in the Japanese memoranda of understanding with other Asian nations. Despite some regional successes, bilateral approaches will not be able to scale to the entire world.

It would be easiest to begin by developing a standard for examination-based certification. Such a standard would provide a reference model for the technical bases (skill set, body of knowledge) of a given national certification scheme. ISO/IEC 12207 and ISO/IEC TR 19759 are internationally accepted documents corresponding to these technical certification bases. It is therefore reasonable to build an approach to standardization of software engineering professional certification that makes use of these documents.

Finally, it will be worthwhile to investigate whether peer-evaluation approaches to certification can be effectively included in a certification standard. This investigation can be built on an expanded version of the certification dimensions introduced in Section 4 above. A first order expansion might be organized as follows:

Dimension 1 (role characterization): description and scope of work for the jobs held by certificate holders, maturity and responsibility expected of the certificate holder

Dimension 2 (skills and abilities): knowledge, skills, aptitude, experience requirements for certificate holders

Dimension 3 (certification process): who is to be assessed, what is to be assessed, how and when is it to be assessed, and by whom it is to be assessed

8. Recommendations

The Study Group makes the following recommendations:

(a) A working group should be established to look at establishing international standards for the certification of software engineers.

(b) The working group should endeavor to coordinate its activities with WG20.

(c) The efforts of the working group shall take account of the following points:

a. The discussion in Section 4 should be considered as an organizing framework for discussion of software engineering professional certification.

b. Within this framework, the guidelines listed in Section 5 should be considered as an appropriate framework for the examination-based certification of software engineers.

c. A standard for professional certification of software engineers may possibly resemble a reference model. Conformance of a particular national approach to an international standard for the certification process would require mapping this approach to the reference model.

d. For example, a certification body administering a software engineering certification examination would demonstrate conformance to an international standard by showing how its scheme is consistent with the guidelines of Section 5.

e. Such a conformance document should include a statement about the mapping of the underlying body of knowledge, appropriate skills, and/or examination specification to international standards, such as ISO/IEC 12207, ISO/IEC 15288, and ISO/IEC TR 19759.

f. A certification body providing peer-based software engineering certification would demonstrate conformance to an international standard for the certification process by showing how its approach maps to the organizing framework of Section 4.

g. The reference model should be used by each certification body as a basis for work with its counterparts in other countries to provide for portability and mutual recognition of software engineering certifications. It must therefore take account of current European efforts to develop tools that support transfer and transparency of qualifications and competences.

h. The reference model should help each certification body to establish an approach to international recognition of the status of individuals recognized as professional (licensed, chartered, or the equivalent) software engineers in its countries or individuals who have been certified through national peer-based certification processes.

Appendix 1. Relevant International Standards

EN 45013:1989 General Criteria for Certification Bodies Operating Certification of Personnel

ISO 9712:1999 Non-destructive testing -- Qualification and certification of personnel

ISO 9712/DIS Non-destructive testing -- Qualification and certification of personnel

ISO/IEC 12207:1995 Information technology -- Software life cycle processes

ISO/IEC 12207:1995/Amd 1:2002

ISO/IEC 12207:1995/Amd 2:2004

ISO/IEC 15288:2002 Systems engineering -- System life cycle processes

ISO/IEC 15504-1:2004 Information technology -- Process assessment -- Part 1: Concepts and vocabulary

ISO/IEC 17024:2003 Conformity assessment -- General requirements for bodies operating certification of persons. It is anticipated that this standard will replace EN45013 on April 1, 2005.

ISO/IEC DTR 19759 Software Engineering -- Guide to the Software Engineering Body of Knowledge – SWEBOK

Appendix 2: Results of CSDP Job Analysis: Knowledge Statements, Task Statements, Statement Mappings

		Tasks	Mapping to 12207 Processes	Mapping to 12207 Amendments Annexes F, G, H	Notes
		Domain 1: Process Management			
1	T1	Perform assignments in an ethical manner (e.g., public interest, client/employer interests, quality product, professional judgment, profession advancement, colleague support, self-improvement)			
2	T2	Identify customers and stakeholders for the software product and process and their communication needs			
3	T3	Manage customer and stakeholder relationships		F.1.1.3, H.1	
4	T4	Develop overarching software mission, goals, objectives, and principles		F.3.1(1), F.3.1.3	
5	T5	Define the software life cycle processes	1.5, 3.11, 5.2.4.2, 5.3.1.1, 7.3.1, B.4, E.11	F.3.1(1,2), F.3.1.1(2,3), F.3.3.1	
6	T6	Follow the software life cycle processes		F.3.3.2	
7	T7	Improve the software life cycle processes	7.3.2, 7.3.3, E.11	F.3.3.3	
8	T8	Identify measures that define success for each project stage		F.3.1(7), F.3.1.6, G.2.1	
9	T9	Establish verification and validation framework based on product criticality and project stages	6.4.1, 6.5.1	F.2.4, F.2.5	
10	T10	Recruit, motivate, and retain adequate staff e.g., project managers, developers, support staff)	7.1.1.2	F.3.4, F.3.4.1, G.3	
11	T11	Identify training needs and ensure that appropriate training is accomplished	7.1.1.2, 7.4	F.3.4, F.3.4.2, G.3	
12	T12	Identify, acquire, and implement methods and tools (e.g., management, development, process)	7.1.1.2	F.3.1(4), F.3.1.3	
13	T13	Establish and manage the computing infrastructure for system development (e.g., LANs, desktops, hardware, software, tools, standards, facilities)	7.2	F.3.1(4), F.3.1.3	
14	T14	Perform customer and stakeholder needs analysis and problem identification		F.1.1(2), F.1.1.1, F1.2(1,2)	
15	T15	Identify, control, and report software change requests and their disposition	5.5	F.1.5(1,2)	
16	T16	Report software quality problems and ensure corrective action is taken	6.3	F.2.2(5), F.2.8	
17	T17	Ensure that control of work products and media is exercised during the project (e.g., documentation, software source code, models)	6.2	F2.2	
18	T18	Manage risks (e.g., identify, prioritize, mitigate risks; develop and execute contingency plans; track risk factors)	5.1.1.6, 5.1.1.8, 5.2.4.4, 5.2.4.5 (k), 5.4.1.1, 6.6.2.1	F.3.1.5	
19	T19	Ensure confidentiality and security (e.g., personal records, intellectual property, physical access, competitive issues, nondisclosure agreements)	5.2.4.5 (l), 5.3.4.1 (e), 6.1.2.1, 6.1.3.1, 6.4.2.1	H.1.14(2), H.2.1.1 (5.1.6b)	
21	T20	Identify, select, and manage suppliers, vendors, and subcontractors (e.g., requirements, schedules, budgets, quality, deliverables)	5.1	F.1.1.2, F.1.1.3, F.1.2(3), H.2.1.3	
		Domain 2: Initiating, Conceptualizing, and Planning			
23	T21	Identify evaluation criteria for selection of candidate solutions		F.1.3	
24	T22	Validate problem definition		F.1.3, F.1.3.1	
25	T23	Develop and validate User Operations Scenario concept (e.g., scope, objectives, policies, constraints, proposed system, modes of operation, user classes, other personnel, support environment)		F.1.4, F.1.4.1, F.1.4.2	
26	T24	Initiate update or reengineering process of current system		F.1.3.1(3), F.1.5	
27	T25	Develop an overall target architecture	5.3.3.1	F.1.3.3	
28	T26	Perform gap analysis between target and base line			
29	T27	Develop high level transition strategy from existing situation to planned system			
30	T28	Perform domain analysis	5.1.1.1	F.3.7	
31	T29	Conduct alternatives analysis (e.g., simulations, models, conceptual prototypes)	5.1.1.2		
32	T30	Perform a feasibility analysis (e.g., technical, business, time to market)	5.1.1.2	F.3.1.3.2(2)	
33	T31	Contribute to product plan development (e.g., schedule, market segment, market growth, launch, competitive analysis, funding success criteria, organizations, pricing)	5.1.1.2		
34	T32	Determine possible courses of action (e.g., build in-house, subcontract, buy off the shelf, go/no go, reuse, modify)	5.1.1.6		
35	T33	Create a project proposal (e.g., technical, management, costs, initial success criteria)	5.1.1.8	F.3.1.3(2,3,4)	
36	T34	Conduct an initial project risk assessment	5.3.2.1	F.3.1.5	
37	T35	Select the software life cycle model (e.g., waterfall, spiral, interative, incremental, evolutionary)	1.5, 3.11, 5.2.4.2, 5.3.1.1, B.4, E.11	F.3.1.3(5)	
38	T36	Plan the organizational interfaces between the project and other stakeholders (e.g., customer, hardware, users, contracts)	5.1.1.8	F.3.1.3(4)	
39	T37	Plan for standards compliance (e.g., identify, select, mandate)	5.1.1.2	H.2.1.2	
41	T38	Plan for configuration management (e.g., identification, control, status accounting, evaluation, release management, organization relationships)	6.2.1.1	F.2.2	
42	T39	Plan for quality assurance (e.g., quality standards, methodologies, procedure and tools; contract review and coordination, quality records, responsibilities)	6.3.1.1	F.2.3, F.3.1.4	
43	T40	Plan for process and product attributes and measures (e.g., measurement objectives, metric definition and election, process and product targets, data collection method, data evaluation techniques)	E.15	F.3.1.6	
44	T41	Plan for verification and validation (e.g., organization, master schedule, integrity level scheme, resources, responsibilities, tools, techniques and methods (traceability, testing, demonstration, static analysis) for each life cycle process)	6.4.1, 6.5.1	F.2.4, F.2.5	
45	T42	Plan for documentation (e.g., definition, design and development, production, storage, distribution, and control)	6.1.1.1	F.2.1	
46	T43	Plan for joint reviews and audits (e.g., timing, purpose, preparation, responsibilities)	6.6.1	F.2.6	
47	T44	Plan for problem resolution (e.g., identification, classification, tracking, resolution, disposition, trend analysis)	6.8.1	F.2.8	
48	T45	Set project objectives and goals based on an understanding of desired project outcomes (e.g., schedule, quality, performance, cost)		G.10 (e,f)	
49	T46	Document and maintain project plans (e.g., schedule, budget, work activities, allocations, policy decisions, contingency plans, start up, closeout)	7.1.2, 7.1.3	F.3.1.3(3,5)	
50	T47	Prepare budgets, including allocating estimated costs to project functions, activities, and tasks	7.1.2		
51	T48	Plan for product support (e.g., help desk, problem resolution, customization, user training)	5.4.1, 5.4.3, 5,4,4, 6.8.1	F.1.4.2	
52	T49	Develop the retirement plan (e.g., criteria, notifications, archiving, residual support, transition to new product, disposal, accessibility to archived data)	5.5.6	F.1.5(6)	
53	T50	Develop disaster recovery plan (e.g., backups, replications, mirror sites)	5.4		
		Domain 3: Doing / Developing			
55	T51	Analyze and develop system requirements	5.3.2	F.1.3.1, F.1.3.2	
56	T52	Develop system architecture (e.g., components, relationships, design principles)	5.3.3	F.1.3.3	
57	T53	Develop user interface prototypes as appropriate (e.g., storyboards, executable interfaces, scenarios, workflow navigation)	5.2.4.5 (j)	F.2.9	
58	T54	Develop prototypes, as appropriate, to evaluate design or implementation alternatives (e.g., technical, marketing, manufacturing)	5.2.4.5 (j)		
59	T55	Conduct technical analyses of the system architecture including tradeoffs (e.g., reliability, security, maintainability, portability)	5.1.1.2, 5.3.3.1, 5.3.3.2		
60	T56	Conduct safety analysis (e.g., system hazard analysis -- failure conditions, effects, classification, safety model, software hazard identification, hardware hazard identification, hazard mitigation)	5.1.1.2, 5,2,4,5 (e), 5.3.1.4, 5.3.2.1, 5.3.4.1, 6,4,2,3		
61	T57	Develop software requirements specification	5.3.4	F.1.3.4	
62	T58	Develop software architecture	5.3.5	F.1.3.5(1,2)	
63	T59	Develop the software detailed design	5.3.6	F.1.3.5(3)	
64	T60	Develop code and conduct unit testing	5.3.7	F.1.3.6	
65	T61	Integrate the software	5.3.8.2	F.1.3.7	
66	T62	Select rebuilt components (e.g., reuse library, third-party components, commercial off-the-shelf software)	5.1.1.6		
67	T63	Conduct performance analysis and take appropriate action (e.g., optimize performance)		F.1.5	
68	T64	Integrate hardware and software	5.3.10.1	F.1.3.9	
69	T65	Prepare installation resources, procedures, information	5.3.12.1	F.1.3.11	
70	T66	Develop documentation (e.g., users guide, maintenance guide, help files principles of operation)	6.1	F.2.1	
71	T67	Collect, validate, analyze, report product process and product attributes and measures (e.g., cost, resources, quality, schedule) and implement corrective action as appropriate	7.1.3	F.3.1.4	
72	T68	Generate test cases and test procedures (e.g., component, integration, system, acceptance and regression)	5.3.7, 5.3.9	F.1.3.10	
73	T69	Close out the project (archive materials, reassign staff, implement lessons learned)	7.1.5		
		Domain 4: Checking			
76	T70	Conduct demonstration activities on software products	5.3.9, 5.3.11	F.1.3.10	
77	T71	Conduct analysis of software specification and source code (e.g., flow, dependence, reachability)			
78	T72	Conduct technical reviews (e.g., peer, status, milestone, users, acceptance, inspections) of work products (e.g., requirements, design, code, test plans)	6.6, 6.7	F.2.6, F.2.7	
79	T73	Evaluate quality attributes (adaptability, dependability, maintainability, portability, stability, usability, availability, reliability, performance, safety, security)	6.3	F.2.3	
80	T74	Evaluate product attributes	5.3.11	F.1.3.10	
81	T75	Conduct management reviews (e.g., status, milestone, customers, acceptance) of the project (e.g., schedules, budgets, contractual commitments)	6.6, 6.7	F.2.6, F.2.7	
82	T76	Verify contract compliance and/or completion criteria	5.1.5, 5.2.7	F.1.1.4	
83	T77	Ensure that the software product performs according to specifications	6.4.2	F.2.4	
84	T78	Ensure that the software product meets common user expectations (e.g., performance, user interface, ease of use, documentation)	6.5.2	F.2.5	
85	T79	Conduct traceability analysis (e.g., User Operational Scenario concepts, requirements, architectures, design, code, test plans, test results)	5.3.3.2, 5.3.4.2, 5.3.5.6, 5.3.6.7, 5.3.7.5	F.1.3.4(4), F.1.3.5(4), F.1.3.6(3), F.1.3.7(6), F.1.3.9(5)	
		Domain 5: Operating, Maintaining, and Retiring			
87	T80	Define, document, and implement maintenance (e.g., corrective, adaptive and perfective) activities	5.5	F.1.5	
88	T81	Determine corrections and enhancements to the software products (e.g., patches, new versions)	5.5.2	F.1.5	
89	T82	Analyze operations logs and incident reports	5.5.2, 6.8	F.1.5, F.2.8	
90	T83	Predict and control software maintainability based on its current state			
91	T84	Provide technical support for software (e.g., help desk, problem resolution, customization, user training)	5.4.4, 7.4	F.1.4	
92	T85	Maintain a library of software releases and change history	6.2.3, 6.2.4, 6.2.6	F.2.2	
93	T86	Review and implement the retirement plan (e.g., validate criteria for reengineering or retiring)	5.5.6	F.1.5(6)	

New Work Item Proposal

February 2005

PROPOSAL FOR A NEW WORK ITEM

Date of presentation of proposal: 2005-02-22	Proposer: ISO/IEC JTC1/SC7
Secretariat: Standards Council of Canada	**ISO/IEC JTC 1 N** XXXX ISO/IEC JTC 1/SC XX N XXX

A proposal for a new work item shall be submitted to the secretariat of the ISO/IEC joint technical committee concerned with a copy to the ISO Central Secretariat.

Presentation of the proposal

Title Software Engineering -- Certification of Software Engineers
Scope This proposal calls for the establishment of a project to develop an international standard for the professional certification of software engineers that is consistent with the approach to certification taken by ISO/IEC 17024, with the software engineering knowledge and processes contained in ISO/IEC 12207 and ISO/IEC TR 19759 and with the systems engineering context for software engineering (and for the software engineering process) provided by ISO/IEC 15288. Note that the European standardization body CEN has replaced EN 45013, the previous European standard for certification bodies, with EN-IS/IEC 17024: 2003, which adopts ISO/IEC 17024 as a whole. The initial focus for the project will be examination-based certification. The resulting standard should provide a reference model that can be used to provide for portability and mutual recognition of professional software engineering certification.
Purpose and justification – Over the past several decades, software has come to play an increasingly critical role in all aspects of society in all countries. As a consequence, nations have realized that it is important to set up processes and procedures to give official recognition to the professional competence of those involved with the software development process. There are significant commonalities shared by the various national perspectives on software engineering professional certification. For example, approaches to certification tend to be based either on examinations or on peer evaluation, and certification examinations generally reference either a body of knowledge or a specific skill set. These commonalities suggest that it would be useful and feasible to think about developing a software engineering certification standard. An international standard for the professional software engineering certification process would make mutual recognition of professional credentials much easier, enabling professionals to move easily within an increasingly global software industry. So far, such recognition can only be achieved by bilateral negotiations. Despite some regional successes, bilateral approaches will not be able to scale to the entire world. The project's primary goal will be to develop a standard for examination-based certification. Such a standard could provide a reference model for the technical bases (skill set, body of knowledge) of a given national certification scheme. ISO/IEC 12207 and ISO/IEC TR 19759 are internationally accepted documents corresponding to these technical certification bases, and the systems engineering context for software engineering, and for the software engineering process, is provided by the ISO/IEC 15288 series. It is therefore reasonable to develop an approach to standardization of software engineering professional certification that makes use of these documents. A reference model could be used by certification bodies in different nations to provide for portability and mutual recognition of software engineering certifications. The model must therefore take account of current European efforts to develop tools that support transfer and transparency of qualifications and competences. The project will also investigate whether peer-evaluation approaches to certification can be effectively included in a standard.

Programme of work

If the proposed new work item is approved, which of the following document(s) is (are) expected to be developed?
_X __a single International Standard

___ more than one International Standard (expected number: ....)
____ a multi-part International Standard consisting of .... parts
____ an amendment or amendments to the following International Standard(s) ....
____ a technical report , type ....

And which standard development track is recommended for the approved new work item?

_X__a. Default Timeframe

____b. Accelerated Timeframe

____c. Extended Timeframe

Relevant documents to be considered:

ISO/IEC 12207:1995 Information technology -- Software life cycle processes, ISO/IEC 12207:1995/Amd 1:2002, ISO/IEC 12207:1995/Amd 2:2004

ISO/IEC DTR 19759 Software Engineering -- Guide to the Software Engineering Body of Knowledge – SWEBOK

ISO 9712:1999 Non-destructive testing -- Qualification and certification of personnel

ISO 9712/DIS Non-destructive testing -- Qualification and certification of personnel

ISO/IEC 17024:2003 Conformity assessment -- General requirements for bodies operating certification of persons (supersedes EN45013)

ISO/IEC 15288:2002 Systems engineering -- System life cycle processes

ISO/IEC 15504-1:2004 Information technology -- Process assessment -- Part 1: Concepts and vocabulary

Co-operation and liaison

Preparatory work offered with target date(s) Final report of JTC1/SC7/WG20 study group on international certification of software engineers (WG20 N3062, Resolution 793), February 2005; included as an annex

Signature:

Will the service of a maintenance agency or registration authority be required? No
- If yes, have you identified a potential candidate? ....
- If yes, indicate name ....

Are there any known requirements for coding? No
-If yes, please specify on a separate page

Does the proposed standard concern known patented items? No

- If yes, please provide full information in an annex

Comments and recommendations of the JTC 1 or SC 7 Secretariat - attach a separate page as an annex, if necessary

Comments with respect to the proposal in general, and recommendations thereon:
It is proposed to assign this new item to JTC 1/SC 7/WG 20

Voting on the proposal - Each P-member of the ISO/IEC joint technical committee has an obligation to vote within the time limits laid down (normally three months after the date of circulation).

Date of circulation: 2005-02-22	Closing date for voting: 2005-MM-DD	Signature of Secretary:

NEW WORK ITEM PROPOSAL - PROJECT ACCEPTANCE CRITERIA		
Criterion	**Validity**	**Explanation**
A. Business Requirement		
A.1 Market Requirement	Essential ___ Desirable __X_ Supportive ___	
A.2 Regulatory Context	Essential ___ Desirable ___ Supportive _X__ Not Relevant __	
B. Related Work		
B.1 Completion/Maintenance of current standards	Yes ___ No_X__	
B.2 Commitment to other organisation	Yes ___ No_X__	
B.3 Other Source of standards	Yes ___ No_X__	
C. Technical Status		
C.1 Mature Technology	Yes _X__ No__	
C.2 Prospective Technology	Yes ___ No_X__	
C.3 Models/Tools	Yes ___ No_X__	
D. Conformity Assessment and Interoperability		
D.1 Conformity Assessment	Yes ___ No_X__	

D.2 Interoperability	Yes ___ No_X__	
E. Cultural and Linguistic Adaptability	**Yes__**X**__** **No_____**	
F. Other Justification		

Notes to Proforma

A. Business Relevance. That which identifies market place relevance in terms of what problem is being solved and or need being addressed.

A.1 Market Requirement. When submitting a NP, the proposer shall identify the nature of the Market Requirement, assessing the extent to which it is essential, desirable or merely supportive of some other project.

A.2 Technical Regulation. If a Regulatory requirement is deemed to exist - e.g. for an area of public concern e.g. Information Security, Data protection, potentially leading to regulatory/public interest action based on the use of this voluntary international standard - the proposer shall identify this here.

B. Related Work. Aspects of the relationship of this NP to other areas of standardisation work shall be identified in this section.

B.1 Competition/Maintenance. If this NP is concerned with completing or maintaining existing standards, those concerned shall be identified here.

B.2 External Commitment. Groups, bodies, or fora external to JTC 1 to which a commitment has been made by JTC for Co-operation and or collaboration on this NP shall be identified here.

B.3 External Std/Specification. If other activities creating standards or specifications in this topic area are known to exist or be planned, and which might be available to JTC 1 as PAS, they shall be identified here.

C. Technical Status. The proposer shall indicate here an assessment of the extent to which the proposed standard is supported by current technology.

C.1 Mature Technology. Indicate here the extent to which the technology is reasonably stable and ripe for standardisation.

C.2 Prospective Technology. If the NP is anticipatory in nature based on expected or forecasted need, this shall be indicated here.

C.3 Models/Tools. If the NP relates to the creation of supportive reference models or tools, this shall be indicated here.

D. Conformity Assessment and Interoperability

D.1 Indicate here if Conformity Assessment is relevant to your project. If so, indicate how it is addressed in your project plan.

D.2 Indicate here if Interoperability is relevant to your project. If so, indicate how it is addressed in your project plan

E. Cultural and Linguistic Adaptability Indicate here if cultural and linguistic adaptability is applicable to your project. If so, indicate how it is addressed in your project plan.

F. Other Justification Any other aspects of background information justifying this NP shall be indicated here