Evolution of the Frameworks Quagmire

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Various combinations of national and international standards bodies, government organizations, professional societies, and other quasilegislative bodies—each vying for influence over a particular market sector—have promulgated a dizzying array of software and system process standards, recommended practices, guidelines, maturity models, and other frameworks.

The resulting quagmire has quenched the ardor of many organizations seeking accreditation for one or more frameworks. Software and systems engineers question whether the qualification process will lead to quarrels over interpretation rather than quick and real progress.

In 1997, the Software Productivity Consortium created a Web site to help organizations understand which frameworks were most important and how they related to each other (http://www.software.org/quagmire). As Figure 1 shows, many new frameworks and updates to existing frameworks have appeared since then. Fortunately, most of these additions recognize the need for compatibility and attempt to define their relationship with other models.

MATURITY MODELS AND GUIDELINES

The Capability Maturity Model for Software (SW-CMM) was the first in a series of capability maturity models that Carnegie Mellon University's Software Engineering Institute (SEI) has created or endorsed. In 2003, the Capability Maturity Model-Integrated (CMMI) product suite will supersede SW-CMM version 1.1, which was released in 1993.

A team of government, industry, and SEI representatives created the Software Acquisition CMM (SA-CMM) to facilitate the government software acquisition process. A CMMI version incorporating parts of the SA-CMM is now available as a draft.

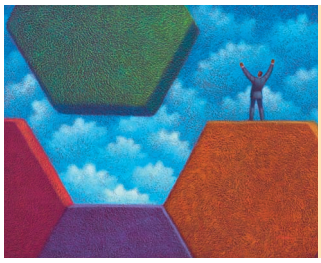
SEI also offers two software project methods. The Personal Software Process (PSP) course takes programmers through 10 exercises to improve their programming predictability and quality. Bridging the gap between the individual-oriented PSP and the organization-oriented SW-CMM, the Team Software Process (TSP) shows engineers how to manage their work as well as maintain ownership of their plans and processes.

SOFTWARE STANDARDS

In 1994, the US Defense Department created MIL-STD-498 to integrate its software development (DOD-STD-2167A), software quality (DOD-STD-2168), and documentation (DOD-STD-7935A) requirements. To demilitarize this standard per a DOD initiative, a joint IEEE and Electronics Industries Association (EIA) committee released J-STD-016, which includes limited changes such as replacing "developer shall" with "contractor does."

The International Organization for Standardization and International Electrotechnical Commission jointly released ISO/IEC 12207, a standard for information technology software life-cycle processes, in 1995. Subsequently, an IEEE-EIA joint working group created IEEE/EIA 12207 by adding an appendix to the ISO/IEC standard. Changes included required compliance with ISO 9000, explicit allowance of object-oriented analysis methods, computer-aided software engineering tools, and non-waterfall life cycles.

Software Considerations in Airborne Systems and Equipment Certification (RTCA DO-178B) addresses aviation software systems safety. Developed independently of the other quagmire frameworks, this guidance document outlines processes for planning, development, configuration management, quality assurance, and verification as applied to software with different safety-critical levels.



As process and quality frameworks continue to change, a consensus is emerging on the need for greater compatibility.

SYSTEMS ENGINEERING CAPABILITY MODELS

A collaboration of eight organizations developed the Systems Engineering Capability Maturity Model (SE-CMM) and its associated SE-CMM Appraisal Method (SAM). The SEI provided administrative oversight and published the standards, and the other seven organizations provided the systems engineering content.

The International Council on Systems Engineering (INCOSE) developed the Systems Engineering Capability Assessment Model. SECAM, which included

both a model and an assessment method, introduced measures of process effectiveness and product quality.

The Systems Engineering Capability Model (EIA/IS 731) merged SE-CMM and SECAM. This interim standard, released in January 1999, includes both a model (EIA/IS 731-1) and an appraisal method (EIA/IS 731-2). EIA/IS 731 also includes process effectiveness and product quality concepts from SECAM as generic attributes. While CMMI does not include the generic attributes, version 2 of the FAA-iCMM does include them. The CMMI is due to supersede EIA/IS 731 in 2003.

SYSTEMS ENGINEERING STANDARDS

In 1992 and 1993, the DOD submitted several versions of a new systems engineering standard for industry review. Industry did not accept the most comprehensive of these standards, MIL-STD-499B, submitted in May 1992. Before industry could approve a revised version, a 1993 DOD initiative canceled additional military standards in favor of commercial alternatives.

Because no commercial alternatives existed, the EIA sponsored a small group of people to make minor wording changes in the MIL-STD-499B draft to create EIA/IS 632, which was approved as an interim standard in December 1994. At the same time, the IEEE used significant industry input to create IEEE 1220, beginning with MIL-STD-499B and an AT&T systems engineering manual. Consequently, IEEE 1220, released as a trial-use standard in 1994 and re-released as a full standard in 1998, has a more commercial life cycle and less military terminology.

The EIA launched a full effort involving INCOSE to create a new systems engineering standard. Having achieved industry consensus, the full standard version EIA 632, which bears little resemblance to EIA/IS 632, was released in January 1999.

The ISO subcommittee that created ISO/IEC 12207 for software life cycles assigned a working group and invited additional systems engineering experts to join in developing a systems life-cycle standard, ISO/IEC 15288, which is still in the draft-and-review stage.

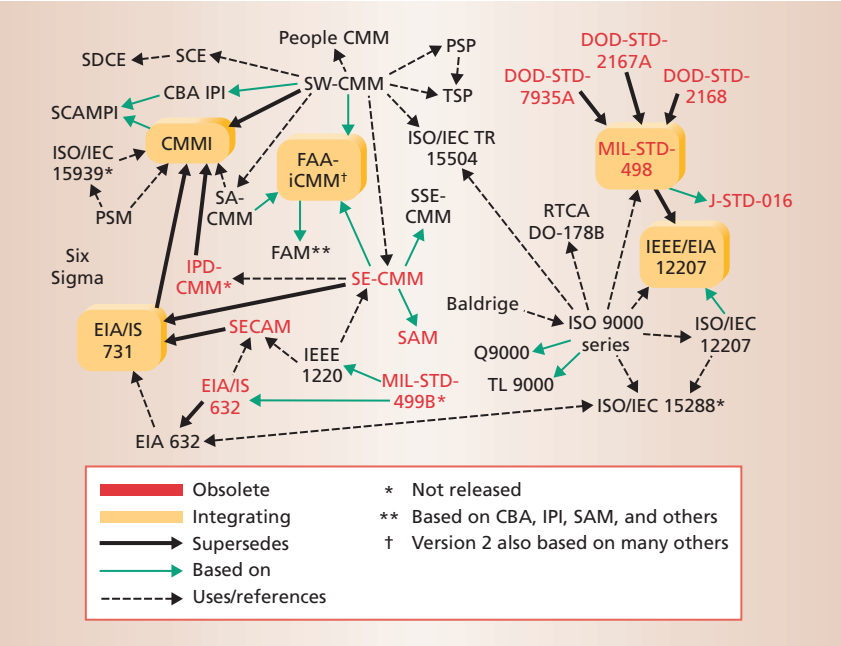


Figure 1. The frameworks quagmire in 2001. Note that most frameworks relate to others, either referencing or otherwise using them or outright superseding them. Thus, frameworks shown in red are now obsolete, and others have evolved related content.

INTEGRATED MATURITY MODELS

Released in December 2000, the CMMI has three versions: one just for software and systems engineering (SE/SW), one that includes integrated product and process development (SE/SW/IPPD), and a draft that includes some acquisition aspects (SE/SW/IPPD/A). Each version also offers both staged and continuous representations.

Before the CMMI was available, the Federal Aviation Administration created its own integrated CMM, FAA-iCMM. Released in November 1997, this model combined the 52 process areas from the SW-CMM, the systems engineering CMM, and the SA-CMM into 23 process areas. Version 2, which also incorporates practices from ISO 9000, ISO/IEC 12207, ISO/IEC 15288, EIA 632, EIA/IS 731, ISO/IEC 15939, and the CMMI, will be released this fall.

EVALUATING MATURITY AND CAPABILITY

Capability models typically include a specific assessment or appraisal method. The most commonly used SW-CMM assessment method is the CMM-Based Appraisal for Internal Process Improvement (CBA IPI), in which an SEI-authorized lead assessor helps an organization conduct a rigorous self-appraisal.

In another method for verifying SW-CMM compliance, outsiders evaluate the company's maturity. A Software Capability Evaluation rates an organization's CMM level as well as its strengths and weaknesses. Version 3 was released in 1996.

The US Air Force developed the Software Development Capability Evaluation (SDCE) from its own Software Development Capability/Capacity Review and the SCE. Focusing on a bidder's strengths and weaknesses relative to a specific contract, the SDCE adds systems engineering and technology questions to the software development questions.

Used for CMMI-based internal assessments, the Standard CMMI Assessment Method for Process Improvement (SCAMPI) is based primarily on the CBA IPI. One goal of the projected 2001 revision, which should include changes reflecting lessons learned from other assessment methods, is to minimize the expense of performing a SCAMPI assessment.

The FAA-iCMM Appraisal Method (FAM) contains six variants of appraisal methods. In addition to a CBA IPI-like internal assessment, FAM includes an SCE-like external evaluation and four quick-look appraisal methods. FAM assessors are SEI-authorized CBA IPI assessors with additional FAM training.

The three systems engineering models use similar methods to perform appraisals, which take five to eight working days on site. Because no official body authorizes assessors, the assessed organization should carefully review a proposed assessor's experience. Some organizations believe that appraisals by outsiders are more credible than ratings conferred by assessors who are employees.

ISO/IEC TR 15504, initially called Software Process Improvement Capability dEtermination (SPICE), has evolved to encompass process assessments in general. Officially a technical report, it describes a method for assessing organizational maturity and capability. Currently undergoing piloting, ISO/IEC TR 15504 includes a reference model that models such as the CMM can replace as long as they comply with certain criteria. Assessment length depends on how many and which process categories an organization selects for assessment.

QUALITY STANDARDS

The Malcolm Baldrige National Quality Award is both a quality standard and a way of comparing various organizations' quality practices. Organizations submit applications describing their practices in seven categories: leadership, strategic planning, customer and market focus, information and analysis, human resources focus, process management, and business results. The criteria evolve each year, but the categories are fairly stable.

In 1994, the ISO released a set of standards and guidelines known as the ISO 9000 series. ISO 9001 applied to organizations developing products as well as building and testing them. Because ISO 9001 was based on manufacturing quality, ISO 9000-3 interpreted its application to software-based products. In addition, the British Standards Institute initiated its own standard for applying ISO 9000 to software and trained software-knowledgeable auditors. Companies that use this method can claim ISO 9001/TickIT registration, the highest level of ISO registration.

An update to the series released last year, ISO 9000:2000, has an expanded scope and incorporates more enterprise focus. ISO 9000-3 is currently under revision, but neither it nor TickIT has been re-released to correlate to ISO 9000:2000.

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The American Society for Quality distributes Q9000 as its version of ISO 9000, and TL 9000 is the telecommunications industry's adaptation of this standard. Other industry-specific adaptations also exist.

MEASUREMENT STANDARDS

The DOD and US Army co-sponsored *Practical Systems and Software Measurement* is a large handbook containing guidelines companies can use to establish issue-driven measurement programs. Version 4, released in 2001, added systems engineering and process improvement measurement to the contents of the former Practical Software Measurement standard.

Information Technology—Software Measurement Process, a new international standard, has not yet been released. Completely consistent with both the PSM and CMMI, ISO/IEC 15939 defines a process that focuses on how software measurements are used.

In the 1980s, Motorola initiated Six Sigma, a program initially intended to increase hardware system quality which the industry is now applying to software systems. Because no standards body defines Six Sigma's meaning or details, implementations vary. The standard works best with companies that have good measurement programs in place.

OTHER STANDARDS AND MODELS

The Systems Security Engineering CMM (SSE-CMM), which includes an assessment method adapted from SAM, adds security-related process areas and generic practices to the SE-CMM.

The collaboration that developed SE-CMM also developed, but did not release, the Integrated Product Development CMM. IPD-CMM's version 0.97 was incorporated into the CMMI.

In 1995, SEI released the People CMM to address human resource management within an organization. An anticipated update will probably contain few changes in content for maturity Levels 1–3.

While there is certainly a need for well-crafted collections of best practices, those who write standards, process models, and contractor selection vehicles must consider existing models and tailor their additions accordingly.

To stay profitable, companies must be cost competitive and offer rapid time to market. Defining and implementing process changes can be both expensive and time consuming. The key to efficiency is using models to provide guidance for describing good business practices, aiming for verified compliance with a minimum set of high-leverage frameworks. Most of the Software Productivity Consortium's member companies are considering using the CMMI and ISO 9000 to achieve this efficiency.

Companies should define their own processes beginning with what is broken and critical to their business. While any framework will help define processes, compliance with frameworks other than the CMMI and ISO 9000 is likely to involve mapping and minor additions, provided the first set of processes truly meets business needs. ✷

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