Fortunately for systems engineering (SE), the recent changes in process standards and capability models are for the better. In addition to documenting and expanding our body of knowledge, the SE community is combining the efforts of several agencies into consolidated documents (Figure 1). These emerging “best practices” will show forward-looking organizations how to stay competitive in our ever-changing field. Of special interest is the expanding role software engineering plays in systems engineering.

**SE Process Standards**

Current and emerging standards on how to engineer a system, although similar, have varied scopes (Figure 2). Their intended audience, e.g., manager, practitioner, determines the level of detail and breadth of coverage. You may choose the standard that best meets your needs or, with the emerging standards, choose only the processes that apply to you.

**Current Standards**

- EIA Interim Standard 632, Processes for Engineering a System
- Institute of Electrical and Electronics Engineers (IEEE) 1220-1994, Application and Management of the Systems Engineering Process

Current standards and models have improved the quality, cost, and repeatability of systems engineering products and processes. However, soon-to-be-published documents are the next step in developing, maintaining, and reengineering large, complex, software-intensive systems. These efforts consolidate existing documents and minimize the impact of transitioning your process improvement activities. This article explains the changes and how they affect you.
the use of a detailed management plan and event-based and time-based schedules.

**Emerging Standards**

The upcoming IEEE 1220 will change little from the "trial use" 1220-1994. Electronics Industry Association (EIA) 632, Processes for Engineering a System, expands on previous work and will be the basis for implementation of International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 15288, System Life Cycle Processes, in the United States. EIA 632 has 13 technical and project processes (Figure 3) that cover:
- Acquisition and supply.
- System design.
- Product realization.
- Technical management.
- Technical support.

The working draft of ISO/IEC 15288 currently has 22 generic processes that address enterprise-wide issues and technical and project concerns (Figure 4). With EIA 632, you apply the appropriate processes (each consisting of one to five requirements along with recommended tasks and expected outcomes) for the top-down design of system products as well as the bottom-up realization of such products (Figure 5). With ISO/IEC 15288, you choose the processes you need (each consisting of two to five activities with recommended tasks) to meet specified lifecycle requirements of a software-intensive system. This process goes down to, but does not include, the software.

**Process Standards for Software**


**SE Capability Models**

Current and emerging capability models for systems engineering aim to repeat the benefits of the Software Engineering Institute's (SEI) Capability Maturity Model for Software (SW-CMM):
- Better competitive position.
- Returns on investment of between 4.5 and 7.7-to-1 (as have been experienced by Hughes, Tinker Air Logistics Center, and Raytheon).
- Predictable and reduced cost and schedule.
- Reduced risks and fewer trouble reports.
- Improved customer satisfaction and employee morale.
- Less overtime, absenteeism, and turnover.

In addition, integrated SE and software models should save time and money and reduce redundancy in assessments for both software and SE process improvement. Fortunately, the models map well to each other (Figure 6). Even at lower levels of detail, the models specify similar functions. Improvement efforts based on older models will not be wasted, and the transition to a newer model should not be traumatic. For example, if winning a contract de-
pends on an evaluation using a newer model, most of what you have already done should “find a home” under a new name.

Current Models
The Systems Engineering Capability Maturity Model (SE-CMM), was published by the Enterprise Process Improvement Collaboration in 1994. About the same time, the International Council on Systems Engineering (INCOSE) developed the Systems Engineering Capability Assessment Model (SECAM). Although SECAM has less visibility than SE-CMM, both are being used in the SE community. Anecdotal evidence from those who have used the SE-CMM suggests a return on investment similar to software CMM use. Lockheed Martin has reported “a positive difference” from “more mature systems engineering processes.”

Last year, the Federal Aviation Administration (FAA) published its Integrated Capability Maturity Model (FAA-iCM M), which combines the software, the systems engineering, and the software acquisition CMMs into one integrated model. FAA uses this in-house and freely distributes it. Plans are under way for three divisions at Warner-Robins Air Logistics Center (software, SE, and acquisition) to use FAA-iCM M and Integrated Process and Product Development (IPPD) as guides for “enterprise-wide process improvement.”

Emerging Models
EIA Interim Standard 731, Systems Engineering Capability Maturity Model (SECM), provides complete coverage of EIA 632 and is consistent with IEEE 1220. SECM (a merging of SE-CMM and SECAM) has 19 focus areas that address technical, management, and environment issues (Figure 7). The future of this interim standard depends on the National Defense Industrial Association’s Capability Maturity Model Integration (CMMI) effort. If CMMI successfully incorporates SECM concepts, EIA Interim Standard 731 would be duplicative and would probably be rescinded. Otherwise, the SECM will progress to a full (vs. interim) standard.

CMMI will provide a common framework for multiple capability models. In its first version, CMMI will integrate SECM, the software CMM, and Integrated Product Development CMM (IPD-CMM) concepts and build on the FAA-iCM M effort. The result will be a core of common processes and additional domain-specific processes for software and for SE (Figure 8). Reportedly, there is much commonality between the three models and few domain-specific processes. CMMI’s first version will give...
three models from which to choose.
• Conduct a software assessment using core processes and software processes.
• Conduct an SE assessment using core processes and SE processes.
• Conduct an integrated assessment using core processes and combined software and SE processes.

The next version of the CMMI is likely to incorporate the software acquisition CMM (SA-CMM). Subsequent versions may address additional models (Secure Systems Engineering CMM, People CMM, Team CMM, etc.)

Capability Models for Software
The CMM for Software (versions 1.0 and 1.1) has seen wide use and acceptance since 1993. SEI has halted the nearly complete update (version 2.0, draft C) in anticipation of CMMI (described above).

Development of Some Models Placed On Hold
Some organizations are so interested in an integrated capability model they are developing their own in-house versions, as the FAA did. However, since CMMI seems imminent, Litton PRC and Rockwell/Collins (and probably others) have halted such efforts. Likewise, SEI will not release version 2.0 of the SW-CMM. It also is uncertain whether the FAA will update its iCMM as planned. Finally, as reported above, EIA Interim Standard 731 (SECM) is not currently being considered for publication as a full standard.

Impetus for Change
You have seen how the SE climate is changing; current standards and models are giving way to better ones. You know the benefits of improving your business; staying competitive is imperative. Structured process improvements are the key to successful adoption of these new technologies.
• “If you don’t know where you are, a map won’t help.” – Watts Humphrey
• “If you don’t know where you are going, any road will do.” – Chinese proverb
• “Even if you’re on the right track, you’ll get run over if you just sit there.” – Arthur Godfrey

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About the Author
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Successfully Adopting New Technologies

Adopting a new technology (whether it is a process, methodology, or tool) means change! This is more than a technical issue; you must overcome social, behavioral, managerial, and organizational barriers. To quote Capers Jones, “As a general rule, technology [adoptions] are not very rapid processes, and the bigger the organization, the longer it takes.”

When adopting new technologies, the STSC recommends implementing them with the aid of the SEI’s IDEAL Model (Figure 9).

- Initiating “sets the stage” for process improvement by stimulating change and laying the necessary groundwork.
- Diagnosing is the gap analysis to see where you are, decide where you want to be, and determine what you will do next.
- Establishing puts the people and plans in place.
- Acting is the execution of your plans with appropriate measures and project tracking.
- Leveraging lets you learn from what you did and do better the next time.

### Document Sources

Copies of the documents discussed in this article can be obtained from the following sources.

#### Capability Maturity Models

**SEI**

Customer Relations

4500 Fifth Avenue

Pittsburgh, PA 15213

Voice: 412-268-5800

E-mail: customer-relations@sei.cmu.edu

Internet: http://www.sei.cmu/pub/documents/

- …/96.reports/pdf/tr24.96.pdf (SW-CMM)
- …/96.reports/pdf/hb004.96.pdf (SE-CMM)
- …/94.reports/pdf/tr24.94.pdf (SW-CMM)

**FAA-iCMM**

Federal Aviation Administration

AFT-5, 800 Independence Avenue SW

Washington, DC 20591

Voice: 202-267-7443

E-mail: linda.ibrahim@faa.dot.gov

Internet: http://www.faa.gov/ait/ait5/FAA-iCMM.htm

**IEEE 1220, IEEE/EIA 12207**

IEEE Service Center

P.O. Box 1331

Piscataway, NJ 08855-1331

Voice: 800-678-4333

E-mail: customer.service@ieee.org

Internet: http://www.ieee.org

**DoD agencies may obtain copies at**

Standardization Order Desk

700 Robbins Avenue, Building 4/D

Philadelphia, PA 19111-5094

**SEACM**

INCOSE, 2033 Sixth Avenue #804

Seattle, WA 98121

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Voice: 800-366-1164, 206-441-1164

E-mail: incose@halcyon.com

Internet: http://www.incose.org/pricelist.html


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15 Inverness Way East

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**Recommended Reading**


