Improvement Stages

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Let us face it: A Capability Maturity Model (CMM) with a single number assessment rating system, such as the CMM for software, is easier to communicate and understand than a multinumber model, such as the Systems Engineering (SE) CMM. Improvement Stages are a way to organize the information in the SE-CMM to simplify the model. As an added benefit, Improvement Stages can be used to bridge the gap between the systems engineering and software CMMs.

The SE-CMM is a tool designed to help organizations measure and improve their systems engineering processes. It is sometimes called a "continuous model," which means the architecture is designed to provide the user with much flexibility and to loosely describe how companies should structure their improvement plans. This contrasts with the CMM for software, termed a "staged model," which uses a more structured and prescriptive architecture that describes a clear sequence for improvement through its maturity levels.

The result of an assessment against a continuous model is a rating profile that gives you a different number for each assessed area, whereas the result of staged model assessment is a single number. Some companies appreciate the flexibility of continuous models, but many find them overly complex, leaving potential users confused and unable to develop an effective plan of attack for deploying the model within their own companies.

There are a number of staged and continuous models being used by industry. While the concepts in this article apply to other models, this article focuses strictly on the Systems Engineering and Software Capability Maturity Models.

Systems Engineering CMM Description

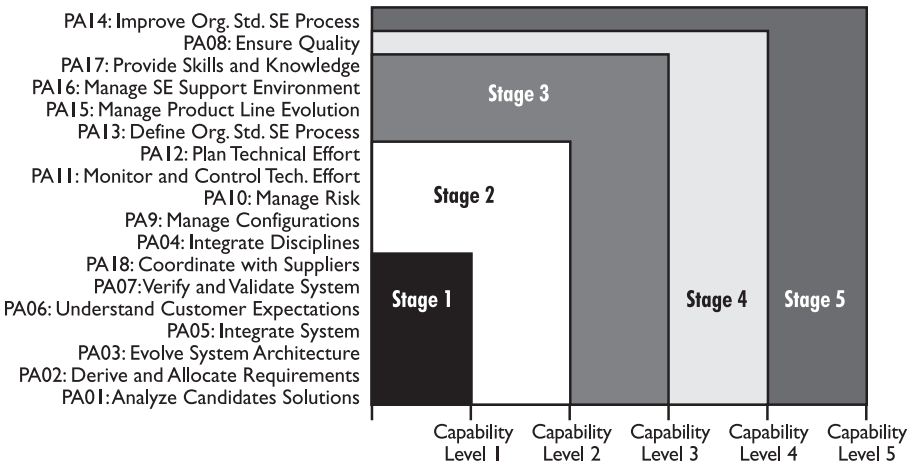
The SE-CMM describes the essential systems engineering and management tasks that any organization needs to perform. These essential tasks are organized into logical groupings called *Process Areas* (all are listed in Figure 1.) The manner in which these essential systems engineering tasks are performed can range from completely ad hoc to continuously improved using statistical data. For each process area, this progression is broken into five primary steps, called *Capability Levels* in the SE-CMM, each of which lays the foundation for the next step.

The SE-CMM architecture allows users to decide which systems engineering tasks (process areas) are essential or most important to their line of work, then lets them decide how well they want to manage those essential tasks (at what Capability Level they want to perform each process area). Because there are 18 process areas in the model, the user has much autonomy but also has many decisions to make.

Many organizations prefer to set performance goals against Capability Maturity Models. Management may be familiar with the software CMM and make statements such as they "want to be Level 2 by the end of the year." Although that statement has a clear meaning in the software CMM, its meaning in the SE-CMM is less than obvious. It is often interpreted at being capability Level 2 in all process areas, but does that make sense?

Most users do not realize that some SE-CMM process areas are far more difficult to accomplish than others. Some have a broader scope, require participation from all levels in the company, or are based on a detailed understanding of an organization's ability to develop a product. An analogy is comparing the SE-CMM process areas to educational classes. Some process areas are at the high school level, whereas others would be completed as part of a doctoral program. And although it may be fair to expect a high school student to get an "A" in a high school-level class, you cannot conclude that the same student is a failure for getting a "D" in a graduate-level class. Quite to the contrary, you would be proud that the student was passing the class. Like-

Figure 1. *Improvement Stages.*



wise, it is unrealistic to expect that a company just starting on the road to continuously improved product development processes is going to achieve a capability Level 2 in all process areas.

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Close examination shows a link between the content of the SE-CMM process areas and the concepts embedded in the capability levels. Because capability levels are designed to represent a gradual progression of improved management and processes, mapping the process areas to the concepts inherent in the capability levels provides

Getting Beyond the Differences

Using the Systems Engineering and Software Capability Maturity Models Together

If you are familiar with the Systems Engineering (SE) and the Software Capability Maturity Models (CMM), you know they have different architectures but much overlap and that the concepts behind the increasing level of process management and control (called capability level in the SE-CMM and maturity level in the software CMM) are nearly identical.

You may ask: "Why bother using two different models when they have about a 70 percent overlap?" In fact, some organizations do want to merge the software and SE-CMMs to better improve their presently separate efforts. The Federal Aviation Administration even created its own integrated Capability Maturity Model. On the other hand, some prefer to keep the models separate, but still need greater coordination between their separate improvement efforts.

No matter what approach you choose, it is important to overcome the differences in architecture. One solution is discussed in this article: "Improvement Stages," which allow you to more clearly see the commonality between the two CMMs. There is some discontinuity because there is no software CMM equivalent of capability Level 1 or Improvement Stage 1. But looking at Improvement Stage 2 though 5, you can see the similarities shown in the table.

Use Improvement Stages to coordinate SE and software improvement efforts. If your goal is maturity Level 3 in the software CMM, you should also try to achieve Improvement Stage 3 in the SE-CMM. If the software and SE improvement groups are both trying to get the organization to maturity Level 3 and Improvement Stage 3 respectively, they will have the added benefit of trying to achieve similar objectives and facing identical problems.

Should you be interested in creating a systems-software model for your own purposes, use the Improvement Stages to make the translation. If you choose to incorporate the SE content into the SW-CMM, pull the SE-specific process areas and capability level practices from the SE-CMM and slide them over to the SW-CMM, keeping them at the same level. If the SE-unique process area was at Improvement Stage 3, it should be at maturity Level 3 in the SW-CMM.

SW-CMM Level	SW-CMM Key Process Area Name	Equivalent SE-CMM Process Area Name	SE-CMM Improvement Stage
2	Requirements Management	(no equivalent)	
2	SW Project Planning	Plan Technical Effort	2
2	SW Project Tracking and Oversight	Monitor and Control Technical Effort	2
2	SW Quality Assurance	Ensure Quality (portion of PA only)	2
2	SW Configuration Management	Manage Configurations	2
2	SW Subcontract Management	Coordinate with Suppliers (started in Improvement Stage 1, but now performed at equivalent level)	2
3	Organizational Process Focus	(similar PA in SE-CMM, but not a clear equivalent)	
3	Organizational Process Definition	Define Organization's SE Process (portion of process area)	3
3	Training Program	Provide Ongoing Skills and Knowledge	3
3	Integrated SW Management	Define Organization's SE Process (portion of process area)	3
3	SW Product Engineering	(no equivalent)	
3	Intergroup Coordination	Integrate Disciplines (started in Improvement Stage 2, but now performed at equivalent level)	3
3	Peer Reviews	Defect review practice at Capability Level 3	3
4	SW Quality Management	Ensure Quality (portion of PA)	4
4	Quantitative Process Management	Ensure Quality (portion of PA)	4
5	Process Change Management	Improve Organization's SE Process	5
5	Technology Change Management	(no equivalent)	
5	Defect Prevention	Causal analysis practice at Capability Level 5	5

an excellent method of organizing the process areas by level of complexity. The following describes how the 18 areas were mapped to a five-stage "Improvement Stages" model.

- Capability Level 1 – ad hoc performance. The primary focus is on getting the system out; few, if any processes are in place. Therefore, the process areas that address performing the systems engineering activities are mapped to this level.
- Capability Level 2 – characterized by planning and tracking within projects. This level includes process areas that deal with project management.
- Capability Level 3 – the key concept is development and use of organizational standards and achieving an aligned organization. Includes all of the process areas that discuss organizational-wide activities or the development of standards.
- Capability Level 4 – characterized by statistical process control; process areas that discuss measuring process quality quantitatively are mapped to this level.
- Capability Level 5 – primarily characterized by continuous improvement using statistical process control data; therefore, the process area that addresses improving the standard process maps to Level 5.

Figure 2 shows the result of mapping the SE-CMM process areas to the capability level concepts. To avoid confusion with other terminology, we call the result of this mapping *Improvement Stages.* Listed on the vertical axis are the 18 process areas in the SE-CMM. Across the horizontal axis are the capability levels. Each Improvement Stage is cumulative, adding on more process areas and capability levels. For example, Stage 2 requires performing all 12 process areas (from Analyze Candidate Solutions to Plan Technical Effort) at a capability Level 2. Stage 3 adds on another four process areas, making a total of 16 process areas that must be performed at a capability Level 3.

Unfortunately, since the authors of the SE-CMM did not have the staging concept in mind when writing the model, the concepts in some process areas span multiple maturity levels. The two problematic process areas are "Ensure Quality" and "Improve Organization's Standard Systems Engineering Process," which both have content that maps to lower capability levels. To avoid encouraging companies from trying to implement these process areas in a manner that does not make sense, they were placed at the higher capability level.

Improvement Stages arrange the processes areas by order of difficulty. I do not mean to imply that a company should put on blinders, not considering any of the process areas in Improvement Stage 3 until they have completely mastered the process areas in Stage 2. One company using this system has referred to Improvement Stages as a primary area of emphasis.

Think of Improvement Stages as a ski slope map. The SE-CMM process areas are similar to a map showing only the location of trails on a mountain. Viewing this map, the skier knows how many slopes there are and where they are but knows nothing of the level of difficulty. The Improvement Stages concept is similar to knowing which trails are appropriate for beginners, intermediates, and advanced skiers. You can always start skiing on the advanced slopes as a beginner, but the odds are good that you will break your neck; likewise, you can tackle a hard process area first, but the odds are good that you will not be able to achieve your expectations.

Conclusions

Although the SE-CMM is an effective systems engineering process measurement and improvement tool, it presents the users with a measure of flexibility that can almost be harmful if to little time is spent to understand the content of the model and the complexity of the individual practices within each of the process areas. Many managers are setting company-wide, single-number goals without understanding that the SE-CMM has a different architecture than the software CMM.

However, even when managers do understand the SE-CMM structure, they are often unsure how to interpret the results of an assessment. Many even look at the 18-number profile and immediately calculate an average, determining that their organization is, for example, a 2.4. Improvement Stages provide a method of using a more meaningful single number score. If your company wants to be "Level 2," consider restating the goal to be "Improvement Stage 2." ◆

About the Author

Kerinia Cusick, a co-founder of SECAT LLC, is one of the authors of the Industrial Collaboration Systems Engineering Capability Maturity Model and an author of the Integrated Product Development Capability Maturity Model. She is an experienced CMM teacher, assessor, and process improvement leader. She started her career at Grumman Aerospace working on digital flight control systems for experimental and fighter aircraft. At Hughes Missile Systems and Hughes Space and Communications, she transferred to systems engineering, working projects ranging from commercial communication satellites to Space Defense Initiative conceptual design studies. She has a master's degree in systems management from the University of Southern California and a bachelor's degree in mechanical engineering from Drexel University.

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