CMMI: Evolutionary Path to Enterprise Process Improvement

By Joan Weszka
Lockheed Martin

Phil Babel
Dayton Aerospace Inc.

Jack Ferguson
Office of the Secretary of Defense

Since 1998, a government-industry-Software Engineering Institute (SEI) collaboration has been under way to develop a product suite of models, training, and assessment methodology that support integrated process and product improvement across the enterprise. These products are intended to replace legacy maturity models, including SW-CMM® and Electronic Industries Association Interim Standard (EIA/IS) 731, the Systems Engineering Capability Model (SECM). This article describes the Capability Maturity Model Integration (CMMI) project, including its drivers, sponsors, organization, scope, products, expected benefits from using the CMMI products, and guidance for transition.

The proliferation of process maturity models and recognition of the inefficiency and ineffectiveness of using multiple, stovepiped models and methods for process improvement was the impetus for the CMMI project. With an initial focus on integrating a subset of existing process maturity models for engineering and Integrated Product and Process Development (IPPD), the CMMI products are being designed using a product line approach to facilitate extension to other disciplines. The objective is to provide a single product suite for enterprise-wide process improvement, with an evolutionary growth path for adoption.

Drivers

Demonstrable benefits from using the SW-CMM v1.1 for process improvement since its release in 1993 have spawned the development of a number of capability models. These have included the Systems Engineering CMM, the Systems Engineering Capability Assessment Method (SECAM), EIA/IS-731, SECM, the Software Acquisition CMM, the People CMM, the System Security Engineering CMM, and the FAA-iCMM. These models, developed by a number of different organizations, have overlapping scopes and lack consistency in architecture, terminology, and assessment methodology. As a result, an organization deploying more than one model is faced with unique training for each, and typically a stovepiped process improvement approach focused on the discipline (e.g., software engineering) covered by the scope of the model. The net effect is often a delta cost of x each time an additional model is deployed in an organization, where x is the cost of deploying a single model. This situation of multiple models, assessment methods, and training deployed in a single organization, at significant cost, was a catalyst for CMMI.

U.S. Air Force	Boeing	Lockheed Martin
U.S. Army	Comarco Systems	Motorola
U.S. Federal Aviation	Computer Sciences Corp.	Northrop Grumman
U.S. National Security Agency	EER Systems	Pacific Bell
U.S. Navy	Ericsson Canada/Q-Labs	Priority Tech
Software Engineering Institute	General Dynamics	Raytheon
ADP, Inc.	Harris Corp.	Rockwell Collins
Andersen Consulting	Honeywell	Sverdrup Corp.
AT&T Labs	IBM	Thomson CSF
BAE Systems	Litton	TRW

Figure 1. *Organizations participating on the CMMI Steering Group and Product Development Team*

A CMMI design goal is to integrate disciplines, starting with existing capability models and eliminating inconsistencies and duplication to streamline and reduce the cost of model-based process improvement, and increase the return on investment.

Sponsors

The Department of Defense's Office of the Secretary of Defense for Acquisition and Technology, in conjunction with the National Defense Industrial Association Systems Engineering Committee, initiated the CMMI Project in January 1998 as a collaborative effort among government, industry and the SEI. Organizations participating in the CMMI Project are listed in Figure 1.

CMMI Project Organization

The project organization (See Figure 2.) consists of a steering group and a Product Development Team (PDT) led by the project managers and organized into Integrated Product Teams, with a Chief Architect to ensure the product line's architectural integrity. The steering group provides direction to the project, and developed the requirements specification. Additional duties include configuration control, status tracking and reporting, product approval, issue resolution, transition planning and support, and information dissemination. The PDT is responsible for managing and developing the CMMI products, as well as pilot testing. There is a Stakeholder/Reviewer Group

Figure 2. *CMMI Project Organization*
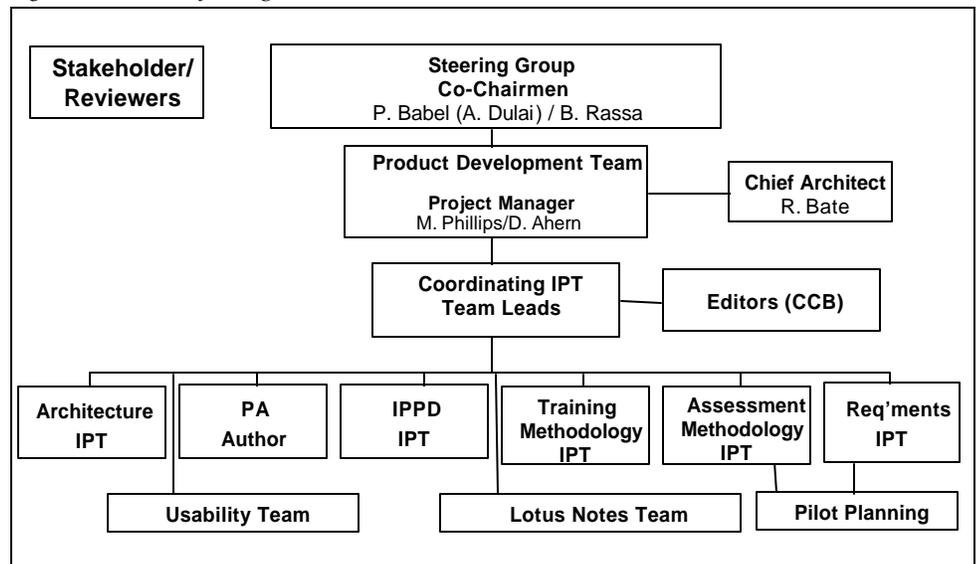
focused on providing review and comment on draft products and recommending improvements. This group also nominated candidates for pilot testing. PDT and Group members are drawn from government, industry, and the SEI.

Scope

The initial CMMI product suite, as defined by the CMMI requirements specification, focuses on integrating systems engineering, software engineering, and Integrated Product and Process Development (IPPD) best practices to produce equivalent process maturity models in staged and continuous representations.[1] The sources for the CMMI best practices are the SW-CMM v2C, EIA/IS-731 SECM, and the IPPD CMM draft v0.98, from which best practices are being culled and coalesced into common core- and discipline-unique practices and process areas. In addition, integrated training and an assessment methodology are being developed using legacy assessment materials from the source models. In the future, additional related disciplines, such as security engineering, can be added to the CMMI product suite in accordance with a process defined by the CMMI Steering Group. The CMMI scope and concept are illustrated in Figure 3.
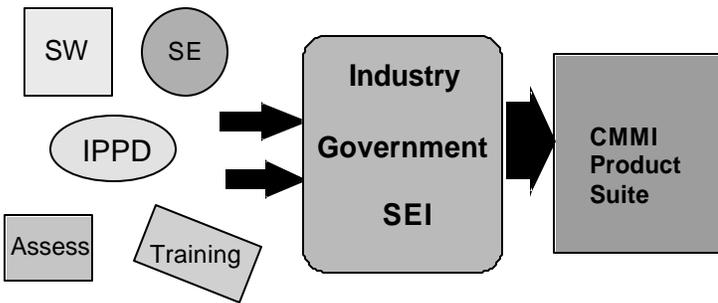

Figure 3. *CMMI Scope and Concept*

What is unique about CMMI?

The CMMI product suite is being structured to integrate multiple disciplines, providing consistent process improvement guidance across related disciplines. The CMMI framework is the backbone of the product suite architecture that implements a product-line approach to enable production of the products from a core asset base. This should result in substantial economies for users, in contrast to working process improvement one discipline at a time in independent efforts, as done in the past for each of the existing single-discipline models. In addition, using the product-line approach should yield significant savings as new disciplines are added over time, and organizations need only adopt a *delta* (for a new discipline) to a CMMI product already in use.

Legacy models as well as other process improvement assets (e.g., training and assessment methods) are being leveraged in the construction of the CMMI product line for generating process improvement tools that can be evolved. In accordance with product line practices, the approach taken is to form new CMMI products using common assets for the disciplines being integrated. This is accomplished by taking applicable components from the asset base, tailoring them as necessary, and assembling them under the umbrella of the CMMI framework, the common, product-wide architecture. Components of the Framework are depicted in Figure 4.
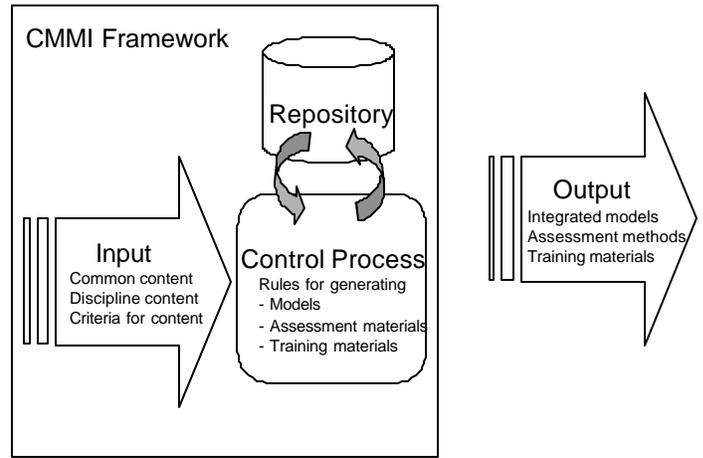

Figure 4. *CMMI Framework Components*

Model Activities/	Process/	Goals/	
	Focus Areas	Themes	Practices
SW-CMM v1.1	18	52	150
SW-CMM v2 Draft C	19	62	318
EIA/IS-731	19	77	383
IPD-CMM v0.98	23	60	865
CMMI-SE/SW v0.2	24	80	431

Figure 5. *Initial Size Comparison of CMMI-SE/SW Model to Legacy Models*

Figure 5 shows a quantitative view of the evolving CMMI model for systems and software engineering, in contrast with the source models. This figure illustrates the comparative size of the models in terms of process or focus areas, goals or themes, and practices or activities. Noteworthy is the significant consolidation and integration of process areas, goals and practices in the CMMI model in comparison with the source models.

CMMI Product Suite

The CMMI product suite will consist of:
- Integrated models for systems engineering, software engineering, and IPPD. Systems and software engineering are addressed in one model; IPPD concepts will expand this model to integrate IPPD processes, goals and accepted best practices. Each model will be produced in two representations to facilitate transition to CMMI: staged and continuous. However, equivalence between the two representations is being defined to achieve parity during assessments so that the results will be consistent, independent of the representation used.
- Assessment method and instruments for the models. A comprehensive assessment method, the Standard CMMI Assessment Method for Process Improvement (SCAMPI), is being developed to meet the Assessment Requirements for CMMI (ARC). Classes of assessment methods, satisfying subsets of the ARC, are being defined. Assessment data collection methods and tools (e.g., questionnaires) and recommended assessment team qualifications are being developed in conjunction with the assessment method description.
- Training products supporting the models and assessment method. Training will include CMMI model and assessment method training for assessment teams and lead assessor training. Like the CMMI model and assessment method, CMMI training is being developed using a product-line approach.

- Common glossary. Starting with the CMMI requirements specification, common terminology will be defined and used throughout CMMI products.
- Tailoring criteria for CMMI products. These address tailoring of the model and the assessment method. Model tailoring is the use of a subset of the model for purposes of making it suitable for a specific application; assessment method-tailoring addresses the selection of assessment options for use in a specific instance. Model tailoring criteria includes using the model for process improvement and benchmarking.
- A framework for generating CMMI products. This framework is designed to provide an internally consistent set of common elements applicable to any discipline that will be included in any CMMI product. The process for producing CMMI products from the framework is illustrated in Figure 6. The framework is designed to facilitate the addition of related disciplines to the CMMI product suite.

Anticipated Benefits

The greatest benefit for CMMI product-use should be improvement in business performance, as has been demonstrated via use of other maturity models like the SW-CMM. Though unique to an organization's business objectives, performance improvements may include improved profitability, improved win rate for new business and improvements to productivity, quality, and cycle time. In addition, the CMMI products are expected to provide a number of other benefits to users:

- More efficient, consistent and effective process assessment and improvement across multiple process disciplines.
- More effectively integrated processes, initially systems engineering, software engineering and IPPD.
- Reduced training and assessment costs.
- A common, integrated vision of process improvement across an organization
- An evolutionary process improvement growth path, allowing for incremental addition of new disciplines to the CMMI product line.

The CMMI product suite will allow a long-term process improvement strategy to be formulated, using a single, consistent CMMI product suite. This will facilitate seamless, incremental adoption of additional disciplines over time.

Release Plans

Public review of the CMMI-Systems/Software Engineering (CMMI-SE/SW) v0.2 concluded in November 1999 with nearly 3000 comments received. Pilot assessments began in November. The CMMI-SE/SW v1.0 and CMMI-SE/SW/IPPD v1.0 models are scheduled for public release in June-August 2000. An additional release, CMMI v1.1, is planned for August 2001 to provide additional refinement and update based on the continuing CMMI pilot program.

What is different for SW-CMM, EIA/IS-731 users?

CMMI provides a single, integrated model for systems and software engineering process improvement. Users of either the SW-CMM v1.1 or EIA/IS-731 find:

- Additional process areas.
- Additional practices.
- Staged and continuous representations.
- Capability level goals, mapped to institutionalization practices, in the staged representation.

An example of a new process area for SW-CMM v1.1 users who are not deploying EIA/IS-731 is the product verification process area that is included in the CMMI-SE/SW v0.2 model. Though *verify system* is a separate focus area in EIA/IS-731, verification is not a process area in SW-CMM v 1.1. Similarly, measurement and analysis is a CMMI-SE/SW v0.2 process area, but is not included as a separate focus/process area in either SW-CMM v 1.1 or EIA/IS-731.
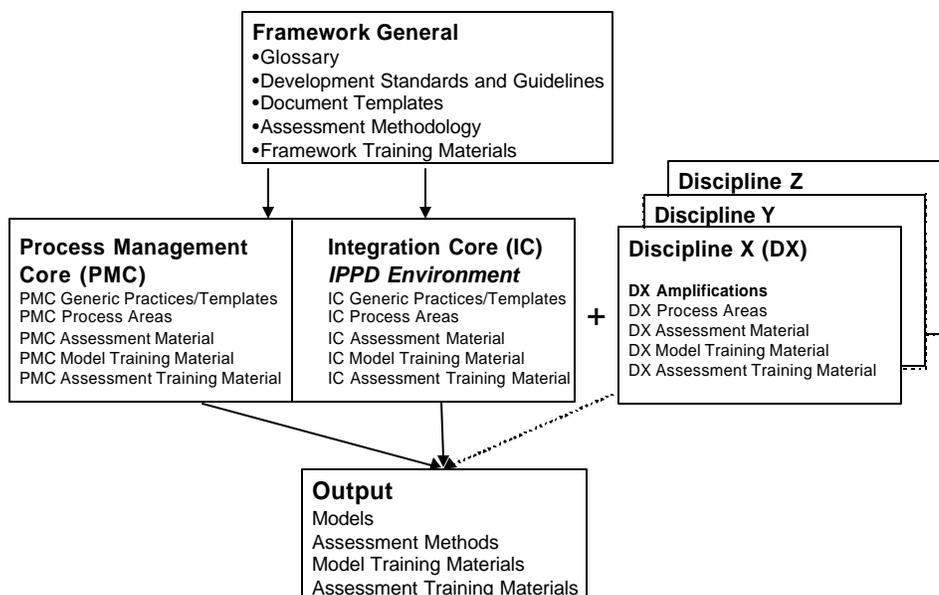
Users of the CMMI-SE/SW model will note one capability level goal in each process area. Initially introduced in SW-CMM v2 Draft C, the goal addresses whether the in-use process achieves the institutionalization activities related to the applicable maturity level. The intent is to capture institutionalization explicitly in rating during an assessment. Although these goals are new, they should have minimal effect on organizations now rigorously applying institutionalization practices.

The assessment method for CMMI is defined based on the CMM-Based Appraisal for Internal Process Improvement and EIA/IS-731.2, the SECM Appraisal method.

What is the best CMMI transition plan?

The transition plan for each organization will be unique, depending on its process maturity, phase in the process improvement life cycle, and business objectives. For example, a mature organization that recently completed assessments using SW-CMM v 1.1 and EIA/IS-731 may choose to define its updated process improvement plan using the CMMI-SE/SW model. In contrast, an organization with a less mature process, (e.g., a SW-CMM 1.1 Level 2 objective

Figure 6. *Process for producing CMMI Products from the CMMI Framework*

Framework General
- Glossary
- Development Standards and Guidelines
- Document Templates
- Assessment Methodology
- Framework Training Materials

Process Management Core (PMC)
PMC Generic Practices/Templates
PMC Process Areas
PMC Assessment Material
PMC Model Training Material
PMC Assessment Training Material

Integration Core (IC)
IPPD Environment
IC Generic Practices/Templates
IC Process Areas
IC Assessment Material
IC Model Training Material
IC Assessment Training Material

Discipline Z
Discipline Y
Discipline X (DX)
DX Amplifications
DX Process Areas
DX Assessment Material
DX Model Training Material
DX Assessment Training Material

+

Output
Models
Assessment Methods
Model Training Materials
Assessment Training Materials

by the end of 2000) may decide to complete its process improvement and formal appraisal plans before establishing a CMMI transition plan. All transition plans should address the mitigation from legacy models to CMMI within a three-year period after CMMI v1.0 is released, since this is the time frame when legacy models are slated for sunset.

Formulating a transition strategy that addresses the approach for adopting a CMMI model is critical to a successful transition to CMMI. Such a strategy would include a definition of how a CMMI model dovetails with the organization's business objectives and process improvement needs. For users of one or more legacy models, preservation of the investment to date in process improvement will be a key ingredient in the strategy, as will establishing the right level of sponsorship for the CMMI process improvement effort. Organizations using one legacy model will likely need to identify a new, higher-level executive to sponsor a broader (e.g. SE/SW/IPPD) enterprise-wide process improvement effort.

Other considerations for a CMMI transition strategy are establishing buy-in, creating/extending the organization's process improvement infrastructure, involving and communicating with customers, identifying training needs, and estimating the budget required for transition and the expected return on investment. Another consideration would be customer expectations for process maturity and/or improvement.

Formulating a CMMI Transition Approach

The first step is to determine the need and support for process improvement. Given the need, organizational sponsorship for the transition, with allocated resources, must be obtained. Following this, an assessment could be performed to identify the scope and nature of the changes required to adopt a CMMI model. Organizations using legacy models could conduct an informal assessment against a CMMI model, potentially with outside support, or may decide to perform a simple analysis of the changes required. The CMMI Project is producing mappings from legacy models to/from the CMMI models as an aid in doing this. These mappings can be used for an initial gap analysis.

The next step is to establish action plans for implementation, including training, tools, and infrastructure focused on the changes involved from legacy models. Deployment would typically start with the organization's set of standard processes, followed by project processes. After pilot use, specific projects could be identified to apply the improved process and measure its effectiveness and contribution to product and process improvement, with focus on the business parameters identified for improvement by the organizational sponsor. Each use of the CMMI products should be followed by a lessons learned phase during which experiences are compiled and communicated to improve subsequent applications.

Risks in Transitioning to CMMI Products

As a new product suite, the CMMI products have had limited use, primarily on pilots, and data are sparse. However, the CMMI models are well-grounded in proven, publicly accepted practices. A plan for systemically collecting quantified improvements in business performance, including quality, productivity, cycle time and customer satisfaction, and secondary benefits such as improved morale, reduced attrition, and decreased overtime, is needed to support the business case for transition to CMMI products. An additional risk is the potential unavailability of CMMI transition products needed by an organization. Since products like training are being developed incrementally, concurrently with the models, they will initially be available only in pilot form, followed by full rollout by the CMMI product suite steward, the SEI, and its transition partners.

How can I obtain more information on CMMI?

Information on the CMMI project and products can be obtained at www.sei.cmu.edu/cmm/cmms/cmms.integration.html✍

Note

1. See pages 5 and 6 for more on this.

About the Authors

Joan Weszka is manager of Process and Program Performance in the Systems & Software Resource Center at Lockheed Martin Mission Systems. She has more than 25 years of experience in software and systems engineering, and program management. At IBM, she held management and technical positions in systems development of commercial and government large-scale, real-time systems. Weszka is a member of the CMMI Steering Group, and previously chaired the Enterprise Process Improvement Collaboration Steering Group and the SEI's SW-CMM Advisory Board.

700 North Frederick Ave.
Gaithersburg, Md. 20879-3328
Voice: 301-240-7013
Fax: 301-240-7009
E-mail: joan.weszka@lmco.com

Phil Babel is a senior associate with Dayton Aerospace Incorporated. He retired from the U.S. Air Force, in 1999, after 34 years with the Aeronautical System Center, where he was a technical advisor for embedded computer systems software. From 1998 until retirement he served as chairman of the CMMI Steering Group. He has a bachelor's degree in electrical engineering from the University of Detroit and a master's degree in computer and information science from Ohio State University.

4141 Colonel Glenn Highway, Suite 252
Dayton, Ohio 45431
Voice: 937-426-4300
Fax: 937-426-1352
E-mail: Phil.babel@daytonaero.com

Jack Ferguson is the Director for Software Intensive Systems in the Office of the Deputy Under Secretary of Defense for Science and Technology. Prior to this , he was CMMI Project Manager at SEI. He has spent more than 30 years in technical, managerial, and teaching capacities, primarily with the DoD space program and software management. He received the U.S. Air Force R&D Award for his work on GPS spacecraft, and was head of the SEI Joint Program Office. He has a doctorate degree in aerospace engineering from the University of Texas.

1931 Jefferson Davis Highway, Suite 104
Arlington Va. 22202
Voice: 703-602-0851
Fax: 703-602-3560
E-mail: FERGUSJ@acq.osd.mil