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Section 1
Introduction

The Promise of CMMI

The Capability Maturity Model©-Integrated (CMMI℠) is for projects or organizations that want to do the following:

- Improve delivery of promised performance, cost, and schedule
- Collaborate with external stakeholders and manage their expectations
- Provide competitive world-class products and services
- Implement an integrated enterprise business and engineering perspective
- Master system-of-systems evolutionary development complexity
- Use common, integrated, and improving processes for systems and software
- Implement proactive program management techniques
- Develop project leaders who look ahead, not over their shoulder
- Develop a staff who use best practices to cope with changing development, technology, and customer environments
- Enable staff to move between projects and still use the same processes
- Create and improve processes that adapt to a changing business environment

It is a process improvement method that provides a set of best practices that address productivity, performance, costs, and stakeholder satisfaction.

> The CMMI is NOT a set of "bolt-on processes" that last only as long as the wheel is squeaking. CMMI provides a consistent, enduring framework that accommodates new initiatives.
>
> CMMI focuses on the total system problem, unlike the SW-CMM or SE-CMM.
>
> CMMI facilitates enterprise-wide process improvement, unlike single-discipline models that can result in confusion and higher costs.

Executive Support

Process improvement using the CMMI improves predictability of the critical measures of cost, schedule, performance, and customer satisfaction. So what are these key and critical processes for process improvement and who is responsible for performing them?

The CMMI provides the processes that help managers break the code of predictability of cost, schedule, performance, and customer satisfaction. Five process areas are related to process management, and six are related to management oversight. The information contained in these eleven process areas assists the executive in:

- Focusing on long-term viability rather than short-term project and contractual issues
- Establishing a strategic business plan
- Providing and protecting resources for long-term improvement of the organization's processes

The Malcolm Baldrige Award provides another, complementary perspective for executives to break the code of predictability of cost, schedule, performance, and customer satisfaction. The following seven areas are evaluated for the prestigious award:

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℠ CMMI is a service mark of Carnegie Mellon University.

- Leadership
- Information and Analysis
- Strategic Planning
- Human Resource Development and Management
- Process Management
- Business Results
- Customer Focus and Satisfaction

At the heart of both the CMMI and the Baldrige Award is the role of the *leader*. The following are critical predictors of the speed and predictability of an organization's effort to improve its processes:

- The leader is able to see the business need and able to express it in a compelling manner.
- The leader is willing to personally lead the effort.
- The leader is capable of changing his own behavior as needed to honor the new processes and to support others as they learn to honor them.

The leader must be proactive, because the most critical element of any implementation is the leadership element. Bottom-up change is too unpredictable. Organizational change must be designed, implemented as a mission-critical project, and led from the top for the following reasons[1] :

- Competing alternative solutions result in piecewise effort vs. integrated effort.
- Resources must be committed and fenced for the process improvement effort.
- The leader must establish a mentoring environment for process improvement, reward process improvement efforts, and discourage resistors to process improvement.
- The leader's behavior is watched and emulated.
- The leader must establish and maintain the vision.

Given that our tactical approach to implementation is through a centralized core team, the role of leadership has an increased criticality. It is essential for senior leadership to be the "champion" of the activity. This involves the following elements[2] :

Establish and Maintain the Vision—It isn't enough just to set long-term organizational goals. There are as many potential paths to the goals as there are people in the organization. Unless the vision includes additional information to limit implementations to a compatible subset, waste and frustration are the likely results. Personally commit to the implementation and positively state that CMMI-based process improvement is the approach that will be employed.

Deduce Objectives—Communication of critical and concrete plans on the path from today to the future is needed to further reduce the waste from misinterpretation of the vision and potentially incompatible implementations. This must include both critical operational mission objectives and critical organizational change/improvement objectives. Engage with internal and external leadership and promote the effort. This would involve personally briefing the leadership on the benefits of the CMMI-based process improvement.

1 *Leading 21st Century Teams*, L. R. Carter, Software Engineering Institute, Carnegie Mellon University, March 2000.
2 ibid.

Select Priorities —Which efforts will receive your most skilled people and first choice on resources. Too often people talk about priorities in the abstract. There aren't enough resources to staff everything to guarantee success. Warriors know some battles must be won and others are not as critical. Hard choices, but they MUST be made! Establish management procedures to monitor the involvement of leadership in the process improvement effort.

Apportion Assets—The other side of prioritize. Many assets are not interchangeable. How assets are best apportioned may change over time even when the priorities have remained fixed. Resource apportionment in the absence of leadership results in politics and rice bowls. Commit resources to the process improvement effort.

Measure Effectiveness—Unambiguous situational awareness is the goal. Are we on track? What might be the impact of a change? Each leader brings a different perspective to their job and the measures that are meaningful and trusted may be unique. A scan pattern is important (different measures need to be assessed at different rates). The transformation from opinion-based decision making to data-driven decision making is not trivial and may require coaching. Establish evaluation criteria for process improvement.

Delegate and Engage—"Get out of the way" in a manner that ensures the critical work actually gets done in line with the vision. There are still many aspects of the work that benefit from having the leader engaged. If total delegation was an option, then why is there a leader at all? Incorporate process improvement in the every-day management.

Develop Subordinates and the Organization—None of us will be here forever. What are we doing to ensure the good work of our people can serve as the foundation for future work? How do we teach our people to learn to stand on the shoulders of giants? How do we ensure it is easy for our successors to leverage the foundational work we have laid without placing them in a box, unable to assert their right to contribute and make the mark they must make in order to survive?

Leaders can delegate authority, but can never delegate away responsibility. The leadership of the organization must make this activity a priority and provide the visible leadership necessary to keep process improvement a high priority within the organization.

Background of the CMMI Project

- Sponsored by The Office of the Secretary of Defense (OSD) and the National Defense Industrial Association
- Capitalizes on the similarities of other process improvement models; eliminates differences that increase effort and expense of "stovepiping" models
- Began with the following source models:
  - SEI's Capability Maturity Model for Software (SW-CMM)
  - Electronic Industries Alliance Systems Engineering Capability Model, Interim Standard (EIA/IS 731)—the result of the merger of the SE-CMM, created by the Enterprise Process Improvement Collaboration (EPIC), and the SECAM, created by INCOSE
  - A draft model covering Integrated Product and Process Development (IPPD), the IPD-CMM, previously released in draft form by EPIC

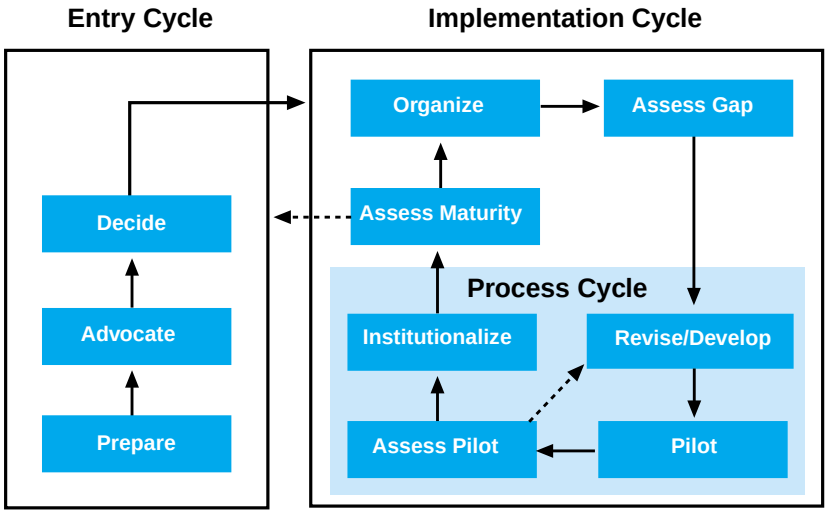
Tailored for Your Organization

CMMI is designed to be tailored to the goals set by your business environment, unlike many previous process improvement models. The built-in flexibility of the CMMI provides you the opportunity to

- fully align process improvement with your business goals
- choose areas providing the biggest "bang for the buck"
- leverage off existing activities
- develop specialized areas to meet your specific business needs
- build on previously isolated activities in software, systems engineering, acquisition, IPPD
- promote maximum flexibility and efficiency in your process improvement approach
- support an enterprise perspective across all business functions

The steps to implementing CMMI are shown in the following roadmap diagram. The purpose of the roadmap is to

- provide a general framework for assisting organizations in transition to CMMI
- show the process required to transition an organization to an enterprise based on CMMI principles and practices



Cycles

The enterprise-level roadmap consists of three cycles as described below:

- **Entry/Rentry Cycle:** Specifies the actions required to evaluate, adopt, and commit to the transition process. This cycle may need to be repeated based on an evaluation of the progress of the transition.
- **Implementation Cycle:** Specifies the actions required to create the environment and the infrastructure needed for transition. This cycle is re-entered periodically to capitalize on lessons learned and environmental changes.
- **Process Cycle:** Specifies the actions required to execute and monitor the transition process. This cycle is repeatedly executed with the objectives of continuous process improvement and institutionalization of CMMI principles and practices.

Requirements in Each Cycle:

Entry/Rentry Cycle:

1. Identify changes required to transition from current practice.
2. Examine and select suitable alternatives.
3. Determine resource requirements and ensure availability.
4. Commit to adopt and implement the transition process.
5. Define assessment points and recycle decision criteria.

Implementation Cycle:

1. Identify and involve key stakeholders.
2. Develop, internalize, and communicate the vision.
3. Define and document goals, expectations, and measures.
4. Establish and charter the change agents.

Process Cycle:

1. Reinforce commitments and involvement with the key stakeholders.
2. Monitor the progress of the change agents.
3. Assess the institutionalization of CMMI principles and practices.
4. Re-evaluate commitments and determine the next steps.

Section 3
Early Adopters

The organizations listed below were some of the first to implement CMMI-based process improvement initiatives.

- ABB
- Accenture
- BAE SYSTEMS
- The Boeing Company
- Computer Sciences Corporation (CSC), Defense Group
- Concurrent Technologies Corporation (CTC)
  National Security Division
- General Dynamics
- Goddard Space Flight Center NASA
- Harris Corporation
- Jacobs/Sverdrup Technology Inc., Advanced Systems Group
  Engineering Performance Improvement Center (EPIC)
- Lockheed Martin
- Lockheed Martin Management & Data Systems
- The MITRE Corporation
- Motorola Inc.
- Northrop Grumman Information Technology Sector
- Northrop Grumman Integrated Systems Sector
  Airborne Early Warning/Electronic Warfare Systems
- Process Assessment, Consulting & Training
- Q-Labs
- Raytheon Company
- Synchro PP&T
- THALES
- TRW
- United Space Alliance
- U.S. Army TACOM-ARDEC Software Enterprise

For additional information, go to
http://www.sei.cmu.edu/cmmi/publications/early-adopters.html

Section 4
Sector Business Case Advantages

Introduction

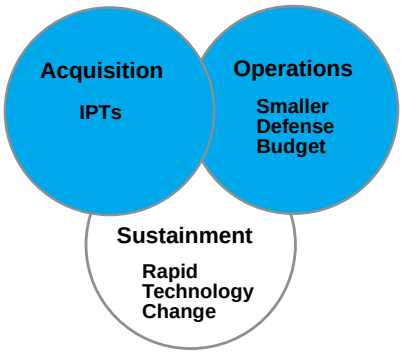
There are a variety of process environments to consider. This section will deal with four specific cases:

- Government
- DoD Contractor
- Joint Government / DoD Contractor
- Commercial

The discussion will be focused on the conditions that generate the need for process and how CMMI-based process improvement can accommodate these environments and meet the process needs.

Government

In viewing the government business case, in particular the DoD, the focus will be on the acquisition, operations, and support segments of the DoD. The relationship between these three segments could be depicted as shown in the following diagram:



The government has become an interdependent set of stakeholders in the 2000s. This interdependency has evolved due to conditions in the various stakeholder communities. These conditions are shown in the following diagram.

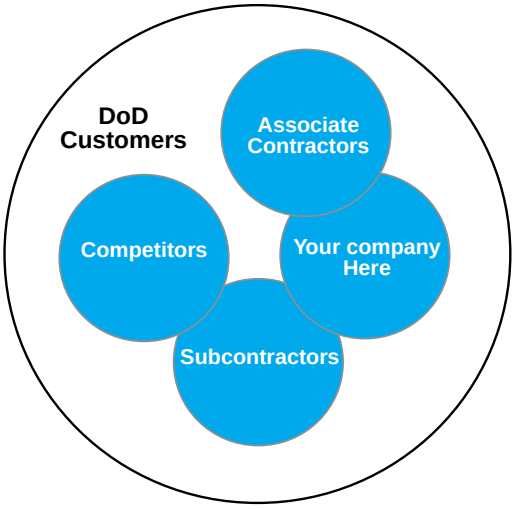
Acquisition	Operations	Sustainment
System of System Demands	Smaller Force	Lean Logistics
Spiral Development & EA	Coalition Operations	Experience Drain
Constant Initiative Flow	Interoperable Systems	Technology Pace
Increased ACQTEMPO	Increased OPSTEMPO	Outsourced Work
Oustsourced Workforce	Changing Missions	COTS vs MILSPEC
Lifecycle Management	Changing Threats	Smaller Workforce
Impatient Customers	CONUS Based	Just-in-Time Supply
Acquisition Reform	Global Commitments	Contractor Logistics Support
TSPR Contracts		Increased "Command Support"
Experience Drain		
Smaller SPOs		

Partnering & Shared Processes

As a result, the Government must be prepared to partner to supplement each sector's conditions. The stakeholders in these sectors must support each other with resources. The sharing of these resources to provide the "force multiplication" impact demands that the sectors become co-sponsors, owners, and users of processes. Due to the diversity of interest in the sectors, engineering, support, and business processes must be established to accommodate the sharing of information for a variety of reasons (e.g., decision making, monitoring, budgeting). The integrated nature of the CMMI is uniquely capable of meeting all these requirements by providing an integrated framework of engineering, program management, and support processes.

DoD Contractor

Potential influences of process maturity on stakeholders



DoD Customers
May require process maturity in RFP implicitly or explicitly
May use maturity as a discriminator

Associate Contractors
Improve integration of products and services

Competitors
Will use process maturity to advise customers
Will use process maturity to competitive advantage

Subcontractors
Improve integration of products and services
Provide insight into subcontractor performance and quality

Various levels of process maturity will influence stakeholder interaction for all organizations involved in all phases of development. DoD contractors are motivated to adopt process improvement initiatives for the following reasons:

- DoD acquisition agencies and policy directives require them for bidding
- To improve performance on software development and systems engineering efforts
- To improve interface compatibility with associate contractors
- To gain insight in vendor, supplier, and subcontractor delivery and performance

Joint Government / DoD Contractor

In viewing this business case, we will build on the business case described above for the government. The added dimension is the contractor(s). In this case one or more DoD contractors become government "force multipliers" in addition to their primary role of product developers.

In the current government business environment, the contractor has become an integral member of the various government sector communities. Some of the roles played by the contractor are described in the following table.

Government Sector	Contractor Roles
Acquisition	• Prime contractor for product development, product, or service • Subcontractors to the prime contractor for material, product, expertise, or service • System engineering support contractor • FFRDCs (MITRE, Aerospace, SEI, etc.)
Operations	• Contract services (training, unit level maintenance, management services, equipment, etc.) • Contract operators • FFRDCs (MITRE, Aerospace, SEI, etc.)
Sustainment	• Contract depots • Contractor logistic support • Prime contractor for parts and services • Contract services (training, equipment)

Given this variety of roles, it can be seen that the contractor in all segments has become a vital member of the team. In addition to the conditions that are requiring the government sectors to form partnerships, the contractors are also experiencing conditions that lead to the need for partnering. The following diagram highlights these conditions.

Contractors

Fewer and Bigger ID/IQ Contracts | Fewer New Starts Outsourced Work

Acquisition	Operations	Sustainment
System of System Demands	Smaller Force	Lean Logistics
Spiral Development & EA	Coalition Operations	Experience Drain
Constant Initiative Flow	Interoperable Systems	Technology Pace
Increased ACQTEMPO	Increased OPSTEMPO	Outsourced Work
Oustsourced Workforce	Changing Missions	COTS vs MILSPEC
Lifecycle Management	Changing Threats	Smaller Workforce
Impatient Customers	CONUS Based	Just-in-Time Supply
Acquisition Reform	Global Commitments	Contractor Logistics Support
TSPR Contracts		Increased "Command Support"
Experience Drain		
Smaller SPOs		

Partnering & Shared Processes

As in the government business case, the result in the Joint Government/DoD Contractor business case is a need to partner and in turn to share processes. Once again the CMMI is uniquely situated to become the framework to facilitate the sharing of processes between the government sectors and contractors. Not only does it integrate the engineering, program management, and support processes into a seamless process set, it does so while meeting both government and contractor needs. As a joint project between the DoD and the National Defense Industrial Association (NDIA), the CMMI has been developed to not only accommodate the unique nature of the government business model, but has been developed to accommodate the diverse needs of the defense industry. Implementation of CMMI affords all stakeholders in the Joint Government/DoD Contractor environment these benefits:

- A common business/process language
- Improvement in business performance through process improvement (more productivity, higher quality, shorter cycle time)
- More consistent and effective process assessment across multiple business units
- Better integrated processes across multiple disciplines

Commercial

Product development in the commercial environment drives revenue for the corporation.

- Strategic planning for the corporation is driven by market pressures with the ultimate goal of improving revenue and profitability.
- Process discipline will enhance productivity by reducing the time to market.
- Customer satisfaction will increase with measurable improvements in reliability and quality.
- Process improvement activities compete for corporate resources.
  - Return on investment must be equal to or better than other opportunities.
  - Examples for software process improvement[3] :
    - Development time — Reduced 73%
    - Rework costs — Reduced 96%
    - Average schedule length — Reduced 37%

[3] *A Business Case for SPI Revised – Measuring ROI from Software Engineering and Management*, DACS, September 1999, <http://www.dacs.dtic.mil/techs/roispi2>.

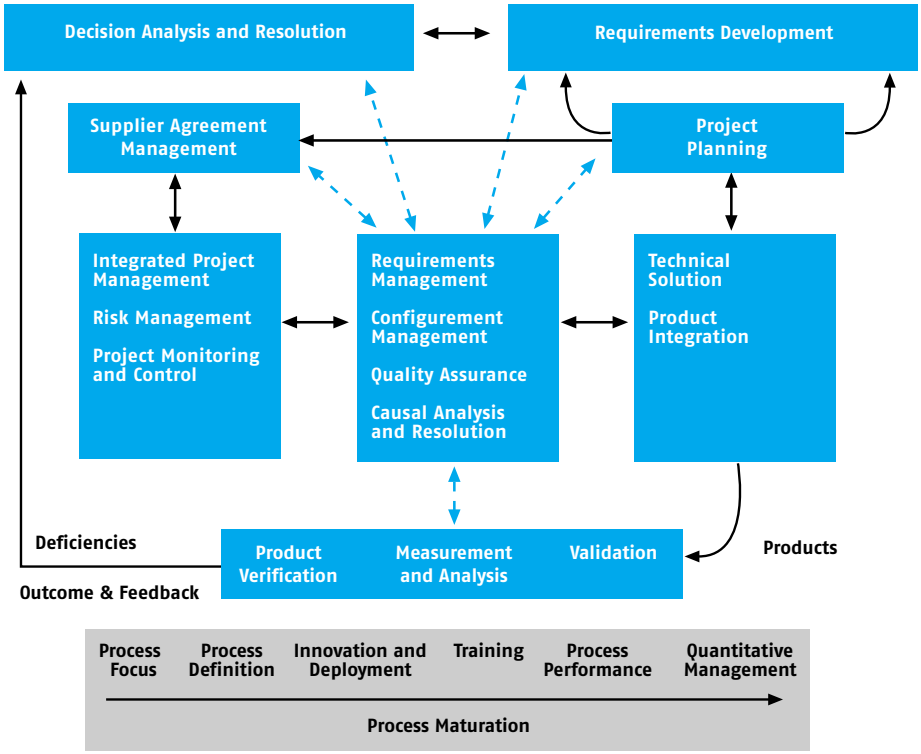
Section 5
CMMI Compatibility With Departure Model

The CMMI is compatible with a wide variety of capability and process improvement frameworks as shown in the following table.

Departure Model	CMMI Compatible	Features Enhanced by CMMI	Additional Features Provide by CMMI
SW-CMM	Yes	Core processes are integrated	System Engineering and project management
EIA-731	Yes	Core processes are integrated	Software System development and project management
ISO 9000:2000	Yes	Organizational institutionalization	Progressive levels
SE-CMM	Yes	Core processes are integrated	Software System development and project management
PMBOK	Yes	Core processes are integrated	System Engineering, Software System development and Integrated Project Manag.
Homemade	Maybe	TBD	TBD
Nothing	Yes	Addition of process framework	Provides integrated project processes

Process Area Integration

The following figure demonstrates the integration of the various processes that enterprises use to conduct business and shows the relationship between the various CMMI process areas.



Process Management Process Areas

- Contain the overarching practices related to implementing a successful and mature process improvement program
- Provide capability to document and share best practices, process assets, and learning
- Provide advanced capability to achieve quantitative objectives for quality and process performance

Process Area	Description
Organizational Process Focus (OPF)	Helps organization establish and maintain understanding of its processes, and identify, plan, coordinate, and implement improvement
Organizational Process Definition (OPD)	Establishes and maintains organization's set of standard processes and supporting assets

Process Area	Description
Organizational Training (OT)	Identifies strategic training needs of organization, as well as tactical training common across projects and support groups
Organizational Process Performance (OPP)	Derives common, quantitative objectives for quality and process performance from organization's business objectives
Organizational Innovation and Deployment (OID)	Selects and deploys proposed incremental and innovative improvements to improve organization's ability to meet quality and process performance objectives

Project Management Process Areas

- Cover the project management activities related to planning, monitoring, and controlling a project
- Provide mechanisms to establish, maintain, and monitor commitments to customers and from suppliers
- Provide mechanisms to establish and maintain collaborative teaming environment
- Provide common method to proactively and quantitatively manage project

Process Area	Description
Project Planning (PP)	Develops and maintains project plan, involves stakeholders appropriately, obtains commitment to the plan
Project Monitoring and Control (PMC)	Monitors activities and takes corrective action, including replanning
Integrated Project Management (IPM)	Adapts organization's processes to project, and establishes project's shared vision
Integrated Teaming (IT)	Identifies and organizes stakeholders into collaborative teams and develops shared vision aligned with project and organization shared vision
Risk Management (RSKM)	Develops and implements proactive strategy to continuously identify, assess, prioritize, and handle program risks
Quantitative Project Management (QPM)	Collects project process and product metrics, and analyzes results to identify process improvement opportunities

Engineering Process Areas

- Support product development life cycle activities, from initial requirements development to transition to operational use

Process Area	Description
Requirements Development (RD)	Collects and harmonizes stakeholder needs to plan, develop, integrate, field, and sustain products, and translates needs into product reqs.
Requirements Management (RM)	Ensures that agreed-to requirements are understood and managed
Technical Solution (TS)	Converts requirements into product architecture, design, and development
Product Integration (PI)	Combines product components and ensures interfaces
Verification (VER)	Ensures product meets specifications ("we built the thing right"), and that deficiencies are tracked, reworked, and retested
Validation (VAL)	Ensures product fills intended use when placed in intended environment ("we built the right thing")

Support Process Areas

- Provide essential processes to support product development and maintenance
- Support establishment and maintenance of a work environment that facilitates and stimulates integration and manages people to enable and reward integrative behaviors
- Provide support functions used by all process areas during product development

Process Area	Description
Measurement and Analysis (MA)	Establishes metrics program to provide objective results that can be used in making informed decisions and in taking appropriate corrective actions
Configuration Management (CM)	Establishes and maintains integrity of work products
Process and Product Quality Assurance (PPQA)	Provides practices for objectively evaluating processes, products, and services
Decision Analysis and Resolution (DAR)	Provides structured decision-making process that ensures alternatives are compared against established criteria, and best alternative is selected
Causal Analysis and Resolution (CAR)	Identifies causes of defects and other problems, and takes action to prevent them from occurring in the future
Organizational Environment for Integration (OEI)	Establishes approach and environment for the implementation of integrated teams

Custom Process Areas

Depending upon business requirements, a customized process area may be required, such as information assurance, enterprise integration, or safety.

Section 7
Adoption Approach

CMMI models are organized in two representations, continuous and staged. They provide alternative approaches to process improvement that leverage users' familiarity with either approach. Guidance for selecting a representation is provided in CMMI training.

The Continuous Representation

The continuous representation is based on process capability—the range of expected results that can be achieved by following a process. Process improvement is measured in capability levels that relate to the achievement of specific and generic goals in each process area.

The continuous representation provides flexibility for organizations to choose which processes to emphasize for improvement, as well as how much to improve each process. It enables selection of the order of process improvement that best meets the organization's business objectives and that most mitigates risk.

The Staged Representation

The staged representation is based on organizational maturity—the combined capabilities of a set of related processes. Organizational improvement is measured in maturity levels. This representation has a recommended order for approaching process improvement, beginning with basic management practices and progressing along a proven path.

Equivalent Staging

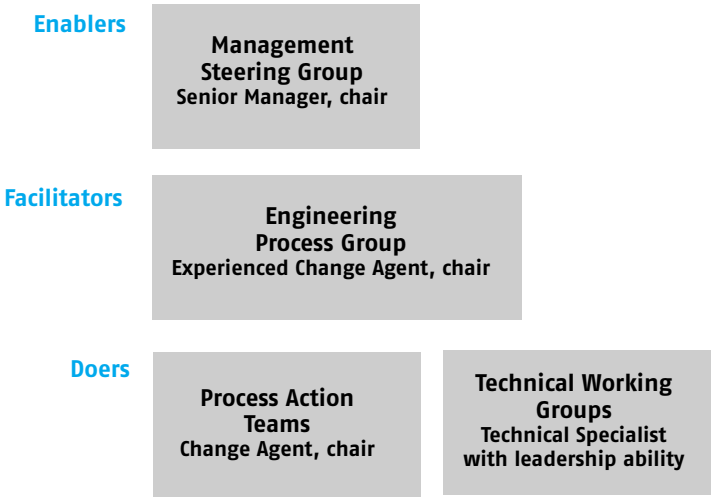
Sometimes it may be desirable to convert an organization's capability level achievements into a maturity level. This conversion is made possible by "equivalent staging." The CMMI model includes rules for determining which capability levels must be satisfied in each process area to achieve each maturity level.

Section 8
Resources

This section describes some of the personnel and training resources that may be required for an effective implementation of CMMI-based process improvement.

Personnel

The following diagram shows one possible organization for process improvement personnel.



Establishing and sustaining a process improvement initiative is critical to its long-term success.

- Management Steering Group
  - Senior manager chairs group of one or more line managers in the organization to authorize process improvement activities
  - Supplies vision for process improvement objectives and establishes clear ties to the organization's business objectives
  - Commits needed resources (people and funding) to accomplish tasks
- Engineering Process Group
  - Chaired by a "change agent," typically with process improvement experience and a sound understanding of how proces improvement relates to the organization's business objectives
  - Able to function as a process improvement mentor in many areas (e.g., process and product quality assurance, configuration management, project management)
  - This group organizes process improvement activities across the enterprise and may be composed of a whole subordinate business down to small, individual projects
  - The process group exists for the duration of the process improvement activity in the organization, possibly in perpetuity

- Process Action Teams
  - Chaired by a "change agent" who understands organization's culture and history and has the ability to effect change in concert with, and sometimes despite, the culture and history
  - Focus is on developing and maintaining action plans to address specific process area work that will be initiated and subsequently improved
  - Should exist for the period of time to get the organization or project from one assessment to the next

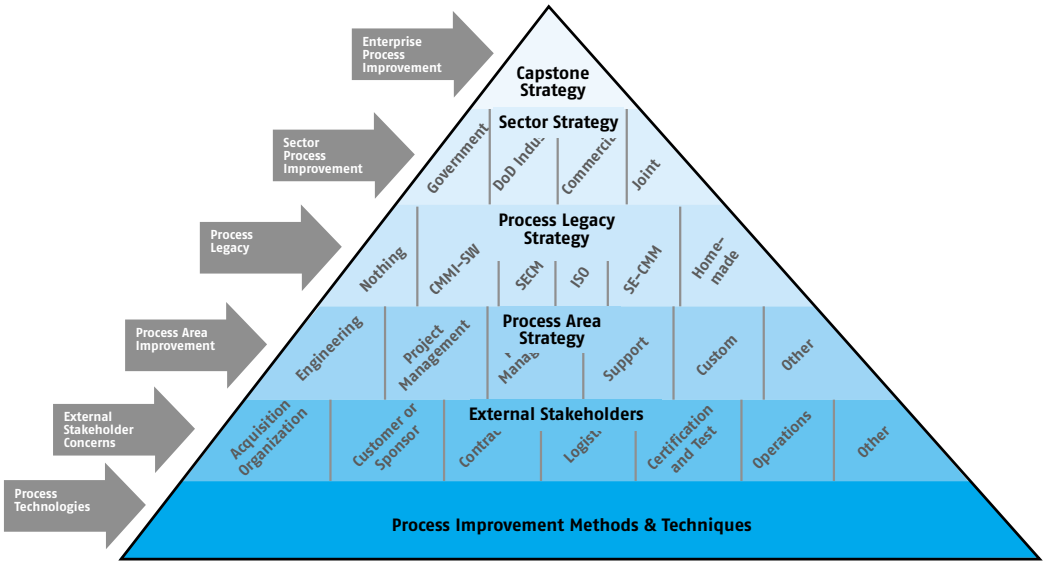
Training

Training must be tailored to various levels of the organization.

	In-House Training	Third Party Training (e.g., SEI)
Enablers	Executive CMMI Overview	
Facilitators	Most process courses taken during "experience gathering" Process Group Operations Change Agent Orientation	Intermediate Concepts of CMMI
Doers	Selected process courses based on process specialty	Introduction to CMMI

Section 9
Adoption Factors

Organizations are approaching CMMI adoption from many different current "states." The pyramid below demonstrates some of the factors that must be considered in building adoption for the total enterprise.



Appendix A
Lessons Learned

At an initial workshop on CMMI transition, a team brainstormed ways to limit or forestall CMMI adoption in an organization. They are presented here for your enjoyment–but perhaps also as reminders of what can go wrong.

- Have process group meetings with no project representation.
- Don't link process to product quality, cost, schedule, and performance.
- Rely on current Introduction to CMMI training as sufficient for appraisal team training.
- Let experts/zealots write the procedures.
- Set artificial level requirements and put the people with the lowest estimate in charge.
- Spend most of your time on the open-ended questions during a SCAMPI appraisal.
- Don't train–it costs too much. Just do it–follow the appraiser.
- Management should dictate process changes without any coordination, because it speeds things up.
- Don't bother to capture the hearts and minds of middle management.
- Select your most important project as your CMMI pilot–get biggest bang for your buck.
- Change the organization structure six months before the appraisal, to clarify reporting structures.
- Include zealots in specific areas in your appraisal team.
- Tell people they can understand the model just by reading it.
- Align your practices exactly to the CMMI, instead of to what you do.
- Use a benchmark method (e.g., Class A appraisal) for your first contact.
- Put as many lead appraisers on your appraisal team as possible. Different opinions add spice!
- Make the Introduction to CMMI course your program managers' first contact with CMMI.
- Rotate your SEPG leader every three months–use someone with a fresh look who has never read the policy.

NOTES

NOTES