

The CMMI:
700 pages of process model in 1 lecture

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Questions on the agenda

- What is CMMI?
- What is in the CMMI models?
 - Model elements
 - Example: project planning
 - What is an assessment and how does it work?
- How does CMMI relate to what you've learned?
 - about the experience factory?
 - about measurement and modeling?
- Lessons learned by high maturity organizations

What is CMMI?

- *CMMI is acronym for Capability Maturity Model Integration, which can mix and match*
 - Software Engineering (SW)
 - System Engineering (SE)
 - Integrated Product and Process Development (IPPD)
 - Supplier Sourcing (SS)
- NASA Goddard is currently using CMMI-SE/SW/IPPD/SS Version 1.1
 - Published March 2002, by the Software Engineering Institute, a DoD organization located at CMU
 - <http://www.sei.cmu.edu/cmmi/models/models.html>

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What is a capability maturity model?

- A capability maturity model IS
 - A MODEL for an organization's process maturity
 - A framework for reliable and consistent assessments
 - A software-industry, community-owned guide
 - A mechanism for identifying & adopting best practices
 - A rare example of national consensus
- A capability maturity model is NOT
 - A prescription or standard
 - Actual processes belong to organization, not SEI
 - A technology, language, or methodology

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Software CMM Background

- US Department of Defense buys a *lot* of software
 - Total budget (FY02 request) -- \$328 BILLION
 - Software cost 5-10% of budget
 - Software Engineering Institute was founded in 1980s to address improvement of DoD software
- Software Capability Maturity Model (CMM)
 - Intended to rate process maturity of contractors
 - Originally proposed by Watts Humphrey in *Managing the Software Process (1989)*
 - SEI published SW CMM version 1.1 in 1993
 - SEI developed other capability maturity models
 - People CMM, Acquisition CMM, Security CMM... 5

CMM Integration Project

- Wouldn't it be nice if all the models fit into a common, consistent framework?
- Source models
 - CMM (software) V2.0 Draft C
 - EIA 731 (system engineering)
 - IPD CMM (integrated product development)
 - SA-CMM (software acquisition)
- The CMMI is that framework
 - Work on revision to SW-CMM was redirected
 - INCOSE participated in integrating system engineering into the model

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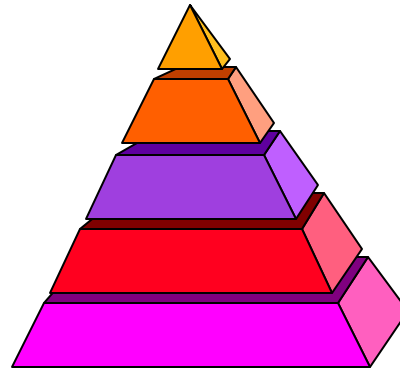
CMMI Overview

- Model Representations
 - Staged: software CMM heritage, gives single level rating
 - **Continuous: system engineering heritage, gives “capability profile” of process**
- Model components
 - Process areas & Process categories
 - Maturity Levels & Capability Levels
 - Specific & Generic Goals
 - Specific & Generic Practices

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CMMI Overview: Staged Representation

- Provides a pre-defined roadmap for organizational improvement based on proven grouping and ordering of processes and associated organizational relationships.
- *Maturity levels build on each other*
- SW-CMM is also a staged model



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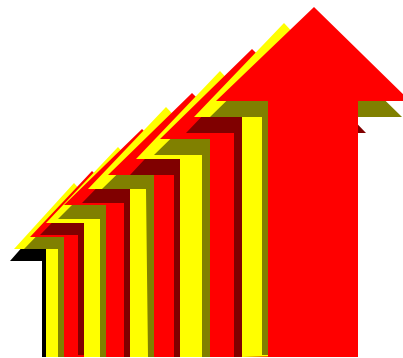
Staged: Maturity Levels & Process Areas

Level	Focus	Process Areas
5 Optimizing	<i>Continuous Process Improvement</i>	Organizational Innovation and Deployment Causal Analysis and Resolution
4 Quantitatively Managed	<i>Quantitative Management</i>	Organizational Process Performance Quantitative Project Management
3 Defined	<i>Process Standardization</i>	Requirements Development Technical Solution Product Integration Verification Validation Organizational Process Focus Organizational Process Definition Organizational Training Integrated Project Management Risk Management Decision Analysis and Resolution
2 Managed	<i>Basic Project Management</i>	Requirements Management Project Planning Project Monitoring and Control Supplier Agreement Management Measurement and Analysis Process and Product Quality Assurance Configuration Management
1 Initial		

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CMMI Overview: Continuous Representation

- Provides maximum flexibility for organizations to choose which processes to emphasize for improvement.
- *Capability level is measured separately for each process area*
- Capability levels build on each other within a process area



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CMMI Overview: Capability Levels

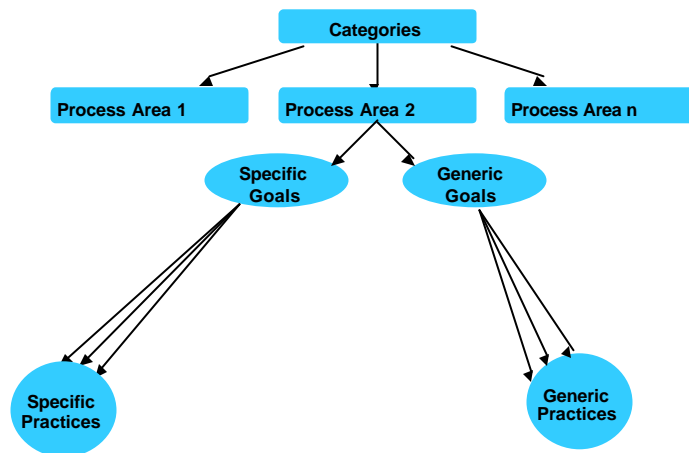
- Capability level is measured for each process area
 - 5 Optimizing
 - 4 Quantitatively Managed
 - 3 Defined
 - 2 Managed
 - 1 Performed
 - 0 Incomplete
- An organization can decide a process area is not applicable (and not be assessed against that area)
 - For example, consider QA for time-to-market driven Web developers & airliner avionics. One could consider omitting PPQA, one should not even think it! ¹¹

Process categories & Process areas

Category	Process Areas
Process Management	Organizational Process Focus Organizational Process Definition Organizational Training Organizational Process Performance Organizational Innovation and Deployment
Project Management	Project Planning Project Monitoring and Control Supplier Agreement Management Integrated Project Management Risk Management Quantitative Project Management
Engineering	Requirements Management Requirements Development Technical Solution Product Integration Verification Validation
Support	Configuration Management Process and Product Quality Assurance Measurement and Analysis Causal Analysis and Resolution Decision Analysis and Resolution

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CMMI Overview: Structure of the Continuous Representation of CMMI



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Example: Project Planning

- Purpose of example
 - Illustrate concepts of goals, practices & capability levels by showing how to rate a single process area
 - We will show for Capability Level 2.
- Project Planning Process Area
 - Practices used by project managers or team leads to create and update plans
 - Maturity Level 2 in staged representation
 - Project management category in continuous representation
 - Used as basis of tracking progress (CMMI defines this in “Project Monitoring and Control”)

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Example: What's a goal in CMMI context?

- Goal:
 - A high-level statement of the outcome to be achieved by effective implementation of a group of practices.
- Specific Goals
 - Group of *implementation practices*
 - Are specific to a process area
- Generic Goals
 - Group of *institutionalization practices*
 - Are identical across all 20-something process areas

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Example: Project Planning Purpose and Specific Goals

- *Purpose*: Establish and maintain plans that define project activities.
- *Specific Goals*:
 - SG 1: *Establish Estimates*
 - Estimates of project planning parameters are established and maintained.
 - SG 2: *Develop a Project Plan*
 - A project plan is established and maintained as the basis for managing the project.
 - SG 3: *Obtain Commitment to the Plan*
 - Commitments to the project plan are established and maintained.

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Example: Generic goals

- Generic goals are the same across all process areas
 - GG1. Achieve Specific Goals
 - Accomplish all the goals & practices for *this* process area (in example, the 3 project planning goals)
 - GG2. Institutionalize a managed process
 - GG3. Institutionalize a defined process
 - GG4. Institutionalize a quantitatively managed process
 - GG5. Institutionalize an optimizing process
- To reach capability level N, you need to meet all generic goals up to GGN.
 - Generic goals 2-5 are truly generic

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Example: Generic goals & practices for Capability Level 1

- GG1. Achieve Specific goals
 - GP1.1 Perform base practices
- Base vs. advanced practices
 - Vestige of previous system engineering model
 - *Most specific practices are “base practices”*
 - Only base practices are required to achieve GG1.
 - Advanced practices are associated with a capability level greater than 1 (system engineering model legacy)
 - Numbering in document: SPg.p-c
 - (g=goal, p=practice, c= capability level)

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Example: Project Planning Specific Goals & Specific Practices

Specific Goal	Specific Practice
<ul style="list-style-type: none"> • Establish Estimates 	<ul style="list-style-type: none"> • Estimate the Scope of the Project • Establish Estimates of Project Attributes • Define Project Life Cycle • Determine Estimates of Effort and Cost
<ul style="list-style-type: none"> • Develop a Project Plan 	<ul style="list-style-type: none"> • Establish the Budget and Schedule • Identify Project Risks • Plan for Data Management • Plan for Project Resources • Plan for Needed Knowledge and Skills • Plan Stakeholder Involvement • Establish the Project Plan
<ul style="list-style-type: none"> • Obtain Commitment to the Plan 	<ul style="list-style-type: none"> • Review Subordinate Plans • Reconcile Work and Resource Levels • Obtain Plan Commitment

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Example: Add practices for generic goal 2 to reach capability level 2

- GG 2. Institutionalize a managed process
 - GP2.1 Establish an organizational policy
 - GP2.2 Plan the process
 - GP2.3 Provide resources
 - GP2.4 Assign responsibility
 - GP2.5 Train people
 - GP2.6 Manage Configurations
 - GP2.7 Identify and Involve relevant stakeholders
 - GP2.8 Monitor and control the process
 - GP2.9 Objectively evaluate adherence
 - GP2.10 Review status with higher level management

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Example: Generic goals & practices for higher capability levels

- GG3. Institutionalize a defined process
 - GP3.1 Establish a defined process
 - GP3.2 Collect improvement information
- GG 4. Institutionalize a quantitatively managed process
 - GP4.1 Establish quantitative objectives for the process
 - GP4.2 Stabilize subprocess performance
- GG5. Institutionalize an optimizing process
 - GP5.1 Ensure continuous process improvement
 - GP5.2 Correct root causes of problems

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Assessment: Overview

- Purpose:
 - Determine organization's process capabilities with respect to a specific external benchmark
- How are they done?
 - Assess representative projects
 - Examine documents, related work products
 - Interviews of project personnel, org. management
 - transition from discovery mode to verification mode
- Types of assessments
 - Class A: organization is getting official certification
 - Other classes used to assess, but not certify

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Assessment: Process

- Preparation
 - Schedule interviews
 - *Acquire project documents & review with respect to CMMI model*
- On-site (= 1 week)
 - *Conduct interviews based on model elements*
 - Aggregate data and present draft findings
 - Make corrections, review any added material
 - Present final findings
- Follow up
 - Prepare action plans based on findings

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Assessment: scoring for continuous model

- Rate each specific & generic practice
 - Must have 2 of direct artifact, indirect artifact, or interview affirmation of practice
 - Rate as fully, largely, partially, or not implemented
- Aggregate to goal level
 - Rate as fully, largely, partially, or not implemented
 - At least half of evidence must be from interviews
- Compute Capability Level for each Process Area
 - Capability level based on which generic goals are met
 - 1st generic goal is to meet the specific goals

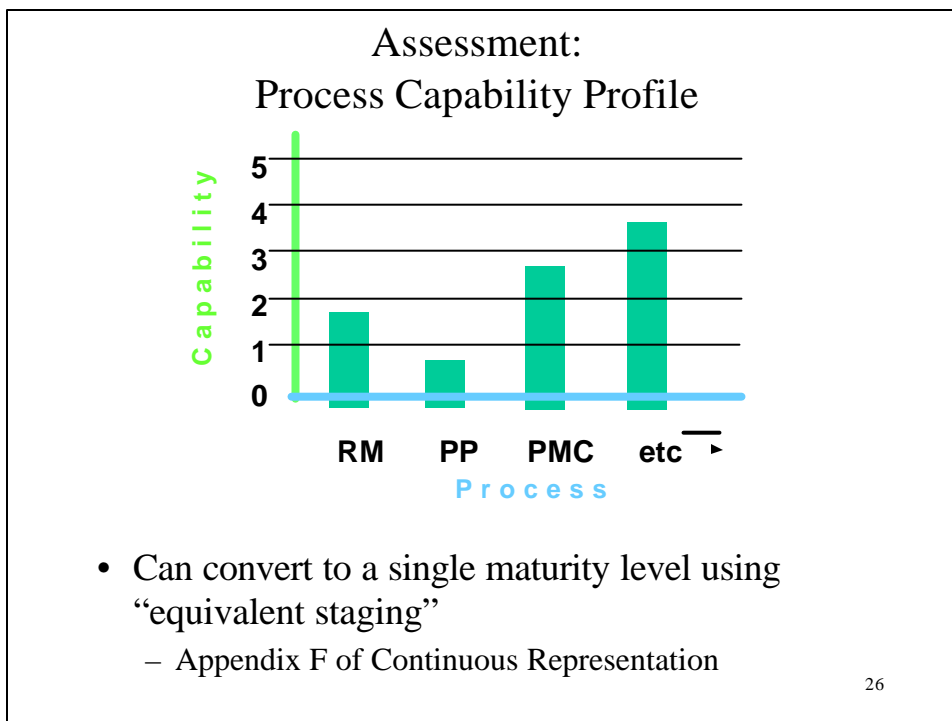
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Assessment: Process Implementation Indicator Documents (PIIDs)

REQM	Direct Artifact	Indirect Artifact	Affirmation	Char.
SP 1.1-1	Requirements Doc	Req. Q & A	PM-affirms	FI
SP 1.2-1	Signatures on Req.	Presentation Mat.		FI
SP 1.3-1	Req. Change History	Slide 11 of CDR	PM affirms	FI
SP 1.4-1	Test Matrix (partial)		PM affirms	LI
SP1.5-1		Slide 14 of CDR	Done sometimes	PI
GP 1.1	Req. Doc., DB's		PM affirms	FI
GP1.2			No org. policy	NI

Key:
 FI: Fully Implemented
 LI: Largely Implemented
 PI: Partially Implemented
 NI: Not Implemented

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CMMI Summary: Comparing the staged & continuous representations

- Both representations provide the same essential content but are organized in different ways.
 - Staged representation organizes process areas into maturity levels
 - Continuous representation organizes process areas into broader categories
- Common misconceptions:
 - Staged: don't work on levels > 2 before reaching ML 2
 - Fallacy -- you change mindset at each level
 - Continuous: can treat process areas independently
 - Fallacy -- generic practices depend on other process areas (e.g. GP2.6 Manage Configuration on CM) 27

CMMI & Experience Factory: How are they related?

- Key Experience Factory components
 - Experience base
 - Experience factory analysts
 - Measurement and modeling activities
- Related process areas: these form the “Process Management” process category
 - Organizational process definition (OPD)
 - Organizational process focus (OPF)
 - Organizational innovation & deployment (OID)
 - Organizational Process Performance (OPP)
 - Organizational Training (OT)

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CMMI & Experience Factory: The Experience Base

- OPD specific goal 1 defines experience base
 - “A set of organizational process assets are established and maintained”
- Specific practices define contents of experience base (process subset of a full experience base)
 - Organization’s set of standard processes
 - Life cycle model descriptions
 - Tailoring criteria and guidelines
 - Organization’s measurement repository
 - Organization’s process asset library

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CMMI & Experience Factory: Organizational Process Focus

- Organizational process focus (OPF)
 - SG 1 Determine process improvement opportunities
 - Includes goal setting, appraisals
 - Incorporate project experience into organization’s process assets
 - SG 2 Plan and implement process improvement activities
 - Plan, implement & deploy improvements
 - THIS IS (LOOSELY) QIP

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CMMI & Experience Factory: OID

- Organizational innovation and deployment (OID)
 - “advanced OPF” -- also can think of as following QIP
 - SG 1. Select improvements
 - Collect and analyze improvement proposals
 - Identify and analyze innovations
 - Pilot improvements
 - Select improvements for deployment
 - SG 2. Deploy improvements
 - Plan the deployment
 - Manage the deployment
 - Measure improvement effects

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CMMI, Experience Factory, Measurement & Modeling

- Measurement & CMMI
 - Why measure?
 - from 1995 NASA Measurement Guidebook
 - Understand software processes & products
 - Manage projects
 - Guide improvement
 - Organizational Process Performance (OPP)
 - SG 1. Establish performance baselines and models
 - Select processes to be analyzed
 - Establish process performance measures
 - Establish quality and process performance objectives
 - Establish process performance baselines
 - Establish process performance models

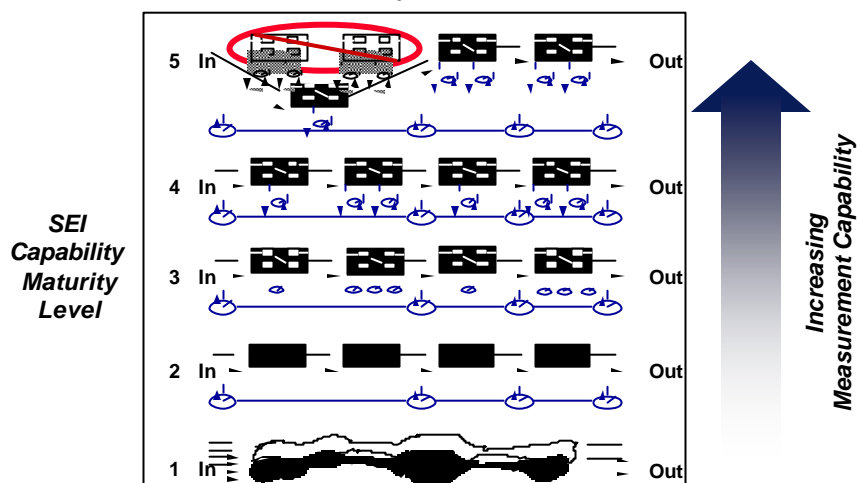
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Measurement: Modeling for process improvement

- Establish baselines
 - Level 2: measure and model at project level
 - Level 3: measure and model at organization level
- Measurement based improvement
 - Level 4: use measurement and models to *reduce variability* between projects
 - Level 5: use measurement and models to *improve mean performance* of projects

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Measurement: Modeling granularity and maturity levels



Ref: Paulk et. al. 94

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Measurement: measurement and analysis (MA) process area

- SG 1. Align measurement and analysis activities
 - Establish measurement objectives
 - Specify measures
 - Specify data collection and storage procedures
 - Specify analysis procedures
- SG 2. Provide Measurement Results
 - Collect measurement data
 - Analyze measurement data
 - Store data and results
 - Communicate results
- Supports GP2.8 “monitor & control the process”

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Measurement: Other process areas

- Levels 4 &5 are ALL about quantitative models
 - Organization Process Performance
 - Detailed baseline models used as basis for project management and driving improvement
 - Quantitative Project Management
 - Manage using baselines
 - Some statistical process control
 - Organizational Innovation & Deployment
 - Improve mean performance for process assets
 - Causal analysis & resolution
 - Identify problems and their causes using metrics

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Measurement: Benchmarking with assessments

- Maturity Level as an ordinal scale
 - 1. Ad hoc process
 - 2. Process is managed by projects
 - 3. Process managed by projects is created using organization process assets
 - 4. Process is managed by projects and organization using quantitative models
 - 5. Process improvement is supported by quantitative modeling
- Multiple levels of detail
 - Single maturity or capability level
 - Implementation ratings for goals and practices

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Lessons Learned: SEAS Process Improvement Experiences*

1. Operate as a level 5 at start
2. Set specific incremental 'gates'
3. Adopt concept of Separation of Concerns
4. Deploy processes to projects
5. Measure improvement by 'Product' not 'Process'
6. Allocate appropriate resources
7. Produce specific products early

* "Attaining Level 5 in CMM Process Maturity" – F. McGarry, W. Decker, J. Haskell, and A. Parra, Computer Sciences Corporation, Software Engineering Workshop, GSFC, December 1999

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Lessons Learned: Operate at level 5

- Don't wait until later
 - to start measurement (use a coarse model)
 - to establish process group (use Experience Factory concepts)
 - to evaluate potential changes (set an improvement goal & use GQM modeling)
- Focus from the start:
 - Goal is to improve product
 - Process and product understanding is
 - needed as baseline for improvement
 - Based on quantitative and qualitative modeling

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Lessons Learned: Experience Factory project management

- Use external benchmarks, project completion as major milestones
 - Project needs should drive detailed work planning
- It is necessary to plan for deployment
 - Writing “big honking binders” is not sufficient
 - Includes training, mentoring of project teams
- Resources
 - Effort estimates in literature vary widely; mostly depends on context, organization goals
- Deliverables
 - Organizational process assets

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Summary

- Organizational processes are defined by the organization, not the CMMI model components.
 - Organization's goals should drive
 - Process content
 - Measurement approach
 - Improvement planning
- CMMI is an assessment model
 - Think of as checklist of best practices
 - Ultimately measures that matter to organizational management are product cost and quality
 - “Capability profile” can be used to assess progress in organizational process improvement

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