

# The Evolution of High Maturity

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# Agenda

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- **Introduction**
- **In the Beginning...**
- **SW CMM**
- **CMMI V1.1**
- **CMMI V1.2**
- **CMMI V1.3**
- **The Future of High Maturity**

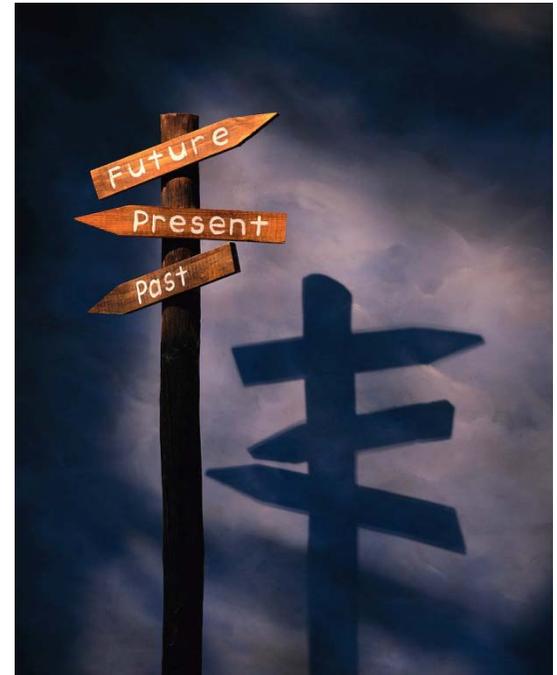
# Introduction

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**“High Maturity” has always been “special” in the world of capability maturity models.**

**High maturity concepts have been debated since the expression was first introduced.**

**This presentation will examine the evolution of high maturity principles and practice, from SW CMM days to its present CMMI incarnation and possible future states.**



# In the Beginning....

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## **Watts Humphrey – Managing the Software Process<sup>1</sup> - 1989**

- Included the “Managed” and the “Optimizing” Processes
- Described “control charts” – with UCL and LCL set at 2 std dev.
- Software Quality Models
  - “To make an accurate quality estimate, it is essential to have a quality model. While this need not be an explicit mathematical model, it should identify the basic assumptions behind the estimates.”

## **The first mention of the expression “high maturity” ....?**

- SW CMM<sup>2</sup>, 1994
- “A High-Maturity Example: Space Shuttle Onboard Software”
  - Software Quality Management and Defect Prevention
    - Defect reports per KSLOC during test/release
    - Established confidence intervals for defect detection

# SW CMM – 1994 (1)

Set an initial standard of expectations for high maturity in a capability maturity model

## Key Process Areas

### Maturity Level 4

- Quantitative Process Management (QPM)
- Software Quality Management (SQM)

### Maturity Level 5

- Defect Prevention (DP)
- Technology Change Management (TCM)
- Process Change Management (PCM)

# SW CMM – 1994 (2)

## Quantitative Process Management

- Organizational and project **goals for performance** established
  - **Process performance is stabilized** within acceptable limits
- Project process performance is controlled quantitatively
  - Expected values for mean and variance are specified for measurements that are used to characterize the process
  - “acceptable limits” for each measurement is defined based on historical data and the project’s process performance baseline is defined
  - Actual performance is compared to the “acceptable limits” (example: comparing peer review hours per KLOC to the acceptable limits)
  - Adjustments are made to bring actual performance within the defined acceptable limits
  - The organization collects process performance data from projects and uses the data to characterize the process capability
  - **Examples of analysis techniques: Pareto, trend and scatter diagrams, and control charts**

# SW CMM – 1994 (3)

## Software Quality Management

- **Quantitative quality goals** are defined
  - The capability of the processes to satisfy the quality goals is assessed
- Actual progress towards achieving the quality goals is quantified and managed.
  - Quality goals for each software life cycle stage are defined and documented
  - Actuals are compared to goals on an event driven basis (at each stage of the life cycle) ***precursor to MODELS???***

## Defect Prevention

- Focused primarily on root cause analysis of “defects”, and resulting actions

## Process Change Management and Technology Change Management

- Focused on tasks for improvement to organizational processes based on business objectives.

## Terminology

- **Process performance baseline** – actual results achieved from following a process (project level)
- **Process capability baseline** – range of expected results achieved by following a specific process. The project process performance baseline data is incorporated, as appropriate, into organizational process capability baselines. (organization level)
- **Special cause (of a defect)** – outside acceptable limits
- **Common cause (of a defect)** – expected result of using the process

## Issues

- Assessing a Level 5 Organization: Paulk and Putman<sup>3</sup>
  - QPM Issues
    - Incorrect application of statistical techniques – not calculated according to control charting principles or were thresholds set by management
    - Some control limits extremely wide – too wide to provide value
  - “Consensus was that although there were some mistakes in the analytical techniques used to control some processes, the general culture of measurement-driven decision making was good, and the analyses, both good and bad, were comparable to those of other Level 4 and 5 organizations.”

# SW CMM – 1994 (6)

## Issues

- QPM and SQM mix project and organizational responsibilities
  - SQM focus is SW quality
- DP, TCM not tied to QPM or SQM (no mention of quantitative quality goals or statistical techniques or changes to process capability/performance baselines).
- PCM does mention quantitative quality goals but not statistical techniques or changes to process capability/performance baselines).
- “A conservative stance was taken in defining Maturity Levels 4 and 5 because of the sparsity of Level 4 and 5 organizations. We have learned much about high maturity practices since then, but Levels 4 and 5 are not as clearly articulated in Version 1.1 as we might wish.”<sup>4</sup>
- Issues were planned to be addressed in SW CMM V2.0 (never released)

# CMMI V1.1 – 2001 (1)

- **Major Changes**
  - More explicit connection between subprocesses, process performance measures and quality and process performance objectives
  - Much more detail on the “measurement and analytic techniques used to statistically manage the selected subprocesses” by high maturity organizations
    - Increased emphasis on understanding special and common causes of variation and stabilizing subprocess performance
    - Statistical management involves statistical thinking and **the correct use** of a variety of statistical techniques, such as run charts, control charts, confidence intervals, prediction intervals, and tests of hypotheses.
  - Composing the defined process using historical stability and capability data
  - Clarified distinction between project level high maturity and organizational high maturity by new process areas
  - Capability Levels 4 and 5 introduced with elaborations in the generic practices
  - Explicitly included of process performance models.

## Process Areas



## Process Areas

- OPP became organizational oriented, absorbing parts of SQM and parts of PCM related to defining organizational goals and measurement plans for software process performance.
- QPM became project oriented, changing from Quantitative Process Management to Quantitative Project Management
- DP evolved to CAR
  - Emphasis slightly expanded to “defects and other problems”.
  - **“The informative material in this process area is written with the assumption that the specific practices are applied to a quantitatively managed process.”<sup>5</sup>**
  - Informative material makes connections to
    - Performing CAR when a stable process is not meeting its quality and process performance objectives
    - Evaluating the effects of a change by its impact on control charts
  - References to stable process and common cause of variation included.

# CMMI V1.1 – 2001 (4)

## Process Areas

- OID
  - Absorbed both process and technology changes from TCM and PCM
  - Purpose statement **directly ties OID to improvements that support the org's quality and process performance objectives (QPPO)s as derived from the organization's business objectives**
  - “The informative material in this process area is written with the assumption that the specific practices are applied to a quantitatively managed process.”<sup>5</sup>
  - **Includes use of process performance models** to analyze impact of process changes
  - Discriminates between simple process improvements and innovative process improvements.
  - Added a goal for deployment of improvements
  - Describes measuring the impact of deployed improvements by analyzing progress towards achieving QPPOs, **but does not reference statistical techniques or changes to process performance baselines or control charts.**

# CMMI V1.1 – 2001 (5)

- **Terminology**
  - “Quality and process performance objectives” replaced “quantitative quality goals” and “goals for the performance of the project’s defined process”
  - **Subprocesses** (defined components of a larger defined process) introduced
  - **Process performance models** introduced
  - “Process capability baseline” discarded in favor of **process performance baseline**
  - Defined **statistically managed process, quantitatively managed process**
- **Issues**
  - Continued incorrect use of control charts
  - Use of process performance models misinterpreted (cost models, deterministic defect models). Lack of acceptable examples in community.
  - Excessive reliance by CMMI on informative material to convey high maturity principles
  - Proliferation of organizations appraised to be high maturity

# CMMI V1.2 – 2006 (1)

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## Major Changes

- No major high maturity changes in the model

## Process Areas

- No new process areas

## Terminology

- No significant terminology changes

## Issues - Same as CMMI V1.1

- Continued incorrect use of control charts
- Use of process performance models misinterpreted (cost models, deterministic defect models)
- Excessive reliance by CMMI on informative material to convey high maturity principles
- Proliferation of organizations appraised to be high maturity

# CMMI V1.2 (2)

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Despite the stability of the high maturity process areas...



... a storm was brewing.

# CMMI V1.2 (3)

As the percentage of organizations appraised at higher maturity continued to grow, customer dissatisfaction grew as well.

	3/2006 M.P. SW CMM (2001-5)	3/2007 M.P. CMMI V1.1
# appraisals (cumulative by model version)	1804	1712
not given		9.0%
ML 1	5.7%	1.7%
ML 2	39.6%	32.7%
ML 3	37.4%	36.1%
ML 4	7.6%	4.2%
ML 5	9.8%	16.4%
ML4 + ML5	17.4%	20.6%

“We have five maturity levels. We know three of them work.”

Mark Schaeffer  
Office of the Under  
Secretary of Defense  
NDIA CMMI Technology  
Conference, 2007

# CMMI V1.2 (4)



And now... 11  
Frequently  
Misinterpreted  
ML 4-5  
Practices!

SCAMPI<sup>SM</sup> High Maturity Lead  
Appraiser Certification  
Announced!



Next up: High Maturity  
Misconceptions - Common  
Misinterpretations of CMMI®  
Maturity Levels 4 and 5!



Informative Material is  
Important to CMMI®  
Model Interpretation and  
Implementation



If You're Living the High  
Life You're Living the  
Informative Material!



# CMMI V1.3 – 2010 (1)

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The primary intent of this release was to “fix High Maturity” and ensure model “requirements” defined in other documents (Quality audit criteria, healthy ingredients and other presentations, Understanding CMMI High Maturity Practices training) were incorporated into the HM PAs at the goal/practice level (required/expected rather than informative).

- **Other Significant Changes across PAs**
  - CL 4 and CL 5 removed, as the full rigor of the HM PAs are needed for HM, and cannot be captured in a few generic practices.
  - Clarifying the expectation that Level 5 PAs apply to data that is quantitatively managed (Level 4).
  - Continued emphasis on business goals and objectives as the starting point for HM activities
  - Ability to create PPMs at not only the organization but also the project level.
  - Bolstered glossary definitions to support goal and practice statements
- **Changes in CMMI V1.3 were clarification-oriented, not philosophical**

## Process Areas



## Process Areas

- QPM
  - Reformatting QPM to align to the structure found in many PAs – planning in Goal 1, execution based on the plan in subsequent goals.
  - Adding a practice to perform root cause analysis in QPM
- OPP
  - Adding emphasis at the practice level on analyzing process performance data, rather than just establishing and maintaining process performance baselines and models.
- OPM
  - Evolution of OID to OPM – ensuring the impact of quantitative management is used to understand and manage business performance, and using the process performance data to maintain the quantitative business objectives that were introduced in OPP.
  - Moving from the distinction between “incremental and innovative” and “process and technology” improvements at the practice level to just “improvements”.
  - Updating the practices to include validation of process improvements, rather than the emphasis on piloting

# CMMI V1.3 – 2010 (4)

- CAR

- Replacing “defects and other problems” with “outcomes”, allowing the potential to use CAR to understand the root cause of positive as well as negative outcomes.

## Terminology

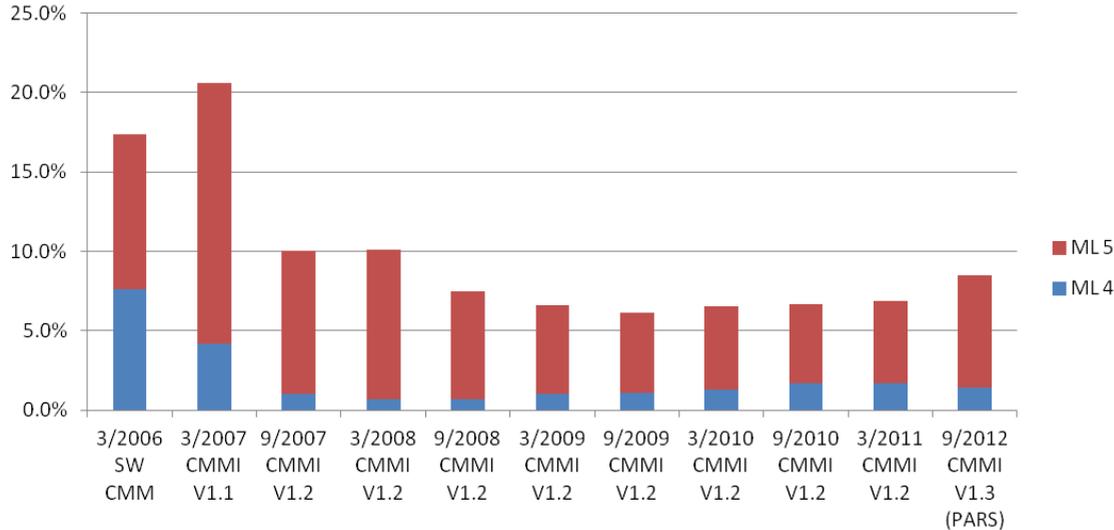
- **Moving away from defining the difference between Level 4 and Level 5 as special cause vs. common cause.**
- Reduced emphasis on “statistical techniques” – move to “statistical and other quantitative techniques”, and including the definition of “statistical and other quantitative techniques” in the glossary
- Updated definition of Process Performance Models in the glossary, including the “healthy ingredients”:
  - Description of **relationships among the measureable attributes** of **one or more processes or work products** that is **developed from historical process performance data** and is used to predict future performance
  - One or more of the measureable attributes represent **controllable inputs tied to a subprocess** to enable **performance of —what-if analyses** for planning, dynamic re-planning, and problem resolution. Process performance models include **statistical, probabilistic and simulation** based models that **predict interim or final results** by **connecting past performance with future outcomes**. They **model the variation of the factors**, and provide insight into **the expected range and variation of predicted results**. A process performance model can be a collection of models that (when combined) meet the criteria of a process performance model.

## Issues

- Is the current definition of process performance models too prescriptive?

# CMMI V1.3 (5)

## High Maturity % of CMM/CMMI Appraisals



Have the CMMI V1.3 changes made a difference?

	3/2006 M.P. SW CMM (2001-5)	3/2007 M.P. CMMI V1.1	9/2007 M.P. CMMI V1.2	3/2008 M.P. CMMI V1.2	9/2008 M.P. CMMI V1.2	3/2009 M.P. CMMI V1.2	9/2009 M.P. CMMI V1.2	3/2010 M.P. CMMI V1.2	9/2010 M.P. CMMI V1.2	3/2011 M.P. CMMI V1.2	9/2012 CMMI V1.3 (PARS)
# appraisals (cumulative by model version)	1804	1712	100	545	958	1500	2053	2753	3284	3798	1281
not given		9.0%	11.0%	6.6%	6.2%	5.8%	5.0%	4.7%	4.5%	4.2%	0.8%
ML 1	5.7%	1.7%	2.0%	1.5%	1.1%	0.8%	0.6%	0.5%	0.4%	0.4%	1.0%
ML 2	39.6%	32.7%	40.0%	33.6%	32.0%	28.5%	27.1%	25.2%	24.5%	23.7%	22.3%
ML 3	37.4%	36.1%	37.0%	43.8%	53.1%	58.3%	61.1%	63.0%	63.9%	64.8%	68.8%
ML 4	7.6%	4.2%	1.0%	0.7%	0.7%	1.0%	1.1%	1.3%	1.7%	1.7%	1.4%
ML 5	9.8%	16.4%	9.0%	9.4%	6.8%	5.6%	5.0%	5.2%	5.0%	5.2%	7.0%
ML 4+ML 5	17.4%	20.6%	10.0%	10.1%	7.5%	6.6%	6.1%	6.5%	6.7%	6.9%	8.5%

# The Future of High Maturity

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- **More focus on performance results**
- **Widen the aperture of what constitutes a process performance model**
  - Statistically-based models and tools that provide increased performance towards business objectives may not always display ALL the “essential ingredients” of the current PPM definition
    - Use of Design of Experiments and combinatorial design methods to optimize test plans
    - Statistically-based cost estimation techniques
  - Do organizations feel that in addition to performance models that add value, they also must produce models that satisfy the healthy ingredients to be appraised High Maturity, but potentially add little business value?

# Questions

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# References

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1. Paulk, Mark C., et al., *The Capability Maturity Model: Guidelines for Improving the Software Process*, Addison-Wesley, Reading, MA, 1995.
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4. Paulk, Mark C.; Goldenson, Dennis; and White, David M., “*The 1999 Survey of High Maturity Organizations*”, Software Engineering Institute, 2000, CMU/SEI-2000-SR-002.
5. CMMI® Models and Reports,  
<http://www.sei.cmu.edu/cmmi/models/>

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