Understanding CMMI Measurement Capabilities & Impact on Performance: Results from the 2007 SEI State of the Measurement Practice Survey

Dennis R. Goldenson
Software Engineering Institute

CMMI Technology Conference
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### Report Documentation Page

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<td>7th Annual CMMI Technology Conference &amp; User Group, 12-15 Nov 2007, Denver, CO.</td>
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Standard Form 298 (Rev. 8-98)  
Prescribed by ANSI Std Z39-18
Today’s Talk

Purpose & scope of the survey

Results

• The respondents & their organizations
• Measurement resources & infrastructure
• Value added by measurement
• Software measures used
• Data quality & integrity
• Organizational perspectives on software measurement

Summary, lessons learned & next steps
Understanding the State of Measurement Practice

Careful & well executed use of measurement & analysis

• Is a well accepted tenet in many fields of endeavor
• Including of course CMMI

Basic aims

• To inform management & technical decisions based on empirical evidence
• & to judge the results of those decisions once made

But, how well, and how frequently, are measurement practices put into effect in our own field?
Surveys & Benchmarking

Benchmarking: The current state

- Some professional & consulting organizations maintain repositories they use for establishing benchmarks & facilitating benchmarking activities
- However, their measures & measurement definitions differ in many ways
- In that sense, one cannot speak confidently about “industry standards”
- Which is why the SEI has launched the Performance Benchmarking Consortium {as described at last year’s CMMI Technology Conference}

The state of the practice surveys

- Aim to provide data that's not yet widely available
  - Updates of trends in typical use of measurement in software & systems engineering
  - To help projects & organizations judge their progress relative to others
- But there also will be a continuing need to track qualitative as well as quantitative descriptions about the quality & frequency of use of measurement in our field
New this year

- Screening question to identify respondents whose organizations develop software but rarely if ever do measurement
- Questions about
  - Resources & infrastructure devoted to measurement
  - Practices to ensure data quality & integrity
  - Value added by doing measurement
  - The kinds of measures used by the responding organizations

Among other things, these questions allow us to make some useful comparisons by CMMI maturity level
1\textsuperscript{st} survey described at last year's CMMI technology Conference

Similar results this year

- Moderately strong relationships exist when comparing the replies of respondents based on:
  - Management versus staff roles
  - Industry \textit{versus} government organizations
  - The United States \textit{versus} other countries
  - Organization size

But that’s a topic for another time
CMMI Measurement Capabilities & Performance Outcomes

Today’s focus

- Provide evidence about the circumstances under which measurement capabilities and performance outcomes are likely to vary
- As a consequence of achieving higher levels of CMMI maturity

Most differences are consistent with expectations based on CMMI

- Which provides confidence in the validity of the model structure & content

However, the results also highlight areas where sometimes considerable room for improvement remains

- Even at maturity levels 4 and 5
- For example
  - A rather strong overall relationship exists between maturity level & use of measures about quality attributes
  - Little attention to quality attributes at the lower maturity levels
  - Yet, almost half of maturity level 4 & 5 respondents’ organizations track quality attributes only occasionally at best
The Sample

Random sample of SEI customers

- 944 valid email invitations to participate

Data collected 20 February through 10 April 2007

- Two reminders

Response rate

- 41% completed all or part of the questionnaire
- N = 384
- Individual questions answered by 75-97% of respondents
  - ~29 – 39% of the sample invitees
Today’s Talk

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Summary, lessons learned & next steps
Role in the Organization

- Executive: 42%
- Program manager: 10%
- Project manager: 13%
- Engineer: 12%
- Programmer: 4%
- Analyst: 9%
- Other: 10%

N = 366
Who are the others?

= 8% of all those responding

Quality: 26%
Process: 20%
Process + Quality: 24%
Consultant: 15%
Management: 9%
Other Others: 6%

N = 155
And who are the other others?

<table>
<thead>
<tr>
<th>Role</th>
<th>Count</th>
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<tbody>
<tr>
<td>Process + Measurement</td>
<td>3</td>
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<tr>
<td>Measurement Specialist</td>
<td>1</td>
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<tr>
<td>Process + Quality + Measurement + Training</td>
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<tr>
<td>Quality + Process + Measurement</td>
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<td>Testing</td>
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<td>N = 31</td>
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</table>

One each:
- Administrative support
- Coach
- Consultant + researcher
- Engineering Manager + Process
- Process + Project engineer
- Program / team lead
- Program manager + Quality + Process
- Project manager + Quality
- Project manager + Engineer
- Not specified
Sector

- Commercial shrink-wrap: 7%
- Custom software development: 37%
- In-house or proprietary: 4%
- Defense contractor: 16%
- Defense or military organization: 5%
- Other government contractor: 11%
- Other government agency: 3%
- Consultancy: 11%
- Other: 13%

N = 366
FTE Staff

N = 364

Percent

50 or fewer  51-100  101-200  201-500  501-2000  More than 2000
Maturity level

N = 365
### Differences by Maturity Level: Use of Measurement in the Organization

<table>
<thead>
<tr>
<th>Maturity Level</th>
<th>N</th>
<th>Use of Measurement</th>
<th>Gamma</th>
<th>p-value</th>
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<tr>
<td>ML1 &amp; DK</td>
<td>151</td>
<td>8%</td>
<td>.73</td>
<td>&lt; .0001</td>
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<tr>
<td>ML2</td>
<td>84</td>
<td>2%</td>
<td></td>
<td></td>
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<tr>
<td>ML3</td>
<td>59</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML4 &amp; 5</td>
<td>71</td>
<td>3%</td>
<td></td>
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</table>

Don't know: 19%
Rare or never: 70%
Occasional: 22%
Routine: 75%

Gamma = .73
Interpreting the results:  
The Respondents’ Measurement Roles

<table>
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<th>Measurement Level (ML)</th>
<th>User</th>
<th>Provider</th>
<th>Both</th>
<th>Neither</th>
<th>Other</th>
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<tr>
<td>ML1 &amp; DK</td>
<td>13%</td>
<td>8%</td>
<td>50%</td>
<td>12%</td>
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<tr>
<td>ML2</td>
<td>23%</td>
<td>17%</td>
<td>38%</td>
<td>17%</td>
<td>11%</td>
</tr>
<tr>
<td>ML3</td>
<td>17%</td>
<td>17%</td>
<td>51%</td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>ML4 &amp; 5</td>
<td>14%</td>
<td>9%</td>
<td>61%</td>
<td>12%</td>
<td>11%</td>
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</table>

N = 151
N = 84
N = 59
N = 70
p = .04
Today’s Talk

Purpose & scope of the survey

Results

- The respondents & their organizations
- **Measurement resources & infrastructure**
- Value added by measurement
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- Organizational perspectives on software measurement

Summary, lessons learned & next steps
How Measurement Work is Staffed

ML1&DK
N = 78

p < .006

3%, 1%, 2% & 3% respectively

Other
Don’t know
Organization
wide group
Project
level
A few key
experts

ML2
N = 60

ML3
N = 58

ML4&5
N = 60

41%
33%
20%
7%
13%
20%
28%
30%
50%
19%
34%
28%
34%
12%
13%
9%

Earmarked Budgets for Measurement

N = 76
ML1&DK
72%
21%
7%

N = 68
ML2
18%
65%

N = 50
ML3
22%
56%

N = 61
ML4&5
28%
34%
38%

p < .0001

Don’t know
No
Yes
Availability of Qualified Measurement Staff

ML1&DK N = 76
ML2 N = 65
ML3 N = 50
ML4&5 N = 61

Gamma = .44  p < .0001
Similar Results

For:

- Automated measurement support for data collection, data management, data analysis & reporting
- Use of commercial measurement packages & tools
- Existence of common, integrated organizational measurement repositories
- Availability of measurement related training

Proportions sometimes vary across the distributions.

But there are consistent differences by maturity level.
Today’s Talk

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Summary, lessons learned & next steps
Effects of Measurement on the Organizations

Better Project Performance

- ML1&DK: 26% always or frequently, 50% half time or on occasion, 24% rare, never, worse, DK or NA
- ML2: 12% always or frequently, 40% half time or on occasion, 49% rare, never, worse, DK or NA
- ML3: 20% always or frequently, 40% half time or on occasion, 35% rare, never, worse, DK or NA
- ML4&5: 27% always or frequently, 70% half time or on occasion, 7% rare, never, worse, DK or NA

Gamma = .41, p < .0001

Better Product Quality

- ML1&DK: 26% always or frequently, 49% half time or on occasion, 26% rare, never, worse, DK or NA
- ML2: 13% always or frequently, 38% half time or on occasion, 34% rare, never, worse, DK or NA
- ML3: 22% always or frequently, 44% half time or on occasion, 48% rare, never, worse, DK or NA
- ML4&5: 7% always or frequently, 63% half time or on occasion, 7% rare, never, worse, DK or NA

Gamma = .34, p < .0002
### Better Tactical Decisions

- **ML1&DK**: N = 74, Gamma = .35, p = .0001
- **ML2**: N = 59, 27% (Rare, never, worse, DK or NA), 20% (Half time or on occasion), 57% (Always or frequently)
- **ML3**: N = 50, 26% (Rare, never, worse, DK or NA), 36% (Half time or on occasion), 38% (Always or frequently)
- **ML4&5**: N = 56, 9% (Rare, never, worse, DK or NA), 38% (Half time or on occasion), 54% (Always or frequently)

### Better Strategic Decisions

- **ML1&DK**: N = 74, Gamma = .31, p = .0008
- **ML2**: N = 59, 38% (Rare, never, worse, DK or NA), 41% (Half time or on occasion), 46% (Always or frequently)
- **ML3**: N = 49, 39% (Rare, never, worse, DK or NA), 39% (Half time or on occasion), 35% (Always or frequently)
- **ML4&5**: N = 55, 35% (Rare, never, worse, DK or NA), 39% (Half time or on occasion), 49% (Always or frequently)
Today’s Talk

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Summary, lessons learned & next steps
Project & Organizational Measurement Results Reported

### Cost Performance

- **Rarely, never, DK, or NA**
  - ML1&DK: 23%
  - ML2: 24%
  - ML3: 27%
  - ML4&5: 25%
- **Occasionally**
  - ML1&DK: 33%
  - ML2: 38%
  - ML3: 38%
  - ML4&5: 53%
- **Frequently**
  - ML1&DK: 23%
  - ML2: 38%
  - ML3: 38%
  - ML4&5: 15%
- **Regularly**
  - ML1&DK: 21%
  - ML2: 11%
  - ML3: 10%
  - ML4&5: 11%

Gamma = .25, p < .03

### Schedule Performance

- **Rarely, never, DK, or NA**
  - ML1&DK: 14%
  - ML2: 19%
  - ML3: 34%
  - ML4&5: 48%
- **Occasionally**
  - ML1&DK: 7%
  - ML2: 11%
  - ML3: 16%
  - ML4&5: 16%
- **Frequently**
  - ML1&DK: 11%
  - ML2: 34%
  - ML3: 73%
  - ML4&5: 61%
- **Regularly**
  - ML1&DK: 33%
  - ML2: 48%
  - ML3: 19%
  - ML4&5: 16%

Gamma = .37, p = .0006
Project & Organizational Measurement Results Reported

Business Growth & Profitability

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<th>ML3 N = 45</th>
<th>ML4 &amp; 5 N = 51</th>
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<td>22%</td>
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<td>Occasionally</td>
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<tr>
<td>Regularly</td>
<td>16%</td>
<td>22%</td>
<td>24%</td>
<td>33%</td>
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Gamma = .20  p = .2244
Product & Quality Measurement Results Reported

Requirements / Architectures

- Rarely, never, DK, or NA
- Occasionally
- Frequently
- Regularly

<table>
<thead>
<tr>
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<th>ML2 N = 55</th>
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Quality Attributes

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<th>ML3 N = 45</th>
<th>ML4&amp;5 N = 52</th>
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<tr>
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<td>16%</td>
<td>18%</td>
<td>18%</td>
<td>31%</td>
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</table>
### Defect Density

- **ML1&DK**
  - N = 70
  - 30% (Rarely
  - 13% (Never, DK, or NA)
  - 11% (Occasionally)
  - 34% (Frequently)
  - 20% (Regularly)
  - Gamma = .41
  - p < .0001

- **ML2**
  - N = 56
  - 31% (Rarely
  - 23% (Never, DK, or NA)
  - 16% (Occasionally)
  - 51% (Frequently)
  - 22% (Regularly)
  - Gamma = .41
  - p < .0001

- **ML3**
  - N = 45
  - 11% (Rarely
  - 22% (Never, DK, or NA)
  - 16% (Occasionally)
  - 58% (Frequently)
  - 33% (Regularly)
  - Gamma = .44
  - p < .0001

- **ML4&5**
  - N = 52
  - 4% (Rarely
  - 6% (Never, DK, or NA)
  - 11% (Occasionally)
  - 33% (Frequently)
  - 22% (Regularly)
  - Gamma = .44
  - p < .0001

### Defect Phase Containment

- **ML1&DK**
  - N = 70
  - 50% (Rarely
  - 29% (Occasionally)
  - 23% (Frequently)
  - 27% (Regularly)
  - Gamma = .44
  - p < .0001

- **ML2**
  - N = 56
  - 30% (Rarely
  - 27% (Occasionally)
  - 29% (Frequently)
  - 20% (Regularly)
  - Gamma = .44
  - p < .0001

- **ML3**
  - N = 45
  - 27% (Rarely
  - 27% (Occasionally)
  - 29% (Frequently)
  - 13% (Regularly)
  - Gamma = .44
  - p < .0001

- **ML4&5**
  - N = 51
  - 8% (Rarely
  - 29% (Occasionally)
  - 29% (Frequently)
  - 14% (Regularly)
  - Gamma = .44
  - p < .0001
Customer Satisfaction

<table>
<thead>
<tr>
<th>Level</th>
<th>Rarely, never, DK, or NA</th>
<th>Occasionally</th>
<th>Frequently</th>
<th>Regularly</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML1 &amp; DK</td>
<td>23%</td>
<td>13%</td>
<td>11%</td>
<td>12%</td>
</tr>
<tr>
<td>ML2</td>
<td>24%</td>
<td>29%</td>
<td>14%</td>
<td>10%</td>
</tr>
<tr>
<td>ML3</td>
<td>36%</td>
<td>21%</td>
<td>49%</td>
<td>48%</td>
</tr>
<tr>
<td>ML4 &amp; 5</td>
<td>17%</td>
<td>38%</td>
<td>49%</td>
<td>24%</td>
</tr>
</tbody>
</table>

N = 70
Gamma = .31
p < .005
Similar Results

For:

- Adherence to work processes
- Effort applied to task
- Estimation accuracy
- Cycle time

Proportions sometimes vary across the distributions.
But there are consistent differences by maturity level.
Today’s Talk

Purpose & scope of the survey

Results

• The respondents & their organizations
• Measurement resources & infrastructure
• Value added by measurement
• Software measures used
• **Data quality & integrity**
• Organizational perspectives on software measurement

Summary, lessons learned & next steps
Differences by Maturity Level: Practices to Ensure Data Quality

Statistical estimates of measurement error

- ML1&DK: N = 74, 61% (Gamma = .44, p < .0001)
- ML2: N = 56, 59%
- ML3: N = 47, 47%
- ML4&5: N = 51, 14%

- ML1&DK: 27% (Gamma = .44, p < .0001)
- ML2: 23%
- ML3: 30%
- ML4&5: 49%

Checks for inconsistent interpretation

- ML1&DK: N = 74, 43% (Always or frequently)
- ML2: N = 57, 25%
- ML3: N = 48, 25%
- ML4&5: N = 50, 20%

- ML1&DK: 31% (Half time or on occasion)
- ML2: 46%
- ML3: 38%
- ML4&5: 74%
Differences by Maturity Level: Practices to Ensure Data Quality

Checks for unusual distribution patterns

- ML1&DK: 39% (N = 74), 31% (N = 58), 25% (N = 48), 12% (N = 51)
- ML2: 28% (N = 33), 33% (N = 31), 36% (N = 44), 44% (N = 25)
- ML3: 32% (N = 36), 36% (N = 31), 44% (N = 86)
- ML4&5: 86% (N = 31)

- Rarely, never, or DK: 2%
- Half time or on occasion: 33%
- Always or frequently: 67%

Gamma = .46
p < .0001
Similar Results

For:

- Out of range & illegal values ... Number & distribution of missing data
- Missing data not treated as zero ... Precision & accuracy tests
- Other aspects of alignment & coordination of measurement activities
  - Understandable & consistent measurement definitions
  - Understandable & interpretable measurement results
  - Use of “standard” measurement methods
  - Measurable product & service criteria
  - Measurement used to understand product & service quality
  - Documented data collection process
  - Documented process for reporting results
  - Corrective action taken when thresholds exceeded
  - Understands purposes of the data collected/reported

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Organizational Perspectives

Not Relevant for Decision Making

- ML1&DK: 23%, N = 102, Gamma = .27, p = .0002
- ML2: 28%, N = 61, 10%
- ML3: 21%, N = 41, 22%
- ML4&5: 55%, N = 53, 59%

Onerous or Burdensome

- ML1&DK: 4%, N = 110, 9%
- ML2: 14%, N = 67, 31%
- ML3: 24%, N = 45, 31%
- ML4&5: 11%, N = 52, 19%

Hardly at All

- ML1&DK: 30%, N = 102, 2%
- ML2: 22%, N = 61, 2%
- ML3: 23%, N = 41, 8%
- ML4&5: 23%, N = 53, 6%

Limited

- ML1&DK: 6%, N = 102, 5%
- ML2: 31%, N = 61, 25%
- ML3: 33%, N = 41, 34%
- ML4&5: 37%, N = 53, 44%

Some

- ML1&DK: 55%, N = 102, 34%
- ML2: 28%, N = 61, 35%
- ML3: 29%, N = 41, 34%
- ML4&5: 22%, N = 53, 55%

Largely

- ML1&DK: 20%, N = 102, 9%
- ML2: 29%, N = 61, 9%
- ML3: 5%, N = 41, 4%
- ML4&5: 8%, N = 53, 3%
Similar Results

For:

• Stated negatively
  – Inappropriate collection & use of data
  – Resistance to “extra” work
• Stated positively
  – Understandable & interpretable results
  – Data collected are regularly analyzed
  – Measurement an integral part of the business
  – Objective results highly valued

Once again:

• Proportions sometimes vary across the distributions.
• But there are consistent differences by maturity level.

Yet resistance to measurement still exists in our field.

• Even in high maturity organizations
Today’s Talk

Purpose & scope of the survey

Results

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Summary, lessons learned & next steps
Summary of Results

Characteristic differences associated with CMMI Maturity level achieved

- Measurement capability & performance outcomes
- Common stair step pattern up the maturity levels
- Some quite substantial

Still, some of the results imply room for improvement

- Sometimes substantial room

Even in higher maturity organizations

- Although the expectations for quality & “goodness” may well be higher there too
- Jim Herbsleb & I saw a similar pattern years ago
  - For process champions versus practitioners & managers
The Future

Relatively little data yet exist for meaningful comparisons among software & systems engineering projects & organizations

- Hence tendency to cover too much at once in a single sample survey

Considering variants on matrix sampling strategies for 2008 survey

- Answer only a subset of questions ... to avoid over-burdening the respondents

“State of the practice” can refer to very different target populations

- The SEI customer base ... the broader software & systems engineering community ... or those organizations that more routinely use measurement?
- Of course, the answer depends on the purposes of the survey
Next Steps

Our plans

• We will track change over time & go into further depth about focused topics from the perspective of current measurement practitioners

Considering parallel samples for 2008

• A short set of questions for tracking the diffusion of measurement through the broader software & systems engineering community

• Possible focus on issues faced with respect to the adoption & use of high maturity measurement practices

Also fielding a survey on Program Office acquisition capabilities (early 2008)

Of course, there is no shortage of additional topics for the future

• In the SEI series or in those that we hope to see done by others
Thank You for Your Attention!

Dennis R. Goldenson
dg@sei.cmu.edu

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213-3890
USA