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Software Engineering Institute

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Measuring Performance: Evidence about the Results of CMMI®

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Today's Talk



Measuring Performance: Why Care? What Counts?

Summary of existing results

More detailed results: Maturity Levels 2 & 3

More detailed results: High Maturity

Current Directions

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Why Measure Performance Outcomes of CMMI?

Initially ...

- To verify that there was value in beginning to use CMMI, in comparison to the SW-CMM

Over the more recent period ...

- To provide ongoing objective evidence about the value of CMMI

In general:

- To support evidentially based continuous process improvement



Why Objective Evidence?

Trustworthy Evidence is Essential for:

- Addressing skepticism about the benefits of any model-based process improvement
- Demonstrating the value of CMMI over its source models

But also for:

- Building commitment & obtaining resources
- Providing input to improve processes & technologies
- Comparing results with other organizations
- Enhancing quantitative management
- Informing the development & evolution of the CMMI Product Suite



What is Legitimate Evidence?

Measured performance results due to:

- Adoption or upgrade to CMMI
- Systems engineering & other “new” model content
- Broadened organizational scope across disciplines
 - Especially integration of software & systems
- Maturity or capability improvement initiatives
 - Comprehensive or selected processes
- Improvement in areas originally defined by the SW-CMM

They're all pertinent ... just different

- It depends on your purpose which ones are of interest
- Be careful to specify your purposes...



What Does it Mean to “Implement” CMMI?

An organization’s processes are not the same as model processes!

- Organizational units implement & institutionalize processes for many reasons
 - Often based on multiple sources & perspectives
- Processes based on the same model can differ widely
- Processes are implemented to achieve different goals and outcomes

Questions:

- Can we expect to find common measures of performance?
- When do we need the common measures?



Are Quantitative Results Enough?

Need more context to make the quantitative results meaningful

- Can we do that without revealing proprietary or other sensitive information?

Need enough detail to describe what was done:

- What improvements have been made?
- Why were these improvements chosen?
- How are the results used?



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Reports & Tutorials

Demonstrating the Impact and Benefits of CMMI®: An Update and Preliminary Results, Special Report, CMU/SEI-2003-SR-009, Software Engineering Institute October 2003.

Conference presentations & posters

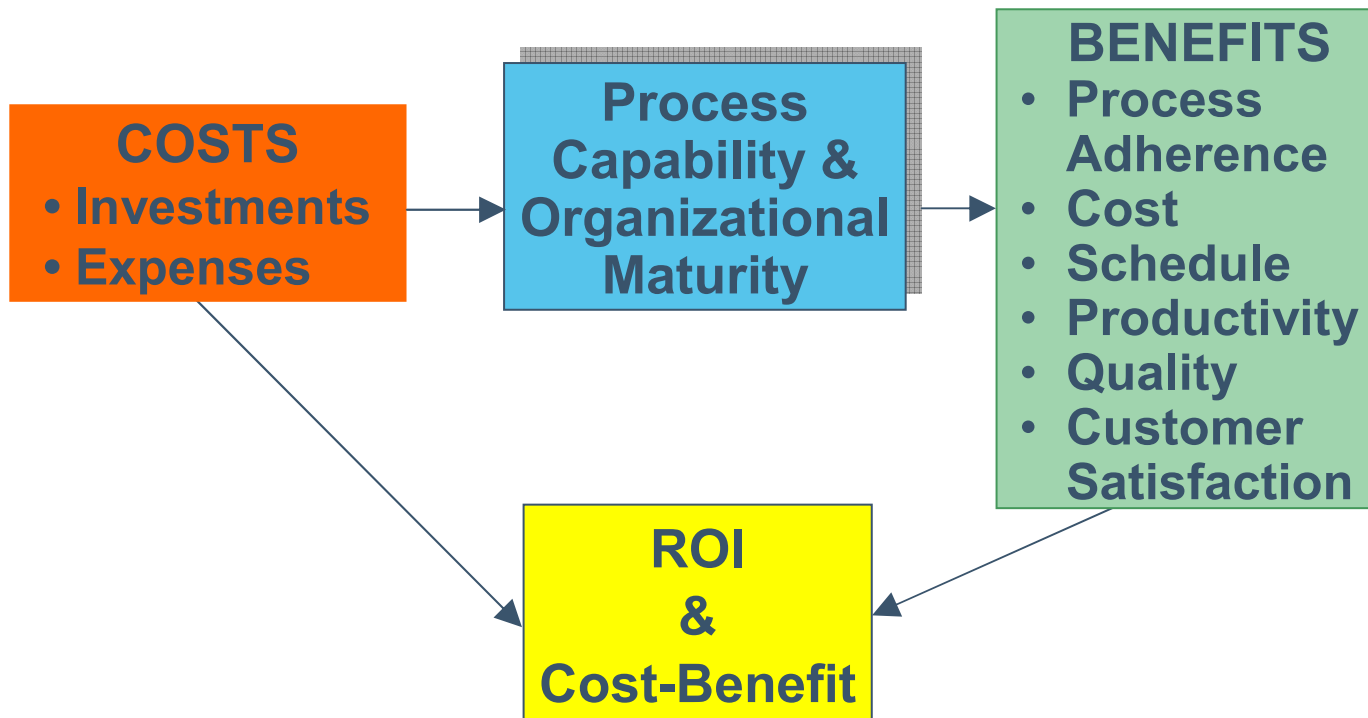
Tutorials:

- Guidance about scoping & calculating ROI analyses
- Processes & models for estimating ROI proactively

Benchmarking CMMI Cost and Impact: Interim Report, December 2004 (Distribution of full document limited to benchmark contributors.)



A Framework of Costs & Benefits





The Documented Results So Far

Evidence from

- Conference presentations
- Published papers
- Direct communication with the SEI

How Trustworthy?

- Public reports from appraised organizations
- Private communications
- Information reviewed by SEI technical staff

Results are drawn from 30 organizations

- Several of which are larger enterprises with more than one constituent organization

Performance Results Summary

Improvements	Median	# of data points	Low	High
Cost	20%	21	3%	87%
Schedule	37%	19	2%	90%
Productivity	67%	16	11%	255%
Quality	50%	18	29%	132%
Customer Satisfaction	14%	6	-4%	55%
Return on Investment	4.8 : 1	14	2 : 1	27.7 : 1

- N = 24, as of 9 November 2005
- Organizations with results expressed as change over time



Existing Measures and Bases for Comparison Differ: Some Caveats

Performance categories combine results from a wide variety of cases

- Ranging from pilot projects about the effects of particular processes
- To organization-wide improvement initiatives covering the full scope of CMMI

Other factors sometimes occur simultaneously with CMMI-based process improvement

- E.g., reuse, personnel changes or new technologies

Specific measures differ as well

- E.g., total cost or cycle time *versus* discrepancies between estimates & actuals



However...

Valid & valuable comparisons can be made

- So long as we distinguish properly among them

Varied cases & measures provide ample proof of concept

- About the potential of CMMI-based process improvement

The same results may not always be repeatable elsewhere

- But, we often see very impressive performance effects
- The probability is very low that such results are due to chance alone

Multi trait, multi method



Variety in measures: Cost

Measures included:

Reductions in

- costs
- cost of quality
- poor quality
- costs of rework
- cost of delivery accuracy
- defect find & fix costs
- variation in CPI
- overhead rate
- software unit costs
- #/cost of process staff

Savings in/due to

- implementing hardware processes

Improved

- budget estimation
- average CPI
- cost variance



Variety in measures: Schedule

Measures included:

Reductions in

- variation in schedule
- performance index (SPI)
- # of days late
- days variance from plan
- slippage of project delivery
- schedule variance

Improved/increased

- average (SPI)
- estimation accuracy (III)
- schedule variance (II)
- % of milestones met
- cycle time (II)



Variety in measures: More Examples₁

Productivity measured in, for example:

- ELOC per labor hour
- function point per FTE
- source statements per month
- testing
- # of releases per year
- comparisons between builds
- software production, in general

Quality measured in

- Defects (different products, stages of the life cycle)



Variety in measures: More Examples₂

Customer Satisfaction measured with

- Award fees
- Ratings

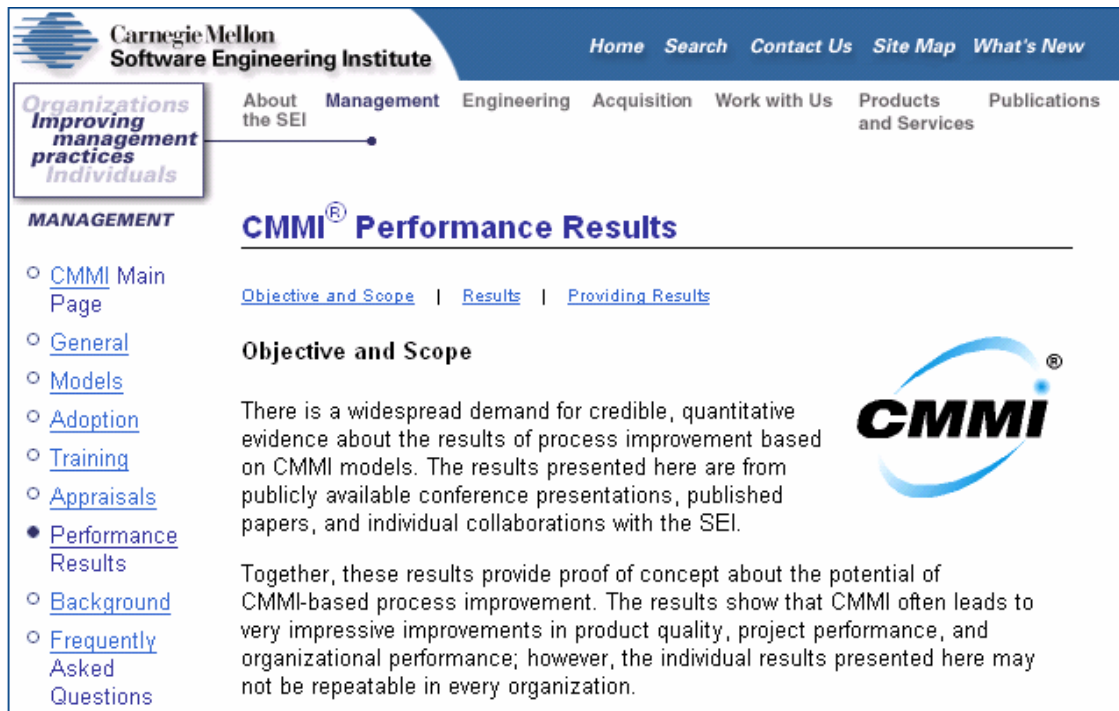
ROI

- Defects avoided
- Post-release defects avoided
- Automation
- Quality activities
- Process Improvement in general
- Maturity Level, in general

CMMI Performance Results Web Site₁

Results by: <http://www.sei.cmu.edu/cmml/results.html>

- Performance category & organization
- Brief statements & graphical examples
- Full source documents



The screenshot shows the Carnegie Mellon Software Engineering Institute website. The header includes the logo and navigation links: Home, Search, Contact Us, Site Map, and What's New. A secondary navigation bar lists: About the SEI, Management, Engineering, Acquisition, Work with Us, Products and Services, and Publications. A sidebar on the left contains a menu with items: CMMI Main Page, General, Models, Adoption, Training, Appraisals, Performance Results (highlighted with a blue dot), Background, and Frequently Asked Questions. The main content area is titled "CMMI® Performance Results" and includes sub-links for "Objective and Scope", "Results", and "Providing Results". The "Objective and Scope" section contains text about the demand for credible evidence and the CMMI logo.

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MANAGEMENT


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CMMI® Performance Results

[Objective and Scope](#) | [Results](#) | [Providing Results](#)

Objective and Scope

There is a widespread demand for credible, quantitative evidence about the results of process improvement based on CMMI models. The results presented here are from publicly available conference presentations, published papers, and individual collaborations with the SEI.



Together, these results provide proof of concept about the potential of CMMI-based process improvement. The results show that CMMI often leads to very impressive improvements in product quality, project performance, and organizational performance; however, the individual results presented here may not be repeatable in every organization.

CMMI Performance Results Web Site₂

View by Organization

The performance results examples contain brief assertion statements and their sources and sometimes are accompanied by graphic illustrations. To view all examples for an organization, click the name of the organization.

Organization

[Accenture](#)

[Anonymous 1](#)

[Anonymous 2](#)

[DB Systems GmbH](#)

[Fire Support Software Engineering Division](#)

[General Dynamics Advanced Information Systems](#)

[General Motors](#)

[Harris Corporation](#)

[IBM Australia Application Management Services](#)

[JPMorgan Chase](#)

[Lockheed Martin Corporation](#)

[Lockheed Martin Management and Data Systems](#)

[Lockheed Martin Maritime Systems & Sensors – Undersea Systems](#)

[Lockheed Martin Maritime Systems and Sensors – Radar Systems](#)

[Lockheed Martin Maritime Systems and Sensors – Syracuse](#)

[Lockheed Martin Systems Integration](#)

[Motorola Global Software Group](#)

[NCR](#)

[Northrop Grumman IT, Defense Enterprise Solutions](#)

[Raytheon Corporation, Anonymous site](#)

[Raytheon Network Centric Systems](#)

[Raytheon North Texas Software Engineering](#)

[Reuters](#)

[SAIC System and Network Solutions Group](#)

[Siemens Information Systems Ltd.](#)

[Systematic Software Engineering](#)

[TATA Consultancy Services](#)

[Thales Air Traffic Management](#)

[The Boeing Company](#)

[Warner Robins](#)



CMMI Performance Results Web Site₃

CMMI[®] Performance Results

IBM Australia Application Management Services

The performance results examples contain brief assertion statements and their sources and sometimes are accompanied by graphic illustrations. To view the graphic or source for a statement, click the View link.

[Cost](#) | [Schedule](#) | [Productivity](#) | [Quality](#) | [Customer Satisfaction](#) |

Cost

Assertion Statement

[View](#) On-budget delivery improved from over 90 percent to nearly 100 percent as the organization moved from SW-CMM maturity level 3 to CMMI maturity Level 5

[top ▲](#)

Schedule

Assertion Statement

[View](#) On-time delivery remained well over 90 percent, with a slight improvement, as the organization moved from SW-CMM maturity level 3 to CMMI maturity level 5

[top ▲](#)

Productivity

Assertion Statement

[View](#) \$99 million dollars saved in development costs due to increased productivity as the organization moved from SW-CMM maturity level 3 toward CMMI maturity level 5

[View](#) \$103 million dollars saved in maintenance costs due to increased productivity as the organization moved from SW-CMM maturity level 3 toward CMMI maturity level 5

[View](#) Over 20 percent improvement in account productivity as the organization moved from SW-CMM maturity level 3 toward CMMI maturity level 5

[top ▲](#)

Quality

Assertion Statement

[View](#) 40 percent reduction in all production problems as the organization moved from SW-CMM maturity level 3 toward CMMI maturity level 5

[View](#) On average, over 95 percent of problems were closed monthly within the customer-specified time frame after the organization achieved CMMI maturity level 5

[View](#) Over 80 percent reduction in Severity 1 problems as the organization moved from SW-CMM maturity level 3 toward CMMI maturity level 5

[top ▲](#)

Customer Satisfaction

Assertion Statement

[View](#) Customer satisfaction remained well over 80 percent after the organization achieved CMMI maturity level 5

[top ▲](#)

Example

CMMI Performance Results Web Site₄

CMMI® Performance Results

Assertion Statement Detail

Statement

Over 20 percent improvement in account productivity as the organization moved from SW-CMM maturity level 3 toward CMMI maturity level 5

Organization

IBM Australia Application Management Services

Graphic

Performance Measure: Productivity

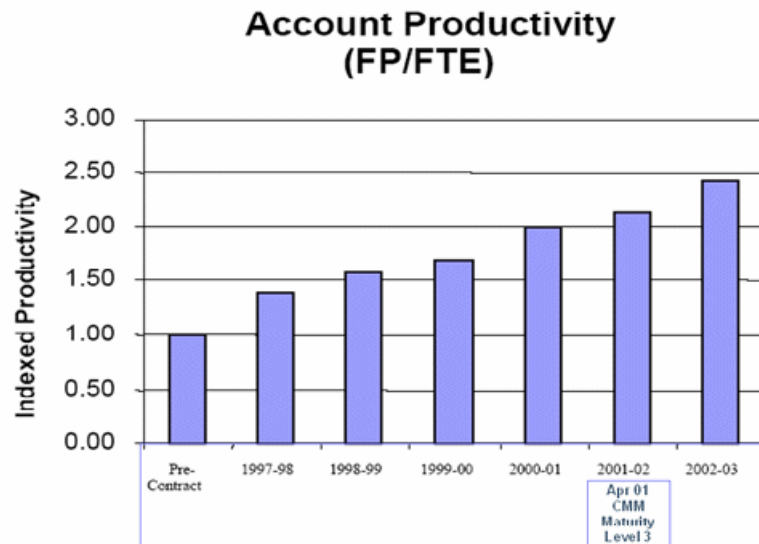


Figure 8: Account Productivity (FP/FTE)

Maturity Level
Notation
added by SEI

Source

IBM Australia Application Management Services. *Software Process Improvement Journey: IBM Australia Application Management Services*. A Report from the Winner of the 2004 Software Process Achievement Award (CMU/SEI-2005-TR-002). Nichols, Robyn & Connaughton, Colin. Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University, 2005.

[View](#)



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Statements, Organizations at ML 2 & 3₁

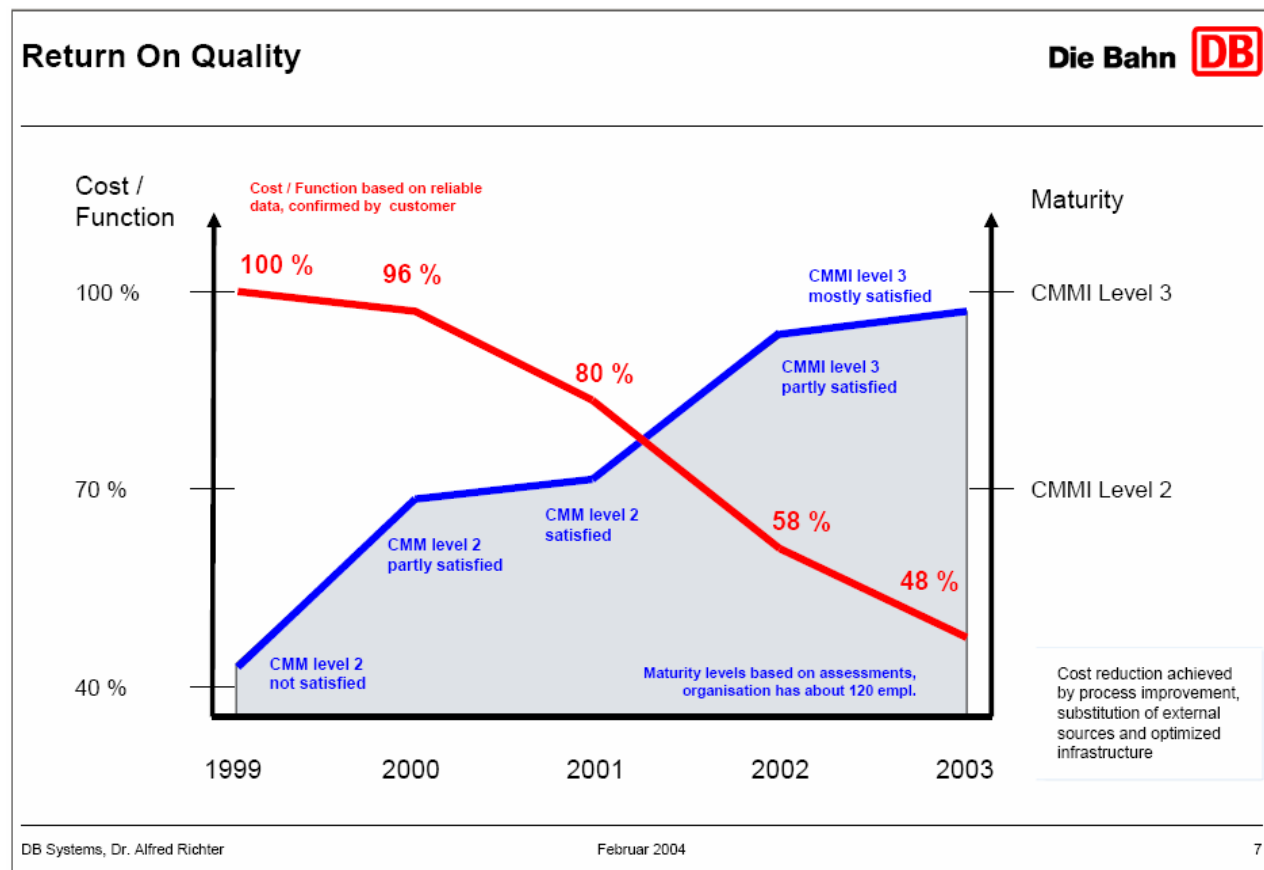
Costs

- Reduced **rework costs** by 42% at CMMI Maturity Level 3 (Raytheon)
- \$2.1 Million in **savings** in hardware engineering processes in an organization moving towards CMMI maturity level 3 (Anonymous)
- From a 1999 baseline prior to improvement, **costs** dropped 48% by 2003, as the organization moved toward CMMI ML3. (DB Systems GmbH)



Performance Measure: Cost

Costs dropped 48 percent from a baseline prior to SW-CMM ML2 as the organization moved toward CMMI ML3





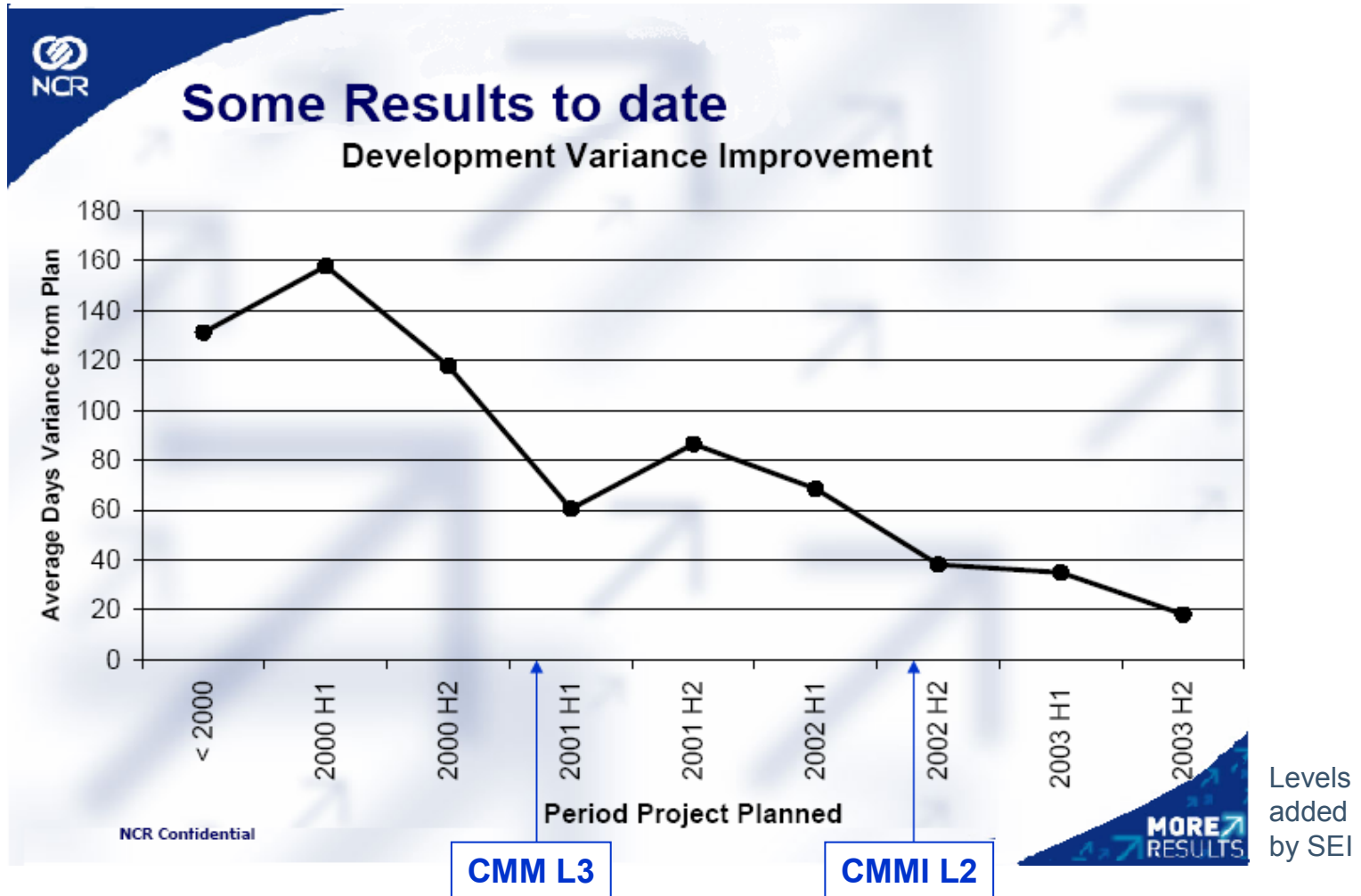
Statements, Organizations at ML 2 & 3₂

Schedule

- Percentage of **milestones met** improved from approximately 50% to approximately 85% following organization focus on CMMI (General Motors)
- Average **variance** from development plan reduced from approximately 60 days to less than 20 days one year after reaching CMMI Maturity Level 2 (NCR)
- Reduced **schedule variance** over 20 percent in an organization moving towards CMMI maturity level 3 (Anonymous)
- Increased **through-put** resulting in more releases per year at CMMI maturity level 3 (JP Morgan Chase)
- Achieved 95 percent **on time delivery** in an organization moving towards CMMI maturity level 3 (Anonymous)



Performance Measure: Schedule





Statements, Organizations ML 2 & 3₃

Productivity

- Used Measurement & Analysis Process Area to realize an 11 percent increase in **productivity**, corresponding to \$4.4M in additional value (Anonymous)

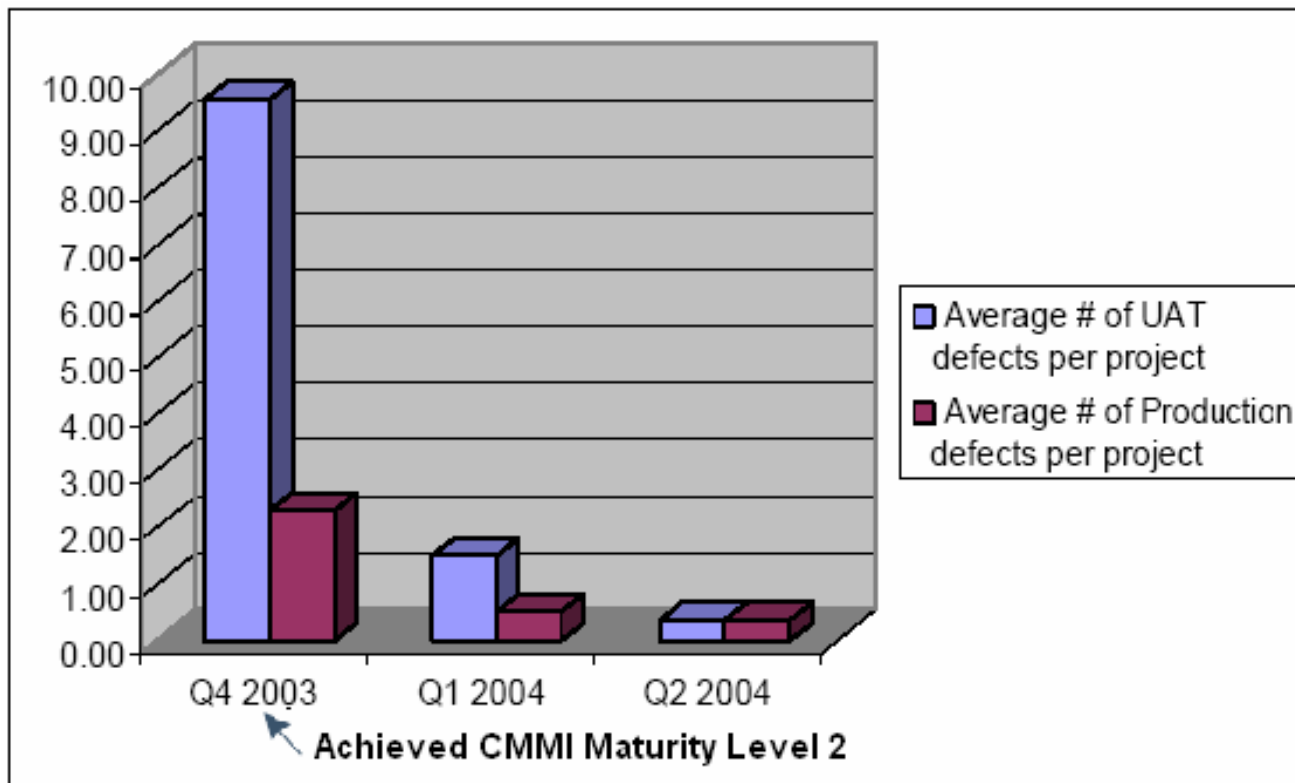
Quality

- Reduction in number and severity of **post release defects** at CMMI ML2 (Anonymous)
- More than 80% **drop in defects** in 6 months after achieving CMMI Maturity Level (JP Morgan Chase)
- 44% **defect reduction** following causal analysis cycle at an organization moving towards CMMI maturity level 3 (Anonymous)



Performance Measure: Quality

Asia Treasury and Credit Rates achieved CMMI level 2 at the end of 2003. In the subsequent 6 months their average number of UAT & production defects dropped by more than 80% (18 projects)





Statements, Organizations at ML 2 & 3₄

ROI

- Used Measurement & Analysis Process Area to realize a 2.5:1 ROI over 1st year, with benefits amortized over less than 6 months (Anonymous)

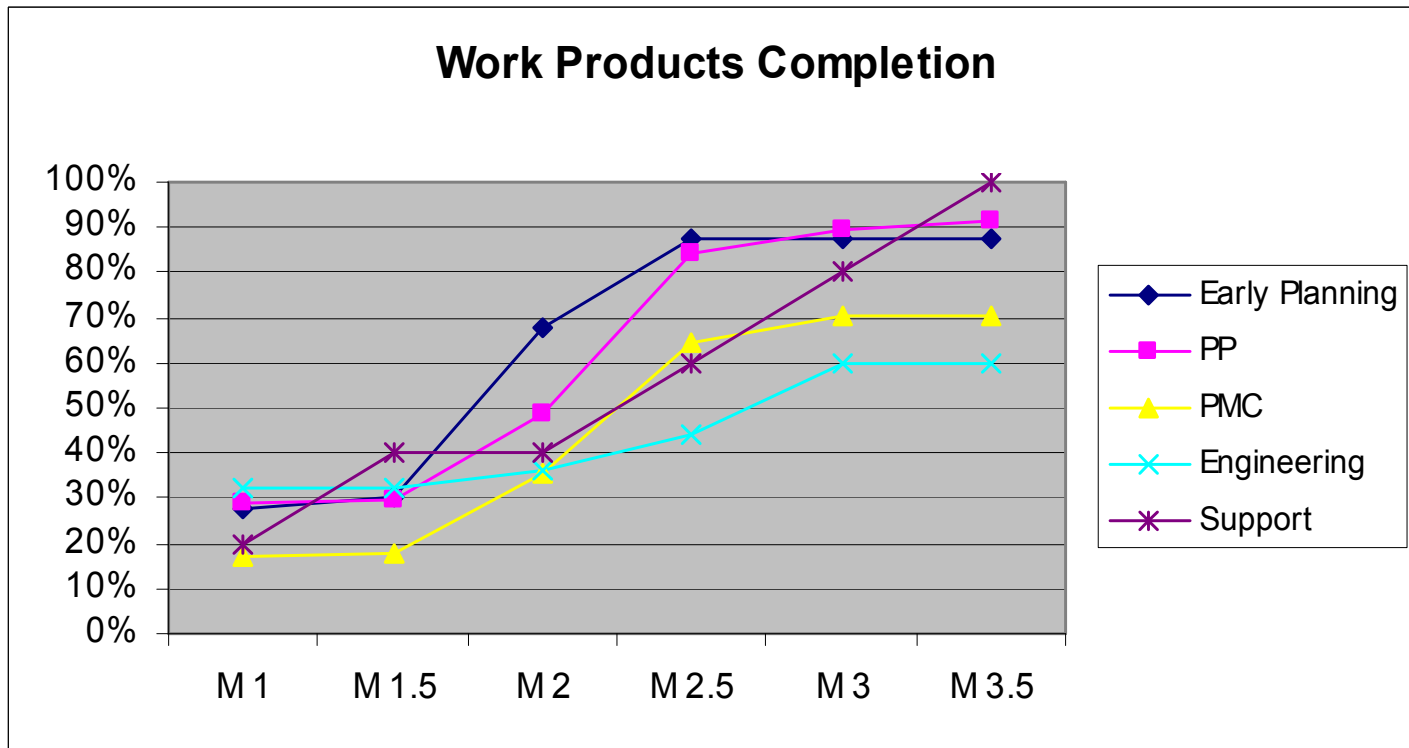
Process Adherence*

- Marked improvements in work product completion after new training instituted on the way to CMMI Maturity Level 3 (CMS Information Systems, Inc.)

* Evidence of this kind is crucial for a better understanding how process changes have been implemented. We have seen very little so far:



Progress during PI Effort





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Performance Measure: Cost

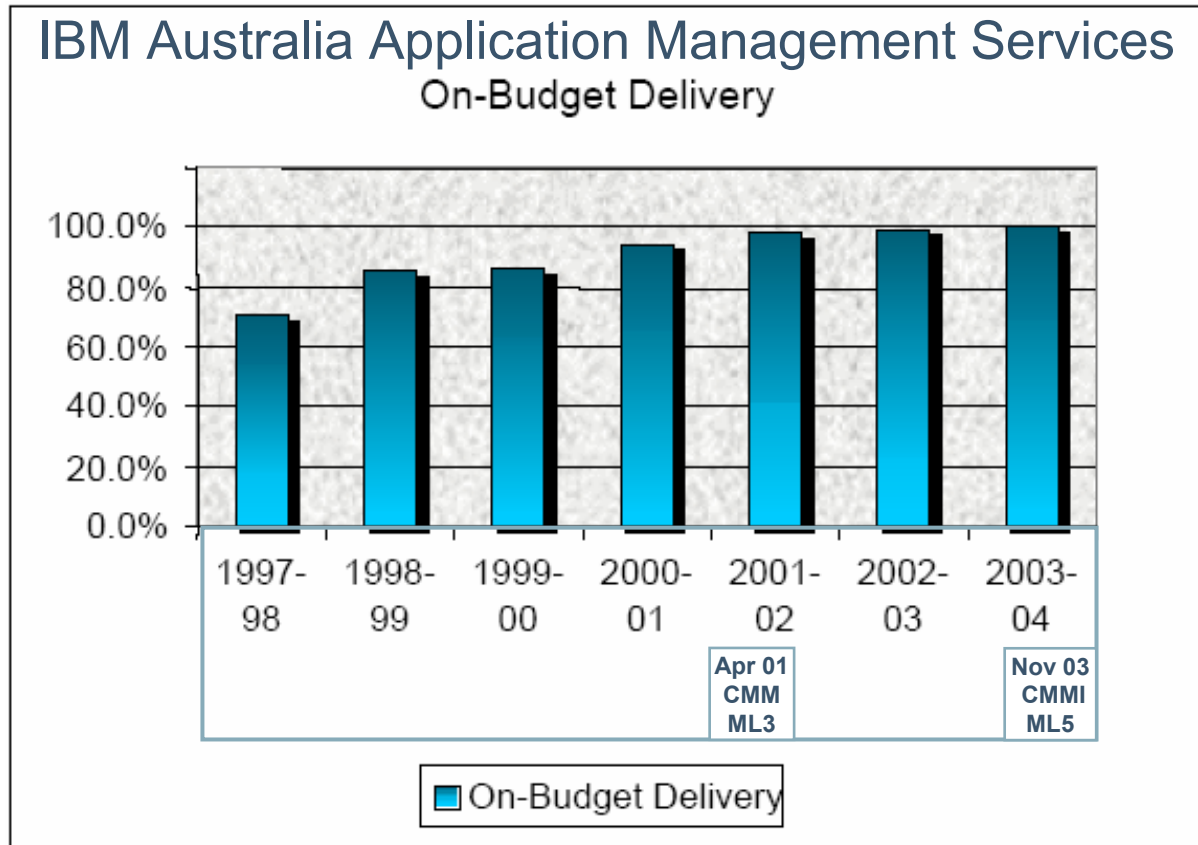
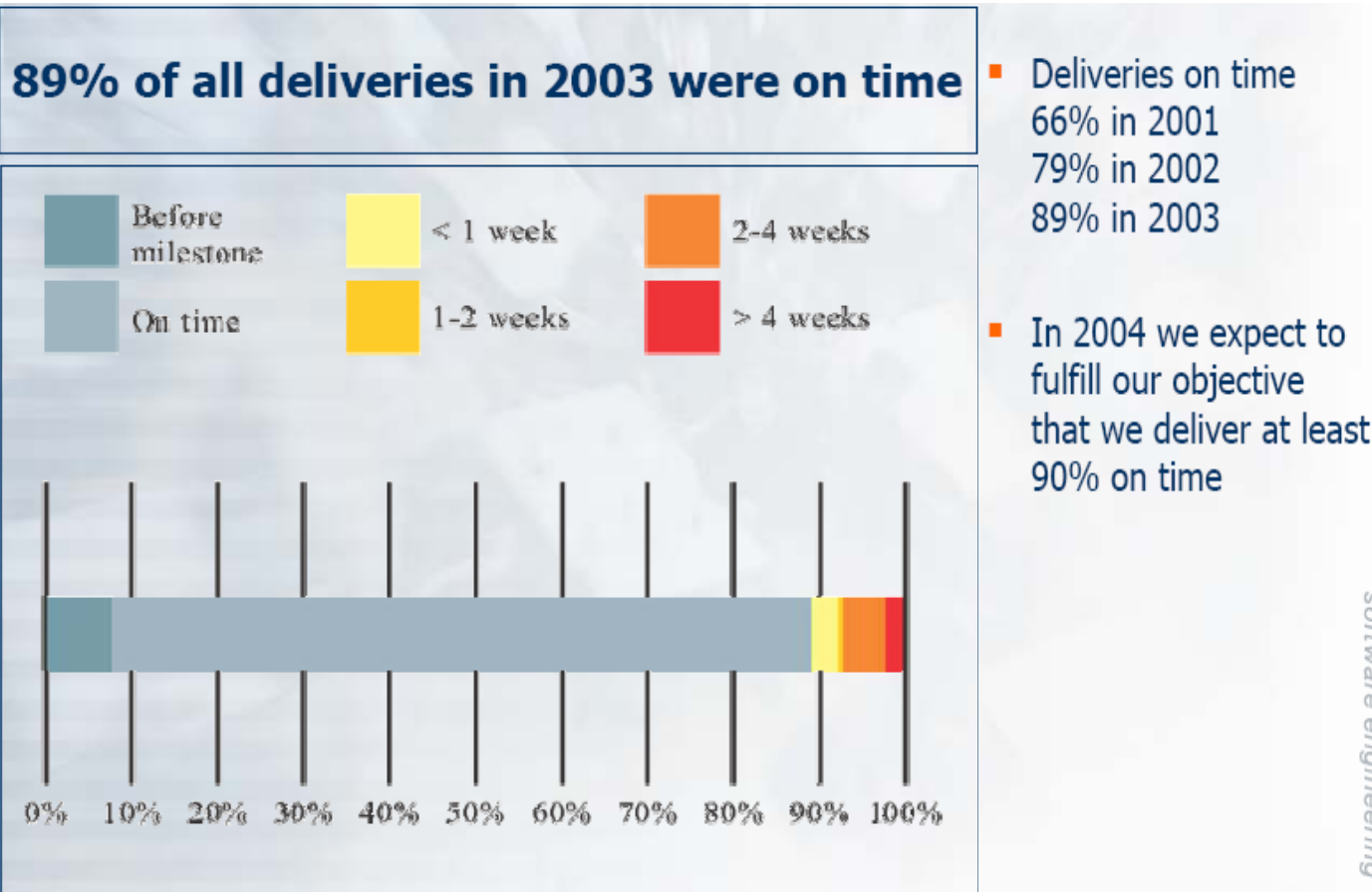


Figure 6: On-Budget Delivery

Maturity Level
Notation
added by SEI



Performance Measure: Schedule



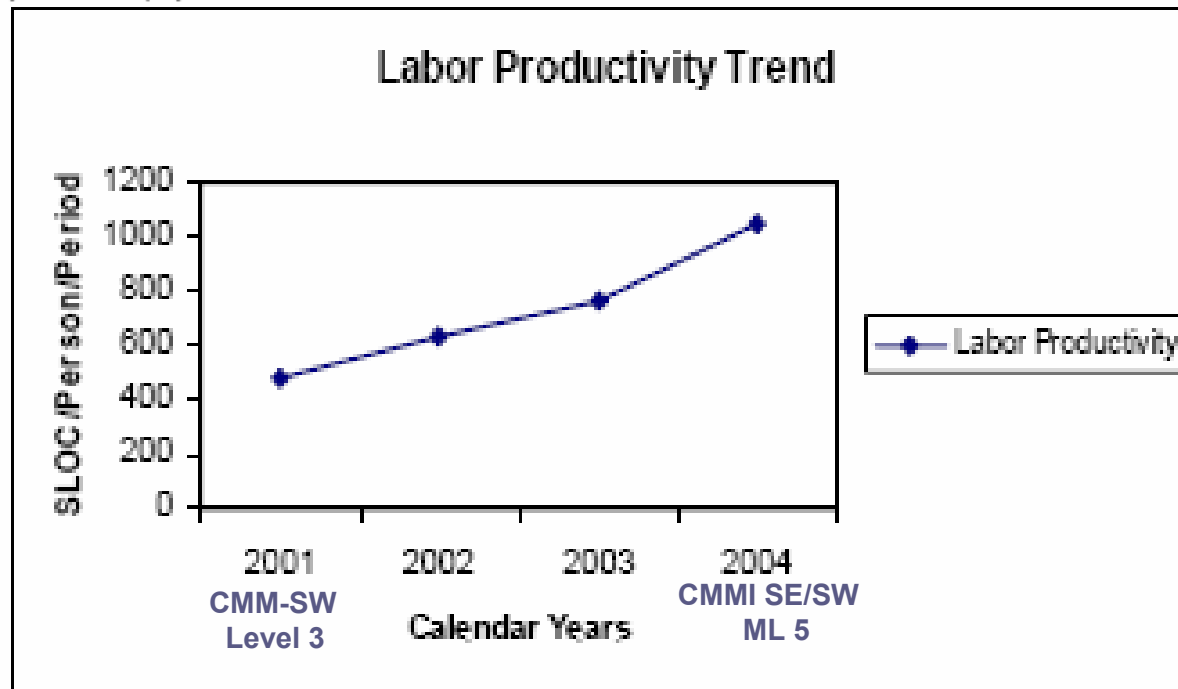
2002 CMM Level 3
2004 CMMI Maturity Level 4



Performance Measure: Productivity



And More Trends ...



Labor productivity averages have increased, influenced by variables such as programming languages, technical improvements, etc.



Performance Measures: Cost, Schedule & Productivity

Comparison of B1 and B2/3/4 Metrics



■ Productivity

B1 SIL I&T Productivity = 2.1 LOC/Hr

B2/3/4 SIL I&T Productivity = 3.4 LOC/Hr

— 62% improvement

Other Factors: Team had gained experience in all aspects of development

■ CPI and SPI

JUL 2001 Cum CPI / SPI = .91 / .93

JAN 2002 Cum CPI / SPI = .96 / .99

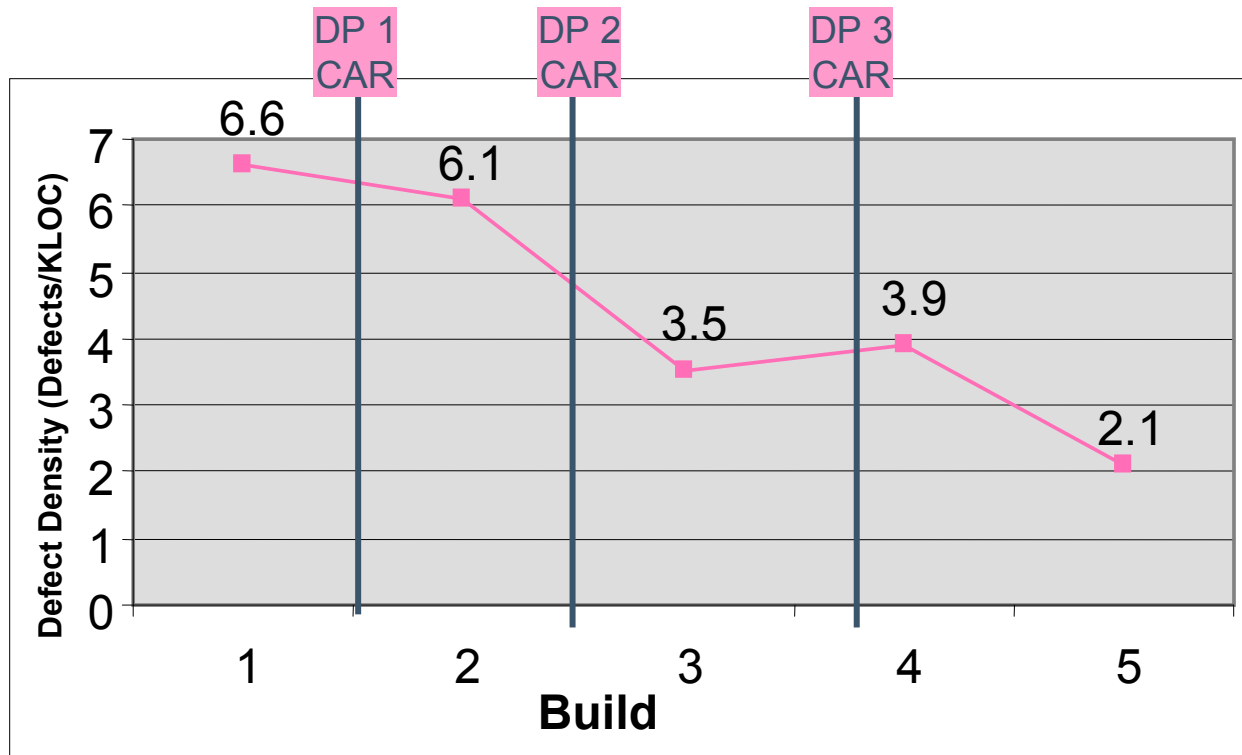
— 5% / 6% improvement

Other Factors: By July 2001, 81% of budget was spent making it difficult to improve the cumulative CPI and SPI



Performance Measure: Quality

Defect prevention using PSP and CAR at CMMI ML5



Integrating PSPsm and CMMI[®] Level 5. Gabriel Hoffman, Northrop Grumman IT . May 1, 2003.



Northrop Grumman IT

Hours invested: 124

- Team training: 48
- Conducting DP/CAR Cycles: 76

Defects avoided: 110

- If defect density had remained at Build 1 baseline

Hours saved: 1650 hours


- At an estimated cost of 15 hours per defect

Return:

- Hours: 1650/124
- ROI: ~13:1




Performance Measure: ROI

 **Delivery processes** 1 of 8

Individual / Project Level: PIPs

- Defect prevention and tools; e.g.,
 - Beyond Compare: to synchronize code configuration between sites **ROI 24.26 and savings of \$58K**
 - Insure++: reduced rework effort through early detection of memory leaks **ROI 4.28 and savings of \$95K**
 - Use case Estimation Guideline and template **ROI 5.33 and savings of \$1.6K**
 - Conversion tools **ROI 8.2 and savings of \$314K**
 - NCR average open days through a Six Sigma project **Reduced from 31 to 12 days**





Remember

Don't over interpret these results out of context

- The cases differ in:
 - Organization & model scope of their process changes
 - The time span of the process or other technology interventions they report
 - The specific measures they use
 - Measures of organizational context
- Some of the results also may be atypical & exemplary

However

- They do constitute ample proof of concept of the potential of model-based process improvement



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Enhancing Quality & Quantity of the Evidence

More & better case studies are not enough

- Broadly based samples needed to attribute results to CMMI based processes *versus* other factors / unintended measurement effects

Need for a viable benchmarking infrastructure & community of practice

- In a field where people aren't comfortable sharing information



What's Needed?

Evidence from case studies can be accused of “cherry picking” -- Fairly or not

Must be proactive: credible comparative evidence is sorely needed

- To better demonstrate the statistical relationships between process capability & program performance
- Controlling for other characteristics that may affect both

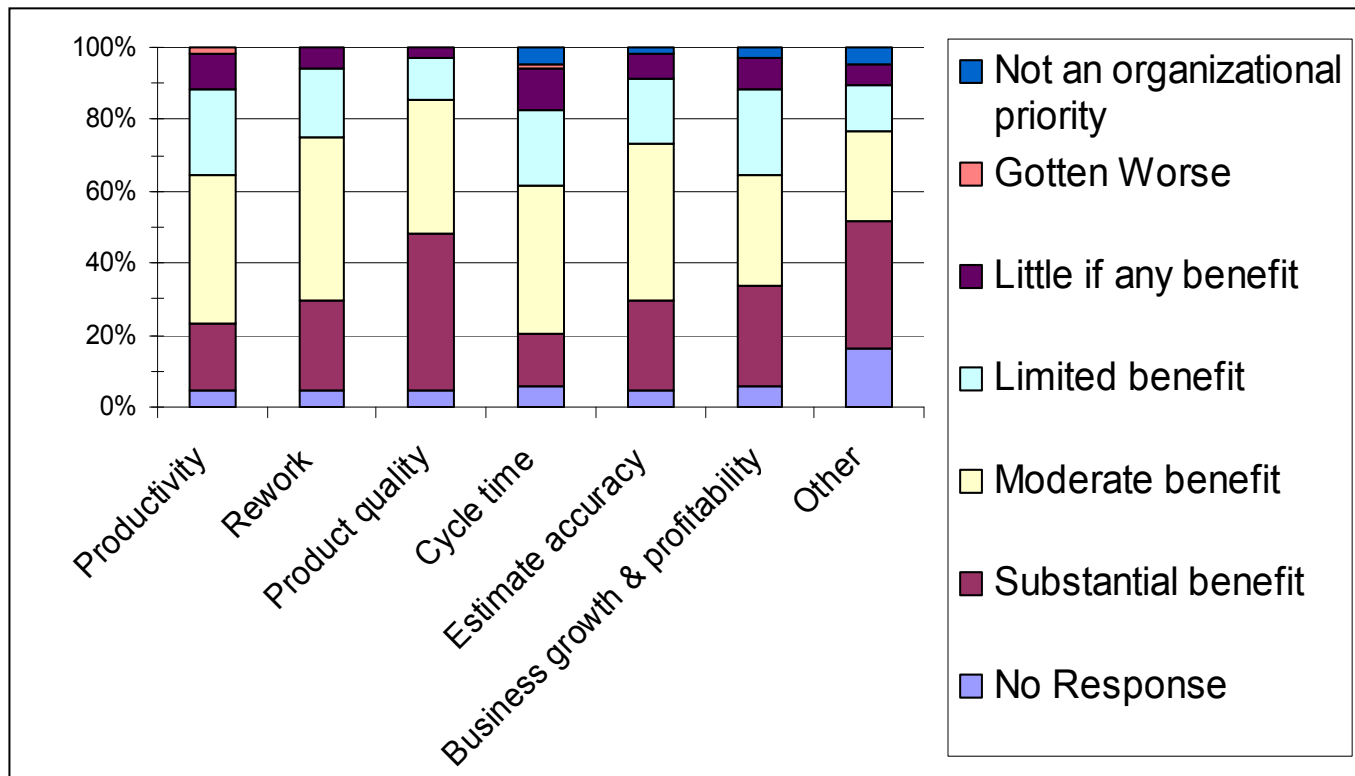
By now are many Maturity Level 4 & 5 organizations

- Over 110, mostly ML5 at this time last year

Many CMMI Maturity Level 2 organizations should have at least selected amounts of pertinent measured results as part of their PP & PMC activities



Some Results of Adopting CMMI



N = 68; Mostly high maturity organizations

Source: *Benchmarking CMMI Cost and Impact: Interim Report*, December 2004
(Distribution of full document limited to benchmark contributors.)



Results From...

Simple benchmarking exercise presented at 4th CMMI Technology Conference in Denver last November

- Focus on:
 - Costs & investment in process improvement
 - CMMI adoption
 - Implementation & appraisal strategies
- A little on benefits of CMMI-based process improvement

Mostly high maturity organizations

- Still, quite promising
- 73% have quantitatively measured improvement results
- 68% have done ROI or related cost benefit analyses
- Accompanied by compelling qualitative descriptions!



What's Next?

CMMI performance results web site

- Updates & enhancements

A new summary TR

- Addition of brief case reviews (“vignettes”)
 - To provide context for the quantitative results

Articles on CMMI performance results

- For *Software Process Improvement and Practice*

Any information you can share with us will be welcomed and appreciated

What Else?

Enterprise performance measurement and benchmarking

- Focus on causal analysis of variation in program success and failure
- Working with organizations that already have or are willing to develop common measures

Exploring several options for emphasis in FY06-07, e.g.:

- A web based benchmarking service
 - Perhaps seeded by a proactive survey
- Focused custom surveys

Any ideas or information you can share with us will be welcomed and appreciated

To Summarize...

There is ample evidence about the results of model-based process improvement

Still, we need more & better evidence

- Serious attention to benchmarking
 - Better understanding the state of the practice
 - Understanding what accounts for relative failure as well as success
- Richer case studies
- Practical guidance
 - Validating estimates and improving ROI & process models
 - Measurement, validation, data quality & analytic methods

Our bottom line: Actionable guidance using measurement to inform better decisions



For more information or to discuss participation, contact:

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