

Process Improvement

From the Software Engineering Institute:

The Software Capability Maturity Model (SW-CMM, CMMI)

(Especially CMMI V1.1 Tutorial)

The Personal Software Process (PSP)

(Also see The Team Software Process (TSP))

Objectives

- Review some of the driving forces and concepts behind process improvement
 - Focus on the SEI Capability Maturity Model – Integrated (CMMI)
- Look at how CMMI presents process areas
- Motivate the use of the SEI, PSP, TSP, and CMMI as a reference for quality system definition

Review:

Quality Systems Frameworks

What is a Quality System?

- An organization uses quality systems to control and improve the effectiveness of the processes used to deliver a quality product or service
- A Quality System is a set of formal and informal practices and processes that focus on ...
 - Customer needs
 - Leadership vision
 - Employee involvement
 - Continual improvement
 - Informed decision making based on real-time data
 - Mutually beneficial relationships with external business partners

... to achieve organizational outcomes

[Adapted from US Food and Drug Administration Staff Manual Guide 2020 http://www.fda.gov/smg/vol3/2000/SMG_2020.pdf]

Some Major Quality Frameworks

(1 of 3)

- ISO 9000 Family of Standards
 - A general international standard for organizational quality systems
 - Specializations for specific types of products and services (including software)
 - Oriented towards assessment and certification
- Malcolm Baldrige National Quality Award
 - Developed by the US Department of Commerce to encourage and recognize excellence
 - Created in 1987 in response to foreign competition eroding US productivity growth by having better product and process quality

Some Major Quality Frameworks

(2 of 3)

- Total Quality Management (TQM)
 - A philosophy and practices for improving quality
 - Build an organization-wide quality culture, focusing on providing customers with the products and services that satisfy their needs
 - Do it right the first time; eliminate defects and waste
- Lean
 - Enable quick responses to customer demands
 - A focus on delivering value to the customer, eliminating waste, setting and attaining performance goals, achieving cadence and synchronization, agile project management, integrated processes, technologies, and knowledge
- Six Sigma
 - Statistical control and performance prediction with stable processes

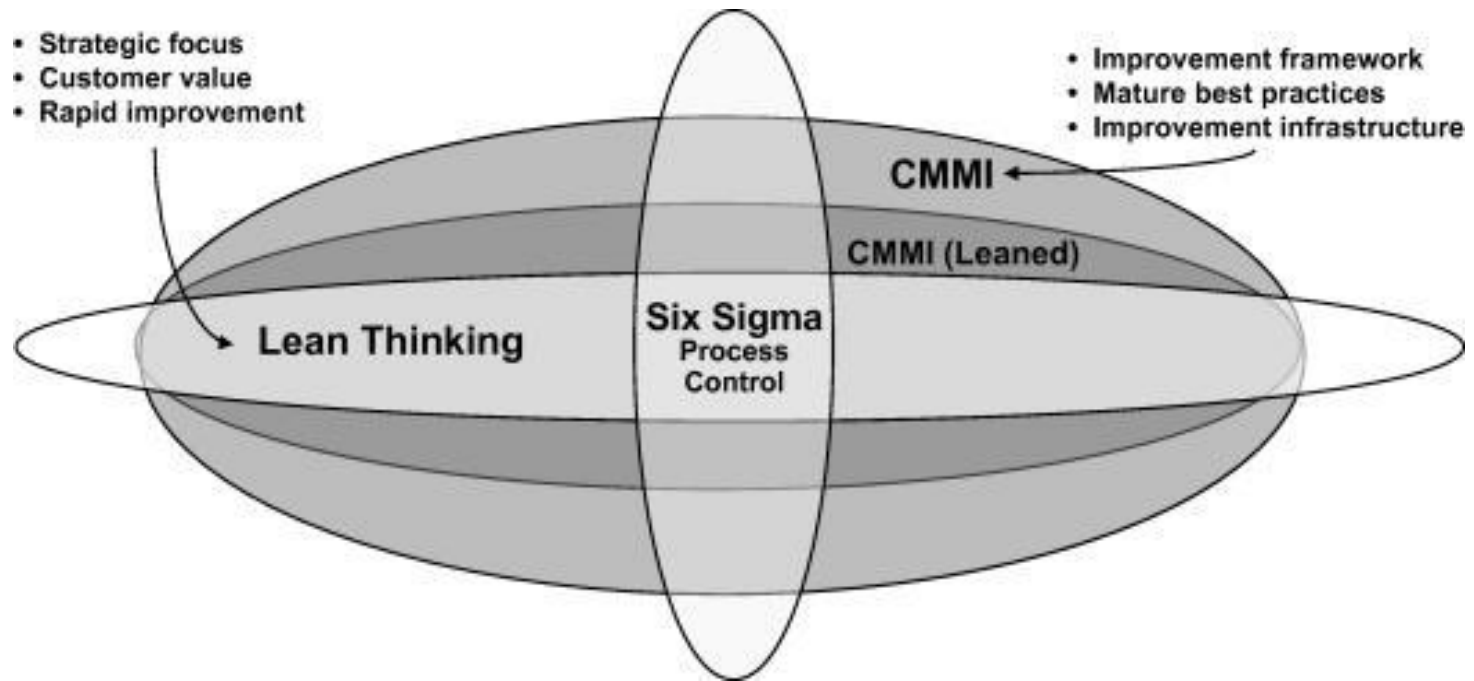
Some Major Quality Frameworks

(3 of 3)

- Information Technology Infrastructure Library (ITIL)
 - Concepts and practices for managing IT services, IT development, and IT operations
- Software Engineering Institute Capability Maturity Models (SEI CMM)
 - Created in response to US Department of Defense needs to improve software development capabilities for large, complex defense and other government systems
 - Originally a software-specific model for assessing the maturity of software development practices
 - Oriented towards both internal self-assessment and improvement and external certification assessment
 - CMM-Integrated includes software engineering, systems engineering, outsourcing (acquisition), services, etc.
 - CMMI v1.2 refactored into CMMI for Development, CMMI for Services, and CMMI for Acquisition

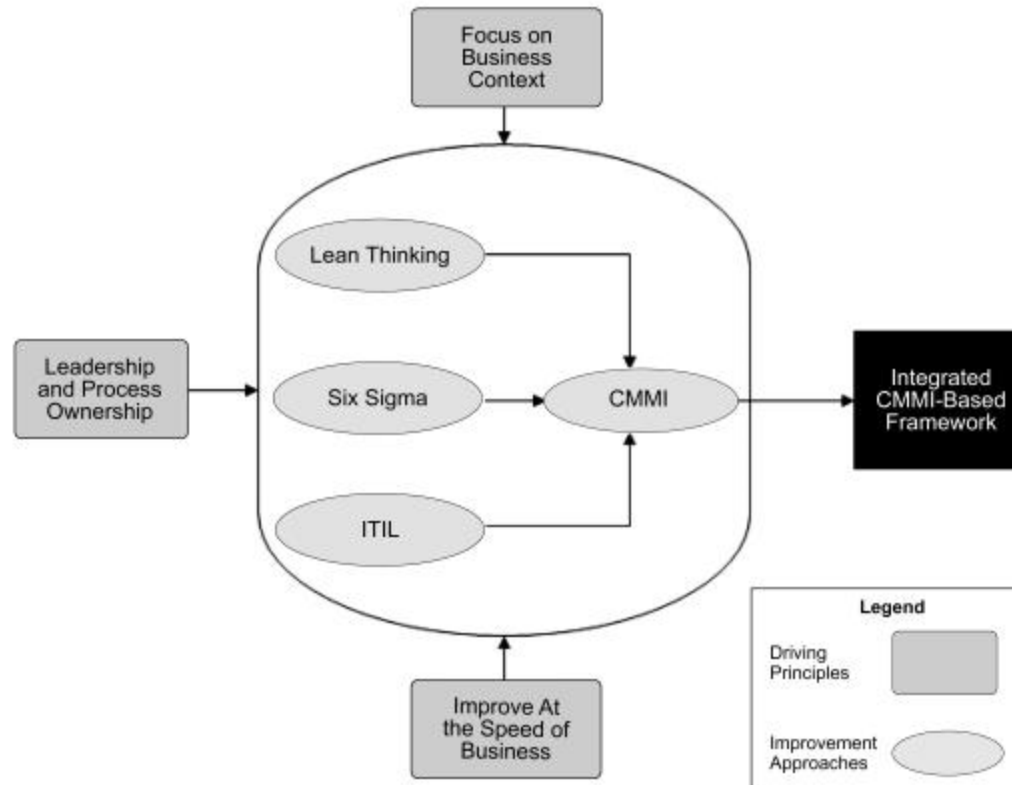
**All the Frameworks Define
Principles That Embrace a
Philosophy and Practice of Quality**

Overlapping Attributes of Improvement Approaches



Jeffrey L. Dutton, "An Integrated Framework for Performance Excellence," *CrossTalk, The Journal of Defense Software Engineering*, January/February 2010, pp. 6-9, <http://www.stsc.hill.af.mil/crosstalk/2010/01/1001Dutton.html> (accessed 2010-02-03)

Four Complementary Approaches in an Integrated Framework



Jeffrey L. Dutton, "An Integrated Framework for Performance Excellence," *CrossTalk, The Journal of Defense Software Engineering*, January/February 2010, pp. 6-9,
<http://www.stsc.hill.af.mil/crosstalk/2010/01/1001Dutton.html> (accessed 2010-02-03)

Focus on SEI Capability Maturity Model for Development

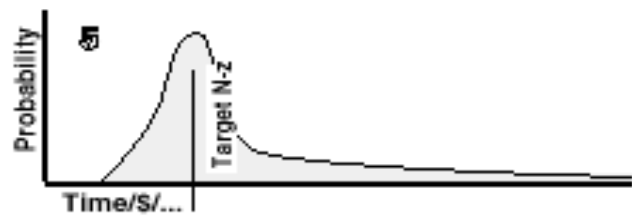
Underlying Premise of Process Improvement

“The quality of a product is largely determined by the quality of the process that is used to develop and maintain it.”

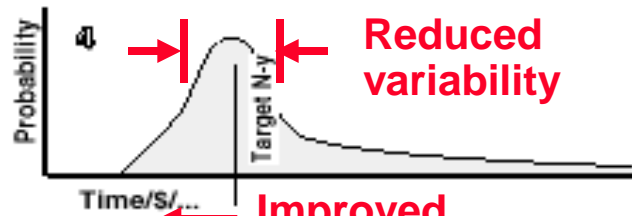
Based on Total Quality Management principles as taught by Shewhart, Juran, Deming and Humphrey.

Why Process Improvement?

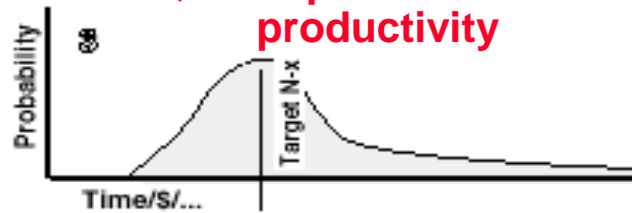
- Good software engineering practice increases the chance of delivering quality software products on time and on budget
- So, improving the software process improves the software product and the business
- Stable, repeatable software processes reduce the variability and risk in development



Performance continuously improves in Level 5 organizations



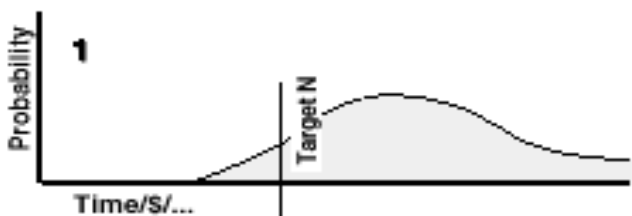
Based on quantitative understanding of process and product, performance continues to improve in Level 4 organizations



With well-defined processes, performance improves in Level 3 organizations



Plans based on past performance are more realistic in Level 2 organizations



Schedule and cost targets are typically overrun by Level 1 organizations.

Process Capability & Performance Prediction

- As Maturity increases, the difference between targeted results and actual results decreases
- Higher maturity → a better way to run a business

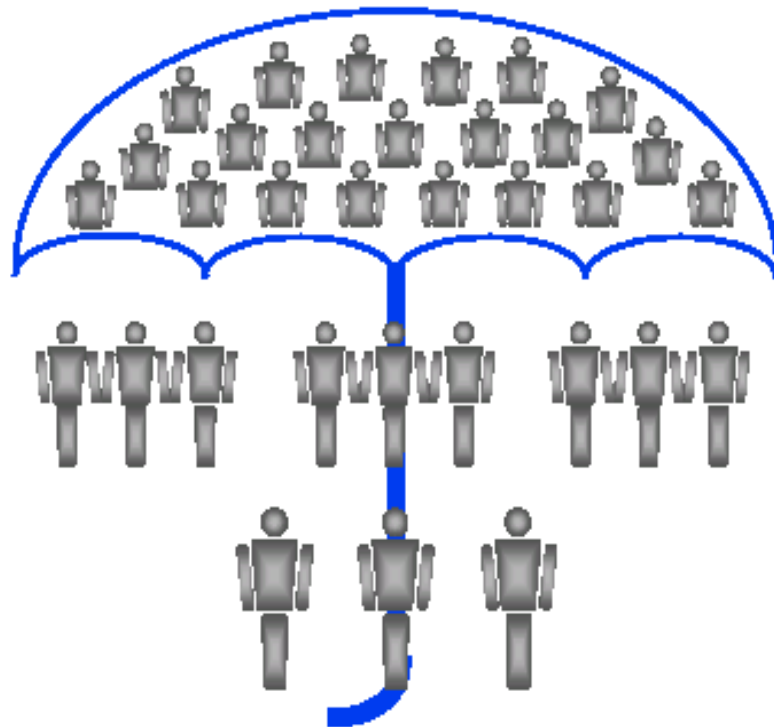
Figure 2.4 Process Capability as Indicated by Maturity Level

CMM, TSP, and PSP

PSP: Personal Software Process

TSP: Team Software Process

CMM: Capability Maturity Model



CMM - Improves organization's capability; management focus.

TSP - Improves team performance; team and product focus.

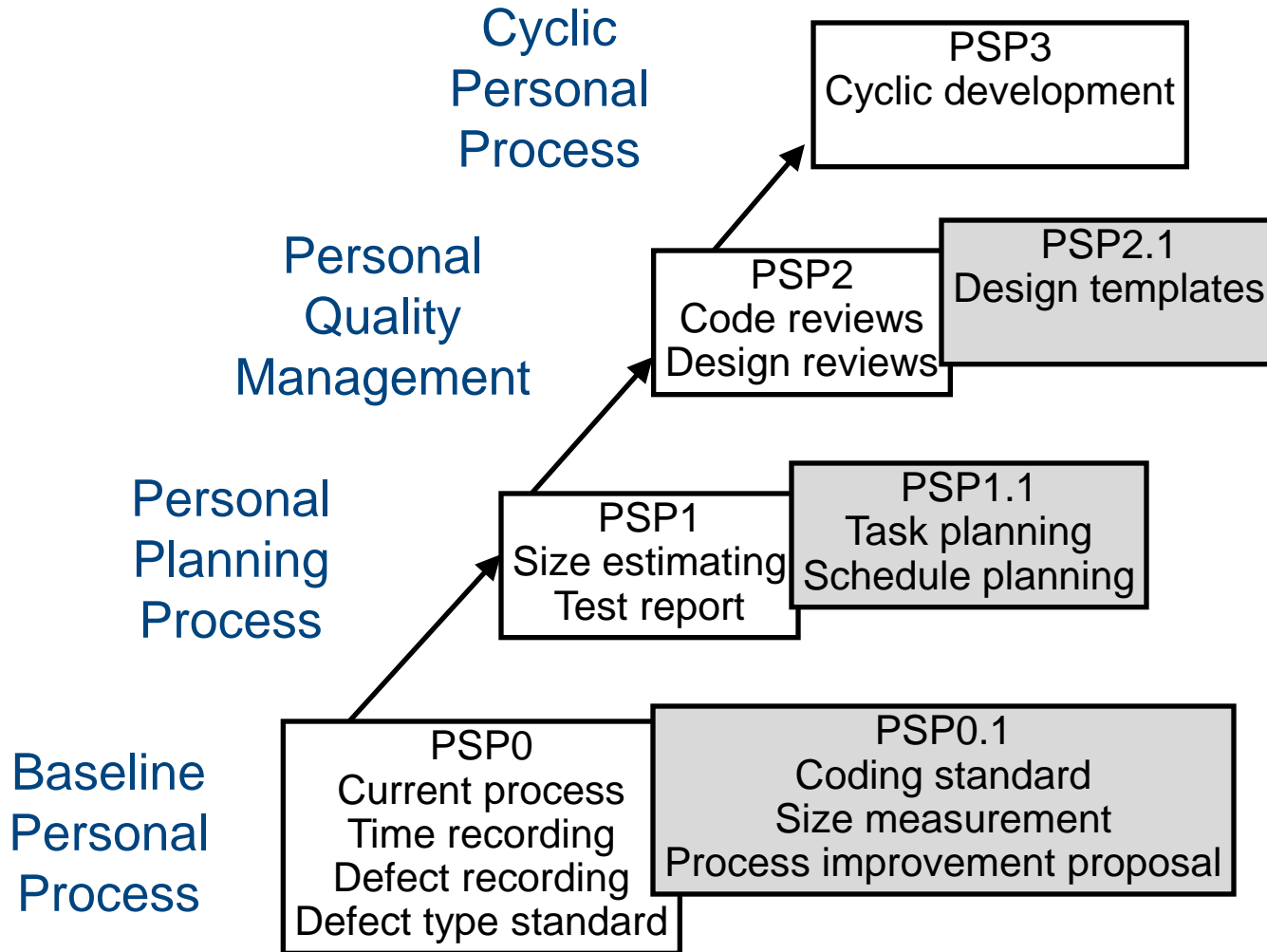
PSP - Improves individual skills and discipline; personal focus.

Personal Software Process (PSP)

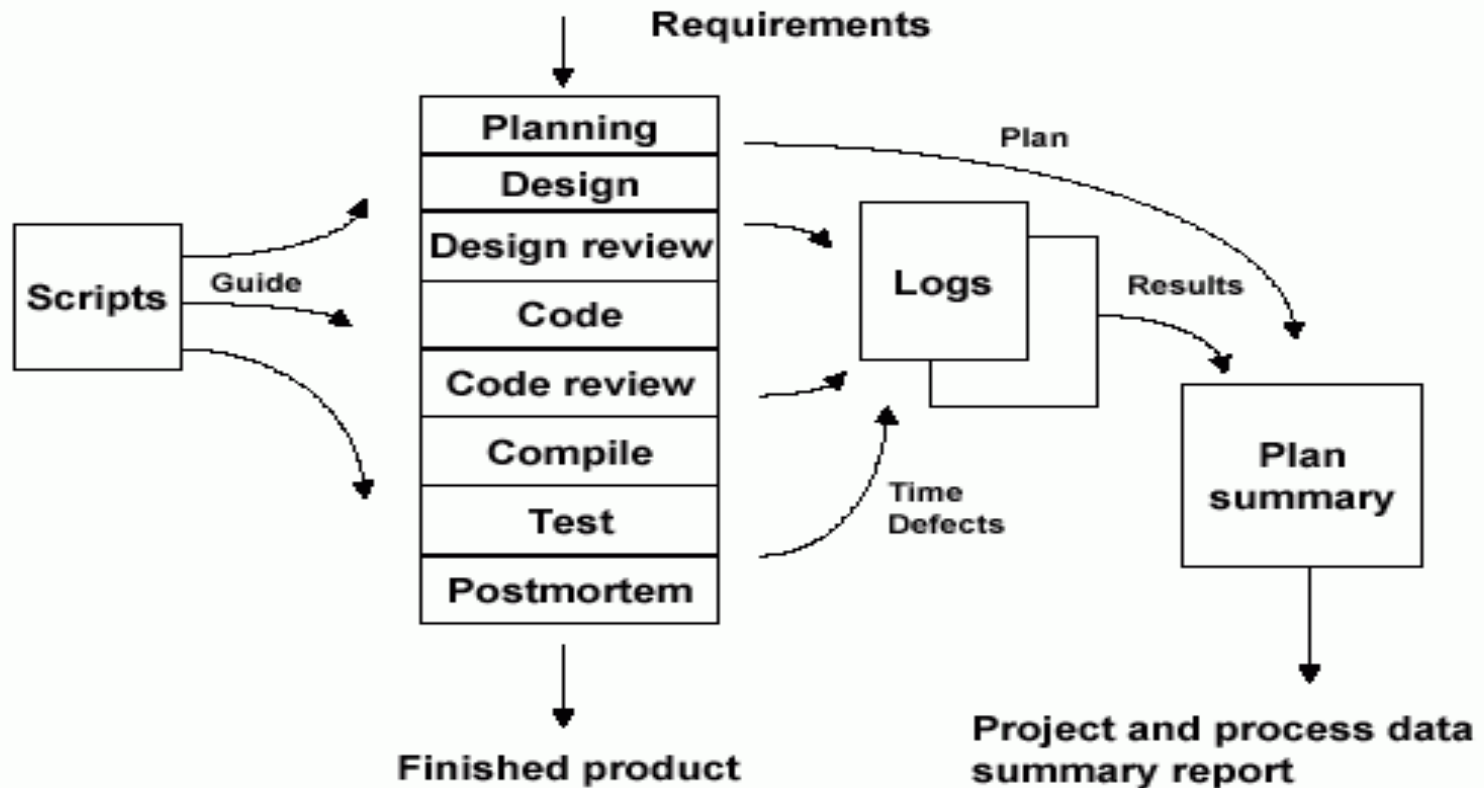
Watts S. Humphrey, *Introduction to the Personal Software Process*, Addison-Wesley, 1997

See also:CMU/SEI-2000-TR-022, ESC-TR-2000-022

PSP: Evolutionary Improvement



PSP Process Structure



Capability Maturity Model for Software

Immature Versus Mature Organizations

Immature

- Software Process, though specified, is not followed/enforced
- Reactionary (Fire-Fighting)
- Software processes are generally improvised by practitioners and managers during the course of the project
- Schedules and budgets keep constantly changing
- No objective basis for judging product quality or for solving product or process problems

Mature

- Software process is accurately communicated to staff and work activities are carried out according to the planned process
- Process improvements are developed through controlled pilot-tests and/or benefit analysis
- Schedules and budgets are based on historical performance.
- There is an objective, quantitative basis for judging product quality and analyzing problems with the product and process

CMMI in a Nutshell

- A CMMI model provides a structured view of process improvement across an organization
- CMMI can help
 - Set process improvement goals and priorities
 - Provide guidance for quality processes
 - Provide a yardstick for appraising current practices

Five Levels of Software Process Maturity

(Staged Representation)

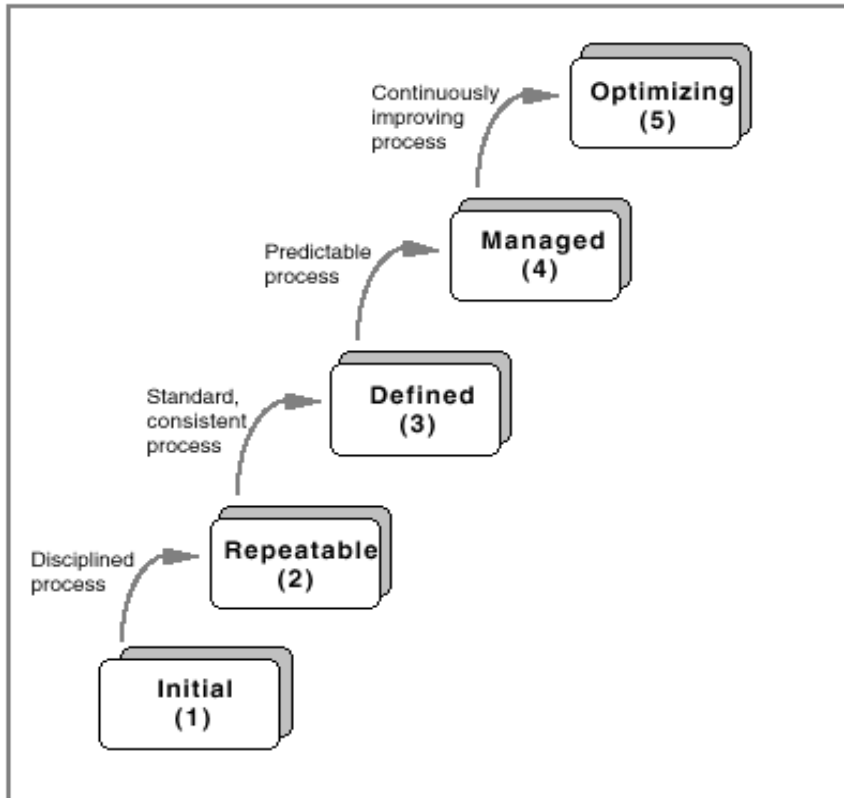


Figure 2.1 The Five Levels of Software Process Maturity

- A maturity level is a well-defined evolutionary plateau towards achieving a mature process
- Each level has a set of goals
- Achieving each level
 - Establishes a different component in the software process
 - Increases the process capability of the organization

The Maturity Levels (Staged Representation)

- **Level 1 – Initial Level**
 - Ad Hoc processes, ineffective planning and reaction-driven systems
 - Crisis – abandon planned procedures & revert to coding and testing
 - Schedules, Budget, Functionality, Product Quality: Unpredictable
 - Software Process Capability: Unpredictable
- **Level 2 – Repeatable Level**
 - Basic Software Management controls
 - Planning/Managing new projects is based on successes with similar projects
 - Realistic project commitments based on empirical knowledge
 - Project managers track software costs, schedules and functionality
 - Project standards are defined and followed
 - Software Process Capability: Disciplined
- **Level 3 – Defined Level**
 - Standard Process for developing and maintaining software is documented and used
 - Organization-wide training program: to ensure that staff and managers have knowledge and skills to fulfill their assigned roles
 - Projects tailor the Standard Process to develop their own well-defined process for their unique project requirements
 - Schedules, Budget, Functionality, Product Quality: Under Control and Tracked
 - Software Process Capability: Standard and Consistent

(continued)

The Maturity Levels (Staged) (continued)

- **Level 4 – Managed Level**

- Quantitative quality goals for products and processes
- Organizational Measurement Program for important software process activities
- Variation in process performance is controlled to be within acceptable range
- Software Process Capability: Predictable

- **Level 5 – Optimizing Level**

- Focus on Continuous Process Improvement
- Identify weakness and strengthen the process proactively
- Perform cost benefit analyses of new technologies and proposed changes to the organization's software process
- Analyze defects to determine their causes – evaluate the software process accordingly
- Software Process Capability: Continuous Improving

Key Process Areas by Maturity Level

- Achieving each level...
 - Establishes a different component in the software process
 - Increases the process capability of the organization

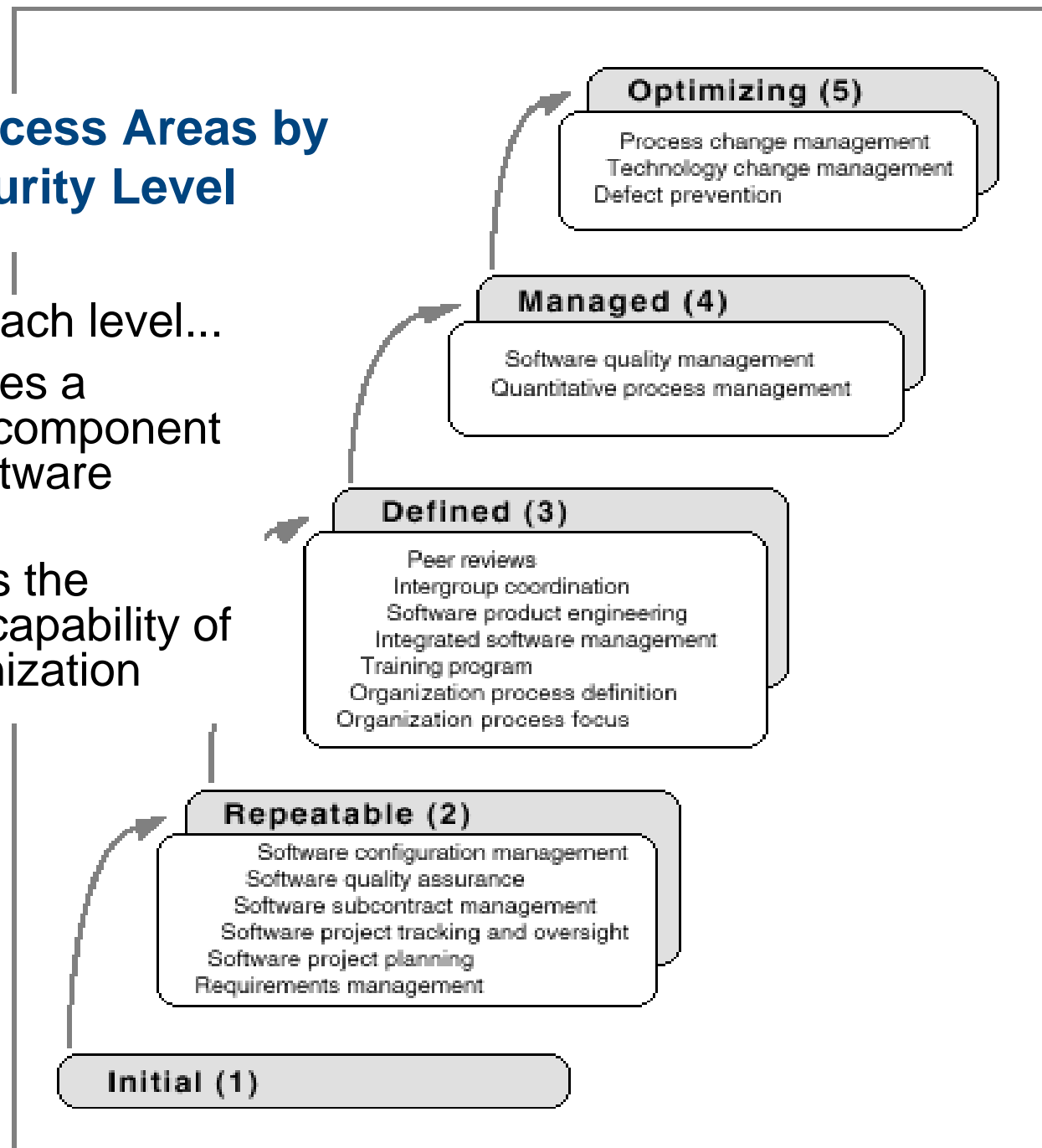


Figure 3.2 The Key Process Areas by Maturity Level

Process Areas

Process Areas

- Process Areas (PAs) are a cluster of related practices.
- They are the major building blocks in establishing process capability.
- Example PA: “Requirements Management”

Organization of Process Areas

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

Organization of Process Areas

Category	Process Area	Metrics/Quality Practices
Project Management	Project Planning Project Monitoring and Control Supplier Agreement Management Integrated Project Management Integrated Supplier Management Integrated Teaming Risk Management Quantitative Project Management	Project Mgmt Metrics Activity Metrics Basic Quality Tools
Support	Configuration Management Process and Product Quality Assurance Measurement and Analysis Causal Analysis and Resolution Decision Analysis and Resolution Organizational Environment for Integration	Maintenance Metrics Basic Quality Tools GQM Measurement Fundamentals Defect Prevention Techniques
Engineering	Requirements Management Requirements Development Technical Solution Product Integration Verification Validation	Requirements Volatility Defect Removal Metrics Reliability Engineering Defect Prevention Techniques Basic Quality Tools
Process Management	Organizational Process Focus Organizational Process Definition Organizational Training Organizational Process Performance Organizational Innovation and Deployment	In-Process Metrics Project Mgmt Metrics Basic Quality Tools

Example: Requirements Management Process Area

Note: The CMM guides you on what needs to be done, but does not tell you how to do it

REQM Process Area - Capability Levels 1 & 2

Requirements Management

Specific practices (CL1 - “base”)

- SP1.1-1: Obtain an Understanding of Requirements
 - SP1.3-1: Manage Requirements Changes
 - SP1.5-1: Identify Inconsistencies Between Project Work and Requirements
-

Specific practices (CL2 - “advanced”)

- SP1.2-2: Obtain Commitment to Requirements
- SP1.4-2: Maintain Bi-directional Traceability of Requirements

Generic practices (CL1)

- GP1.1: Perform Base Practices

Generic practices (CL2)

- 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

REQM - Capability Level 3

Requirements Management

Note that much of the capability for Requirements Management was established at maturity levels 1 and 2

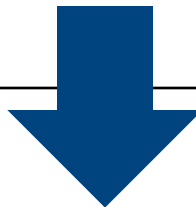
Specific practices (CL1 & CL2)

- SP1.1-1: Obtain an Understanding of Requirements
- SP1.2-2: Obtain Commitment to Requirements
- SP1.3-1: Manage Requirements Changes
- SP1.4-2: Maintain Bi-directional Traceability of Requirements
- SP1.5-1: Identify Inconsistencies Between Project Work and Requirements

Generic practices (CL1 & CL2)

- GP1.1: Perform Base Practices
- GP2.1: Establish an Organizational Policy
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- 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 w/Higher Level Management

CL-2



CL-3

Specific practices (CL3)

All the CL1 & CL2 Specific Practices

Generic practices (CL3)

All the CL1 & CL2 Generic Practices plus(+):

- GP3.1: Establish a Defined Process
- GP3.2: Collect Improvement Information

REQM - Capability Levels 4 & 5

Requirements Management

Specific practices (CL4)

All the CL1 & CL2 Specific Practices

Generic practices (CL4)

All the CL1 & CL2 & CL3 Generic Practices plus(+):

GP4.1: Establish Quantitative Objectives for the Process

GP4.2: Stabilize Subprocess Performance

Specific practices (CL5)

All the CL1 & CL2 Specific Practices

Generic practices (CL5)

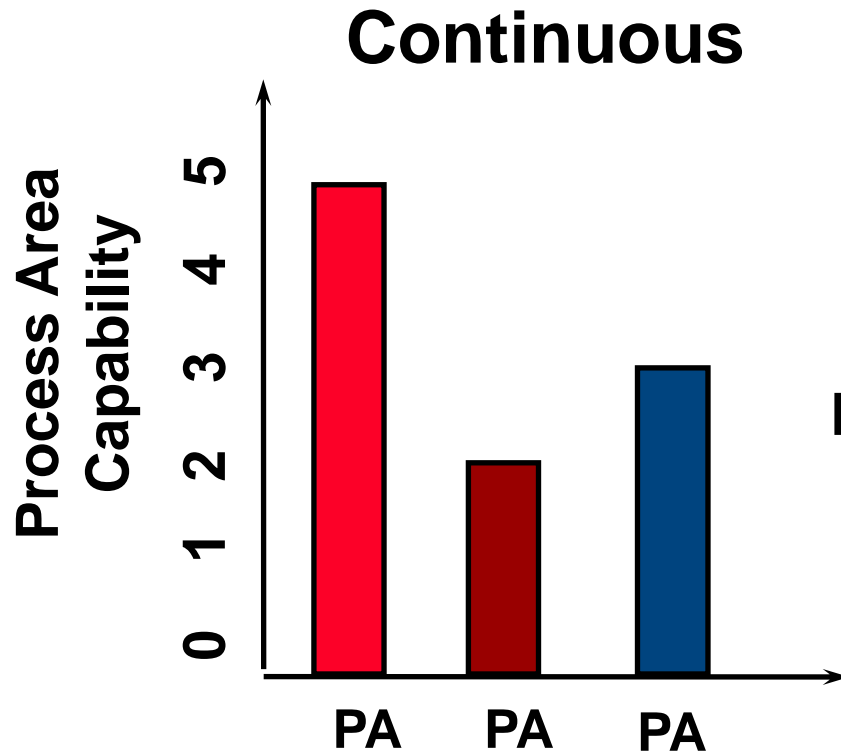
All the CL1 & CL2 & CL3 & CL4 Generic Practices plus(+):

GP5.1: Ensure Continuous Process Improvement

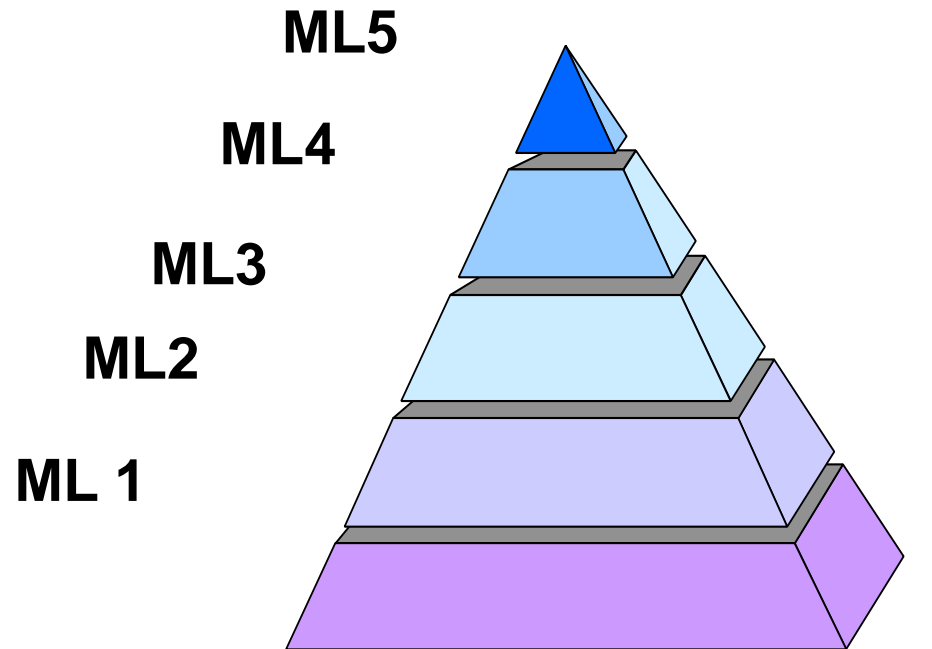
GP5.2: Correct Root Causes of Problems

Comparing Model Representations

Staged



...for a single process area or a set of process areas



...for an established set of process areas across an organization

The Bottom Line ¹

Process improvement should be done to help the business—not for its own sake.



**“In God we trust,
all others bring data.”**

- W. Edwards Deming

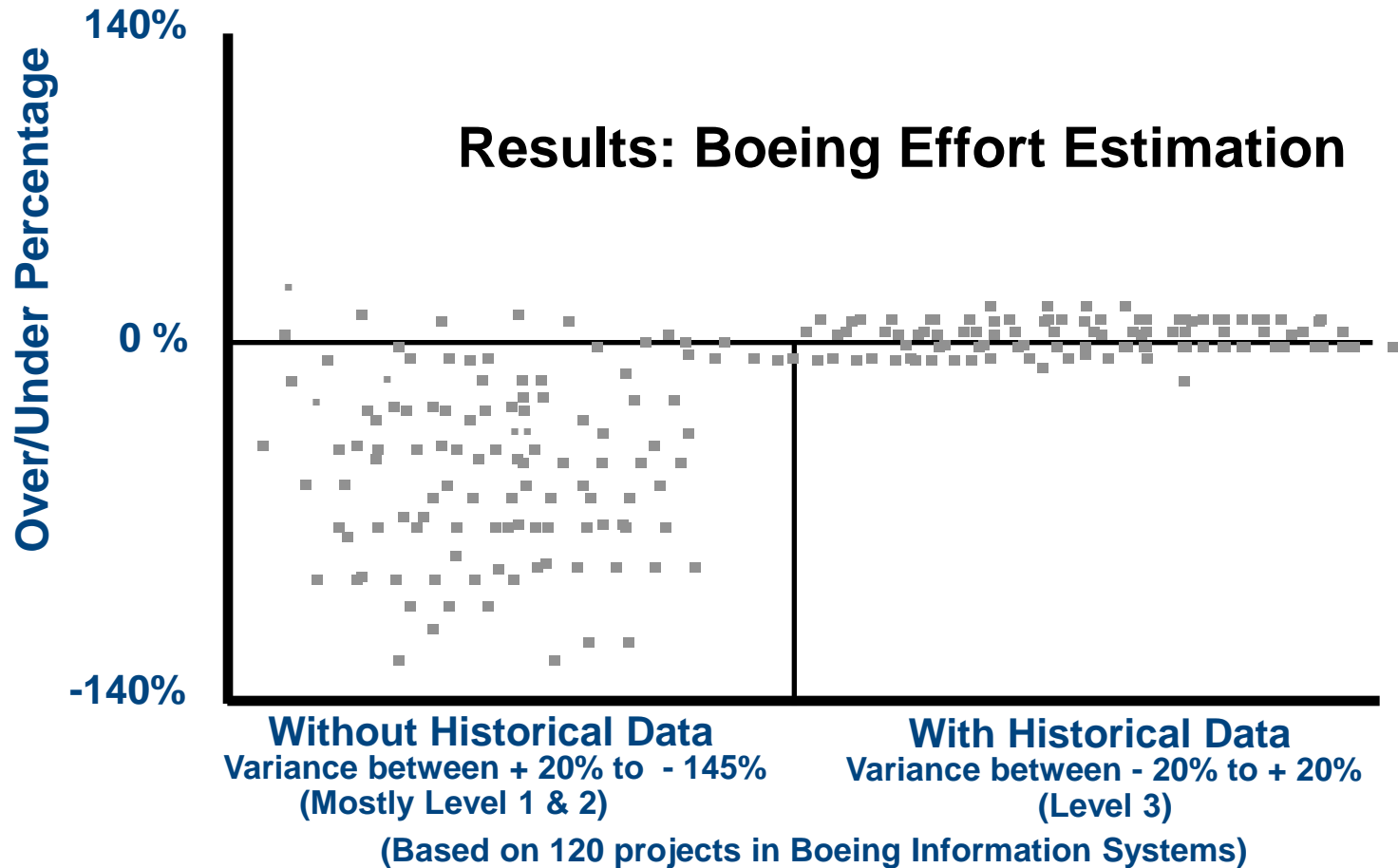
The Bottom Line ²

- Improvement means different things to different organizations:
 - What are your business goals?
 - How do you measure progress?
- Improvement is a long-term, strategic effort:
 - What is the expected impact on the bottom line?
 - How will impact be measured?

Categories of Process Improvement Benefits

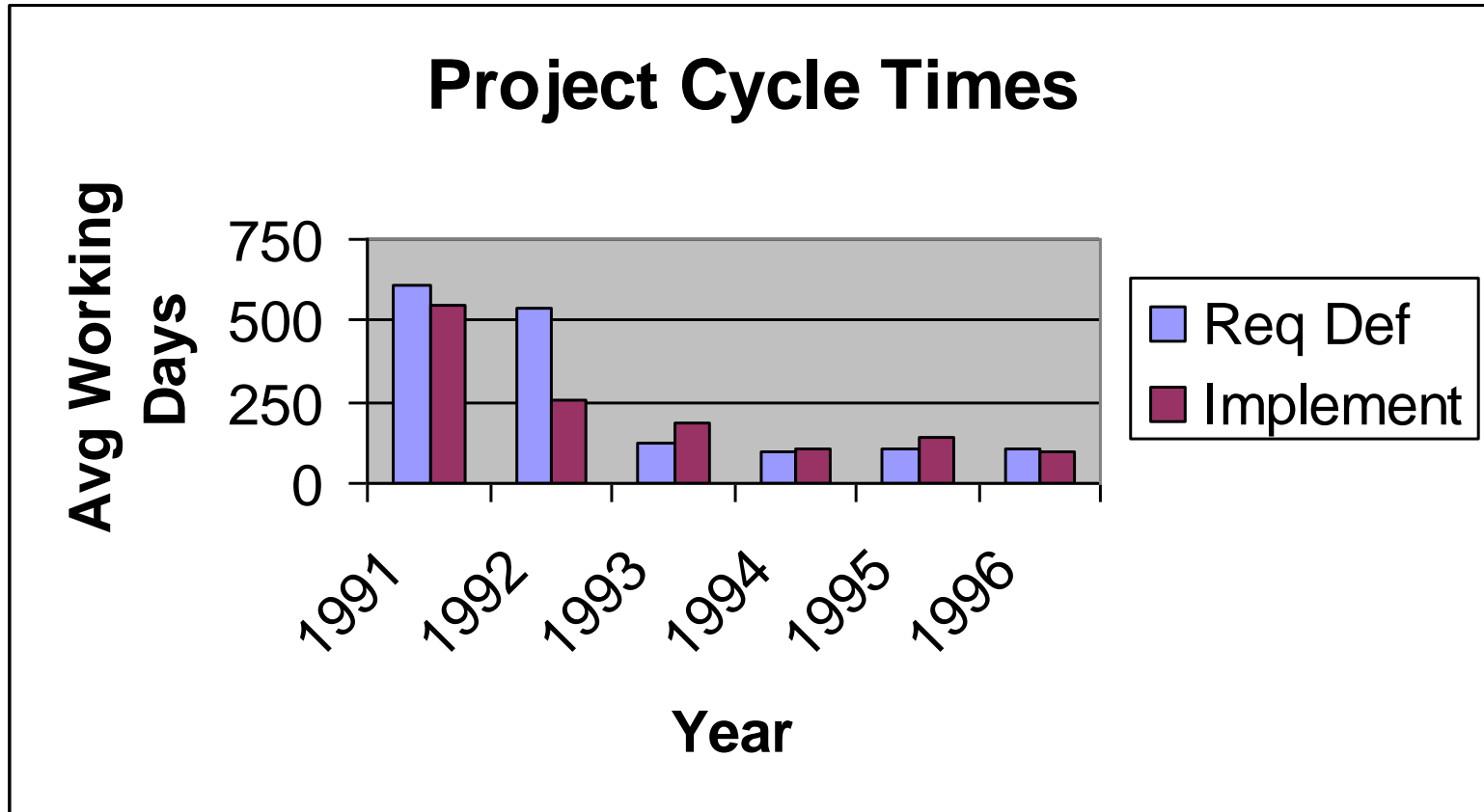
- Process improvement benefits fall into one of eight general categories:
 - Improved schedule and budget predictability
 - Improved cycle time
 - Increased productivity
 - Improved quality (as measured by defects)
 - Increased customer satisfaction
 - Improved employee morale
 - Increased return on investment
 - Decreased cost of quality

Improved Schedule and Budget Predictability



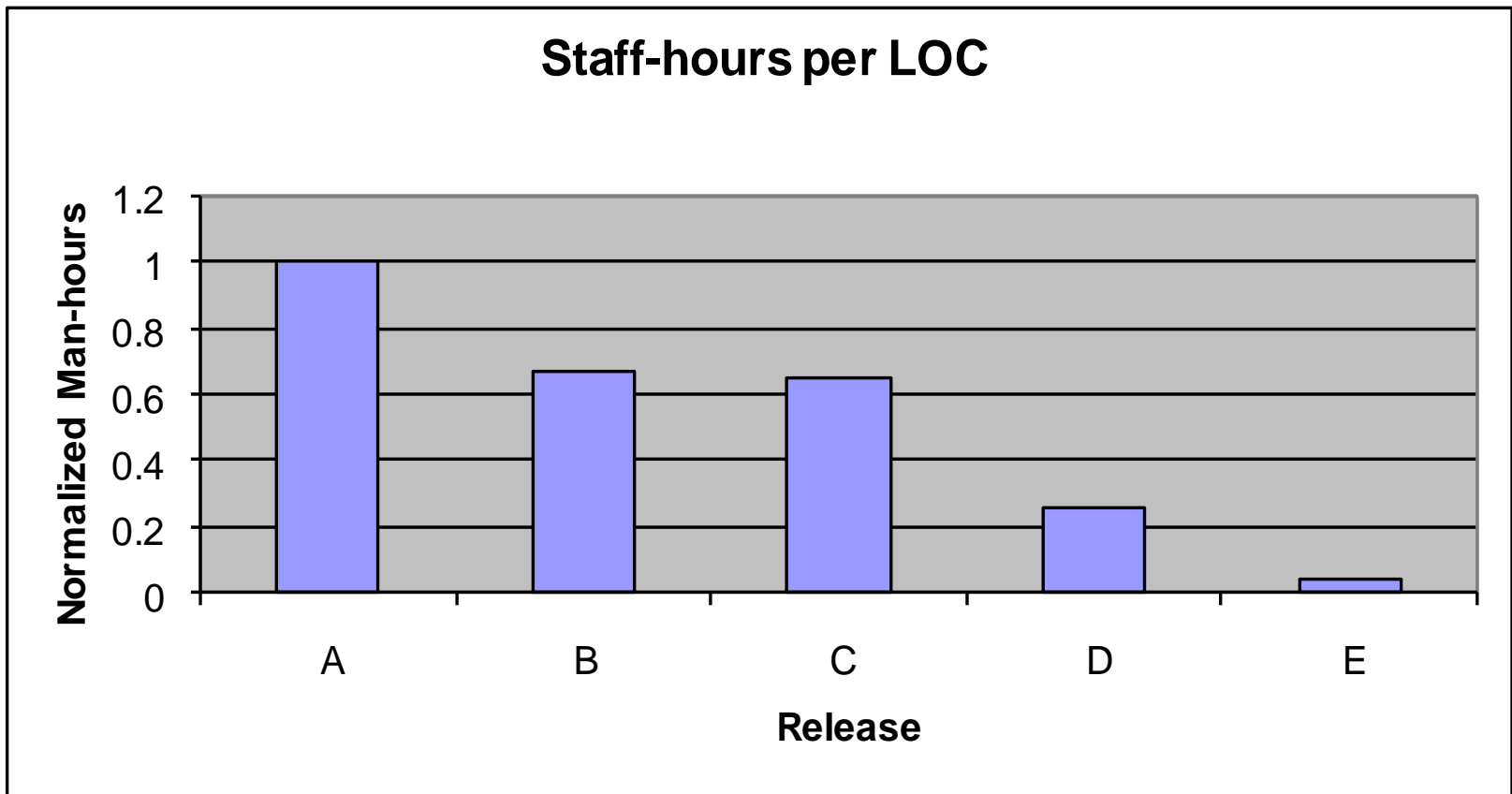
Reference: John D. Vu. "Software Process Improvement Journey: From Level 1 to Level 5." 7th SEPG Conference, San Jose, March 1997.

Improved Cycle Time



Source: Software Engineering Div., Hill AFB, Published in Crosstalk May 1999

Increased Productivity

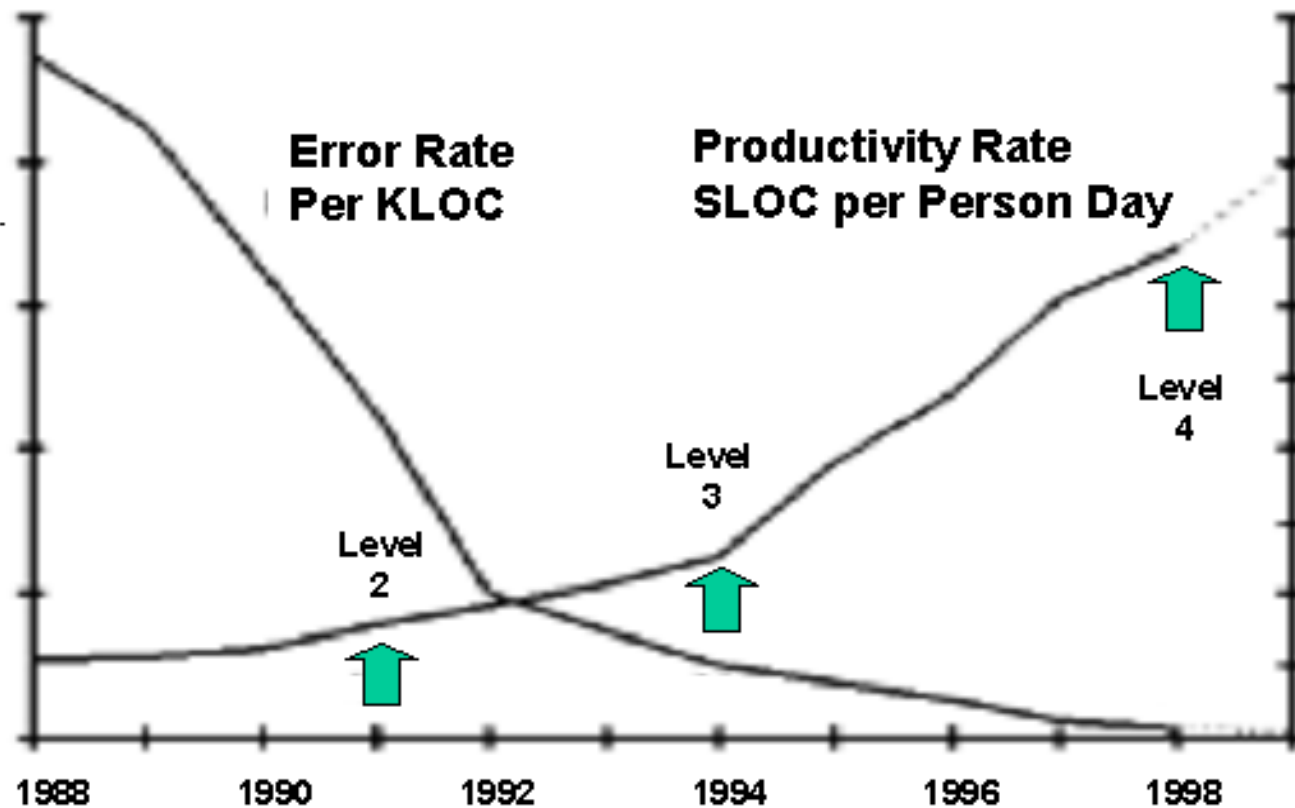


Source: Software Engineering Div., Hill AFB, Published in Crosstalk May 1999

Increased Productivity and Quality

Productivity Rate and Quality Performance

* For Software Programs



Productivity
Increased By
80% As Error
Rates
Decreased

SEI CMMI-DEV Summary

- Process Areas identify “what you do”
 - The SEI CMMI provides a rich catalog of process activities that software development organizations might perform
- Capability Levels identify “how well you do it” (but not “how to do it”)
 - The organization of the SEI CMMI into capability levels ...
 - Helps an organization assess their ability to implement projects at various levels of technical and managerial complexity
 - Helps an organization plan incremental, focused process improvement
- The CMMI model should be applied using intelligence, common sense, and professional judgment
 - Driven by organizational goals and needs
- Quality practices and metrics are an integral part of improving process maturity