

COSC 310:

Software Engineering

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Brief Review of Refactoring

- What is an example of refactoring?
- Should we perform refactoring when tests are unstable?
- If your team's code is not smelly, and no refactoring has been done, what does that tell you about upfront design? Is your team more likely to be agile or plan driven?

5 Years From Now ...

- You run a small company based on an awesome idea (several investors and clients)
- All the employees work hard
- From your perspective, you see that:
 - budget is always tight, most of your time is spent finding more investors
 - things aren't progressing as fast as you want/expect
 - employees are always overworked, yet deadlines are almost never met
 - quality of products vary (sometimes drastically)

Then You Hear ...

- Improved On-Time Delivery
 - Raytheon North Texas Software Engineering improved schedule performance by 8%, with a 50% decrease in variation

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- Decreased Costs
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- Improved Quality
 - Siemens Information Systems Ltd. reduced defect density an average of 71% in three technical areas

What's the Magic?

- What needs to change?
- You start to remember all those concepts from 310 ...
 - SDLC?
 - Project Management?
 - People Management?
 - Planning and Progress Monitoring?
 - Quality Assurance?
- Where do you start?
- Who can help?

Capability Maturity Model Integration (CMMI)

- Approach to process improvement
- Provides organizations with essential elements of effective processes improve performance
- Developed by CMU's Software Engineering Institute in 2006
 - Overcomes limitations of the original CMM (1990)

CMMI

- Multiple models = collections of best practices and process improvement goals
 - **Foundation** - core company processes
 - **Acquisition** - supply chain management
 - **Development** - products/services focus
 - **Services** - superior service delivery

Example Organizational Processes

- Core Process Areas
 - Organizational training
 - Project Planning
 - Measurement and Analysis
 - Configuration management
 - Decision Analysis and Resolution
 - ...
- Acquisition Process Areas
- Development Process Areas
- Services Process Areas

Example Organizational Processes

- Core Process Areas
- Acquisition Process Areas
 - Solicitation and Supplier Agreement Development
 - Agreement Management
 - Acquisition Technical Management
 - ...
- Development Process Areas
- Services Process Areas

Example Organizational Processes

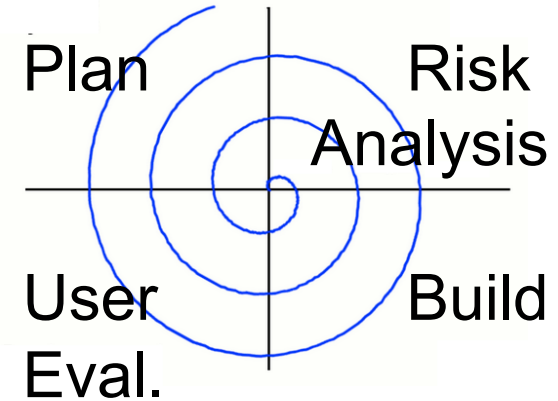
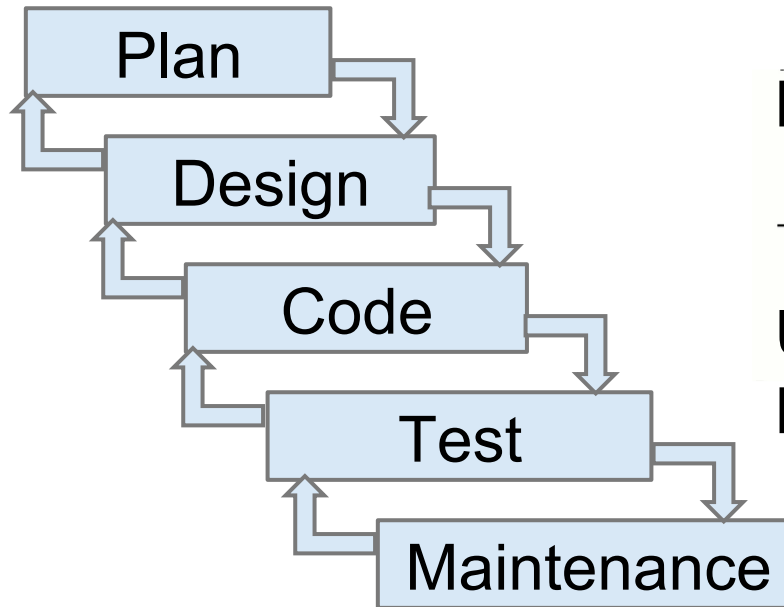
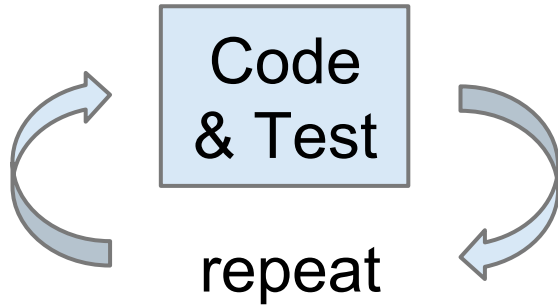
- Core Process Areas
- Acquisition Process Areas
- Development Process Areas
 - Product Integration
 - Requirements Development
 - Technical Solutions
 - Validation
 - Verification
 - ...
- Services Process Areas

Example Organizational Processes

- Core Process Areas
- Acquisition Process Areas
- Development Process Areas
- Services Process Areas
 - Incident Resolution and Prevention
 - Service Continuity
 - Service Delivery
 - Service System Transition
 - ...

Project vs. Organizational Processes

- Recall:



- Contrast to organizational processes

- How things happen across teams, projects, departments

Main Idea

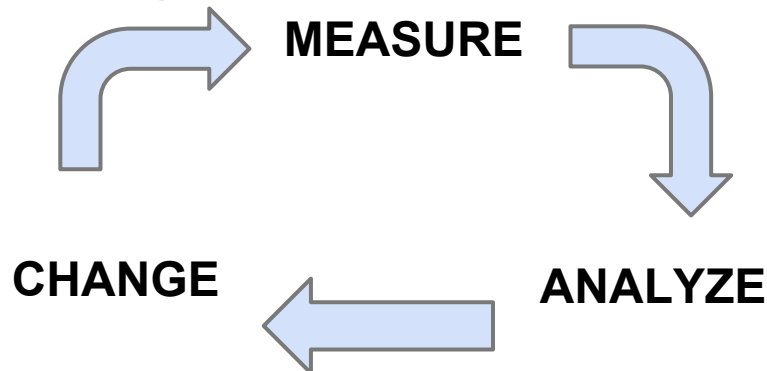
- The more *mature* an organization is ...
 - the easier it is to repeat processes systematically
 - the easier it is to measure what works well and not
 - the easier it is to optimize processes
- What makes an organization "mature"?

Process Maturity

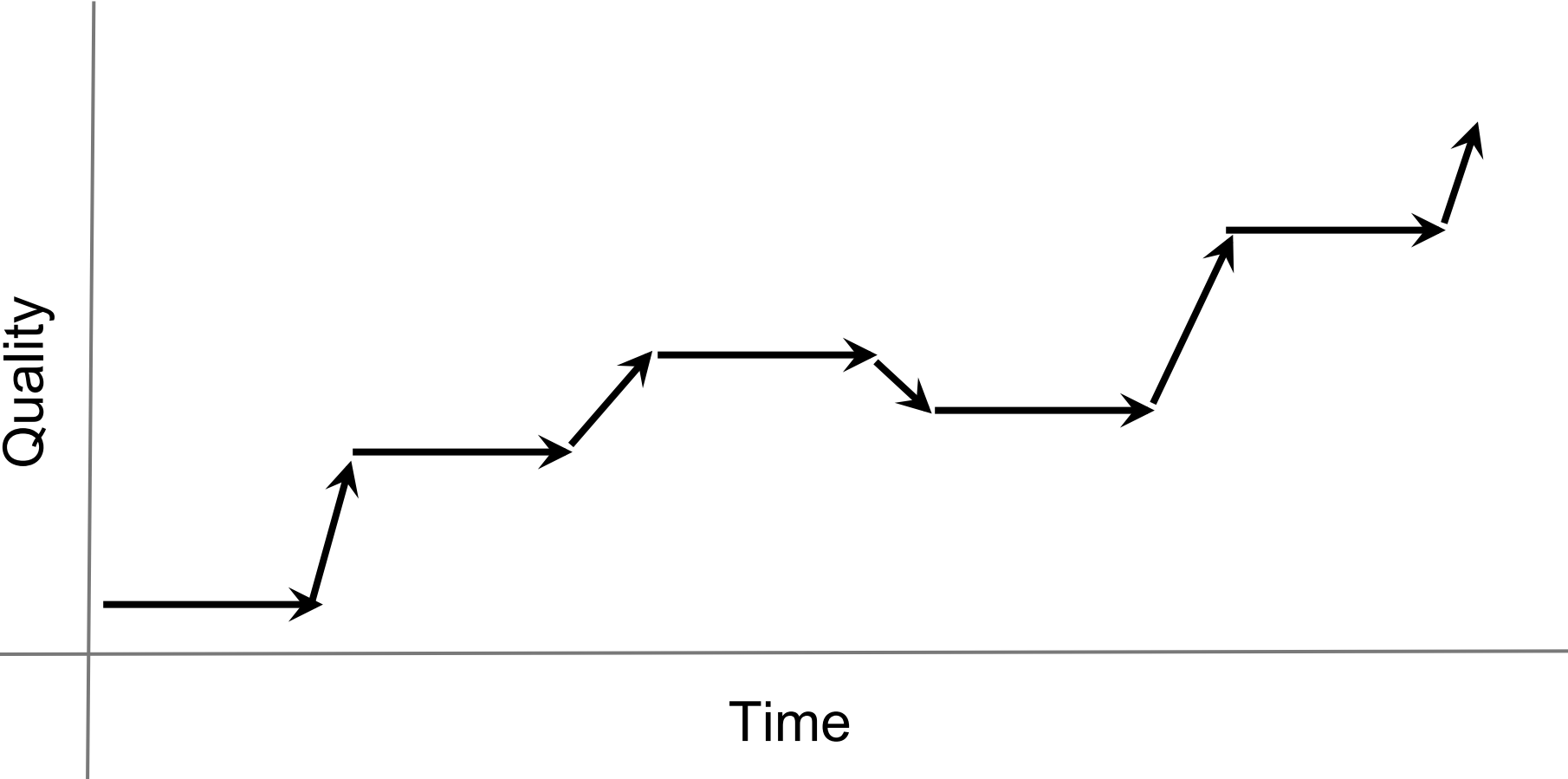
- Considerations:
 - What types of processes are there?
 - Where do processes come from?
 - Are they well defined?
 - How much variance is there each time a process is implemented?
 - Do they work well?
- Significant emphasis on "maturity of processes" within an organization, not just individual projects

Process Improvement

- Involves understanding existing processes
- Introduce changes to improve quality, reduce cost, accelerate schedules
- Process improvement cycle:
 - **measure** current process outputs and metrics
 - **analyze** metrics to discover areas of improvement
 - **change** existing process to improve outputs



Visualizing Process Improvement



How to Conduct an Assessment?

- Measure performance of processes and quality of work products using **metrics**
- Ex: Consider a manufacturing process building cars on an assembly line. How could we measure the performance of the manufacturing process?
 - **Cost**: what is the cost per car? cost per component?
 - **Time**: how long does it take per car?
 - **Output rate**: how many cars per day?
 - **Defect rate**: how many defects per car?
 - others?

Appraisal

- Past: assessment via organizational questionnaire

Appraisal

- Past: assessment via organizational questionnaire
- Now: assessment through *appraisal*
 - Scope jointly defined, so assessment is tailored
 - Verifies/validates objective evidence
 - Provide benchmark quality ratings according to defined processes and maturity levels
 - Comparison with other organizations in the industry
 - Focus on improvements that are most beneficial to the current state of the organization
 - Derive organization's capability and maturity levels
 - Outline risks for the current state of the organization

CMMI Maturity Level 1: Initial

- Ad-hoc approach
 - Entire process is unpredictable
 - Case-by-case
 - Anything goes
 - Development without an explicit process
 - Uncontrolled
 - Teams put in extra hard work to achieve results (stronger team; don't like guidelines)
 - **Reactive management:** Responses to crises
- Most organizations worldwide are at this level!

CMMI Maturity Level 2: Managed (Repeatable)

- Management of organizational requirements
 - Processes that are planned, performed, tracked, controlled
- Applies basic software management
 - Decisions based on previous similar experiences
 - Basic PM measurements are made
 - When problems arise, corrective action is taken
- Some repeated processes
 - Guidelines are documented or well-established, so can be repeated next time
 - Measurements can be used in future projects

CMMI Maturity Level 3: Defined

- Improvement over Level 2
 - Describes organizational processes in standards, procedures, tools, methods
 - Focus on reusability
- Standard processes are fully documented
 - Managerial and technical aspects are clearly defined
 - Both process and product activities are defined
 - Efforts to standardize activities across company
 - Continual efforts are made to improve quality and productivity
 - CASE tools are applied

CMMI Maturity Level 4: Quantitatively Managed

- Process control via quantitative measures
 - Quantitatively record measurements on various aspects
 - Project (metrics?)
 - Product (metrics?)
 - Human resources (metrics?)
- Set quality and productivity goals
 - Quantitatively analyze measurements
 - Monitor quality and productivity
 - Statistical quality controls are in place
 - Make plans and predictions using metrics

CMMI Maturity Level 5: Optimizing

- Continuous process improvement
 - Incremental and innovative technological improvements
 - Quantitative tools and objectives to manage:
 - Planning and resource allocation
 - Quality
 - Process controls
 - Feedback from one project to the next
- Compare:
 - Level 2 (Repeatable): Detection and correction of faults
 - Level 5 (Optimizing): Prevention of faults

CMMI Maturity "Grades"

- Level 1 (Initial)
 - Ad-hoc, often chaotic processes
- Level 2 (Managed/Repeatable)
 - Organizational requirements, basic PM
- Level 3 (Defined)
 - Standards, procedures, tools, methods established
- Level 4 (Quantitatively Managed)
 - Process control via quantitative measurements
- Level 5 (Optimizing)
 - Improvement guided by quantitative measurements

Example:

Company FUN - Which Level?

- 15 employees and 1 PM
- 7 projects at any one time
- Project plans are sometimes created
- Project (final) reports are sometimes written
- Design, code, test as needed
- Documentation - nowhere to be found
- Requirements and deliverables negotiated regularly with the client
- New employees start working right away

Example:

Company **GAMES** - Which Level?

- 10 employees, 2 PM's, 2 major projects
- Everything is heavily documented
- Design, code, test as individual programmer sees fit
- Requirements are developed through detailed elicitation and analysis steps
- Deliverables stick closely to project plans
- Regular project meetings and progress reviews
- Train new employees through documentation

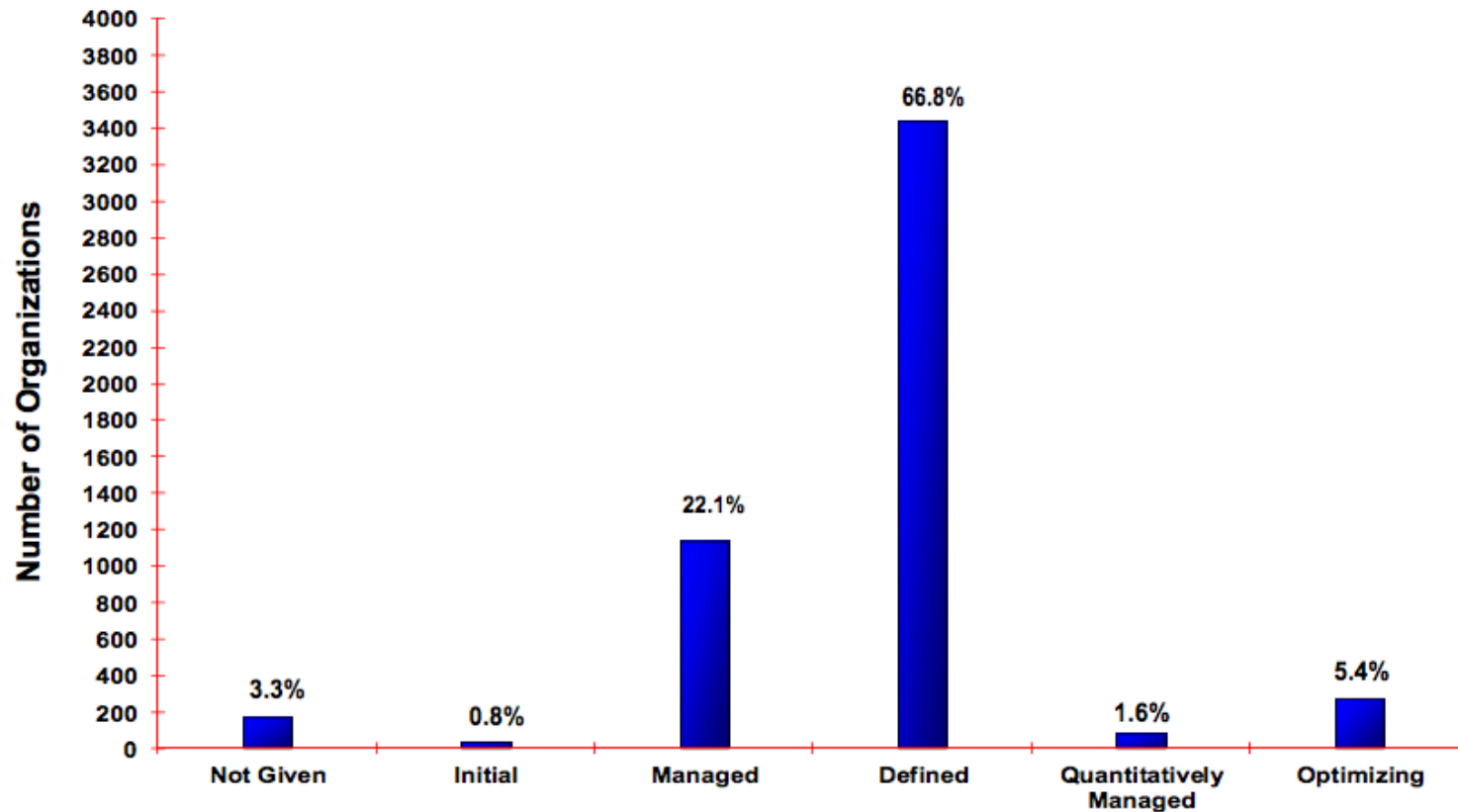
Example:

Company CHAINS - Which Level?

- 7000 employees, 900 PM's, 3 major projects, tons of small projects
- Documentation everywhere, everyone writes in their own preferred way
- Meetings and reviews for everything
- Requirements are derived from contracts
- Deliverables vary, deadlines and budgets are not met
- Long training periods with new employees through documentation

SEI/CMU Appraisal Results 2012

Process Maturity Profile by All Reporting Organizations



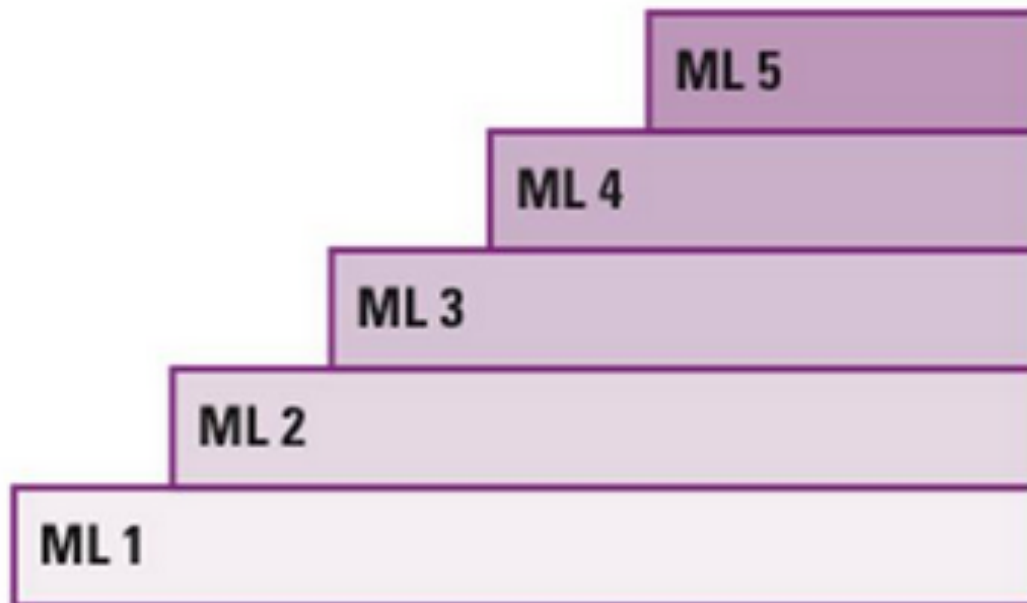
Based on most recent appraisal of 5159 organizations

Why Assess Companies?

- Aside from cost reduction, on-time delivery, improved quality, what are other benefits?
- Know your own strengths and weaknesses
- Strategy to meet your business objectives
 - Set measurable goals
 - Measure, analyze, improve, ...
- Some contracts require at least a Level 3 (e.g., U.S. Department of Defense)

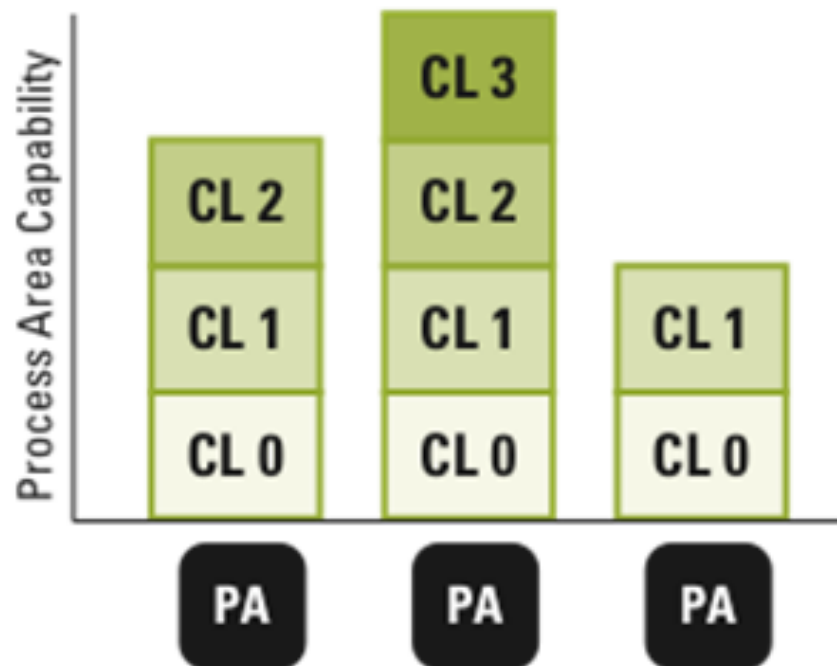
CMMI Maturity Levels

- Provide a staging of processes for improvement across an organization
- Improvement involves achieving the goals of the process areas at each level



CMMI Capability Levels

- Focus process improvement efforts by process area
- Level 0 = Not performed



CMMI Advancement

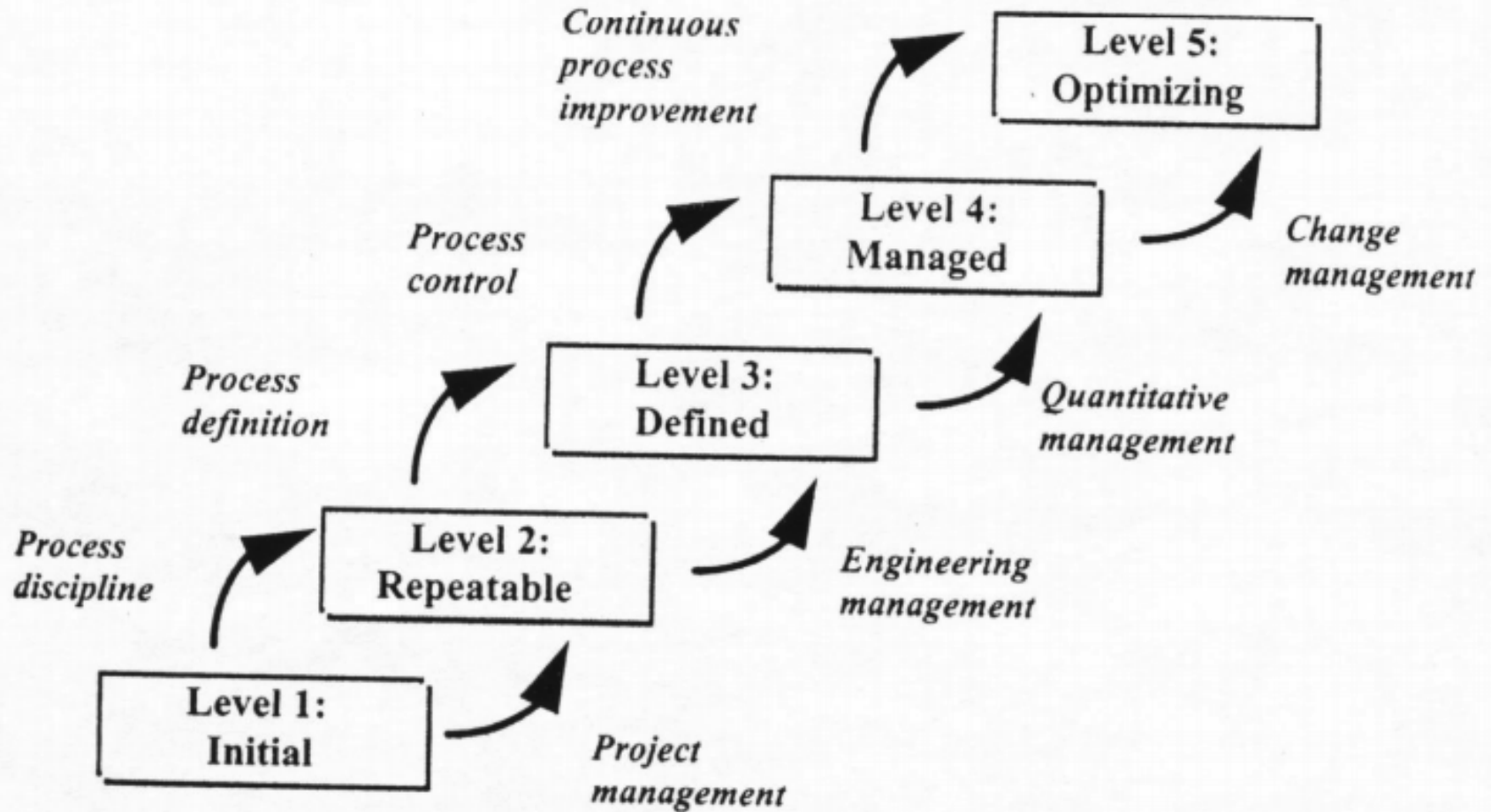


Figure 3.3: The Software Engineering Institute's levels of process maturity

How to Move Up Levels?

- One level at a time
 - Level 1 company can't jump to Level 4
- CMMI: Appraisal result
 - Assessment designed for elicited business objectives
 - Achieve all the goals for process areas associated to specific levels
 - Customized strategy for advancement

Example: Requirements Development (RD)

REQUIREMENTS DEVELOPMENT

Process Area Name

A Support Process Area at Maturity Level 3

Maturity Level

Purpose

Process Area Category

The purpose of Requirements Development (RD) is to elicit, analyze, and establish customer, product, and product component requirements.

Introductory Notes

Purpose Statement

This process area describes three types of requirements: customer requirements, product requirements, and product component requirements. Taken together, these requirements address the needs of relevant stakeholders, including needs pertinent to various product lifecycle phases (e.g., acceptance testing criteria) and product attributes (e.g., responsiveness, safety, reliability, maintainability). Requirements also address constraints caused by the selection of design solutions (e.g., integration of commercial off-the-shelf products, use of a particular architecture pattern).

Introductory Notes

All development projects have requirements. Requirements are the basis for design. The development of requirements includes the following activities:

Stakeholder needs, expectations, constraints, and interfaces are collected and translated into customer requirements.

The needs of stakeholders (e.g., customers, end users, suppliers, builders, testers, manufacturers, logistics support staff) are the basis for determining customer requirements. The stakeholder needs, expectations, constraints, interfaces, operational concepts, and product concepts are analyzed, harmonized, refined, and elaborated for translation into a set of customer requirements.

SP 1.1 Elicit Needs

Elicit stakeholder needs, expectations, constraints, and interfaces for all phases of the product lifecycle.

Specific Practice

Eliciting goes beyond collecting requirements by proactively identifying additional requirements not explicitly provided by customers. Additional requirements should address the various product lifecycle activities and their impact on the product.

Examples of techniques to elicit needs include the following:

- Technology demonstrations
- Questionnaires, interviews, and scenarios (operational, sustainment, and development) obtained from end users
- Quality attribute elicitation workshops with stakeholders
- Prototypes and models
- Brainstorming
- Market surveys
- Observation of existing products, environments, and workflow patterns
- Use cases
- Customer satisfaction surveys

Example Work Product

Example Work Products

1. Results of requirements elicitation activities

Subpractice

Subpractices

1. Engage relevant stakeholders using methods for eliciting needs, expectations, constraints, and external interfaces.

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process.

Generic Goal

GP 2.1 Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the process.

Generic Practice

The purpose of this generic practice is to define the organizational expectations for the process and make these expectations visible to those members of the organization who are affected. In general, senior management is responsible for establishing and communicating guiding principles, direction, and expectations for the organization.

Not all direction from senior management will bear the label "policy." The existence of appropriate organizational direction is the expectation of this generic practice, regardless of what it is called or how it is imparted.

CAR Elaboration

This policy establishes organizational expectations for identifying and systematically addressing causal analysis of selected outcomes.

CM Elaboration

This policy establishes organizational expectations for establishing and maintaining baselines, tracking and controlling changes to work products (under configuration management), and establishing and maintaining integrity of the baselines.

DAR Elaboration

This policy establishes organizational expectations for selectively analyzing possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria. The policy should also

Generic Practice Elaboration

Process Area Components

- Each process area has:
 - **Required** components
 - **Expected** components
 - **Informative** components

Required Components

- Essential to achieving process improvement
- Goal satisfaction determine whether process area is achieved in appraisal
 - **Specific goals** - unique to process areas
 - EX in RD:
"Develop customer requirements."
 - **Generic goals** - applies to multiple process areas
 - EX: "The process is institutionalized as a managed process."
- How to know if goals are achieved?

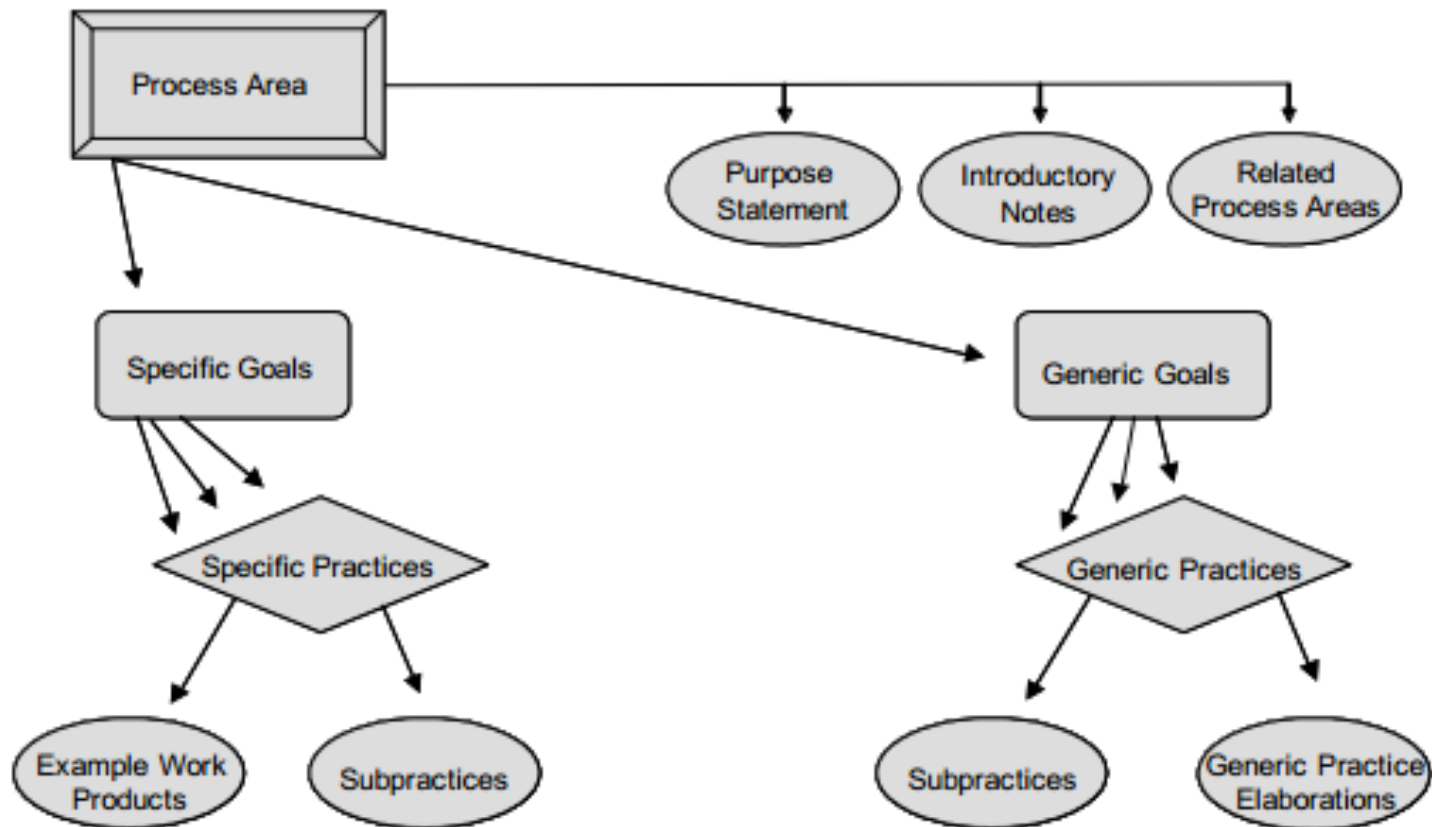
Expected Components

- Activities in achieving a required component
- Presence of these practices indicate whether corresponding goals are satisfied
 - **Specific practices** - unique to process areas
 - EX in RD:
"Elicit needs."
 - **Generic Practices** - applies to multiple process areas
 - EX: "Establish an organizational policy."
- How to know if practices are performed?

Informative Components

- Help to understand required and expected components
- Consist of:
 - Examples
 - Detailed explanations
 - Subpractices
 - References
 - Example work products

Process Area Components



KEY:



Not Just for Business Owners

- When things don't work smoothly and you wonder what exactly is wrong or how things can be improved
- CMMI can help others too
 - Project managers
 - Requirements engineers / Analysts
 - Business process analysts
 - Product manager
 - Quality assurance manager
 - Organizational change manager

Experience

- Appraisal highlight shortcomings and suggest ways to improve the process
- It takes:
 - 3-5 years to get from Level 1 to Level 2
 - 1.5-3 years to get from Level 2 to Level 3
- Typically takes longer from Level 1 → Level 2 than from Level 3 → Level 4 → Level 5
(why?)

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- Typically takes longer from Level 1 → Level 2 than from Level 3 → Level 4 → Level 5
 - Initial "learning curve"
 - Hesitation towards processes (task/self-oriented types)

Profitability

- Hughes Aircraft
 - Spent \$500K moving from Level 2 to Level 3 (1987-1990)
 - Savings: \$2M per year

- Raytheon
 - Moved from Level 1 in 1988 and then eventually to Level 3 in 1993
 - Productivity doubled
 - Return of \$7.70 per dollar invested in process improvement

SEI Early Report

- Data from 13 organizations

Category	Range	Median	Number of Data Points
Years engaged in software process improvement (SPI)	1–9	3.5	24
Yearly cost of SPI per software engineer	\$490–\$2004	\$1375	5
Productivity gain per year	9%–67%	35%	4
Early defect detection gain per year	6%–25%	22%	3
Yearly reduction in time to market	15%–23%	19%	2
Yearly reduction in post-release defect reports	10%–94%	39%	5
Business value (saving/cost of SPI)	4.0–8.8:1	5.0:1	5

Summary

- Main CMMI concepts:
 - Process improvement
 - Organizational processes
 - CMMI levels
 - Measure, analyze, change loop
 - Process advancement
- Next class: review for midterm

References

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