

## Process improvement

### Lecture 1

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## Topics covered

- ✧ The process improvement process
- ✧ Process measurement
- ✧ Process analysis
- ✧ Process change
- ✧ The CMMI process improvement framework

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## Process improvement

- ✧ Many software companies have turned to software process improvement as a way of enhancing the quality of their software, reducing costs or accelerating their development processes.
- ✧ Process improvement means understanding existing processes and changing these processes to increase product quality and/or reduce costs and development time.

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## Approaches to improvement

- ✧ The process maturity approach, which focuses on improving process and project management and introducing good software engineering practice.
  - The level of process maturity reflects the extent to which good technical and management practice has been adopted in organizational software development processes.
- ✧ The agile approach, which focuses on iterative development and the reduction of overheads in the software process.
  - The primary characteristics of agile methods are rapid delivery of functionality and responsiveness to changing customer requirements.

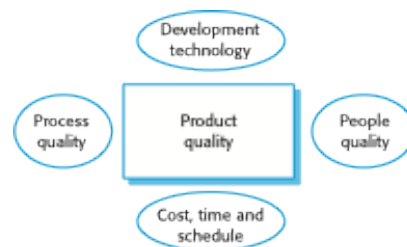
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## Process and product quality

- ✧ Process quality and product quality are closely related and process improvement benefits arise because the quality of the product depends on its development process.
- ✧ A good process is usually required to produce a good product.
- ✧ For manufactured goods, process is the principal quality determinant.
- ✧ For design-based activities, other factors are also involved, especially the capabilities of the designers.

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## Factors affecting software product quality



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## Quality factors



- ✧ For large projects with 'average' capabilities, the development process determines product quality.
- ✧ For small projects, the capabilities of the developers is the main determinant.
- ✧ The development technology is particularly significant for small projects.
- ✧ In all cases, if an unrealistic schedule is imposed then product quality will suffer.

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## Process improvement process



- ✧ There is no such thing as an 'ideal' or 'standard' software process that is applicable in all organizations or for all software products of a particular type.
  - You will rarely be successful in introducing process improvements if you simply attempt to change the process to one that is used elsewhere.
  - You must always consider the local environment and culture and how this may be affected by process change proposals.
- ✧ Each company has to develop its own process depending on its size, the background and skills of its staff, the type of software being developed, customer and market requirements, and the company culture.

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## Improvement attributes



- ✧ You also have to consider what aspects of the process that you want to improve.
- ✧ Your goal might be to improve software quality and so you may wish to introduce new process activities that change the way software is developed and tested.
- ✧ You may be interested in improving some attribute of the process itself (such as development time) and you have to decide which process attributes are the most important to your company.

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## Process attributes



| Process characteristic | Key issues  |
|------------------------|---|
| Understandability      | To what extent is the process explicitly defined and how easy is it to understand the process definition?   |
| Standardization        | To what extent is the process based on a standard generic process? This may be important for some customers who require conformance with a set of defined process standards. To what extent is the same process used in all parts of a company? |
| Visibility             | Do the process activities culminate in clear results, so that the progress of the process is externally visible?  |
| Measurability          | Does the process include data collection or other activities that allow process or product characteristics to be measured?  |
| Supportability         | To what extent can software tools be used to support the process activities?  |

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## Process attributes



| Process characteristic | Key issues   |
|------------------------|--|
| Acceptability          | Is the defined process acceptable to and usable by the engineers responsible for producing the software product?       |
| Reliability            | Is the process designed in such a way that process errors are avoided or trapped before they result in product errors? |
| Robustness             | Can the process continue in spite of unexpected problems?  |
| Maintainability        | Can the process evolve to reflect changing organizational requirements or identified process improvements?             |
| Rapidity               | How fast can the process of delivering a system from a given specification be completed?                               |

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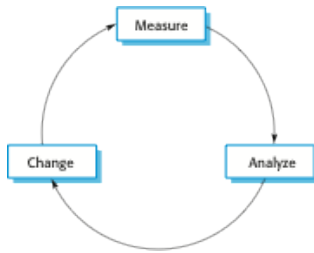
## Process improvement stages



- ✧ Process measurement
  - Attributes of the current process are measured. These are a baseline for assessing improvements.
- ✧ Process analysis
  - The current process is assessed and bottlenecks and weaknesses are identified.
- ✧ Process change
  - Changes to the process that have been identified during the analysis are introduced.

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## The process improvement cycle



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## Process measurement

- ✧ Wherever possible, quantitative process data should be collected
  - However, where organisations do not have clearly defined process standards this is very difficult as you don't know what to measure. A process may have to be defined before any measurement is possible.
- ✧ Process measurements should be used to assess process improvements
  - But this does not mean that measurements should drive the improvements. The improvement driver should be the organizational objectives.

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## Process metrics

- ✧ Time taken for process activities to be completed
  - E.g. Calendar time or effort to complete an activity or process.
- ✧ Resources required for processes or activities
  - E.g. Total effort in person-days.
- ✧ Number of occurrences of a particular event
  - E.g. Number of defects discovered.

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## Goal-Question-Metric Paradigm

- ✧ Goals
  - What is the organisation trying to achieve? The objective of process improvement is to satisfy these goals.
- ✧ Questions
  - Questions about areas of uncertainty related to the goals. You need process knowledge to derive these.
- ✧ Metrics
  - Measurements to be collected to answer the questions.

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## GQM questions

- ✧ The GQM paradigm is used in process improvement to help answer three critical questions:
  - Why are we introducing process improvement?
  - What information do we need to help identify and assess improvements?
  - What process and product measurements are required to provide this information?

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## The GQM paradigm



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## Process analysis



- ✧ The study of existing processes to understand the relationships between parts of the process and to compare them with other processes.
- ✧ Process analysis and process measurement are intertwined.
- ✧ You need to carry out some analysis to know what to measure, and, when making measurements, you inevitably develop a deeper understanding of the process being measured.

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## Process analysis objectives



- ✧ To understand the activities involved in the process and the relationships between these activities.
- ✧ To understand the relationships between the process activities and the measurements that have been made.
- ✧ To relate the specific process or processes that you are analyzing to comparable processes elsewhere in the organization, or to idealized processes of the same type.

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## Process analysis techniques



- ✧ Published process models and process standards
  - It is always best to start process analysis with an existing model. People then may extend and change this.
- ✧ Questionnaires and interviews
  - Must be carefully designed. Participants may tell you what they think you want to hear.
- ✧ Ethnographic analysis
  - Involves assimilating process knowledge by observation. Best for in-depth analysis of process fragments rather than for whole-process understanding.

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## Aspects of process analysis



| Process aspect                | Questions   |
|-------------------------------|---|
| Adoption and standardization  | Is the process documented and standardized across the organization? If not, does this mean that any measurements made are specific only to a single process instance? If processes are not standardized, then changes to one process may not be transferable to comparable processes elsewhere in the company.  |
| Software engineering practice | Are there known, good software engineering practices that are not included in the process? Why are they not included? Does the lack of these practices affect product characteristics, such as the number of defects in a delivered software system?  |
| Organizational constraints    | What are the organizational constraints that affect the process design and the ways that the process is performed? For example, if the process involves dealing with classified material, there may be activities in the process to check that classified information is not included in any material due to be released to external organizations. Organizational constraints may mean that possible process changes cannot be made. |

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## Aspects of process analysis



| Process aspect | Questions   |
|----------------|---|
| Communications | How are communications managed in the process? How do communication issues relate to the process measurements that have been made? Communication problems are a major issue in many processes and communication bottlenecks are often the reasons for project delays. |
| Introspection  | Is the process reflective (i.e., do the actors involved in the process explicitly think about and discuss the process and how it might be improved)? Are there mechanisms through which process actors can propose process improvements?                              |
| Learning       | How do people joining a development team learn about the software processes used? Does the company have process manuals and process training programs?  |
| Tool support   | What aspects of the process are and aren't supported by software tools? For unsupported areas, are there tools that could be deployed cost-effectively to provide support? For supported areas, are the tools effective and efficient? Are better tools available?    |

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## Process models



- ✧ Process models are a good way of focusing attention on the activities in a process and the information transfer between these activities.
- ✧ Process models do not have to be formal or complete – their purpose is to provoke discussion rather than document the process in detail.
- ✧ Model-oriented questions can be used to help understand the process e.g.
  - What activities take place in practice but are not shown in the model?
  - Are there process activities, shown in the model, that you (the process actor) think are inefficient?

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## Process exceptions



- ✧ Software processes are complex and process models cannot effectively represent how to handle exceptions:
  - Several key people becoming ill just before a critical review;
  - A breach of security that means all external communications are out of action for several days;
  - Organisational reorganisation;
  - A need to respond to an unanticipated request for new proposals.
- ✧ Under these circumstances, the model is suspended and managers use their initiative to deal with the exception.

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## Key points



- ✧ The goals of process improvement are higher product quality, reduced process costs and faster delivery of software.
- ✧ The principal approaches to process improvement are agile approaches, geared to reducing process overheads, and maturity-based approaches based on better process management and the use of good software engineering practice.
- ✧ The process improvement cycle involves process measurement, process analysis and modeling, and process change.
- ✧ Measurement should be used to answer specific questions about the software process used. These questions should be based on organizational improvement goals.

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## Process improvement

### Lecture 2



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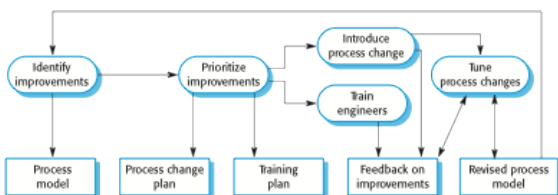
## Process change



- ✧ Involves making modifications to existing processes.
- ✧ This may involve:
  - Introducing new practices, methods or processes;
  - Changing the ordering of process activities;
  - Introducing or removing deliverables;
  - Introducing new roles or responsibilities.
- ✧ Change should be driven by measurable goals.

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## The process change process



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## Process change stages



- ✧ Improvement identification
  - This stage is concerned with using the results of the process analysis to identify ways to tackle quality problems, schedule bottlenecks or cost inefficiencies that have been identified during process analysis.
- ✧ Improvement prioritization
  - When many possible changes have been identified, it is usually impossible to introduce them all at once, and you must decide which are the most important.
- ✧ Process change introduction
  - Process change introduction means putting new procedures, methods and tools into place and integrating them with other process activities.

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## Process change stages



### ✧ Process change training

- Without training, it is not possible to gain the full benefits of process changes. The engineers involved need to understand the changes that have been proposed and how to perform the new and changed processes.

### ✧ Change tuning

- Proposed process changes will never be completely effective as soon as they are introduced. You need a tuning phase where minor problems can be discovered, and modifications to the process can be proposed and introduced.

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## Process change problems



### ✧ Resistance to change

- Team members or project managers may resist the introduction of process changes and propose reasons why changes will not work, or delay the introduction of changes. They may, in some cases, deliberately obstruct process changes and interpret data to show the ineffectiveness of proposed process change.

### ✧ Change persistence

- While it may be possible to introduce process changes initially, it is common for process innovations to be discarded after a short time and for the processes to revert to their previous state.

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## Resistance to change



### ✧ Project managers often resist process change because any innovation has unknown risks associated with it.

- Project managers are judged according to whether or not their project produces software on time and to budget. They may prefer an inefficient but predictable process to an improved process that has organizational benefits, but which has short-term risks associated with it.

### ✧ Engineers may resist the introduction of new processes for similar reasons, or because they see these processes as threatening their professionalism.

- That is, they may feel that the new pre-defined process gives them less discretion and does not recognize the value of their skills and experience.

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## Change persistence



### ✧ The problem of changes being introduced then subsequently discarded is a common one.

- Changes may be proposed by an 'evangelist' who believes strongly that the changes will lead to improvement. He or she may work hard to ensure the changes are effective and the new process is accepted.
- If the 'evangelist' leaves, then the people involved may therefore simply revert to the previous ways of doing things.

### ✧ Change institutionalization is important

- This means that process change is not dependent on individuals but that the changes become part of standard practice in the company, with company-wide support and training.

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## The CMMI process improvement framework



### ✧ The CMMI framework is the current stage of work on process assessment and improvement that started at the Software Engineering Institute in the 1980s.

### ✧ The SEI's mission is to promote software technology transfer particularly to US defence contractors.

### ✧ It has had a profound influence on process improvement

- Capability Maturity Model introduced in the early 1990s.
- Revised maturity framework (CMMI) introduced in 2001.

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## The SEI capability maturity model



### ✧ Initial

- Essentially uncontrolled

### ✧ Repeatable

- Product management procedures defined and used

### ✧ Defined

- Process management procedures and strategies defined and used

### ✧ Managed

- Quality management strategies defined and used

### ✧ Optimising

- Process improvement strategies defined and used

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## Process capability assessment



- ✧ Intended as a means to assess the extent to which an organisation's processes follow best practice.
- ✧ By providing a means for assessment, it is possible to identify areas of weakness for process improvement.
- ✧ There have been various process assessment and improvement models but the SEI work has been most influential.

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## The CMMI model



- ✧ An integrated capability model that includes software and systems engineering capability assessment.
- ✧ The model has two instantiations
  - Staged where the model is expressed in terms of capability levels;
  - Continuous where a capability rating is computed.

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## CMMI model components



- ✧ Process areas
  - 24 process areas that are relevant to process capability and improvement are identified. These are organised into 4 groups.
- ✧ Goals
  - Goals are descriptions of desirable organisational states. Each process area has associated goals.
- ✧ Practices
  - Practices are ways of achieving a goal - however, they are advisory and other approaches to achieve the goal may be used.

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## Process areas in the CMMI



| Category           | Process area                                   |
|--------------------|--|
| Process management | Organizational process definition (OPD)        |
|                    | Organizational process focus (OPF)             |
|                    | Organizational training (OT)                   |
|                    | Organizational process performance (OPP)       |
|                    | Organizational innovation and deployment (OID) |
| Project management | Project planning (PP)                          |
|                    | Project monitoring and control (PMC)           |
|                    | Supplier agreement management (SAM)            |
|                    | Integrated project management (IPM)            |
|                    | Risk management (RSKM)                         |
|                    | Quantitative project management (QPM)          |

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## Process areas in the CMMI



| Category    | Process area                                  |
|-------------|---|
| Engineering | Requirements management (REQM)                |
|             | Requirements development (RD)                 |
|             | Technical solution (TS)                       |
|             | Product integration (PI)                      |
|             | Verification (VER)                            |
| Support     | Validation (VAL)                              |
|             | Configuration management (CM)                 |
|             | Process and product quality management (PPQA) |
|             | Measurement and analysis (MA)                 |
|             | Decision analysis and resolution (DAR)        |
|             | Causal analysis and resolution (CAR)          |

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## Goals and associated practices in the CMMI



| Goal  | Associated practices   |
|---|--|
| The requirements are analyzed and validated, and a definition of the required functionality is developed. | Analyze derived requirements systematically to ensure that they are necessary and sufficient.  |
|   | Validate requirements to ensure that the resulting product will perform as intended in the user's environment, using multiple techniques as appropriate. |
| Root causes of defects and other problems are systematically determined.                                  | Select the critical defects and other problems for analysis.   |
|   | Perform causal analysis of selected defects and other problems and propose actions to address them.  |
| The process is institutionalized as a defined process.  | Establish and maintain an organizational policy for planning and performing the requirements development process.  |
|   |  |

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## Examples of goals in the CMMI

| Goal   | Process area                                   |
|--|--|
| Corrective actions are managed to closure when the project's performance or results deviate significantly from the plan. | Project monitoring and control (specific goal) |
| Actual performance and progress of the project are monitored against the project plan.                                   | Project monitoring and control (specific goal) |
| The requirements are analyzed and validated, and a definition of the required functionality is developed.                | Requirements development (specific goal)       |
| Root causes of defects and other problems are systematically determined.   | Causal analysis and resolution (specific goal) |
| The process is institutionalized as a defined process.   | Generic goal                                   |

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## CMMI assessment

- ✧ Examines the processes used in an organisation and assesses their maturity in each process area.
- ✧ Based on a 6-point scale:
  - Not performed;
  - Performed;
  - Managed;
  - Defined;
  - Quantitatively managed;
  - Optimizing.

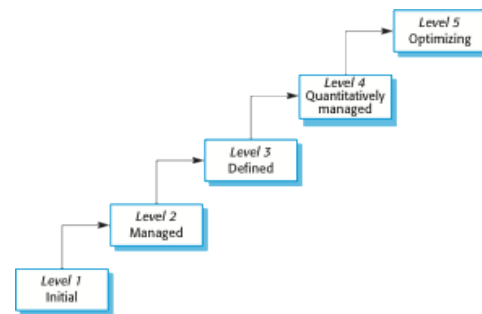
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## The staged CMMI model

- ✧ Comparable with the software CMM.
- ✧ Each maturity level has process areas and goals. For example, the process area associated with the managed level include:
  - Requirements management;
  - Project planning;
  - Project monitoring and control;
  - Supplier agreement management;
  - Measurement and analysis;
  - Process and product quality assurance.

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## The CMMI staged maturity model



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## Institutional practices

- ✧ Institutions operating at the managed level should have institutionalised practices that are geared to standardisation.
  - Establish and maintain policy for performing the project management process;
  - Provide adequate resources for performing the project management process;
  - Monitor and control the project planning process;
  - Review the activities, status and results of the project planning process.

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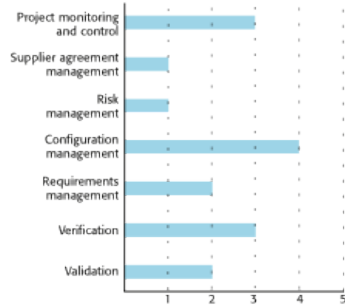
## The continuous CMMI model

- ✧ This is a finer-grain model that considers individual or groups of practices and assesses their use.
- ✧ The maturity assessment is not a single value but is a set of values showing the organisations maturity in each area.
- ✧ The CMMI rates each process area from levels 1 to 5.
- ✧ The advantage of a continuous approach is that organisations can pick and choose process areas to improve according to their local needs.

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### A process capability profile



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### Key points



- ✧ The CMMI process maturity model is an integrated process improvement model that supports both staged and continuous process improvement.
- ✧ Process improvement in the CMMI model is based on reaching a set of goals related to good software engineering practice and describing, standardizing and controlling the practices used to achieve these goals.
- ✧ The CMMI model includes recommended practices that may be used, but these are not obligatory.

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