Process Improvement

Objectives

- To explain the principles of software process improvement

- To explain how software process factors influence software quality and productivity

- To explain how to develop simple models of software processes

- To explain the notion of process capability and the CMMI process improvement model

Topics covered

- Process and product quality

- Process classification

- Process measurement

- Process analysis and modelling

- Process change

- The CMMI process improvement framework

Process improvement

- Understanding existing processes and introducing process changes to improve product quality, reduce costs or accelerate schedules.

- Most process improvement work so far has focused on defect reduction. This reflects the increasing attention paid by industry to quality.

- However, other process attributes can also be the focus of improvement

Process attributes

| Process characteristic	Description
Understandability	To what extent is the process explicitly defined and how easy is it to understand the process definition?
Visibility	Do the process activities culminate in clear results so that the progress of the process is externally visible?
Supportability	To what extent can CASE tools be used to support the process activities?
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 organisational requirements or identified process improvements?
Rapidity	How fast can the process of delivering a system from a given specification be completed?

The process improvement cycle
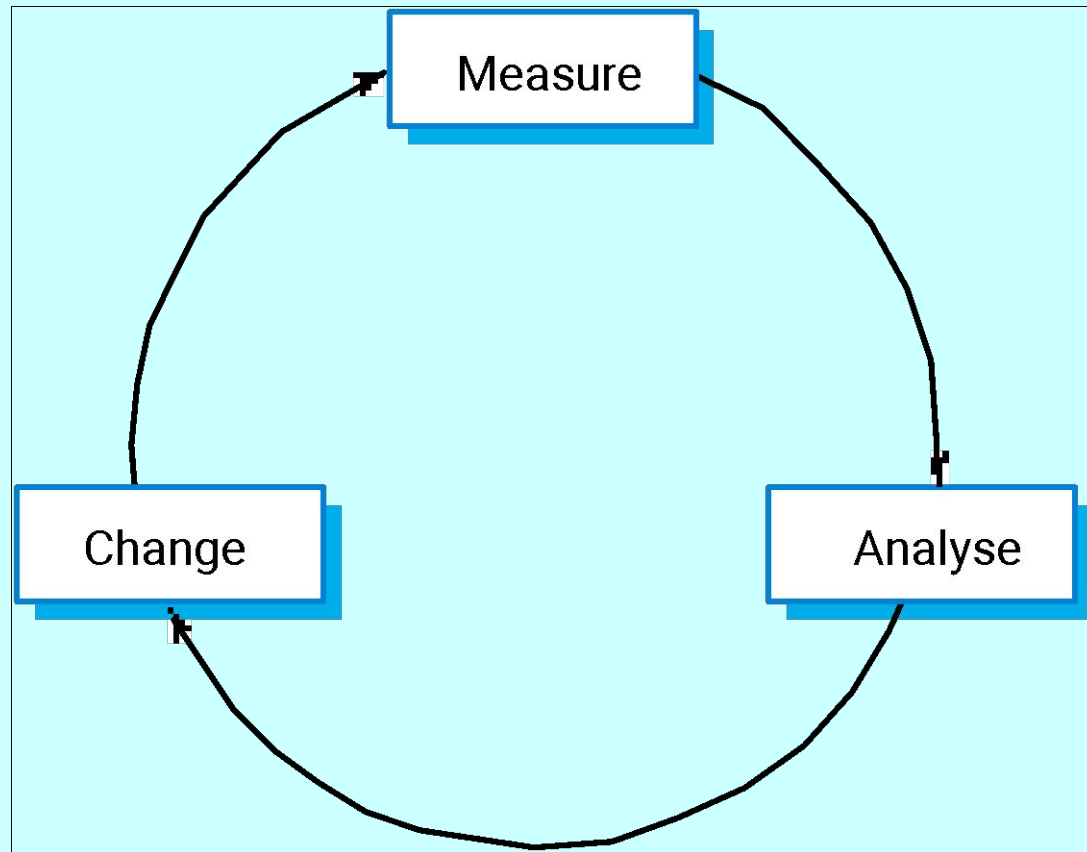
Process improvement stages

- ## 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.

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 activity, other factors are also involved especially the capabilities of the designers.
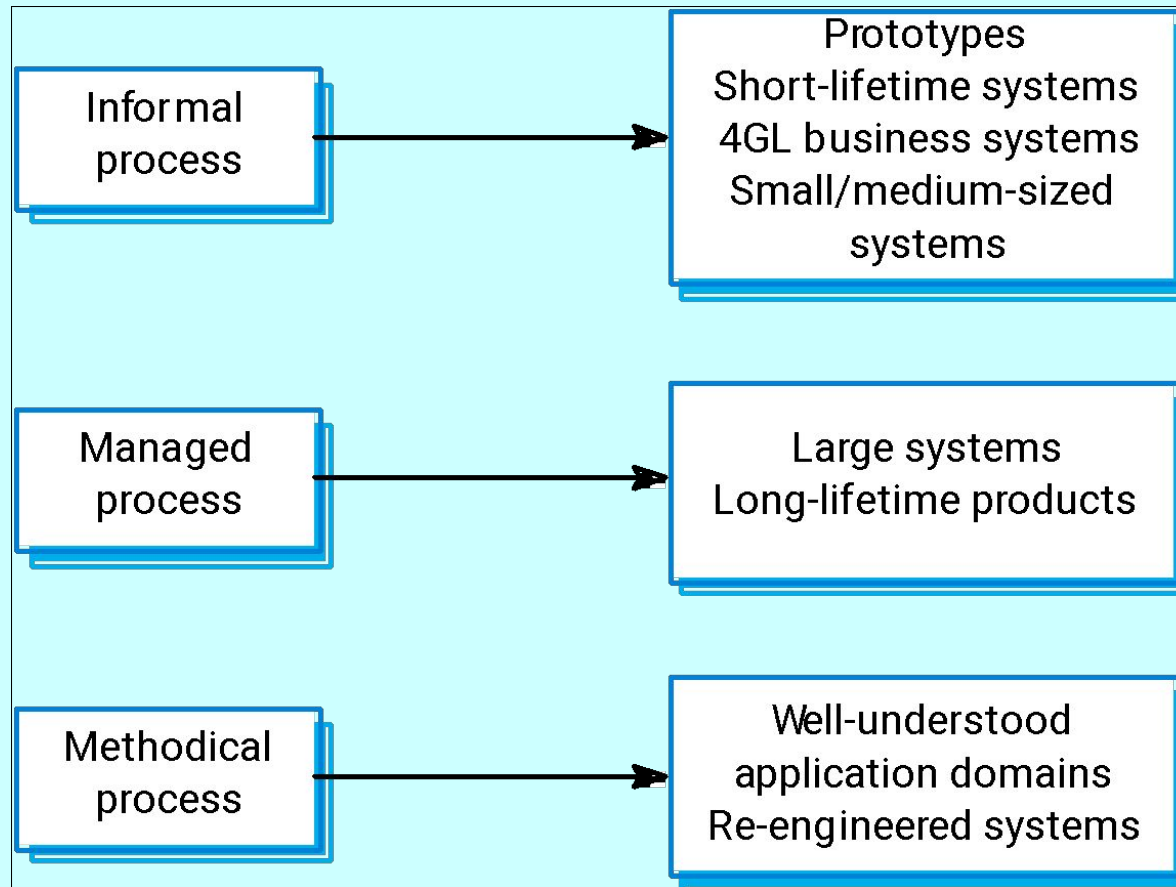
Principal product quality factors
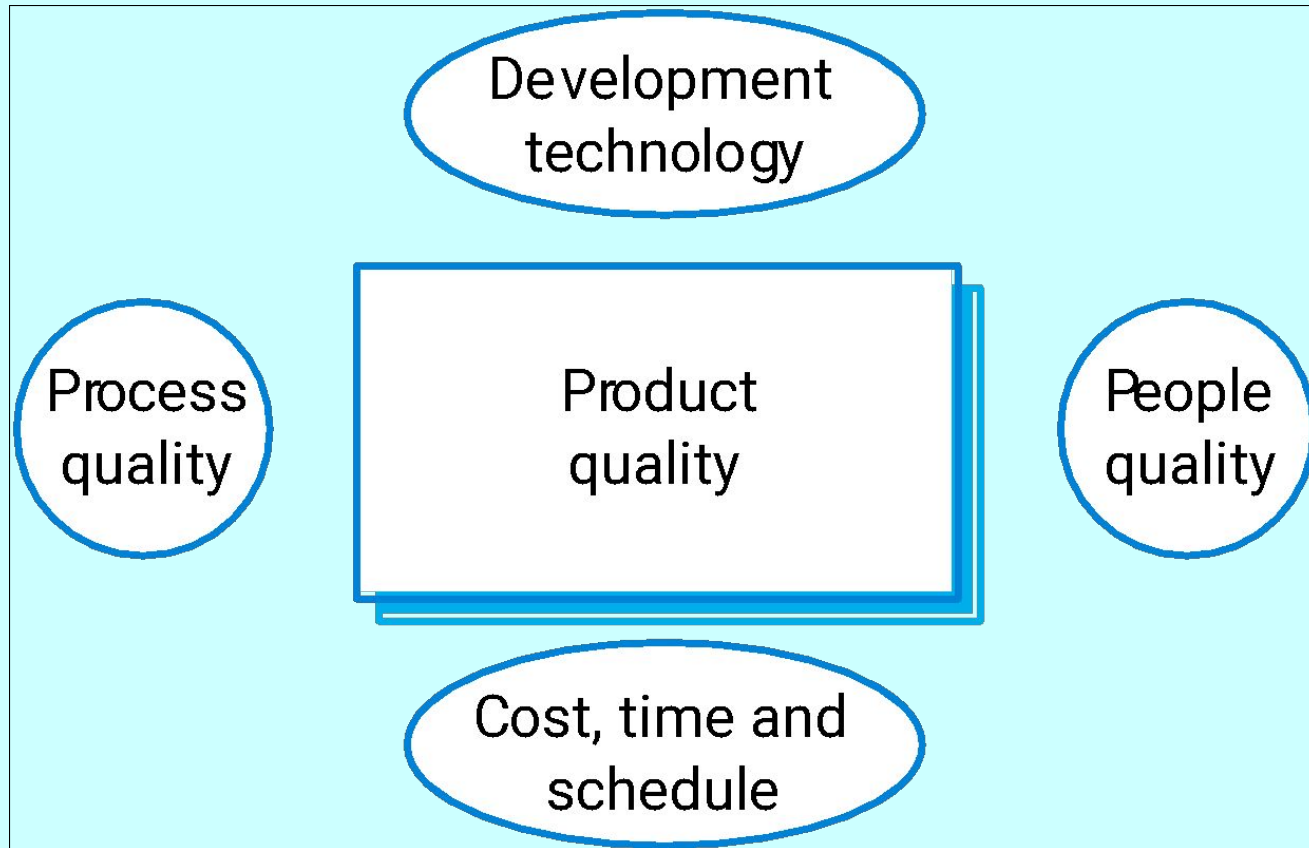
Quality factors

- 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.

Process classification

- Informal
  - No detailed process model. Development team chose their own way of working.
- Managed
  - Defined process model which drives the development process.
- Methodical
  - Processes supported by some development method such as the RUP.
- Supported
 - Processes supported by automated CASE tools.

Process applicability

Informal process	Prototypes Short-lifetime systems 4GL business systems Small/medium-sized systems
Managed process	Large systems Long-lifetime products
Methodical process	Well-understood application domains Re-engineered systems

Process choice

- Process used should depend on type of product which is being developed
  - For large systems, management is usually the principal problem so you need a strictly managed process;
  - For smaller systems, more informality is possible.
- There is no uniformly applicable process which should be standardised within an organisation
  - High costs may be incurred if you force an inappropriate process on a development team;
  - Inappropriate methods can also increase costs and lead to reduced quality.

Process tool support
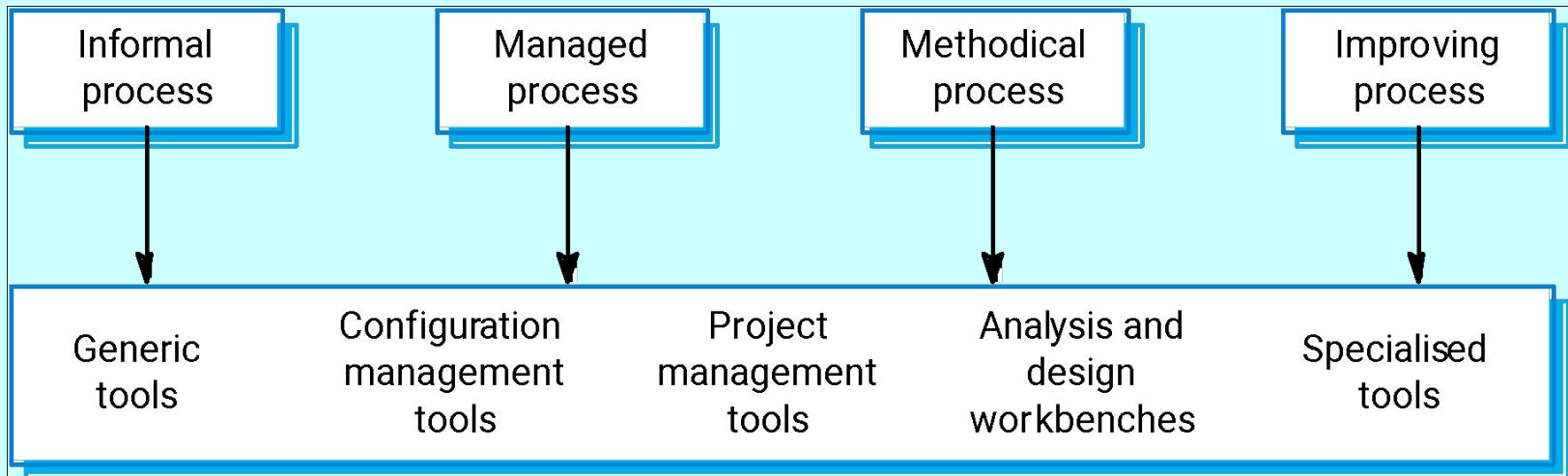
Process measurement

- 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.

Classes of process measurement

- 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.

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.

Process analysis and modelling

- Process analysis
    - The study of existing processes to understand the relationships between parts of the process and to compare them with other processes.

- Process modelling
    - The documentation of a process which records the tasks, the roles and the entities used;
    - Process models may be presented from different perspectives.

Process analysis and modelling

- Study an existing process to understand its activities.

- Produce an abstract model of the process. You should normally represent this graphically. Several different views (e.g. activities, deliverables, etc.) may be required.

- Analyse the model to discover process problems. This involves discussing process activities with stakeholders and discovering problems and possible process changes.

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.

Process model elements 1

Activity (shown as a round-edged rectangle with no drop shadow)	An activity has a clearly defined objective, entry and exit conditions. Examples of activities are preparing a set of test data to test a module, coding a function or a module, proof-reading a document, etc. Generally, an activity is atomic i.e. it is the responsibility of one person or group. It is not decomposed into sub-activities.
Process (shown as a round-edged rectangle with drop shadow)	A process is a set of activities which have some coherence and whose objective is generally agreed within an organisation. Examples of processes are requirements analysis, architectural design, test planning, etc.
Deliverable (shown as a rectangle with drop shadow)	A deliverable is a tangible output of an activity that is predicted in a project plan.
Condition (shown as a parallelogram)	A condition is either a pre-condition that must hold before a process or activity can start or a post-condition that holds after a process or activity has finished.

Process model elements 2

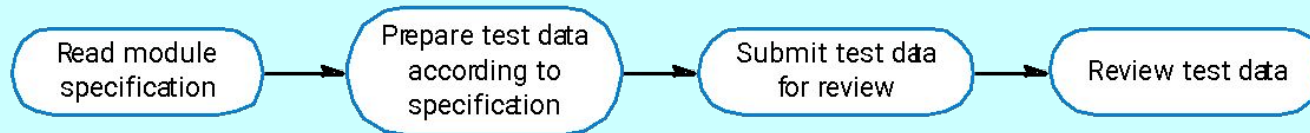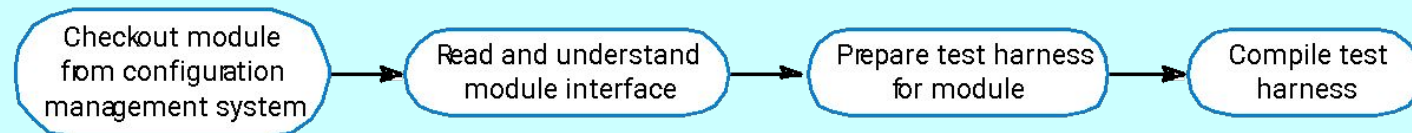|	
Role (shown as a circle with drop shadow)	A role is a bounded area of responsibility. Examples of roles might be configuration manager, test engineer, software designer, etc. One person may have several different roles and a single role may be associated with several different people.
Exception (not shown in examples here but may be represented as a double edged box)	An exception is a description of how to modify the process if some anticipated or unanticipated event occurs. Exceptions are often undefined and it is left to the ingenuity of the project managers and engineers to handle the exception.
Communication (shown as an arrow)	An interchange of information between people or between people and supporting computer systems. Communications may be informal or formal. Formal communications might be the approval of a deliverable by a project manager; informal communications might be the interchange of electronic mail to resolve ambiguities in a document.

The module testing activity
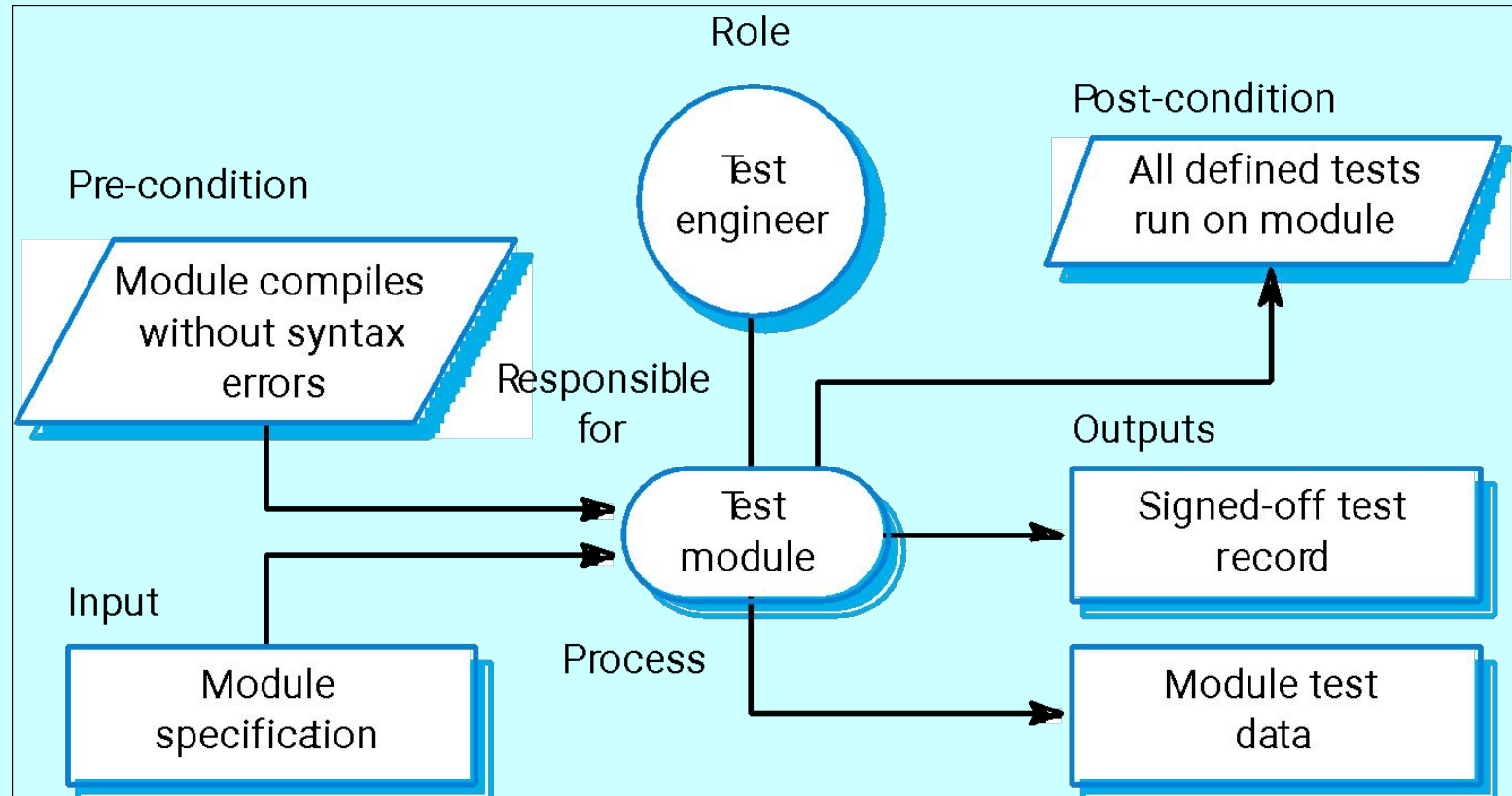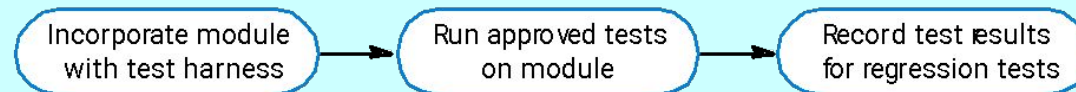
Activities in module testing

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.

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.

The process change process
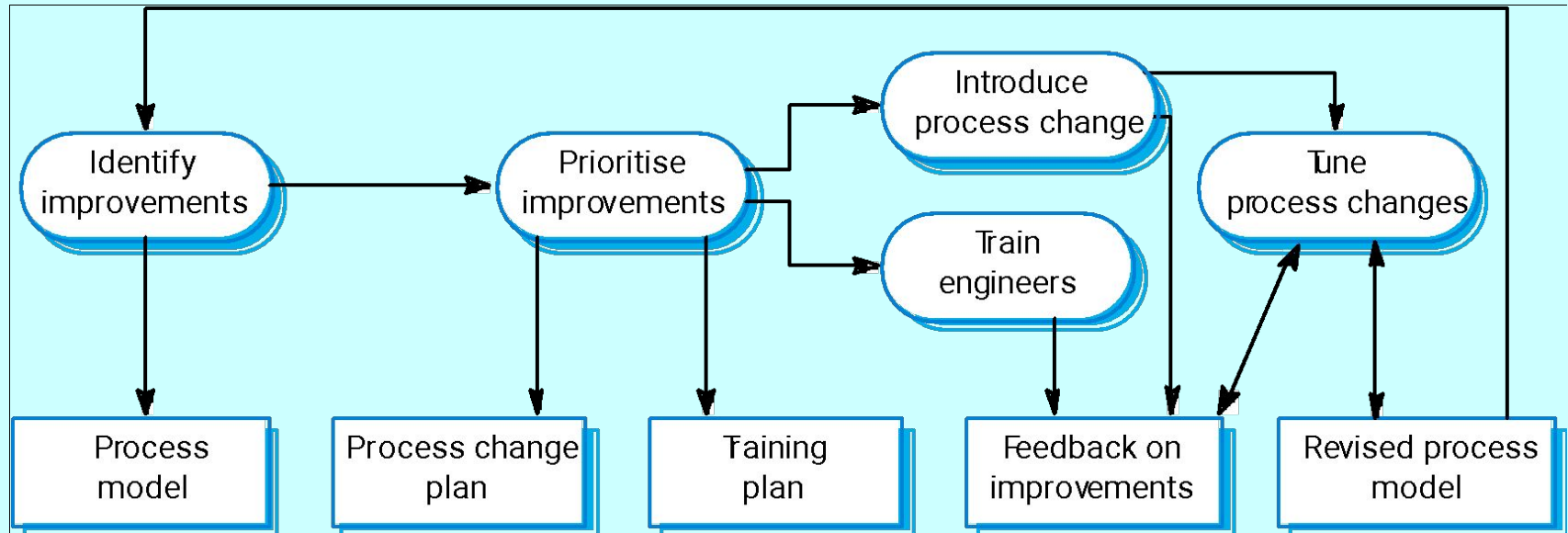
Process change stages

- Improvement identification.
- Improvement prioritisation.
- Process change introduction.
- Process change training.
- Change tuning.

The CMMI 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.

Process capability assessment

- Intended as a means to assess the extent to which an organisation's processes follow best practice.

- My 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.

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

Problems with the CMM

- Practices associated with model levels
    - Companies could be using practices from different levels at the same time but if all practices from a lower level were not used, it was not possible to move beyond that level

- Discrete rather than continuous
    - Did not recognise distinctions between the top and the bottom of levels

- Practice-oriented
    - Concerned with how things were done (the practices) rather than the goals to be achieved.

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.

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.

CMMI process areas 1

Process management	Organisational process definition
	Organisational process focus
	Organisational training
	Organisational process performance
	Organisational innovation and deployment
Project management	Project planning
	Project monitoring and control
	Supplier agreement management
	Integrated project management
	Risk management
	Integrated teaming
	Quantitative project management

CMMI process areas 2

Engineering	Requirements management
	Requirements development
	Technical solution
	Product integration
	Verification
	Validation
Support	Configuration management
	Process and product quality management
	Measurement and analysis
	Decision analysis and resolution
	Organisational environment for integration
	Causal analysis and resolution

CMMI goals

Goal	Process area
Corrective actions are managed to closure when the projectǒ performance or results deviate significantly from the plan.	Specific goal in Project Monitoring and Control
Actual performance and progress of the project is monitored against the project plan.	Specific goal in project monitoring and control
The requirements are analysed and validated and a definition of the required functionality is developed.	Specific goal in requirements development.
Root causes of defects and other problems are systematically determined.	Specific goal in causal analysis and resolution.
The process is institutionalised as a defined process.	Generic goal

CMMI practices

| Practice	Associated goal
Analyse derived requirements to ensure that they are necessary and sufficient	The requirements are analysed and validated and a definition of the required functionality is developed.
Validate requirements to ensure that the resulting product will perform as intended in the userÕs environment using multiple techniques as appropriate.	
Select the defects and other problems for analysis.	Root causes of defects and other problems are systematically determined.
Perform causal analysis of selected defects and other problems and propose actions to address them.	
Establish and maintain an organisational policy for planning and performing the requirements development process.	The process is institutionalised as a defined process.
Assign responsibility and authority for performing the process, developing the work products and providing the services of the requirements development process.	

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.

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.

The staged CMMI model
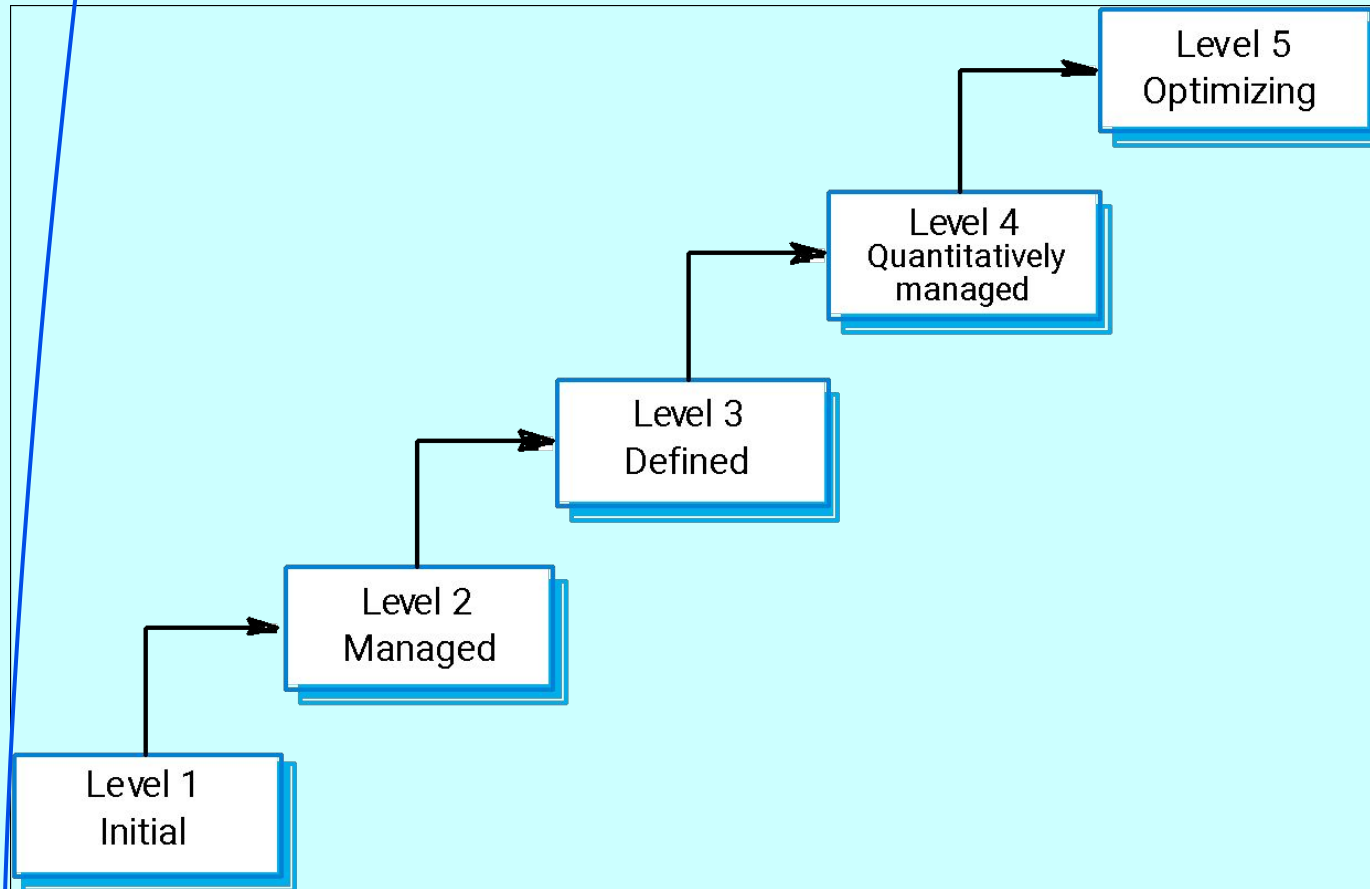
Institutional practices

- 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.

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.

A process capability profile
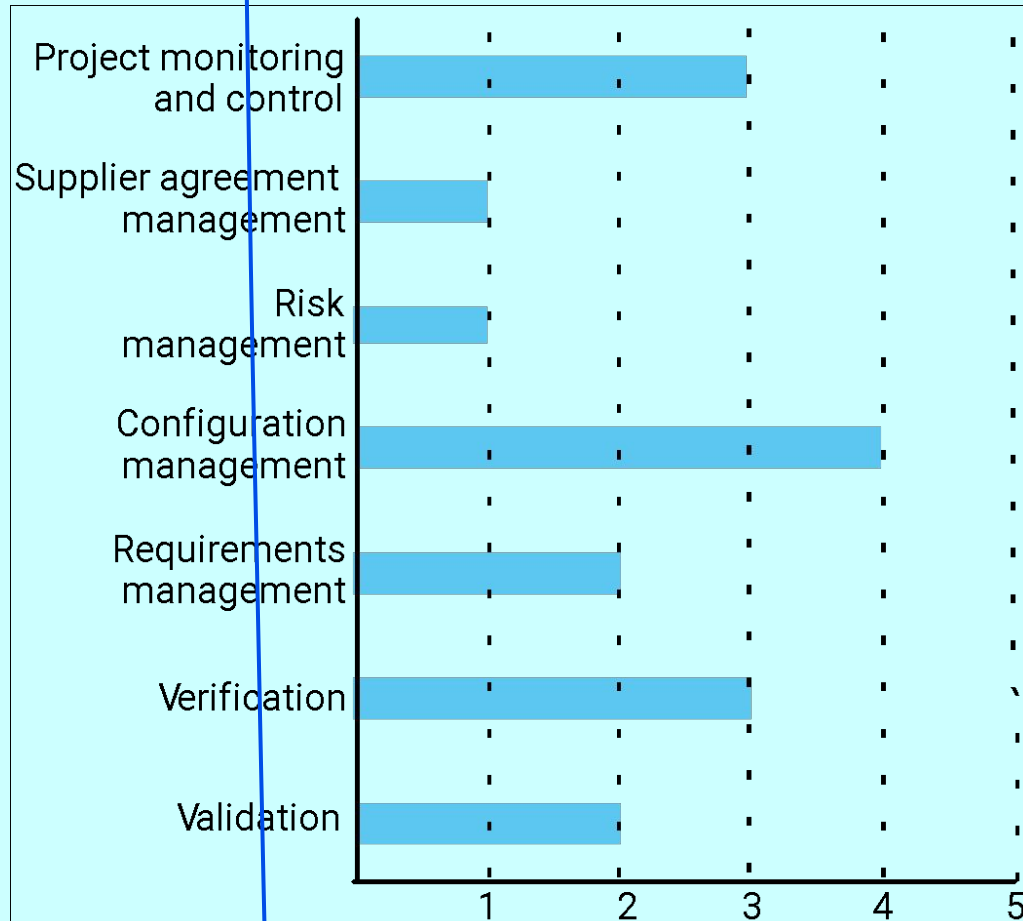
Key points

- Process improvement involves process analysis, standardisation, measurement and change.

- Processes can be classified as informal, managed, methodical and improving. This classification can be used to identify process tool support.

- The process improvement cycle involves process measurement, process analysis and process change.

- Process measurement should be used to answer specific process questions, based on organisational improvement goals.

Key points

- The three types of process metrics used in the measurement process are time metrics, resource utilisation metrics and event metrics.

- Process models include descriptions of tasks, activities, roles, exceptions, communications, deliverables and other processes.

- The CMMI process maturity model integrates software and systems engineering process improvement.

- Process improvement in the CMMI model is based on reaching a set of goals related to good software engineering practice.