Module Overview

Major topics in SPI to be covered

- Introduction
  - What is SPI
  - Software Quality
  - Reviewed CAS35
  - Software Process Models
  - Reviewed CAS35
- Process topics
  - Process Focus
  - Process Frameworks
  - Discipline and Environment
  - Assessment
  - Measurement
  - Planning
  - Implementation
  - Benefits
- Industry Examples
- Case Studies
- Process Frameworks
  - CMMI
- Agile Methods
  - eXtreme programming (XP)
- Future of SPI

Exam and assessment procedure

<table>
<thead>
<tr>
<th>Assessment</th>
<th>25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>End of semester examination</td>
<td>75%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

- You must pass both components to pass the module
- Project
  - What is EIT
  - Research papers
  - Full details on website
- Timing
  - Due date...
  - Any project which is not received by the deadline will automatically receive a mark of zero (FAIL)
  - There will be no exceptions to this
- If you have a specific reason (e.g., illness) for not submitting you may write to the Programme Board explaining the situation and enclosing appropriate documentation (e.g., a doctors certificate). This can be done by sending a letter to the Faculty Office. Under such circumstances you will still be awarded a mark of zero (FAIL), but your case will be discussed by the Programme Board.

Reading List

- S. Zahran
  - Software Process Improvement. Addison Wesley
- T. Dyba, T. Dillingsoyr and N. Brede-Moe
- W. Humphrey (Addison Wesley SEI Series)
  - Managing the Software Process
  - A Discipline for Software Engineering
  - Introduction to the Personal Software Process
  - Introduction to the Team Software Process
- Safari on-line Books
  - There are several

Where does SPI fit in? (1)

Software Engineering
Software Quality
Software Process
Software Process Improvement

Where does SPI fit in? (2)

- Software Engineering
  - No standard definitions
  - Aimed at large software
  - Systematic and well-defined techniques, methodologies and tools
  - To design, code, test and maintain quality software
- Software Quality
  - Concerned with ensuring that the required level of quality is achieved in a software product
  - Involves defining appropriate quality standards and procedures and ensuring that these are followed
  - Quality of
    - Product quality
    - Process quality
Where does SPI fit in? (3)

- **Software Process**
  - Coherent sets of activities for specifying, designing, implementing and testing software systems.
  - A software process model is an abstract representation of a process.
  - It presents a description of a process from some particular perspective.

- **Software Process Improvement**
  - Understanding existing processes.
  - Introducing process changes to achieve organisational objectives which are usually focused on quality improvement, cost reduction and schedule acceleration.
  - 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 be the focus of improvement.

Lecture Overview

- Software product lifecycle
- Phases of Software Development
- Software process models

Lifecycle phases of a product

The identifiable phases between the product’s “birth” and its eventual “death”

Software Methods, Modeling, and Processes

- **Software Process**
  - The set of activities, methods, and practices that are used in the production and evolution of software.
  - **Software Process Model**
    - One specific embodiment of a software process architecture.
    - These terms are not exact - different authors use different definitions.
    - Particularly for Processes vs. Methods.

- **Some key people**
  - Leon Osterweil
    - "Software Processes are Software Too"  
    - www.cs.umass.edu
  - Watts Humphrey
    - Process maturity
    - www.sei.cmu.edu
Why Model software processes?

- To provide a common understanding
  - To whom?
    - Everyone...
- To locate and remove
  - Inconsistencies
  - Redundancies
  - Omissions
- To understand the development goals and provide early evaluation
- To assist the development team to understand any special situation

Example Process

High level view of 4th year project

- Concept creation
- Supervisor review
- Agreed proposal
- Design
- Implementation
- Design
- Code
- Testing
- System demonstration
- Testing
- System

Common Software Process Models

- Waterfall Model
- Spiral Model
- Prototyping Model
- Phased Development Model
  - Incremental development model
  - Iterative development model
- Formal Systems Development

See – Ian Sommerville, Software Engineering, 5/6/7 editions for good chapter on process models

Waterfall Model

- Classical
- One-shot approach
- Effective control
- Limited scope of iteration
- Long cycle time
- Not suitable for system of high uncertainty

Prototyping Model

- Goals
  - Meet (some) user requirements at an early stage
  - Reduce risk and uncertainty
  - Verify a design or implementation approach
- Forms of Prototypes
  - Mock-ups
  - Simulated interaction
  - Partial working model
- Three-way
  - After users agree the requirements of the system, the prototype will be discarded.
  - Evolutionary
  - Modifications are based on the existing prototype.
  - Incremental
  - Functions will be arranged and built accordingly.
**Incremental Model**

- Break system into small components
- Implement and deliver small components in sequence
- Every delivered component provides extra functionality to user

**Software Process Improvement**

- No matter which approach (waterfall, incremental, etc.) you take to developing software all the activities need to be managed within certain constraints
  - Thus project management
  - We need a model for software development
  - Thus process management
  - We need to improve the way we do it
  - Thus process improvement

**Lecture Overview**

- Process Focused organisations
  - Process Thinking
  - Process Defined
  - Process Internalisation Vs Process Institutionalisation
  - Process Focus

**Thinking about process**

- All business should think in terms of process
  - Process thinking
    - Many business focus on tasks, jobs, people, structures and not the process
    - Stop thinking about organisational structure and focus on the processes that control the customer interface
  - Task-based thinking
    - Fragmenting work into small components
    - Has been major influence on organisational management
  - Argument is that task-based thinking has failed in modern business environment due to rapid change

**What is Process Thinking?**

- We acquire knowledge through experience
- This knowledge is automatically retrieved when we face similar situations
- Our actions are nearly automatic
  - The process has been "internalised" by us
  - We can perform the process as part of our natural behaviour
  - Following an "internalised" process is painless
- When learning to drive, the first few lessons were difficult. Continuous practice and the process becomes repeatable and painless... internalised
- Process thinking in teams
  - Without focus and alignment towards common goals, the activities of teams could contradict each other
  - A process focus brings discipline to the individuals activities and alignment towards the project goals

**3 Aspects of the process**

- A process definition that exists only on paper, with no one knowing about it is only 'shelfware'
- A defined process that everyone has been trained in but no one uses is a 'waste of time'
- A defined process, in which everyone has been trained and which everyone follows to perform their tasks, in an 'effective process'.

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*Click to buy NOW!*
Process Internalisation and Process Institutionalisation

- A disciplined process will manifest itself in ordered and consistent patterns of behavior, whether by an individual or by a group of people following a common process.
- When a process is performed professionally and naturally by a person it is described as being "internalized" by that person.
- In organizations the process involves groups and teams of people.
- To get process discipline, the process needs to be established or "institutionalized" in the organization.
- Without established process across the organization, each person will follow their own way of performing a task.
- In organizations where common processes are institutionalized, staff will perform the process painlessly and in harmony with each other.
- The process itself becomes transparent.

Process Focus

- Many organizations are product focused.
  - In such organizations there is likely to be resistance to activities that do not contribute directly to short term tangible deliverables.
- In process-focused organisations, the objective is the acceptance and consistent use of the process, and the process itself is viewed as a disciplined way of conducting business.
- For example:
  - Imagine a development team who do not have a common process.
  - Each person is left to follow his own way of achieving the common goal.
  - Team members could be developing different programming languages, using different naming conventions, not coordinating with peers...
  - Result would be chaos...
  - This is what is likely to happen in the absence of process focus.

Absence of process focus

- Project managers should manage projects and development teams through managing the process and process performance.
- A process focus for managing projects will lead to better management practices that are more likely to lead to successful projects and effective team performance.
- Absence of process focus
  - Ed Demming, Statistical process control expert post WWII
  - Coined term "Fire fighting"
  - "One gets a good rating for fighting a fire... The result is visible and can be quantified... If you do it right first time you are invisible... Mess it up and correct it later and you become a hero..."

Lecture Overview

- Process Frameworks
  - Process Maturity
  - Process Standards
  - Process Improvement

Process maturity

- Organisations at various levels of process discipline are like people at different levels of maturity.
- Software process maturity is the extent to which a specific software process is explicitly defined, implemented, managed, measured, controlled, and effective.
- Maturity implies a potential for growth in capability and indicates both the richness of an organization’s software process and the consistency with which it is applied in projects throughout the organization.
- The process is well-understood throughout a mature organization, usually through documentation and training, and the process is continually being monitored and improved by its users.
- The capability of a mature process is known.
- Software process maturity implies that the productivity and quality resulting from an organization’s software process can be improved over time through consistent gains in the discipline achieved by using its software process.

Process Maturity History

- In the 1970s and 80s we were concerned with process (lifecycle) models and structured methods.
- From late 80s onwards, we are more concerned with software engineering as an engineering discipline.
- Balsmore focused process improvement.
- Thus...
  - Process maturity
  - Process maturity frameworks

- 1930s
  - Walter Stewart
  - Statistical process control
- 1950s
  - Ed Demming
  - Statistical process control
- 1980
  - Phil Crosby
  - Quality maturity grid
- 1986
  - Watts Humphrey
  - Suggested levels of Process maturity
- 1990s
  - SEI, CMU, PSP, TSP
  - ISO, 9000, CMM, SPICE
- 2000...
  - IBM
Process Maturity and Standards

- CMM and CMMI
  - Capability Maturity Model
  - Capability Maturity Model Integration
- ISO
  - ISO 9000
  - ISO 15504 (SPICE)
- Bootstrap
  - ESPRIT project from 1991-93
  - European methodology for assessment

ISO 9000

- ISO 9000 is a general standard applicable to products of almost anything
  - A family tour...
    - ISO 9000-1 is a general guideline which gives background information about the family of standards
    - ISO 9001, ISO 9002, and ISO 9003 are standards in the family, containing requirements on a supplier
    - ISO 9002 and ISO 9003 are subsets of ISO 9001
    - ISO 9002 applies when there is no design
    - ISO 9003 applies when there is neither design nor production
    - ISO 9004 is a comprehensive guideline to the use of the ISO 9000 standards
    - For software development, ISO 9001 is the standard to use
    - ISO 9000-3 is a guideline on how to use ISO 9001 for software development
    - ISO 9004-2 is a guideline for the application of ISO 9001 to the supply of services (including computer centers and other suppliers of data services)

ISO / IEC 15504

- ISO 15504 resulted from SPICE project
  - Software Process Improvement and Capability Determination
  - SPICE was a major international initiative to develop a standard for Software Process Assessment (SPA)
- 15504 standard includes
  - How to use the results
  - A reference model and rating scheme
- SPICE Vs CMM
  - CMM gives the picture of the capability of an organization as a whole based on certain areas at each level.
  - SPICE has a different approach - it identifies the whole range of processes that go into a function and evaluates each process, thereby succeeding in giving a profile of the organization taking in a lot more information into account and giving out lot more information at the end level.

BOOSTRAP

- Focus of BOOSTRAP method are:
  - Valuation of the capability level on SPU (Software Producing Unit) and project level for
    - process categories
    - each process
  - Comparison of capability levels between the projects and the SPU
  - Benchmarking the capability level against European mean value
    - overall
    - in the defined business segment
  - Identifying the main strengths and weaknesses of the company
  - Support to define adequate business goals
  - Define and implement an improvement plan
- http://www.bootstrap-institute.com

CMM / CMMI

- The CMMI is a model for judging the maturity of the software processes of an organization and for identifying the key practices that are required to increase the maturity of these processes
- CMMI developed by
  - SEI (Software Engineering Institute) at CMU (Carnegie Mellon University)
  - In association with US DoD (Dept. of defence)
- www.sei.cmu.edu/cmmi/
- Probably the most popular process improvement model
- CMMI: Capability Maturity Model Integration
  - SW-CMM Capability Maturity Model for Software (aka. The CMM)
  - P-CMM People Capability Maturity Model
  - SA-CMM Software Acquisition Capability Maturity Model
  - SE-CMM Systems Engineering Capability Maturity Model
  - IPD-CMM Integrated Product Development Capability Maturity Model

Process Improvement

- So far we have discussed
  - What SPI is
  - What Process Focus is
  - Some frameworks
- Next we will discuss a environment for continuous software process improvement
- A suitable environment for SPI supports:
  - Process definition and documentation
  - Process monitoring
  - Process feedback
  - Process improvement based on feedback
- This should lead to continuous software process improvement
Framework for SPI

- The main components of any SPI framework are:
  - Software process infrastructure
  - Organisation and management infrastructure
  - Technical infrastructure
  - Software process improvement roadmap
  - Software process assessment method
  - Software process improvement plan

Lecture Overview

- Process Discipline
- Process Environment
  - Process and Organisational Culture
  - Management and Process
  - Effective use of process in organisations
  - Process Culture

Process Discipline

- Discipline refers to the discipline of individuals in following the process
- A process is disciplined when it specifies the set of rules that would result in its behaviour consistent with those rules
- A disciplined process is a mature process
- An undisciplined, immature process is one that does not specify a set of rules and does not result in behaviour consistent with such rules
- Arguments for process discipline centre on the assertion that defining and enforcing processes lead to better definition of requirements, improved efficiency and productivity, and overall success of the organization

Can process discipline be prohibitive?

- There is a fine line between discipline and bureaucracy
- There is a risk that managers could opt for restrictive processes that could inhibit rather than assist
- A bureaucratic process has too many unnecessary authorizations and paperwork
- Process users should have a large say in process design
- Process users should also have a mechanism to provide feedback
- A process should be supportive of its users

Benefits of Process Discipline

- Process discipline results in patterns of collective behaviour
- Process discipline streamlines and aligns the activities of team members towards achieving the common process goals
- The team should be judged on process performance which reflects the degree to which the process goals have been achieved
- Process discipline increases team capability
- Process discipline leads to teams performing tasks in harmony with each other towards achieving the common goal
- This increases overall team capability
- Undisciplined processes diminish the teams capability
- Process discipline is vital in life-critical situations
  - Where process goals are life-critical, any deviation could lead to disaster
Process Discipline & Product Quality

Disciplined process leads to quality
- It is widely accepted that the quality of a software product is largely determined by the quality of the process used to develop it
- Process people argue that having disciplined software processes should result in high quality software products
- However, a good process does not necessarily deliver a good product
- Disciplined teams will perform the tasks for analysing the quality of the product and for tracing the reasons for poor product quality
- They may identify weaknesses in the process as well

Comparison between mature & immature process environments

<table>
<thead>
<tr>
<th>Measure</th>
<th>Literature</th>
<th>Mature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roles &amp; responsibilities</td>
<td>Not well defined, every person assumes what he does is. Could lead to overlapping &amp; unclear ownership &amp; responsibility.</td>
<td>Well defined, with well defined jobs &amp; measures. Responsibilities clearly defined.</td>
</tr>
<tr>
<td>Varying with change</td>
<td>Subjects people working differently &amp; invent their own ways to do things.</td>
<td>People follow a planned process, share &amp; work from experience &amp; follow a consistent process.</td>
</tr>
<tr>
<td>Reacting to problems</td>
<td>Chaos reigns, fire-fighting is normal &amp; everybody claims to be a hero.</td>
<td>Problems are analysed &amp; addressed from a base of sound knowledge.</td>
</tr>
<tr>
<td>Accountability</td>
<td>Delivery sometimes late or over budget. Unreliable estimates.</td>
<td>Accurate and project scope controlled.</td>
</tr>
<tr>
<td>Staff rewards</td>
<td>Rewards go to the fire-fighters. Not justified.</td>
<td>Rewards go to those who produce high quality products. Fire prevention is rewarded rather than firefighting.</td>
</tr>
<tr>
<td>Predictability</td>
<td>You are never quite sure how it is going. Quality in variable. Schedules &amp; budgets not based on experience.</td>
<td>Process is predictable &amp; is in a measurable and continuously improving.</td>
</tr>
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Process focused organisations

Some characteristics that distinguish process-focused from non-process-focused organisation
- Process is central
  - Central to the organisation and management and provides stability across people, process & technology to meet business goals.
- Multi-layer process
  - Document, training and mechanism to ensure the process is followed.
- Process definition
  - Is more than a list of activities. It includes goals, activities, abilities, commitments, measurement and verification.
- Process coverage
  - Covers end-to-end flow of activities across all functions and roles.

Process Focused Companies

- Michael Hammer & James Champy, Reengineering the Corporation, 1995
- Argue for process-orientated organisation rather than task-orientated or function-orientated organisation
- Next slide show some of their main arguments...

Making a process effective

- Followed consistently
- Enforced consistently
- Monitored and measured consistently
- Benchmarking/PD measurement
- Staff trained in how to apply
- New staff properly trained in the process
- Owned
  - Must have accountable ownership
- Visibly supported by management
- Staff incentives are aligned with process goals
- Staff feedback is encouraged and may lead to process improvement
- Process supported by technology
  - Process modeling & monitoring, data capture

Process Training

- A process that is not consistently trained will be ineffective
  - It will be performed inconsistently
  - Will deteriorate over time
- Many different categories of staff must be trained:
  - Management sponsors
  - Process groups (SEPG)
  - Project managers
  - Project members
  - Quality teams
- Each group should be trained in accordance with their role
Process Culture

- Process institutionalisation is achieved when the process becomes embedded in the day-to-day activities of the organisation
- Requires a Process culture and process infrastructure to be in place
  - Culture - shared understand of the process with strong management support.
  - Process culture is driven by vision and strategic direction from the top
  - Infrastructure - operational support for process activities in terms of roles and tools
- Without correct infrastructure, culture will only be 'lip service'
- Can a process be sustained in these two elements are lacking?

Lecture Overview

- Process Assessment
  - Assessment overview
  - Assessment principles
  - Assessment process

Assessment overview (1)

- A process assessment is an appraisal or review of an organisation's software process
- Process assessment was pioneered primarily by defence industry – US DoD, UK MoD, also Bell and BT
- ISO Definition of Process Assessment
  - The disciplined examination of the processes by an organisation against a set of criteria to determine capability of those processes to perform within quality, cost and schedule goals
- It helps organisations improve themselves by identifying their critical problems and establishing improvement priorities
- The basic assessment objectives are:
  - To learn how the organisation works
  - To identify its major problems
  - To get backing of team for process change

Assessment overview (2)

- When you start working with improvement you need to know
  - the state of the organisation's current software process
  - and the goals for the future
  - You also need to know whether you have reached your goals when the planned improvement activities are finished
- There are a number of ways to determine the state of an organisation's current software process
  - Gut feeling
  - Interviews
  - Opinion of majority of staff / team / group
- A more formalised approach is usually preferred

Why perform an assessment?

- To understand and determine the organisation's current software engineering practices and to learn how the organisation works
- To identify and prioritise strengths, major weaknesses and key areas for SPI
- Find information on business environment issues that may influence the SPI work
- To facilitate the initiation and planning of SPI activities and enrol leaders in change process
- To help obtain sponsorship and support for actions through following a participative approach to assessment

Audit Vs Assessment

- Assessment ≠ Audit
- An Audit is an independent examination of a product(s) to assess compliance with a specifications, standards or other criteria
  - Eg. Formal financial inspection of accounts
- Watts Humphrey...
  - Software Process Assessment is is not an audit, but a review of a software organisation to advise management and other in organisation, on how they can improve their operation
- In Process world...
  - Audit or certification refers to independent / 3rd party assessment against a particular standard such as CMM
Types of Assessment

- Three main types
  - Self (1st party) assessment
    - Main objective is to identify own capability and create SPI plan
  - 2nd party assessment
    - Aka Capability Determination
    - Uses external assessors
    - Main objective is to assess organisations capability to fulfill specific contract requirements
  - 3rd party assessment
    - Aka Capability Determination
    - Conducted by 3rd party independent organisation
    - Main objective is to verify organisations capability to enter contracts or fulfill certification to a selected standard

Basic Assessment Principles

- Because the software process is a human-intensive activity, some special considerations should be kept in mind
  - The need for a process model as a basis for the assessment
  - Assessment implies a standard to be compared against
  - Without a process model for foundation, an assessment could easily degenerate into unstructured exercises or even corruption
  - The requirements for confidentiality
    - Assessment purpose is to support improvement, not report problems to management
    - Confidentiality permits assessors to talk freely to all staff at all levels in organisation
  - Senior management involvement
    - With this support, assessment could be a waste of time
  - Respect for work of people in organisation being assessed
    - Assessment can seem arrogant - external people telling you what you did wrong
    - The assumption must be that on-site professionals are smart, motivated & have good ideas
  - Action orientation
    - To have a lasting effect, the assessment must be directed towards improvement action
    - If management won’t focus on taking action, why do assessment in first place?

Assessment Phases

- Usually conducted in 3 phases
  - Preparation
    - Senior management commit to the process, agree to take and support action
    - 1 or 2 day training programme for assessment team
  - Assessment
    - On site assessment
    - Typically takes several days to several weeks
    - Conclude with preliminary report to management
  - Recommendations
    - Findings and action recommendations are presented
    - Local action team is assembled to plan and implement recommendations
    - Assessing organisation may provide support and participate in follow-up assessment

The Assessment Process

- The first step in any assessment is to identify the organisation to be assessed and form a team to do it.
- This requires site managers commitment to doing the assessment and willingness to assign sufficient skilled people and recourses to get it done
- Since professional assessment groups are rare, most organisations will have to assemble an assessment team of their own
- Main steps in process are:
  - Form an assessment team
  - Self-assessment considerations
  - Assessment ground rules
  - Assessment team training
  - On-site period

Post-Assessment – What Next?

- Action Plans
  - Action plans are prepared by local site organisation
  - A key manager should be given responsibility for implementation
- Reassessment
  - Organisations should generally conduct follow-up assessments 1-2 years after initial initial action have been developed and approved
  - This is important because:
    - It assess is progress has been made
    - Provides future milestone for completion of actions from prior assessment
    - Establishes new priorities for continued improvement

Example

Preliminary findings from assessment

- Ability to deliver on schedule
- Average gap per person 1.9
- Levels to choose
- Current strength
- Future importance

Post-Assessment – What Next?
Lecture Overview

- Measurement and metrics
  - Measurement principles
  - Measurement methods
  - AMI

Why Process Measurement?

- Need for quantitative data
  - "what you cannot measure you cannot manage".
- If you do not measure SPI results, SPI effort could be addressing wrong issue
- Humphrey on PSP
  - "A defined process permits you to gather data on the time you spend on each software task and track the number of defects you introduce and remove in each process step. These data can then help you analyse your process, to understand its faults and to improve it."
- Process assessment tends to gather qualitative measurement
- Organisations also need to gather quantitative measurement

Principles of Software Measurement

- Define clear objectives of measurement programme
  - Without objectives, could end up with mountains of unused data
  - Measurement objectives should be related to SPI objectives
- Measurement programme must have management support
  - Measurement requires resources - time and money in particular
  - Management support ensures resource availability
- Measurement roles and responsibilities must be allocated
  - Project managers implement project data gathering
  - PIT’s define measures in specific process areas
- SEPG usually analyse process performance data
- Measurement should cover both process and product
  - We need to analyse process performance and well as product quality

Example of Software Process Measurement Method

- AMI (application of metrics in industry) was a European Commission sponsored project aimed to promote the use of measurement in software development through the development and promotion of the AMI method
- It is an instance of applying two processes techniques
  - Goal-Question-Metric (GQM) paradigm
  - and process assessment
- Once process problems have been identified an organisation goal is to make improvements in its software process
- Therefore they must define and use effective metrics to track progress towards this goal
- The book

AMI Approach

Four distinct activities

- Assess
  - your project environment to define primary goals for measurement
  - Managers who initiate measurement must be involved in this activity
- Analyse
  - the primary goals to derive sub-goals and the relevant metrics.
  - This analysis is formalised as a goal tree with a corresponding set of questions to which these metrics are linked
  - The participants affected by the metrication goals will generally carry out this activity.
- Metricate
  - by implementing a measurement plan and then process the collected primitive data into measurement data.
  - The metrics promoter will write the measurement plan and co-ordinate its implementation.
- Improve
  - as the participants affected by the goals start to use the measurement data and implement actions.
  - Comparison of the measurement data with the goals and questions in the measurement plan will guide you towards achievement of your immediate project goals.
  - When your measurements show that you have achieved a goal, you have improved enough to reexamine your primary goals.

The Assessment Methods

- The method is a sequence of 12 steps with a series of support tools (guidelines, templates and examples) to make it easy to use.
  - Steps 1 to 3 – Defining Primary Goals
    - The first phase of the method addresses how to assess the project environment in order to define and evaluate primary goals for subsequent metrication
    - These primary goals may be business driven or may evolve more directly from the project environment
  - Steps 4 to 6 – Defining Metrics
    - The purpose of the second phase is to break down the primary goals into more manageable sub-goals, and to clarify the measurement objectives in the measurement process.
  - Steps 7 to 9 – Implementing a Measurement Plan
    - Describe how to write a measurement plan, how to implement the plan and then how to go about collecting the primitive data from which the metrics are derived.
  - Steps 10 to 12 – Exploiting your Measures
    - The three last steps of the method make recommendations on how improvement can be achieved through the exploitation of the measurement data.
Basic Metrics Set

- Process measures
  - Number of change requests
  - Amount of rework
  - Number of process problems
  - Quality trends
  - Cost of non-quality
  - Maturity level
- Project measures
  - Development time
  - Slippage
  - Funds expended
  - Staff productivity
  - Resource usage
  - Deviation - estimate Vs actual
- Product & Customer measures
  - Number of defects
  - User reported bugs
  - Number of products faults
  - Usability problems
  - Customer satisfaction
  - System / source code size

GQM

- GQM is about defining specific improvement goals, ask concrete questions, define metrics, collect measurement data, answer questions and draw conclusions on whether the goals were reached or not
- 5 elements of GQM
  - Object - what is the object of the analysis
  - Purpose - what is the purpose of the analysis
  - Quality focus - which quality aspects of the objects shall the analysis focus on
  - Viewpoint - from what viewpoint shall the quality focus be analysed
  - Environment - in which environment shall the analysis take place

Example of using GQM

- A goal specifies an analytical task that should be achieved using measurement
- “Analyse the <object> for the purpose of <purpose> with respect to <quality focus> from the viewpoint of <viewpoint> in the following environment <environment>”

<table>
<thead>
<tr>
<th>Goal</th>
<th>Question</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Product</em></td>
<td>What is the failure rate before delivery</td>
<td>Number of failures before delivery of the system</td>
</tr>
<tr>
<td><em>Process</em></td>
<td>What is the distribution of failure causes before delivery of the system</td>
<td>Failure categories</td>
</tr>
</tbody>
</table>

Lecture Overview

- Creating Software Process Improvement Plan
- Implementing Software Process Improvement Plan

Software Process Improvement Plan

- After conducting an assessment, an organisation knows
  - The state of its software processes
  - Where on the process roadmap they are
  - Were is you target for improvement
- What next
  - Convert the assessment findings into an improvement action plan
    - SPI plan proposals
    - The plan itself
    - Roles and responsibilities of those involved

Creating an SPI action plan

- Should follow a structured approach to convert assessment findings into an action plan
- Assessment findings are generally expressed in general terms
- Will require further review
- Steps to develop plan
  - Convert assessment findings into recommendations
  - Convert recommendations into actions
  - Group actions into action plan (work packages)
  - Allocate the action plans to PRTs

Example of using GQM

- A goal specifies an analytical task that should be achieved using measurement
- “Analyse the <object> for the purpose of <purpose> with respect to <quality focus> from the viewpoint of <viewpoint> in the following environment <environment>”

<table>
<thead>
<tr>
<th>Goal</th>
<th>Question</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Product</em></td>
<td>What is the failure rate before delivery</td>
<td>Number of failures before delivery of the system</td>
</tr>
<tr>
<td><em>Process</em></td>
<td>What is the distribution of failure causes before delivery of the system</td>
<td>Failure categories</td>
</tr>
</tbody>
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Implementing SPI

SPI implementation is about the management of change

Four main stages

1. Create SPI improvement plan
   - Use assessment recommendations as basis for action plan
   - Allocate responsibilities for SPI
     - Roles and responsibilities, ie. who does what
   - Implement SPI actions
   - Execute the plan
2. Institutionalising SPI
   - Make SPI part of the corporate culture

Stages for making SPI happen

1. Zahran's suggested approach...
   - Launching
     - Introduce concept of SPI to managers and technical staff
     - Convince them of benefits
   - This is essential for setting SPI effort on right track
   - Implementing
     - Adopt a strategy for SPI, conducting the assessment, implementing the action plan
   - Institutionalisation
     - Ensure that SPI is continuous and is embedded in the organisation
   - Measuring
     - Measure the benefits and ensure alignment with business goals
   - Improving
     - Assess the measurements and devise plans to improve the process in order to enhance the benefits of the process discipline

Critical success factors for SPI

1. The following are CSFs which represent ingredients for successful implementation of SPI.
   - Alignment with business strategy and goals
   - Consensus and buy-in from all stakeholders
   - Senior management and middle management support
   - Dedicated resource to manage the implementation and coordination of process improvement activities
   - Sensitivity to the organisational context
   - Management of change
   - Prioritisation of change
   - Creation of support infrastructure
   - Monitoring the results of SPI
   - Learning from feedback results
2. See Zahran for detailed list

Need for an SPI model / roadmap / framework

1. An implementation model for SPI could serve as a generic step by step guide to defining an SPI programme

   - Such a guide should answer questions such as:
     - How to prepare a business justification for investing in SPI
     - How to gain commitment / sponsorship from senior management
     - How to launch an SPI programme
     - How to get buy-in from engineers, projects managers, etc,
     - What are the components of the overall plan for an SPI programme
     - What are the roles and responsibilities required to support SPI activities
     - How is the SPEG to be formed
     - How are PIT's to be formed
     - How are the changes introduced by SPI managed
   - An example of an implementation model is SEI IDEAL

   - We will see this later

Implementing SPI and managing change

1. Process improvement actions
   - PIT implement the SPI projects
2. Process design / redesign
   - PITs often follow a model for process design
   - SEI template for KPA (Key Process Areas) is commonly used
3. Managing the change
   - Change management is difficult task
   - Involves creating new roles and responsibilities, creating new policies and procedures, continuing management, establishing measurement and enforcement mechanisms
   - There is many potential sources of resistance to change
4. Strategies for implementing organisational change
   - Many business courses / texts deal with this topic
   - The skill & cleverness is in the approach adopted to introduce & implement change
**IDEAL**

- SEI approach to answer question
  - What should I do, once I have been assessed, to start an improvement programme and what activities will the programme entail?
- The IDEAL model depicts the activities of a process improvement programme and what is involved in transitioning the CMM into an organisation's practice
- It has 5 main stages:
  - A analysing the lessons learned and the business results of the improvement effort and revising the approach
  - Leveraging
  - Executing the plans and recommended practices
  - A ctioning
  - E stablishing

**Lecture Overview**

- Process Guides
  - A structured document (text and diagrams) describing the workflow for one of several processes
  - Purpose
    - To help people implement the process
    - The description must be simple to understand and easy to follow
    - Why people don't like them
      - Some people think of process guide in the same way as documenting code - a necessary evil
      - Some people have had poor experiences using procedure manuals - treated as 'shelfware'
      - Sometimes seen as bureaucratic
    - If developed in a proper way, they can be very helpful
      - When the same job (coding, testing, etc) needs to be done many times, number of faults may be reduced and time estimates may be more realistic

**Example Process Guide**

- **Requirement Analysis**
  - Requirements document
- **Design Review**
  - Detailed design
- **Customer**
  - Requirements model
- **Design Review**
  - Detailed design
- **Quality Manager**
  - Quality specifications

**What is a process guide?**

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**Why is a process guide useful?**

- It is a practical guide describing how tasks are normally done
  - Useful for newly employed people
  - Useful to estimate scope of new projects
  - Initiate discussion on working methods
  - Develop understanding and context concerning a problem in a project
  - Help doing a job - read instructions in a guide to get trivial tasks done quickly and correctly
  - Find facts on how a task is usually solved
  - Anticipate what will happen further along the project based on what usually takes place
  - It is important to find a balance to make a process guide useful in practical work...not to become 'shelfware'
Example - Module testing

Activities in module testing (2)

How to develop a process guide

Adapting a process guide
Adapting a process guide (2)

- Some companies develop different versions of the process guide, adapted to the type of projects they are running - small, medium, large, simple, complex, etc.
- Example of what “must”, “should” and “may” be included in projects of different sizes

<table>
<thead>
<tr>
<th>Activity</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>Must</td>
<td>Should</td>
<td>May</td>
</tr>
<tr>
<td>Design</td>
<td>Must</td>
<td>Should</td>
<td>May</td>
</tr>
<tr>
<td>Code</td>
<td>Must</td>
<td>Should</td>
<td>May</td>
</tr>
<tr>
<td>Module test</td>
<td>Must</td>
<td>Should</td>
<td>May</td>
</tr>
<tr>
<td>Integration</td>
<td>Must</td>
<td>Should</td>
<td>May</td>
</tr>
</tbody>
</table>

Maintaining a process guide

- A process should be revisited regularly in order to incorporate changes coming from practice or suggested improvements
- Main types of maintenance
  - Updating as you go
  - During project work people may find faults in process descriptions, or better ways of doing things
  - Should be allowed to a) revise process or b) suggest revisions to SEPG
  - Revising
  - Post-mortem - when a project is finished the project group should assess which processes worked well and which did not and revise process guide as appropriate
  - SPI changes / PIE’s
  - Changes suggested as part of SPI activity, process assessment or PIE

Lecture Overview

- Benefits of SPI
- Justifying the investment

Benefits of SPI

- One of the major obstacles for the adoption of SPI is the reluctance of business management to invest in SPI because they do have convincing evidence of the return on investment
- There is a general lack of reliable information on the business benefits of SPI and there is little hard evidence of satisfactory ROI from SPI
- Questions we must ask are
  - Can we measure improvements in our software processes?
  - Can we measure subsequent benefits to our business?
  - Can we show a causal relationship?

An Example

Cost-Benefit Justification for moving from CMM L1 to L2

- Justification for setting up a Requirements Management process:
  - Cost: What is the cost to the project and to the business of ambiguous requirements which are unmanaged and uncontrolled?
  - Benefits: What are the benefits of a clear and consistent requirements that are properly managed?
- Justification for setting up a Project Planning process:
  - Cost: What is the cost of to the project of wrong estimates and unrealistic project plan?
  - Benefit: What are the benefits of accurate estimate and realistic plan?
- Justification for setting up a Project Tracking process:
  - Cost: What is the cost of failure to accurately track the project progress and to plan for any deviations?
  - Benefit: What are the benefits of accurate tracking of the project progress and an effective project oversight?
- Justification for setting up a Quality Assurance process:
  - Cost: What is the cost of faulty code that does not satisfy the requirements?
  - Benefit: What are the benefits of high quality code that matches the requirements?

SEI study on SPI Benefits

- SEI conducted a study of 13 organizations’ experiences with CMM-based SPI.
- The goals were
  - To collect and publish data that management can use to help guide decisions about investment in SPI
  - Provide managers and practitioners with SPI experiences linked to the adoption of CMM practices
  - 13 organizations participated
  - Represent a wide range of process maturity levels
  - Diverse range of application areas

- Motorola
- BellNynex
- GTE Government Systems
- Hewlett Packard
- Hughes Aircraft Co.
- Local Federal Systems
- Lockheed Sanders
- Northrup
- Schlumberger
- Siemens Stromberg-Carlson
- Texas Instruments
- U.S. AF - Tinker Air Logistics Center
- U.S. Navy Fleet Combat Direction Systems Support Activity
SEI study on SPI Benefits cont.

Summary Results

<table>
<thead>
<tr>
<th>Category</th>
<th>Range</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Engaged in SPI</td>
<td>1 - 6</td>
<td>2.5</td>
</tr>
<tr>
<td>Early Cost of SPI per Software Engineer</td>
<td>$480 - $200K</td>
<td>$775</td>
</tr>
<tr>
<td>Productivity Gain per Year</td>
<td>6% - 67%</td>
<td>25%</td>
</tr>
<tr>
<td>Early Defect Detection Gain per Year</td>
<td>6% - 25%</td>
<td>22%</td>
</tr>
<tr>
<td>Early Reduction in Time to Market</td>
<td>15% - 25%</td>
<td>18%</td>
</tr>
<tr>
<td>Early Reduction in Post-Release Defect Reports</td>
<td>12% - 94%</td>
<td>38%</td>
</tr>
<tr>
<td>Business Value (savings/cost of SPI)</td>
<td>$3.0 - $8.0 - 1</td>
<td>$5.0 - 1</td>
</tr>
</tbody>
</table>

Justifying company investment in SPI

- It is generally difficult to justify a ROI (Return-On-Investment) for SPI in monetary terms.
- Sound management and engineering practices should not have to be ROI issues.
- Organisations with no process discipline don’t have enough data to develop ROI arguments.
- ROI arguments ignore intangible benefits.
- Process improvement programs are shown in the report to reduce development costs and rework costs, as well as to improve productivity, cycle time and quality.
- These improvements, once implemented by an organization, are shown to have a significant positive ROI to the improved organization.

Costs / Benefits of SPI

**Typical Costs**
- Training fees, labor hours, travel costs
- Policies, procedures, processes, life cycles
- Project costs, activity costs, administration
- Documents, reports, records, memos
- Indocitration costs of custom processes
- Response conditioning costs
- Mock appraisal costs, appraisal costs

**Typical Benefits**
- Higher quality
- Fewer defects
- Lower maintenance
- Less rework
- Higher productivity
- Few development costs
- Faster cycle times
- Quick time-to-market
- Greater value
- More product features
- Greater variety
- More product variations
- High customer satisfaction
- More contracts

Some evidence...(1)

- IBM Federal Systems Company (Loral / Lockheed Martin)
  - Ability to predict costs within 10%
  - Only 1 deadline missed in 15 years
  - Learned the relative cost of fixing defects ranged from 1x during inspection to 13x during system test and 92x during operation
  - Productivity 180-200 SLOC/MM
  - Maintenance cost of ~$20/SLOC
  - 1/3 of the maintenance costs of other IBM software shops
  - Early error detection (%) went from 48 to 95% from 1982 – 1993
  - Reconfiguration time went from 11 weeks to 5 weeks from 1982/85
  - Product error rate (defects/KSLOC) went from 2.0 to 0.1 from 1982/93
Some evidence...(2)

- Motorola India Electronics, LTD (MIEL)
  - Productivity increased about 3.5X moving from CMM L3 to L5
  - Post release quality of better than 2 defects per 930 KLOCs
  - 50% with no known defects
  - In-process quality of less than 1.1 defects per KNLocs
  - Less than 3.75% rework due to in-process faults
  - Cost of error detection and correction less than 17% of total costs
  - Estimation accuracy on project schedule and effort better than 90%
  - Cycle time was reduced by 40% in a 12 month period
- MIEL was assessed at SEI CMM Level 5

Choosing the Right Solution

Some evidence...


Lecture Overview

- Case Studies
  - Cunav Technologies
    - Aim was to improve Requirements Analysis
  - Peregrine Systems
    - Aim was to improve Source Code Management and Defect Control

Cunav Technologies

- Who are they?
  - Was a software development consulting company
  - Became NewWorld Commerce - now part of NewWorldIQ
- What do they do?
  - They are software systems development and consulting company, which provides IT resources and solutions to customers operating in a variety of application areas, with a focus on web-based development
  - Had approximately 20 staff when they participated in the project that supported focused process improvement projects in small organisations
  - This case study relates to their experience with SPIRE in 1998
  - They used the services of a mentor
    - Fran O’Hara - http://www.insight.ie

What next?

- An SPI mentor was provided to support the organisation during the pilot
- The first task of the mentor was to help identify the process area to improve based on business drivers and the results of a facilitated SPICE self-assessment
- This facilitated self-assessment involved using an assessment tool to gather data on their processes based on round table discussions with key personnel
- It also involved an SPI questionnaire to gather, from a wider group, the attitude towards SPI before and after the improvement pilot
- The self-assessment took one day and had minimal impact on resources
- It was by no means comprehensive but gave a reasonable indication of strengths and weaknesses for the purpose of the pilot

Identified Problems

- They performed a review of previous project post-mortems and found some difficulties
  - managing customer expectations on some projects
  - excessive amounts of rework due to misunderstanding of initial requirements
- What the found out
  - Requirements analysis was a key process
  - They had a low capability score
  - Meeting customer needs and improving project estimates and visibility with the customer were to be the key drivers for SPI
- As a small organisation, improvements needed to minimise impact on resources and yet maximise the return on any investments by aligning them with the key business drivers
The Improvement Project

- Conduct an initial investigation into various approaches to capture and management of software requirements
- Used help of external consultant
- Candidate process was selected
- It was documented
- They were trained
- Process was tested
- Implement new process of 2 test / pilot projects
- Measure success / failure
  - Choose process metrics
  - Time spent vs estimated
  - Budget spent vs budget estimated
  - Requirements bugs found during development
- Collect data
- Analyze
- Compare to historic

The Benefits

- They achieved immediate benefits from the pilot projects with the requirements process improvements.
  - This was indicated from data they collected for requirements-related rework and time/budget estimates
  - Example
    - 90% decrease in amount of re-work
    - Increase of 17% in accuracy time estimate
    - Increase of 48% in accuracy budget estimate
  - Customers also provided direct feedback on how impressed they were with improved ability to deliver what they wanted
  - Similarly, the improvements in the project planning and tracking processes (especially in relation to risk management and estimation) resulted in a significant high risk project being delivered successfully

Peregrine Systems

- Who are they?
  - Was a software development company
- What do they do?
  - Business process automation application software to financial services companies and government
- Purpose of project
  - Improve existing procedures for
    - Source code management
    - Defect control
- This case study relates to their experience with SPIRE in 1998