Familiarisation to the Capability maturity Model Integration (CMMI)℠

CMMI℠ is a service mark of Carnegie Mellon University

Objectives

1. Examine the risks and problems with immature processes
2. Provide an overview of the Capability Maturity Model (CMM)
3. Review the characteristics of Level 2 and Level 3
4. Identify the purpose and benefits of Level 2 and Level 3
5. Contrast the characteristics of immature and mature organizations
References

- **Capability Maturity Model® Integration (CMMI®) for Development, Version 1.2**, Software Engineering Institute, August 2006.
- [www.sei.cmu.edu](http://www.sei.cmu.edu)

References

- Mary Beth Chrissis, Mike Konrad, Sandy Shrum, ‘CMMI®: Guidelines for Process Integration and Product Improvement’.
  - Second Edition
  - ISBN: 0-321-27967-0
  - Addison Wesley Professional, 2007
References


References

References


Definition of Process

A process is a set of practices performed to achieve a given purpose; it may include tools, methods, materials, and/or people.
Federally funded research and development center sponsored by the U.S. Department of Defense.

The SEI contract was competitively awarded to Carnegie Mellon University in December 1984.

The SEI staff has extensive technical and managerial experience from government, industry, and academia.

**Mission**
- The SEI mission is to provide leadership in advancing the state of the practice of software engineering to improve the quality of systems that depend on software.

**Principal Areas of Work**
- **Software Engineering Management Practices**
  - Focus on the ability of organizations to predict and control quality, schedule, cost, cycle time, and productivity when acquiring, building, or enhancing software systems.

- **Software Engineering Technical Practices**
  - To improve the ability of software engineers to analyze, predict, and control selected functional and non-functional properties of software systems.
    - Focused on defining, maturing, and accelerating the adoption of improved technical engineering knowledge, processes, and tools.

The Software Process - An Outsider’s View

“Build me Software for my Widget”  Then a Miracle Happens  Done.

What Potential Problems are associated with this process?
What Potential Problems are associated with this process?

1. Development team roles undefined, uncoordinated
2. Teamwork and process performance impaired by performance gaps and conflicts
3. Limited insight into process and product quality
4. Limited control of product configurations
5. Delivery is later than originally scheduled
6. Job costs much more than estimated
7. Software doesn’t do what customer wants
Common Characteristics of Immature Organizations

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CHARACTERISTIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Involvement</td>
<td>Unaware, too busy</td>
</tr>
<tr>
<td>Project staff</td>
<td>Poorly trained, inexperienced, disorganized</td>
</tr>
<tr>
<td>Development process</td>
<td>Undefined, random</td>
</tr>
<tr>
<td>Management style</td>
<td>Crisis Management</td>
</tr>
<tr>
<td>Product quality</td>
<td>Not measured</td>
</tr>
<tr>
<td>Product configuration</td>
<td>Not controlled</td>
</tr>
<tr>
<td>Project success</td>
<td>Depends on heroes</td>
</tr>
</tbody>
</table>

Common Results Produced by Immature Organizations

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>Poorly controlled, requirements “creep”</td>
</tr>
<tr>
<td>Product performance</td>
<td>Unpredictable, doesn’t meet user needs</td>
</tr>
<tr>
<td>Product configuration</td>
<td>Not managed</td>
</tr>
<tr>
<td>Product Quality</td>
<td>Unknown, defect ridden</td>
</tr>
<tr>
<td>Costs</td>
<td>Poorly tracked, often overrun</td>
</tr>
<tr>
<td>Schedule</td>
<td>Frequently late</td>
</tr>
</tbody>
</table>
### Variety in Measures of Cost

<table>
<thead>
<tr>
<th>Reductions In</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs (general category)/Cost of delivery</td>
<td>Cost of quality/Cost of poor quality</td>
</tr>
<tr>
<td>Overhead rate</td>
<td>Costs of rework/Defect find &amp; fix costs</td>
</tr>
<tr>
<td>Number/Cost of process staff</td>
<td>Software unit costs</td>
</tr>
<tr>
<td>Variation in cost performance index (CPI)</td>
<td></td>
</tr>
<tr>
<td><strong>Savings in or due to</strong></td>
<td></td>
</tr>
<tr>
<td>Implementing hardware processes</td>
<td></td>
</tr>
<tr>
<td><strong>Improved</strong></td>
<td></td>
</tr>
<tr>
<td>Budget estimation accuracy</td>
<td>Average cost performance index (CPI)</td>
</tr>
</tbody>
</table>


### Variety in Measures of Schedule

<table>
<thead>
<tr>
<th>Reductions In</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation in schedule</td>
<td>Schedule performance index (SPI)</td>
</tr>
<tr>
<td>Number of days late</td>
<td>Days variance from plan</td>
</tr>
<tr>
<td>Slippage of project delivery</td>
<td></td>
</tr>
<tr>
<td><strong>Improved or increased</strong></td>
<td></td>
</tr>
<tr>
<td>Cycle time</td>
<td>Average schedule performance index (SPI)</td>
</tr>
<tr>
<td>Proportion of milestones met</td>
<td>Estimation accuracy</td>
</tr>
</tbody>
</table>

Variety in Measures of Productivity

<table>
<thead>
<tr>
<th>Lines of code per labor hour</th>
<th>Number of releases per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source statements per month</td>
<td>Testing rates</td>
</tr>
<tr>
<td>Function points per full time equivalent staff</td>
<td>Time comparisons by build</td>
</tr>
<tr>
<td>Software production (general category)</td>
<td></td>
</tr>
</tbody>
</table>

Variety in Measures of Return on Investment

<table>
<thead>
<tr>
<th>Example benefits and costs avoided</th>
<th>Examples of improvement investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rework avoided due to fewer defects</td>
<td>Quality activities</td>
</tr>
<tr>
<td>Improved productivity</td>
<td>Automation</td>
</tr>
<tr>
<td>Increased revenue due to shorter cycle time</td>
<td>Process improvement in general</td>
</tr>
</tbody>
</table>


Intangible Benefits

- Improved quality of work life/working conditions
  - Fewer overtime hours
  - Fewer problems/crisis
  - Less stress/pressure
  - Increased levels of confidence
  - More stable work environment
- Improved organisation communications
  - Improved communications upwards to management
  - Improved communications downwards from management
  - Improved communications across projects/teams
- Improved organisation learning and efficiencies
  - Improved ability to educate/train software professionals
  - Improved understanding of how the organisation develops software
  - Improved portability of people across projects/teams
  - Improved ability to change
- Improved ability to attract, retain and develop software professionals
  - Improved ability to recruit new staff
  - Fewer resignations
  - Better opportunities for promotion and development
- More coherent organisation culture
  - Improved understanding of the organisation’s mission and vision
  - Shared sense of pride
  - Participation in process improvement activities
  - Improved morale

Hyde, K., Wilson, D., Intangible Benefits of CMM-based Software Process Improvement, Software Process Improvement and Practice, 9, 217-228, 2004
Two solitudes

- Systems and software disciplines have traditionally not been well integrated
- The importance of software in systems has increased dramatically
  - Example: % of requirements allocated to software:
    - B-2 Stealth Bomber -- 65%
    - F-22 Raptor -- 80%
- The DOD has emphasized the need to make the systems/software interface more seamless

Bridging the Divide

- Systems engineering and software engineering processes are integrated.
- Integrates systems and software disciplines into one process improvement framework.
- Provides a framework for introducing new disciplines as needs arise.


### Systems Engineering

- Systems engineering covers the development of total systems, which may or may not include software. Systems engineers focus on transforming customer needs, expectations, and constraints into product solutions and supporting these product solutions throughout the life of the product.

Source: CMMI V1.1, 2002, SEI.

### What is a Capability Maturity Model (CMM) ?

1. **Concept:** The application of process management and quality improvement concepts to development and maintenance.

2. **Model:** A model for organizational improvement.

3. **Guidelines:** A guide for evolving toward a culture of engineering excellence.

4. **Basis for Measurement:** The underlying structure for reliable and consistent process assessments, capability evaluations, and interim profiles.

CMMI and Business

- The CMM is an application of Total Quality Management principles to engineering.
- Emphasis should be on customer satisfaction.
- The result should be higher quality products produced by more competitive companies.


Common Points in the Quality Movement

1. Enabling quality improvement is a management responsibility.
2. Quality improvement focuses on fixing the process, not the people.
3. Quality improvement must be measured.
4. Rewards and incentives are necessary to establish and maintain an improvement effort.
5. Quality improvement is a continuous process.

The Software Capability Maturity Model (SW-CMM)

1. Developed at the DoD-sponsored Software Engineering Institute (SEI)
2. Focused on practices that are under control of the software group
3. Presents a minimum set of recommended practices that have been shown to enhance a software development and maintenance capability
   – It defines the expectation (the “what”)
   – Without overly constraining the implementation (the “how”)
4. Used by Governments and industries around the world to measure maturity of software development organizations

History of CMMI for Development

- SW-CMM (Software Capability Maturity Model)
  – Version 1.1 published in 1993, Version 2.0 (not published)

- SE-CMM (Systems Engineering Capability Maturity Model), 1994.

- CMMI for development
  – Started in 2000 – draft
  – March 2002, Version 1.1
  – August 2006, Version 1.2
Two representations

Continuous

Staged

. . .for a single Process Area (PA) or a set of process areas
. . .for an established set of process areas across an organization

Capability Levels | Maturity Levels
---|---
Level 0: Incomplete | N/A
Level 1: Performed | Initial
Level 2: Managed | Managed
Level 3: Defined | Defined
Level 4: Quantitatively Managed | Quantitatively Managed
Level 5: Optimizing | Optimizing

Source: CMMI V1.1 and Appraisal Tutorial, Mike Phillips, 2004, SEI.

Source: CMMI V1.2, SEI.
### Avantages de chaque représentation

<table>
<thead>
<tr>
<th>Continuous Representation</th>
<th>Staged Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides maximum flexibility for order of process improvement</td>
<td>Predefined and proven path with case study and ROI data</td>
</tr>
<tr>
<td>High visibility of improvement within process areas</td>
<td>Focuses on organizational improvement</td>
</tr>
<tr>
<td>Easy upgrade from SE-CMM, EIA 731</td>
<td>Easy upgrade from SW-CMM</td>
</tr>
<tr>
<td>Easy comparison to ISO 15504</td>
<td>Provides familiar benchmarking capability</td>
</tr>
<tr>
<td>Improvement of process areas can occur at different rates</td>
<td>Overall results summarized in a maturity level</td>
</tr>
</tbody>
</table>

Source: CMMI V1.2, SEI

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### Process Area

Cluster of related practices in an area that, when performed collectively, satisfy a set of goals considered important for making significant improvement in that area.

Practices are actions to be performed to achieve the goals of a process area.

All CMMI process areas are common to both continuous and staged representations.

A Process Area is NOT a process description.

Source: Software Engineering Institute, Carnegie Mellon University
**Required Vs Expected Vs Informative**

- **Required**
  - Specific and Generic Objectives
- **Expected**
  - Specific and Generic Practices
- **Informative**
  - Intention, introduction, note, work product, sub-practices, amplification, elaboration, reference.

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**Goals and Practices**

- *Goals* and *Practices* are the model elements used to realize the values on both the capability and process dimensions.
  
  - **Goal**
    - A high level statement of the outcome to be achieved by effective implementation of a group of practices. (These are “required.”)
  
  - **Practice**
    - A description of an action that is necessary to enact a key element of a process area. (These are “expected,” and “alternate practices” are acceptable.)
  
  - **Subpractice**
    - An informative model component that provides guidance for interpreting and implementing a specific or generic practice.

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Source: Software Engineering Institute, Carnegie Mellon University
Generic and Specific Goals and Practices

- **Generic Goals and Generic Practices**
  - Realize the **capability dimension**
  - Apply across **all Process Areas**

- **Specific Goals and Specific Practices**
  - Realize the **process dimension**
  - Apply to a **particular Process Area**

Generic Practices (GPs)

Activities that ensure that the processes associated with the process area will be **effective, repeatable, and lasting**.

Generic practices **contribute** to the achievement of the **generic goal** when applied to a particular process area.

There are:

- 1 GP for level 1
- 10 GPs for level 2 (Staged representation only)
- 2 GPs for level 3 (Staged representation only)
- 2 GPs for level 4 *
- 2 GPs for level 5 *

* Generic goals 4 and 5 and their associated generic practices are not used. This is because not all processes will be “raised” above (i.e., matured beyond) a defined process. Only select processes and subprocesses will be quantitatively managed and optimized
Exemple: Manage Requirements

- **SG 1 Manage Requirements**
  - SP 1.1-1 Obtain an Understanding of Requirements
  - SP 1.2-2 Obtain Commitment to Requirements
  - SP 1.3-1 Manage Requirements Changes
  - SP 1.4-2 Maintain Bi-directional Traceability of Requirements
  - SP 1.5-1 Identify Inconsistencies between Project Work and Requirements

Generic Goal and Practice at Level 1*- Performed

- **GG 1 – Achieve Specific Goals**
  - The process supports and enables achievement of the specific goals of the process area by transforming identifiable input work products to produce identifiable output work products.

- **GP 1.1 – Perform Specific Practices**
  - Perform the specific practices of the process area to develop work products and provide services to achieve the specific goals of the process area.
    - Practices may be done informally, without following a documented process description or plan.
    - Rigor with which these practices are performed depends on the individuals managing and performing the work and may vary considerably.

* Level 0 in continuous model = not achieving GG1
A Managed Process – Level 2

- **Is a performed process that is:**
  - Planned and executed in accordance with policy;
  - Employs skilled people having adequate resources to produce controlled outputs;
  - Involves relevant stakeholders;
  - Is monitored, controlled, and reviewed;
  - Is evaluated for adherence to its process description.

Source: Software Engineering Institute, Carnegie Mellon University

GG 2 - Institutionalize a Managed Process

- GP 2.1: Establish an Organizational Policy
- GP 2.2: Plan the Process
- GP 2.3: Provide Resources
- GP 2.4: Assign Responsibility
- GP 2.5: Train People
- GP 2.6: Manage Configurations
- GP 2.7: Identify and Involve Relevant Stakeholders
- GP 2.8: Monitor and Control the Process
- GP 2.9: Objectively Evaluate Adherence
- GP 2.10: Review Status with Higher Level Management

**Elaboration:** to provide guidance on how the generic practice should be applied uniquely to the process area.
Generic practices of Level 2

GP 2.1: Establish an Organizational Policy
Establish and maintain* an organizational policy for planning and performing the <x> process.

GP 2.2: Plan the Process
Establish and maintain the plan for performing the <x> process.

GP 2.3: Provide Resources
Provide adequate resources for performing the <x> process, developing the work products, and providing the services of the process.

* Means that not only must a policy be formulated, but it also must be documented and it must be used throughout the organization.

Source: Software Engineering Institute, Carnegie Mellon University

GP 4.4: Assign Responsibility
Assign responsibility and authority for performing the process, developing the work products, and providing the services of the <x> process.

GP 4.5: Train People
Train the people performing or supporting the <x> process as needed.

GP 4.6: Manage Configurations
Place designated work products of the <x> process under appropriate levels of configuration management.

Source: Software Engineering Institute, Carnegie Mellon University
Generic practices of Level 2

GP 2.7: Identify and Involve Relevant Stakeholders
Identify and involve the relevant stakeholders of the <x> process as planned.

GP 2.8: Monitor and Control the Process
Monitor and control the <x> process against the plan for performing the process and take appropriate corrective action.

GP 2.9: Objectively Evaluate Adherence
Objectively evaluate adherence of the <x> process against its process description, standards, and procedures, and address non-compliance.

GP 2.10: Review Status with Higher Level Management
Review the activities, status, and results of the <x> process with higher level management and resolve issues.

Generic Goal at Level 3 - Defined

GG 3 - The process is institutionalized* as a defined process.

A defined process is a managed process that is:

- Tailored from the organization’s set of standard processes according to the organization’s tailoring guidelines;
- Has a maintained process description;
- Contributes work products, measures, and other process-improvement information to the organizational process assets.

A defined process clearly states the following:
Purpose, Inputs, Entry criteria, Activities, Roles, Measures, Verification steps, Outputs, Exit criteria.

* Institutionalization The ingrained way of doing business that an organization follows routinely as part of its corporate culture.
**Generic Practices Under GG 3**

**GP 3.1: Establish a Defined Process**

Establish and maintain the description of a defined <x> process.

**GP 3.2: Collect Improvement Information**

Collect work products, measures, measurement results, and improvement information derived from planning and performing the <x> process to support the future use and improvement of the organization’s processes and process assets.

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**Generic Goal and Practices at Level 4**

**GG4 – Institutionalize a Quantitatively Managed Process**

- **GP 4.1 Establish Quantitative Objectives for the Process**
  - Establish and maintain quantitative objectives for the <x> process that address quality and process performance based on customer needs and business objectives

- **GP 4.2 Stabilize Subprocess Performance**
  - Stabilize the performance of one or more subprocess to determine the ability of the <x> process to achieve the established quantitative quality and process performance objectives
Generic Goal and Practices at level 5

GG 5 – Institutionalize an Optimizing Process

• GP 5.1 Establish an Optimizing Process
  – Ensure continuous improvement of the <x> process in fulfilling the relevant business objectives of the organization

• GP 5.2 Correct Root Causes of Problems
  – Identify the correct root cause of defects and other problems in the <x> process

Work Products

• A Work product is ‘any artefact produced by a process.’
  – e.g. files, documents, services, processes, invoices.
Capability Levels

- A well-defined evolutionary plateau describing the capability of a process area.
- There are six capability levels.
- Each level is a layer in the foundation for continuous process improvement.
- Capability levels are cumulative
  - i.e., a higher capability level includes the attributes of the lower levels.

Continuous Representation

Source: Software Engineering Institute, Carnegie Mellon University
Capability Levels (CL)

- **GP1.1 through GP5.2**
  - **CL5 Optimizing**
    - Defect prevention, proactive improvement, innovative technology insertion and deployment

- **GP1.1 through GP4.2**
  - **CL4 Quantitatively Managed**
    - Measure process performance, stabilize process, control charts, deal with causes of special variations

- **GP1.1 through GP3.2**
  - **CL3 Defined**
    - Project’s process is tailored from organization’s standard processes, understand process qualitatively, process contributes to the organizations assets

- **GP1.1 through GP2.10**
  - **CL2 Managed**
    - Adhere to policy, follow documented plans and processes, apply adequate resources, assign responsibility and authority, train people, apply CM, monitor, control, and evaluate process, identify and involve stakeholders, review with management

- **GP1.1**
  - **CL1 Performed**
    - Perform the work

- **No GPs or SPs exist**
  - **CL0 Incomplete**

Example of Process Areas Capability Profile

- **Capability**
- **Process Area**
  - REQM
  - PP
  - PMC
  - etc
<table>
<thead>
<tr>
<th>Category</th>
<th>Process Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Management</td>
<td>Project Planning&lt;br&gt;Project Monitoring and Control&lt;br&gt;Supplier Agreement Management&lt;br&gt;Integrated Project Management (IPPD)&lt;br&gt;Integrated Supplier Management (SS)&lt;br&gt;Integrated Training (IPPD)&lt;br&gt;Risk Management&lt;br&gt;Quantitative Project Management</td>
</tr>
<tr>
<td>Support</td>
<td>Configuration Management&lt;br&gt;Process and Product Quality Assurance&lt;br&gt;Measurement and Analysis&lt;br&gt;Causal Analysis and Resolution&lt;br&gt;Decision Analysis and Resolution&lt;br&gt;Organizational Environment for Integration (IPPD)</td>
</tr>
<tr>
<td>Engineering</td>
<td>Requirements Management&lt;br&gt;Requirements Development&lt;br&gt;Technical Solution&lt;br&gt;Product Integration&lt;br&gt;Verification&lt;br&gt;Validation</td>
</tr>
<tr>
<td>Process Management</td>
<td>Organizational Process Focus&lt;br&gt;Organizational Process Definition&lt;br&gt;Organizational Training&lt;br&gt;Organizational Process Performance&lt;br&gt;Organizational Innovation and Deployment</td>
</tr>
</tbody>
</table>

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**SW-CMM → CMMI**

**LEVEL 5**
- Defect Prevention<br>- Causal Analysis and Resolution<br>- Organizational Innovation & Deployment<br>- Process Change Management

**LEVEL 4**
- Quantitative Process Mgmt<br>- Organizational Process Performance<br>- Quantitative Project Management
- Organization Process Focus<br>- Organization Process Definition<br>- Integrated Software Mgmt<br>- Integrated Project Management
- Risk Management<br>- Requirements Development<br>- Technical Solution<br>- Product Integration<br>- Verification<br>- Validation
- Decision Analysis and Resolution

**LEVEL 3**
- Organization Process Focus<br>- Organization Process Definition<br>- Integrated Software Mgmt<br>- Integrated Project Management
- Software Product Engr<br>- Intergroup Coordination<br>- Peer Reviews
- Requirements Management<br>- Requirements Management
- Software Project Planning<br>- Project Planning
- Software Project Tracking & Oversight<br>- Project Monitoring and Control
- Software Subcontract Mgmt<br>- Supplier Agreement Management
- Software Quality Assurance<br>- Product & Process Quality Assurance
- Software Configuration Mgmt<br>- Configuration Management
- Measurement and Analysis

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Source: Software Engineering Institute, Carnegie Mellon University
Maturity Levels

- A defined evolutionary plateau of process improvement.
- There are five maturity levels.
- Each level is a layer in the foundation for continuous process improvement using a proven sequence of improvements, beginning with basic management practices and progressing through a predefined and proven path of successive levels.
- For an organization to be recognized as a level 4, it must have met all the goals of the process areas of level 2, 3 and 4.

Source: Software Engineering Institute, Carnegie Mellon University

A Level cannot be skipped

Each maturity level provides a necessary foundation for effective implementation of processes at the next level.
- Higher level processes have less chance of success without the discipline provided by lower levels.
- The effect of innovation can be obscured in a noisy process.

Higher maturity level processes may be performed by organizations at lower maturity levels, with the risk of not being consistently applied in a crisis.

Source: Software Engineering Institute, Carnegie Mellon University
Familiarisation au modèle CMMI
Level 1 and 2

Level 1:
Just do it.

Level 2:
Think before you act, and think after you act, just to make sure you did it right.

Planning

Activity to produce
Results

Evaluation

Activity

Level 3

Planning

Activity to produce
Results

Evaluation

Standards

Use your lessons learned.

Level 4

Predict the results you need and expect and then create opportunities to get those results

Level 5

Create lessons learned, and use lessons learned to create more lessons learned, and use more lessons learned to create even more lessons learned, and use even more lessons learned to create... etc.
Benefits of Level 1

If you are the hero:
- you are worshiped as a deity
- in reality your manager ‘reports’ to you
- constantly doing the impossible is addictive
- large crowds attend your funeral (pre-mature heart attack)

If you are not the hero:
- company buys most of your dinners (you love pizza)
- you can work any way you want
- you are not a guru, but you can get away with acting like one
- amidst the chaos no one notices your mistakes
- you are relieved of planning your weekends

Level 2 Benefits – Managers

They take commitments seriously
- build commitment-based culture
- honesty in estimating
- learn to say ‘no’
- do not make commitments without consulting developers

They protect sound development practices
- provide time to repeat what has worked in the past
- ensure sound practices are followed, even with schedule pressure
- corrective action taken when behind schedule

They control baselines
- manage requirements changes against plans
- ensure deliverables under configuration control

Source: Schneider, H., Overview of the CMMI, TeraQuest/Borland
Level 2 Benefits – Developers

They have time to do a professional job
- participate in establishing commitments
- take commitments seriously

They can meet schedules
- realistic commitments
- protection from constant disruption

Morale increases
- less burnout from working nights and Weekends
- blame is eliminated
- pride in meeting commitments

Source: Schneider, H., Overview of the CMMI, TeraQuest

Level 3 Benefits – Managers

Organization
- Processes already defined from best Practices
- Templates for planning and managing
- History from similar projects

Estimates are more accurate
- Common measures across projects
- Better negotiating position—data on a defined process

Cost, schedule, and functionality in control

Quality improves
- Most defects detected before the start of integration tests
- Large reductions in defects delivered to customers

Source: Schneider, H., Overview of the CMMI, TeraQuest
Level 3 Benefits – Developers

Common foundation for professional work
• processes built from ‘best’ practices
• well understood roles

Foundation for technology benefits
• more effective selection of tools
• trusted processes produce reusable components

Transfer among projects is enhanced
• lessons learned
• people

A common engineering culture emerges

Management Visibility

Process Capability

Levels

Probability

Target

Time/$/...

In

Out

6/30/2008

Source: Software Engineering Institute, Carnegie Mellon University
Staged Representation

<table>
<thead>
<tr>
<th>Level</th>
<th>Focus</th>
<th>Process Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Optimizing</td>
<td>Continuous Process Improvement</td>
<td>Organizational Innovation and Deployment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Causal Analysis and Resolution</td>
</tr>
<tr>
<td>4 Quantitatively Managed</td>
<td>Quantitative Management</td>
<td>Organizational Process Performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quantitative Project Management</td>
</tr>
<tr>
<td>3 Defined</td>
<td>Process Standardization</td>
<td>Requirements Development</td>
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<td>Technical Solution</td>
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<td>Product Integration</td>
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<td>Verification</td>
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<td></td>
<td></td>
<td>Validation</td>
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<td>Integrated Project Management + IPPD</td>
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<td>Process and Product Quality Assurance</td>
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<td>Configuration Management</td>
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</table>

Maturity Level 1 “Initial”

1. Processes are performed but often in an ad hoc and occasionally chaotic manner.

2. Performance is dependent on the competence and heroics of the people.

3. High quality and exceptional performance is possible, as long as the best people can be assigned to the task.

4. Performance is difficult to predict.

5. Management practices may not be effective.

[DoD 87, Paulk 89]
Maturity Level 1 “Initial” Performance is Unpredictable

- Requirements flow in.
- A product is (sometimes) produced by some amorphous process.
- The product flows out and (we hope) works.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
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<td>Continuous Process</td>
<td>Organizational Innovation and Deployment</td>
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<td>Improvement</td>
<td>Causal Analysis and Resolution</td>
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<td>4 Quantitatively</td>
<td>Managed</td>
<td>Quantitative Process Performance</td>
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<td></td>
<td>Managed</td>
<td>Quantitative Project Management</td>
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<td>3 Defined</td>
<td>Process Standardization</td>
<td>Requirements Development</td>
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<td>Technical Solution</td>
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<td>Organizational Process Focus</td>
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<td>Configuration Management</td>
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<td>1 Initial</td>
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<td>Quality Productivity</td>
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<td>Risk</td>
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<td></td>
<td>Rework</td>
</tr>
</tbody>
</table>

Source: Software Engineering Institute, Carnegie Mellon University
Maturity Level 2
Process is “Managed”

1. Requirements flow in.
2. Plans are developed in accordance with policies.
3. Activities are performed in accordance with plans.
4. Measurements and reviews occur at defined points.
5. The product flows out and (usually) works.

Requirements Management

Purpose: To manage the requirements of the project’s products and product components and to identify inconsistencies between those requirements and the project’s plans and work products.

Bi-directional Traceability

Source: Software Engineering Institute, Carnegie Mellon University
Requirements Management

Specific Objective

SG 1. Manage Requirements
Requirements are managed and inconsistencies with project plans and work products are identified.

Specific Practices

- SP1.1 Obtain an Understanding of Requirements
  - Develop an understanding with the requirements providers on the meaning of the requirements.
- SP1.2 Obtain Commitment to Requirements
  - Obtain commitment to the requirements from the project participants.
- SP1.3 Manage Requirements Changes
  - Manage changes to the requirements as they evolve during the project.
- SP1.4 Maintain Bidirectional Traceability of Requirements
  - Maintain bidirectional traceability among the requirements and work products.
- SP1.5 Identify Inconsistencies Between Project Work and Requirements
  - Identify inconsistencies between the project plans and work products and the requirements.

Source: Software Engineering Institute, Carnegie Mellon University
SP 1.1 Obtain an Understanding of Requirements

- Develop an understanding with the requirements providers on the meaning of the requirements.
  - As the project matures and requirements are derived, all activities or disciplines will receive requirements.
  - To avoid requirements creep:
    - criteria are established to designate appropriate channels, or official sources, from which to receive requirements.
  - The receiving activities conduct analyses of the requirements with the requirements provider:
    - to ensure that a compatible, shared understanding is reached on the meaning of the requirements.
  - The result of this analysis and dialog is an agreed-to set of requirements.

Source: Software Engineering Institute, Carnegie Mellon University

SP1.1 Subpractices

1. Establish criteria for distinguishing appropriate requirements providers.
2. Establish objective criteria for the evaluation and acceptance of requirements.
   - Lack of evaluation and acceptance criteria often results in inadequate verification, costly rework, or customer rejection.
   - Examples of evaluation and acceptance criteria include the following:
     - Clearly and properly stated
     - Complete
     - Consistent with each other
     - Uniquely identified
     - Appropriate to implement
     - Verifiable (testable)
     - Traceable
3. Analyze requirements to ensure that the established criteria are met.
4. Reach an understanding of the requirements with the requirements provider so that the project participants can commit to them.

Source: Software Engineering Institute, Carnegie Mellon University
SP1.1 - Typical Work Products

1. List of criteria for distinguishing appropriate requirements providers
2. Criteria for evaluation and acceptance of requirements
3. Results of analyses against criteria
4. An agreed-to set of requirements

Project Planning

Purpose: to establish and maintain plans that define project activities.

- Define the software life cycle
- Identify software work products
- Document the Software Development Plan
- Estimate size, cost, effort
- Schedule the activities
Project Planning

Specific Goals

SG 1: Establish Estimates

Estimates of project planning parameters are established and maintained.

SG 2: Develop a Project Plan

A project plan is established and maintained as the basis for managing the project.

SG 3: Obtain Commitment to the Plan

Commitments to the project plan are established and maintained.

Project Monitoring And Control

Purpose: To provide an understanding of the project’s progress so that appropriate corrective actions can be taken when the project’s performance deviates significantly from the plan.

Track actual size, costs, and efforts against estimates

Use DP to track activities

Track actual progress against the schedule

Take timely corrective action as necessary
Project Monitoring And Control

Specific Goals

SG 1: Monitor Project Against Plan
Actual performance and progress of the project are monitored against the project plan.

SG 2: Manage Corrective Action to Closure
Corrective actions are managed to closure when the project’s performance or results deviate significantly from the plan.

Process and Product Quality Assurance

Purpose: To provide staff and management with objective insight into processes and associated work products.

- Review software engineering activities (processes) to verify compliance
- Identify deviations in activities and work products
- Audit work products for compliance

Source: Software Engineering Institute, Carnegie Mellon University
Process and Product Quality Assurance

Objectively Evaluate Processes and Work Products

Objectively Evaluate Processes

Objectively Evaluate Work Products & Services

Reports and Records

Provide Objective Insight

Communicate and Ensure Resolution of Non-compliance Issues

Establish Records

Objective Evaluate Work Products & Services

Objectively Evaluate Processes

Work Products

Reports and Records

People

Process and Product Quality Assurance

Configuration Management

Purpose: To establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.

Place work products under CM

Record, review, approve, and track changes and problems

Control changes to baselines

Control releases from baselines

BASELINE LIBRARY

DESIGN

CODE

TEST

Source: Software Engineering Institute, Carnegie Mellon University

6/30/2008 87

6/30/2008 88
**Configuration Management**

- Establish a Configuration Management System
- Create or Release Baselines
- Identify Configuration Items
- Establish Integrity
- Establish Config Mgmt System
- Perform Configuration Audits
- Change Requests
- Change Request Database
- Track and Control Changes
- Track Change Requests
- Control Configuration Items
- Audit Results
- Action Items
- Status

---

**Supplier Agreement Management**

**Purpose:** To manage the acquisition of products from suppliers.

- Designate someone for managing contract
- Define Statement of Work; select qualified contractor
- Review contractor's accomplishments and products
- Approve contractor's SDP to track activities

Source: Software Engineering Institute, Carnegie Mellon University
Supplier Agreement Management

- Establish Supplier Agreements
- Determine Acquisition Type
- Select Suppliers
- Establish Supplier Agreements
- Supplier Requirements
- Product
- Supplier Agreement
- Satisfy Supplier Agreements
- Review COTS Products
- Accept the Acquired Product
- Transition Products
- Execute the Supplier Agreement

Measurement and Analysis

**Purpose:** To develop and sustain a measurement capability that is used to support management information needs.

**Defined Objectives:**
- Collect data
- Data is analysed and published
- Source: Software Engineering Institute, Carnegie Mellon University
Changing Immature Processes into Repeatable, Mature Processes

Level 3

Source: Software Engineering Institute, Carnegie Mellon University
Quelles sont les caractéristiques indésirables de cette organisation?

Risques potentiels:

1. Processus fragmentés et appliqués différemment dans l’organisation.
2. L’organisation n’est pas constante dans la qualité de ses produits.
3. Le succès d’un projet dépend des développeurs et du processus utilisé.
4. Les pratiques techniques sont incomplètes et non intégrées avec les pratiques de gestion qui sont appliquées.
5. Les pratiques exemplaires de l’organisation n’ont pas d’influence dans le reste de l’organisation
   - Les pratiques inefficaces se perpétuent
   - Les îlots d’excellence fleurissent et s’estompent.
A **defined process** is a **managed** process that is:

- Tailored from the organization’s set of standard processes according to the organization’s tailoring guidelines;
- Has a **maintained** process description;
- **Contributes** work products, measures, and other process-improvement information to the organizational process assets.
- A defined process clearly states the following:
  - Purpose, Inputs, Entry criteria, Activities, Roles, Measures, Verification steps, Outputs, Exit criteria.

---

**Le niveau 3 –Defined**

1. L’emphase passe des **projets** (niveau 2) à l’**organisation** (niveau 3)
2. Les **processus** sont **personnalisés**
3. Les **pratiques techniques** de l’ingénierie sont établies et **intégrées** avec les pratiques de **gestion**
4. Une discipline « processus » de base est établie **travers** l’**organisation**
5. Un programme de **formation** est défini
Sample Level 3 Organization: Processes based on organization’s PAL

Level 3 - Defined

<table>
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<tr>
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</tbody>
</table>

Source: Software Engineering Institute, Carnegie Mellon University
Level 3 – Defined

- **GG3 - Institutionalize a Defined Process**
  - **GP 3.1 Establish a Defined Process**
    - Establish and maintain the description of a defined process.
  - **GP 3.2 Collect Improvement Information**
    - Collect work products, measures, measurement results, and improvement information derived from planning and performing the process to support the future use and improvement of the organization’s processes and process assets.

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Level 4 - Quantitatively Managed

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</table>
Du niveau 3 au niveau 4

• Au niveau 3
  – Des mesures sont définies et collectées systématiquement

• Au niveau 4
  – Les décisions sont faites à partir des données collectées

W. Edwards Deming

‘ In God we trust, all others bring your data. ’
From Level 3 to Level 4

- Level 3 - Traditional Project Management Approach
  1. Planning is based on goals, budgets, targets
  2. Tracking is performed against plans
  3. No insight into how process works and contributes to results
  4. No emphasis on continuous process improvement

- Level 4 - Quantitative Process Management Approach
  1. Planning is based on process performance baselines
  2. Tracking is based on level of variation around a baseline
  3. Provides insight into process stability
  4. Performance is predictable
  5. Commitment to process improvement
Stable vs Capable Processes

- Stable Process
  - Process is within control limits

- Capable Process
  - Process performance meets customer requirements or organizational goals

Process Capability

- Defect density per page for each document inspected

Defect densities have gone out of control, perhaps preparation time has been shortened in a schedule crunch

Keller (1992)
Performance du processus organisationnel

**Intention:** Établir et maintenir une appréciation quantitative de la performance de l’ensemble des processus normalisés de l’organisation au soutien des objectifs de qualité et de performance des processus. Ce domaine de processus vise aussi à fournir des données sur la performance des processus, des référentiels et des modèles pour permettre au projet de l’organisation d’appliquer une approche de gestion quantitative.

**Résultats réels**

Source: Software Engineering Institute, Carnegie Mellon University
Gestion de projet quantitative

**Intention:** Gérer quantitativement le processus personnalisé du projet en vue de rencontrer les objectifs de qualité et de performance du processus établi pour le projet.

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**Level 5 - Optimizing**

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Source: Software Engineering Institute, Carnegie Mellon University
Du niveau 4 au niveau 5

- Au niveau 4
  - Les processus sont gérés quantitativement
- Au niveau 5
  - L’amélioration continue des processus est intégrée aux activités journalières
  - Entre 70% et 80% des membres de l’organisation participent aux activités d’amélioration

Amélioration continue

Effort Deviation Individual Value Control Chart - Commercial Systems

- Effort Deviation 85%
- Effort Deviation 17%
- Effort Deviation 4%

Date of Project Phase Start

**Innovation et déploiement organisationnels**

**Intention:** Sélectionner et déployer des améliorations incrémentielles ou innovatrices qui améliorent de façon mesurable les processus et les technologies de l’organisation. Ces améliorations soutiennent les objectifs de qualité et de performance de processus de l’organisation tels que qu’établis en fonction des objectifs d’affaire de l’organisation.

![Diagramme de l'innovation et déploiement organisationnels](image1)

Source: Software Engineering Institute, Carnegie Mellon University

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**Analyse causale et résolution**

**Intention:** Identifier les causes des défauts et des autres problèmes et de faire en sorte de prévenir leur récurrence dans le futur.

![Diagramme de l'analyse causale et résolution](image2)

Source: Software Engineering Institute, Carnegie Mellon University
Process Maturity Profile

CMMI®
SCAMPSM Class A Appraisal Results
2007 Mid-Year Update

September 2007

We could not produce this report without the support of the organizations and lead appraisers who reported their appraisal results to the SEI®.

Our many thanks for their continuing cooperation with our data collection and analysis efforts.

CMMI Appraisal Program

Process Maturity Profile by All Reporting Organizations

- 2,464 appraisals
- 2,140 organizations
- 1,417 participating companies
- 273 reappraised organizations projects
- 10,338
- 67.1% Non-USA organizations

Number of Organizations

Not Given Initial Managed Defined Quantitatively Managed Optimizing

6/30/2008
Familiarisation au modèle CMMI
Méthode d’évaluation des capacités

- Des méthodes d’évaluation des capacités ont été développées par le SEI
  - SCAMPI
    - Standard CMMI Appraisal Method for Process Improvement
    - Class A, B, C
  - ‘Registered’ Appraisals for Source Selection
- D’autres organisations ont aussi développé des méthodes (utilisée à l’interne)
  - e.g. Motorola et Harris
Standard CMMI Appraisal Method for Process Improvement (SCAMPI)

- **Utilization of the method**
  1. Diagnostic
  2. Identify strengths and weaknesses
  3. Prioritize improvements
  4. Set goals
  5. Identify training needs
  6. Select suppliers
  7. Gather information for investment purposes
  8. Support outsourcing activities *

Support Outsourcing

1. Évaluer ‘quoi’ externaliser
2. Définir/évaluer la méthode d’externalisation
3. Définir le périmètre à externaliser
4. Identifier les changements en vue de l’externalisation
5. Audit de contrôle
6. Préserver la réversibilité
7. Prouver le dysfonctionnement

Source: Alcyonix, journée VIP, 13 septembre 2004, brochure corporative.
**Other utilisations**

- **Acquisition de logiciels**
  - Définir les critères d’évaluation des offres
  - Sélectionner les candidats
  - Qualifier les risques
    - Imposer des pratiques
  - Audit de contrôle

- **Fusion**:
  - Définir la démarche de rapprochement
  - Identifier les ‘meilleures’ pratiques de chacun

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**Appraisal Method Classes**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of objective evidence gathered (relative)</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Ratings generated</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Resource needs (relative)</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Team size (relative)</td>
<td>Large</td>
<td>Medium</td>
<td>Small</td>
</tr>
<tr>
<td>Appraisal Team Leader Requirements</td>
<td>Lead Appraiser</td>
<td>Lead Appraiser or person trained and experienced</td>
<td>Person trained and experienced</td>
</tr>
</tbody>
</table>

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Source: CMMI V1.1 and Appraisal Tutorial, Mike Phillips, 2004, SEI.
Comparaison des méthodes d’évaluation

**Évaluations SCAMPI**
- Résultats appartenant à l’organisation
- Décisions relatives aux ressources prises par l’organisation en vue de l’amélioration du processus
- Auto-motivation pour que l’organisation entreprenne l’amélioration du processus
- Collaboration entre les membres de l’équipe et les représentants de l’organisation
- Portée déterminée en fonction des besoins de l’organisation

**Évaluations de la capacité (CE)**
- Résultats appartenant au client
- Décisions relatives à l’organisation logiciel (adjudication des contrats, honoraires, etc.) prises par le client
- Motivation imposée de l’extérieur pour que l’organisation entreprenne l’amélioration du processus
- Interface formelle entre les membres de l’équipe et les représentants de l’organisation
- Portée déterminée en fonction des besoins du client

Source: Software Engineering Institute, Carnegie Mellon University

What are Practice Implementation Indicators (PIIs)?

Based on the presumption that the conduct of an activity or the implementation of a practice will result in “footprints” which are attributable to the activity or practice.

6/30/2008

Source: CMMI V1.1 and Appraisal Tutorial, Mike Phillips, 2004, SEI.

6/30/2008
Types of Practice Implementation Indicators

- **Direct Artifacts**
  - Tangible outputs resulting directly from implementation of a practice (e.g., Work Products)

- **Indirect Artifacts**
  - Artifacts that are a side-effect or indicative of performing a practice (e.g., meeting minutes, reviews, logs, reports)

- **Affirmations**
  - Oral or written statements confirming or supporting implementation of the practice
  - e.g., interviews, questionnaires

Example – Indicators of Practice Implementation

**PP SP1.1-1:**

*Indirect artifacts:*
- Meeting minutes,
- Team charter,
- WBS development notes

*Primary artifacts:*
- Top-level WBS
- Task descriptions
- Work package descriptions

**Establish**

a top-level work breakdown structure (WBS)
to estimate the scope of the project.

*Affirmations:*
- “I worked on the WBS team”
- “We used the WBS”
Other CMMI

- **Safety**
  - Safe is a Safety Extension to CMMI

- **Safety and Security Assurance**
  - **Purpose**
    - To establish and maintain a safety and security capability, define and manage requirements based on risks attributable to threats, hazards, and vulnerabilities, and assure that products and services are safe and secure.
    - Application Area (AA 01) used in conjunction with the FAA iCMM and CMMI

- **Work Environment (WE) Process Area**
  - Sometimes called the support environment or the infrastructure
La culture de l’organisation

- **Communications Layer**
  - Artifacts such as documents, data, quality records and activities to produce artifacts

- **Expectations Layer**
  - Organization’s goals, values, desirable behaviors, results

- **Assumptions Layer**
  - Invisible aspects of the culture
  - Influence people’s expectations, activities and artifacts produced

La culture de l’organisation un exemple

- Project Plan is an artifact
  - Assumption is that a project plan is important
    - People will expect to see a project plan, participate in planning activities, produce and use a project plan
  - Assumption is that project plans are unnecessary paperwork because nothing goes according to plan
    - Project plans will likely slip away or be target of criticisms. People will not waste time to prepare project plans

Les hypothèses qui sous-tendent le CMM

1. To build quality into products of large size and complexity, engineering discipline is required.

2. One person can’t track all the details, and error detection is more probable when the work is examined by more than one person.

3. Our success, in software, is dependent on other groups and customers.

4. The organization uses process definition to transmit the culture’s quality values (e.g. capture and pass on lessons learned)
Les hypothèses qui sous-tendent le CMM

5. Les projets utilisent la définition du processus pour incorporer les valeurs de qualité culturelles (par exemple, tirer parti des leçons apprises).


7. Survivre dans un monde d'affaires qui est constamment en évolution nécessite une constante adaptation et apprentissage.

Trouvez des hypothèses qui interfèrent

1. La discipline (par exemple, le processus) interfère toujours avec la créativité – c'est-à-dire, la discipline et la créativité ne peuvent pas coexister à la même époque.

2. Le planning est fixé, les ressources sont fixées, le contenu des fonctionnalités est fixé, et nous n'avons pas de choix. Le niveau de qualité est fixé également. Le niveau de qualité est ce que cela coûte le jour de livraison.

3. Gérer les exigences est un gaspillage de temps, car les exigences changent trop souvent.
Les hypothèses qui interfèrent

4. The sooner we get the software into testing, the sooner we can get the product out.

5. We can test the quality into the product.

6. If we define one common process and get everyone to follow it, it will guarantee the quality of the product.

7. We don’t have enough time and resources to follow the defined process.

8. Our project is different. The process do not apply to us.

9. The overhead will kill the project.

Les hypothèses qui interfèrent

1. Good people can do it without a process.

2. We always hire qualified people, so we don’t need any training.

3. Our people are so good that we don’t need to have their work inspected (peer review)

4. The customers don’t really know what they want, so it would be a waste of time to discuss it with them.

5. We know what we are doing, but other groups never tell us what they are doing.
Les hypothèses qui interfèrent

1. We’ve always done it this way. Why change?

2. This is just another quality initiative and if we ignore it, it will go away.

3. Who is paying for it? If it isn’t paid for, we’re not doing it.

4. We have a process, so everybody follows it.

5. We have tried process improvement before, and it didn’t buy us anything.

Les hypothèses qui interfèrent

1. It’s too much trouble. We don’t have time to do things this way. I have a schedule deadline to meet. My management doesn’t really want me to do this if it means I will miss my schedule deadline.

2. Who else is doing this? If I do it, will I be the only one?

3. What if I have trouble with the process? Who will support me if I do it?

4. We don’t need engineering discipline, we’ve got engineering finesse!
Les hypothèses qui interfèrent

1. Management rewards firefighters and heroes
2. The best technical people make the best technical managers
3. We are the best
4. Training does not get us more marketable
5. Process improvement does not show profit improvement while we are doing it.

La clarification des hypothèses

1. What assumptions are motivating the current practices in your organization?
2. Are your assumptions in alignment with the CMMI assumptions?
3. Are your assumptions working for you or working against your good intentions, pushing you in the wrong direction?
4. Which assumptions are not acted upon?
5. What are the assumptions that interfere?