IMPROVEMENT OF THE TEST PROCESS
using TPI®

T.Koomen, M. Pol
Sogeti Nederland B.V.
Software Control

P.O. Box 263, 1110 AG Diemen
The Netherlands
Tel: +31 20 6606600
Fax: +31 20 6953298
e-mail: tpi@sogeti.nl
English TPI® website: www.sogeti.nl/tpi

Abstract

This paper presents the TPI®-model, which is based on current state-of-the-art test process improvement practices. The model gives practical guidelines for assessing the maturity level of testing in an organisation and for step by step improvement of the process. The purpose of such improvement could be reaching CMM level 3.

The model consists of 20 key areas, each with different levels of maturity. The levels of all key areas are set out in a maturity matrix. Each level is described by several checkpoints. Improvement suggestions, which help to reach a desired level, are part of the model.

The paper includes a general description of the application of model, which deals with how to implement and how to consolidate the improvements.

1 How good is your test process ?

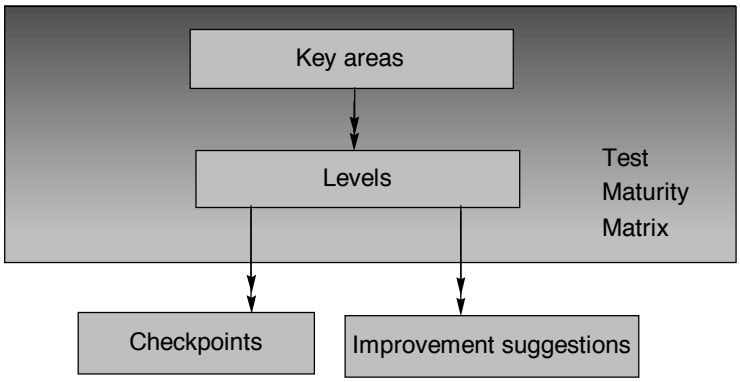
This seemingly easy question turns out to be very hard to answer in reality. Testing is often experienced as a troublesome and uncontrollable process. Testing takes too much time, costs a lot more than planned, and offers insufficient insight in the quality of the test process and, therefore, the quality of the information system under test and the risks for the business process itself. But can we do something about this ?

Many organisations realise that improving the test process can solve these problems. However, in practice it turns out to be hard to define what steps to take for improving and controlling the process, and in what order. A comparison can be made with improvement of the total software process, where models like the Capability Maturity Model© (CMM) offer support.

Based on the knowledge and experiences of a large number of professional testers the Test Process Improvement (TPI®) model has been developed. The TPI model supports the improvement of test processes. The model offers insight in the "maturity" of the test processes within your organisation. Based on this understanding the model helps to define gradual and controllable improvement steps.

2 Description of the model

The model is visualised as follows:



Key areas

In each test process certain areas need specific attention in order to achieve a well defined process. These **Key areas** are therefore the basis for improving and structuring the test process. The TPI model has 20 key areas.

The scope of test process improvement usually comprises high-level tests like system and acceptance tests. Most key areas are adjusted to this. However, to improve more "mature" test processes, attention must also be given to verification activities and low-level tests like unit and integration tests. Separate key areas are included in order to give due attention to these processes as well.

A full list of key areas is given below, followed by an explanation.

Test strategy	Test environment	Defect management
Life-cycle model	Office environment	Testware management
Moment of involvement	Commitment and motivation	Test process management
Estimating and planning	Testing functions and training	Evaluation
Test specification techniques	Scope of methodology	Low-level testing
Static test techniques	Communication	
Metrics	Reporting	
Test automation		

Key area	Description
Test strategy	The test strategy has to be focused on detecting the most important defects as early and as cheaply as possible. The test strategy defines which requirements and (quality) risks are covered by what tests. The better each test level defines its own strategy and the more the different test level strategies are adjusted to each other, the higher the quality of the overall test strategy.
Life-cycle model	Within the test process a number of phases can be defined, such as planning, preparation, specification, execution and completion. In each phase several activities are performed. For each activity the following aspects should be defined: purpose, input, process, output, dependencies, applicable techniques and tools, required facilities, documentation, etc.. The importance of using a life-cycle model is an improved predictability and controllability of the test process, because the different activities can be planned and monitored in mutual cohesion .
Moment of involvement	Although the actual execution of the test normally begins after the realisation of the software, the test process must and can start much earlier. An earlier involvement of testing in the system development path helps to find defects as soon and easy as possible and perhaps even to prevent errors. A better adjustment between the different tests can be done and the time that testing is on the critical path of the project can be kept as short as possible.
Estimating and planning	Test planning and estimating indicate which activities have to be carried out when, and the necessary resources (people). Good estimating and planning are very important, because they are the basis of, for example, allocating resources for a certain time frame.
Test specification techniques	The definition of a test specification technique is "a standardised way of deriving test cases from source information". Applying these techniques gives insight into the quality and depth of the tests and increases the reusability of the test.
Static test techniques	Not everything can and should be tested dynamically, that is, by running programs. Inspection of products without running programs, or the evaluation of measures which must lead to a certain quality level, is called static tests. Checklists are very useful for this.
Metrics	Metrics are quantified observations of the characteristics of a product or process. For the test process, metrics of the progress of the process and the quality of the tested system are very important. They are used to control the test process, to substantiate the test advice and also to make it possible to compare systems or processes. Why has one system far fewer failures in operation than another system, or why is one test process faster and more thorough than another? Specifically for improving the test process, metrics are important by evaluating consequences of certain improvement actions, by comparing data before and after performing the action.
Test automation	Automation within the test process can take place in many ways and has in general one or more of the following aims: - fewer hours needed, - shorter lead time, - more test depth, - increased test flexibility, - more and/or faster insight in test process status, - better motivation of the testers.
Testing environment	The test execution takes place in a so-called test environment. This environment mainly comprises the following components: - hardware; - software; - means of communication; - facilities for building and using databases and files; - procedures.

	The environment should be composed and set up in such a way that by means of the test results it can be optimally determined to what extent the test object meets the requirements. The environment has a large influence on the quality, lead time, and cost of the test process. Important aspects of the environment are responsibilities, management, on-time and sufficient availability, representativeness, and flexibility.
Office environment	The test staff need rooms, desks, chairs, PCs, word-processing facilities, printers, telephones, and so on. A good and timely organisation of the office environment has a positive influence on the motivation of the test staff, on communication in- and outside the team, and on the efficiency of the work.
Commitment and motivation	The commitment and the motivation of the persons involved in testing are important prerequisites for a smoothly running test process. The persons involved are not only the testers, but also, for example, the project management and the line management personnel. The latter are mainly important in the sense of creating good conditions. The test process thus receives enough time, money, and resources (quantitatively and qualitatively) to perform a good test, in which cooperation and good communication with the rest of the project results in a total process with optimum efficiency.
Testing functions and training	In a test process the correct composition of a test team is very important. A mix of different disciplines, functions, knowledge, and skills is required. Besides specific test expertise, knowledge of the subject matter, knowledge of the organisation and general IT knowledge is required. Social skills are also important. For acquiring this mix, training etc. is required.
Scope of methodology	For each test process in the organisation a certain methodology or working method is used, comprising activities, procedures, regulations, techniques etc.. When these methodologies are different each time or when the methodology is so generic that many parts have to be drawn up again each time, it has a negative effect on the test process efficiency. The aim is that the organisation uses a methodology which is sufficiently generic to be applicable in every situation, but which contains enough detail so that it is not necessary to rethink the same items again each time.
Communication	In a test process, communication with the people involved must take place in several ways, within the test team as well as with parties such as the developer, the user, the customer, etc.. These communication forms are important for a smoothly running test process, not only to create good conditions and to optimize the test strategy, but also to communicate about the progress and the quality.
Reporting	Testing is not so much "defect detection" as about giving insight in the quality level of the product. Reporting should be aimed at giving well-founded advice to the customer concerning the product and even the system development process.
Defect management	Although managing defects is in fact a project matter and not specifically of the testers, the testers are mainly involved in it. Good management should be able to track the life-cycle of a defect and also to support the analysis of quality trends in the detected defects. Such analysis is used, for example, to give well-founded quality advice.
Testware management	The products of testing should be maintainable and reusable and so they must be managed. Besides the products of the testing themselves, such as test plans, specifications, databases and files, it is important that the products of previous processes such as functional design and realisation are managed well, because the test process can be disrupted if the wrong program versions, etc. are delivered. If testers make demands upon version management of these products, a positive influence is exerted and the testability of the product is increased.
Test process management	For managing each process and activity, the four steps from the Deming circle are essential: plan, do, check and act. Process management is of vital importance for the realisation of an optimal test in an often turbulent test

	process.
Evaluation	Evaluation means inspecting intermediate products such as the requirements and the functional design. The importance of evaluation is that the defects are found at a much earlier stage in the development process than with testing. This makes the rework costs much lower. Also, evaluation can be set up more easily because there is no need to run programs or to set up an environment etc..
Low-level testing	The low-level tests are almost exclusively carried out by the developers. Well-known low-level tests are the unit test and the integration test. Just as evaluation, the tests find defects at an earlier stage of the system development path than the high-level tests. Low-level testing is efficient, because it requires little communication and because often the finder is both the error producer as well as the one who corrects the defect.

Levels

The way key areas are organised within a test process determines the 'maturity' of the process. It is obvious that not each key area will be addressed equally thoroughly: each test process has its strengths and weaknesses.

In order to enable insight in the state of the key areas, the model supplies them with **Levels** (from A to B to C). On the average, there are three levels for each key area.

Each higher level (C being higher than B, B being higher than A) is better than its prior level in terms of time (faster), money (cheaper) and/or quality (better). By using levels we can unambiguously assess the current situation of the test process. It also increases the ability to advice targets for stepwise improvement.

Each level consists of certain requirements for the key area. The requirements (= checkpoints) of a certain level also comprise the requirements of lower levels: a test process at level B fulfils the requirements of both level A and B. If a test process does not satisfy the requirements for level A, it is considered to be at the lowest and, consequently, undefined level for that particular key area.

Below a description is given of the different levels of the key areas.

Levels **Key area**	A	B	C	D
Test strategy	Strategy for single high-level test	Combined strategy for high-level tests	Combined strategy for high-level tests plus low-level tests or evaluation	Combined strategy for all test and evaluation levels
Life-cycle model	Planning, Specification, Execution	Planning, Preparation, Specification, Execution, Completion		
Moment of involvement	Completion of test basis	Start of test basis	Start of requirements definition	Project initiation
Estimating and planning	Substantiated estimating and planning	Statistically substantiated estimating and planning		
Test specification techniques	Informal techniques	Formal techniques		
Static test techniques	Inspection of test basis	Checklists		
Metrics	Project metrics (product)	Project metrics (process)	System metrics	Organisation metrics (>1 system)
Test automation	Use of tools	Managed test automation	Optimal test automation	
Test environment	Managed and controlled environment	Testing in most suitable environment	Environment on call	
Office environment	Adequate and timely office environment			
Commitment and motivation	Assignment of budget and time	Testing integrated in project organisation	Test-engineering	
Test functions and training	Test manager and testers	(Formal) Methodical, technical and functional support, management	Formal internal Quality Assurance	
Scope of methodology	Project specific	Organisation generic	Organisation optimising (R&D)	
Communication	Internal communication	Project communication (defects, change control)	Communication within the organisation about the quality of the test processes	
Reporting	Defects	Progress (status of tests and products), activities (costs and time, milestones), defects with priorities	Risks and recommendations, substantiated with metrics	Recommendations have a Software Process Improvement character
Defect management	Internal defect management	Extended defect management with flexible reporting facilities	Project defect management	
Testware management	Internal testware management	External management of test basis and test object	Reusable testware	Traceability system requirements to test cases
Test process management	Planning and execution	Planning, execution, monitoring, and adjusting	Monitoring and adjusting within organisation	
Evaluation	Evaluation techniques	Evaluation strategy		
Low-level testing	Low-level test life-cycle: planning,	White-box techniques	Low-level test strategy	

	specification and execution			

Checkpoints

In order to determine levels, the TPI model is supported by an objective measurement instrument. The requirements for each level are defined in the form of **Checkpoints**: questions that need to be answered positively in order to classify for that level. Based on the checkpoints a test process can be assessed, and for each key area the proper level can be established. As each next level of a key area is considered an improvement, this means that the checkpoints are cumulative: in order to classify for level B the test process needs to answer positively to the checkpoints both of level B and of level A.

Test Maturity Matrix

After determining the levels for each key area, attention should be directed as to which improvement steps to take. This is because not all key areas and levels are equally important. For example, a good test strategy (level A of key area Test Strategy) is more important than a description of the test methodology used (level A of key area Scope of Methodology). In addition to these priorities there are dependencies between the levels of different key areas. Before statistics can be gathered for defects found (level A of key area Metrics), the test process has to classify for level B of key area Defect management. Such dependencies can be found between many levels and key areas.

Therefore, all levels and key areas are related to each other in a **Test Maturity Matrix**. This has been done as a good way to express the internal priorities and dependencies between levels and key areas. The vertical axis of the matrix indicates key areas, the horizontal axis shows scales of maturity. In the matrix each level is related to a certain scale of test maturity. This results in 13 scales of test maturity. The open cells between different levels have no meaning in themselves, but indicate that achieving a higher maturity for a key area is related to the maturity of other key areas. There is no gradation between levels: as long as a test process is not entirely classified at level B, it remains at level A.

Scale / **Key area**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Test strategy		A					B				C		D	
Life-cycle model		A			B									
Moment of involvement			A				B				C		D	
Estimating and planning				A							B			
Test specification techniques		A		B										
Static test techniques					A		B							
Metrics						A			B			C		D
Test automation				A				B			C			
Test environment				A				B						C
Office environment				A										
Commitment and motivation		A				B						C		
Test functions and training				A			B			C				
Scope of methodology					A						B			C
Communication			A		B							C		
Reporting		A			B		C					D		

Scale / Key area	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Defect management		A				B		C						
Testware management			A			B				C				D
Test process management		A		B								C		
Evaluation							A			B				
Low-level testing					A		B		C					

The main purpose of the matrix is to show the strong and weak sides of the current test process and to support prioritising actions for improvement. A filled in matrix offers all participants a clear view of the current situation of the test process. Furthermore, the matrix helps in defining and selecting proposals for improvement.

The matrix works from left to right, so low mature key areas are improved first. As a consequence of the dependencies between levels and key areas, practice has taught us that real 'outlyers' (i.e., key areas with high scales of maturity, whereas surrounding key areas have medium or low scales) give little return on investment. For example, what is the use of a very advanced defect administration, if it is not used for analysis and reporting? Without violating the model, deviation is permitted, but sound reasons should exist for it.

In the example below, the test process does not classify for the lowest level of the key area test strategy(level < A), the organisation is working conform a life-cycle model (level A) and the testers are involved at the moment when the specifications are completed (level A).

Scale / Key area	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Test strategy		A					B				C		D	
Life-cycle model		A			B									
Moment of involvement			A				B				C		D	
etc.														

Based on this instance of the matrix, improvements can be discussed. In this example, a choice is made for a combined test strategy for high-level tests (=> level B) and for a full life-cycle model (=> level B). Earlier involvement is at this moment not considered to be of relevance. The required situation is represented in the following matrix.

Scale / Key area	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Test strategy		A					B				C		D	
Life-cycle model		A			B									
Moment of involvement			A				B				C		D	
etc.														

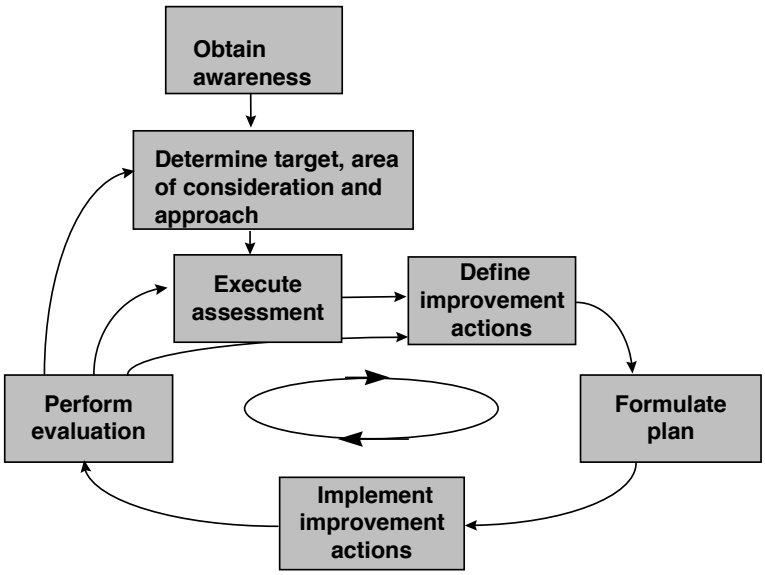
Improvement Suggestions

Improvement actions can be defined in terms of desired higher levels. For reaching a higher level the checkpoints render much assistance. Beside these, the model has other means of support for test process improvement: the **Improvement Suggestions**, which are different kinds of hints and ideas that help to achieve a certain level of test maturity. Unlike the use of

checkpoints, the use of improvement suggestions is not obligatory. Each level is supplied with several improvement suggestions.

3 Application of the TPI model

The process of test improvement is similar to any other improvement process. The figure below shows the various activities of an improvement process. These activities are discussed, with special attention for the places where the TPI model can be used.



Obtain awareness
The first activity of a test improvement process is to create awareness for the necessity to improve the process. Generally speaking, a number of problems concerning testing is the reason for improving the test process. There is a need to solve these problems and an improvement of the test process is regarded as the solution. This awareness also implies that the parties mutually agree on the outlines and give their commitment to the change process. Commitment should not only be acquired at the beginning of the change process, but be retained throughout the project. This requires a continuous effort.

Determine target, area of consideration, and approach
We determine what the improvement targets are and what the area of consideration is. Should testing be faster, cheaper or better? Which test processes are subjects for improvement, how much time is available for the improvement and how much effort is it allowed to cost?

Execute assessment
In the assessment activity, an evaluation is given of the current situation. The use of the TPI model is an important part of the assessment, because it offers a frame of reference to list the strong and weak points of the test process. Based on interviews and documentation, the levels per key area of the TPI model are examined by using checkpoints, and it is determined which checkpoints were met, which were not met, or only partially. The Test Maturity Matrix is used here to give the complete status overview of the test process. This will show the strengths and weaknesses of the test process in the form of levels assigned key areas and their relative position in the matrix.

Define improvement actions
The improvement actions are determined based on the improvement targets and the result of the assessment. These actions are determined in such a way that gradual and step by step improvement is possible.

The TPI model helps to set up these improvement actions. The levels of the key areas and the Test Maturity Matrix give several possibilities to define gradual improvement steps. Depending on the targets, the scope, the available time and the assessment results, it can be decided to carry out improvements for one or more key areas. For each selected key area it can be decided to go to the next level or, in special cases, even to a higher level. Besides this, the TPI model offers a large number of improvement suggestions which help to achieve higher levels.

Formulate plan
A detailed plan is drawn up to implement (a part of) the short term improvement actions. In this plan the aims are recorded and it is indicated which improvements have to be implemented at what time to realise these aims. The plan deals with activities concerning the content of the test process improvement as well as general activities needed to steer the change process in the right direction.

Implement improvement actions
The plan is executed. Because during this activity the consequences of the change process have the largest impact, much attention should be spent on communication. Opposition, which no doubt is present, must be brought to the surface and be discussed openly.
It has to be measured to what extent actions have been executed and have been successful. A means for this is the so-called "self assessment", in which the TPI model is applied in order to quickly determine the progress. Here, the persons involved inspect their own test processes using the TPI model.
Another vital part of this phase is consolidation. It should be prevented that the implemented improvement actions have a once-only character.

Perform evaluation
To what extent did the implemented actions yield the intended result? In this phase the aim is to see to what extent the actions were implemented successfully as well as to evaluate to what extent the initial targets were met. A decision about the continuation of the change process is made based on these observations.

4 Conclusions and remarks

Current developments proceed at a very high speed. The productivity of developers is rising continuously and the customers demand ever higher quality. Even if your current test process is fairly satisfactory, your process will need to improve in the future. The TPI model can help you with this.

The TPI model is an objective means to gain quick insight in the current situation of the test process. The model greatly offers help for improvement in the form of key areas, levels and improvement suggestions. It supports the definition of small and controlled improvement steps, based on priorities.

The reader might get the impression that use of the TPI model automatically leads to good analysis of the current and required situation. This is not true. The model should be seen as a tool for structuring the improvement of the test process and as a very good means of communication. Apart from the tool, improvement of test processes demands a high degree of knowledge and expertise of people involved, at least in the areas of testing, organisation and change management.

Book:
Koomen, T., Pol, M. (1999), Test Process Improvement, a practical step-by-step guide to structured testing, Addison-Wesley, ISBN 0 201 59624 5

Internet:
at 'www.sogeti.nl/tpi' several TPI products can be viewed and downloaded. Also questions can be asked and remarks can be made.

