

Level 2 Phase Definition

Testing is a defined process and is clearly separated from debugging. In the context of structuring the test process, a test strategy and test plans are established. The test approach is determined using risk management techniques and is based on documented requirements. For deriving and selecting test cases from requirement specifications documented test design techniques are applied. However, testing still starts relatively late in the development life cycle, e.g. during the design or even during the coding phase. The main objective of testing in TMM level 2 organisations is to verify that the software product satisfies the specified requirements.

The process areas for level 2 are:

- 2.1 Test Policy and Goals
- 2.2 Test Planning
- 2.3 Test Techniques and Methods
- 2.4 Test Environment

Test Policy and Goals

Introduction

The *purpose* of 'Test Policy and Goals' is to develop and establish a test policy and an overall test strategy containing amongst others test objectives, responsibilities and main tasks for each test level. The purpose is also to clearly differentiate the processes of testing and debugging.

When an organisation wants to improve its test process, it should first clearly define a test policy. The test policy defines the organisation's overall test objectives, view points regarding testing and the level of independence. It is important that the test policy is aligned with the overall business (quality) policy of the organisation. A test policy is necessary to attain a common view on testing between all stakeholders within an organisation. This common view is indispensable to align further test process improvement activities. The test policy should address both new development and maintenance testing activities. Within the test policy the objectives of test process improvement should be stated. These objectives should be translated into a set of key test performance indicators. The establishment of performance objectives and indicators provides clear direction and communication of expected and achieved levels of testing performance.

Based upon the test policy a test strategy will be defined. The test strategy covers the generic test requirements for an organisation or programme (one or more projects). The test strategy addresses the risks and presents a process for mitigating those risks in line with the testing policy. A typical test strategy will include a description of the test levels that are to be used, for example: unit, integration, system and acceptance test. For each test level the objectives, responsibilities and main tasks are defined. The test strategy serves as a starting point for the test projects. Test projects are set up according to the overall test strategy. When an overall test strategy is defined and followed, less overlap between the test levels is likely to occur leading to a more efficient test process.

Scope

The process area 'Test Policy and Goals' addresses the definition of a test policy and test strategy. Within the test strategy, test levels are identified. For each test level, goals, responsibilities and main tasks are defined. The process area 'Test Policy and Goals' covers the TMM *maturity goal* 'Develop Testing and Debugging Goals and Policies'.

Goals

Goal 1

A test policy, aligned with the business (quality) policy, is defined and agreed upon.

Goal 2 A test strategy is defined and deployed, identifying the test levels including goals, responsibilities and main tasks for each test level.

Goal 3 A set of test process performance indicators is defined and deployed.

Common features

Commitment to perform

Policy 1 A documented and approved business (quality) policy exists.

1 The business (quality) policy typically specifies:

- A mission statement
- User and business needs regarding the products
- Business drivers
- Main focus (goals) of quality program
- Responsibilities regarding quality (improvement)
- Starting points regarding the quality approach

Ability to perform

Responsibility 1 A group with the authority and knowledge is designated to be responsible for defining a test policy and test strategy.

1 The group consists of all stakeholders

- Resource management
- Business management
- Quality management
- Project management
- Test management
- Test engineers

2 The group develops, documents, distributes, and supports procedures, goals and policies for testing.

Activities performed

Activity 1 A test policy is defined and documented.

1 The test policy typically includes:

- A definition of testing
- A definition of debugging, to allow a clear distinction with testing
- Basic view points regarding testing and the testing profession
- The objectives of testing
- Quality levels to be achieved
- The level of independence of the test organization
- High level test process definition
- The responsibilities of the test manager
- The organisational approach to and objectives of test process improvement

Examples of test process improvement objectives are:

- Higher number of defects found
- Increased visibility
- Higher level of test coverage
- Higher level of product quality
- Increased predictability
- Decreased test effort / cost
- Shorter test execution throughput time
- Early defect detection

2 The test policy is aligned with the business (quality) policy

3 The test policy is reviewed by the stakeholders

Activity 2

A test strategy is defined and documented.

1 The test strategy typically contains:

- ❑ The overall test model (V-model, incremental model)
- ❑ The identified test levels (e.g. unit, integration, system and acceptance test)
- ❑ The goals, responsibilities and main tasks at each test level

Examples of test goals at various test levels are:

For unit testing

- Verifying that the unit operates as specified in the unit design
- A certain level of code coverage is achieved

For integration testing

- Verifying that the units operate as specified in the global design
- Verifying that the interfaces operate as specified in the interface specification

For system testing

- Verifying that the system operates as specified in the interface requirements specification

For acceptance testing

- Verifying that the system satisfies acceptance criteria
- Validating whether the system is 'fit for use'

- ❑ The test case design techniques to be used
- ❑ The test completion criteria
- ❑ Any standard that must be complied with
- ❑ The environment in which the tests will be executed
- ❑ The approach to automation

2 Unit test activities are clearly separated from debugging activities

3 The test strategy is aligned with the test policy

4 The test strategy is reviewed by the stakeholders

Note that the test strategy will serve as a starting point for the test projects. However, each project can tailor the general strategy to its needs. Non-compliances shall be clearly documented.

Activity 3

Test process performance indicators are defined and documented.

- 1 The performance indicators are aligned with the test policy and objectives for test process improvement

Examples of test process performance indicators are:

- Test effort and cost
- Test throughput time
- Number of defects found
- Defect detection percentage
- Test maturity level

Activity 4

Test process performance indicators are deployed.

- 1 The performance indicators are tracked on a periodic basis
- 2 The performance indicators are distributed to the stakeholders

Directing implementation

Stakeholders 1

The test policy and test strategy are distributed to the stakeholders.

Various mechanisms can be used to distribute the policy and test strategy. It can be done by means of documenting them in a handbook, posters on the wall and/or by means of making these issues part of the departmental introduction program

Verifying implementation

Configuration mgt. 1

The documented test policy and test strategy are managed and controlled using configuration management practices.

Examples of configuration management include version control, change history and control, status identification and usage of CM-tooling for storage.

Adherence 1

The quality assurance group reviews and/or audits the test policy and goals activities and work products.

- 1 Results are reported to:
 - Resource management
 - Business management
 - Test management
- 2 At a minimum, the reviews and/or audits verify:
 - The test policy is reflected in test plans
 - The test strategy is reflected in test plans
 - The test professionals are familiar with the test policy and test strategy
 - Test process performance indicators are defined
 - Test process performance indicators are tracked and results are distributed to the stakeholders

Review 1

The activities for test policy and goals are reviewed with management on a periodic basis and event driven basis.

- 1 Issues that are typically addressed are:
 - ❑ The test policy
 - ❑ The test strategy
 - ❑ Adherence by projects
 - ❑ Test process performance indicators
- 2 Performance indicators are reviewed to determine whether the objectives for test process improvement are being met
- 3 Review related action items are assigned, reviewed and tracked to closure
- 4 A summary report is prepared and distributed to the affected groups and individuals

Recommended Literature

- Austin C. (1999), When it's a Question of Policy..., in: *Professional Tester*, December 1999
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Test Planning

Introduction

The *purpose* of 'Test Planning' is defining a committed test approach, based on the test strategy, and to establish well-founded plans for performing and managing the test. Planning is essential for a process that is to be repeatable defined and managed.

After confirmation of the test assignment, a general study is made of the system to be tested, the project, the functional and quality requirements, and the organisation of the development process. As part of test planning, the test approach is defined by means of a risk assessment. Depending on the risks, it is decided which requirements of the system will be tested, and in what depth. For it is impossible to test the entire system, as test techniques providing 100% coverage exists only in theory. Moreover, no single company would be willing to afford the resources required for this purpose. The objective is to provide the best possible degree of coverage in the right place. Such matters are, of course, agreed specifically with the stakeholders. Testers should not take these decisions themselves. The test plan will either confirm, or explain non-compliance, with the test strategy. Within test planning, the test organisation is also set up, the test deliverables that are to be provided are identified, and aspects relating to infrastructure and management are defined. In addition, risks regarding the test project are identified. Finally, the test plan is prepared and agreed upon.

Scope

The process area 'Test Planning' addresses the establishment of thorough test plans, the accompanying techniques for risk analysis and defining the test approach. It also deals with test effort and cost estimation. Basic planning tools are evaluated and applied. At level 2 a test plan typically addresses one specific test level (phase). The process area 'Test Planning' covers the TMM *maturity goal* 'Initiate a Test Planning Process'.

Goals

Goal 1	A project's test approach is defined and agreed upon, and has used the system requirements as a major input
Goal 2	Test project activities and commitments are planned and documented.
Goal 3	Well-founded estimates are made for use in planning and monitoring the test project.
Goal 4	The test policy and test strategy are reflected in the established test plans.

Common features

Commitment to perform

Policy 1	The projects follow a documented organisational policy for test planning. The policy typically specifies: 1 Each test project defines a test plan that includes a test approach and the accompanying effort and estimates
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- 2 The project's test approach is derived from the test strategy
- 3 A test plan shall be defined using a standard procedure and a template
- 4 The requirements are used as a basis for test planning activities
- 5 The test project's commitments are negotiated with between:
 - Business management
 - Project management
 - Test management
 - Resource management
- 6 Involvement of other affected groups in the test activities is negotiated with these groups
- 7 Affected groups review the test project's:
 - Approach
 - Effort and cost estimates
 - Schedules
 - Risks
 - Other commitments
- 8 Management reviews all test project commitments made to groups external to the organisation
- 9 The project's test plan is managed and controlled

Ability to perform

Resources 1

A documented and approved assignment exists for the test project.

- 1 The assignment typically covers:
 - The sponsor
 - The identification of the test team
 - Goals and objectives
 - Release criteria
 - The items and features to be tested
 - Type of testing to be done
 - Imposed standards
 - Cost and schedule constraints
 - Resource constraints
 - Starting points
- 2 The assignment is reviewed by:
 - Test management
 - Other affected groups

Resources 2

Adequate resources and funding are provided for the test planning activities.

- 1 Adequate time is provided to test management to perform the test planning activities
- 2 Experienced individuals, who have expertise in the application domain of the test object and those who have expertise on the

development process are available to support the development of the test plan

3 Tools to support the test planning activities are available

Examples of tools are:

- Project planning and scheduling tools
- Estimation tools
- Tools to support the risk analysis process

Responsibility 1

A group with the authority and knowledge is designated to be responsible for defining the test planning process.

1 The group consists of all stakeholders

- Resource management
- Business management
- Quality management
- Project management
- Test management
- Test engineers

2 The group develops, documents, distributes, and supports procedures, goals and policies for test planning

Responsibility 2

A test manager is designated to be responsible for negotiating commitments and developing the test plan.

1 The test manager, directly or by delegation, co-ordinates the project's test planning process.

Training 1

Test management, and other individuals or groups involved in test planning are trained in test planning and the accompanying procedures and techniques.

1 The test planning training typically consists of the following elements:

- Structured testing
- Planning principles
- Test strategy
- Risk assessment and test approach
- Test plan aspects and standards
- Test organisation
- Test monitoring and control
- Test effort and cost estimation
- Introduction on test design techniques

Process 1

A procedure (including a template) for test planning is specified and documented.

1 The procedure states that test planning should be aligned with the test strategy

2 The procedure and template address all levels of testing

3 The procedure typically consists of the following tasks for high level testing (Pol *et al*, 2002):

- Studying the test assignment

- ❑ General review and study of the available system and project documentation
 - ❑ Establishing the test basis
 - ❑ Defining a test approach
 - ❑ Setting up the organisation
 - ❑ Specifying test deliverables
 - ❑ Specifying the infrastructure
 - ❑ Organising management and control
 - ❑ Test project risk analysis
 - ❑ Defining test estimation and schedules
 - ❑ Drawing up test plan.
 - ❑ Approving and reviewing the test plan and its commitments
- 4 The procedure typically consists of the following tasks for low level testing (BS 7925-2, 1998), (IEEE 1008, 1987):
- ❑ Specify the techniques and their rationale
 - ❑ Specifying test completion criteria
 - ❑ Specify the degree of independence
 - ❑ Specify the integration approach (e.g. top-down / bottom-up)
 - ❑ Specify the test environment (hardware and software)
 - ❑ Specify (reference) the test process
 - ❑ Specify the testing activities
 - ❑ Specify test schedule

Note the integration and component test plan may also be part of the overall project plan.

- 5 A test plan (especially for high level testing) template typically covers (IEEE 829, 1994):
- ❑ An overall identification & introduction
 - ❑ Test items (the test object and the accompanying documentation)
 - ❑ Features to be tested
 - ❑ Features not to be tested
 - ❑ Test approach
 - ❑ Entry and exit criteria for the test levels
 - ❑ Pass/fail criteria
 - ❑ Test deliverables
 - ❑ Environmental needs
 - ❑ Organisation (staffing and training)
 - ❑ Tasks and schedule
 - ❑ Test project risks
 - ❑ Estimates of the test project's efforts and costs

Process 2

Techniques and a procedure are defined and documented for risk analysis and test approach determination.

- 1 The projects' test approach is based on the overall test strategy. In case of non-compliances, these shall be explicitly explained in the test plan.
- 2 The test approach is based on a risk assessment regarding the requirements. This means assessing the risks of the consequences of defects, undetected prior to operation and occurring during operation. Because of the complexity of the matter, it is impossible to assess such risks with complete objectivity and in detail: it is a high level assessment. It is therefore important for the risk assessment not to be carried out

by test management alone. If possible, a large number of stakeholders should contribute: customer, user, business, development team, operations, customer support, accountants, IT auditors and so on.

- 3 The risk assessment is based on two elements:
 - ❑ The probability of a defect occurring in a certain system component¹
 - ❑ The consequences if a defect occurs in a certain system component
- 5 The identified list of system components is derived from the documented system requirements
- 5 The object of defining the test approach is to ensure that the test is organised in such a way that testing has clear priorities and targets:
 - ❑ The most important defects will be detected
 - ❑ Defects will be detected at an early stage of the testing process
 - ❑ The defects requiring most rework time will be found first
 - ❑ Accurate quality recommendations can be given at early stage and on completion

Process 3

A procedure for test estimation is specified and documented.

- 1 Test estimates are typically based on three elements:
 - ❑ Size and complexity of the product to be tested
 - ❑ The test approach
 - ❑ Productivity of the test team
- 2 Test estimation can be done either top-down (formula based), using for example
 - ❑ Function points
 - ❑ Test points (Pol *et al*, 2002)
 - ❑ Software development data (e.g. 40% for new software)

or bottom-up based on a detailed work breakdown structure of all test activities.

Activities performed

Activity 1

A test plan is defined according a documented procedure.

- 1 The test plan is based on and conforms to:
 - ❑ The approved test assignment
 - ❑ The product requirements
 - ❑ The test policy and strategy
- 2 The test plan is documented, based on the test plan standard
- 3 The test plan is reviewed by management and other stakeholders

¹ The term system component is used as a generic term. One could also use the term subsystem, feature, group of requirements, etc. depending on the terminology used with the organisation.

4 The test plan is managed and controlled

Activity 2

Risk analysis and test approach determination are carried out according to a documented technique and procedure.

- 1 A risk analysis is done using input from the various stakeholders
- 3 The test approach is reviewed by all stakeholders
- 4 The test approach is documented in the test plan, including its rationale

Activity 3

A test life cycle with predefined stages of manageable size is identified and defined in the test plan.

- 1 The test life cycle is aligned with the test approach
- 2 The main stages of the test life cycle typically are:
 - Planning
 - Preparation
 - Execution
- 3 Milestones are identified for each test stage

Activity 4

Test project commitments made to groups external to the organisation are explicitly reviewed by management.

Activity 5

Estimates for test effort and costs are established according to a documented procedure.

- 1 A test estimation typically includes:
 - Number of hours
 - Throughput time
 - Number of test engineers needed
 - Other resources such as test environments and tooling
- 2 Assumptions made in deriving the estimates are documented, reviewed, and agreed upon
- 3 Test estimation data is recorded; it includes the associated information needed to reconstruct the estimates
- 4 The test estimates are reviewed and agrees upon

Activity 6

The risks associated with the test project are identified, assessed and documented.

- 1 Test project risks are identified in a risk meeting involving the stakeholders
- 2 The test project risks are prioritised based on their potential impact to the test project
- 3 Contingencies for the test project risks are identified

Directing implementation

Configuration mgt. 1

The documented test plan is managed and controlled using configuration management guidelines.

Examples of configuration management include version control, change history and control, status identification and usage of CM-tooling for storage

Measurement 1

Goal-oriented measurements are made and used to determine the status of the test planning activities.

- 1 Measurement are based upon the goals of the test planning process area and upon the organisational policy
- 2 Measurements focus the level of deployment, and the effectiveness and efficiency of the test planning activities

Examples of measurements are:

- Percentage of test plans established according to procedure and template
- Percentage of test plans that have a full risk analysis and test approach
- Percentage of test plans formally reviewed and approved by management
- Test planning effort
- Test estimation accuracy

Verifying implementation

Adherence 1

The quality assurance group reviews and/or audits the test planning activities and work products .

- 1 The results are reported to:
 - Test management
 - Project management
 - Resource management
- 2 At a minimum, the reviews and/or audits verify:
 - Compliance to the test strategy
 - Compliance to the standards (procedures and templates)
 - The test approach and risk analysis
 - The test estimation
 - The activities for reviewing and making test commitments

Review 1

The activities for test planning are reviewed with management on a periodic basis and event driven basis.

- 1 Issues that are typically addressed are:
 - The test approaches applied
 - The technical, cost, staffing and schedule performance
 - Conflicts and issues not resolvable at lower levels
 - Test project risks
- 2 Review related action items are assigned, reviewed and tracked to closure

- 3 A summary report of the management review is prepared and distributed to the affected groups

Recommended literature

- BS 7925-2 (1998), *Standard for Software Component Testing*, British Standards Institution
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- Veenendaal, E.P.W.M. van (2002), *The Testing Practitioner* (Part 2 'Test and Risk Management'), UTN Publishing, 's Hertogenbosch, The Netherlands, ISBN 90-72194-65-9

Test Techniques and Methods

Introduction

The *purpose* of 'Test Techniques and Methods' is to improve test process capability during test design and execution by applying basic test techniques and methods and standard procedures at multiple test levels.

Well-founded testing means that test design techniques and methods are applied, supported (if possible and beneficial) by tools. Test design techniques are used to derive and select test cases from requirements and development documentation. A test case consists of the description of the starting situation (including the test input), the change process, and the expected result. The test cases are documented in a so-called test design specification. At a later stage, as more information becomes available on the actual implementation, the test designs are translated into test procedures. In a test procedure the specific test actions and checks are arranged in an executable sequence. The tests can subsequently be executed using these test procedures. The test design and execution follow the pre-defined test approach in the test plan.

During the test execution stage, incidents (defects) are found and test incident reports written. Incidents are be logged using an incident management system and thorough communication about the incidents with stakeholders is established. For incident management a basic incident classification scheme is established, and a basic incident repository is put into place.

Scope

The process area 'Test Techniques and Methods' addresses the application of test design techniques to derive the test cases and subsequently execute the tests based on structured test procedures at multiple test levels. It also addresses the supporting tools and incident management. The process area 'Test Techniques and Methods' covers the TMM *maturity goal* 'Institutionalize Basic Testing Techniques and Methods'.

Note that test techniques such as risk analysis, test approach determination, and reviews are not within the scope of this process area. These techniques are addressed in the process area to whom they provide support, e.g. test approach determination techniques are addressed as part of the 'Test Planning' process area.

Goals

- | | |
|--------|--|
| Goal 1 | Test design techniques are evaluated, recommended and consistently applied throughout the test design stage. |
| Goal 2 | Test execution is performed using documented test procedures. |
| Goal 3 | Incidents found during testing are managed and reported using a incident classification scheme. |
| Goal 4 | Supporting tools are evaluated, recommended and consistently applied where possible for test design, test execution and incident management. |

Common features

Commitment to perform

Policy 1

The projects follow a documented organisational policy for test design and execution.

The policy typically specifies:

- 1 A set of suitable test design techniques will be identified, defined and consistently applied throughout the organisation
- 2 Test designs techniques will be supported by appropriate templates
- 3 Test execution will be done using formal test procedures
- 4 Test techniques and methods are applied at unit, integration, system and acceptance test level
- 5 Supporting tools will be evaluated, recommended and applied, where possible and beneficial

Policy 2

The projects follow a documented organisational policy for incident management.

The policy typically specifies:

- 1 Incidents are documented and reported according to a documented procedure
- 2 The status of the incidents will be managed and tracked
- 3 Reported incidents are evaluated, classified and processed according to a documented procedure. A basic incident classification scheme is established.
- 4 Supporting tools will be evaluated, recommended and applied, where possible and beneficial. A basic incident repository is put into place.

Ability to perform

Resources 1

Adequate resources and funding is provided to the test engineers to perform formal test design and test execution.

- 1 The test design and execution activities are explicitly scheduled as part of the (test) project schedule at multiple test levels.

Resources 2

Adequate resources and funding are provided for evaluating, implementing and maintaining tools to support test design, test execution and incident management.

- 1 Individuals, who have test tool expertise, are available to support the evaluation and implementation activities
- 2 Adequate time is provided to to set up a tool evaluation and/or implementation project
- 3 Adequate time and budget is available for maintaining the supporting tools

Examples of tools that can support test design and execution are:

- Test data generator

- Capture and playback
- Coverage analysis
- Comparator
- Dynamic analysis

Responsibility 1

A group with the authority and knowledge is designated to be responsible for defining the test techniques and methods process.

- 1 The group consists of all stakeholders
 - ❑ Resource management
 - ❑ Quality management
 - ❑ Project management
 - ❑ Test management
 - ❑ Test engineers
- 2 The group develops, documents, distributes, and supports procedures, goals and policies for test techniques and methods

Responsibility 2

A group (or person) is designated to be responsible for the evaluation, implementation and maintenance of supporting test tools.

Training 1

Test engineers (and software engineers) are trained in test design techniques and methods, and test execution.

- 1 The training typically consists of the following elements:
 - ❑ Basic knowledge of formal test design techniques
 - ❑ Test design activities
 - ❑ Application of test design techniques; designing test cases and subsequently documenting test procedures
 - ❑ Test execution activities
 - ❑ Test incident reporting and procedure

Training 2

Test engineers (and software engineers) involved in the application of supporting tools are trained.

- 1 The training typically consists, amongst others of the following elements:
 - ❑ Basic knowledge of different types of test tools
 - ❑ Insight in the cost, pitfalls, benefits and consequences of automated testing
 - ❑ Data driven testing and automated scripting techniques
 - ❑ Test tool evaluation process
 - ❑ Test tool implementation process

Process 1

A documented set of test design techniques (including template) is available for the different test levels.

- 1 Appropriate test design techniques are evaluated, selected and documented for on the identified test levels

It is recommended to include both formal and informal test design techniques in the evaluation and selection process.

Test design techniques are selected based on the risk level of the systems being developed, the project's software process and documentation, the skills of the test engineers, availability of

training, contractual requirements, ease of use, and support services.

Test design techniques are divided into white-box and black-box techniques. White-box techniques are based on an analysis of the internal structure of the unit. Black-box techniques are based on an analysis of the unit without reference to its internal workings (BS 7925-1, 1997).

Examples of white box test design techniques are:

- Statement coverage
- Decision coverage
- Condition coverage
- Data-flow test
- Linear Code Sequence And Jump (LCSAJ)

Examples of black box test design techniques are:

- Equivalence partitioning
- Boundary value Analysis
- Cause effect graphing
- State transition testing

- 2 More than one test design techniques should be available for each test level in order to effectuate the test approach and differentiate in test coverage
- 3 The test design template typically covers (IEEE 829, 1994):
 - Test design specification identifier
 - Features to be tested
 - Approach refinements
 - Test case specification
 - Test items
 - Input specifications
 - Output specifications
 - Environmental needs
 - Special procedural requirements
 - Intercase dependencies
 - Feature pass/fail criteria

Process 2

A procedure for test execution is specified and documented.

- 1 The procedure typically consists of the following tasks (Pol *et al*, 2002):
 - Intake test object (confidence test)
 - Setting up initial test database
 - Executing (re)tests
 - Checking and assessing the test results
 - Test reporting

Process 3

A procedure for test incident management is specified and documented.

- 1 The procedure typically consists of the following steps (IEEE 1044, 1993)
 - Recognition
 - Investigation

- Action
- Disposition

The three administrative activities applied to each sequential step are as follows:

- Recording
- Classifying
- Identifying impact

2 A test incident report typically consists of the following elements (IEEE 829, 1994):

- Test incident report identifier
- Summary
- Incident description
This should include the following items inputs, expected outcome, anomalies, date and time, procedure step, environments, attempts to repeat, testers, observers
- Impact

Process 4

Supporting tools for test design, test execution and incident management are evaluated, recommended and implemented.

1 The evaluation, selection and implementation of the test tools consists of the following activities (Fewster and Graham, 1999)

- Evaluation of the current situation
- Decision about what type of tool is needed
- Decision about requirements and acceptance criteria for the tool
- Understanding any constraints
- Presentation of the business case for the tool
- Investigation into the available tools and suppliers
- Selection of the tool
- Setting up the implementation team
- Pilot project and evaluation
- Phased installation and evaluation

2 The results of the evaluation and selection process are documented

3 Selected supporting test tools are specified and documented

Activities performed

Activity 1

Test cases are specified according to a documented set of test design techniques.

- 1 The most appropriate test design techniques are selected according to the test strategy and test approach
- 2 Test designs and test procedures are documented and reviewed
- 3 Test designs and test procedure are changed accordingly whenever the requirements, the design or code being tested change

Activity 2

Test execution is performed using documented test procedures and according to a documented procedure.

Activity 3

Selected supporting tools are applied for test design and test execution.

Activity 4

Test incidents are reported and managed according to a documented procedure.

- 1 Test incidents identified during testing are documented and tracked to closure
- 2 Test incidents are classified using a basic defect classification scheme
- 3 Test incidents are documented and used as the basis for determining whether the system satisfies its requirements
- 4 Test incidents are managed and controlled

Activity 5

Selected supporting tools are applied for incident management.

- 1 A basic incident repository is put into place

Directing implementation

Configuration mgt. 1

The documented test designs and test scripts are managed and controlled using configuration management guidelines.

Examples of configuration management include version control, change history and control, status identification and usage of CM-tooling for storage

Measurement 1

Goal-oriented measurements are made and used to determine the status of the test techniques and methods activities.

- 1 Measurement are based upon the goals of the test techniques and methods process area and upon the organisational policy
- 2 Measurements focus the level of deployment, and the effectiveness and efficiency of the test design and execution activities

Examples of measurements include:

- Number of test designs established using test design techniques (black-box, white-box)
- Time spent per test design
- Incident reports by severity
- Incident throughput time

Verifying implementation

Adherence 1

The quality assurance group reviews and/or audits the test design and execution activities and work products.

- 1 The results are reported to:
 - Test management
 - Resource management
- 2 At a minimum, the reviews and/or audits verify:

- ❑ Selected test design techniques are applied
- ❑ The procedure for test execution is applied
- ❑ The usage of templates
- ❑ The procedure for reporting and managing test incidents is applied
- ❑ The training received by the test engineers

Review 1

The activities for test design techniques and methods and test execution are reviewed with management on a periodic basis and event driven basis.

- 1 Issues that are typically addressed are:
 - ❑ The quality of the test cases derived
 - ❑ Conflicts and issues not resolvable on lower levels
 - ❑ Supporting tools
 - ❑ Incident management
- 2 Review related action items are assigned, reviewed and tracked to closure
- 3 A summary report is prepared and distributed to the affected groups

Recommended literature

- Beizer, B. (1990), *Software Testing Techniques (second edition)*, Thomson Computer Press, Boston, ISBN 1850328803
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- Veenendaal, E.P.W.M. van (2002), *The Testing Practitioner* (Chapters 12 'Testing Techniques', 13 'Exploratory Testing', 16 'The Bug Reporting Process' and 20 'Tool evaluation and selection'), UTN Publishing, 's Hertogenbosch, The Netherlands, ISBN 90-72194-65-9
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Test Environment

Introduction

The *purpose* of 'Test Environment' is to establish and maintain an integrated software and hardware environment in which it is possible to execute tests in a manageable and repeatable way.

A test environment is needed to obtain test results under conditions which are as close as possible to the 'real-life' situation, especially for higher level testing. Furthermore, at any test level the reproducibility of test results should not be endangered by undesired or unknown changes in the test environment.

Specification of the test environment is carried out early in test projects. The specifications is reviewed to ensure their correctness, suitability, feasibility and its representativeness towards the 'real-life' environment. Early specification has the advantage that there is more time to develop any special simulators, stubs or drivers.

Availability of a test environment encompasses a number of issues which need to be dealt with: Is it necessary for testing to have an environment per test level? A separate test environment can be very expensive. It must therefore be decided how to use them as efficiently as possible. Maybe it is possible to have the same environment shared between testers and developers. But then strict management and control is necessary as both testing and development activities are done in the same environment. When poorly managed, this situation can cause many problems ranging from conflicting reservations to people finding the environment in an unknown or undesired state when starting one's activities. Reconfiguring an environment to reach a known initial state can take days, depending on its size and complexity. Another approach for test environments is to let them 'grow' in parallel with the test levels. For example, one can decide to test a certain requirement at a higher test level to prevent the development of stubs that are needed to simulate specific subsystems that *are* available at higher levels.

Throughout the project the test environment is subject to changes due to for example hardware changes, incremental test environment development and changes in the test object. Thorough (configuration) management on the test environment is needed to cope with these changes.

Scope

The process area 'Test Environment' addresses all activities for specifying, managing (including configuration management), and ensuring availability of an adequate test environment for both lower and higher test levels.

Goals

- | | |
|---------------|--|
| Goal 1 | Test environments are specified early, and their availability is ensured on- time in projects. |
| Goal 2 | For higher test levels the test environment is as much as possible "real-life". |
| Goal 3 | Test environments are managed and controlled according to documented procedures. |

Common features

Commitment to perform

Policy 1

The projects follow a documented organisational policy for specifying, managing and controlling test environments.

This policy typically specifies:

- 1 Specification, management and control of test environments is performed according to documented procedures
- 2 Responsibilities with respect to test environments are assigned
- 3 Test environment specification is part of the test planning process
- 4 Higher levels tests will be carried out in an environment that is as much as possible 'real-life'
- 5 Lower level tests, e.g. unit and integration testing, shall apply stubs and drivers for testing, if possible supported by tools

Ability to perform

Resources 1

Adequate personnel, funding and facilities are provided for specifying, managing and controlling test environments.

- 1 Experienced individuals, who have expertise and technical knowledge are available to support the specification and implementation of the test environment
- 2 Configuration management tooling is available for managing (changes to) the test environment
- 3 Adequate time and resources are provided to the test project to implement an adequate test environment
- 4 Adequate time and resources are provided to engineers to develop stubs and drivers needed for lower level testing

Responsibility 1

A group with the authority and knowledge is designated to be responsible for defining the test environment process.

- 1 The group consists of all stakeholders
 - Resource management
 - Quality management
 - Project management
 - Test management
 - Test engineers
- 2 The group develops, documents, distributes, and supports procedures, goals and policies for test environment

Responsibility 2

A group (or person) is designated to be responsible for management and control of the test environment.

- 1 The responsibility typically covers (Pol *et al*, 2002):

- ❑ Specifying and implementing test environments
- ❑ Carrying out market surveys to evaluate commercially available test tools, e.g. simulators
- ❑ Configuration management of the test environment
- ❑ Solving technical problems related to the test environment
- ❑ Ensuring that tests are reproducible with respect to the test environment
- ❑ Support and consultancy on test environment-related procedures and technical issues
- ❑ Ensuring the availability of the test environment

Training 1

The (test) engineers involved in managing, controlling and using the test environment are trained in the technical aspects of the test environment and the accompanying procedures.

- 1 The training typically consists of the following elements:
 - ❑ Using the test environment
 - ❑ Operating the test environment
 - ❑ Test environment procedures
- 2 Test engineers using the test environment are trained in the relevant aspects of the test environment and the accompanying procedures

Process 1

The test planning procedure addresses the specification, and management and control of the test environment.

- 1 The test planning procedure typically consists of the following tasks:
 - ❑ Defining test environment requirements
 - ❑ Defining a high level specification of test environment
 - ❑ Identifying risks of non-conformance to requirements
 - ❑ Defining responsibilities
 - ❑ Defining test environment procedures
 - ❑ Estimating of costs, effort and schedule

Process 2

Procedures for managing and controlling the test environment are specified and documented.

- 1 The procedures typically address the following issues:
 - ❑ Back-up and restore
 - ❑ Change management
 - ❑ Configuration management

Note: for configuration management it is important that the relationship between the test object and test environment is part of this process. For every major change in the test object the impact on the test environment needs to be determined

Process 3

A procedure for ensuring the availability of the test environment is specified and documented.

- 1 The procedure typically consists of the following parts:
 - ❑ Making reservations for the test environment
 - ❑ Aligning time slots between testing and development

- ❑ Shutting-down the environment correctly after usage (e.g. information on how to update the environment's change log, bring it back in a known state and removing test files)

Activities performed

Activity 1

The test environment is specified early in the project according to a documented procedure.

- 1 The test environment specification typically includes:
 - ❑ Hardware components
 - ❑ Network components
 - ❑ Software components (e.g. operating systems, firmware)
 - ❑ Simulators, stubs and drivers
 - ❑ Identification of supporting documentation (e.g. user guides, technical guides, installation manuals)
 - ❑ Tools to support the development of stubs and drivers
- 2 The test environment specification is reviewed by:
 - ❑ Project management
 - ❑ Technical experts
 - ❑ Other affected groups
- 3 The specification is typically reviewed on:
 - ❑ Technical correctness
 - ❑ Technical suitability of the environment for test purposes
 - ❑ 'Real-life' environment representativeness
 - ❑ Technical and economical feasibility
 - ❑ Feasibility of on-time delivery

Activity 2

Management and control of the test environment is carried out according to documented procedures.

Activity 3

The availability and usage of the test environment by testing and development is coordinated according to a documented procedure.

Activity 4

Test environment incidents are reported according to a documented procedure.

- 1 Test environment incidents identified are documented and tracked to closure
- 2 Test environment incidents are managed and controlled

Directing implementation

Measurement 1

Goal-oriented measurements are made and used to determine the status of the test environment activities.

- 1 Measurement are based upon the goals of the test environment process area and upon the organisational policy
- 2 Measurements focus the level of deployment, and the effectiveness and efficiency of the test environment activities

Examples of measurements are:

- Percentages of test plans that include a test environment specification
- Number of conflicting environment reservations
- Effort needed for maintenance, repair and updates
- Number of test case failures due to the test environment
- Average down-time of the test environment
- Number of test environment incidents reported
- Percentage of test environments available on time and according to specification

Verifying implementation

Adherence 1

The quality assurance group reviews and/or audits the activities and work products for test environment.

- 1 Results are reported to:
 - Test management
 - Project management
 - Resource management
- 2 At a minimum, the reviews and/or audits verify that:
 - Test environments specification is carried out according to the documented procedure
 - The test environment is as much as possible 'real-life'
 - The availability of the test environment is at an adequate level and carried out according to the documented procedure
 - Test environments management and control is carried out according to the documented procedures

Review 1

The activities for test environment are reviewed with management on a periodic basis and event driven basis.

- 1 Issues typically addressed are:
 - Test environment adequacy
 - The technical, cost and staffing performance
 - Conflicts and issues not resolvable on lower levels
- 2 Review related action items are assigned, reviewed and tracked to closure
- 3 A summary report is prepared and distributed to the affected groups

Recommended literature

- IEEE (Institute of Electrical and Electronic Engineers) (1994), *IEEE 829 Standard for Software Test Documentation*, IEEE Standards Board, New York
- Pol. M., R.A.P. Teunissen and E.P.W.M. van Veenendaal (2002), *Software Testing; A Guide to the TMap approach* (chapters 8.2.7 'Definition of infrastructure', 8.3.4 'Specification of infrastructure', 19 'Test functions' and 26 'Test Environments'), Addison-Wesley, ISBN 0-201-74571-2