QUALITY EFFECTS OF TEST MATURITY MODEL ON SOFTWARE COMPANIES

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QUALITY EFFECTS OF TEST MATURITY MODEL ON SOFTWARE COMPANIES

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Submitted by **Başak ZÜLFİKAR**

Approval of the Graduate School of Natural and Applied Sciences, Çankaya University.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT

QUALITY EFFECTS OF TEST MATURITY MODEL ON SOFTWARE COMPANIES

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Hereby in this thesis study, Test Maturity Model is examined. The rules and constraints are described the model expressed as TMMi in the literature. Furthermore, assessment criteria set is developed to apply this published model on software companies. These criteria are determined from process areas and work areas which are defined for the testing process by test maturity model. A study group has been established by the companies known as the active in the software industry. Assessment criteria applied to these companies extracted the thesis. The created assessment criteria of the thesis applied to these companies and the test maturity levels of the companies are determined. The criteria need to be provided are explained in order to have higher TMMi levels for companies. Moreover, the project outputs of the companies are gathered. Various equations are created as quality metrics from these outputs to examine the quality of products. Quality metrics of each company are analyzed. It is investigated the relationship between testing maturity model and product quality by the analyzed quality metrics.

Keywords: Test Maturity Model, TMMi, Quality, Quality Metric, Assessment of Test Maturity Model

ÖZ

TEST OLGUNLUK MODELİNİN YAZILIM FİRMALARI ÜZERİNDEKİ KALİTE ETKİSİ

ZÜLFIKAR, Başak
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Bu tez kapsamında test olgunluk modeli incelenmiştir. Literatürde TMMi olarak ifade edilen bu modelin hangi kurallara sahip olduğu ve bu kuralların hangi kısıtlar doğrultusunda üretildiği açıklanmıştır. Bunun ötesinde, yayınlanmış bu modelin yazılım firmaları üzerinde uygulanabilir hale gelmesi için değerlendirme kriterleri oluşturulmuştur. Bu kriterler, test olgunluk modelinin test süreci için tanımladığı çalışma süreç alanlarından analiz edilerek çıkarılmıştır. Yazılım sektöründe aktif olarak bilinen firmalardan bir çalışma grubu oluşturulmuştur. Tez bünyesinde oluşturulan değerlendirme kriterleri bu firmalara uygulanmış ve firmaların test olgunluk seviyelerinin neler olduğu belirlenmiştir. Bir üst TMMi seviyesine sahip olabilmeleri için tamamlanması gereken kriterler açıklanmıştır. Ayrıca, firmalardan yazılım projelerinden elde ettikleri çıktılar alınmıştır. Bu çıktılardan ürün kalitesini incelemek için çeşitli denklemler kalite metriği olarak yaratılmıştır. Her firmanın kalite metrikleri analiz edilmiştir. Analiz edilen bu kalite metrikleriyle, test olgunluk modeli ve ürün kalitesi arasındaki ilişki incelenmiştir.

Anahtar Kelimeler: Test Olgunluk Modeli, TMMi, Kalite, Kalite Metrikleri, Test Olgunluk Modeli Değerlendirmesi

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LIST OF ABBREVIATIONS

TMMi	Test Maturity Model Integration
CMMi	Capability Maturity Model Integration
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ISTQB	International Software Testing Qualifications Board
SW	Software

CHAPTER 1

1 INTRODUCTION

1.1 Background

There are many software standards and maturity models for processes in the development life cycle. All of them are a common purpose, each step of the software product to decontaminate of the chaotic nature, progress and to improve continuously in a specified order. When looking at the history of the development of Software products, many models and standards are a set of experiences and needs appeared in based on the rules. Software development process models such as CMMI (CMM) and Spice models are aimed at the progress of standards both as software-as documentation. The main point of these objectives is the success of software projects. Until recently, the success of software projects was a subjective assessment, customer satisfaction, and quality products can be measured now. The success of a software project is directly proportional to the product quality and customer satisfaction.

The customer is most active in the test is process of all software processes. Because the customer evaluates the output of both the integration and acceptance testing on whole testing process as the main variables. For this reason, "quality and customer satisfaction" and "quality and testing" they have a direct relationship between each other. This is why the software testing process is now being given more cost within the project budget and test activities are started from the beginning of software development life cycle. Testing maturity model is a new model that explains about how he should handle the integration module testing process.

For the first time, this model was published by the Illinois Institute of Technology in 2012. When the model is defining testing maturity levels in the process, the process areas of the testing also includes a detailed study how they need to handle. The basis of the structure the TMMi is based from CMMi fully, it focuses on the testing process of the software projects. After beginning studies for Test Maturity Model by

TMMi Foundation Team in 2006, TMMi Framework is published in 2012. Very different test maturity model has been published after the TMM model. TMMi applied and usable model in the testing process for a lot of companies in terms of being is still the most popular. Of course, this is due to the prevalence of the CMM model is based on it.

While TMMi model is constructed, a lot of software testing and quality standards were examined and they are modeled in 5 levels after completing stage investigation. There are 5 levels of TMMi model; Level-1 Initial, Level-2 Managed, Level-3 Defined, Level-4 Measured and Level-5 Optimization.

The TMMi framework, defining stages and levels should take part in the testing process, does not explain how the TMMi assessment of a company is done. Hereby in the scope of this thesis, the analysis and implementation of various evaluation criteria on the basis of the TMMi model are targeted to practice the test maturity assessment of companies.

1.2 Objectives

The main purpose of this study is to investigate the TMMi Framework and to develop assessment criteria set as the TMMi framework explained. TMMi framework is a maturity model has been created for software test processes. The model that aims to bring a standard to the complex workflows in test stages, regulates the test process intrinsic to many software models within certain rules. TMMi assigns CMMi structure as an instance for itself. TMMi also consists of 5 levels such as CMMi.

Within this study firstly, it is going to be examined that TMMi Framework levels and which stages are included in these levels. Although TMMi Framework was published in 2012, it does not have any section about how to make the evaluation within the framework. TMMi explains the scope of testing maturity model, but does not publish any assessment criteria. Therefore, the assessment criteria of the TMMi model is

going to be composed based upon the TMMi framework. Composed criteria will be conducted by examining all the necessary materials and processes, as it is in the CMMi framework, rather than as a survey directed to the company.

The another focus of this thesis study is the application of TMMi assessment to the companies in the software industry. The levels of the company and phases that should be carried out in order to ensure a higher level of TMMi, will be examined in the results of the evaluation.

While evaluation criteria are directed for the analysis of test maturity level of the companies, the additional test and acceptance process variables of some of the projects in that company will be required. The main point of requesting variables is to establish a relationship between the quality of a software product developed according to TMMi levels. Quality metrics will be determined as expressed in several software standards and the purpose of this metrics is particularly for the measurement of the test process.

1.3 Organization of Thesis

In this study, test and quality concepts will be explained first. The significance of the quality and test within software lifecycle is located under Section-2.

TMMi, the main focus point of the thesis, will be described in Section-3. The information about what the TMMi is, why it is needed and how it is emerged can be accessed through Section-3. Besides, TMMİ which is developed on the basis of CMMi, its relation with the CMMi, and the points of their differentiation can be followed through Section-3.2. TMMi consists of 5 levels. All levels of TMMi and focused criteria at these levels, process areas and work areas are described in Section-3.3.

Section-4 is the heading describing the assessment criteria issued in the TMMi framework and how these criteria are composed. All of the information about which

evaluation criteria is the subject of which process area, and which process areas correspond to which TMM levels, is described in Section-4. Besides, evaluation rules are also included in this section.

Expected collection of values from the company that TMMi models will be evaluated, in which formulas those values are used, the purpose of those formulas, and the purpose of them as quality metrics for in this study, are all located under the Section-5.

The companies which TMMi assessments are examined can be found under Section-6. The information about succeeded process areas of companies is accessible through this section. The work needed to get to a higher TMMi level is described in sub-sections for each company.

The results of this thesis study can be found under Section-7.

CHAPTER 2

2 TEST AND QUALITY

Testing is an activity on software products which improving quality and product, identifying defects finding bugs and problems.
It can be seen from this definition that Test and Quality has a relation to SW process directly. The test process is the most important indicator to show the degree of the quality.

2.1 Test Process on Software Products

ISTQB defines Testing is that “The process consisting of all lifecycle activities, both static and dynamic, concerned with planning, preparation, and evaluation of software products and related work products to determine that they satisfy specified requirements, to demonstrate that they are fit for purpose and to detect defects.”

Software Testing is a process in development life cycle indicating that if a software is an inadequate quality and it is developed in accordance with customer's request.

Test phase, if to be described as practiced in a conventional manner, can be considered as the detection and notification of errors in the short term. However, the software testing today is a process of affecting all stages of the software development life cycle and evaluated in long-term goals.

The testing phase begins with the analysis of software project requirements and continues until the end of the acceptance or maintenance stage of the project.

There is a testing process corresponding to each software development process. This condition is described as V-Model [8]. V model explains software process as two parts for testing. These parts are Static Testing and Dynamic Testing. Static testing means verification and dynamic Testing means validation on the software project. V-model says that every development stage corresponds a specific test stage. The detail of V-Model can be seen in Figure 1 [20].

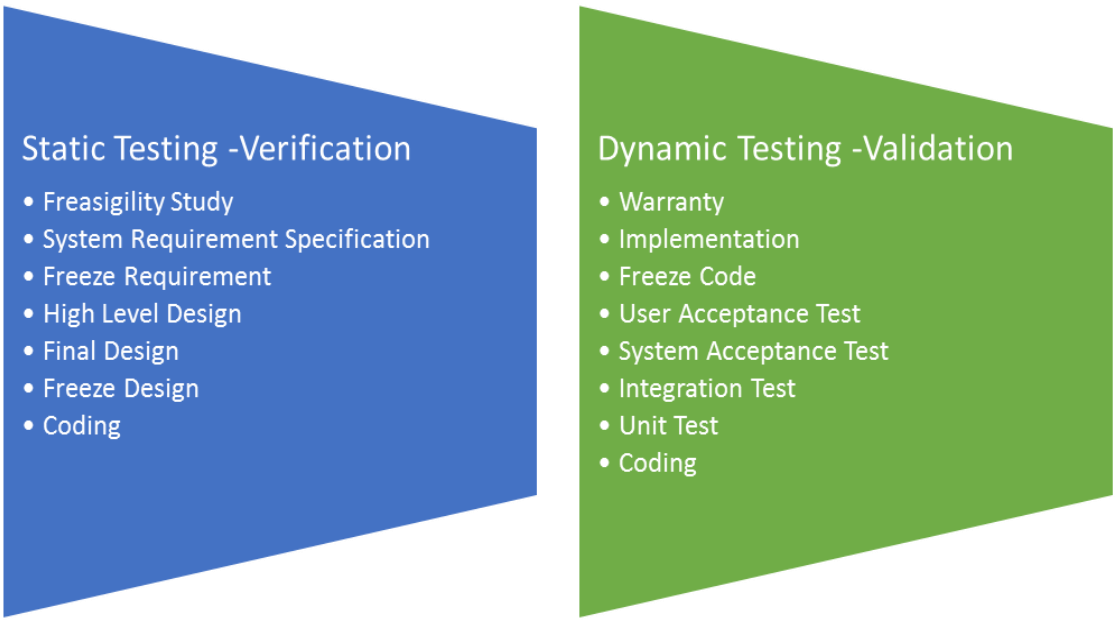

Figure 1

Software test concept mainly consists of test levels, tests types and testing techniques.

Test Levels: Unit Test, System Test, Integration Test, User Acceptance Test
Test Types: Functional Test, Performance Test, Structural Test, Regression Test,
Test Design Techniques: Black Box Test, White Box Test, Grey Box Test and Experience Based Test

- ➔ Black Box Test: Equivalence Class, Decision Table, Use Case Test, Work - Flow Test Case
- ➔ Experience Based Test: Ad-hoc Test, Exploratory Test

2.2 Quality on Software Products

Quality is that a characteristic of a product or service provided to a customer or an organization which has satisfied all of its stakeholders.
Today, software is a necessity in every industry and every organization has a need to use. In each industry, software is used as a product as well as services. Software quality is an element that shows the business success of these products and services.
What is software quality?
ISO9001-00 defines that the degree to which a set of inherent characteristic fulfills requirements [21]
The degree to which a system component or process meets specified requirement. With the different definition, the degree to which a system, component or process satisfied to customer or user needs or expectations.
Thus, quality is the most important element on SW project for the companies. There are a lot of answers for "Why is quality important for Software projects" question.

- ➔ Customer satisfaction and stakeholder satisfaction
- ➔ Sustainability for software products.
- ➔ Ensure the success of the company

There are quality metrics at each stage in software projects from proposal stage until the closing stages. Quality actively contributes defining the project plan, processes, methodologies, the structure of the documentation, and the risk plan at the beginning of each project. At every stage of the software development lifecycle (analysis,

design, development, testing, acceptance, maintenance, closing etc.) the quality level of projects is defined by the quality metric determined for that stage.

Software quality helps to see and manage stability and cost of the product (employees, price, time…etc.). It enables to make the right decision at critical times on the projects.

According to SWBOK (Software Engineering Body of Knowledge) Software quality has 3 main topics [8]:

- ➔ Software Quality Fundamentals
- ➔ Software quality Management Process
- ➔ Practical Considerations

On Figure 2 the details of the Software Quality Categories can be followed.

Figure 2

Firstly, the software engineers analyze customer requirements. Then they determine quality requirements which are related with functional or non-functional

requirements of customers. All processes associated with software quality. So system requirements, software requirements, design module, code, test documentation or reports produced as a result of quality analyses tasks. (SWBOK-11-3) [8]

On a software project, software processes, products and resources should be followed on a quality perspective. So to follow them, software quality management process is a need.
Some of the specific Software quality management process are defined on IEEE 122070-96 [12].

- ➔ Quality assurance process
- ➔ Verification process
- ➔ Validation Process
- ➔ Review Process
    - Managements reviews
    - Technical reviews
    - Inspections reviews
    - Audits

In this study, it is really important to convey the significance of quality in software projects. Particularly the testing phase as will be shown to have a direct relationship to the quality; software quality assurance, validation, and verification stages are considered in direct testing process.

Software quality measurement is another important item in the quality structure.
Practical measurements that will take place in this thesis study shows the quality ratio determined by some parameters of the developed software product. Whether the expected quality goals are achieved as well as evaluation of customer satisfaction is assessed by these methods.

When quality assurance engineer measures the quality of the software project, they use product features and term results as parameters. Then they create mathematical equations which applied to see quality metrics. They separate these metrics as categories and discussed.

For example, the number of the defects or number of functional requirements can be used as an equation to measure the product quality.

CHAPTER 3

3 What is Test Maturity Model Integrated? (TMMi)

TMMi, has been developed as a model in software design for test engineers, test managers and software quality professionals. TMMi is mainly focused on testing stage of software projects. TMMi TMMi acknowledges the testing stages as defined by ISTQB, and has created the modeling through it. TMMi reviews the quality of products through the entire testing phase [1].

Figure 3

3.1 *History*

TMMi has been created by TMMi Foundation Team as a framework and reference guide. Firstly, TMMi was developed as a model in 2006. Then, the first book of TMMi Foundation was published on 2012 by Illinois Technology Institute.
TMMi, takes CMMi modelling as its own samples. Acts itself as a complement to CMMs. Identical to CMMi, TMMi has a stage architecture for developing process. This phase consists of 5 levels like to follow on Figure 3. It advocates each organization must reach a level of maturity for testing. Achievements at each level are the key to moving on to the next level [3]

3.2 *CMMi & TMMi relation*

TMMi levels have a relationship with CMMi levels. Process areas and practices are defined with the CMMi. Process areas, specific goals, and generic goals are referenced from CMMi on TMMi as a model structure. TMMi does not need to explain these parts. These parts are already elaborated by CMMi as configuration management, quality management, test process… etc. So TMMi uses the same architecture of CMMi.

TMMi, imitate CMMi as a structural instance and levels are determined through the testing process just fine. It redirects to improve process unlike CMMi. For example, TMMi redirects a company with TMMi Level 2 according to the equation needs to do to be in Level 3 due to less complex way than CMMi because CMMi reviews each process according to the maturity from bidding stage until the closing stage, since TMMi is only focused on the process of testing [1]

TMMi level has the same specific support from process areas with CMMi Levels. But TMMi uses process areas to be corresponding CMMI level or from higher CMMI levels. For example, process areas are defined on Level 2 of CMMi which are defined on Level 3 of TMMi. The differences between CMMi and TMMi for the same processes areas can be followed from Table 1. Different parts of the process can be seen on the different levels. For example, configuration management process area is seen on the different part of the TMMi. Because some responsibilities should

be proved for configuration management on the every level of TMMi. But configuration management process are is always Level-2 on CMMi.

TMMi	CMMi	CMMi Process Areas for TMMi Levels
2	2	Configuration Management Process and Product Quality Assurance Project Control and Monitor Project Planning Measurement and Analysis Requirements Management
2	3	Requirements Development Risk Management
3	2	Configuration Management Measurement and Analysis Process and Product Quality Assurance Project Planning
3	3	Organizational Process Definition Organizational Process Focus Organizational Training Verification
4	2	Configuration Management Measurement and Analysis Process and Product Quality Assurance
4	3	Organizational Process Definition Organizational Process Focus
4	4	Quantitative Project Management
5	2	Configuration Management Measurement and Analysis Process and Product Quality Assurance
5	3	Organizational Process Definition Organizational Process Focus
5	4	Organizational Process Performance

5	5	Causal analysis and Resolution Organizational Innovation and Deployment

Table 1

3.3 *TMMi Levels*

TMMi has 5 maturity levels. The first level doesn't explain any procedure for improving test process. So TMMi starts with 2. Level – Managed.

So TMMi starts with the level 2 basically and The next level can be examined after the steps in each level and its sub-processes completed. For instance, to have Level 3 degree, it is required to be achieved all process areas of Level 2 and Level 3. Figure 4 explains the process areas of TMMi Levels [1]

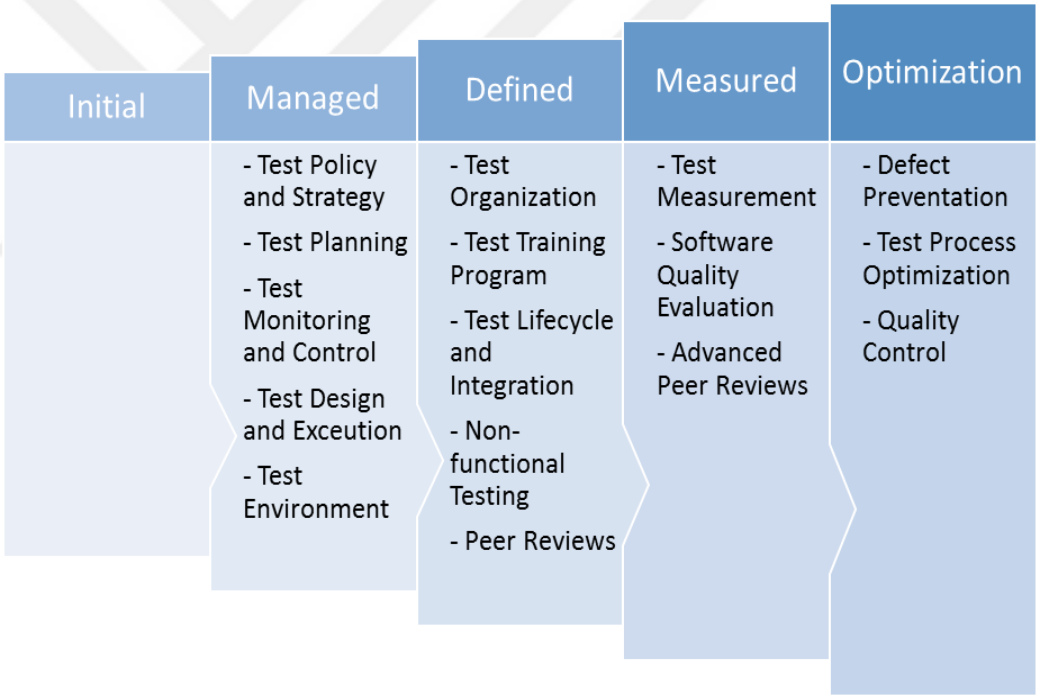

Figure 4

3.3.1 Level 1 – Initial

TMMi Level 1 is valid for projects having undefined processes, without any test environment and project errors are determined by debugging phase. Uncertain processes, such as rough testing and reporting of the software without any test plan

and without defining any testing requirements and test cases in a short time after development phase completion, state that the project does not have any maturity level within TMMi.

3.3.2 Level 2- Managed

TMMi levels are started by Level-2 Managed. Testing at Level 2 takes place as a process in the project. Testing activities begin without waiting for the completion of the development phase. Firstly, it is necessary to define the test plan. The test plan is created by evaluating project risks, the demands of stakeholders, project schedule, time cost, project requirements and product requirements. Similarly, the test plan and strategies are constituted for the benefit of the project and the company's strategies [1]

Level 2- Managed performs the testing process in 4 layers. These are component, integration, system ve acceptance. The tasks are assigned to the official testing professionals within these layers. Monitoring and control stage of these tasks are performed in the testing process and updated as necessary conditions.

In Test Plan Document, the testing techniques which is required for the relating software project are defined. It is determined which testing techniques and business processes to be used. Usable test cases are prepared depending on these techniques and process. So it is also a process area of the preparation and running of the test design within Level 2. Besides, it is necessary to have divergent test environments from development environments of the product to perform out of the tests designed by testing professionals.

If it needs to be classified mentioned above as process areas:

- ➔ Test policy and Strategy
- ➔ Test Planning
- ➔ Test Monitoring and Control
- ➔ Test Design and Execution

➔ Test Environment

a) Test Policy and Strategy

If a company demands to improve software and test processes, it needs to be determined a test policy and strategy evaluating both the company and the project variables before the test process begins.

The test policy should define organization's test objectives, purpose, and strategy for testing. Is should be aligned with the overall quality policy of the project and the stakeholders.

The test strategy needs to cover the test requirement for the one or more projects (or all projects of the company). Test strategy defines from project risks, product risks, and product requirements/ project requirements. A test strategy includes a description of the test levels, test objectives, responsibilities, main and sub-tasks, starting points of the execution. Test policy and strategy include definition test performance indicators, deployment, and test performance indicators.

b) Test Planning

The purpose of the test plan is explaining the defined test approach, defining the testing strategies considering the product risks, planning the testing cost and managing the test activities.

Test planning is a necessary process area of level 2 on TMMi and also, test planning has specific goals:

➔ Perform a Product Risk assessment

➔ Establish test approach

➔ Develop commitment to the test plan

c) Test Monitoring and Control

The purpose of test monitoring and control is tracking and supervision of the test plan and testing applications considering the product quality and expectations of stakeholders.

“The progress of testing is monitored by company the status of actual test, tasks, effort, cost and schedule to what is identified in the test plan”
(TMMi framework page 47)

The process area test monitoring and control is a test progress which includes documentation, estimations, commitments, plans, executions and reporting on the quality perspective of stakeholders.

Specific goals of monitoring and control:

- ➔ Monitor Test progress against plan
- ➔ Monitor product quality against plan and expectations
- ➔ Manage corrective action to closure

d) Test Design and Execution

The aim of test design and execution is that establishing test design specifications, using defined test design techniques, following test execution process and manage all of them. Test design and execution apply to select test conditions and test cases, create test data and using documents of test procedures.
Specific goals of test design and execution:

- ➔ Perform Test analysis and design with using test techniques
- ➔ Perform test implementation
- ➔ Perform test execution
- ➔ Manage test indicates to closure

e) Test Environment

The goal of test environment is to establish and maintain the environment, keep data, execute tests on the independent environment in a repeatable way.

The tracking of the environment and installation requirements, analysis of the test data and findings after execution of the test data, configuration management and control is provided by the test environment. It is provided to be caught of errors that can be encountered in the real environment in the early stages by the test environment established correlated with the actual environment and the test data appropriate to it.

Specific goals of test environment:

- ➔ Develop test environment requirement
- ➔ Perform test environment implementation
- ➔ Manage and control test environment

3.3.3 Level 3 – Defined

Testing takes place in all phases of the software processes depending on the milestones of Level 3 – Defined. It is initiated the documentation of the master test plan at the beginning of the customer requirements analysis phase.
The Level 3 can only be started to examine if all the process areas expressed in the Level 2 are to be completed in advance. The organization of a test, the training of the testing professional and the determination of testing professionals having the necessary skills are the processes of this stage [1].
The Process areas:

a) Test Organization
b) Test training program
c) Test Lifecycle and Integration
d) Non-functional testing
e) Peer reviews

a) Test Organization:

Test organization is the main process area in Level 3. Establishing a testing organization for the project or the company, giving out tasks and responsibilities to a group of experts by evaluating their abilities, and making the evaluation and managing of them within test process are considered to be the stages of the test organization process area.

Test organization defines tasks, responsibilities, reporting activities and position of test teams. Test roles, functions, and career paths are included on a professional disciple.

Specific goals of test organization:

- ➔ Establish test organization
- ➔ Establish test functions for test specialists
- ➔ Establish test career paths
- ➔ Determine, plan and implement test process improvements
- ➔ Deploy the organizational test process and incorporate lessons learned

b) Test Training program:

The purpose of test training program is to evaluate knowledge and skills of people. Resulting in, test engineer can perform tasks and role in the project more effectively.

Test training programs should be in a line with the objectives of the company (or test organization).

Test manager should identify needs for the project. These needs can be new test technologies or development of skills of test engineers. For test training program the main objectives are to support training test specialists when managers focus benefits of the project, customer, organization, stakeholders.

A test organization should establish test training programs plan; it is a need for a high-quality testing staff. Accordance the knowledge area of the test engineers, test principles, test techniques, test management, test tools, its knowledge, system engineering, requirement engineering topics can be categories. These categories are linked to the test functions, and test roles to facilitate test career paths. When the implementing test training program on a test organization, training objectives,

training needs, developing training modules, the knowledge, and skills of the people should be identified for an effective training program.

Specific goals of test training:

- ➔ Establish an organizational test training capability
- ➔ Provide test training

c) Test Lifecycle and Integration

The main responsibilities of the test organization are to define and establish document and standard test process in line with the test policy of test organization. Investigating test lifecycle and integration support this as a process. All of the set of organizational test process assets, work environment standards synchronize the test lifecycle with a development lifecycle can be provided via test lifecycle and integration.

The collection of these items includes descriptions of test process, descriptions of test lifecycle models, supporting test tools, guidelines and a test process library.

A standard defines the main phase, activities and test levels makes test process modeling. The standard test lifecycle models are aligned with the development to integrate the testing activities in terms of phasing, milestones, deliverables and activities (ref: TMMi book page 102) All of them are defined in the test plan to coordinate and plan testing responsibilities and tasks, test approach, improvements. So a Master test plan and level test plans should be established for every test levels. And master test plan should define to apply the test lifecycle and integration models on the project.

Specific goals of test lifecycle and integration:

- ➔ Establish Organizational Test Process Assets
- ➔ Integrate the Test Lifecycle Models with the Development Models
- ➔ Establish a Master Test Plan

d) Non-Functional Testing:

Non-functional testing is a section to support level-3 of TMMi. For an improving test process, test organization should include non-functional testing process on the test process with all parts like non-functional test planning, non-functional test design, and execution. Non-functional part of the project should be planned, controlled, executed like functional testing. Organizations need to improve the structure of the non-functional testing in the test process of the projects.
Non-functional tests as functional tests are also within the scope of the quality in terms of the satisfaction of the customer and stakeholders. Because nın-functional requirements show the engineers to the answers of the following questions "what/how customer needs" and "What/how the product does".

Test approach for non-functional tests should be defined, and the non-functional product risks are analyzed. Like functional testing, test cases, test conditions should be defined and they should address the related non-functional requirements. Manel and Automated test cases are established and their scripts are already before executing test cases.

Specific goals of non-functional testing:

- ➔ Perform a Non-Functional Product Risks Assessment
- ➔ Establish a Non-functional Test Approach
- ➔ Perform Non-functional Test Analysis and Design
- ➔ Perform Non-Function Test Implementation
- ➔ Perform Non-functional Test Execution

e) Peer Reviews

The main purpose of peer review process areas is the correct identification of the requirements and to prevent defects originated by analyzing in the early stages of the

project. Peer reviews also provide the correct understanding of product to be developed in advance.
Peer reviews can be conducted in transversely. Quality team, test team and development team should play an active role in the review process. Reviews may be conducted based on the knowledge and experience of software specialists worked on similar projects. Project's targets and main objectives according to the review process area should be defined as well as many process area of the project. Peer reviews should be defined in various types and stating the way to apply these types, in accordance with the objectives and targets as stated in IEEE 1028.

Peer reviews should be performed to ensure the TMMi Level 3, before starting the dynamic test.

Specific goals of peer reviews:
→Establish a peer review approach
→Perform peer reviews

3.3.4 Level 4: Measured

After successful completion of the whole process of TMMi Level 2 and Level 3, the examination of Level 4 can be performed. The purpose of Level 4 is supplying the improvement of the testing process and the ways of monitoring the testing process, gathering the necessary data, a collection of measurement and analysis to ensure this purpose. Test process should be a measure of test quality improvement process across the company. The test process is observed and the necessary measurements are collected and analyzed. Quality constraints required for product quality evaluation is defined within the project. These quality constraints are issued to cover reliability, usability, and maintainability. Advanced reviews should be conducted for TMMi Level 4. Reviews and inspections should be a part of the testing process and quality process. The relationship between the dynamic tests and peer reviews (static tests) should be defined within Level 4. Domain information, the conditions of the test environment, test data and test cases should be prioritized according to the results of the static tests [1].

TMMi Level 4 is formed by three process area.

a) Test Measurement
b) Product Quality Evaluation
c) Advanced Reviews

a) Test Measurement:

The test process is tracked by test measurement, and information about the process are collected manually or using tools. This collected information is analyzed and appropriate target process' tracking is provided in an efficient manner. By test measurement, the performance of the test team, whether the application is at the targeted level, development of product quality, and test improvement can be tracked.

If the company is providing TMMi Level 2 and Level 3 successfully, the conditions required to conceive the test measurements are provided.

Test measurement is the continuous process of identifying, collect and analyzing data on test process and the product quality.

Specific goals of test measurement:

- ➔ Align Test Measurement and Analysis Activities
- ➔ Provide Test Measurement Results

b) Product Quality Evaluation

To develop a successful product that satisfies customers indicates that the product is of high quality. It is necessary to define and track quality metrics for advancing the product in the same quality within the project.

Quantitative product quality of the project and its objectives must be identified for product quality evaluation. A plan related to product quality should be published and it should be tracked that whether every milestone in this plan meets those objectives. The activities to be performed should be defined and product quality status needs to be updated.

Having a product quality process is necessary for the customers, users, company and the employee. The renewal of the test strategy reduces work/time costs depending on which quality goals of the project are achieved.

Product quality evaluation focuses on the development stage, as well it focuses on testing phase of the project. Product quality goals should be defined at the beginning of the test/development phase of the project, need to be measurable, and should be updated based on the success of the desired objectives.

Specific goals of product quality evaluation

- ➔ Project for product quality and their priorities are established
- ➔ Actual progress toward achieving the project's product quality goals is quantified and managed

c) Advanced Reviews:

Advanced reviews process area includes providing and development of all peer reviews located within Level 3. Naturally, complete Level 3 has to be provided successfully to perform advanced review examination of the subjects in Level 4.

Advanced reviews, starts with product quality measurement and objectives since the project's early stages and it covers the relationship between static test (peer review) and dynamic tests (test execution). In accordance with taking part of advanced reviews in the testing process and generated review results, the testing approach is updated. Besides, it is provided tracking to achieve success objectives.

“Peer reviews, as an isolated process are an effective way to identify defects and product risks before actual product risks” (TMMi)

Advanced review process tracks testing approaches, peer reviews, peer review results, dynamic tests and relationship between static tests and dynamic tests. Targeted success are inferred according to measurements and gathered data, testing approaches are updated and published. Peer review process is applied to the repeated documentation and testing methodology in this cycle.

Specific goals of advanced reviews:

- ➔ Coordinate the peer review approach with the dynamic test approach
- ➔ Measure product quality early in the lifecycle by means of peer reviews
- ➔ Adjust test approach based on review results early lifecycle

3.3.5 Level 5: Optimization

Required for work areas of Level 5 can be examined for test organizations after successfully completing all the previous levels of TMMi. Level 5, argues that testing organizations need to be developed to come to the required maturity for test processes. Therefore, the scope of TMMi Level 5 covers the following questions: Are there regular improvements of test processes? Are these improvements updated and tracked? Are they measured? Are they statistically inferred and analyzed? Are testing techniques and methods updated or optimized for the respective projects according to the results? TMMi Level 5 examines testing processes improvement of testing organization (team) within the company independent from projects [1].

Level 5-Optimization is defined in TMMi framework with the following items. “An optimized test process, as defined by the TMMi, is one that is”

- Managed, defined, measured, efficient and effective
- Statistically controlled and predictable
- Focused on defect prevention

- Support by automation as much as deemed an effective use of resources
- Able to support technology transfer from the industry to the organization
- Able to support re-use of test assets
- Focused on process change to achieve continuous improvement

TMMi Level 5 is formed from three process areas.

a) Defect Prevention
b) Quality Control
c) Test Process Optimization

a) Defect Prevention

Defect prevention process area covers to analyze the causes of the defects in the development lifecycle, grouping of the defects and to prevent the similar future defects.

The testing phase is also a covering stage in the development life cycle to prevent defects as well to have the ability to identify defects. To prioritize defects, it is needed to identify the types of the past defects, to separate those defects into groups, to study causes, to analyze the cost of defects in the test and development stage, to take action items to prevent similar defects and to prioritize these action items according to risk factors. Defect prevention provides to acquire the lessons learned and the transfer of knowledge in other projects as well it helps to improve the quality of products. When the defect prevention practices implemented within a company, the cost of pre-preventing defects drags down much further than preventing them during the tests (and even during acceptance testing / maintenance phase).

Test prevention activities are not only a process area of interest to the testing phase. It should be taken action items in coordination with requirement engineering,

systems engineering, and all other software development disciplines. It is needed to be applied these action items and to be provided the prevention of defects.

Specific goals of defect prevention:

- ➔ Determine Common Causes of defects
- ➔ Prioritize and define actions to systematically eliminate root causes of defects

b) Quality Control

Quality control indicates that whether the testing process are managed correctly and followed with statistics. It is examined that defining accepTable and applicable limits to optimize and stabilize the performance of the testing process within quality control phase. Thus, it is provided that performing the test in more efficient ways to get the product in a qualified manner, and to vision product quality in advance by statistical methods.

Quality Control focuses primarily on standards and requirements. A quality control procedure should be published basing on these priorities. This procedure should cover the creation stage of product in the project and must create feedback loops in order to improve and optimize the process and to prevent defects in advance.

While the testing process is examined by Quality Control process area, all steps of testing process should be analyzed, they must be split into baselines and input/output criteria should be defined statistically for every baseline bearing in mind of quality.

Target and actual values are compared as long as the testing process is tracked and the necessary data is gathered. The reasons for differences that occurred are examined. Causes are analyzed according to several variations. It is examined which variation will affect which steps of the process.

“An organization that controls its processes quantitatively will be able to do the following

- Determine the stability of process

- Identify the process performance within the defined natural boundaries
- Identify unpredictable processes
- Identify the improvement opportunities in existing processes
- Identify the best performing processes”

Specific goals of defect prevention:

➔ Establish a statistically controlled test process

➔ Testing is performed using statistical methods

c) Test Process Optimization

The main objective of the test process optimization process area is continuous development and improvement of test processes and testing organization's current state.

To provide the highest level of TMMi in the project and within the testing, organization improvements should be continuous. Test process optimization is an ongoing, living process area. Test organization is also required to be continuously growing and progressing independently from the project. This progress covers standards, training activities, facilities that help the development of the test team, examination and implementation of new test tools, and continuous improvement of the organizational structure. Test process assessments are needed to be published test process improvement procedures are need to be defined within test process optimization. These definitions should be specified by test team and in the presence of a leader as pursuing the coextensive responsibilities in the entire team.

Engagement with the new technologies or improvement of the structure of the testing organization should be performed in an incremental manner. Continuity of testing tools usage, the progress of technologies, and processes development improvements must be ensured. High-quality testing values applicable to all projects should be possessed within testing organizations and they should be reusable.

Specific goals of defect prevention:

- ➔ Select test process improvements
- ➔ New testing technologies are evaluated to determine their impact on the testing process
- ➔ Deploy test improvements
- ➔ Establish re-use of high-quality test process assets

CHAPTER 4

4 TMMi Assessment and Questions of the assessment

TMMi Framework explains the assessment process and how to investigate the company profile in detail. However, this details includes the steps that should be in companies' assessments of test maturity level; do not include the necessary evaluation questions to determine their TMMi level or how to investigate their processes. Another study in this thesis is to conceive evaluation criteria and what to be examined for expectations of organizations on test phases about evaluation processes of companies in keeping with the TMMi structure.

TMMi makes an assessment of the test process maturity levels for examining three components. These three components are required components, expected component and informative components.

A required component is set of compulsory criteria that a process area must be provided successfully within itself. There are generic and specific goals for each process area described in the TMMi framework. Provision of criteria described in these specific and generic goals indicates that the process area is at the satisfactory level. For instance, it is expected that the testing strategy should be analyzed at the beginning of the test process for Test policy and Strategy process under the heading of the Level-2 and also include product risks, the test plan, and testing levels.

However, it is not required criteria that the documentation does not need to meet with the IEEE standards expected in the same process area.

Expected components are supportive variables needed to be implemented aside from the required criteria. These are described as specific or generic practices within each process area. The criteria expressed as expected components, are complementary and supportive set of essential criteria. It is necessary to ensure successful implementation of specific and generic goals for provision of specific and generic practices in that process area.

Terminally, the denominated category as informative components are steps that will help the development of the organization. These are described as sub-practices, work products, and examples in the TMMi framework. Informative components take part as a complement of required and expected components in the model.

Five levels are presented in TMMi framework as described in the previous sections. It is required to provide the subjacent maturity level for examination of each maturity level. Nevertheless, there are some process areas to be examined within each maturity level. The entire testing process is divided into N process area. Specific goals, specific practices, generic goals and generic practices are available for each process areas grouped in maturity levels.

Generic and specific goals are enacted primarily for each process area covered by TMMi framework in the scope of this study. The criteria of what need to be evaluated in test maturity process are defined for each goal. Similarly, generic and specific practices are analyzed and criteria of practices are defined for each test area.

There are many criteria defined for each level. Questioned criteria consist of 123 items to ascertain the desired level of maturity of companies. This article contains majorly sub-criteria and questions can be directed to companies.

Some of the issued criteria are mandatory and some are optional in loyalty of TMMi framework. To ensure any level of TMMi, it is necessary to provide all the process

areas within that level. The required criteria in that process are marked as mandatory in the thesis work.

This work has set rules for the TMMi evaluation of the testing organization as follows;

- ➔ A process area is necessary to provide that the entire mandatory criteria in which to be succeed.
- ➔ A process area is necessary to provide that the majority of the optional criteria in which to be succeed.
- ➔ Mandatory criteria and optional criteria may have sub-criteria set.
- ➔ All sub-sections of mandatory criteria are also mandatory.
- ➔ In case the majority of sub-sections of optional criteria is provided, it is regarded as successful.
- ➔ Failure to provide any of the optional criteria does not indicate that the process area is directly failed.
- ➔ Failure to provide any of the mandatory criteria indicates that the process area failed.
- ➔ Failure to provide a process area indicates that the TMMi level of the defined process area is also failed.
- ➔ Provision of a process area does not indicate the direct provision of TMMi level of the defined process area. All necessary process areas need to be provided successfully in that TMMi level.
- ➔ Successful completion of the relevant TMMi level provides an examination of superior level.
- ➔ If all the process areas of a level do not be provided, the superior TMMi level cannot be evaluated.

TMMi Level-1 is the state of a company that the test maturity level is not sought or at least the company does not meet the criteria as expected that are expressed for Level-2.

The Leveling state of TMMi begins with the Level-2. The criteria shown in Table 2 are expected items in Level-2. It is shown in the Table that which criteria are mandatory, and which are optional. Level-2 contains 25 main criteria and 17 of them are mandatory.

Level 2-	
A- **Test Policy and Strategy**	
1- Do you define a test policy on the project?	M
2- Does your test policy include the following topics? :	M
i. Objectives	
ii. Business objectives	
iii. Quality objectives	
iv. Quality Planning	
v. Risk Levels	
3- Do your company have a standard documentation which is defined by the quality team for your test policy?	O
4- Is the test policy review by test experts as internal? Does stakeholder review the test policy?	M
5- Do you have a test strategy?	M
a. Are the product risks defined on the test strategy?	
b. Which are variables used to categorize the product risks	
c. Which risks of the product are assessed when defining the test model of your project (V-model, incremental, lifecycle)	
d. Do you determine your objectives, personnel responsibilities, their tasks for each test level in the test strategy?	M
i. Unit test	
ii. Integration Test	
iii. System test	
iv. Acceptance test	
B- **Test Planning**	
6- Do you have a test plan?	M
7- Are the product risks defined in the test plan?	O
8- Does the test plan have test approaches and test techniques?	O

9- Does your test plan have the following topics?	O
a. Experiences of the test engineers	
b. Cost per man/day for the project	
c. Development lifecycle	
d. Bug fix & Re-test	
e. Documentation standards & review process	
f. Regression tests	
g. Manuel & Automation tests	
h. Test tools will be used	
i. Constraints in the test environment	
j. Project deadline & test deadline	
10- Do your customer and stakeholders review the test plan?	M
11- In the Test Plan, do you have a process and its test report to find and fix defects for each test phases? (or Does test process have these phases?)	M
12- Does the test plan have test schedule?	O
a. How long will the testing activities	
b. Which will test phases	
c. Which tests will be entered which phase	
d. Milestones/ checkpoints	
13- Do you have master and sub test plans? Which phase are they updated/ how often are they updated	M
C- **Test Monitoring and Control**	
14- Do you keep the test execution performance?	M
a. How many test cases are executed on how long time?	
b. The amount of the test cases is run by a tester on a day. (the similar measurements …etc.)	
15- Do you follow the cost and effort of test execution? How often? Which variables are based?	M
16-Do you analysis to completion test tasks and cost of test?	M
17- Do you determine the cost of defects to fix and re-test for each test tasks?	O
a. Number of Defects (for component, system, sub system)	
b. Do you define the priorities of the defects	
c. Do you establish the rates of the defects which are found and fixed on each test process	
d. Are the defects defined according to the following variables	
i. Data	

ii. Requirement	
iii. System	
iv. External Systems	
v. Configuration	
D- **Test Design and Execution**	
18- Which phases do you prefer black box/white box testing on	O
a. Black box, equivalence, boundary, decision Table, state transition	
b. White box, statement, decision branch, condition testing	
19- Do you use test conditions when test cases are created?	M
20- Are pass/fail criteria defined?	M
21- Are your test cases reviewed?	M
22- Do your test cases include the following topics?	O
a. Test Case identifier	
b. Environment requirements	
c. Preconditions	
d. Input/output specifications	
23- Do you smoke test before beginning the test cases on the environment?	O
a. All basic functions work?	
b. Positive test cases on functions of all components work correctly?	
c. Interface of the application is correct?	
d. A component and another component work together correctly?	
e. Application has connections with external systems, it works correctly with that systems?	
24- Are test Documentation, user manuals and integration manuals ready before beginning tests?	O
25- Is it getting recorded and reported that (test Environment, test data, test documentation...etc.) the cause of the problems during the test? (Blocking test execution)	M

Table 2

23 of main criterion have been identified as mandatory in TMMi Level- 3 criteria. The remaining criteria are optional. All of the Level-3 criteria are described in Table 3.

Level-3-	
A- **Test Organization**	

26- Do you have a test organization (test team or group) on the company?	M
27- What is the place of your test organization on the organization schema of the company?	M
a. What is the relation between development team and test team? Is the test group depending on development team directly?	
b. Who assign the tasks and responsibilities for the test team?	
c. How is reporting process path? Do you establish the test reports to development team or PM team?	
d. Do test organization and stakeholders review your documentations?	
e. Do you have a documentation for review commits?	
28- On the test organization, do you have responsibilities definition as the following topics	M
a. Test manager	
b. Test team leader	
c. Test designer	
d. Test Consultant	
e. Test environment engineer	
Do responsibilities on the test group is determined as follows in accordance with requirements?	O
a. Test automation architect	
b. Test automation engineer	
c. Performance test engineer	
d. Usability test engineer	
e. Test process improvement specialist	
30- Do you have specialist personnel who are not test specialist but they support test process?	O
a. SW developer	
b. System engineer	
c. System integrator	
d. User representative	
31- Does your company have titles as junior, intermediate, senior etc. for your test specialist?	M
a. Definition a framework for the carrier of a test specialist?	
b. Tasks and Responsibilities of the test specialist hierarchical?	
c. HR defines and applies the same hierarchical structure for test organization?	

32- Does your company have a personal career development plan & path for test engineer? Are these revised if it is need?	M
33-On test organization,	O
a. Do you define test process improvement?	
b. Do you update test organization structure for test improvements?	
c. How do you monitor and control on the test organization?/ Who monitor and control on the test organization	
d. Do you update responsibilities and tasks accordance with resource and schedule?	
e. Do you review and update your test process improvements?	
34- Do you have a deployment plan defined in the project?	M
35- Do you have a checklist related for deployment? Does it update?	M
36- Do the training exist to change process and documents for deployment and tests ?	O
37- Are the test metrics, test DB, test tools and resolved/re-test approach explained to the test team? And Do you keep on any document recording?	O
38- Do you have "Change Management" process on the test organization?	O
39- Do you use a test model like TMMi or another model when you create test organization structure?	O
a. Do you make test process improvement plan?	
b. Do you make test process deployment plan?	
B- **Test Training Program**	
40- Do you have professional training and certificate programs for test engineers?	M
41- Do you have internal training for test engineers?	M
42- Do you choose training which is parallel subjects with the projects?	O
43- How do you define needs of test training?	O
a. Is test schedule created depending on the training activities?	
b. Do you have training materials? Are they kept accordance with any software standards?	
c. Do you choose the following topics for test engineers trainings:	
i. Requirement engineering	
ii. Test Automation	
iii. Database Management	
iv. UML Design	
v. Risk Management	
vi. Configuration Management	

vii. Development lifecycle	
d. Do you have cross training on your test organization? Do test engineers who take different training make knowledge transfer?	
44- Are new topics defined for the training programs accordance the projects?	O
45- Do you make an assessment such as successful/unsuccessful to test engineers for test training?	M
46- When internal training on the test organization, Do you define a standard like the following topics?	O
a. Knowledge and Skill need analysis	
b. Course design	
c. Training delivery methods	
d. Refreshing training on subject matter	
C- Test Life Cycle & Integration	
47- Have you defined your test life cycle model in an arbitrary document?	M
48- Are the following topics defined depending on the test lifecycle model?	O
a. Test strategy, testing levels and test objectives	
b. Phases, planning control stages, execution, and test implementations	
c. Test input/output criteria for every single phase	
d. Responsibilities for every single phase	
e. Milestones for every single phase	
49- Are the phases of your test lifecycle model synchronized with the development lifecycle model?	M
a. Are the tests performed in parallel dependency with the requirements developed?	
b. Is there any prioritization among your test objectives? Are you updating the prioritization depending on the development plan?	
c. Is your document updated and reported depending on change requests among objectives?	
50- For any defined process inside test lifecycle	O
a. Are you recording the testing estimations and its output? (job quantity, effort, cost)	
b. Do you have quality measurement metrics?(priority level, defect count)	
c. Do you have peer review?	
d. Do you have test coverage?	
e. Do you use reliability measurements?	

51- Do you use the following tools for testing management	O
a. Database management tools	
b. Process modeling tools	
c. Web page builders	
d. Project planning/scheduling, configuration management, test management tools.	
52- Do you consider the following topics for test tracking and control in test lifecycle?	O
a. Change request count of requirements for any test process	
b. Daily development requirements of test process and changed test process	
c. Is the master plan revised periodically?	
d. Test items and risk levels of the test items?	
e. Is the effort, cost and schedule are revised following any sub test plan?	
D- Non-Functional Testing	
53- Do you define non-functional product risks?	M
54- Do you use some of the following techniques	O
a. Risk workshops	
b. Brain storming	
c. Expert interviews	
d. Check list	
e. Lesson learned	
In the process of defining non-functional risks	
f. Do you grade and prioritize them?	
55- Do you classify non- functional product output criteria like following?	O
a. For reliability Mean time between failures (MTBF), Mean time to repair (MTTR)	
b. For usability (User satisfaction, average time to perform the functions)	
c. For efficiency (mean response time, memory utilization)	
d. For maintainability (average effort to change, availability of documentation)	
56- Do you define the non-functional test conditions (or requirements) or non-functional test design specifications of the product?	M
57- Do you have traceability matrix for non-functional req./test conditions? Do you cover non-functional requirements with corresponding test cases? Are these test cases performed?	M

58- Do you setup data/test scripts for non-functional tests?	O
59- Do you setup test environments for non-functional tests?	M
60- Do you setup test procedure, test data and test scripts in advance of performing non-functional test cases?	O
a. Do you record and report the tests?	
b. Do you compare the results with the expected results?	
c. Are the tests repeated for resolved cases?	
d. Do you make regression for non-functional tests?	
61- Do you make reviews for non-functional tests?	M
62- Do you use tools for non-functional tests?	O
63- Do you report your test results?	M
64- Do you perform measurement with regard to test effort?	O
E- Peer Reviews	
65- Do you list the jobs needing reviews?	M
66- Do you define an approach regarding how to review? (What do you pay attention with jobs to be done. etc.)	O
67- Are you logging reading reviews done?	M
68- Do you have peer reviews schedule?	M
69- Does your peer reviews include following stages?	O
a. Inspection (Control)	
b. Walkthrough (itinerary/sampling)	
c. Technical review	
d. Informal review	
70- Do you prepare your review approaches with the stakeholders?	O
71- Do you have a form for keeping records of peer reviews?	O
72- Do you take an action item for the cases generated after review result?	M
73- Do you publish a report for regard to peer reviews?	M
74- Do you define an input/output criteria for regard to pre-peer review findings (defect)?	O
75- Do you analyze your peer reviews?	O
a. Do you define estimated time and time spent rates for peer reviews?	
b. Do you make an expected findings estimation before review?	
c. Do you classify findings according to priority and types?	

d. Do you inspect the reasons of situations mentioned in the findings?	
e. Do you analyze the time cost for resolving of these situations?	
76- Do you discuss the results of peer review with the stakeholders?	O
77- Do you have a role distribution of peer review like following?	O
a. Review leader (Moderator)	
b. Checker (Reviewer)	
c. Scribe (Recorder/Note taker)	
d. Author (Preparer)	
78- Does your employee get training associated with peer review?	O
a. Do you have training materials?	
79- Do you publish rules and checklists about the peer review documents?	O

Table 3

16 main criterions are located in TMMi Level-4. the criteria covering Level-4 are defined with the status of being mandatory or optional in the Table 4.

Level -4	
A- Test Measurement	
80- Do you define your test measurement objectives?	M
a. Do you get related information from the customers and stakeholders in the definition stage?	
b. Do you use traceability matrix for test measurement objectives?	
c. Do you verify and query your defined test measurement objectives?	
81- Do you define estimated/actual measurement rates of test effort and test cost?	M
a. Do you evaluate and measure regarding estimated/actual test cases?	
b. Do you classify the defects according to severity and priority?	
c. Do you calculate the defect detection rate?	
d. Do you have structural coverage and code coverage process?	
e. Do you use requirement coverage?	
f. Do you use Mean Time Between Failures (MTBF) and Mean Time to repair (MTTR)?	

g. Do you use burn down measurement? (I.e. for weekly test case execution)	
82- Do you have a data collection and storage procedure for measured data?	O
a. Do you have a defined procedure for gathering data, do you have a guide consisted of these processes?	
b. Are the data saved according to a time-line order?	
c. Do you have a defined security/authorization procedure for data collection?	
d. Is your data collection process is also automated? Do you use a collection tool for this?	
e. How do you analyze the defected/faulty data? Do you use a verification tool for this?	
f. Do you share the measurement data with the stakeholders?	
83- Do you have a draft version and/or standard about test measurement reports?	M
84- Do you revise the measurement data?	M
a. Do you have an authorization in order to access data?	
85- Does your employee get training associated with test measurement process?	O
86- Do you classify test measurement data and address them with test measurement objectives?	O
B- Product Quality Evaluation	
87- Do you define the product quality requirements and purposes?	M
88- Do you apply following quality requirement processes with the customers and stakeholders?	O
a. Do you apply surveys and questionnaires?	
b. Do you separate quality requirements into focus groups?	
c. Do you make brainstorming?	
89- Do you define the attributes of product quality like following?	M
a. Functionality	
b. Reliability	
c. Maintainability	
d. Portability	
e. Efficiency	
90- Do you define a quantitative product purpose for any quality attribute?	O
91- Do you establish a traceability between product quality purposes and the requirements?	M

92- Do you collect quality measurement data and review them?	M
a. Do you report them?	
b. Do you use them in the presentations with customers and stakeholders?	
c. Do you take corrective actions according to quality measurement data?	
93- Do you use any tools for Quality Measurement Analysis?	M
a. Do you analyze a cost for quality metrics?	
(Cost of poor quality & cost for achieving quality goals)	
C- Advanced Reviews	
94- Do you review the product risk plan?	M
95- Do you review the product work breakdown?	M
96- Do you review the master test plan?	M
a. Do you document and save the review commits applied?	
97- Do you define review types for every work done?	M
98- Is the review planning applied in the test approach coordination phase?	O
a. Proper source for review	
b. Proper potential reviewers according to knowledge and talent	
c. Review task planning for project and test deadline	
d. Effort/cost defining and falling them within test plan	
99- Do you have measurement guidelines for peer review?	O
a. Do you have rules and review checklist?	
b. Do you have sample guidelines?	
c. Do you have perspective based reading procedures?	
d. Do you record checking rate? (i.e. Hourly review paper count)	
100- Are you logging peer reviews?	M
a. Do you construct an action list for peer reviews?	
b. Do you report and store them?	
c. Do you compare peer review results according to output criteria?	
101- Do you measure peer reviews based on product quality?	M
102- Do you apply a review for product quality measurement at the beginning of the application development lifecycle? (static tests)	O
103- Are peer reviews also performed in a group supervised by a leader or a moderator?	M

a. Are review meeting organized?	
b. Are the provisions organized like meeting schedule and location?	
104- Is the method of peer review process is specified in the master test plan?	O
105- Do you cover the following topics in peer review process?	O
a. Product risk assessment	
b. Defining a coordinate test approach	
c. Types of reviews	
d. Defining peer reviews quantitative exit criteria	
e. Document rules and checklist	
f. Sampling practices	
g. Perspective based ready	
h. Data collection, analysis, reporting	

Table 4

11 mandatory main criterions are located in TMMi Level-5. It is described in Table 5 that which criteria are mandatory and which ones are optional.

Level- 5	
A- Defect Prevention	
106- Do you construct a schema when classifying defects?	M
107- Do you define defect selection parameters?	M
a. Do you analyze classified defects?	
b. Do you specify their reasons?	
108- When specifying defect selection parameters	M
a. Do you estimate the potential harm of a defect?	
b. Do you determine the incidence frequency of a defect?	
c. Do you plan the time cost and effort of fixing the defect?	
d. Do you calculate the time cost and effort of prevent the defect?	
e. Do you organize the scope of the negative effects of a defect?	
109- Do you share selection parameters with the customer and stakeholders for them to review?	M
a. Do you report selection parameters defect classification schemas?	
b. Do defect reports cover static/dynamic tests and operational usage (actual user tests and actual user operational usage)?	

110- Do you separate defects as	O
a. Root cause of selected defects	
b. Common cause of selected defects	
when analyzing selection defects	
c. Do you use one or some of the following methods when analyzing root causes?	
i. Cause/effect diagrams	
ii. Ishikawa fishbone diagrams	
iii. Fault tree analysis	
iv. Process analysis	
v. Use standard defect classifications (IEEE 1044)	
vi. FMEA (Failure mode effect analysis)	
vii. Hardware and Software Interaction analysis	
d. Do you categorize common causes in analysis one or some of the following?	
i. Process	
ii. People	
iii. Organization	
iv. Communication	
v. Architecture	
vi. Technology	
vii. Tools	
viii. Environment	
111- Do you define possible solutions for defects?	M
(Process, work product standard, organizational structure, training, review activities, test strategy, methods and technologies, checklist, coding standards, tools) and do you define these solutions?	
112- Do you have defect prevention process?	M
a. Do you specify organizational objectives for defect prevention?	
b. Do you perform key measurements for it?	
c. Are quality metrics and root causes are associated with firms expectations?	
d. Does testing team (or process improvement team) coordinate defect prevention activities?	
e. Is any plan prepared for defect prevention process and is updated in case of necessity?	
113- Is the following defect prevention measurements performed?	O

a. Cost of defect prevention activities	
b. # defect analyzed	
c. # root cause identified	
d. # action proposal outstanding and how long	
e. # action proposal submitted	
B- **Quality Control**	
114- Are test process associated with quality control processes? (Statistically controlled test process)	M
a. Do you publish test process performance objectives?	
i. Do you revise quantitative objectives for test process performance?	
1. When organization's business objectives are changed	
2. When organization's test process are changed	
3. When objectives are not coherent with the actual results or test process performance	
b. Do you perform test process performance measurements?	
i. Are test process performance measurements reviewed?	
ii. Are these measurements revised?	
c. Do you have test process performance baselines?	
i. Do you analyze the data gathered through test process performance measurements?	
1. Do you define moral validating this data along with the customer?	
2. Do you revise your baselines?	
d. Apply statistical methods to understand variations	
i. Do you collect measurements performed?	
ii. Do you publish upper and lower boundaries?	
iv. Do you install control charts, histograms, run charts, prediction intervals?	
e. Monitor performance	
i. Do you compare test process performance objective with the boundaries?	
ii. Do you perform reviews periodically? Do you conclude test process success and perfection?	

iii. Do you publish test process capability deficiencies and document it?	
115- Do you define and develop operational and usage models?	M
a. Develop customer profile	
b. User profile	
c. System mode profile	
d. Functional profile	
e. Operational profile	
f. Review operational profiles (stakeholders)	
g. Are these profiles revised?	
116- Are test cases reviewed by the stakeholders?	O
a. Are test cases covered with actual usage?	
b. Are test cases revised?	
c. Are test results analyzed and recorded?	
117- Do you define severity level of defects?	O
a. Are confidence goal/measurements coherent with reliability?	
b. Are they Documented and reviewed?	
118- Are the following tools used for Quality Control process?	O
a. DB management tools	
b. Process modeling tools	
c. Statistical analysis package	
d. Incident management tools	
e. Coverage tools	
f. Statistical process and quality control package	
g. Reliability measurement tools	
119- Does your employee get training associated with quality control process?	O
C- Test Process optimization	
120- Do you specify test process improvements initially or afterward a project?	M
a. Do you gather and analyze test process improvement proposals?	
b. Do you evaluate these proposals as a pilot?	
c. Do you specify needed test process improvements to apply?	
121- Do you define new test techniques in case of improvement in test process?	O
a. Do you examine and analyze new test techniques?	

b. Do you apply new test techniques and technologies as a pilot?	
c. Do you constitute new test technologies to apply?	
122- Do you apply test improvements?	M
a. Planning	
b. In management & trailing	
c. Do you measure the effects of improvements?	
123- Do you re-use of high quality test process assets?	M
a. Do you define your assets?	
b. Do you use a library to re-use assets specified?	
c. Do you utilize your reusable test assets in other projects?	

Table 5

Percentile of the mandatory and optional criteria are shown in Figure 5. Mandatory criteria have a ratio of 52% of the entire model. The density of mandatory and optional questions is ensured to be equivalent within the model.

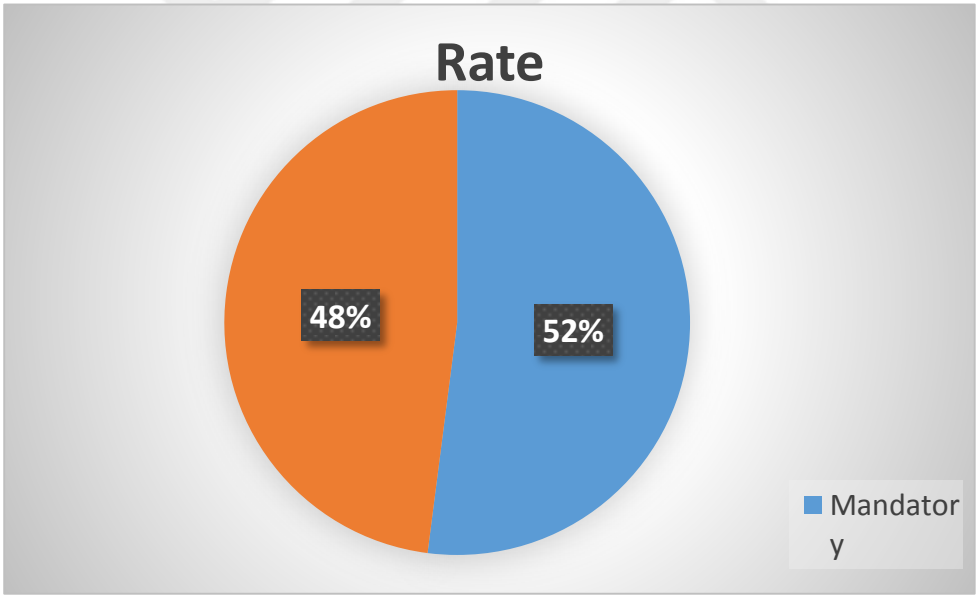

Figure 5

Criteria of each process area are available in different proportions within TMMi levels. Due to the fact that Level-3 area has more process areas and work areas depending on those process areas, it possesses the largest criteria set. There are different proportions of mandatory and optional criteria evaluating each TMMi level

as can be followed in the Figure 6. This is because each process area within TMMi levels has different requirements. There are 15 mandatory and 10 optional questions in Level-2 despite Level-3 has 23 mandatory, 31 optional questions.

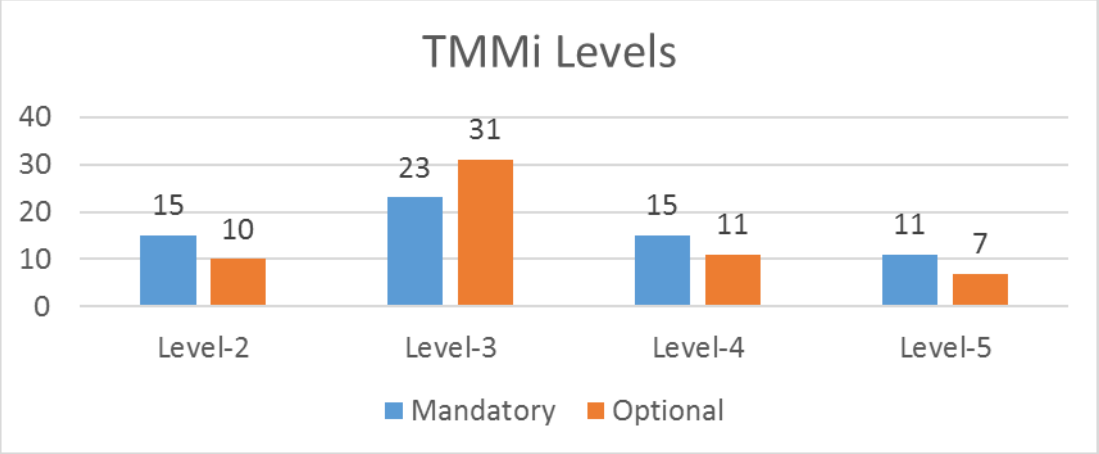

Figure 6

CHAPTER 5

5 Quality Metrics of a Software product

In this study, variety of software metrics are analyzed to validate TMMi modeling. These metrics are commonly based on underlying variables used to measure the quality of software projects and to ensure customer satisfaction. Many of the equation expressed hereinafter are quality metrics in today's software projects evaluated in quality processes.

It is expected that a company having TMMi Level-4 need to have following quality ratio and keep these values organizationally and for its software projects.

Quality engineers define targets in relation to these values, the rates will be utilized, what variables to use, what values expected at each check point stages, the boundaries and thresholds of these rates at the project opening. The purpose of the conception of these metrics is customer satisfaction, monitoring the quality of the product and processes.

Causes of demanding the metrics from the organization in this study are to measure the analogy between company's testing maturity model and the product quality. These universal metrics used helps to get comparative answers to the question of a company applying the testing process in accordance with the TMMi model can also be able to generate products that have demanded quality.

All of the following metrics are selected to indicate test process performance as focusing on the spots that test, requirement, acceptance, and post-acceptance. These quality metrics are divided into four categories to provide information about the different points of the testing process.

a- Two equations have been selected to determine the value of how much post-acceptance requirements are covered. Total number of requirements, the number of requirements have been passed during the acceptance and also the number of requirements have been tested (test case are written) prior to acceptance are required, in order to analyze these rates. These metrics which related to the requirements provide the direct rate of success of both dynamic test and static test.

The rate of how many of the total requirements are passed after completion acceptance stage can be deducted from Equation-1.

$$\frac{\text{Number of requirements passed after acceptance}}{\text{Number of total requirements}}$$

In Equation-2, how many requirements are included in the test phase (portion of requirements that was tested) and also the ratio of the total requirement has been analyzed.

$$\frac{The\ number\ of\ requirements\ tested\ pre\ acceptance}{Number\ of\ total\ requirements}$$

b- Three equations are determined for the defect rate in the acceptance and post-acceptance. In order to reach the proportion of these equations, it is needed that how many defects occurred, the total number of requirements, the total number of code lines and the man/day cost that spent for the correction of these defects in the acceptance stage and the stage after project advanced to live (by a certain period of time). The purpose of using these metrics is the direct indication of the test process success on customer side.

Equation-1 is the rate of number of defects occurred on total requirement count. This equation refers the average of how many defects occurred for a requirement.

$$\frac{\text{Number of defects}}{\text{Number of total requirements}}$$

The number of defects and for the number of total lines of code are required for Equation-2. This rate will express that how faulty the code.

$$\frac{\text{Number of defects}}{\text{Number of total lines of Code}}$$

The number of defects and man-days effort in order to fix these defects are necessary for Equation-3. This ratio indicates the average spending of cost/time for for a defect.

$$\frac{\text{Number of defects}}{\text{man} - \text{days effort}}$$

c- Two equations are set for the analysis of change request rate in the testing process and the acceptance process. In order to reach the proportion of these equations, it is needed that change request count, the total number of requirements the number of test cases to affect that change requests and total test case count. The metrics in this category directly affects the requirements. Therefore, it indicates a value about accuracy of implementation of the static test process.

A ratio of total change request values that encountered while test process running on and total requirement count are analyzed in the Equation-1 in this category.

$$\frac{\text{Total change request in test process}}{\text{Total requirement count}}$$

In Equation-2, a ratio that how much test case are affected by change requests is analyzed.

$$\frac{\text{Test case count affected by the incoming change request}}{\text{Total test case count}}$$

d- In this category, it is analyzed that the ratio of defect frequency in a specified time and spending cost in the acceptance stage and after. It has been determined two equations for this. The number of defects from the live environment is required in acceptance and post-acceptance. These values are determined by placing a certain time constraint considering the post-acceptance. It is not included directly incoming defects in the entire maintenance process. The purpose of this category is an analysis of the ratio that how quickly the primary defects are found by end users or customers in the system. Thus, it is aimed to find out the quality of the testing activities carried out within the project.

For the Equation-1, the ratio of defect count and defect frequency for a specific time is required in acceptance and post-acceptance.

$$\frac{\text{Defect count}}{\text{Time}}$$

Equation-2 gives the ratio of time to resolve these defects and effort of man-days cost.

$$\frac{\text{Defect count}}{\text{Total effort spent in terms of time}}$$

CHAPTER 6

6 Analysis TMMi Level of the companies

The main purpose of this study is to analyze the effects of test maturity model to the company quality results. Therefore, it is required real companies that TMMi model can be applied to and project/test process information of those companies. Since TMMi evaluation criteria are not like a survey, companies are required to evaluate the whole process of testing and quality for measuring the maturity model. However, a very precise information about the project results should also be accessible for quality metrics. In addition, companies that be evaluated are expected to already have the test team, to include the testing process into the software process, to be able to allocate the necessary budget for software testing. Because the lack of a test team or the absence of test process of the selected company will be unable to go beyond Level-1 in TMMi maturity levels. Several companies have been contacted keeping these variables in mind. However, due to certain binding pledge and confidential information in the project of some selected companies, it is could not be practiced an evaluation process with all the contacted companies. Three companies are subjected to the testing maturity assessment through the selected working group.

During the assessment, verification of technologies that use documentations are made delivery of reference documents or showing live to evaluators in addition to the responses.

The two of evaluated companies mentioned in this study would not be uncomfortable with the clarification of the company name while the other company did not desire to use its name.

Therefore, there will be a mapping Table 6 relating to all companies and will be referred as Company-A, Company-B and Company-C. Names and details of the companies who agreed to express the name of themselves takes place in the related Table while only the sector and general information about the third company are stated. Still, at the points that they have been evaluated in the thesis, are referred as Company-A, Company-B, and Company-C.

#	Information of Companies
Company-A	There are many projects in the telecommunications sector of the international company. It having worked with many of telecommunications companies in Turkey, shared necessary process documents and quality metrics of one of their projects to one of the largest telecommunications companies while evaluation of TMMi model.
Company-B	There are many projects in the telecommunications, defense industry and public domain of the international company. It described its processes over a defense industry project having a European customer which is not preferred to express the name while evaluation of TMMi model.
Company-C	The company with domestic capital has several projects in telecommunications and the public sector. It has many projects with one of the today's largest telecommunications companies. TMMi evaluation is performed on the basis of one of these projects.

Table 6

While examining the TMMi level of companies, each company's maturity level will be examined under a separate heading and the processes that should be developed in response to the TMMi level will be described under the sub-headings.

6.1 *Analysis TMMi Level of Company-A*

6.1.1 TMMi Level of Company-A

The first assessment is made with the Company-A in the telecom sector through a project currently still in progress. During the related studies, authorities of the company answer the questions of those criteria over many documents and the standard and the technology they use.

Detailed answers to the process areas and related TMMi levels of Company-A can be tracked in Appendix-1.

It is indicated that all of the process areas within TMMi Level-2 are provided as expressed in Table 1. The fact that test training program, non-functional testing and peer reviews process areas are not provided, the maturity level of the company cannot be raised to the Level-3. Besides, all process areas located in Level-4 Level-5 have failed.

TMMi Levels & Process Areas	**Status of Process Areas**	**Status of Levels**
Level-2		Success
A- Test Policy and Strategy	Success	
B- Test Planning	Success	
C- Test Monitoring and Control	Success	
D- Test Design and Execution	Success	
Level-3		Failed
A- Test Organization	Success	
B- Test Training Program	Failed	
C- Test Lifecycle & Integration	Success	
D- Non-Functional Testing	Failed	

E- Peer Reviews	Failed	
Level -4		Failed
A- Test Measurement	Failed	
B- Product Quality Evaluation	Failed	
C- Advanced Reviews	Failed	
Level- 5		Failed
A- Defect Prevention	Failed	
B- Quality Control	Failed	
C- Test Process optimization	Failed	

Table 7

As shown in Table 7, Company-A is at maturity Level-2 Defined. Company does just not provide one question of the optional criteria in Level-2. Question of the criteria that unsuccessful is: "Does the test plan have test approaches and test techniques?"

Company has been unsuccessful in 50 criteria to a total of 123. 22 of the non-provided 50 criteria are mandatory.

It should also provide more three mandatory criteria in order to provide TMMi Level-3. It is seen that Company-A was unable to provide 14 of the optional criteria in Level-3. However, these non-provided optional criteria do not affect Level-3 state directly. Company-A can provide Level-3 if these 3 mandatory criteria are successfully achieved.

As it can be seen in Figure 7, while Company-A achieves 19 of the 23 mandatory criteria in Level-3, the ratio gets less and less for Level-4 Level-5. In fact, this output shows that the modeling works correctly on certain points. The argument, a company cannot provide Level-3 also cannot largely achieve Level-4 and Level-5 criteria, is verified in this way.

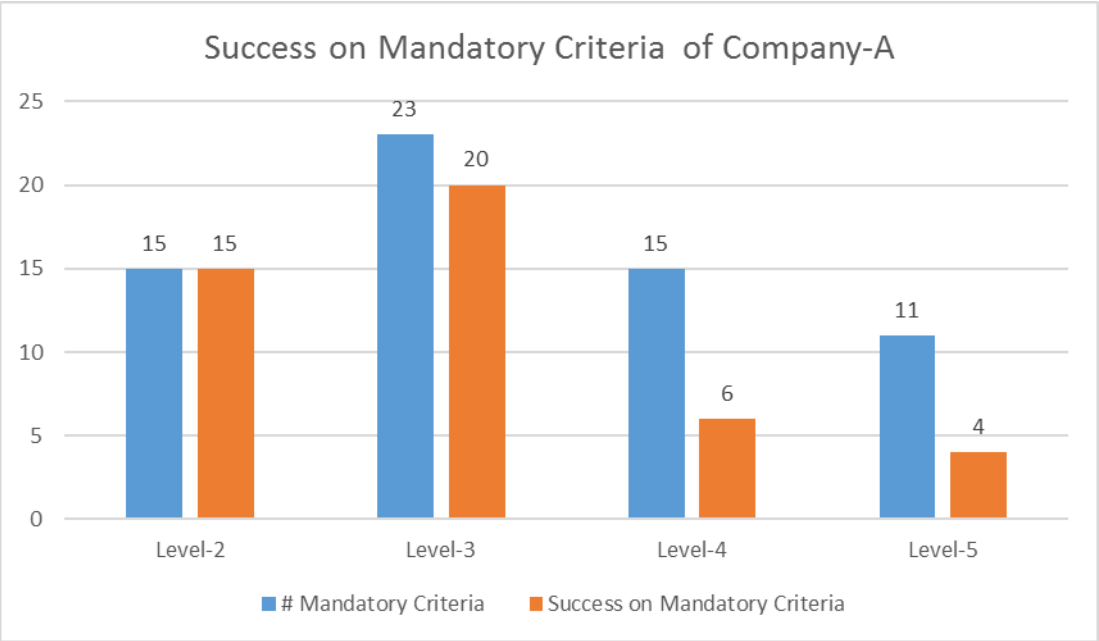

Figure 7

Three items that Company-A fails to provide are as follows:

"40- Do you have professional training and certificate programs for test engineers?"
"53- Do you define non-functional product risks?"
"67- Are you logging reading reviews done?"

When looking at failed criteria it is appeared to belong different process areas.
40th criterion is one of the main criteria of testing program process area and the reason for the failure of this criteria is that Company-A does not assure test engineers to get necessary professional trainings and certification programs. Regarding this situation, it is stated that there will be some changes and future planning in the organizational structures of the company in order to give the necessary training to the test engineers.

Another criterion 53th is that the reason for not providing Level-3 is related to the non-functional testing process area. Failure to provide these criteria directly leads to fail the non-functional testing process area. Company-A needs to do a more detailed study in non-functional test phases and to construct a test plan in their projects, and this test plan should include the risks associated with non-functional requirements.

Finally, 67th criterion is not provided. This is a mandatory question of peer review process area. It is needed peer reviews to be recorded over a form, be performed cross-check under the necessary conditions and be logged and kept due to authorization.

After ensuring that the 3 of the mandatory criteria, Company-A is expected to provide the majority of the optional criteria to have access to get Level-3 maturity. As it may be able to follow on Figure 8, now with its labor the Company-A already provides 54% of the optional criteria of Level-3. Besides, attempting to improve all of the optional criteria will help to improve the process areas of other levels and make tracing process to get rid of a chaotic circle.

Detailed answers for the other TMMi levels and procurement information about whole criteria of Company-A can be tracked in Appendix-1.

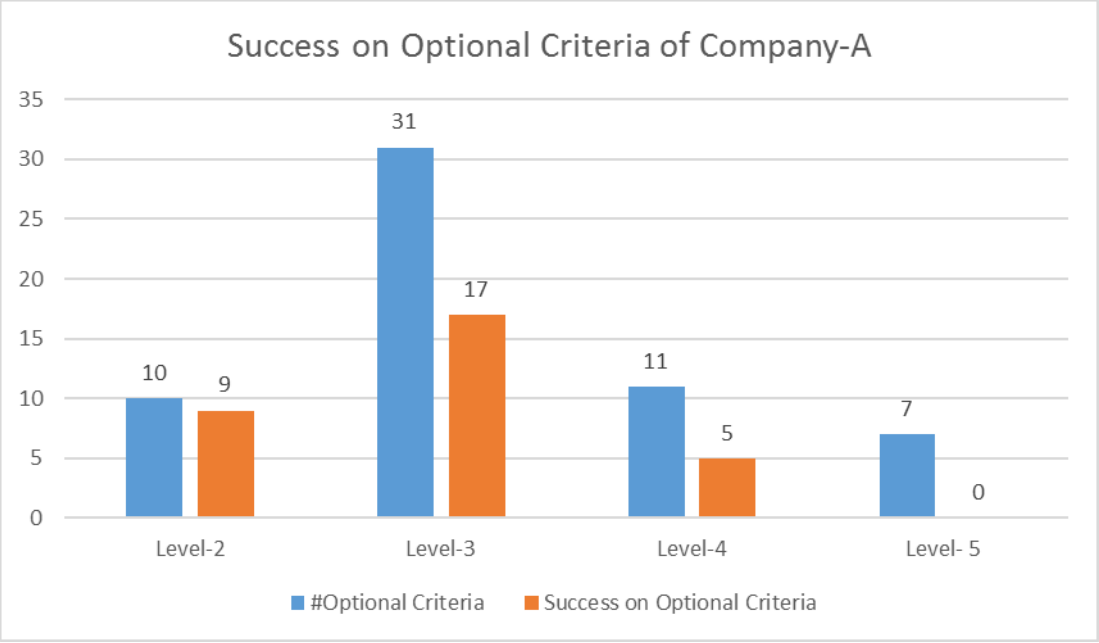

Figure 8

6.1.2 Quality Values of Company-A

Company-A stated that the necessary parameter values for related quality metrics will be given to evaluator but this information was not shared during the complete study. Within this study, there is no numeric value available to evaluate the outputs in the project of Company-A. There is an inconsistency between the answers about keeping the quality metrics within test maturity model and the failure to meet those metrics on demand.

1- The ratio of covered requirements of post-acceptance

$$\frac{\text{Number of requirements passed after acceptance}}{\text{Number of total requirements}}$$

$$\frac{\textit{The number of requirements tested pre acceptance}}{\textit{Number of total requirements}}$$

2- Defect rate of acceptance and post- acceptance

$$\frac{\text{Number of defects}}{\text{Number of total requirements}}$$

$$\frac{\text{Number of defects}}{\text{Number of total lines of Code}}$$

$$\frac{\text{Number of defects}}{\text{man} - \text{days effort}}$$

3- Incoming change request rate in test and acceptance process

$$\frac{\text{Total change request in test process}}{\text{Total requirement count}}$$

$$\frac{\text{Test case count affected by the incoming change request}}{\text{Total test case count}}$$

4- Defect frequency for a specific time and the ratio of time to resolve these defects

$$\frac{\text{Defect count}}{\text{Time}}$$

$$\frac{\text{Defect count}}{\text{Total effort spent in terms of time}}$$

6.2 *Analysis TMMi Level of Company-B*

6.2.1 TMMi Level of Company-B

For another company, TMMi criteria were examined based on one of the defense industry projects with Company-B. During the evaluation of TMMi by the help of many competent on the assessment process; many documents, materials, standards and technologies, used for projects and organization itself, was shared with the evaluator.

Detailed answers to the process areas and related TMMi levels of Company-B can be tracked in Appendix-1.

It is indicated that all of the process areas within TMMi Level-2 and Level-3 are provided as expressed in Table 8. Company-B failed to provide one mandatory criterion for each Level-4 and Level-5. Company-B can provide Level-4, if one mandatory criterion is successfully achieved. Furthermore, Company-B was unable to provide the two of the optional criteria within Level-4. However, these optional two criteria are not directly effective regarding the company's Level-4 degree.

TMMi Levels & Process Areas	Status of Process Areas	Status of Levels
Level-2		Success
A- Test Policy and Strategy	Success	
B- Test Planning	Success	
C- Test Monitoring and Control	Success	
D- Test Design and Execution	Success	
Level-3		Success
A- Test Organization	Success	
B- Test Training Program	Success	
C- Test Lifecycle & Integration	Success	
D- Non-Functional Testing	Success	
E- Peer Reviews	Success	
Level -4		Failed
A- Test Measurement	Success	
B- Product Quality Evaluation	Success	
C- Advanced Reviews	Failed	
Level- 5		Failed
A- Defect Prevention	Success	
B- Quality Control	Success	
C- Test Process optimization	Failed	

Table 8

How many mandatory questions are provided for which levels within the TMMi can be followed on Figure 9 for Company- B having Test Maturity Level-3. As it is seen, Company-B has provided all the mandatory criteria within Level-2 and Level-3, but one mandatory criterion for each Level-4 Level-5 remained missing. Company-B is

required to provide 101th criterion: "Do you measure peer reviews based on product quality?" to get Level-4 degree.

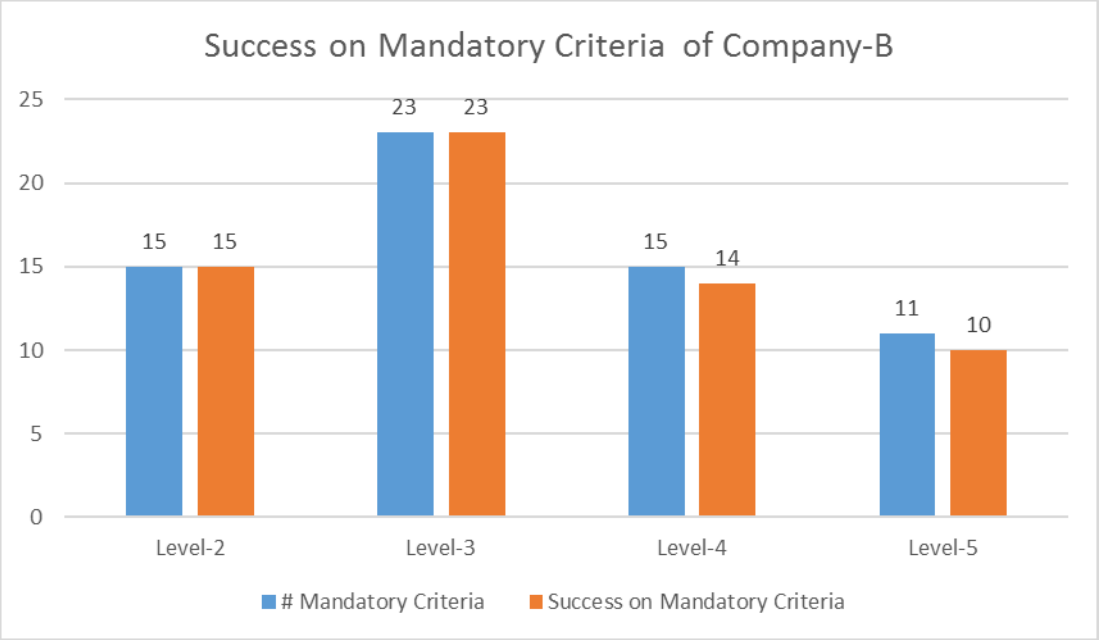

Figure 9

As can be seen in Figure 10 Company-B provides the majority of the optional criteria for each level and each process area. In case of completing mandatory criteria in this form, it will be successful in evaluation of Level-4 or Level-5 with current optional criteria situation.

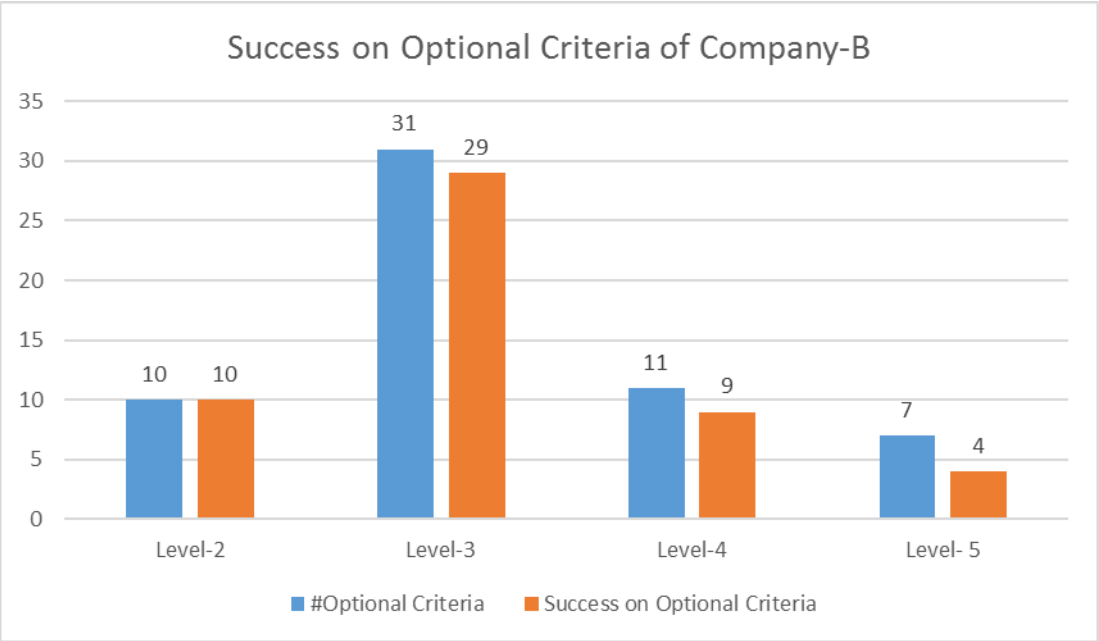

Figure 10

When looking at the mandatory criteria failed for Compnay-B within test maturity model, it is found having trouble about measurements of advanced reviews. In fact, it was observed trying to do both peer reviews and advanced reviews right but it is found that advanced reviews and quality processes are not parallel. As arising from this cause, it is expressed that the required measurements and estimations of reviews cannot be performed. Company-B is required to provide 122th criterion: "Do you apply test improvements?" to get Level-5 degree in case of already providing Level-4. In fact, although the organizational test improvements are analyzed as project outcomes, there are no improvement plans and test process about regular transfer of them to new projects is not made towards.

Detailed answers for the other TMMi levels and procurement information about whole criteria of Company-B can be tracked in Appendix-1.

6.2.2 Quality Values of Company-B

Based on quality metrics described in Section 5, various values over assessed project of Company-B have been obtained and required rates have been analyzed as follows. Company-B values are categorized in 4 and evaluated as expressed in Section-5. Outcome rates are also located within those categories.

1- The ratio of covered requirements of post-acceptance

$$\frac{\text{Number of requirements passed after acceptance}}{\text{Number of total requirements}}$$

1084 / 1137 = 95.3%

In the metric above, the total number of requirements and the requirement number at the end of the acceptance stage for Company-B is located. As can be seen, Company-B has a success rate like 95% in the acceptance process.

$$\frac{\textit{The number of requirements tested pre acceptance}}{\textit{Number of total requirements}}$$

1137 / 1137 = 100%

Company-B has analyzed test plan and test cases to cover all the requirements. Therefore, all the requirements have been tested before the acceptance testing.

2- Defect rate of acceptance and post- acceptance

$$\frac{\text{Number of defects}}{\text{Number of total requirements}}$$

675 / 1137 = 0.59

Defect emerging during acceptance and coming from users at post-acceptance and total requirement ratio for Company-B is 59%. The 59% of the total requirements considered as defective in acceptance and post-acceptance.

$$\frac{\text{Number of defects}}{\text{Number of total lines of Code}}$$

675 / 512K = 0.13%

This metric is issued the ratio of defect on acceptance and post-acceptance and the number of code lines. This shows that the code is defective out of 0,13%. There is 1.3 defective lines in the code out of every thousand lines.

$$\frac{\text{Number of defects}}{\text{man} - \text{days effort}}$$

675 / 980 = 0.69

The number of defects and man/days effort information is analyzed to evaluate how long it takes for the correction of the defects. It is reached to the knowledge that each of these defects can be fixed approximately in half a day. According to information provided by the Company-B, it has been committed to the company's customers that a developer will fix 2 bugs in a day in average. Company-B seems to fulfill this commitment in accordance with these results.

3- Incoming change request rate in test and acceptance process

$$\frac{\text{Total change request in test process}}{\text{Total requirement count}}$$

14 / 1137 = 0.012

The ratio of change requests from the customer in the testing process and acceptance process is 0.012. This also shows that 1.2% of the total requirement has been demanded a change.
This rate shows that static tests are largely performed and they are transferred to the dynamic test.

$$\frac{\text{Test case count affected by the incoming change request}}{\text{Total test case count}}$$

101 / 9716 = 0.0104

Total number of the test cases affected by change requests coming to Company-B and number of total test cases show that of 1.04% of test cases is affected by change requests.

4- Defect frequency for a specific time and the ratio of time to resolve these defects(*)

(*) There will be a certain time interval for each project for the defects from acceptance and after

$$\frac{\text{Defect count}}{\text{Time}}$$

675 / 28 = 24.11

The ratio of number of defects at UAT and after and return time from the customer for Company-B shows that an average of 24 defects have been found by customer daily.

$$\frac{\text{Defect count}}{\text{Total effort spent in terms of time}}$$

675 / 980 = 0.689

The effort of the correction of defects found (man/days cost) is 2 bugs in a day. This shows that half of the day is spent for each developer to fix an occurred bug.

6.3 *Analysis TMMi Level of Company-C*

6.3.1 TMMi Level of Company-C

TMMi criteria have been examined with Company-C based one of the telecom projects. During the evaluation of TMMi, more than one competent in the company has been interviewed, but the examination of materials and verification of documents has been limited due to the preference of the company.

Detailed answers to the process areas and related TMMi levels of Company-C can be tracked in Appendix-1.

As can be seen in Table 9, Company-C has been successful for Level-2 in terms of the answers they gave to the process areas. Yet, there are process areas failed for investigation of Level-3, Level-4 and Level-5. As Table 3 also stated, to provide Level-3, test organization, test lifecycle integration, and peer review improvements are required.

TMMi Levels & Process Areas	**Status of Process Areas**	**Status of Levels**
Level-2		Success
A- Test Policy and Strategy	Success	
B- Test Planning	Success	
C- Test Monitoring and Control	Success	
D- Test Design and Execution	Success	

Level-3		Failed
A- Test Organization	Failed	
B- Test Training Program	Success	
C- Test Lifecycle & Integration	Failed	
D- Non-Functional Testing	Success	
E- Peer Reviews	Failed	
Level -4		Failed
A- Test Measurement	Failed	
B- Product Quality Evaluation	Failed	
C- Advanced Reviews	Failed	
Level- 5		Failed
A- Defect Prevention	Failed	
B- Quality Control	Failed	
C- Test Process optimization	Failed	

Table 9

Company-C does not provide four of the mandatory criteria within TMMi Level-3. Deficiencies of mandatory criteria in the other maturity levels are also available, as it would be followed detailed by Figure 11. The following are mandatory criteria cannot be provided for Level-3. The 28th criterion is a question about the testing organization. It has been expressed that although titles used for test teams resemble, the distribution of tasks and responsibilities do not change considering the appropriate titles they use in Company-C. In addition, it has been observed that there are on responsibilities for sub-occupational groups like test manager, test designer or test environment engineer. It has been failed to meet the requirements for synchronization of testing and development lifecycle models that expressed in item 49, so the test lifecycle and integration process area has also failed. The last two mandatory criteria for the peer review process area are not also received affirmative responses.

“28- On the test organization, do you have responsibilities definition as the following topics?

a. Test manager

b. Test team leader

c. Test designer

d. Test Consultant

e. Test environment engineer

49- Are the phases of your test lifecycle model synchronized with the development lifecycle model?

65- Do you list the jobs needing reviews?

73- Do you publish a report for regard to peer reviews?"

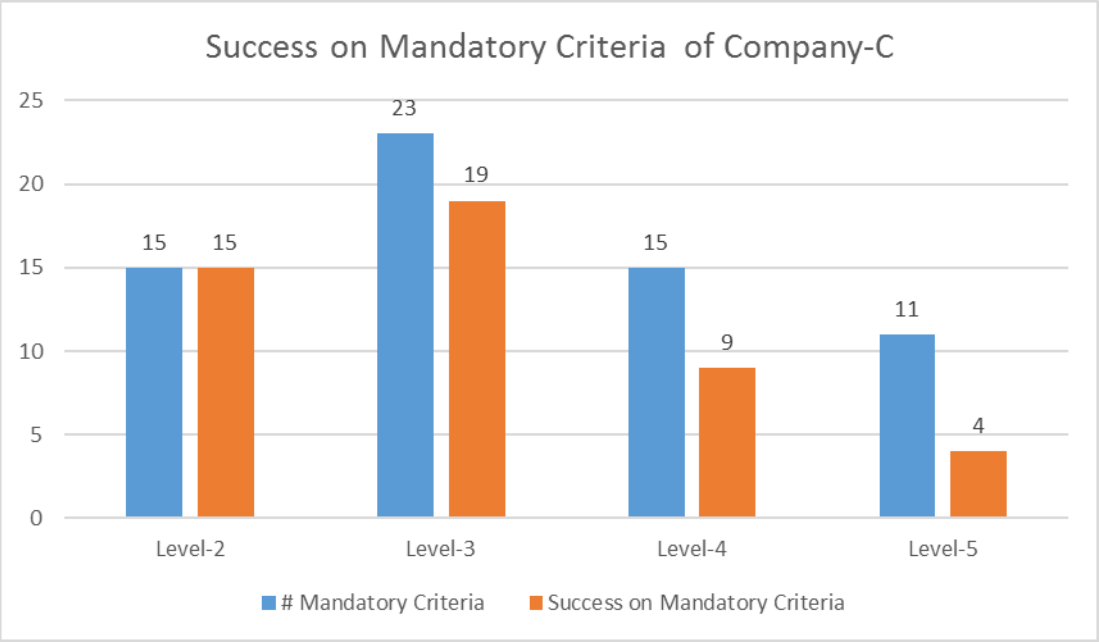

Figure 11

Optional criteria that are provided by Company-C in all models and in all the levels of maturity is shown in Figure 12 detailed. According to the answers to directed questionnaire that have been given, Company-C is failed to provide 17 of all the optional criteria in the TMMi model. Minimum optional criteria necessary to provide Level-3 are successful. If Company-C can succeed to provide four of the required mandatory criteria in the current state, it can be successful to achieve Level-3 maturity level with those optional criteria.

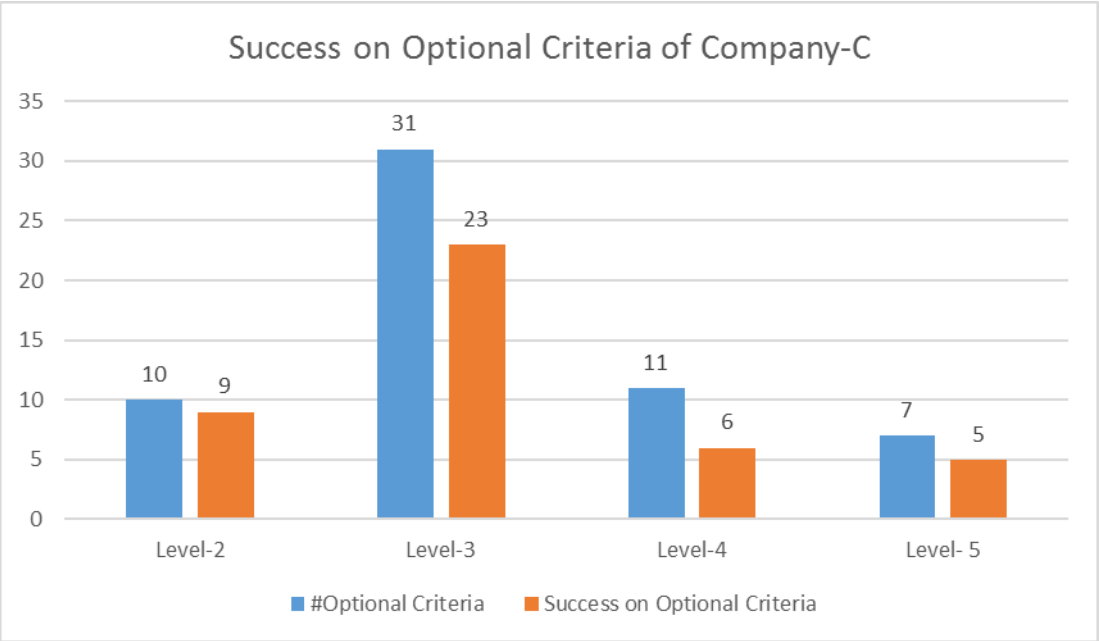

Figure 12

Detailed answers for the other TMMi levels and procurement information about whole criteria of Company-C can be tracked in Appendix-1.

6.3.2 Quality Values of Company-C

1- The ratio of covered requirements of post-acceptance

$$\frac{\text{Number of requirements passed after acceptance}}{\text{Number of total requirements}}$$

%100

The information about quantity of requirements passed was requested from Company-C In the acceptance phase. It was not given any information about the number of total requirements and passed requirements. The ratio given are provided without relying on any digital data. The above rate is 100% depending on the information given. Having such a result, Company-C should have no defects during whole acceptance stage. This is a much-unexpected situation in the software projects generally.

$$\frac{The\ number\ of\ requirements\ tested\ pre\ acceptance}{Number\ of\ total\ requirements}$$

%100

In the Company-C test cases are written in the testing stages prior to acceptance to cover all the requirements. Thus, tests of all the requirements need to be performed before acceptance.

2- Defect rate of acceptance and post- acceptance

Company-C does not keep any value for the following quality metrics and this information cannot be accessed.

$$\frac{\text{Number of defects}}{\text{Number of total requirements}}$$

$$\frac{\text{Number of defects}}{\text{Number of total lines of Code}}$$

$$\frac{\text{Number of defects}}{\text{man} - \text{days effort}}$$

3- Incoming change request rate in test and acceptance process

$$\frac{\text{Total change request in test process}}{\text{Total requirement count}}$$

1/300

Company-C mentioned that they can give out approximate information about above metrics and no numerical values for the above parameters are shared for this study. The ratio of change requests was reported to be approximately 0.003%.

$$\frac{\text{Test case count affected by the incoming change request}}{\text{Total test case count}}$$

1/300

Company-C stated the same value 0.003% for above metrics as for the change request and total requirement metrics. No numerical values used.

4- Defect frequency for a specific time and the ratio of time to resolve these defects(*)

(*) There will be a certain time interval for each project for the defects from acceptance and after

Company-C does not keep any value for the following quality metrics and this information cannot be accessed.

$$\frac{\text{Defect count}}{\text{Time}}$$

$$\frac{\text{Defect count}}{\text{Total effort spent in terms of time}}$$

CHAPTER 7

7 Conclusion

In this thesis study, the analyzing of TMMi is that test maturity model of test process which is more important and has more cost increasingly on the software project. In addition, assessment criteria definition of TMMi and apply TMMi on the software companies is included. Test process shows correctly product quality and customer satisfaction. And this thesis focuses on explaining TMMi framework and standards under which test process. TMMi framework defines process areas for test process but any study is not existing any assessment on the TMMi framework. In this thesis, assessment criteria of TMMi are defined within the limits of test maturity model. This study signifies the criteria which process area or which maturity level for TMMi.

To verify that correct working of the TMMi model, live and real companies which have test process on the development life cycle of their projects are needed to determine their TMMi Levels.

When choosing software companies, it was an attention that they have actively test process on the software development life cycle. For this reason, that is likely to Level-1 companies are already excluded from the scope of this thesis. TMM 3 companies who accept the assessment process have been examined for the assessment criteria. Section 6, assessment results of each company, TMMi levels are described in detail. The organizations are named as Company-A, Company-B, and Company-C. Company-B of them has been shown to have a Level-3 maturity. The others have Level-2 maturity.

This is another of the scope of this study, the model really is the effects of a product/project success. So the main purpose to make a study to find the answer is that the process areas of TMMi and applying primarily these process areas on the

projects, has an effect or not to develop a quality software product? In accordance with this purpose, some quality metrics have been defined. These metrics which are separated into 4 categories focus are determined by focusing directly affect the output. TMMi Level specified companies have been aimed to measure the success of the product and satisfaction via these metrics. The TMMi Levels of the companies has been investigated what the direct impact on the quality metrics results.

In the evaluation, the maturity level of the Company-A is reached Level-2. Quality metrics need for numerical values could not be collected from the Company-A. The test maturity Level of Company-B is Level-3 on the end of the evaluation. It was observed that Company-B keeps the all required parameters for quality metrics measurement. Also, the same measurement is used and reported on the project. The test maturity level of the Company-C is also Level-2. the company is not keeping the quality metric measurements completely and has not been shown to be of similar quality. Evaluation of actual numerical data could be provided by only Company-B from all companies. At this point, although no statistical data of all companies can be compared with each other, Company-B of all companies tries to make some works to satisfy customer, its indicators are that Company-B ensures necessary process areas of Level-3, keeps data for test measurement and collects them, analysis output of the test process and compare estimations real outputs. All of them these activities are the expected work area on TMMi Level-4. For this study, the model verification is not possible at this point, even if the numerical data, this includes another indicator that assessment cannot be made to ensure a high level unless a lower level as advocated by TMMi. If the scope of test measurement process area and product quality process evaluation process area on Level-4 is not provided, Level-4 will be failed for TMMi. With this information, Company-B can keep and measure this quality metric and also, it can provide these process areas of the Level-4. On the other hand, It can be followed on Table 9, both of Company-A and Company-C have Level-2 maturity level. They cannot complete all process areas of Level-3 successfully. When these companies are determined for Level-4, all process areas of Level-4 were failed for Company-A and Company-C assessments. So it shows that a company should be at a low Level-3 to analysis quality metric of the companies. Moreover, it shows us

another point, while a level is not provided completely, process areas of a higher level is not provided anyway as TMMi considers.

TMMi Levels & Process Areas	Company-B	Company-A	Company-C
Level-2			
A- Test Policy and Strategy	Success	Success	Success
B- Test Planning	Success	Success	Success
C- Test Monitoring and Control	Success	Success	Success
D- Test Design and Execution	Success	Success	Success
Level-3			
A- Test Organization	Success	Success	Failed
B- Test Training Program	Success	Failed	Success
C- Test Lifecycle & Integration	Success	Success	Failed
D- Non-Functional Testing	Success	Failed	Success
E- Peer Reviews	Success	Failed	Failed
Level -4			
A- Test Measurement	Success	Failed	Failed
B- Product Quality Evaluation	Success	Failed	Failed
C- Advanced Reviews	Failed	Failed	Failed
Level- 5			
A- Defect Prevention	Success	Failed	Failed
B- Quality Control	Success	Failed	Failed
C- Test Process optimization	Failed	Failed	Failed

Table 10

On the assessments of Company-A and Company-C, any criteria of process areas of Level-4 and Level-5 are not provided. When the rules are examined on the TMMi, this is an expected case. Similarly, while Company-B is not providing Level-4, it cannot provide the criteria of Level-5.

This output shows that every process areas of a maturity level are binding for the process areas of a high level. When Level-2 is not completed successfully, Leve-3 evaluation cannot be made due to this ionic bond of the process areas each other.

Likewise, software process models such as TMMi have some objectives to measure customer satisfaction, measure test process, monitor and order chaotic test process. So it is already not expected that a company which has Level-2, have achieved full result data for quality metrics or be better than other companies in Level-3/4. Thus, Level-2 Companies is not made these measurements but any other Level-3 companies can achieve this data. It means that TMMi has correct assessment criteria in its consistent and rules. TMMi can be argued for producing the correct output.

After this study, there are new several goals for the development of TMM level. The most important ones of these goals that a study group can be created to analyze every TMMi levels on different areas of the software industry. The companies on these study groups will be made TMMi assessment to find TMMi Levels and the necessary statistical quality metrics can be gotten and researched from this study group.

Another apparent point is to be developed, new/different assessment can be improved for TMMi each level. If the effect of optional criteria increases in the process areas and new assessment and scaling are added, new sub-levels can be defined on each TMMi levels. Model is an obvious improvement to identify the sub-levels with focusing on the optional criteria at each TMMi Levels.

The lastly, TMMi assessment can be applied to a study group which is software companies again. But all companies will have different levels on CMMi. Companies in different CMMi Level will be researched their TMMi Levels. According to a similar process area of the CMMi and TMMi, the differences between CMMi and TMMi can be studied statistically. And the effects each other can be investigated.

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APPENDICES

APPENDIX 1

Overview of TMMi Assessment

Parameters2	Values	Meaning
Result of the company	1	Provide
	0	Not Provide
Providing conditions	0	All section Not Provide
	1	All section Provide
	M	Mandatory
	O	Optional
Mandatory Criteria Color	Not Provide	
Optional Criteria Color	Not Provide	

1- Answers of Company-A for TMMi Assessment

Levels and Questions	Result of the company	providing conditions	Column1
Level 2-			
A- Test Policy and Strategy			Success
1- Do you define a test policy on the project?	1	1	M
2- Does your test policy include the following topics? :	1	1	M
i. Objectives	1		
ii. Business objectives	1		
iii. Quality objectives	1		
iv. Quality Planning	1		
v. Risk Levels	1		
3- Do your company have a standard	1	1	O

documentation which is defined by the quality team for your test policy?			
4- Is the test policy review by test experts as internal? Does stakeholder review the test policy?	1	1	M
5- Do you have a test strategy?	1	1	M
a. Are the product risks defined on the test strategy?	1		
b. Which are variables used to categorize the product risks	1		
c. Which risks of the product are assessed when defining the test model of your project (V-model, incremental, lifecycle)	1		
d. Do you determine your objectives, personnel responsibilities, their tasks for each test level in the test strategy.	1		
i. Unit test	1		
ii. Integration Test	1		
iii. System test	1		
iv. Acceptance test	1		
B- Test Planning			Success
6- Do you have a test plan?	1	1	M
7- Are the product risks defined in the test plan?	1	1	O
8- Does the test plan have test approaches and test techniques?	0	0	O
9- Does your test plan have the following topics?		1	O
a. Experiences of the test engineers	0		
b. Cost per man/day for the project	1		
c. Development lifecycle	1		
d. Bug fix & Re-test	1		
e. Documentation standards & review process	1		
f. Regression tests	1		
g. Manuel & Automation tests	1		
h. Test tools will be used	1		
i. Constraints in the test environment	1		
j. Project deadline & test deadline	1		
10- Do your customer and stakeholders review the test plan?	1	1	M
11- In the Test Plan, do you have a process and its test report to find and fix defects for each test	1	1	M

phases? (or Does test process have these phases?)			
12- Does the test plan have test schedule?	1	1	O
a. How long will the testing activities	1		
b. Which will test phases	1		
c. Which tests will be entered which phase	1		
d. Milestones/ checkpoints	0		
13- Do you have master and sub test plans? Which phase are they updated/ how often are they updated	1	1	M
C- Test Monitoring and Control			Success
14- Do you keep the test execution performance?	1	1	M
a. How many test cases are executed on how long time?	1		
b. The amount of the test cases are run by a tester on a day. (the similar measurements …etc.)	1		
15- Do you follow the cost and effort of test execution? How often? Which variables are based?	1	1	M
16-Do you analysis to completion test tasks and cost of test?	1	1	M
17- Do you determine the cost of defects to fix and re-test for each test tasks?	1	1	O
a. Number of Defects (for component, system, sub system)	1		
b. Do you define the priorities of the defects	1		
c. Do you establish the rates of the defects which are found and fixed on each test process	1		
d. Are the defects defined according to the following variables	1		
i. Data	1		
ii. Requirement	1		
iii. System	1		
iv. External Systems	1		
v. Configuration	1		
D- Test Design and Execution			Success
18- Which phases do you prefer black box/white box testing on		1	O
a. Black box → equivalence → boundary → decision Table →state transition	1		
b. White box → statement → decision branch → condition testing	0		

19- Do you use test conditions when test cases are created?	1	1	M
20- Are pass/fail criteria defined?	1	1	M
21- Are your test cases reviewed?	1	1	M
22- Do your test cases include the following topics?		1	O
a. Test Case identifier	1		
b. Environment requirements	1		
c. Preconditions	1		
d. Input/output specifications	1		
23- Do you smoke test before beginning the test cases on the environment?	1	1	O
a. All basic functions work?	1		
b. Positive test cases on functions of all components works correctly?	1		
c. Interface of the application is correct?	1		
d. A component and another component work together correctly?	1		
e. Application has connections with external systems, it works correctly with that systems?	1		
24- Are test Documentation, user manuals and integration manuals ready before beginning tests?	1	1	O
25- Is it getting recorded and reported that (test Environment, test data, test documentation...etc.) the cause of the problems during the test? (Blocking test execution)	1	1	M
Level-3-			
A- Test Organization			Success
26- Do you have a test organization (test team or group) on the company?	1	1	M
27- What is the place of your test organization on the organization schema of the company?	1	1	M
a. What is the relation between development team and test team? Is the test group depending on development team directly?	1		
b. Who assign the tasks and responsibilities for the test team?	1		
c. How is reporting process path? Do you establish the test reports to development team or PM team?	1		
d. Do test organization and stakeholders review your documentations?	1		

e. Do you have a documentation for review commits?	1		
28- On the test organization, do you have responsibilities definition as the following topics		1	M
a. Test manager	1		
b. Test team leader	1		
c. Test designer	1		
d. Test Consultant	1		
e. Test environment engineer	1		
Do responsibilities on the test group is determined as follows in accordance with requirements?		1	O
a. Test automation architect	0		
b. Test automation engineer	1		
c. Performance test engineer	1		
d. Usability test engineer	0		
e. Test process improvement specialist	1		
30- Do you have specialist personnel who are not test specialist but they support test process?		0	O
a. SW developer	0		
b. System engineer	0		
c. System integrator	1		
d. User representative	0		
31- Does your company have titles as junior, intermediate, senior ..etc for your test specialist?	1	1	M
a. Definition a framework for the career of a test specialist?	1		
b. Tasks and Responsibilities of the test specialist hierarchical?	1		
c. HR defines and apply the same hierarchical structure for test organization?	1		
32- Does your company have a personal career development plan & path for test engineer? Are these revised if it is needed?	1	1	M
33-On test organization,		1	O
a. Do you define test process improvement?	1		
b. Do you update test organization structure for test improvements?	1		
c. How do you monitor and control on the test organization?/ Who monitor and control on the	1		

test organization			
d. Do you update responsibilities and tasks accordance with resource and schedule?	1		
e. Do you review and update your test process improvements?	1		
34- Do you have a deployment plan defined in the project?	1	1	M
35- Do you have a checklist related to deployment? Does it update?	1	1	M
36- Do the training exist to change process and documents for deployment and tests ?	1	1	O
37- Are the test metrics, test DB, test tools and resolved/re-test approach explained to the test team? And Do you keep on any document recording?	1	1	O
38- Do you have "Change Management" process on the test organization?	0	0	O
39- Do you use a test model like TMMi or another model when you create test organization structure?	0	0	O
a. Do you make test process improvement plan?	0		
b. Do you make test process deployment plan?	1		
B- Test Training Program			Failed
40- Do you have professional training and certificate programs for test engineers?	0	0	M
41- Do you have internal training for test engineers?	1	1	M
42- Do you choose training which is parallel subjects with the projects?	0	0	O
43- How do you define needs of test training?		0	O
a. Is test schedule created depending on the training activities?	0		
b. Do you have training materials? Have they kept accordance with any software standards?	0		
c. Do you choose the following topics for test engineers training:	0		
i.			

Requirement engineering			
ii. Test Automation			
iii. Database Management			
iv. UML Design			
v. Risk Management			
vi. Configuration Management			
vii. Development lifecycle			
d. Do you have cross training on your test organization? Do test engineers who take different training make knowledge transfer?	1		
44- Are new topics defined for the training programs accordance the projects?	0	0	O
45- Do you make an assessment such as successful/unsuccessful to test engineers for test training?	1	1	M
46- When internal training on the test organization, Do you define a standard like the following topics?		0	O
a. Knowledge and Skill need analysis	1		
b. Course design	1		
c. Training delivery methods	0		
d. Refreshing training on subject matter	0		
C- Test Lifecycle & Integration			Success
47- Have you defined your test life cycle model in an arbitrary document?	1	1	M
48- Are the following topics defined depending on the test lifecycle model?		1	O
a. Test strategy, testing levels and test objectives	1		
b. Phases, planning control stages, execution and test implementations	1		
c. Test input/output criteria for every single phase	1		
d. Responsibilities for every single phase	1		
e. Milestones for every single phase	1		
49- Are the phases of your test lifecycle model synchronized with the development lifecycle	1	1	M

model?				
a. Are the tests performed in parallel dependency with the requirements developed?	1			
b. Is there any prioritization among your test objectives? Are you updating the prioritization depending on the development plan?	1			
c. Is your document updated and reported depending on change requests among objectives?	1			
50- For any defined process inside test lifecycle			1	O
a. Are you recording the testing estimations and its output? (job quantity, effort, cost)	1			
b. Do you have quality measurement metrics? (priority level, defect count)	1			
c. Do you have peer review?	1			
d. Do you have test coverage?	1			
e. Do you use reliability measurements?	1			
51- Do you use the following tools for testing management			1	O
a. Database management tools	1			
b. Process modeling tools	1			
c. Web page builders	0			
d. Project planning/scheduling, configuration management, test management tools.	1			
52- Do you consider the following topics for test tracking and control in test lifecycle?			1	O
a. Change request count of requirements for any test process	1			
b. Daily development requirements of test process and changed test process	1			
c. Is the master plan revised periodically?	1			
d. Test items and risk levels of the test items?	1			
e. Is the effort, cost and schedule are revised following any sub-test plan?	0			
D- Non-Functional Testing				Failed
53- Do you define non-functional product risks?	0	0		M
54- Do you use some of the following techniques	0	0		O
a. Risk workshops	0			

b. Brainstorming	0			
c. Expert interviews	0			
d. Checklist	0			
e. Lesson learned	0			
In the process of defining non-functional risks				
f. Do you grade and prioritize them?	0			
55- Do you classify non- functional product output criteria like following?	0	0	O	
a. For reliability (Mean time between failures →MTBF) (Mean time to repair →MTTR)	0			
b. For usability (User satisfaction, average time to perform the functions)	0			
c. For efficiency (mean response time, memory utilization)	0			
d. For maintainability (average effort to change, availability of documentation)	1			
56- Do you define the non-functional test conditions (or requirements) or non-functional test design specifications of the product?	1	1	M	
57- Do you have traceability matrix for non-functional req./test conditions? Do you cover non-functional requirements with corresponding test cases? Are these test cases performed?	1	1	M	
58- Do you setup data/test scripts for non-functional tests?	1	1	O	
59- Do you setup test environments for non-functional tests?	1	1	M	
60- Do you setup test procedure, test data and test scripts in advance of performing non-functional test cases?	1	1	O	
a. Do you record and report the tests?	1			
b. Do you compare the results with the expected results?	1			
c. Are the tests repeated for resolved cases?	1			
d. Do you make regression for non-functional tests?	0			

61- Do you make reviews for non-functional tests?	1	1	M
62- Do you use tools for non-functional tests?	1	1	O
63- Do you report your test results?	1	1	M
64- Do you perform measurement with regard to test effort?	1	1	O
E- Peer Reviews	1		Failed
65- Do you list the jobs needing reviews?	1	1	M
66- Do you define an approach regarding how to review? (What do you pay attention with jobs to be done. etc.)	1	1	O
67- Are you logging reading reviews done?	0	0	M
68- Do you have peer reviews schedule?	1	1	M
69- Does your peer reviews include following stages?	1	1	O
a. Inspection (Control)	1		
b. Walkthrough (itinerary/sampling)	1		
c. Technical review	1		
d. Informal review	1		
70- Do you prepare your review approaches with the stakeholders?	1	1	O
71- Do you have a form for keeping records of peer reviews?	0	0	O
72- Do you take an action item for the cases generated after review result?	1	1	M
73- Do you publish a report for regard to peer reviews?	1	1	M
74- Do you define an input/output criteria for regard to pre-peer review findings (defect)?	0	0	O
75- Do you analyze your peer reviews?	1	1	O
a. Do you define estimated time and time spent rates for peer reviews?	1		
b. Do you make an expected findings estimation before the review?	0		
c. Do you classify findings according to priority and types?	1		
d. Do you inspect the reasons of situations	1		

mentioned in the findings?			
e. Do you analyze the time cost for resolving of these situations?	0		
76- Do you discuss the results of peer review with the stakeholders?	1	1	O
77- Do you have a role distribution of peer review like following?	0	0	O
a. Review leader (Moderator)	0		
b. Checker (Reviewer)	0		
c. Scribe (Recorder/Note taker)	0		
d. Author (Preparer)	0		
78- Does your employee get training associated with peer review?	0	0	O
a. Do you have training materials?	0		
79- Do you publish rules and checklists about the peer review documents?	0	0	O
Level -4			Failed
A- Test Measurement			
80- Do you define your test measurement objectives?	1	0	M
a. Do you get related information from the customers and stakeholders in the definition stage?	1		
b. Do you use traceability matrix for test measurement objectives?	1		
c. Do you verify and query your defined test measurement objectives?	0		
81- Do you define estimated/actual measurement rates of test effort and test cost?	1	0	M
a. Do you evaluate and measure regarding estimated/actual test cases?	1		
b. Do you classify the defects according to severity and priority?	1		
c. Do you calculate the defect detection rate?	1		
d. Do you have structural coverage and code coverage process?	0		
e. Do you use requirement coverage?	1		
f. Do you use Mean Time Between Failures (MTBF) and Mean Time to repair (MTTR)?	1		
g. Do you use burn down measurement? (I.e. for weekly test case execution)	1		
82- Do you have a data collection and storage procedure for measured data?	1	1	O

a. Do you have a defined procedure for gathering data, do you have a guide consisted of these processes?	0		
b. Are the data saved according to a timeline order?	1		
c. Do you have a defined security/authorization procedure for data collection?	1		
d. Is your data collection process is also automated? Do you use a collection tool for this?	1		
e. How do you analyze the defected/faulty data? Do you use a verification tool for this?	0		
f. Do you share the measurement data with the stakeholders?	1		
83- Do you have a draft version and/or standard about test measurement reports?	1	1	M
84- Do you revise the measurement data?	0	0	M
a. Do you have an authorization in order to access data?	0		
85- Does your employee get training associated with test measurement process?	0	0	O
86- Do you classify test measurement data and address them with test measurement objectives?	0	0	O
B- Product Quality Evaluation			Failed
87- Do you define the product quality requirements and purposes?	1	1	M
88- Do you apply following quality requirement processes with the customers and stakeholders?		1	O
a. Do you apply surveys and questionnaires?	0		
b. Do you separate quality requirements into focus groups?	1		
c. Do you make brainstorming?	1		
89- Do you define the attributes of product quality like following?	0	0	M
a. Functionality	0		
b. Reliability	0		
c. Maintainability	0		
d. Portability	0		
e. Efficiency	0		
90- Do you define a quantitative product purpose for any quality attribute?	0	0	O
91- Do you establish a traceability between product quality purposes and the requirements?	1	1	M

92- Do you collect quality measurement data and review them?	0	0	M
a. Do you report them?	1		
b. Do you use them in the presentations with customers and stakeholders?	1		
c. Do you take corrective actions according to quality measurement data?	0		
93- Do you use any tools for Quality Measurement Analysis?	1	0	O
a. Do you analyze a cost for quality metrics? (Cost of poor quality & cost for achieving quality goals)	0		
C- Advanced Reviews			Failed
94- Do you review the product risk plan?	0	0	M
95- Do you review the product work breakdown?	1	1	M
96- Do you review the master test plan?	1	0	M
a. Do you document and save the review commits applied?	0		
97- Do you define review types for every work done?	0	0	M
98- Is the review planning applied in the test approach coordination phase?	1	1	O
a. Proper source for review	1		
b. Proper potential reviewers according to knowledge and talent	1		
c. Review task planning for project and test deadline	1		
d. Effort/cost defining and falling them within test plan	1		
99- Do you have measurement guidelines for peer review?	0	0	O
a. Do you have rules and review checklist?	0		
b. Do you have sample guidelines?	0		
c. Do you have perspective based reading procedures?	0		
d. Do you record checking rate? (i.e. Hourly review paper count)	0		
100- Are you logging peer reviews?	1	1	M
a. Do you construct an action list for peer reviews?	1		
b. Do you report and store them?	1		
c. Do you compare peer review results according to output criteria?	0		

101- Do you measure peer reviews based on product quality?	0	0	M
102- Do you apply a review for product quality measurement at the beginning of the application development lifecycle? (static tests)	0	0	O
103- Are peer reviews also performed in a group supervised by a leader or a moderator?	1	1	M
a. Is review meeting organized?	1		
b. Are the provisions organized like meeting schedule and location?	1		
104- Is the method of peer review process is specified in the master test plan?	0	0	O
105- Do you cover the following topics in peer review process?		0	O
a. Product risks assessment	0		
b. Defining a coordinate test approach	0		
c. Types of reviews	0		
d. Defining peer reviews quantitative exit criteria	0		
e. Document rules and checklist	0		
f. Sampling practices	0		
g. Perspective based ready	0		
h. Data collection, analysis, reporting	1		
Level- 5			
A- Defect Prevention			Failed
106- Do you construct a schema when classifying defects?	1	1	M
107- Do you define defect selection parameters?	0	0	M
a. Do you analyze classified defects?	0		
b. Do you specify their reasons?	0		
108- When specifying defect selection parameters		0	M
a. Do you estimate the potential harm of a defect?	1		
b. Do you determine the incidence frequency of a defect?	0		
c. Do you plan the time cost and effort of fixing the defect?	1		
d. Do you calculate the time cost and effort of preventing the defect?	1		
e. Do you organize the scope of the negative effects of a defect?	1		
109- Do you share selection parameters with the	0	0	M

customer and stakeholders for them to review?				
a. Do you report selection parameters defect classification schemes?	0			
b. Do defect reports cover static/dynamic tests and operational usage (actual user tests and actual user operational usage)?	0			
110- Do you separate defects as		0	O	
a. Root cause of selected defects	1			
b. Common cause of selected defects	0			
when analyzing selection defects				
c. Do you use one or some of the following methods when analyzing root causes?	0			
i. Cause/effect diagrams	0			
ii. Ishikawa fishbone diagrams				
iii. Fault tree analysis				
iv. Process analysis				
v. Use standard defect classifications (IEEE 1044)				
vi. FMEA (Failure mode effect analysis)				
vii. Hardware and Software Interaction analysis				
d. Do you categorize common causes in analysis one or some of the following?	0			
i. Process				
ii. People				
iii. Organization				
iv. Communication				
v. Architecture				
vi. Technology				
vii. Tools				
viii. Environment				
111- Do you define possible solutions for defects? (Process, work product standard, organizational structure, training, review activities, test strategy, methods and technologies, checklist, coding standards, tools) and do you define these solutions?	1	1	M	
112- Do you have defect prevention process?	0	0	M	

a. Do you specify organizational objectives for defect prevention?	0		
b. Do you perform key measurements for it?	0		
c. Are quality metrics and root causes are associated with firms expectations?	0		
d. Does testing team (or process improvement team) coordinate defect prevention activities?	0		
e. Is any plan prepared for defect prevention process and is updated in case of necessity?	0		
113- Is the following defect prevention measurements performed?	0	0	O
a. Cost of defect prevention activities	0		
b. # defect analyzed	0		
c. # root cause identified	0		
d. # action proposal outstanding and how long	0		
e. # action proposal submitted	0		
B- Quality Control			Failed
114- Are test process associated with quality control processes? (Statistically controlled test process)	1	0	M
a. Do you publish test process performance objectives?	0		
i. Do you revise quantities objectives for test process performance?			
1. When organization's business objectives are changed			
2. When organization's test process are changed			
3. When objectives are not coherent with the actual results od test process performance			
b. Do you perform test process performance measurements?	0		
i. Are test process performance measurements reviewed?			
ii. Are these measurements revised?			
c. Do you have test process performance baselines?	1		
i. Do you analyze the data gathered through test process performance measurements?			

1. Do you define moral validating this data along with the customer?			
2. Do you revise your baselines?	0		
a. Apply statistical methods to understand variations			
i. Do you collect measurements performed?			
ii. Do you publish upper and lower boundaries?			
iv. Do you install control charts, histograms, run charts, prediction intervals?			
b. Monitor performance			
i. Do you compare test process performance objective with the boundaries?			
ii. Do you perform reviews periodically? Do you conclude test process success and perfection?			
iii. Do you publish test process capability deficiencies and document it?			
115- Do you define and develop operational and usage models?	0	0	M
a. Develop customer profile			
b. User profile			
c. System mode profile			
d. Functional profile			
e. Operational profile			
f. Review operational profiles (stakeholders)			
g. Are these profiles revised?			
116- Are test cases reviewed by the stakeholders?	0	0	O
a. Are test cases covered with actual usage?	0		
b. Are test cases revised?	0		
c. Are test results analyzed and recorded?	0		
117- Do you define severity level of defects?	1	0	O
a. Are confidence goal/measurements coherent with reliability?	0		
b. Are they Documented and reviewed?	0		
118- Are the following tools used for Quality Control process?		0	O
a. DB management tools	0		
b. Process modeling tools	1		
c. Statistical analysis package	0		
d. Incident management tools	0		
e. Coverage tools	0		
f. Statistical process and quality control	0		

package			
g. Reliability measurement tools	1		
119- Does your employee get training associated with quality control process?	1	1	O
C- Test Process optimization			Failed
120- Do you specify test process improvements initially or afterward a project?	0	0	M
a. Do you gather and analyze test process improvement proposals?	0		
b. Do you evaluate these proposals as a pilot?	0		
c. Do you specify needed test process improvements to apply?	0		
121- Do you define new test techniques in case of improvement in test process?	0	0	O
a. Do you examine and analyze new test techniques?	0		
b. Do you apply new test techniques and technologies as a pilot?	0		
c. Do you constitute new test technologies to apply?	0		
122- Do you apply test improvements?	0	0	M
a. Planning	0		
b. In management & trailing	0		
c. Do you measure the effects of improvements?	0		
123- Do you re-use of high-quality test process assets?	1	0	M
a. Do you define your assets?	0		
b. Do you use a library to re-use assets specified?	0		
c. Do you utilize your reusable test assets in other projects?	1		
c. Do you utilize your reusable test assets in other projects?			
c. Do you utilize your reusable test assets in other projects?			

2- Answers of Company-B for TMMi Assessment

Levels and Questions	Result of the company	providing conditions	Column 1
Level 2-			
A- Test Policy and Strategy			Success
1- Do you define a test policy on the project?	1	1	M
2- Does your test policy include the following topics? :	1	1	M
i. Objectives	1		
ii. Business objectives	1		
iii. Quality objectives	1		
iv. Quality Planning	1		
v. Risk Levels	1		
3- Do your company have a standard documentation which is defined by the quality team for your test policy?	1	1	O
4- Is the test policy review by test experts as internal? Does stakeholder review the test policy?	1	1	M
5- Do you have a test strategy?	1	1	M
a. Are the product risks defined on the test strategy?	1		
b. Which are variables used to categorize the product risks	1		
c. Which risks of the product are assessed when defining the test model of your project (V-model, incremental, lifecycle)	1		
d. Do you determine your objectives, personnel responsibilities, their tasks for each test level in the test strategy?	1	1	M

i. Unit test	1			
ii. Integration Test	1			
iii. System test	1			
iv. Acceptance test	1			
B- Test Planning				Success
6- Do you have a test plan?	1	1	M	
7- Are the product risks defined in the test plan?	1	1	O	
8- Does the test plan have test approaches and test techniques?	1	1	O	
9- Does your test plan have the following topics?		1	O	
a. Experiences of the test engineers	0			
b. Cost per man/day for the project	0			
c. Development lifecycle	1			
d. Bug fix & Re-test	1			
e. Documentation standards & review process	1			
f. Regression tests	1			
g. Manuel & Automation tests	1			
h. Test tools will be used	1			
i. Constraints in the test environment	1			
j. Project deadline & test deadline	1			
10- Do your customer and stakeholders review the test plan?	1	1	M	
11- In the Test Plan, do you have a process and its test report to find and fix defects for each test phases? (or Does test process have these phases?)	1	1	M	
12- Does the test plan have test schedule?	1	1	O	
a. How long will the testing activities	1			
b. Which will test phases	1			
c. Which tests will be entered which phase	1			

d. Milestones/ checkpoints	1		
13- Do you have master and sub-test plans? Which phase are they updated/ how often are they updated	1	1	M
C- Test Monitoring and Control			Success
14- Do you keep the test execution performance?	1	1	M
a. How many test cases are executed on how long time?	1		
b. The amount of the test cases is run by a tester on a day. (the similar measurements …etc.)	1		
15- Do you follow the cost and effort of test execution? How often? Which variables are based?	1	1	M
16- Do you analysis to completion test tasks and cost of test?	1	1	M
17- Do you determine the cost of defects to fix and re-test for each test tasks?	1	1	O
a. Number of Defects (for component, system, sub system)	1		
b. Do you define the priorities of the defects	1		
c. Do you establish the rates of the defects which are found and fixed on each test process	1		
d. Are the defects defined according to the following variables	1		
i. Data	1		
ii. Requirement	1		
iii. System	1		
iv. External Systems	1		
v. Configuration	1		
D- Test Design and Execution			Success
18- Which phases do you prefer black box/white box testing on	1	1	O

a. Black box → equivalence → boundary → decision Table →state transition	1		
b. White box → statement → decision branch → condition testing	1		
19- Do you use test conditions when test cases are created?	1	1	M
20- Are pass/fail criteria defined?	1	1	M
21- Are your test cases reviewed?	1	1	M
22- Do your test cases include the following topics?		1	O
a. Test Case identifier	1		
b. Environment requirements	1		
c. Preconditions	1		
d. Input/output specifications	1		
23- Do you smoke test before beginning the test cases on the environment?	1	1	O
a. All basic functions work?	1		
b. Positive test cases on functions of all components work correctly?	1		
c. The interface of the application is correct?	1		
d. A component and another component work together correctly?	1		
e. The application has connections with external systems, it works correctly with that systems?	1		
24- Are test Documentation, user manuals and integration manuals ready before beginning tests?	1	1	O
25- Is it getting recorded and reported that (test Environment, test data, test documentation...etc.) the cause of the problems during the test? (Blocking test execution)	1	1	M
Level-3-			Success
A- Test Organization			
26- Do you have a test organization (test team or group) on the company?	1	1	M

27- What is the place of your test organization on the organization schema of the company?	1	1	M
a. What is the relation between the development team and test team? Is the test group depending on development team directly?	1		
b. Who assign the tasks and responsibilities for the test team?	1		
c. How is reporting process path? Do you establish the test reports to the development team or PM team?	1		
d. Do test organization and stakeholders review your documentations?	1		
e. Do you have a documentation for review commits?	1		
28- On the test organization, do you have responsibilities definition as the following topics		1	M
a. Test manager	1		
b. Test team leader	1		
c. Test designer	1		
d. Test Consultant	1		
e. Test environment engineer	1		
Do responsibilities on the test group is determined as follows in accordance with requirements?	1	1	O
a. Test automation architect	1		
b. Test automation engineer	1		
c. Performance test engineer	1		
d. Usability tests engineer	1		
e. Test process improvement specialist	1		
30- Do you have specialist personnel who are not testing specialist but they support test process?	1	1	O
a. SW developer	1		
b. System engineer	0		
c. System integrator	1		
d. User representative	1		

31- Does your company have titles as junior, intermediate, senior ..etc. for your test specialist?	1	1	M
a. Definition a framework for the career of a test specialist?	1		
b. Tasks and Responsibilities of the test specialist hierarchical?	1		
c. HR defines and apply the same hierarchical structure for test organization?	1		
32- Does your company have a personal career development plan & path for test engineer? Are these revised if it is needed?	1	1	M
33-On test organization,		1	O
a. Do you define test process improvement?	1		
b. Do you update test organization structure for test improvements?	1		
c. How do you monitor and control on the test organization?/ Who monitor and control on the test organization	1		
d. Do you update responsibilities and tasks accordance with resource and schedule?	1		
e. Do you review and update your test process improvements?	1		
34- Do you have a deployment plan defined in the project?	1	1	M
35- Do you have a checklist related to deployment? Does it update?	1	1	M
36- Do the training exist to change process and documents for deployment and tests ?	1	1	O
37- Are the test metrics, test DB, test tools and resolved/re-test approach explained to the test team? And Do you keep on any document recording?	1	1	O
38- Do you have "Change Management" process on the test organization?	1	1	O

39- Do you use a test model like TMMi or another model when you create test organization structure?	1	1	O
a. Do you make test process improvement plan?	1		
b. Do you make test process deployment plan?	1		
B- Test Training Program			Success
40- Do you have professional training and certificate programs for test engineers?	1	1	M
41- Do you have internal training for test engineers?	1	1	M
42- Do you choose training which is parallel subjects with the projects?	1	1	O
43- How do you define needs of test training?	1	1	O
a. Is test schedule created depending on the training activities?	1		
b. Do you have training materials? Have they kept accordance with any software standards?	1		
c. Do you choose the following topics for test engineers training:	1		
i. Requirement engineering	1		
ii. Test Automation	1		
iii. Database Management	1		
iv. UML Design	1		
v. Risk Management	1		
vi. Configuration Management	1		
vii. Development lifecycle	1		

d. Do you have cross training on your test organization? Do test engineers who take different training make knowledge transfer?	1			
44- Are new topics defined for the training programs accordance the projects?	1		1	O
45- Do you make an assessment such as successful/unsuccessful to test engineers for test training?	1		1	M
46- When internal training on the test organization, Do you define a standard like the following topics?	0		0	O
a. Knowledge and Skill need analysis				
b. Course design				
c. Training delivery methods				
d. Refreshing training on subject matter				
C- Test Lifecycle & Integration				
47- Have you defined your test life cycle model in an arbitrary document?	1		1	M
48- Are the following topics defined depending on the test lifecycle model?	1		1	O
a. Test strategy, testing levels and test objectives	1			
b. Phases, planning control stages, execution, and test implementations	1			
c. Test input/output criteria for every single phase	1			
d. Responsibilities for every single phase	1			
e. Milestones for every single phase	1			
49- Are the phases of your test lifecycle model synchronized with the development lifecycle model?	1		1	M
a. Are the tests performed in parallel dependency with the requirements developed?	1			
b. Is there any prioritization among your test objectives? Are you updating the prioritization depending on the development plan?	1			
c. Is your document updated and purported depending on change requests among objectives?	1			

50- For any defined process inside test lifecycle		1	O
a. Are you recording the testing estimations and its output? (job quantity, effort, cost)	1		
b. Do you have quality measurement metrics? (priority level, defect count)	1		
c. Do you have peer review?	1		
d. Do you have test coverage?	1		
e. Do you use reliability measurements?	1		
51- Do you use the following tools for testing management		0	O
a. Database management tools	1		
b. Process modeling tools	0		
c. Web page builders	0		
d. Project planning/scheduling, configuration management, test management tools.	1		
52- Do you consider the following topics for test tracking and control in test lifecycle?		1	O
a. Change request count of requirements for any test process	1		
b. Daily development requirements of test process and changed test process	1		
c. Is the master plan revised periodically?	1		
d. Test items and risk levels of the test items?	1		
e. Is the effort, cost and schedule are revised following any sub-test plan?	0		
D- Non-Functional Testing			Success
53- Do you define non-functional product risks?	1	1	M
54- Do you use some of the following techniques		1	O
a. Risk workshops	1		
b. Brainstorming	0		
c. Expert interviews	1		
d. Checklist	0		
e. Lesson learned	1		

In the process of defining non-functional risks			
f. Do you grade and prioritize them?	0		
55- Do you classify non- functional product output criteria like following?		1	O
a. For reliability (Mean time between failures →MTBF) (Mean time to repair →MTTR)	1		
b. For usability (User satisfaction, average time to perform the functions)	1		
c. For efficiency (mean response time, memory utilization)	1		
d. For maintainability (average effort to change, availability of documentation)	1		
56- Do you define the non-functional test conditions (or requirements) or non-functional test design specifications of the product?	1	1	M
57- Do you have traceability matrix for non-functional req./test conditions? Do you cover non-functional requirements with corresponding test cases? Are these test cases performed?		1	M
58- Do you setup data/test scripts for non-functional tests?	1	1	O
59- Do you setup test environments for non-functional tests?	1	1	M
60- Do you setup test procedure, test data and test scripts in advance of performing non-functional test cases?	1	1	O
a. Do you record and report the tests?	1		
b. Do you compare the results with the expected results?	1		
c. Are the tests repeated for resolved cases?	1		
d. Do you make regression for non-functional tests?	1		
61- Do you make reviews for non-functional tests?	1	1	M
62- Do you use tools for non-functional tests?	1	1	O
63- Do you report your test results?	1	1	M

64- Do you perform measurement with regard to testing effort?	1	1	O
E- Peer Reviews			Success
65- Do you list the jobs needing reviews?	1	1	M
66- Do you define an approach regarding how to review? (What do you pay attention with jobs to be done. etc.)	1	1	O
67- Are you logging reading reviews done?	1	1	M
68- Do you have peer reviews schedule?	1	1	M
69- Does your peer reviews include following stages?		0	O
a. Inspection (Control)	0		
b. Walkthrough (itinerary/sampling)	0		
c. Technical review	1		
d. Informal review	1		
70- Do you prepare your review approaches with the stakeholders?	1	1	O
71- Do you have a form for keeping records of peer reviews?	1	1	O
72- Do you take an action item for the cases generated after review result?	1	1	M
73- Do you publish a report for regard to peer reviews?	1	1	M
74- Do you define an input/output criteria for regard to pre-peer review findings (defect)?	1	1	O
75- Do you analyze your peer reviews?	1	1	O
a. Do you define estimated time and time spent rates for peer reviews?	1		
b. Do you make an expected findings estimation before the review?	0		
c. Do you classify findings according to priority and types?	1		
d. Do you inspect the reasons of situations mentioned in the findings?	1		
e. Do you analyze the time cost for resolving of these situations?	1		

76- Do you discuss the results of peer review with the stakeholders?	1	1	O
77- Do you have a role distribution of peer review like following?	1	1	O
a. Review leader (Moderator)	1		
b. Checker (Reviewer)	1		
c. Scribe (Recorder/Note taker)	1		
d. Author (Preparer)	1		
78- Does your employee get training associated with peer review?	1	1	O
a. Do you have training materials?	1		
79- Do you publish rules and checklists about the peer review documents?	1	1	O
Level -4			Success
A- Test Measurement			
80- Do you define your test measurement objectives?	1	1	M
a. Do you get related information from the customers and stakeholders in the definition stage?	1		
b. Do you use traceability matrix for test measurement objectives?	1		
c. Do you verify and query your defined test measurement objectives?	1		
81- Do you define estimated/actual measurement rates of test effort and test cost?	1	1	M
a. Do you evaluate and measure regarding estimated/actual test cases?	1		
b. Do you classify the defects according to severity and priority?	1		
c. Do you calculate the defect detection rate?	1		
d. Do you have structural coverage and code coverage process?	1		
e. Do you use requirement coverage?	1		
f. Do you use Mean Time Between Failures (MTBF) and Mean Time to repair (MTTR)?	1		

g. Do you use burn down measurement? (I.e. for weekly test case execution)	1		
82- Do you have a data collection and storage procedure for measured data?	1	1	O
a. Do you have a defined procedure for gathering data, do you have a guide consisted of these processes?	1		
b. Are the data saved according to a time-line order?	1		
c. Do you have a defined security/authorization procedure for data collection?	1		
d. Is your data collection process is also automated? Do you use a collection tool for this?	1		
e. How do you analyze the defected/faulty data? Do you use a verification tool for this?	1		
f. Do you share the measurement data with the stakeholders?	1		
83- Do you have a draft version and/or standard about test measurement reports?	1	1	M
84- Do you revise the measurement data?	1	1	M
a. Do you have an authorization in order to access data?	1		
85- Does your employee get training associated with test measurement process?	1	1	O
86- Do you classify test measurement data and address them with test measurement objectives?	1	1	O
B- Product Quality Evaluation			Success
87- Do you define the product quality requirements and purposes?	1	1	M
88- Do you apply following quality requirement processes with the customers and stakeholders?	1	1	O
a. Do you apply surveys and questionnaires?	1		
b. Do you separate quality requirements into focus groups?	0		
c. Do you make brainstorming?	1		
89- Do you define the attributes of product quality like following?	1	1	M
a. Functionality	1		
b. Reliability	1		

c. Maintainability	1		
d. Portability	1		
e. Efficiency	1		
90- Do you define a quantitative product purpose for any quality attribute?	1	1	O
91- Do you establish a traceability between product quality purposes and the requirements?	1	1	M
92- Do you collect quality measurement data and review them?	1	1	M
a. Do you report them?	1		
b. Do you use them in the presentations with customers and stakeholders?	1		
c. Do you take corrective actions according to quality measurement data?	1		
93- Do you use any tools for Quality Measurement Analysis?	0	0	O
a. Do you analyze a cost for quality metrics?			
(Cost of poor quality & cost for achieving quality goals)			
C- Advanced Reviews			Fail
94- Do you review the product risk plan?	1	1	M
95- Do you review the product work breakdown?	1	1	M
96- Do you review the master test plan?	1	1	M
a. Do you document and save the review commits applied?	1		
97- Do you define review types for every work done?	1	1	M
98- Is the review planning applied in the test approach coordination phase?	1	1	O
a. Proper source for review	1		
b. Proper potential reviewers according to knowledge and talent	1		
c. Review task planning for project and test deadline	1		
d. Effort/cost defining and falling them within test plan	1		

99- Do you have measurement guidelines for peer review?	0	0	O
a. Do you have rules and review checklist?	0		
b. Do you have sample guidelines?	0		
c. Do you have perspective based reading procedures?	0		
d. Do you record checking rate? (i.e. Hourly review paper count)	0		
100- Are you logging peer reviews?	1	1	M
a. Do you construct an action list for peer reviews?	1		
b. Do you report and store them?	1		
c. Do you compare peer review results according to output criteria?	1		
101- Do you measure peer reviews based on product quality?	0	0	M
102- Do you apply a review for product quality measurement at the beginning of the application development lifecycle? (static tests)	1	1	O
103- Are peer reviews also performed in a group supervised by a leader or a moderator?	1	1	M
a. Is review meeting organized?	1		
b. Are the provisions organized like meeting schedule and location?	1		
104- Is the method of peer review process is specified in the master test plan?	1	1	O
105- Do you cover the following topics in peer review process?	0	0	O
a. Product risk assessment			
b. Defining a coordinate test approach	1		
c. Types of reviews	1		
d. Defining peer reviews quantitative exit criteria			
e. Document rules and checklist	1		
f. Sampling practices			
g. Perspective based ready			

h. Data collection, analysis, reporting			
Level- 5			
A- Defect Prevention			Success
106- Do you construct a schema when classifying defects?	1	1	M
107- Do you define defect selection parameters?	1	1	M
a. Do you analysis classified defects?	1		
b. Do you specify their reasons?	1		
108- When specifying defect selection parameters	1	1	M
a. Do you estimate the potential harm of a defect?	1		
b. Do you determine the incidence frequency of a defect?	1		
c. Do you plan the time cost and effort of fixing the defect?	1		
d. Do you calculate the time cost and effort of prevent the defect?	1		
e. Do you organize the scope of the negative effects of a defect?	0		
109- Do you share selection parameters with the customer and stakeholders for them to review?	1	1	M
a. Do you report selection parameters defect classification schemas?	1		
b. Do defect reports cover static/dynamic tests and operational usage (actual user tests and actual user operational usage)?	1		
110- Do you separate defects as		0	O
a. Root cause of selected defects	1		
b. Common cause of selected defects	1		
when analyzing selection defects			
c. Do you use one or some of the following methods when analyzing root causes?	1		
i. Cause/effect diagrams	1		
ii. Ishikawa fishbone diagrams	1		
iii. Fault tree analysis	0		
iv. Process analysis	1		

v. Use standard defect classifications (IEEE 1044)	0			
vi. FMEA (Failure mode effect analysis)	1			
vii. Hardware and Software Interaction analysis	0			
d. Do you categorize common causes in analysis one or some of the following?	1			
i. Process	1			
ii. People	1			
iii. Organization	1			
iv. Communication	1			
v. Architecture	1			
vi. Technology	1			
vii. Tools	1			
viii. Environment	1			
111- Do you define possible solutions for defects?	1	1	M	
(Process, work product standard, organizational structure, training, review activities, test strategy, methods and technologies, checklist, coding standards, tools) and do you define these solutions?				
112- Do you have defect prevention process?	1		M	
a. Do you specify organizational objectives for defect presentation?	0			
b. Do you perform key measurements for it?	1			
c. Are quality metrics and root causes are associated with firms expectations?	1			
d. Does testing team (or process improvement team) coordinate defect prevention activities?	1			
e. Is any plan prepared for defect presentation process and is updated in case of necessity?	0			
113- Is the following defect prevention measurements performed?	0	0	O	

a. Cost of defect prevention activities	0		
b. # defect analyzed	1		
c. # root cause identified	1		
d. # action proposal outstanding and how long	0		
e. # action proposal submitted	0		
B- Quality Control			Success
114- Are test process associated with quality control processes? (Statistically controlled test process)	1	1	M
a. Do you publish test process performance objectives?	1		
i. Do you revise quantities objectives for test process performance?	1		
1. When organization's business objectives are changed	1		
2. When organization's test process are changed	1		
3. When objectives are not coherent with the actual results the test process performance	1		
b. Do you perform test process performance measurements?	1		
i. Are test process performance measurements reviewed?	1		
ii. Are these measurements revised?	1		
c. Do you have test process performance baselines?	1		
i. Do you analyze the data gathered through test process performance measurements?	1		

1. Do you define moral validating this data along with the customer?	1		
2. Do you revise your baselines?	1		
a. Apply statistical methods to understand variations	1		
i. Do you collect measurements performed?	1		
ii. Do you publish upper and lower boundaries?	1		
iv. Do you install control charts, histograms, run charts, prediction intervals?	1		
b. Monitor performance			
i. Do you compare test process performance objective with the boundaries?	1		
ii. Do you perform reviews periodically? Do you conclude test process success and perfection?	1		
iii. Do you publish test process capability deficiencies and document it?	1		
115- Do you define and develop operational and usage models?	1	1	M
a. Develop customer profile	1		
b. User profile	1		
c. System mode profile	1		
d. Functional profile	1		
e. Operational profile	1		
f. Review operational profiles (stakeholders)	1		
g. Are these profiles revised?	1		
116- Are test cases reviewed by the stakeholders?	1	1	O

a. Are test cases covered with actual usage?	1		
b. Are test cases revised?	1		
c. Are test results analyzed and recorded?	1		
117- Do you define severity level of defects?	1	1	O
a. Are confidence goal/measurements coherent with reliability?	1		
b. Are they Documented and reviewed?	1		
118- Are the following tools used for Quality Control process?	1	1	O
a. DB management tools	1		
b. Process modeling tools	1		
c. Statistical analysis package	0		
d. Incident management tools	1		
e. Coverage tools	1		
f. Statistical process and quality control package	0		
g. Reliability measurement tools	1		
119- Does your employee get training associated with quality control process?	1	1	O
C- Test Process optimization			Fail
120- Do you specify test process improvements initially or afterward a project?	1	1	M
a. Do you gather and analyze test process improvement proposals?	1		
b. Do you evaluate these proposals as a pilot?	0		
c. Do you specify needed test process improvements to apply?	1		
121- Do you define new test techniques in case of improvement in test process?	1	1	O
a. Do you examine and analyze new test techniques?	1		
b. Do you apply new test techniques and technologies as a pilot?	1		
c. Do you constitute new test technologies to	1		

apply?			
122- Do you apply test improvements?	1	0	M
a. Planning	1		
b. In management & trailing	0		
c. Do you measure the effects of improvements?	0		
123- Do you re-use of high quality test process assets?	1	1	M
a. Do you define your assets?	1		
b. Do you use a library to re-use assets specified?	0		
c. Do you utilize your reusable test assets in other projects?	0		

3- Answers of Company-C for TMMi Assessment

Levels and Questions	Result of the company	providing conditions	Column 1
Level 2-			
A- Test Policy and Strategy			Success
1- Do you define a test policy on the project?	1	1	M
2- Does your test policy include the following topics? :	1	1	M
i. Objectives	1		
ii. Business objectives	1		
iii. Quality objectives	1		
iv. Quality Planning	1		
v. Risk Levels	1		
3- Do your company have a standard documentation which is defined by the quality team for your test policy?	1	1	O
4- Is the test policy review by test experts as internal? Does stakeholder review the test policy?	1	1	M
5- Do you have a test strategy?	1	1	M

a. Are the product risks defined on the test strategy?	1		
b. Which are variables used to categories the product risks	1		
c. Which risks of the product are assessed when defining the test model of your project (V-model, incremental, lifecycle)	1		
d. Do you determine your objectives, personnel responsibilities, their tasks for each test level in the test strategy?	1		
i. Unit test	1		
ii. Integration Test	1		
iii. System test	1		
iv. Acceptance test	1		
B- Test Planning			Success
6- Do you have a test plan?	1	1	M
7- Are the product risks defined on the test plan?	1	1	O
8- Does the test plan have test approaches and test techniques?	1	1	O
9- Does your test plan have the following topics?	1	1	O
a. Experiences of the test engineers	1		
b. Cost per man/day for the project	1		
c. Development lifecycle	1		
d. Bug fix & Re-test	0		
e. Documentation standards & review process	0		
f. Regression tests	1		
g. Manuel & Automation tests	0		
h. Test tools will be used	1		
i. Constraints in the test environment	1		
j. Project deadline & test deadline	1		
10- Do your customer and stakeholders review the test plan?	1	1	M
11- In the Test Plan, do you have a process and its test report to find and fix defects for each test phases? (or Does test process have these phases?)	1	1	M

12- Does the test plan have test schedule?	1	1	O
a. How long will the testing activities	1		
b. Which will test phases	1		
c. Which tests will be entered which phase	1		
d. Milestones/ checkpoints	1		
13- Do you have master and sub test plans? Which phase are they updated/ how often are they updated	1	1	M
C- Test Monitoring and Control			Success
14- Do you keep the test execution performance?	1	1	M
a. How many test cases are executed on how long time?	1		
b. The amount of the test cases is run by a tester on a day. (the similar measurements …etc.)	1		
15- Do you follow the cost and effort of test execution? How often? Which variables are based?	1	1	M
16- Do your analysis to completion test tasks and cost of test?	1	1	M
17- Do you determine the cost of defects to fix and re-test for each test tasks?	1	1	O
a. Number of Defects (for component, system, sub system)	1		
b. Do you define the priorities of the defects	1		
c. Do you establish the rates of the defects which are found and fixed on each test process	1		
d. Are the defects defined according to the following variables	1		
i. Data	1		
ii. Requirement	1		
iii. System	1		
iv. External Systems	1		
v. Configuration	1		
D- Test Design and Execution			Success

18- Which phases do you prefer black box/white box testing on	1	1	O
a. Black box → equivalence → boundary → decision Table →state transition	1		
b. White box → statement → decision branch → condition testing	1		
19- Do you use test conditions when test cases are created?	1	1	M
20- Are pass/fail criteria defined?	1	1	M
21- Are your test cases reviewed?	1	1	M
22- Do your test cases include the following topics?	1	1	O
a. Test Case identifier	1		
b. Environment requirements	1		
c. Preconditions	1		
d. Input/output specifications	1		
23- Do you smoke test before beginning the test cases on the environment?	0	0	O
a. All basic functions work?	0		
b. Positive test cases on functions of all components work correctly?	0		
c. The interface of the application is correct?	0		
d. A component and another component work together correctly?	0		
e. The application has connections with external systems, it works correctly with that systems?	0		
24- Are test Documentation, user manuals and integration manuals ready before beginning tests?	1	1	O
25- Is it getting recorded and reported that (test Environment, test data, test documentation...etc.) the cause of the problems during the test? (Blocking test execution)	1	1	M
Level-3-			
A- Test Organization			Failed
26- Do you have a test organization (test team or group) on the company?	1	1	M

27- What is the place of your test organization on the organization schema of the company?	1	1	M	
a. What is the relation between development team and test team? Is the test group depending on development team directly?	1			
b. Who assign the tasks and responsibilities for the test team?	1			
c. How is reporting process path? Do you establish the test reports to development team or PM team?	1			
d. Do test organization and stakeholders review your documentations?	1			
e. Do you have a documentation for review commits?	1			
28- On the test organization, do you have responsibilities definition as the following topics	1	0	M	
a. Test manager	1			
b. Test team leader	1			
c. Test designer	0			
d. Test Consultant	1			
e. Test environment engineer	0			
Do responsibilities on the test group is determined as follows in accordance with requirements?	1	1	O	
a. Test automation architect	0			
b. Test automation engineer	1			
c. Performance test engineer	1			
d. Usability test engineer	1			
e. Test process improvement specialist	1			
30- Do you have specialist personnel who are not test specialist but they support test process?	0	0	O	
a. SW developer	0			
b. System engineer	0			
c. System integrator	0			
d. User representative	0			
31- Does your company have titles as junior, intermediate, senior ..etc. for your test specialist?	1	1	M	
a. Definition a framework for the carrier of a	1			

test specialist?			
b. Tasks and Responsibilities of the test specialist hierarchical?	1		
c. HR defines and apply the same hierarchical structure for test organization?	1		
32- Does your company have a personal career development plan & path for test engineer? Are these revised if it is needed?	1	1	M
33-On test organization,	1	1	O
a. Do you define test process improvement?	1		
b. Do you update test organization structure for test improvements?	1		
c. How do you monitor and control on the test organization?/ Who monitor and control on the test organization	1		
d. Do you update responsibilities and tasks accordance with resource and schedule?	1		
e. Do you review and update your test process improvements?	0		
34- Do you have a deployment plan defined in the project?	1	1	M
35- Do you have a checklist related for deployment? Does it update?	1	1	M
36- Do the training exist to change process and documents for deployment and tests ?	1	1	O
37- Are the test metrics, test DB, test tools and resolved/re-test approach explained to the test team? And Do you keep on any document recording?	0	1	O
38- Do you have "Change Management" process on the test organization?	1	1	O
39- Do you use a test model like TMMi or another model when you create test organization structure?	0	1	O
a. Do you make test process improvement plan?	1		
b. Do you make test process deployment plan?	1		

B- Test Training Program			Success
40- Do you have professional training and certificate programs for test engineers?	1	1	M
41- Do you have internal training for test engineers?	1	1	M
42- Do you choose training which is parallel subjects with the projects?	1	1	O
43- How do you define needs of test training?	1	1	O
a. Is test schedule created depending on the training activities?	1		
b. Do you have training materials? Have they kept accordance with any software standards?	0		
c. Do you choose the following topics for test engineers training:	1		
i. Requirement engineering	0		
ii. Test Automation	1		
iii. Database Management	1		
iv. UML Design	1		
v. Risk Management	0		
vi. Configuration Management	0		
vii. Development lifecycle	1		
d. Do you have cross training on your test organization? Do test engineers who take different training make knowledge transfer?	1		
44- Are new topics defined for the training programs accordance the projects?	1	1	O
45- Do you make an assessment such as successful/unsuccessful to test engineers for test training?	1	1	M
46- When internal training on the test organization, Do you define a standard like the	0	0	O

following topics?			
a. Knowledge and Skill need analysis	0		
b. Course design	0		
c. Training delivery methods	0		
d. Refreshing training on subject matter	0		
C- Test Lifecycle & Integration			Failed
47- Have you defined your test life cycle model in an arbitrary document?	1	1	M
48- Are the following topics defined depending on the test lifecycle model?		1	O
a. Test strategy, testing levels and test objectives	1		
b. Phases, planning control stages, execution and test implementations	1		
c. Test input/output criteria for every single phase	0		
d. Responsibilities for every single phase	1		
e. Milestones for every single phase	1		
49- Are the phases of your test lifecycle model synchronized with the development lifecycle model?	1	0	M
a. Are the tests performed in parallel dependency with the requirements developed?	1		
b. Is there any periodization among your test objectives? Are you updating the periodization depending on the development plan?	1		
c. Is your document updated and reported depending on change requests among objectives?	0		
50- For any defined process inside test lifecycle		1	O
a. Are you recording the testing estimations and its output? (job quantity, effort, cost)	1		
b. Do you have quality measurement metrics? (priority level, defect count)	1		
c. Do you have peer review?	1		
d. Do you have test coverage?	1		
e. Do you use reliability measurements?	1		
51- Do you use the following tools for testing		1	O

management			
a. Database management tools	1		
b. Process modeling tools	1		
c. Web page builders	0		
d. Project planning/scheduling, configuration management, test management tools.	1		
52- Do you consider the following topics for test tracking and control in test lifecycle?		1	O
a. Change request count of requirements for any test process	1		
b. Daily development requirements of test process and changed test process	1		
c. Is the master plan revised periodically?	0		
d. Test items and risk levels of the test items?	1		
e. Is the effort, cost and schedule are revised following any sub test plan?	1		
D- Non-Functional Testing			Success
53- Do you define non-functional product risks?	1	1	M
54- Do you use some of the following techniques	1	1	O
a. Risk workshops	1		
b. Brain storming	1		
c. Expert interviews	1		
d. Check list	1		
e. Lesson learned	1		
In the process of defining non-functional risks			
f. Do you grade and prioritize them?	1		
55- Do you classify non- functional product output criteria like following?	1	1	O
a. For reliability (Mean time between failures →MTBF) (Mean time to repair →MTTR)	0		
b. For usability (User satisfaction, average time to perform the functions)	1		
c. For efficiency (mean response time, memory utilization)	1		
d. For maintainability (average effort to change, availability of documentation)	1		

56- Do you define the non-functional test conditions (or requirements) or non-functional test design specifications of the product?	1	1	M
57- Do you have traceability matrix for non-functional req./test conditions? Do you cover non-functional requirements with corresponding test cases? Are these test cases performed?	1	1	M
58- Do you setup data/test scripts for non-functional tests?	1	1	O
59- Do you setup test environments for non-functional tests?	1	1	M
60- Do you setup test procedure, test data and test scripts in advance of performing non-functional test cases?	1	1	O
a. Do you record and report the tests?	1		
b. Do you compare the results with the expected results?	1		
c. Are the tests repeated for resolved cases?	1		
d. Do you make regression for non-functional tests?	0		
61- Do you make reviews for non-functional tests?	1	1	M
62- Do you use tools for non-functional tests?	1	1	O
63- Do you report your test results?	1	1	M
64- Do you perform measurement with regard to test effort?	1	1	O
E- Peer Reviews			Failed
65- Do you list the jobs needing reviews?	0	0	M
66- Do you define an approach regarding how to review? (What do you pay attention with jobs to be done. etc.)	0	0	O
67- Are you logging reading reviews done?	1	1	M
68- Do you have peer reviews schedule?	1	1	M
69- Does your peer reviews include following stages?	0	0	O

a. Inspection (Control)	0		
b. Walkthrough (itinerary/sampling)	0		
c. Technical review	0		
d. Informal review	0		
70- Do you prepare your review approaches with the stakeholders?	0	0	O
71- Do you have a form for keeping records of peer reviews?	1	1	O
72- Do you take an action item for the cases generated after review result?	1	1	M
73- Do you publish a report for regard to peer reviews?	0	0	M
74- Do you define an input/output criteria for regard to pre-peer review findings (defect)?	0	0	O
75- Do you analyze your peer reviews?	1	1	O
a. Do you define estimated time and time spent rates for peer reviews?	1		
b. Do you make an expected findings estimation before review?	0		
c. Do you classify findings according to priority and types?	1		
d. Do you inspect the reasons of situations mentioned in the findings?	1		
e. Do you analyze the time cost for resolving of these situations?	1		
76- Do you discuss the results of peer review with the stakeholders?	0	0	O
77- Do you have a role distribution of peer review like following?	0	0	O
a. Review leader (Moderator)	0		
b. Checker (Reviewer)	0		
c. Scribe (Recorder/Note taker)	0		
d. Author (Preparer)	0		
78- Does your employee get training associated with peer review?	1	1	O
a. Do you have training materials?	0		

79- Do you publish rules and checklists about the peer review documents?	1	1	O
Level -4			
A- Test Measurement			Failed
80- Do you define your test measurement objectives?	1	1	M
a. Do you get related information from the customers and stakeholders in the definition stage?	1		
b. Do you use traceability matrix for test measurement objectives?	0		
c. Do you verify and query your defined test measurement objectives?	1		
81- Do you define estimated/actual measurement rates of test effort and test cost?	1	1	M
a. Do you evaluate and measure regarding estimated/actual test cases?	1		
b. Do you classify the defects according to severity and priority?	1		
c. Do you calculate the defect detection rate?	1		
d. Do you have structural coverage and code coverage process?	0		
e. Do you use requirement coverage?	1		
f. Do you use Mean Time Between Failures (MTBF) and Mean Time to repair (MTTR)?	0		
g. Do you use burn down measurement? (I.e. for weekly test case execution)	1		
82- Do you have a data collection and storage procedure for measured data?	1	0	O
a. Do you have a defined procedure for gathering data, do you have a guide consisted of these processes?	0		
b. Are the data saved according to a time-line order?	1		
c. Do you have a defined security/authorization procedure for data collection?	0		

d. Is your data collection process is also automated? Do you use a collection tool for this?	1		
e. How do you analyze the defected/faulty data? Do you use a verification tool for this?	0		
f. Do you share the measurement data with the stakeholders?	0		
83- Do you have a draft version and/or standard about test measurement reports?	0	0	M
84- Do you revise the measurement data?	0	0	M
a. Do you have an authorization in order to access data?	1		
85- Does your employee get training associated with test measurement process?	0	0	O
86- Do you classify test measurement data and address them with test measurement objectives?	0	0	O
B- Product Quality Evaluation			Failed
87- Do you define the product quality requirements and purposes?	1	1	M
88- Do you apply following quality requirement processes with the customers and stakeholders?	1	1	O
a. Do you apply surveys and questionnaires?	1		
b. Do you separate quality requirements into focus groups?	0		
c. Do you make brainstorming?	1		
89- Do you define the attributes of product quality like following?	1	1	M
a. Functionality	1		
b. Reliability	1		
c. Maintainability	1		
d. Portability	1		
e. Efficiency	1		
90- Do you define a quantitative product purpose for any quality attribute?	1	1	O
91- Do you establish a traceability between product quality purposes and the requirements?	0	0	M

92- Do you collect quality measurement data and review them?	1	1	M
a. Do you report them?	1		
b. Do you use them in the presentations with customers and stakeholders?	1		
c. Do you take corrective actions according to quality measurement data?	1		
93- Do you use any tools for Quality Measurement Analysis?	1	1	O
a. Do you analyze a cost for quality metrics?	1		
(Cost of poor quality & cost for achieving quality goals)	1		
C- Advanced Reviews			Failed
94- Do you review the product risk plan?	0	0	M
95- Do you review the product work breakdown?	1	1	M
96- Do you review the master test plan?	1	1	M
a. Do you document and save the review commits applied?	1		
97- Do you define review types for every work done?	1	1	M
98- Is the review planning applied in the test approach coordination phase?	1	0	O
a. Proper source for review	1		
b. Proper potential reviewers according to knowledge and talent	1		
c. Review task planning for project and test deadline	1		
d. Effort/cost defining and falling them within test plan	1		
99- Do you have measurement guidelines for peer review?	0	0	O
a. Do you have rules and review checklist?	1		
b. Do you have sample guidelines?	0		
c. Do you have perspective based reading procedures?	1		
d. Do you record checking rate? (i.e. Hourly review paper count)	0		
100- Are you logging peer reviews?	1	0	M

a. Do you construct an action list for peer reviews?	1		
b. Do you report and store them?	0		
c. Do you compare peer review results according to output criteria?	0		
101- Do you measure peer reviews based on product quality?	0	0	M
102- Do you apply a review for product quality measurement at the beginning of the application development lifecycle? (static tests)	1	1	O
103- Are peer reviews also performed in a group supervised by a leader or a moderator?	1	1	M
a. Is review meeting organized?	1		
b. Are the provisions organized like meeting schedule and location?	1		
104- Is the method of peer review process is specified in the master test plan?	1	1	O
105- Do you cover the following topics in peer review process?	1	1	O
a. Product risk assessment	1		
b. Defining a coordinate test approach	0		
c. Types of reviews	1		
d. Defining peer reviews quantitative exit criteria	0		
e. Document rules and checklist	1		
f. Sampling practices	1		
g. Perspective based ready	0		
h. Data collection, analysis, reporting	1		
Level- 5			
A- Defect Prevention			Failed
106- Do you construct a schema when classifying defects?	1	1	M
107- Do you define defect selection parameters?	1	1	M
a. Do you analysis classified defects?	1		
b. Do you specify their reasons?	1		
108- When specifying defect selection parameters		1	M
a. Do you estimate the potential harm of a	1		

defect?			
b. Do you determine the incidence frequency of a defect?	1		
c. Do you plan the time cost and effort of fixing the defect?	1		
d. Do you calculate the time cost and effort of preventing the defect?	0		
e. Do you organize the scope of the negative effects of a defect?	1		
109- Do you share selection parameters with the customer and stakeholders for them to review?	0	0	M
a. Do you report selection parameters defect classification schemas?	0		
b. Do defect reports cover static/dynamic tests and operational usage (actual user tests and actual user operational usage)?	0		
110- Do you separate defects as		1	O
a. Root cause of selected defects	1		
b. Common cause of selected defects	1		
when analyzing selection defects			
c. Do you use one or some of the following methods when analyzing root causes?	0		
i. Cause/effect diagrams	0		
ii. Ishikawa fishbone diagrams	0		
iii. Fault tree analysis	0		
iv. Process analysis	0		
v. Use standard defect classifications (IEEE 1044)	0		
vi. FMEA (Failure mode effect analysis)	0		
vii. Hardware and Software Interaction analysis	0		

d. Do you categorize common causes in analysis one or some of the following?	1		
i. Process	1		
ii. People	1		
iii. Organization	1		
iv. Communication	1		
v. Architecture	1		
vi. Technology	1		
vii. Tools	1		
viii. Environment	1		
111- Do you define possible solutions for defects?	1	1	M
(Process, work product standard, organizational structure, training, review activities, test strategy, methods and technologies, checklist, coding standards, tools) and do you define these solutions?	1		
112- Do you have defect prevention process?	1	0	M
a. Do you specify organizational objectives for defect prevention?	1		
b. Do you perform key measurements for it?	0		
c. Is quality metrics and root causes are associated with firms expectations?	1		
d. Does testing team (or process improvement team) coordinate defect prevention activities?	1		
e. Is any plan prepared for defect prevention process and is updated in case of necessity?	0		
113- Is the following defect prevention measurements performed?	0	0	O
a. Cost of defect prevention activities	0		
b. # defect analyzed	0		
c. # root cause identified	0		

d. # action proposal outstanding and how long	0		
e. # action proposal submitted	0		
B- Quality Control			Failed
114- Are test process associated with quality control processes? (Statistically controlled test process)	1	0	M
a. Do you publish test process performance objectives?	0		
i. Do you revise quantities objectives for test process performance?	0		
1. When organization's business objectives are changed	0		
2. When organization's test process are changed	0		
3. When objectives are not coherent with the actual results the test process performance	0		
b. Do you perform test process performance measurements?	1		
i. Are test process performance measurements reviewed?	0		
ii. Are these measurements revised?	1		
c. Do you have test process performance baselines?	1		
i. Do you analyze the data gathered through test process performance measurements?	1		
1. Do you define moral validating this data along with the customer?	0		
2. Do you revise your baselines?	1		
d. Apply statistical methods to understand variations			
i. Do you collect measurements performed?	1		
ii. Do you publish upper and lower boundaries?	0		

iv. Do you install control charts, histograms, run charts, prediction intervals?	1		
e. Monitor performance	0		
i. Do you compare test process performance objective with the boundaries?			
ii. Do you perform reviews periodically? Do you conclude test process success and perfection?	1		
iii. Do you publish test process capability deficiencies and document it?	0		
	0		
115- Do you define and develop operational and usage models?	0	0	M
a. Develop customer profile	0		
b. User profile	0		
c. System mode profile	0		
d. Functional profile	0		
e. Operational profile	0		
f. Review operational profiles (stakeholders)	0		
g. Are these profiles revised?	0		
116- Are test cases reviewed by the stakeholders?	1	1	O
a. Are test cases covered with actual usage?	0		
b. Are test cases revised?	1		
c. Are test results analyzed and recorded?	1		
117- Do you define severity level of defects?	1	1	O
a. Are confidence goal/measurements coherent with reliability?	1		
b. Are they Documented and reviewed?	1		
118- Are the following tools used for Quality Control process?		0	O
a. DB management tools	0		
b. Process modeling tools	1		
c. Statistical analysis package	0		
d. Incident management tools	0		
e. Coverage tools	0		

f. Statistical process and quality control package	0		
g. Reliability measurement tools	0		
119- Does your employee get training associated with quality control process?	1	1	O
C- Test Process optimization			Failed
120- Do you specify test process improvements initially or afterward a project?	1	0	M
a. Do you gather and analyze test process improvement proposals?	1		
b. Do you evaluate these proposals as a pilot?	0		
c. Do you specify needed test process improvements to apply?	1		
121- Do you define new test techniques in case of improvement in test process?	1	1	O
a. Do you examine and analyze new test techniques?	1		
b. Do you apply new test techniques and technologies as a pilot?	1		
c. Do you constitute new test technologies to apply?	1		
122- Do you apply test improvements?	1	0	M
a. Planning	1		
b. In management & trailing	1		
c. Do you measure the effects of improvements?	0		
123- Do you re-use of high-quality test process assets?	1	1	M
a. Do you define your assets?	1		
b. Do you use a library to re-use assets specified?	1		
c. Do you utilize your reusable test assets in other projects?	1		

APPENDIX 2

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Zülfikar, Başak

Date and Place of Birth: 01 January 1988, Mersin

Marital Status: Single

Phone: +90 554 911 82 18

Email: basak.zulfikar@atos.net

EDUCATION

Degree	Institution	Year of Graduation
M.Sc.	Çankaya Univ., Information Technologies Master Degree with thesis (scholarship)	2016
B.Sc.	Çankaya Univ., Mathematical and Computer Sciences (scholarship)	2011
High School	MTSO Anatolian High School	2006

WORK EXPERIENCE

Year	Place	Enrollment

2014-Present	ATOS Turkey	Test Engineer
2013- 2014	İnnova Bilişim Çözümleri A.Ş.	Software Test Specialist
2011-2013	LS-Pro Yazılım ve Bilişim LTD.	Software Analyst
2010 July	AGMLab	Trainer

FOREIN LANGUAGES
Advanced English, Beginner Germany

PROJECTS

1. MERSIS (E-government Central registry records system) Software Analysis, Test, Design Process
2. CRM (Customer Relationship Management for E-Sign Company) Software Analysis, Test, Design Process
3. Accounting Management Systems, Software Analysis, Test Process
4- TELCO OSS- TMS (Telekom Customer System) Test and Analysis Process
5- TELCO OSS- SOM (Service Order Management) Test Process
6- AIRC2IS- NATO Project- CSC Test, Functional Test, Security Test

HOBBIES
Voluntary work for stray animals, an amateur actress.