Test Maturity Model integration (TMMi)
Results of the first TMMi benchmark – where are we today?

Erik van Veenendaal &
Jan Jaap Cannegieter

EuroSTAR
Software Testing
Community

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TMMi[1] is a non-commercial, organization-independent test maturity model. With TMMi, organizations can have their test processes objectively evaluated by certified assessors, improve their test processes and even have their test process and test organization formally accredited if it complies with the requirements. TMMi uses the concept of maturity levels for process evaluation and improvement. Furthermore process areas, goals and practices are identified. Practical experiences have already shown that applying the TMMi maturity criteria will improve the test process and is likely to have a positive impact on product quality, test productivity, and test lead time.

The full TMMi model (release 1.0) has recently become available and there is rapidly growing world-wide TMMi interest and recognition. As the first version of the TMMi was already published four years ago, many organizations have since used the TMMi to evaluate and improve their test processes. Erik van Veenendaal and Jan Jaap Cannegieter, also co-authors for the "The Little TMMi", have analyzed the results of almost fifty (50) TMMi assessments. The results provide an indication of testing maturity today.

TMMi: The Model

Background

For the past decade, the software industry has invested substantial effort to improve the quality of its products. This has been a difficult job, since the size and complexity of software increases rapidly while customers and users are becoming more and more demanding. Despite encouraging results with various quality improvement approaches, the software industry is still far from zero defects. To improve product quality, the software industry has often focused on improving its development processes.

A guideline that has been widely used to improve the development processes is the Capability Maturity Model. The Capability Maturity Model (CMM) and its successor, the Capability Maturity Model Integration (CMMI), are often regarded as the industry standard for software process improvement. The CMM provided process improvement projects with the necessary structure and direction. CMM became a model to determine how mature the organization is, or as Watts Humphrey likes to state: "If you don't know where you are, a map won't help." However, for the testing community, CMM was insufficient. Despite the fact that testing often accounts for at least 30-40% of the total project costs, only limited attention is given to testing in the CMM. At maturity level 3 of the CMM there are some requirements for the testing process, but these are of such a high level of abstraction that they are hardly usable in practice.

The successor of the CMM, the Capability Maturity Model Integration for Development (CMMI) has two dedicated process areas (verification and validation) that provide more focus on testing. Still CMMI has too few practical tools to support a step by step improvement of the testing process. The emphasis of CMMI is on organizational, and software and system engineering processes and not so much on the characteristics of a mature testing process. As an answer, the TMMi Foundation has created its own improvement model: the Test Maturity Model integration (TMMi). TMMi is a detailed model for test process improvement and is positioned as being complementary to CMMI.

[1] *TMMi® is a registered trademark of TMMi Foundation*

Origin and Structure

The TMMi framework has been developed by the TMMi Foundation as a guideline and reference framework for test process improvement and is positioned as a complementary model to CMMI Version 1.3, addressing those issues important to test managers, test engineers and software quality professionals. Testing as defined in the TMMi is applied in its broadest sense to encompass all software product quality-related activities.

Just like the CMMI staged representation, TMMi also uses the concept of maturity levels for process evaluation and improvement. Furthermore process areas, goals and practices are identified. Applying the TMMi maturity criteria will improve the test process and have a positive impact on product quality, test engineering productivity, and cycle-time effort. TMMi has been developed to support organizations with evaluating and improving their test process.

Practical experiences are positive and show that TMMi supports the process of establishing a more effective and efficient test process. By following the TMMi guidelines, testing becomes a profession and a fully integrated part of the development process. As stated, the focus of testing changes from defect detection to defect prevention.

Advantages

The application of TMMi will lead to a structured and controlled test process, a higher level of product quality, improved productivity of the test organization and, frequently, a shorter lead time. TMMi has been developed to support organizations to evaluate and improve their test processes. Within TMMi testing moves from a chaotic, unstructured process with a shortage of skilled testers and tools, to a mature and controlled process that has defect prevention as its main objective.

Scope

TMMi is intended to support testing activities and test process improvement in both the systems engineering and software engineering disciplines. Systems engineering covers the development of total systems, which may or may not include software. Software engineering covers the development of software systems.

Whereas some models for test process improvement focus mainly on high-level testing, e.g., Test Process Improvement (TPI) and its successor TPI-Next, or address only one aspect of structured testing e.g., the test organization, TMMi addresses all test levels (including static testing) and aspects of structured testing. With respect to dynamic testing, both low-level testing and high-level testing are within the scope of TMMi. Studying the model more in detail one will learn that the model addresses all four cornerstones for structured testing (lifecycle, techniques, infrastructure and organization).
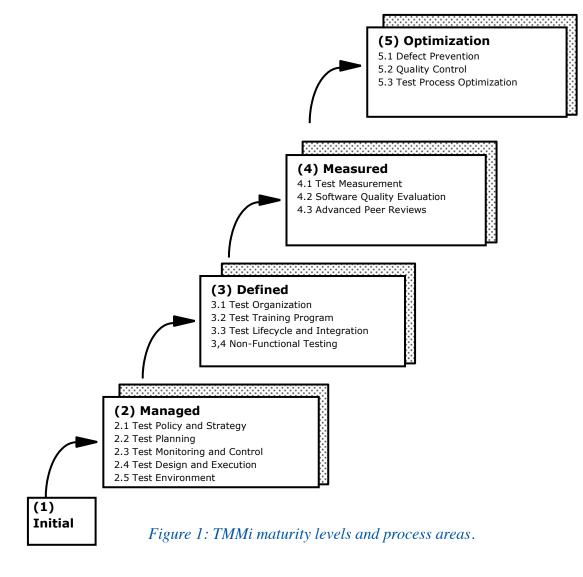
TMMi model overview

TMMi has a staged architecture for process improvement. It contains stages or levels through which an organization passes as its testing process evolves from one that is ad hoc and unmanaged to one that is managed, defined, measured, and optimized. Achieving each stage ensures that all goals of that stage have been achieved and the improvements form the foundation for the next stage.

The internal structure of TMMi is rich in testing practices that can be learned and applied in a systematic way to support a quality testing process that improves in incremental steps. There are five levels in TMMi that prescribe the maturity hierarchy and the evolutionary path to test process improvement. Each level has a set of process areas that an organization must implement to achieve maturity at that level.

Experience has shown that organizations do their best when they focus their test process improvement efforts on a manageable number of process areas at a time, and that those areas require increasing sophistication as the organization improves. Because each maturity level forms a necessary foundation for the next level, trying to skip a maturity level or a process area is usually counterproductive. At the same time, it is important to recognize that test process improvement efforts should focus on the needs of the organization in the context of its business environment and the process areas at higher maturity levels may address the current needs of an organization or project. For example, organizations seeking to move from maturity level 1 to maturity level 2 are frequent encouraged to establish a test group, which is addressed by the Test Organization process area that resides at maturity level 3. Although the test group is not a necessary characteristic of a TMMi level 2 organization, it can be a useful part of the organization's approach to achieve TMMi maturity level 2.

(5) Optimization
5.1 Defect Prevention
5.2 Quality Control
5.3 Test Process Optimization

(4) Measured
4.1 Test Measurement
4.2 Software Quality Evaluation
4.3 Advanced Peer Reviews

(3) Defined
3.1 Test Organization
3.2 Test Training Program
3.3 Test Lifecycle and Integration
3,4 Non-Functional Testing

(2) Managed
2.1 Test Policy and Strategy
2.2 Test Planning
2.3 Test Monitoring and Control
2.4 Test Design and Execution
2.5 Test Environment

(1) Initial

Figure 1: TMMi maturity levels and process areas.

The process areas for each maturity level of TMMi are shown in Figure 1. Note that TMMi does not have a specific process area dedicated to test tools and/or test automation. Within TMMi test tools are treated as a supporting resource (practice) and are therefore part of the process area where they provide support, e.g., applying a test design tool is a supporting test practice within the process area Test Design and Execution at TMMi level 2 and applying a performance testing tool is a supporting test practice within the process area Non-Functional Testing at TMMi level 3.

TMMi assessments

In a TMMi assessment the maturity of test processes is measured. An assessment can also determine if an organization has achieved a certain test maturity level or not. The results of the assessment can be used to formulate recommendations for improvement. The assessment results and recommendations help to determine action plans to implement improvements in test processes. TMMi assessments can be executed at various moments. For example, a test process improvement program can start with an assessment to find the areas that need to be improved. During an improvement program, a TMMi assessment can be used to determine which accomplishments have been made so far. When an organization thinks a certain TMMi maturity level has been reached, this can be proven by a lead assessor conducting a formal assessment.
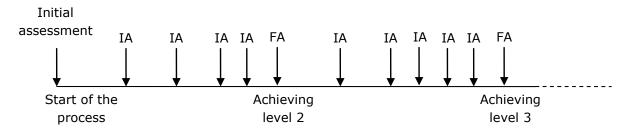
The TMMi Assessment Method Application Requirements (TAMAR) have been developed to execute assessments. TAMAR is not a defined assessment approach, but describes the requirements that TMMi assessments must meet. Organizations should develop their own assessment approach that is appropriate for their business; when this approach meets TAMAR, it can be officially accredited by the TMMi Foundation.

There are two assessment types: formal and informal. A formal assessment has enough depth to officially determine to what extent an organization meets the requirements as defined in TMMi. An informal assessment does not lead to an official result about the process maturity; it only provides an indication. An informal assessment is often used to identify the major improvements that need to be made and it can also be used determine the progress of a TMMi implementation. An informal assessment is often adequate as an initial survey, although a formal assessment can also be used for this. Deciding which of the two assessment types is best depends on the requirements and expectations an organization has about the assessment. An example of the use of the two assessment types plotted against time is shown in Figure 2.

Formal Assessments

Formal assessments must be led by an accredited lead assessor. Lead assessor accreditation can only be achieved through the TMMi Foundation. For a formal assessment the assessment team must consist of a lead assessor and at least one other accredited assessor. Additional assessment team members need not be accredited.

Formal assessments require a strict level of evidence for the achievement of specific and generic goals of the relevant TMMi process

Initial assessment   IA   IA   IA IA   FA   IA   IA IA IA IA   FA

Start of the process   Achieving level 2   Achieving level 3

IA = informal assessment
FA = formal assessment

Figure 2: TMMi maturity levels and process areas.

areas. Evidence from multiple sources is needed to conduct a formal assessment. For a formal assessment it is mandatory for the assessment team to conduct staff interviews as one point of evidence. The data collected from the interviews must to be corroborated with the findings from the document study. Data for a formal assessment can also be collected from other sources, such as questionnaires and customer surveys. The data must be collected from different sources and different parts of the organization to determine whether a TMMi practice has been institutionalized. One of the results of a formal assessment is a full gap analysis showing the strengths and weaknesses of an organization against the TMMi model. This gap analysis can be used as the basis for future improvement projects.

Informal Assessments

Informal assessments are conducted with less rigor than is required by formal assessments and are, therefore, faster and cheaper, but are also less precise. Informal assessments are designed as an initial indicative view and 'quick check' to evaluate the current state of the test processes against TMMi. Informal assessments are led by an experienced assessor, who need not be formally accredited although this is highly recommended.

An assessment team for an informal assessment can consist of a single person. This corresponds with the aim of informal assessments being quick, low-impact evaluations that may result in less accurate outcomes. To draw conclusions in an informal assessment only one type of evidence needs to be supplied, any type of evidence is accepted and no formal corroboration of the evidence is needed.

From the analyzed TMMi assessments, 14% were classified as being formal TMMi assessments, the other 86% therefore were informal assessments. Based on both authors

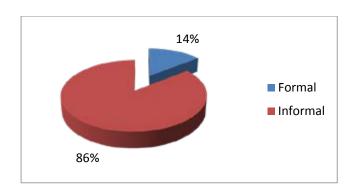experiences these numbers are representative for the TMMi assessment market.

Figure 3: TMMi assessments by type.

Benchmark results

Maturity levels

Based on the benchmark results no less than 84% of the test organizations assessed are still at TMMi maturity level 1, a mere 10% is at TMMi maturity level 2 and only 6% of the organizations is at level 3. None of the organizations that were assessed, fulfilled the requirements of TMMi levels 4 or 5.
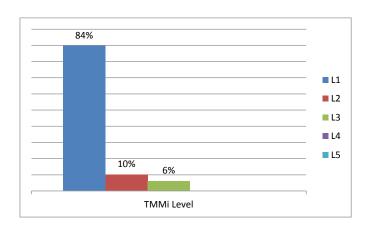

Figure 3: Maturity of the organizations

Thus, today most of the organizations are still at TMMi maturity level 1. Of course within level 1 organizations many differences in maturity can be observed. In some organizations testing is highly chaotic with no defined process, while

others are almost at TMMi maturity level 2. Even on level 1, a test project can be successful, however this is achieved by the dedication and effort of the so-called 'test heroes', not by means of a managed and repeatable test process.
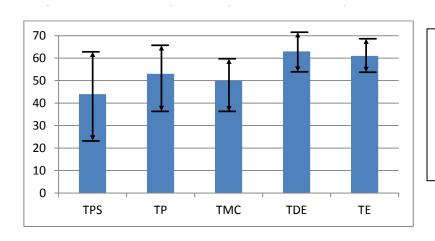
TMMi maturity level 2

Organizations at TMMi maturity level 2 can be perceived as being in the testing "premier league". There are still a rare breed. The main objective of testing in a TMMi level 2 organization is to verify that the product satisfies the specified requirements. At TMMi level 2, testing is a managed process. At component level it is clearly separated from debugging and a company-wide or program-wide test strategy is established. Test plans are written, that include a concrete test approach based on the result of a product risk assessment. The test plan defines what testing is required, when, how and by whom. Testing is monitored and controlled to ensure it is proceeding according to plan and appropriate actions are taken when deviations from plan occur. Test design techniques are applied for identifying and defining test cases from requirements. However, testing may still start relatively late in the development lifecycle, e.g., during the design or even at the beginning of the implementation phase.

TMMi maturity level 3

Organisations at TMMi maturity level 3 can be perceived as being in the testing "champions league". At TMMi level 3, testing is no longer confined to a lifecycle phase after implementation. It is fully integrated into the development lifecycle and its associated milestones. Test planning is done at an early stage of the project, e.g., during the requirements phase, and is documented by means of a master test plan. Master test planning builds on the test planning skills and commitments acquired at TMMi level 2. The organization's set of standard test processes, which is the basis for maturity level 3, is established and improved over time. Both a dedicated test organization and a specific test training program exist, and testing is now perceived as being a profession with career paths. Organizations at TMMi level 3 understand the importance of reviews in developing a quality product. A review program is implemented, however not yet linked to the dynamic testing process at this level. Test process improvement is fully institutionalized being one of the test organization's practices.

Process areas

In figure 4 the maturity scores per TMMi level 2 process area are listed.

TPS – Test Policy and Strategy

TP – Test Planning

TMC – Test Monitoring and Control

TDE – Test Design and Execution

TE – Test Environment

Figure 4: Scores (incl. standard deviation) per TMMi level 2 process area

One can observe in figure 4 that the operational testing process areas, Test Design and Execution, and Test Environment, are the typically the process areas with the highest maturity score. The managerial process areas (Test Policy and Strategy, Test Planning and Test Monitoring and Control) have a large distribution in their maturity score. Although the mean maturity score for these process areas is lower compared to the operational process areas, there are many organizations that have implemented these process areas already quite well. However, there are also many organizations that have a very low maturity score for these managerial process areas. In these organizations, typically testing is not well integrated and linked to the business drivers and quality policies, and lacks management commitment.

CMMI and TMMi

Practical experiences have shown that TMMi can also be applied successfully in organizations who are not at all familiar with CMMI. However, implementing TMMi is perhaps slightly easier in organizations that are already familiar with CMMI. Analyzing the assessment data, a significantly higher maturity score was observed on especially the managerial TMMi process areas for organizations that are also using the CMMI (in blue) compared to those that are not also using the CMMI (in red).
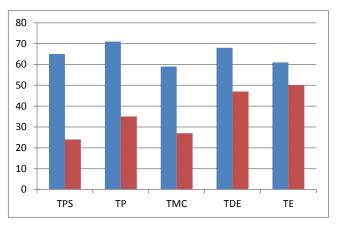
Figure 5: TMMi maturity score – CMMI organizations vs. non-CMMI organizations.

The authors believe that the reason for this could be that organization also using the CMMI, already have experience in both defining, implementing and using policies and planning and monitoring processes. This probably goes for having experience in any other software improvement model. It's the experience with process improvement in general that is important and helps, not so much the specific experiences with CMMI.

Branch results

An analysis was also done on the maturity scores per domain. Is testing maturity on average higher in some domains compared to others? Based on the assessed organizations three domain were distinguished that had enough data points to be analyzed: industrial organizations, financial institutions and governmental bodies. From figure 6 one can learn that industry (e.g., medical, automotive, embedded software) has a significantly higher maturity score compared to finance and government. The average maturity score for industry is even higher for all TMMi level 2 process areas, but especially for Test Policy and Strategy and Test Planning.
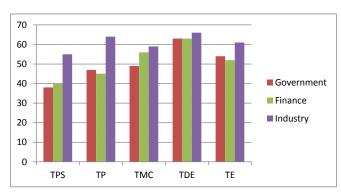
Figure 6: TMMi level 2 maturity scores per domain.

Probably due to the risk-level of the systems being developed, industry is more mature regarding testing compared to the other domain analyzed.

Test practices

Although it was hard to draw conclusions for specific practices based on the available assessment data, it was observed that some specific practices within the TMMi process areas were much more commonly applied that others. Incident management and test environment control are typically strong practices and fully implemented. However, reliable test estimation, the application of test design techniques and documenting test environment requirements are typical problem areas for many organizations. These observations are much in line with practical experiences of both authors; providing a reliable and well-founded test estimate is a problem for most test managers, test design techniques are often not explicitly used, and in practice we rarely see that requirements for test environments are elicitated and specified.

Closing comments

In recent years much have been invested in improving the testing processes. In some organizations this has lead to remarkable results, but surely not in every organization for many reasons. With the TMMi now being fully available, it is expected that it will become even more popular and the standard test maturity framework to assess and improve one's test processes against. Based on the benchmark results the testing industry still has many steps to take towards maturity. There is long but rewarding road ahead of us.

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Authors

Erik van Veenendaal (www.erikvanveenendaal.nl) is a leading international consultant and trainer, and a widely recognized expert in the area of software testing and quality management with over 20 years of practical testing experience. He is the founder of Improve Quality Services BV (www.improveqs.nl). He holds the EuroSTAR record, winning the best tutorial award three times! In 2007 he received the European Testing Excellence Award for his contribution to the testing profession over the years. He has been working as a test manager and consultant in various domains for more than 20 years. He has written numerous papers and a number of books, including "The Testing Practitioner", "ISTQB Foundations of Software Testing" and "The Little TMMi". Erik is also a former part-time senior lecturer at the Eindhoven University of Technology, vice-president of the International Software Testing Qualifications Board (2005–2009) and currently vice chair of the TMMi Foundation.

Jan Jaap Cannegieter is Vice President of SYSQA B.V., an independent Dutch consultancy. Jan Jaap has 20 years of experience in requirements, quality assurance and testing, is author of nine books, including 'The little TMMi'.

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