

Test Maturity Model integration (TMMi): Trends of worldwide test maturity and certifications

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Abstract:

Test Maturity Model integration (TMMi) is a popular model for maturity assessment and capability improvement of software testing practices in industry. Originally inspired by the Capability Maturity Model Integration (CMMI), and managed by the TMMi Foundation, the TMMi specification provides detailed guidelines for assessing and improving testing capabilities of teams and organizations. We present in this paper a status report about TMMi, motivations for and benefits of using TMMi, and how companies have been ranked in each of its process areas.

Keywords:

Test Maturity Model integration, TMMi, trend analysis, test maturity certifications

1 INTRODUCTION

In response to the growing demand for software quality, various initiatives, models and approaches have been presented in the software industry since 1980's. Examples include the Capability Maturity Model Integration (CMMI) model (cmmi.institute.com) and the ISO/IEC 15504 standard, also known as the Software Process Improvement and Capability Determination (SPICE) model.

Over the past three decades, CMMI adoption has gradually increased, mostly for organizations working in governmental and defense projects. According to the CMMI Institute (sas.cmmi.institute.com/pars/pars.aspx), as of this writing (December 2020), 9,650 companies have received appraisals (certifications) for CMMI.

While studies have reported that models such as CMMI and SPICE could be useful in certain contexts, their primary focus are process improvements on the "overall" software development process. Such process improvement models do not often provide specific improvement recommendations for software testing. For this reason, various models have been developed for dedicated improvements of software testing practices. A 2018 survey paper in IEEE Software [1] reported a catalogue of 58 models for test maturity and capability improvements, e.g., the Test Maturity Model integration (TMMi) (tmmi.org).

The authors, one of them from the TMMi Foundation, report in this paper a brief status report about the trends of worldwide TMMi assessments and certifications. Let us note that the TMMi model has been in existence since 2012, and thus the paper's goal is certainly not to present TMMi, but the motivations for and benefits of using TMMi, and how companies have been ranked in each of its process areas. The data have been compiled and prepared in an anonymous manner from the internal assessments and certifications database of the TMMi Foundation.

We start by presenting a brief overview of TMMi.

2 A BRIEF OVERVIEW OF TMMI

The roots of TMMi goes back to Gelperin and Hetzel's evolutionary testing model [2], published in 1988, and an early test improvement model named Test Maturity Model (TMM) [3]. By seeing the need for a more focused test improvement model, several test and quality experts (volunteers) came together (mainly based in Europe) in 2005 and formed the TMMi Foundation. The first version of the TMMi specification (1.0) [4] and was presented by the foundation in 2012. The latest version of specification, as of this writing, is 1.2 [5] (released in 2018).

The TMMi framework [5] is a guideline and reference framework for test process improvement. TMMi uses the concept of maturity levels for process evaluation and improvement. Furthermore, for each maturity level, a set of process areas, goals and practices are identified. The foundation is supported by the so-called TMMi Local Chapters that provide and organize TMMi-based consulting services locally in their country / region. At the time of this writing, 22 TMMi Local Chapters are in existence, e.g., in China, US, Spain, Brazil, and France.

TMMi is aligned with international testing standards, and the syllabi and terminology of the International Software Testing Qualifications Board (ISTQB). The TMMi Foundation has consciously not introduced new or their own terminology but re-uses the ISTQB terminology. This is an advantage for all those test professionals who are ISTQB-certified (approximately 700,000 worldwide at the time of this writing). With TMMi, organizations can have their test processes objectively evaluated by accredited assessors. It is also possible for test professionals and consultants to be personally certified as a "TMMi Professional".

Similar to CMMI, TMMi has a “staged” scheme for test process assessment and improvement. It contains stages or levels through which an organization passes as its testing process evolves from one that is ad-hoc, also called “initial or unmanaged” (level=1) to one that is managed (level=2), defined (level=3), measured (level=4), and optimized (level=5).

Figure 1 shows the five maturity levels of TMMi, their 16 Process Areas (PA), and structure of TMMi as a meta-model. To achieve any level by a given test team/organization requires that all process areas of that level and the lower levels have been satisfied.

In a hierarchical setting, each PA has several specific goals (SG), specific practices (SP), sub-practices (SP), generic goals (GG) and generic practices (GP). Across the five levels, there are in total 50 SGs, 173 SPs, 845 SPs, 32 GGs, and 192 GPs. Details of those elements can be found in the TMMi specification [5].

For instance, the maturity level 2 (“managed”), has five PAs, e.g., PA 2.1 (Test policy and strategy). This PA has three SGs: SG 1 (Establish a test policy), SG 2 (Establish a test strategy), and SG 3 (Establish test performance indicators). The above SG 1, in turn, has three SPs, e.g., SP 1.1 (Define test goals), and SP 1.2 (Define test policy).

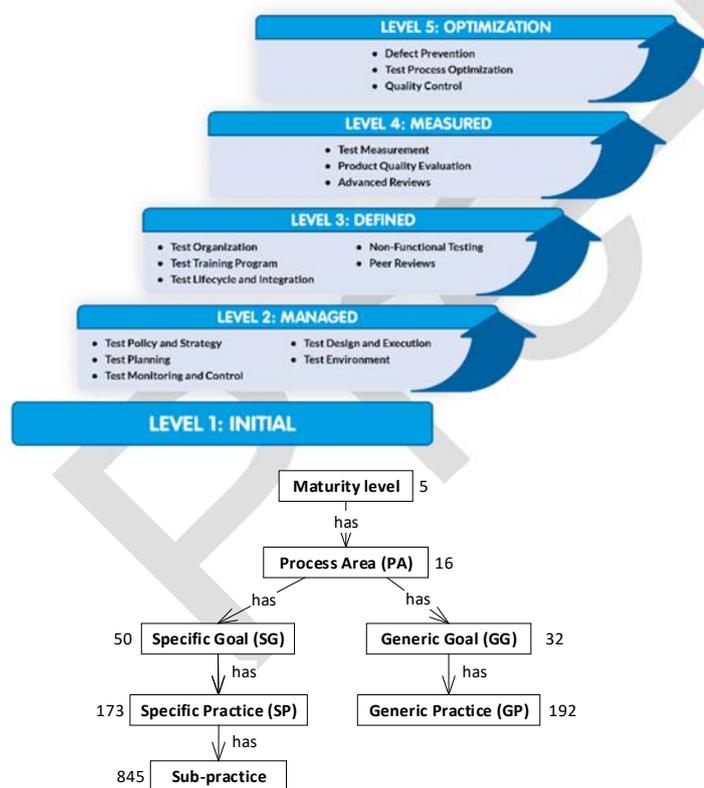


Figure 1-Top: Maturity levels of TMMi and their Process Areas (PA). Bottom: Structure of TMMi as a meta-model

A main underlying principle of the TMMi is that it is a “generic” model applicable to various lifecycle models. The model has been translated into several languages, e.g., Spanish, French, Portuguese and Chinese. Several experience reports and case studies from industrial application of TMMi have been published, e.g., [1, 6-8].

For instance, the study [7] reported a single-object case study of test process improvement using TMMi by an Estonian gaming software company. The study empirically found that the comprehensive and detailed documentation of TMMi framework in terms of the reference model, assessment method and data submission requirements provided adequate support in assessing and improving organisations.

In another study [8], both TMMi and TPI-Next were applied in the context of a large Swedish company (Volvo IT). The study found that, even though the two models generally show strong similarities, differences in the assessment results are noticeable due to their different model representations. Mapping and comparison of the assessment results indicated that the requirements of the maturity levels in TMMi are much stricter and more difficult to reach than in TPI-Next. Also, “the work examples in TMMi give very detailed descriptions of the testing process, which provides a good guidance in conducting the assessment”. Furthermore, the industrial study found that, for the successful application of both approaches, extended knowledge in software testing is essential.

A logical question to explore is about the motivations of companies to assess and improve their processes using TMMi. Maturity models which address the entire Software Development Life Cycle (SDLC), e.g., CMMI, provide only some high-level assessment and improvement criteria for software testing and, thus, are of limited use for test process improvement (TPI). By surveying both academic and grey literature, a study [1] reported that in general, three main drivers for utilizing TPI models are: need for increasing software quality, needs for decreasing cost of testing, and process and operational needs. A recent survey performed by the TMMi Foundation in 2020 (results are not published yet) shows that the main reasons (motivations) for the adoption of TMMi are: to enhance product quality, to reduce product risk, increase testing productivity (efficiency), benchmarking against an internationally-used model, and increasing the prestige of testing teams.

As discussed earlier, there are more than 58 models for TPI [1]. We were interested to objectively compare the industry diffusion / penetration of different models. However, there are very limited data for this. In a survey study [1], which reviewed 181 sources from both industry and academia, 57 out of the 181 sources used TMMi,

whereas 18 used a model named TPI-Next [9]. In the absence of objective statistics for popularity of maturity models in industry, the above numbers could serve as popularity measures for TMMi and TPI-Next.

While TMMi is an independent model and managed by the TMMi Foundation, TPI-Next model has been developed by a software consulting company. We compare TMMi and TPI-Next in Table 1.

Table 1-Comparison of TMMi and TPI-Next

Criteria	TMMi	TPI-Next
Representation	Staged model	Continuous model
Test levels	All test levels (unit, integration, system, user-acceptance testing)	Focus on higher test levels (System and user-acceptance testing)
Supported test methodology	Test-method independent	Linked to TMap (tmap.net)
Terminology	ISTQB based	TMap based
Base SPI model	Related to CMMI	None
Certification	Possible through formal assessment	None

In terms of how TMMi compares with other existing models, an earlier study [1] discussed that TMMi and TPI-Next are both “general-purpose” models for test process improvements, while there are “special-purpose” models such as Unit Test Maturity Model (UTMM), and Automated Software Testing Maturity Model (ASTMM) [1]. From the set of 58 models in this area [1], it is not really easy to identify the most “promising” model from the point of view of the completeness of evaluations. Depending on its needs, a given team/company would choose and apply the right improvement model.

3 A GROWING NUMBER OF CERTIFICATIONS

According to the internal certifications database of the TMMi Foundation, until the end of 2019, 187 companies worldwide have submitted assessment applications to the Foundation. 73 companies have applied for “informal” assessments, as their purpose was to get “an indicative [rating] rather than formal detailed maturity rating” [5]. 114 companies have applied for “formal” assessments, since their need was to receive “a detailed assessment and/or considered embarking on a path to certification”. Out of those, 111 certificates have been issued (the list can be found in tmmi.org). All the assessments are systematically conducted by a team of Certified TMMi (Lead) Assessors. For assessments, in addition to the specification [5], there is another document named *TMMi Assessment Method Application*

Requirements (TAMAR) [10], which is used to ensure rigor and consistency in assessments.

Figure 2 shows the cumulative trend of TMMi assessments between 2011-2019, which shows an increasing interest to get TMMi assessments.

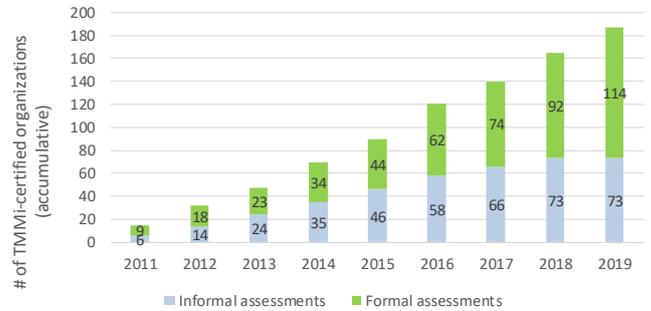


Figure 2-Growing number of TMMi assessments and certifications since 2011

When analyzing the assessments and certifications database, we were interested to get an insight the regions and countries which have had highest and lowest representation in TMMi assessments. In Figure 3, we show that data. UK, South Korea and China are the top-3 countries. It is interesting that certain countries have had higher uptake rates. In the UK for example, TMMi has been widely adopted in the governmental units, and there are also media news articles¹ about it. This is partly due to the fact that the Foundation has made more efforts to publicize the model in certain countries (due to the efforts of its members and Local Chapters). We should add that the Foundation started from the UK initially.

Furthermore, we feel that the work culture of certain countries (being “process-oriented”), and also the large presence of CMMI in some regions are other factors impacting higher penetration of TMMi in certain countries.

Note that some important IT-active countries are still missing in Figure 3. It is expected that this is soon to be changed. For example, three TMMi Local Chapters have recently been established in Canada, Italy and Turkey. Others such as Germany and Russia are in the process of becoming a TMMi Local Chapter.

¹ www.theguardian.com/government-computing-network/2011/sep/01/tmmi-hoit-testing

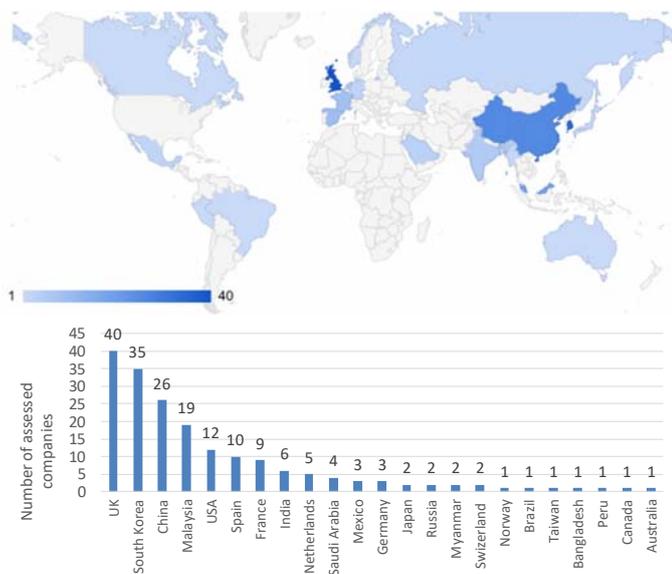


Figure 3- Countries (locations) of the organizations which have received TMMi assessments

One way to make more sense of the above country data was to correlate it with another metric in the foundation's database, the locations (residence countries) of certified *TMMi Professionals*. *TMMi Professional* is a certification that is open to everyone with an interest in TMMi. Holding the *TMMi Professional* certificate is a prerequisite to becoming an accredited *TMMi Assessor*, the holders of which have the authority to conduct TMMi assessments.

Based on the compiled data, we show in Figure 4 the scatter-plot of the number of TMMi Professionals in countries (as of end of 2019) versus the number of assessed organizations in those countries. Note that, for brevity, only countries with higher representation in terms of both metrics are shown in this figure (at least 3 in each metric). The Pearson correlation coefficient of the two series is 0.51, denoting a moderate correlation. Thus, we can say that generally speaking, the higher the number of TMMi Professionals in a country, more chance to have more assessed organizations in that country. This is indeed expected since when there are more TMMi Professionals in a country, they help increase the awareness for TMMi and also encourage more organizations to apply for assessments and certifications. We could also see other various interesting insights in the scatter-plot of Figure 4, e.g., India has the 3rd largest TMMi Professional community but has ranked low on the number of TMMi-certified organizations. It could be that companies do not see enough motivations/reasons to get the certifications, e.g., no enforcement by the governmental agencies, like the case of UK as discussed above. Also, note that not all organizations utilizing TMMi will indeed go for certification. There may be many

professionals doing TMMi related work, but for organizations, "just" achieving benefits, e.g., in terms of software quality, is often sufficient, and they may not go as far as getting the certification.

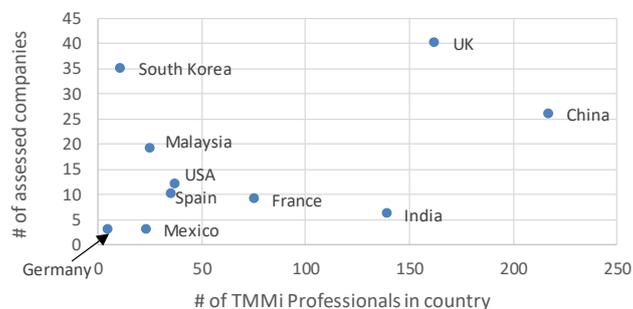


Figure 4- Country locations of TMMi Professionals versus the number of assessed organizations

4 TMMi LEVELS ACHIEVED BY COMPANIES

The other data in the certifications database were the "grades" for each process area (PA) and specific goal (SG) achieved by each applicant company or organizational unit.

We show in Figure 5 an "individual-value" plot including the "moving" averages (length=10) of the TMMi levels achieved in all certifications (n=111). We have also looked at the median and mean values for each year. As we can see, the moving averages fluctuated between 3 and 4 mostly in the window of eight year. For example, during year 2011, eight certificates were issued, to companies with rather low TMMi levels (between 1-3). Overall, we do not observe any increasing trend in TMMi levels achieved in the certifications over the years. Main reason is that, on a given year, any number of companies with any level of maturity could have applied and received certifications in different levels. Also, the dataset of maturity levels are not for the same set of companies over different years.



Figure 5- Mean (average) and median of TMMi levels achieved by certifications annually

5 SCORE OF EACH PROCESS AREA (PA)

We also had detailed data for each PA. Let us recall from Figure 1 that across the five levels of TMMi, there are in total 16 PAs. We were wondering if there are any particular PAs in which companies typically were more “challenged” to pass. We should mention that, to rank the score of each PA for a given applicant (company or team), the TMMi TAMAR document [10] provides a 5-point rubric (scale): (1) fully achieved (or fully implemented), (2) largely achieved, (3) partially achieved, (4) not achieved, and (5) not reviewed; which is similar to CMMI assessments.

Figure 6 shows the stack chart for each of the 16 PAs and the five scale of the scores, for the 114 companies who had applied for formal assessments. As we can see, most PAs were scored as “fully achieved” for most of the applicants. Some PA were “largely achieved”. A small ratio was partially or not achieved. For many of the applicants, PAs in levels 4 and 5 were “not reviewed”, since when submitting an application, a company specifies the level that they are intending to have the assessments done. Most of the applications targeted levels 2 or 3, and thus PAs in levels 4 and 5 did not have to be assessed.

A maturity level may be rated as “achieved” by the organization if all PAs in scope have been rated as either Largely Achieved or Fully Achieved. Furthermore, higher maturity level cannot be achieved without lower levels also being achieved. Thus, it is critical that a given applicant company ensures that it has the evidence/capability to “largely” or “fully” achieve (satisfy) all PAs of the level that it intends to get certified for.

Back to our question of whether there were any particular PAs in which companies typically were more challenged, we found that PA2.5 (Test environment) and PA3.4 (Non-functional testing) have relatively more “not achieved” scores compared to other PAs (this is visually visible in Figure 6). It seems that these two PAs have certain challenges in the pool of assessments, e.g., it could be that some companies had not invested enough in setting up systematic test environments and conducting non-functional testing. Non-functional is often a specific expertise that needs more resource investments and is often more difficult to get mature at, than other process areas. Thus, an actionable insight for teams considering to apply for TMMi is to ensure improving those aspects in their teams.

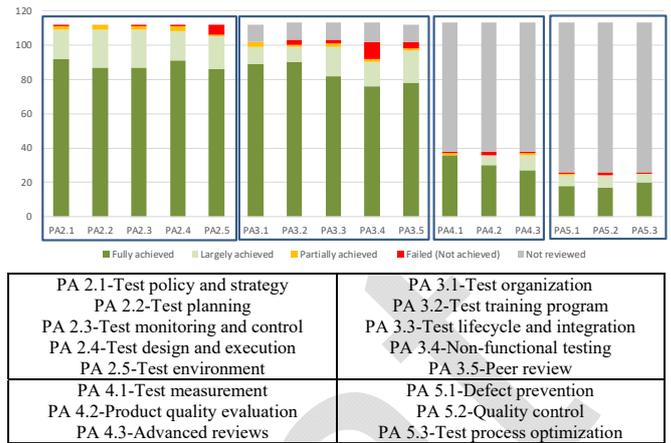


Figure 6- Score of each Process Area (PA) for the 114 companies undergone formal assessments

6 CONCLUDING REMARKS AND ROAD AHEAD FOR TMMi

This brief status report aimed at providing insights into the trends of worldwide TMMi assessments and certifications, and a general picture of how the companies get ranked in TMMi maturity levels.

Of course, there are several other important issues related to TMMi which are worth investigating, e.g., impacts of a TMMi certification on the quality of software developed by an organization. Data from a recent survey performed by the TMMi Foundation in 2020 (results are not published yet) could shed some lights on this important question. Three TMMi level-3 companies, who had participated in the survey, self-reported Defect Detection Percentage (DDP) improvements of 10%, 20% and 22% (17% on average). Let us remind that DDP is the number of defects found by a test phase, divided by the number found by that test phase and any other means afterwards. Thus, these are some evidence of impacts / benefits of TMMi certifications for software teams.

Despite many software quality initiatives in the last several decades, the software industry is still struggling to deliver perfect (defect-free) software. It has become apparent that, to achieve higher levels of product quality, a higher level of test maturity is required. As more awareness is raised for cost of poor testing, e.g., [11], industry is investing more resources on software testing. Companies are finding ways to conduct testing in more effective and efficient ways, often by conducting test process improvements. TMMi is one of the established means to do so. When using TMMi, various benefits have been reported on both product quality (test effectiveness) and test efficiency [12], reduction in test execution times, and increased Defect Detection Percentage (DDP).

Since there are similarities between TMMi and CMMI, it is also important to compare them. Starting in late 1980's, CMMI has become a popular model for software process improvement with a large uptake world-wide, mostly in the government and defense sectors. The fact that CMMI was initially required by the US DoD (Department of Defense) helped enormously to achieve its popularity. For the case of TMMi, such a driving force is slowly happening. For example, the Malaysian government issued a policy in 2018 that a company can only be assigned as an IV&V (Independent Verification and Validation) provider for the public-sector ICT projects if they are TMMi level 3 or above (bit.ly/MalaysiaTMMi).

Our analysis in this paper showed that, since starting the TMMi assessments in 2011, the number of annual assessments have been between 15-30 companies each year. In 2019, there has already been a growth in the uptake of the TMMi (as depicted in Figure 2).

Another interesting recent development (since 2017) for TMMi is probably the establishment of so-called TMMi local chapters. A TMMi Local Chapter ensures that TMMi Professional training and assessment services are available locally. Already the success from this approach is reflected in the recent growth numbers.

Furthermore, the TMMi Foundation and ISTQB, the world leading organization for test certifications, entered into an alliance in mid-2019 to further promote the software testing profession together. The alliance aims to bring together the people (ISTQB) and process (TMMi) aspects of testing.

Based on the above, we forecast more TMMi "uptake" in the coming years as more and more companies are seeing the benefits of TMMi.

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