

# Comparative Study of Software Engineering Processes in Egyptian Cmmi Companies

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**Abstract:** The Egyptian government has paid special attention to the software industry as Egypt to provide it with a competitive advantage that makes this emerging industry promising. Thus, the State has supported the Egyptian companies to make use of the Capability Maturity Model Integration (CMMI). Since 2009, more than thirty companies obtained the CMMI at different levels. However, these companies suffer from lack of a mechanism to exchange experience and information among themselves although they could be similar in the culture of their engineers and perhaps in the nature and size of their software projects. So, we provide in this research a survey to gauge the quality of methods, tools and processes used in these Egyptian companies winning the CMMI. Then we analyzed the results to reach the recommendations aimed at enriching the software industry in Egypt.

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## 1. Introduction

In 1993, the Software Engineering Institute (SEI) released the Capability Maturity Model Integration (CMMI) with five staged maturity levels as a means to both appraise maturity level and guide process improvement efforts for software organizations. This model has since been widely accepted around the world, especially in Egypt where the CMMI has helped many software companies [1, 2, 3, 4, and 5].

CMMI combines software engineering, systems engineering, integrated products and procurement to design and improve all types of processes. CMMI has become an international standard for devising software development processes and is credited with helping Egypt rise rapidly to become among the world's software exporters. CMMI provides guidance to improve organizations processes and ability to manage the development, acquisition, and maintenance of products or services. The process areas are grouped into four categories: Process Management, Project Management, Engineering, and Support [6, 7, 8, 9, and 10].

Around the world, there are fast growing CMMI companies. Many countries use the CMMI model extensively e.g. India, China, Japan, Australia, Russia, USA, S.Korea, France, Germany, Brazil, Argentine, Canada and Taiwan. For example in Taiwan seven companies hold Level 2 accreditation, two have Level 3 accreditation and one (IBM Taiwan) has already achieved Level 5 accreditation. In 2009

more than 500 companies in the U.S. were certified to CMMI standard [11, 12, and 14].

Today, use of CMMI in Software industry in Egypt has been increasing to improve software processes. By June 2009, thirty-one software companies achieved CMMI accreditation levels, from Level 2 to Level 5. One of the problems that face CMMI companies in Egypt is lack of conferences that enable specialists to meet to share their experience about software engineering processes. Also, there is lack of researches that reflect the experiences and provides comparative studies. So, we made the CMMI Survey in 2009 to help organizations identify the best practices and enhance the maturity of their processes. By investigating most of the organizations that have been appraised, processes automation, success factors, keep performance indicator (KPI), benefits of CMMI implementation are identified [13].

## 2. Survey Design

We designed a Survey for CMMI companies in Egypt. The target of the survey is to make a comparative study of the process implementation, best practices, tools, and techniques used in these companies. The target of these questions is to give informative details about the CMMI companies to get clear and transparent information about the software industry in Egypt [13]. These survey requirements were divided into twelve sections, covering most areas of operations in the maturity model with the aim of measuring the capacity of the second and third division levels.

The results were as follows: The first section was to get general information about the company characteristics in terms of size and structure, other sections of the survey focus on processes implementation and tools used for different process areas of levels two and three. Level two includes Project Management, Requirement Management, Measurements and Analysis, Quality Assurance and Configuration Management. Level three includes Technical Solutions, Product Integration, Risks Management, Testing, Decision Analysis and Resolutions, Process Improvement, and CMMI satisfaction[3,9].

The survey was launched in 2009. Through Software Engineering Competence Center (SECC) in the Egyptian Ministry of Communications, the thirty-one Egyptian CMMI companies were requested to fill the survey to answer 65 questions addressing different sections of programming activities in Egypt. Then four experts from software engineering processes and CMMI section were contacted to define the key points which Egyptian companies need to relay their experience. Based on these needs we divided the survey as follows:

- 1) General Information
- 2) Individual Evaluation System
- 3) Engineering Processes Group
- 4) Project Management
- 5) Requirement Management
- 6) Measurements and Analysis
- 7) Quality Assurance
- 8) Technical Solution and Product Integration
- 9) Testing
- 10) Risks
- 11) Process Improvement
- 12) Satisfaction with CMMI based processes

### 3. Survey Implementation

This survey was sent to 31 companies in Egypt that obtained the Capability Maturity Model Integration (CMMI) at different levels: eighteen companies were granted the second level (58.2%), ten received third level (32.3%), one got level four (3.2%), and two obtained the fifth level (5.6%).

From the results of the survey, we find that 14 companies participated as follows: 8 companies got the second level (57.1%) got the third level (28, 6%), and two got the fifth level (14.3%). most companies responded to all questions included in the survey. However, some vague points were not answered by few companies.

### 4. Results and Evaluations

#### A. General Information

As a result of evaluation, the following rates were obtained from responding companies:

- ❖ A percent of 58.3 % have projectized structures, while 41.7 % are matrix organizations. This is striking if we bear in mind that most companies and projects are individual and small-scale projects. The importance of the adoption of the Matrix Organization is demonstrated when the companies are large, including a multiplicity of departments and skills. But in a small institution, it is usually advisable to adopt a system of Projectized Organization, where the responsibilities and tasks are more specific and there is speed in decision-making, flexibility in management, and easy follow-up on the other hand. Please note that in medium-sized companies (where the number of employees is less than fifty) 50% of the employees use the matrix model. So we recommend that these medium-sized companies adopt a projectized system.
- ❖ 36% of the companies got the Capability Maturity Model Integration (CMMI) before 2006, 36.4% before 2007, and 27.6% by the year 2008.
- ❖ All companies on the second level have valid plans to get the third level in a year or two, which indicates:
  - a. Growing awareness of the importance of quality systems and the positive repercussions on companies.
  - b. Companies are satisfied with returns resulting from the application of quality systems (Return on Investment).
- ❖ All the companies that got the third level in re-evaluation (reappraisal) after expiry of the first evaluation aim at higher level of the CMMI Levels 4 and 5 but this is impaired by the financial constraints, as the Egyptian Government supports only the companies that plan to get the second and third levels.
- ❖ The ISO 9001 certification was a good start for Egyptian companies, as 43% of the participants, received the ISO certification before they got the CMMI. This can be explained as the required specifications in ISO 9001 focus on the administrative side, at the same time the CMMI standards focus on the specifications of the technical operations, especially in the third level and above. This is why we recommend the companies that got the ISO certification or wishing to start a quality journey to follow the experience gained and the methodology proposed by [Chanwoo, 2006].

#### B. Individual Evaluation System

Individual Evaluation is a key success factor for organization. Having good measures and processes for performance evaluation affects the employee's satisfaction and turn over rate. In 55% of the companies, where the individual survey system was applied the direct manager alone filled the survey. This reflects two facts:

- a. Companies need performance indicators which truly reflect the real level of performance of engineers.
- b. Companies need to design questionnaires on specific scientific basis which reflect the level of performance of software engineers from different points of view. For example, designing a system of individual performance appraisal method based on the Three-Hundred and Sixty Degrees method can be a good choice. Hence it is recommended that researchers in the field of software engineering would address this need and give it priority in their research.

#### C. Engineering Process Group (EPG)

At the beginning of the processes improvement initiative, there are usually some important questions, e.g. How many people are needed for the EPG? Should they be dedicated process engineers or normal software engineers who spend some time in processes? What are the criteria for EPG member selection? The paragraphs below help the decision maker through highlighting the actual performance.

- ❖ 83% of the companies that dealt with the survey are of small and medium SME.
- ❖ 53.8% of the companies prefer to have the engineering team dedicated to this work size (Static EPG), while in 46.2% of the companies, EPG members are originally working in software projects (such as a systems analyst, developer, tester) and those who deal with process improvement tasks would, take over these functions to complement their own tasks (Virtual EPG).

The average overall efforts to improve operations in companies have a monthly rate of 1.25 employees. This will be useful later to show the amount of spending on improving processes, calculate the resulting returns and consequently access the return on expenditure (Return on Investment, ROI).

#### D. Project Management (PM)

Project managers face challenges of selecting the suitable quick and detailed estimation techniques and the adopted software life cycle. They are also required to select the project management tools and decide about the meetings frequency. Challenge facing the project manager to select the appropriate method to estimate the size of the product backend

forums and then estimate the cost and time, has emerged from the questionnaire which also revealed that:

- ❖ 42.9% of the companies use the Microsoft Professional project management (Microsoft Project Professional).
- ❖ 36% use the Microsoft Advanced Project Management (Microsoft Enterprise Project).
- ❖ 21.1% are using a spreadsheet (Excel sheet). These rates are consistent with the nature of projects which are based on dealing with the user.
- ❖ 53.8% Use Case Points (Use Case Point) as a tool to estimate the size of projects.
- ❖ 38.2% use point of the task (Function Point), and 8% use COSMIC tool.
- 78.6% have a preliminary technical assessment (Initial Estimation Technique), and 21.4% do not.

#### E. Requirement Management

A percent of 46.2% of the companies use spreadsheet software for management of requirements. However, complex software systems steadily increase the list of requirements which makes it is difficult to manage and follow-up. It is also difficult to link design and test programs and schemes corresponding to each requirement (Traceability Matrix). Accordingly, we recommend, in such case, use of special programs to manage the requirements of software systems to enhance the efficiency of the management process requirements.

#### F. Measurements and Analysis (M&A)

The number of key performance indicators (KPI) in projects and institutions in general was great compared to company sizes. So as, each KPI has a cost for managing it (e.g. collecting KPI values, verifying their validity, and analyzing them), we recommend training specialists to calculate the cost of these indicators (cost/benefit analysis) in order to be able to take the right decision for selection of numbers and quality.

In 50% of the companies, key performance indicators for the (KPIs) are less than 4 and more than 7, and 33% less than 4, in 17% it is more than 4, this is compared to the number of key performance indicators where in 64.2% of companies the number of KPI is between 4 and 7, and in 30.8% the number of is less than 4, and in 23% is more than 7. We find that 85.7% of the companies take advantage of the actual analysis of performance indicators to improve operations.

#### G. Quality Assurance (QA)

How many process QA engineers are needed? Is it useful to get QA approval before a projects is closure?

When should QA issues be escalated? The results below express the real situation in Egyptian CMMI Companies. The senior management support to a quality assurance is an essential element in the commitment of staff operations that are in line with quality systems. It has been found that 57.1% of the companies need to get the approval of the project manager of quality assurance team (QA approval) at the end of any project, and in 71.4% of the companies, the number of quality assurance engineers was more than three. These are good promising an indicator of the manager is concern to stress the value of the quality of operations and give it direct support.

#### H. Technical Solution and Product Integration

For developers, it is important to determine how unit testing is performed and to define dedicated positions for architecture, analysis, and design are used. It is equally important to define who is responsible for support documentation. The results of that survey are given below.

- ❖ 78.6% of the companies perform automatic unit testing, and 57.1% perform the testing manually. This reduces efficiency as much as it lowers the productivity of the developer/tester. These companies are recommended to adopt unit testing and general testing. We also recommend training developers on tools unit testing automatically, and training testers to use automated testing tools.
- ❖ 27.3% of the companies use dot-net (Dot Net) as a tool for program development. 27.3% use the Java language (Java), 9.1% use the Oracle (Oracle) language, while 36% use other languages such as Delphi (Delphi).
- ❖ There is no specialization in technical writing where developers and testers take the responsibility of preparing documents associated with the product code. This is, in most cases, not accomplished professionally which reduces companies' efficiency. So, we recommend that company's employee technical writer who would be responsible for documentation especially since the cost incurred may be less than the cost of employing a developer or tester.

#### I. Testing

- ❖ It is noted that the checking bugs (Bugs), and problem issues (Issues) are checked manually in 57.1% of the companies. Perhaps this makes it difficult to follow-up and may affect the quality of products and processes. Hence, we propose that companies automate this process, either through

their own software or through readymade software.

- ❖ Manuscript rapid testing (rapid testing script) is very important to examine applications in a limited time. The importance of this testing is Highlighted in the maintenance phase of software systems. However, we find that 71.4% of the companies do not have this facility. Therefore, we recommend its provision for testers and training them to use it.
- ❖ The rate of developers to testers in the companies was at an average of one laboratory for each 3.7 developers. This reflects the distribution of effort in software projects, where this ratio is severely limited if compared to the ratio of 1: 2 approximately [17] in COCOM I and COCOM II. This indicates a weak interest in testing the products adequately. So, it is recommended to invest more effort in testing products which would improve the quality and increase competitiveness of Egyptian software.
- ❖ 78% of the companies perform unit tests manually, and 57.1% do screening tests manually. This reduces efficiency as much as it reduces the productivity of the developer/tester. Thus, we recommend companies to adopt mechanical unit testing. We also recommend training developers to perform the Tools unit test automatically, and training examiners to use automated testing tools.

#### J. Risks

54.5% of the companies use spreadsheets to manage risks, 18.2% use radar (Radar), and 27.3% use other programs such as (Microsoft Project Server) for the management of risks.

#### K. Overall Satisfaction with CMMI

- ❖ Generally, the companies applying the CMMI are satisfied which is a good sign. However, there are complaints from the complexity of operations there is an urgent need to review the operations approved by each company in the system to alleviate any burden carried by these processes (Process overhead). To accomplish this, we recommend that companies work on some ideas inspired by the Agile Models and trying to integrate them in their quality system which is compatible with the CMMI, especially as most companies are small and thus need flexible and simple processes.
- ❖ 21% of the projects in the companies do not follow the processes set forth by the CMMI quality system. When these companies were asked, the answer was that pressure from

customers to get the product forces them not to follow the internal CMMI quality systems. This in fact represents a threat to the quality of processes and then the quality of products in these projects. So, it is proposed that companies apply another Simple Process to speed the completion of work such as the Agile Model, and thus Subject all company projects whether complex processes or simple operations, to the internal quality system according to the standard set by the companies to follow the appropriate processes.

- ❖ The percentage of delay in software projects delivery date was 58% and the average percentage of projects costing more than the approved budget is estimated by 45.5%. This is consistent with global figures estimated by 75% and 50% respectively. It is observed that most international projects that suffer from delays and cost increase are large-scale projects, while the projects in the Egyptian companies are not huge. According to [18], the most important reasons at the global level are:
  - a. poor planning and management
  - b. changing objectives of projects during their implementation
  - c. Non-participation of senior management in the follow-up projects and consequently not giving enough support.

We find that the second and third reasons may not apply directly to the Egyptian companies which are relatively small in size. Also, the number of projects is limited, which reduces the likelihood of changing objectives and lack of support from senior management. Thus, the primary cause is the most influential and therefore it is recommended to raise the skills of project managers through training to use the specific and effective methods of project management software.

## 5. Conclusion

Through this paper we are providing the results of a questionnaire to investigate the processes and Tools used in CMMI software companies in Egypt. By analyzing the results and conclusion obtained, we recommend that:

1. Small and medium companies adopt a structural Projectized Organization process, where the responsibilities and tasks are more specific and there is speed in decision-making and flexibility in management and follow-up.
2. Training the responsible personal to estimate the cost of key performance indicators (analysis of the relationship between expenses and profit) in order to be able to reach a wise decision for selection of

performance indicators with respect to quality and quantity.

3. Carrying performance unit tests and general tests automatically. Also, training developers to perform the Tools unit tests automatically, and testers to automated testing tools.
4. Automation of the follow-up bugs (Bugs), and issues (Issues) either through their own software or through ready-made software's.
5. Training testers to prepare and implement rapid testing (rapid testing script) to support the maintenance of software products.
6. With the steady complexity of the code systems and growth of the list of requirements which is difficult to manage and follow-up, it becomes difficult to link it to design, test programs and plans corresponding to each requirement (Traceability Matrix). Preparation and use of special programs to manage the requirements of software systems, to enhance the efficiency of the management process requirements.
7. Exerting more effort in the work of a good testing of products in order to increase the quality and competitiveness of Egyptian software.
8. Companies employ a technical writer, especially since the cost incurred is less than that of employee a programmer or tester.
9. Enhancing skills of project managers through training on the unique and effective methods of project management software.
10. Companies prepare new classifications for simple operations (Simple Process) in order to be able to speed the completion of work by following the Agile model and thus subject all projects to their special quality system (both for complex or simple operations) according to the standard they set.
11. Companies holding ISO 9001 or wishing to start a trip to ISO quality should follow the experience gained and the methodology proposed in [19]. The ISO 9001 certification was a good start for many Egyptian companies. Forty-three percent of the participating companies received a certificate of the ISO before they got the Capability Maturity Model. This can be explained by the required specifications in both, where the ISO 9001 focuses on the administrative side, at the same time the Capability Maturity Model identifies standards of technical operations, notably in the third level and above.
12. There is an urgent need to review the operations approved by each company in its system, and for this process said companies try to make use of Agile models and integrate them in their quality system which is compatible with the CMMI to decrease the Process overhead,

especially as most companies are small and need to be flexible, and simple.

13. Researchers in the field of software engineering should study to find indications of a genuine performance which truly reflects the performance of engineers to design by questionnaires on the basis of special scientific programmed software which describe the performance of engineers from different points of view, for example, designing a system to assess individual performance depending on the method of Three Hundred and Sixty Degrees.

#### Future Work

After publication of this paper we shall supply the participating companies with the results through the Egyptian Ministry of Communications represented by SECC. Through participation in Arab conferences we hope that government's private institutions Adopt these recommendations and spread them in their countries.

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