Software Development Process Assessment With MMIS v.2, an ISO/IEC 33000-Based Model

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While, historically, software quality focused on identifying and mitigating defects, today, companies that want to digitally transform their products and services are changing the manner and scope of their quality assurance processes. Based on the ISO/IEC 33000 family of standards for process assessment, we have built a new maturity model called MMIS V2.0. This new model has been applied in more than 20 companies. Here, we present the experience of these companies in carrying out the MMIS implantation and certification, evaluating its usefulness, and obtaining feedback to improve it. In addition, during this study, we have identified the processes that are more difficult for companies to implement (based on their own perception and on the number of nonconformities identified during certification audits), as well as the main software tools and frameworks used to support the development lifecycle.

Software quality has in recent times become a key success factor in digital transformation. Organizations and companies have realized the importance of having software applications with appropriate quality, which they can rely on to manage their business processes and the productive activity of the company. As ISO/IEC 25000 conveys, the quality of software is determined not only by its functional suitability (that is, its compliance with user needs and expectations in a complete and correct way), but also by other nonfunctional characteristics, such as security (paramount nowadays), performance efficiency, usability, or maintainability. Software quality matters: For the year 2020, CISQ estimated the total Cost of Poor Software Quality in the US to be $2.08 trillion.[1] That is why, as the last World Quality Report 2020–2021[2] makes clear, today organizations invest around 23% of their IT budget in QA and testing tasks.

Software quality has traditionally been approached mainly from two complementary points of view: software product quality[3] and software process quality. Several models and standards have been used for improving software process quality. Initially, the most important ones were CMM, CMMI, and ISO/IEC 15504.[4] Other models used are MPS.BR,[5] CERTICS,[6] Competisoft,[7] K-model,[8] ISO 9001,[9] and ISO/IEC 29110.[10] Recently the new ISO/IEC 33000 family[11] has been published, revising ISO/IEC 15504.

When compared to ISO/IEC standards, the CMMI model and its appraisal method have several shortcomings, which, for example, led the US DoD to abandon CMMI as a requirement for suppliers, as they considered the CMMI rating not very trustworthy. One cause for this could be that appraisals are conducted every three years, which can be quite a distance, leading some organizations to relax in applying the practices established by the model. From the technical point of view, CMMI proposes more rigid and complex

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practices than the ISO/IEC standards and has a more costly scheme, requiring a bigger investment in effort, training, and resources from companies implementing it. The recent CMMI V2[12] is intended to address most of these shortcomings.

MMIS V2.0 (SOFTWARE ENGINEERING MATURITY MODEL)

We built a new maturity model called MMIS v2.0[13] (Software Engineering Maturity Model) based on ISO/IEC 33000. This new model has been institutionalized in more than 20 companies, both large and small, which have subsequently undergone a certification process. The certification scheme for the model is based on the following standards:

- The process reference model based on ISO/IEC/IEEE 12207,[14] which defines a set of lifecycle processes specific to software development.
- The process capability assessment model proposed by ISO/IEC 33000.
- The requirements for the certification audit process proposed by ISO/IEC 17021[15] (the same one used in the certification of other ISO standards such as ISO 14000 or ISO 27000).

Specifically, the following processes in the reference model were assigned to the different maturity levels of the MMIS model:

- Level 1: Project Planning Process and Implementation Process.
- Level 2: Supply process, life cycle model management process, project assessment and control process, configuration management process, measurement process, stakeholder needs and requirements definition process and quality assurance process.
- Level 3: Infrastructure management process, human resource management process, decision management process, risk management process, systems/software requirements definition process, architecture definition process, integration process, verification process, and validation process.
- Level 4: Portfolio management process.
- Level 5: Knowledge management process and business or mission analysis process.

Although MMIS 2.0 is a process framework, we incorporated some recommendations regarding the implementation of the above processes, such as following agile practices: iterative and incremental development in short time boxes, involvement of a product owner, continuous integration/continuous delivery, incorporating DevOps, etc. These practices are not mandatory in most cases though, since the outcomes of the processes can be achieved by also following more traditional approaches.

MMIS APPLICATION

The authors have participated in all the MMIS certification audits carried out to date. Besides reviewing records and work products resulting of the software development lifecycle, these audits involve interviewing different roles in the company, including managerial and technical-oriented personnel. Key roles in the implementation process are the sponsor (normally assumed by an executive, such as the CEO or CIO) and the implementation leader (typically assumed by the CTO or Quality Director), who is responsible for assuring that the processes are implemented and followed correctly daily, as well as continuously improved. During the audits, project managers, analysts, system architects, programmers, testers, quality managers, etc., are also interviewed to verify how the MMIS model processes are implemented, as well as the main difficulties that they face and the solutions that they conceive of when implementing them.

In addition, the authors have prepared a questionnaire for gathering further insights, opinions, and improvement suggestions from the certified companies regarding their implementation of the model, answered by the sponsor (general questions related to sector, personnel, revenue, certifications, etc.) and the implementation leader (questions regarding technology, methodologies, tools, and process implementation).

Overview of the Companies

There are 20 companies that have already obtained the MMIS certification, most of them from Spain, and two from Latin America (Table 1). Most of these companies have software development as their main activity or as a significant part of the IT services that they provide to other businesses, although there are also some companies in other sectors in which software development supports their main activity. Of the 20 certified companies listed, 35% are big companies, 25% medium, and 40% small (according to the definition by the European Commission[a]).

Roughly 33% of the above companies develop custom software or systems, 20% develop specific

[a] https://ec.europa.eu/regional_policy/sources/conferences/state-aid/sme/smedefinitionguide_en.pdf

TABLE 1. Characteristics of the companies certified to ISO/IEC 33000.

ENTERPRISE	COUNTRY	SIZE	MAIN ACTIVITY	MATURITY LEVEL
ASMET SALUD EPS SAS.	Colombia	Big	Healthcare, health insurance	2
CONSULTIA IT, S.L.	Spain	Medium	IT services	3
CORE GRID, S.L.	Spain	Small	IT services	2
DOCPATH DOCUMENT SOLUTIONS, S.L.	Spain	Medium	Software development	2
GESTIÓN CUATROCIENTOS, S.L.	Spain	Small	Software development	2
GRUPO CMC - COGNICASE MANAGEMENT CONSULTING, S.L.	Spain	Big	IT services	3
INDENOVA, S.L.	Spain	Medium	Software development	3
INERZA, S.A.	Spain	Small	IT services	2
OESÍA NETWORKS, S.L.	Spain	Big	IT services, industrial engineering	3
PERSEI VIVARIUM, S.L.	Spain	Small	eHealth	2
PERSEI CONSULTING, S.L.	Spain	Small	Software development	2
QUENTAL TECHNOLOGIES, S.L.	Spain	Big	IT services	2
SIA - SISTEMAS INFORMÁTICOS ABIERTOS, S.A.	Spain	Big	IT services	3
SOCIAL-IT SpA	Chile	Small	IT services	2
SIEMENS RAIL AUTOMATION, S.A.U.	Spain	Big	Systems development	4
TELEFÓNICA SOLUCIONES DE INFORMÁTICA Y COMUNICACIONES DE ESPAÑA, S.A.U.	Spain	Big	IT services	3
ULMA EMBEDDED SOLUTIONS S.COOP.	Spain	Small	Systems development	2
UNATEC ICT, S.L.	Spain	Small	Software development	2
VÍNTEGRIS, S.L.	Spain	Medium	Software development	2
XERIDIA, S.L.	Spain	Medium	IT services	3

products that are offered as commercial off-the-shelf solutions, while the remaining 46% of companies carry out both types of development. The sectors for which the certified companies develop software (and/or systems) are represented in Figure 1.

As for the context or environment of the software, most of the companies develop web and cloud applications, followed closely by mobile and desktop applications, with embedded software being developed by only a minority of the certified companies.

As regards development methodologies, agile frameworks (mainly Scrum, but also Extreme Programming) are the most popular among the companies, with traditional methodologies (waterfall) and unified process being in a minority, although most of them also follow hybrid approaches combining traditional and agile elements.

When asked about their objectives for pursuing ISO/IEC 33000 certification, the companies reported the following answers (in order of their frequency, which is shown in parentheses):

1. Improving the quality of the products (15).
2. Establishing an organizational culture (13).
3. Increasing customer satisfaction (11).
4. Supporting organized future growth (11).
5. Supporting evolution and continuous improvement (11).

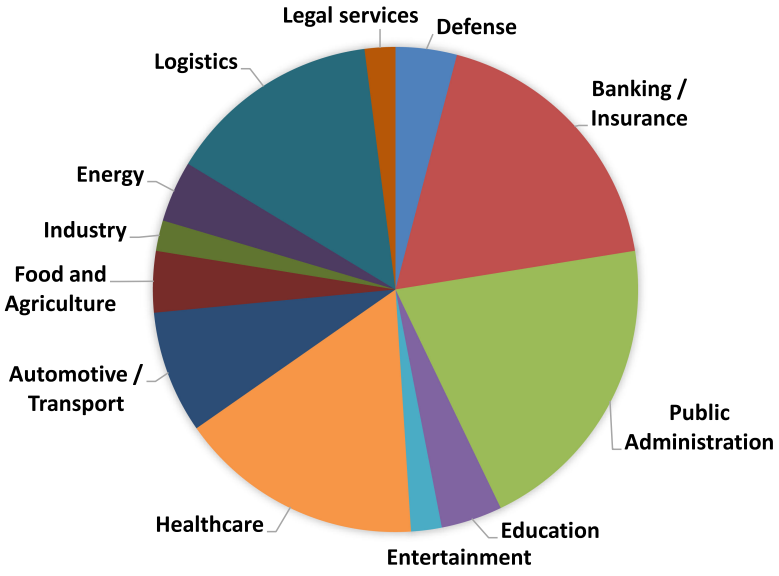

FIGURE 1. Sectors of the clients of MMIS certified companies.

6. Complying with regulations for public tenders (9).
7. Gaining competitive advantage and differentiation (8).
8. Improving productivity (7).
9. Obtaining an internationally recognized quality seal (7).
10. Facilitating international development (3).

Software Processes

The certified companies consider requirement analysis, testing, and design to be the most critical areas, as these have the greatest impact on the quality of the developed product and the success of a project. They consider requirements analysis as being the most important process since having a clear understanding of the needs of the customer and users is essential in order to develop a quality product. Testing is likewise considered essential, since delivering software with defects impacts deeply upon customer satisfaction and leads to further corrective maintenance effort, when it is preferable to instead channel that effort toward adding new features and improving the existing ones. The third most important process, according to the answers to the questionnaire, is software design. This process is sometimes overlooked by development teams, who jump straight into coding after the requirements analysis, but it has a profound effect on the lifecycle of the software as it determines its security, adaptability, scalability, and maintainability.

When asked which specific ISO/IEC 12207 processes included in the MMIS model have provided them with the greatest business value, the certified companies reported the information that is shown in Figure 2.

Figure 3 shows the MMIS processes that companies consider most difficult to implement, with a high level of agreement regarding measurement being the most difficult, followed by quality assurance. These survey results confirm the perceptions we obtained through the audits. Companies struggle with the definition of process efficiency indicators that are really useful and easy to measure (many times some automation of the measurement process is required). Regarding the quality assurance process, companies seemingly find it difficult to dedicate adequate resources to the supervision and audit of the processes being followed, in order to assure that they are consistent with quality management policies, procedures, and requirements. If we look at the nonconformities found during certification audits, the results are fairly aligned with the difficulties reported by the companies regarding the processes shown in Figure 3.

Frameworks and Tools

To achieve the different outcomes of the development lifecycle processes efficiently, companies use different frameworks and tools.[16] Table 2 shows the most used frameworks and tools for these different purposes.

Advantages of the ISO/IEC 33000 Implementation

When asked about the implementation of ISO/IEC 33000 and the MMIS model, the certified companies reported having gained the following advantages:

FIGURE 2. MMIS processes that provide the greatest business value.

FIGURE 3. MMIS processes most difficult to implement.

1. Having better control and status visibility of software development projects and their lifecycle.
2. Standardizing processes and tools throughout different areas and projects.
3. Improving the quality of the resulting software products.
4. Assuring the continuous improvement of the development processes by detecting and removing anomalous and chaotic situations.

TABLE 2. Main tools used by the companies certified to ISO/IEC 33000.

PURPOSE	TOOLS
Project management	JIRA, Confluence, Redmine, Microsoft Project, OpenProject, Rational Team Concert
Requirements management	JIRA, Redmine, DOORS, Confluence, MS Word/Excel
Testing	JIRA, Confluence, TestLink, Redmine, MS Word/Excel, JUnit, Selenium, JMeter
Integration	Jenkins, Maven, Team City
Software quality control	SonarQube, VectorCast, Polyspace
Configuration management	GIT, Subversion, Nexus, CVS, Synergy, Team Foundation Server

5. Establishing a culture of quality in the organization that permeates to the development teams.
6. Obtaining a competitive edge and a differentiating element.
7. Achieving a better documentation of technical and functional specifications.

Effort and Costs

Implementing a maturity process model, such as MMIS, requires that companies dedicate some effort to defining their processes in alignment with the requirements of the model, that they get personnel to learn and adapt the way they work in accordance with those processes, and that they appoint people to supervise the implementation of the model and assure that it is being done correctly.

In terms of the effort required to implement the processes of MMIS, an average of six person-months was found to be necessary (considering that several companies had previous experience in ISO/IEC 15504 and ISO 9001).

Regarding the economic cost that the implementation entailed, the answers of the participants in the questionnaire show that they range between 10 000 and 40 000 euros, with the average estimated cost being around 15 000 euros. This estimated cost considers the effort made by the personnel in order to document and institutionalize the processes define templates for work products, implement tools that support the processes, buy licenses for said tools (in some cases), learn to use said tools, take training courses, etc.

CONCLUSION

Through their answers to the questionnaire and the interviews, most of the companies highlighted their satisfaction with the model. They emphasized its usefulness, its capability to be adopted without excessive effort and costs, and its great value to any organization that either develop software or have a development department.

We are pleased to report that from one third of the companies, we received some very useful feedback: They would like us to ensure that the MMIS model places more emphasis on continuous feedback and improvement; that we "agilize" the model activities; and that we clarify some aspects using examples.

Although the companies know that the model must be "technology-agnostic," they also asked us to complement the model with a set of suitable tools for supporting each process. This study is, in part, an answer to this petition.

As for future work, we need to extend the geographical scope of the application of the model, as in this first stage almost all the companies were from Spain, and also, we want to examine more deeply the two highest maturity levels (4 and 5), incorporating new elements for project management at these levels, and clarify some issues regarding software process statistical control.

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