MMSIA: Towards AI Systems Maturity Assessment

Rubén Márquez Villalta[1,2][a], Javier Verdugo Lara[1,2][b], Moisés Rodríguez Monje[1,2][c] and Mario Piattini Velthuis[1,2][d]

[1] *AQCLab Software Quality, C/ de Moledores s/n, 13071 Ciudad Real, Spain*

[2] *Instituto de Tecnologías y Sistemas de Información (UCLM), Paseo Universidad, 4, 13071 Ciudad Real, Spain*

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Abstract: The emergence of artificial intelligence (AI) has caused a technological revolution in society in recent years, and a growing number of companies are implementing or creating systems that use this technology across a range of industries. In order to guarantee quality procedures on these systems, there is an immediate demand for quality standards as a result of this rise. Based on a variety of international standards, including the ISO/IEC 5338 standard as a reference model for AI processes and the ISO/IEC 33000 family of standards to establish a software process assessment and maturity model, this paper shows an Artificial Intelligence Software Maturity Model (called MMSIA). The main objective of the MMSIA model is to give businesses creating AI systems a framework for evaluating and continuously improving the software processes used in the creation of these kinds of systems, which will raise the level of AI applications.

1 INTRODUCTION

Artificial Intelligence (AI) has become a fundamental technology in today's society, and this has been reflected in recent years, where it is increasingly common to see people using tools that use AI techniques in their daily lives. In recent years, this discipline has made its way into different areas of society, such as medicine (Wang and Preininger, 2019); business decision-making and data analysis (Enholm et al., 2022); or the automation of repetitive and tedious jobs in general (Ribeiro et al., 2021).

The new digital transformation that AI is driving and the impact it has had on the world is remarkable, even being compared to the industrial or digital revolutions, as, in these years, AI is changing aspects of our society in a radical way (Makridakis, 2017). Moving to the business world, more and more organizations are looking to use AI to gain an advantage over their competitors and gain value. Looking ahead, it is expected that by 2030, AI could contribute \$15.7 trillion to the global economy, equivalent to a 14% increase in global GDP (Anand and Verweij, 2017). Moreover, 55% of organizations have incorporated AI into one of their processes (Bughin et al., 2018). Similarly, this growth has shown that 59% of companies that have incorporated AI systems into their processes in recent years have increased their revenues, and 42% have seen a decrease in their costs. Furthermore, if we look at scientific journal publications, these have increased by 4.5% for the last years for those related to the field of AI, and 30.2% for the conference publications (Maslej et al., 2024).

However, as in other technological areas, the development of AI software tools involves certain particularities that present additional risks and challenges to those already found in traditional software development, and that need to be addressed and taken into account throughout these developments. Studies such as the European Commission's *White Paper On Artificial Intelligence - A European approach to excellence and trust* (European Commission, 2020) already address the concern for establishing regulatory frameworks and standards that promote responsible and quality development in the field of AI. It is worth noting that different institutions are already focusing on mitigating this lack of regulation. Such is the case of the European Union (EU) with the proposed comprehensive regulation on AI in the EU AI Act (European Commission, 2021).

Although advances in AI regulation are yielding

[a] https://orcid.org/0000-0002-1907-1701
[b] https://orcid.org/0000-0002-2526-2918
[c] https://orcid.org/0000-0003-2155-7409
[d] https://orcid.org/0000-0002-7212-8279

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results, there is a critical gap in creating frameworks directly focused on companies engaged in the development of AI systems to assist them in their development processes. While research to support organizations in these processes is scarce, certain advances are beginning to emerge, such as the recent publication of the ISO/IEC 5338 (ISO, 2023c) standard. This standard aims to identify and define a reference model for process improvement in the field of AI.

Therefore, this paper presents the Artificial Intelligence Software Maturity Model (MMSIA with its acronym in Spanish), based on the ISO/IEC 33000 (ISO, 2015a) family of standards and using the recent ISO/IEC 5338 standard as a process reference model. This model has been developed with the objective that it can be incorporated in organizations (either in specific projects or in the global organization) to improve the quality of the processes necessary in the development of AI systems and, in this way, to obtain systems with a sufficiently high level of quality to satisfy the requirements of the client and with appropriate efficiency.

This is followed by an indication of how the rest of the document is organized. The next section provides more detail on the context of this work. Section 3 provides more details about the new ISO/IEC 5338 standard, on which the model presented is based. Section 4 describes the proposed MMSIA model, indicating the processes involved, the maturity levels and the phases of which it is composed. Finally, the last section presents lessons learned, conclusions and future work.

2 CONTEXT

In order to provide a set of best practices, guidelines, and norms that assist companies in managing and improving the quality of their software products and guaranteeing customer satisfaction, a number of standards, frameworks, and models have emerged in the literature in recent years.

There are two distinct aspects of software quality: processes and products. In the case of advances in quality improvement focused on AI products, the ISO/IEC 25059 (ISO, 2023b) standard modifies four of the eight essential characteristics that a quality software product must have as established in ISO/IEC 25010 (ISO, 2023a). Also, this standard introduces new important sub-characteristics to be taken into account in AI products, such as transparency, functional adaptability or interoperability. Additionally, other works, like (Oviedo et al., 2024) have made progress to improve the quality of AI products through the development of an environment for assessing the suitability of AI systems.

Nevertheless, there is a direct correlation between processes and product, so that if the quality of the software processes used for the development of AI systems were improved, they would produce quality products (Pino et al., 2006). The activities, methods, procedures, and tools applied to create and maintain the final product constitute these processes. In light of this, companies that employ a software process-based strategy concentrate on the ongoing enhancement of their processes, which requires the accurate definition and identification of activities, roles, inputs, and outputs (Oktaba and Piattini, 2008).

In the case of advances in the publication of standards and norms that offer quality improvement in the lifecycle processes of AI systems, these are scarce, and associations such as the International Standardization Organization (ISO) have started to unify a standard under the AI processes. However, it is still common to use standards, frameworks and models, focused on improving the processes used in traditional software development, for the AI field. Some of these standards or models are the following:

- Capability and Maturity Model Integrated (CMMI) v3.0 (CMMI Institute, 2023): Defines a process assessment framework that helps organizations beyond software engineering to understand their current level of capability and performance, providing a roadmap for optimizing business outcomes.
- ISO/IEC/IEEE 12207 (ISO, 2017): Establishes a process reference model focusing on life cycle processes for the development and maintenance of traditional software systems.
- ISO/IEC 33000 family of standards (ISO, 2015a): Provides a framework for software process assessment and continuous process improvement, replacing ISO/IEC 15504, better known as Software Process Improvement and Capability dEtermination (SPICE).
- Maturity Model for Software Engineering (MMIS) v2.0 (Rodriguez et al., 2021): Proposes a framework for assessing and improving the quality of development processes, in accordance with ISO/IEC 33000 and ISO/IEC 12207.
- SMMT maturity model (Sonntag et al., 2024): Presents a maturity model designed to assess the ability of manufacturing companies to incorporate AI tools into their processes to optimize their operations.
- AI and Big Data Maturity Model (Fornasiero et al., 2025): Proposes a maturity model to eval-

uate the capacity of industry companies in the adoption and management of AI and Big Data solutions within their operations, with the objective of optimizing their processes and decision making.

The models found in the literature, such as the last two, are focused on companies that want to incorporate AI-related tools or solutions in some of their processes, and not on companies that develop those AI solutions and want to improve their development life cycle processes. Other standards and models, such as CMMI or MMIS have been highly extended in software development, nevertheless, the field of AI software requires some specialization. This domain involves a much more specific set of tasks, roles and processes that need to be addressed directly for the improvement of development. For example, new roles as data engineer or data scientist, due to the great importance of data in the creation of such systems; in addition to new development activities such as data extraction, preparation, documentation, monitoring and maintenance, activities to be taken into account, because if they are not well implemented, they can lead to risks and challenges (Sugali, 2021), such as the correct partitioning of training and test sets, the incomprehensibility of the developed AI models, overfitting problems, the absence of good measures of effectiveness or documentation problems. These issues have to be addressed and taken into account at the process level in order to anticipate them.

In relation to the aforementioned situation, it is important that organizations dedicated to the development of AI systems focus on the improvement and correct definition of the processes used for the development of these systems. Thus, ISO has recently published a standard known as ISO/IEC 5338 "AI system life cycle processes" (ISO, 2023c), which establishes the bases and good practices of the necessary processes that organizations must follow for the development of AI systems. The ISO/IEC 5338 has been designed to serve as an AI process reference model. It provides a suite of processes designed to assist in defining, controlling, managing, implementing and improving AI systems. These AI systems, to which the standard refers, are based on those systems that use Machine Learning and/or Heuristic Systems. This implies systems that make explicit use of data or expert knowledge for the learning of models and hence the inference of the required knowledge. ISO/IEC 5338 is the result of the consolidation of other more general standards, such as ISO/IEC/IEEE 15288 "System life cycle processes" (ISO, 2023d) and ISO/IEC/IEEE 12207 "Software life cycle processes" (ISO, 2017), whose processes have been integrated for this new standard. In addition, other standards more specific to the field of AI have also been integrated, such as ISO/IEC 22989 "Artificial intelligence concepts and terminology" (ISO, 2022a) and ISO/IEC 23053 "Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)" (ISO, 2022b), which define concepts specific to AI development and a framework describing the components and functions involved in the development of AI systems, respectively. The latter two standards have been used to incorporate AI-specific processes and to modify existing processes in ISO/IEC/IEEE 12207 by incorporating key aspects and concepts from this area.

In detail, ISO/IEC 5338 defines a total of 33 processes, and as in ISO/IEC/IEEE 12207, the processes have also been grouped into 4 large groups, according to a set of aspects that organizations developing AI systems must take into account. These aspects range from the management of different elements involved in the development to support, including the evaluation of the performance of the processes themselves, resulting in a classification of processes based on the organizational objectives that it provides and giving rise to:

- Agreement Processes: to secure an agreement between two organizations with the objective of providing an AI product or service.
- Organizational Project-Enabling Processes: to follow a process-oriented approach which guides projects and provides the resources and infrastructure needed to achieve the objectives.
- Technical Management Processes: to provide the resources, establish the plans, monitor, evaluate and manage the progress of the implementation of a project.
- Technical Processes: to define the requirements and needs of the client, and to transform them into the design, development and testing of the final product.

Although this standard establishes a process reference model for AI software, it is necessary to analyze which are the particularities offered in relation to those already implemented for traditional software.

3 DIFFERENCES BETWEEN ISO/IEC 5338 STANDARD AND ISO/IEC 12207

One of the first steps in the construction of the maturity model for AI systems has been the analysis and subsequent comparison of the ISO/IEC 5338 standard, focused on the best practices and processes necessary for the development of systems under an AI life cycle, and the ISO/IEC/IEEE 12207 standard, more focused on a traditional software development environment and whose processes extend to the AI standard mentioned above.

Through this analysis, the changes, extensions and reductions introduced by this new standard have been verified in order to define the MMSIA model. Thus, by focusing in detail on the types of modifications that have been carried out for the creation of ISO/IEC 5338, 3 types of processes can be distinguished:

- Generic Processes [G], for those processes that have not undergone specific modifications as a result of their incorporation in the AI field and are used entirely as defined in ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207.
- Modified Processes [M], for those processes that have undergone changes, additions or deletions in their elements (purpose, outcomes or activities) in order to adjust them to the AI environment, since certain specific particularities of that field must be taken into account.
- AI-Specific Processes [AI], for those processes with specific AI characteristics, which have been expressly defined for this standard.

The Figure 1 shows a summary of the processes included in ISO/IEC 5338 grouped by scope and identifying those that have been modified.

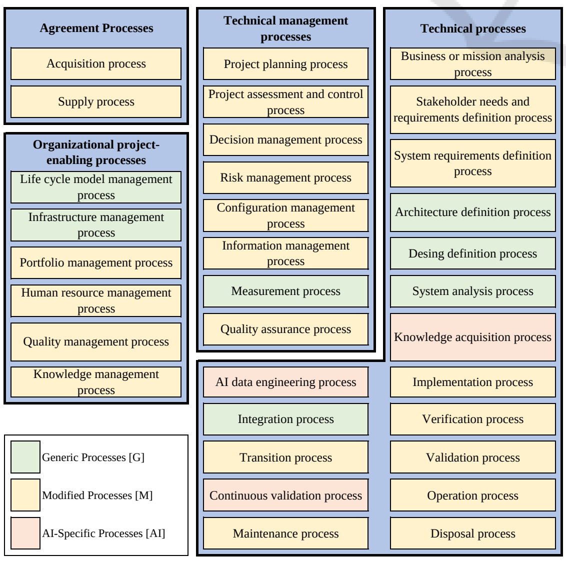

Figure 1: Software lifecycle process groups according to ISO/IEC 5338.

Three processes that have been created specifically for this AI standard can be identified, they are the following:

- Knowledge acquisition process: Knowledge of the domain and the problem are essential in AI systems, so this process seeks to provide the necessary knowledge for the development of models used by these systems. The results of this process are the correct identification, storage and traceability of the knowledge with the model. In addition, activities such as the definition of the scope, the search for knowledge sources or the performance of knowledge acquisition tasks about the domain and the problem are included.
- AI data engineering process: The objective of this process is to ensure that the data can be used in the model. Some outputs of this process are the acquisition of data sets, the correct formatting and preparation of training and test data, the provision of metadata for data documentation, traceability and maintenance, or the identification of automated processes for data extraction or processing. Some of the activities included in the process are acquisition or selection, labeling, digitization, quality analysis, documentation, cleaning and preparation, and data protection.
- Continuous validation process: Its objective is to control that the AI models would work correctly once the system has gone into production, since the behavior of a model or its performance may be affected. The results of the process are the addition of a validation log and the decision to perform AI model retraining. The results of the process are the addition of a validation record and the decision to perform model retraining. This includes a set of activities such as monitoring data drift, model performance or any aspect that affects the model and may be altered over time.

As for the other 30 processes, 7 of them have not been modified with respect to the original standards, so they can be directly applied in this field. And the rest (23) have undergone modifications in some of their aspects, purpose, results, activities or tasks, to adjust them to the particularities of the field of AI, which has been necessary to analyze and study their impact. Some of these modifications are due to the importance of data/knowledge in an AI project, such as the problems added in the acquisition of data for the acquisition process or the importance of the quality of the dataset in the quality management process. It is also important to highlight that new roles are introduced in this field such as data scientists, which must be considered in the human resources management process, or the inclusion of new phases in the development of AI systems, such as algorithm selection or model training, which is remarkably important in the implementation process.

Consequently, a reference model of processes for creating high-quality AI systems is established. Nevertheless, a model designed to assist enterprises in creating AI systems in assessing and continuously enhancing these specified processes involved in their development is required.

4 MMSIA, A MATURITY MODEL FOR AI PROCESS ASSESSMENT

Once the analysis of the ISO/IEC 5338 standard has been carried out, the Artificial Intelligence Software Maturity Model (titled MMSIA, with its acronym in Spanish) has been defined, a model through which companies dedicated to developing AI systems can evaluate and improve their software processes at both the project and organizational levels, which is based on the following points:

- ISO/IEC 5338: The new ISO standard that presents a reference model for AI system lifecycle processes.
- ISO/IEC 33000 family of standards: The latest version of the existing ISO standards for determining process capability and organizational maturity.

Based on ISO/IEC 33004 (ISO, 2015b), it is determined that for the defined MMSIA model, a domain of the reference model is specified that represents the processes that are considered fundamental for the development of AI systems by a small AI development organization (although it can be applied to any type of organization), from the conception of the need to the construction and production of the system that satisfies that need.

The process reference model provides a structured collection of processes useful for the development of AI systems, together with best practices that describe the characteristics of these processes. For the creation of the AI system lifecycle reference model for the MMSIA model, the processes described in the ISO/IEC 5338 standard were used as a basis.

Therefore, several of the processes proposed by ISO/IEC 5338, such as, the operation process, maintenance process or the disposal process, are outside the scope of the domain defined for the MMSIA model. Thus, the MMSIA model makes use of a total of 24 processes taken from ISO/IEC 5338. Each process identifies: a purpose; a set of outcomes, which represent the characteristics that must be implemented to satisfy the process; a set of activities and tasks, used to interpret and guarantee these outcomes; and work products.

Once the process reference model is provided, a mapping of the relation between the defined processes and their intended context of use is necessary. This relationship is described in the way the processes form part of the levels described in the maturity model and regarding a number of aspects that AI system development organizations need to consider in terms of project management, organizational management, resource management, data and expert knowledge management, engineering, model development and training, and product and process performance evaluation.

The agreement to include the processes in the process reference model and their allocation to the different maturity levels has a theoretical basis supported by a set of experts with experience in the development of maturity models, as is the case of the MMIS model, used as a maturity model for the assessment of the processes required in traditional software development, through the ISO/IEC/IEEE 12207 standard.

In this way, five maturity levels are defined, where each level will introduce new processes to be implemented in the organization and will represent a further step in the incremental approach to organizational maturity. The following list shows the classification of the processes of the reference model and their correspondence with the maturity levels.

- **Level 1: Basic.** Project Planning Process, Implementation Process and AI Data Engineering Process
- **Level 2: Managed.** Supply Process, Life Cycle Model Management Process, Quality Assurance Process, Project Assessment and Control Process, Measurement Process, Configuration Management Process, Stakeholder Needs and Requirements Definition Process and Knowledge Acquisition Process
- **Level 3: Established.** Infrastructure Management Process, Human Resources Management Process, Decision Management Process, Risk Management Process, Architecture Definition Process, Integration Process, Verification Process, Validation Process, System Requirements Definition Process and Continuous Validation Process
- **Level 4: Predictable.** Portfolio Management Process
- **Level 5: Innovative.** Knowledge Management Process and Business Analysis Process

Once the processes necessary for the development of AI systems have been established through a reference model with the different maturity levels, the MMSIA model establishes a measurement and assessment process using the ISO/IEC 33000 standards. One of the most essential aspects of assessing the processes of an organization based on the ISO/IEC 33000 family is the measurement of the capability level of each process. Assessing the capability of a software process means determining the level at which a process is implemented in an organization. To measure the capability of a process, a series of Process Attributes (PAs) are defined, which represent elements that allow evaluating, individually, a specific aspect of the capabilities and aptitudes of a process. These attributes are transversal and apply to all processes. These attributes are composed of management practices and generic work products. These elements represent the process capability indicators, through which their individual measurement is performed to determine the degree of achievement of the attribute and, therefore, the level of process capability to be evaluated. The following list shows these capability levels and the corresponding process attributes defined by ISO/IEC 33020 (ISO, 2019).

- **Level 0. Incomplete Process.**
- **Level 1. Performed Process.** Process performance (PA 1.1)
- **Level 2. Managed Process.** Performance management (PA 2.1) and Document information management (PA 2.2)
- **Level 3. Established Process.** Process definition (PA 3.1), Process deployment (PA 3.2) and Process assurance (PA 3.3)
- **Level 4. Predictable Process.** Quantitative analysis (PA 4.1) and Quantitative control (PA 4.2)
- **Level 5. Innovating Process.** Process innovation (PA 5.1)

The assessment of the capability level of a particular process can be made on the outcomes and the attributes observed in the assessment of each of the attributes of the evaluated process.

After establishing the different processes and their attributes and characteristics in the MMSIA model, the assessment process with its different stages has been defined. The evaluation process consists of a systematic evaluation in which an evaluator profile and another more proficient profile participate as the main evaluator, with the latter performing the task of reviewing the evaluations carried out. (Unterkalmsteiner et al., 2011) This process begins with a documentary review of the different elements involved in the development of the AI systems to be evaluated, which is carried out through a series of interviews with the different people involved in the development of these systems. These interviews are composed by a series of questions to the interviewees about elements, outcomes or activities that are necessary in the AI systems development life cycle, which have been extracted through the characteristics offered by each of the processes in the process reference model. The questions are divided into different sections of the AI system development lifecycle, such as the design and development phase, evaluation and continuous validation, or the data and knowledge acquisition and refinement phase. Throughout the interviews, those people involved will show a series of evidences, which will allow the evaluator to determine observations about the degree of implementation, on the project or organization, of the processes that have been used in the development life cycle. Based on this evidence, an assessment stage of the capability level of each of the processes involved will be carried out. For this, the process attributes, defined in ISO/IEC 33020, and the individual results used for PA 1.1 are used. Each process attribute is a measurable property of the process capability within this process measurement framework.

Consequently, the process attribute assessment is an evaluator's judgment on the fulfillment of the elements of the process attribute and defined outcomes, through the evidence and findings detected in the evaluation. A process attribute or outcome is measured using an ordinal scale, which has the following grades: N (Not implemented) for those process attributes that have no evidence of their definition in the process under assessment; P (Partially implemented) for those process attributes that have some evidence of focusing and achieving it; L (Largely implemented) for those process attributes that have evidence of a systematic approach and significant achievement; and F (Fully implemented) for those process attributes that have evidence of a comprehensive and systematic approach and full achievement. To obtain the value of the capability level of each process, an aggregation method is used based on the following criterion: a process is at capability level X if all the process attributes of the previous levels have a rating of "Fully implemented" (F) and the process attributes of capability level X have a rating of at least "Largely implemented" (L).

Once the capability levels of an organization's processes have been obtained, the organizational maturity assessment is carried out. This assessment consists of determining the degree to which an organization performs the processes necessary to contribute to the fulfillment of its business objectives in an AI development environment. Using the process profiles defined for each of the maturity levels listed above, it is possible to represent organizational behaviors and assist in continuous and incremental process improvement. However, in order to define a maturity level for an organization, it is necessary to establish a correspondence between the capability levels for the processes and the maturity levels for the organization. For this reason, the Figure 2 represents relationships between capability levels and corresponding maturity levels for the MMSIA model.

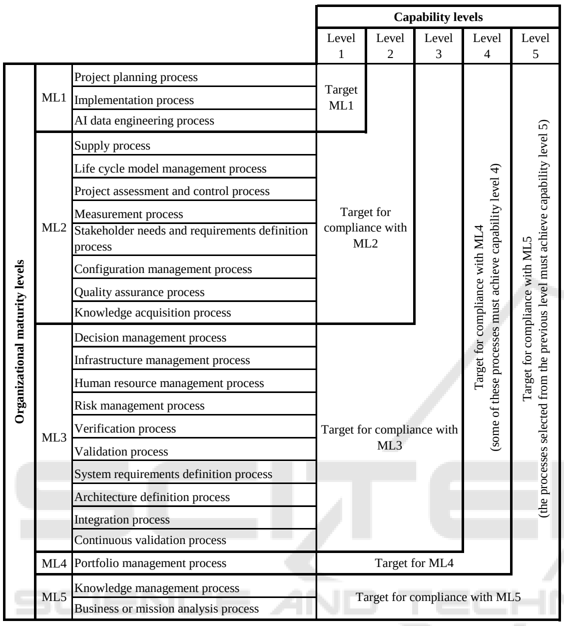

Figure 2: Correlation between maturity levels and capability levels.

5 CONCLUSIONS

This paper has shown that AI has become an essential tool nowadays with the aim of making people's lives easier. Therefore, it is important that in order to build complete and flawless AI solutions, it is necessary to give importance to the quality assurance of the final product in the life cycle of such systems, not only directly, but also through the improvement of the quality of the processes involved in its development.

Nevertheless, the advances in the assessment and improvement of the quality of the processes involved in the development of AI systems are scarce. Among them, the recent ISO/IEC 5338 standard stands out, which identifies and defines a reference model for the improvement of AI processes. While this is a great step forward, there is still a need for tools directly oriented to enterprises. For this reason, the contribution of this work has been a first step in solving this problem, with the creation of an assessment model together with an organizational maturity model for the development of AI systems, based on the ISO/IEC 5338 standard. Through this model, it is intended to provide AI development organizations with a framework that allows its incorporation in order to carry out an assessment and continuous improvement of the quality of the processes used for such development.

While the definition of this model establishes a foundation and a starting point to help AI organizations improve the quality of their processes, further progress is needed in order to improve it to a more robust model. These next steps are:

1. A real case study needs to be carried out in which the proposed model is tested and put into practice. For this purpose, a validation process is already underway in collaboration with a Spanish company specialized in developing technological solutions through the use of AI techniques. In this process, we are conducting a series of interviews with people involved in a project developed by this company, in order to extract a series of evidences and findings on the degree of implementation of the processes used on the project developed. The objective of this case study is to verify the practical viability of the application of the model, detecting possible defects and improvements that lead to the improvement of the model. On the other hand, we are currently discussing with other companies to carrying out more case studies.
2. The implementation of an software tool will be carried out to register the results in a repository of the findings detected in the process evaluations, as well as to define, plan and monitor the improvement actions traced to the findings. In this way, the aim is to provide support to companies to measure the capacity of their processes, and to carry out automatic assessments, with the objective of offering continuous improvement to the organization.

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