DOI: 10.15514/ISPRAS-2024-36(6)-5

Project Management Maturity Models: A Systematic Review

[1] *J. F. Ruiz-Lopez, ORCID: 0009-0003-9888-8537 <d19ce063@cenidet.tecnm.mx>*
[1] *J. Ortiz-Hernandez, ORCID: 0000-0002-6481-1537 <javier.oh@cenidet.tecnm.mx>*
[2] *E. Bonjour, ORCID: 0000-0001-7851-1095 <eric.bonjour@univ-lorraine.fr>*
[3] *J.-P. Micaelli, ORCID: 0000-0002-9403-1419 <jean-pierre.micaelli@univ-lyon3.fr>*
[1] *Y. Hernandez, ORCID: 0000-0002-8842-0899 <yasmin.hp@cenidet.tecnm.mx>*

[1] *National Technology of Mexico, National Center of Research and Technological Development, Cuernavaca, México.*
[2] *Research Team on Innovative Processes, University of Lorraine, Nancy, France.*
[3] *Magellan Research Laboratory, Lyon 3, University of Lyon, Institute of Business Administration, Lyon, France.*

Abstract. Project management is a field that has been applied in various areas of knowledge, particularly in engineering and software development. For organizations, projects are a central element for generating value. They allow to reach the organizational goal by using specific methodologies, tools and software. One of the most recognized tools, even in other fields of knowledge, for its impact on process improvement is maturity models. These models have already begun to be implemented in project management. Project Management Maturity Models are useful tools to evaluate the management process using a process reference (e.g., PMBOK). This process reference describes the best practices to achieve success in projects. The purpose of this paper is the identification of research papers that present maturity models specifically for project management. A useful classification for project managers using maturity models in a project management context is generated from the results of the review.

Keywords: project management; maturity models; systematic review.

For citation: Ruiz-Lopez J. F., Ortiz-Hernandez J., Bonjour E., Micaelli J.-P., Hernandez Y. Project Management Maturity Models: A Systematic Review. Trudy ISP RAN/Proc. ISP RAS, vol. 36, issue 6, 2024. pp. 83-102. DOI: 10.15514/ISPRAS-2024-36(6)-5.

Модели зрелости управления проектами: систематический обзор литературы

[1] *Х. Ф. Руис-Лопес, ORCID: 0009-0003-9888-8537 <d19ce063@cenidet.tecnm.mx>*
[1] *Х. Ортис-Эрнандес, ORCID: 0000-0002-6481-1537 <javier.oh@cenidet.tecnm.mx>*
[2] *Э. Бонжур, ORCID: 0000-0001-7851-1095 <eric.bonjour@univ-lorraine.fr>*
[3] *Ж.-П. Микаэлли, ORCID: 0000-0002-9403-1419 <jean-pierre.micaelli@univ-lyon3.fr>*
[1] *Я. Эрнандес, ORCID: 0000-0002-8842-0899 <yasmin.hp@cenidet.tecnm.mx>*

[1] *Национальный технологический университет Мексики,*
Национальный центр исследований и технологических разработок, Куэрнавака, Мексика.
[2] *Исследовательская группа по инновационным процессам,*
Лотарингский университет, Нэнси, Франция.
[3] *Исследовательская лаборатория Магеллана, Лион 3,*
Лионский университет, Институт управления бизнесом, Лион, Франция.

Аннотация. Управлять выполнением проектов необходимо в различных областях знаний, особенно в области проектирования и разработки программного обеспечения. Для организаций проекты являются центральным элементом создания стоимости. Они позволяют достигать поставленных целей с помощью конкретных методологий, инструментов и программного обеспечения. Одним из наиболее признанных инструментов по степени влияния на улучшение процессов, и не только в этой области знаний, являются модели зрелости. Эти модели уже начали внедряться в управление проектами. Модели зрелости управления проектами являются полезными инструментами для оценки процесса управления с помощью референтных процессов (например, PMBOK). Референтные процессы описывают лучшие практики, позволившие достичь успеха в реализации проектов. Целью данного документа является выявление исследовательских работ, которые описывают модели зрелости, предложенные специально для управления проектами. На основе проведенного анализа для руководителей проектов, использующих модели зрелости в контексте управления проектами, создана полезная классификация.

Ключевые слова: управление проектом; модели зрелости; систематический обзор.

Для цитирования: Руис-Лопес Х. Ф., Ортис-Эрнандес Х., Бонжур Э., Микаэлли Ж.-П., Эрнандес Я. Модели зрелости управления проектами: систематический обзор литературы. Труды ИСП РАН, том 36, вып. 6, 2024 г., стр. 83–102 (на английском языке). DOI: 10.15514/ISPRAS–2024–36(6)–5.

1. Introduction

Today, maturity models have been adopted by various industries and knowledge domains, including human resources, quality management, software development processes, manufacturing project management, products, and supply chain. This adaptation is due to the three main uses of maturity models reported in [1]: (1) to measure the level of maturity, (2) to provide a guide to achieve the maximum level of maturity, and (3) to establish a comparison with other organizations. In general terms, a maturity model can be defined as a collection of best practices that assist organizations in improving their processes[2]. According to [3], in 1986, the Software Engineering Institute began the development of a process maturity framework aimed at helping improve its software process. The first maturity model was published in 1988 [4] and called the Capability Maturity Model (CMM) by the Software Engineering Institute at Carnegie Mellon University in the United States, funded by the U.S. Department of Defense. The goal of this model was to assess the quality and capability of software companies providing services to the U.S. Department of Defense.

Due to its great utility, the models have been adopted by other domains such as processes, organizational management, software development, human resources, quality, project management, product development, and supply chain. In general, organizations recognize models as useful tools for assessing the status of specific or general processes. They allow for determining whether

processes have room for improvement. Maturity models present significant complexity because they lack a standardized manual for their application and may involve terminological biases that are not commonly used by those implementing them [5]. Models also require a considerable number of resources and time to be implemented properly and obtain a meaningful evaluation [6].

Garzás [7] stated that international efforts have been made to narrow down and adapt the software maturity models. Despite the difficulty of their implementation, software maturity models have given rise to project management maturity and assessment models. This difficulty lies in the fact that they are conceived as reference frameworks that establish the criteria for the operation of the area to be evaluated, based on pre-established manuals and/or standards, and do not explicitly state how to perform the evaluation. The most widely used manual or standard for building project management maturity models is the Project Management Book of Knowledge (PMBOK).

Many companies are motivated to implement project management to reduce process errors and drive improvements. In other cases, the motivation is to comply with standards or certifications that companies must meet to sell their products internationally. Based on this need to develop projects, companies use methodologies and tools, in some cases with computer support, to ensure their success.

The architecture of a system for predicting the performance of a project based on the evaluation of the project management maturity criteria is presented in [8]. In this research, an analysis of the mission statements of Sopra Steria Consulting and of the available literature on project management and maturity models has been carried out. It was found that, due to a lack of clarity in the concepts, the current maturity models are ambiguous in the way they should be applied in organizations. A standardization of some categories is proposed, which are included in a model called Invariant Based Maturity Model (IB2M). Also, a causal model is proposed to prove the existence of a relationship between project management maturity and cost overruns, showing that the maturity of the project management process is a significant determinant of the risk of cost overruns. This work is relevant to the research since it seeks to improve the area of project management using a tool such as the maturity assessment and for its methodological proposal to group and conceptualize in a clear and precise way maturity assessment criteria.

The remainder of the paper is organized as follows. Section 2 describes the systematic review process. Section 3 presents the analysis of the systematic review considering the quantitative and qualitative approaches. Section 4 describes the proposed classification of project management maturity models. In section 5, the future directions of project management maturity models are described. In section 6, a discussion is presented considering the results of this research. And finally, in section 7, the conclusions of this systematic review describe the main findings.

2. Systematic review methodology

The methodology of the systematic review is that proposed by [9]. It consists of three main phases: review planning, implementation of the review, and systematic reporting of the review. The detailed steps followed during the implementation of this state-of-the-art review methodology are described below.

2.1 Review planning

In this phase, the following aspects were identified and integrated as relevant for this precursor phase to the implementation of the review: rationale, approach, research question, and criteria.

2.1.1 Identification of the need for a systematic review

For the characterization of the justification, the particular interest in identifying the key aspects of the project management maturity models was considered to compare them and identify the areas of opportunity and the relevance of each model identified.

2.1.2 Development of the review protocol

A first version of the protocol was developed and analyzed to determine if it complied with two important aspects: completeness and consistency with the objectives of the review. The protocol was composed of the following parts: background, strategy for formulating the research question, strategy for selecting primary studies, selection criteria, strategy for establishing quality assessment criteria, data extraction strategy, synthesis strategy, dissemination strategy, and establishment of a schedule of activities.

2.2 Implementation of the review

In this phase, the systematic review protocol is used to develop the tasks established in the methodology for this phase. Previously the protocol went through a process of refinement and revision.

2.2.1 Identification of the research

In this section, the research question is formulated to help to identify project management maturity models. For the formulation of this question, the great importance of engineering project management maturity models was taken into consideration. Fig. describes the research question proposed.

What are the project management maturity models reported in the literature?

Fig. 1. Research Question.

2.2.2 Selection of primary studies

The selection followed the strategy outlined in the systematic review protocol, which consisted of searching for publications using search terms in search engines and repositories. Fig. 1 describes the research strings used in search engines in Spanish and English.

- *Improvement AND Project AND Management AND engineering,*
- *Evaluation AND Maturity AND Project AND Engineering,*
- *Evaluación AND Madurez AND Proyectos AND Ingeniería (research string used in Spanish),*
- *Maturity evaluation AND Project management,*
- *Mejora AND Proyecto AND Gestión AND Ingeniería (research string used in Spanish),*
- *Maturity evaluation AND project management AND SMES,*
- *Maturity evaluation and project management and systematic review.*

Fig. 1. Research Strings.

It was identified that the main keywords of the search string were as follows: Maturity and Project Management. A total of 1423 articles were reviewed considering only the title and keywords, after this review only 78 articles were considered primary studies. The inclusion and exclusion criteria in this phase of the process were only the title and keywords.*2.2.3 Characterization of the quality of publications.*

At this point, the following information was extracted for each publication: name of the article, number of pages, focus, number of citations, year of publication, and keywords, in addition to checking the availability of the article. After characterization, inclusion, and exclusion criteria were applied to each publication. The inclusion and exclusion criteria that were considered for the selection of articles to answer the research question are the following:

- Title: The title of the articles must include at least the keywords: Project Management and Maturity Model.
- Year of publication: Only articles from the last 10 years from 2012 to 2022 were selected.
- Number of citations: The number of citations of the articles was considered to determine their relevance to this research. For publications from 2022 and 2020, no filter applies, 2019 at least 4 citations, from 2018 at least 6 citations, from 2017 at least 8 citations, from 2016 at least 10 citations, from 2015 at least 12, from 2014 at least 14, from 2013 at least 16, from 2012 at least 18.
- Language: The languages selected were English and Spanish.

After the application of the inclusion and exclusion criteria only 32 articles were recognized as relevant to this research.

2.2.4 Data extraction and synthesis.

This step was carried out only based on the publications that passed the quality filters and were identified as relevant. In the synthesis task, each of the relevant publications was analyzed to identify project management maturity models, and a summary was produced because of this analysis.

2.3 Systematic reporting of the review

In this phase, a quantitative and qualitative analysis of the literature on project management maturity models was carried out. The objective of this analysis is to compare the publications and identify their contributions in terms of project management maturity models. Likewise, this stage seeks to show the results obtained from the implementation of the systematic review.

2.3.1 Quantitative analysis

The objective of the quantitative analysis provides a detailed overview of the evolution and distribution of relevant publications in the field of project management maturity models.

2.3.2 Qualitative analysis

The qualitative analysis provides an in-depth examination of relevant publications on project management maturity models, exploring various aspects and approaches.

3. Systematic review analysis

The existence of many articles related to project management maturity models involves a large amount of analysis time and depends on the subjectivity of the reader to determine their relevance. The main objective of systematic reviews is to apply a methodology to identify relevant papers reported in the literature that answer one or more research questions. To answer these questions, it is necessary to perform a qualitative and quantitative analysis of the articles and identify areas of opportunity not reported in the literature.

3.1 Quantitative analysis

The objective of the quantitative analysis is to provide a detailed overview of the evolution and distribution of relevant publications in the field of project management maturity models. This

includes analyzing the annual trend of publications, the distribution by search engines and repositories, identifying the most cited publications and the most frequent keywords, as well as evaluating the effectiveness of the search strings used. This approach highlights the importance and impact of these models in the scientific community and industry.

3.1.1 Publications by Year

With the quantitative analysis of this section, it was possible to identify that in 2014 there were a total of 7 relevant publications on project management maturity models, and in 2018 a total of 5 publications. In

Fig. 2, we observe this trend in the increase in the number of publications highlighting the importance of maturity models and project management for the scientific community and industry.

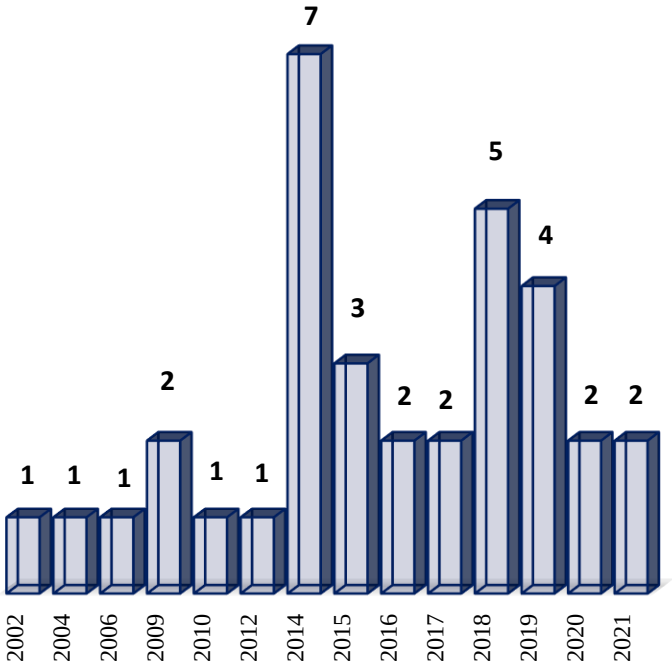

Fig. 2. Number of relevant PMMM publications by year.

3.1.2 Publications by Research Engine

To select the search engines, we considered the reports in the literature on digital libraries and indexing systems highly adopted by the scientific community. The most recognized search engines are Google Scholar and Worldwide Science, which is also highlighted in the scientific community for being the only search engine powered by Deep Technologies, a company dedicated to extracting scientific knowledge from the Deep Web.

In

Fig. 3, a pie chart shows the proportionality of the number of publications identified by title and keyword. In blue, the search engine Google Scholar with 61 publications; in orange and the search engine WorldWide Science with five publications.

3.1.3 Publications by Repository

The repositories consulted for this research were ScienceDirect and ACM Digital Library. However, other repositories were also identified where at least one publication on maturity models and project management was found.

Fig. 4 shows the number of publications identified by the repository in a bar chart. The repositories with the highest number of publications identified were Science Direct and Xplore.

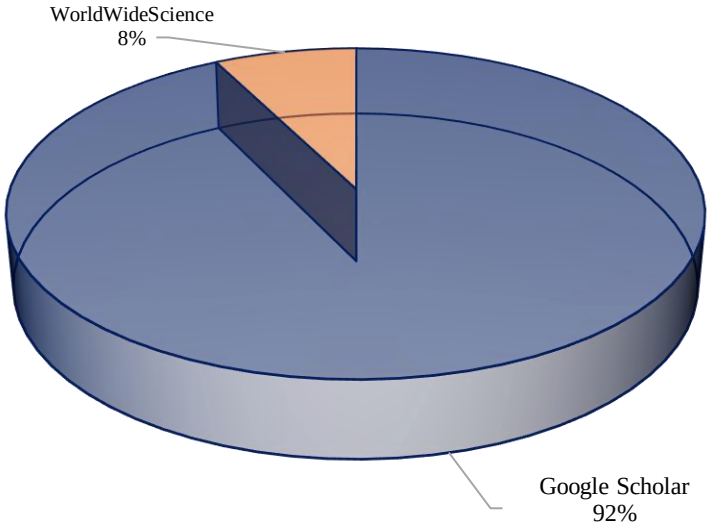

Fig. 3. Distribution of publications on PMMM by search engine.

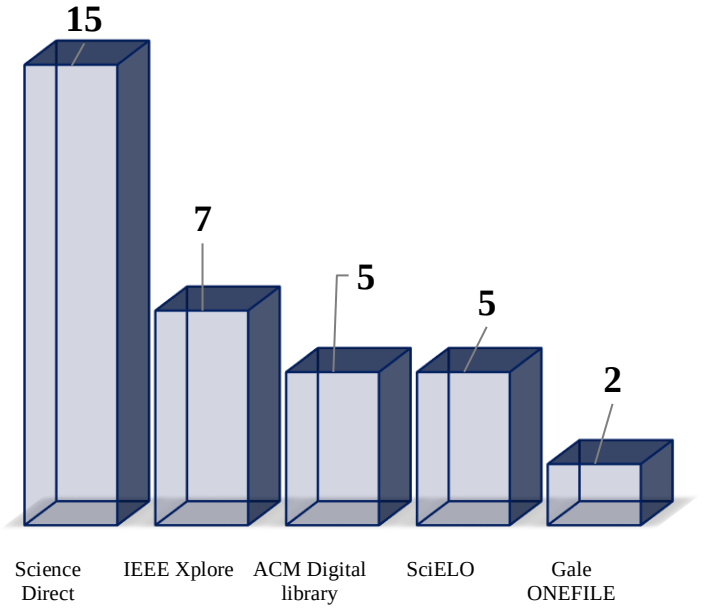

Fig. 4. Number of PMMM publications by repository.

3.1.4 Most Cited Publications

The collection of the number of citations made it possible to identify the most relevant publications on project management maturity models.

Fig. 5 describes the 10 most cited publications after applying the quality criteria to determine their relevance

3.1.5 Keywords

The analysis of the keywords of the publications on project management maturity models was useful in identifying current trends in this subject. Publications were identified that mixed the keywords: project management, maturity models, and software development, with which, it is easy to identify that at the beginning the maturity models were intended to evaluate in a general way to software development companies, which caused it to be implemented in project management of these types of companies. Consequently, due to their usefulness, the models began to be used in other fields of application such as engineering.

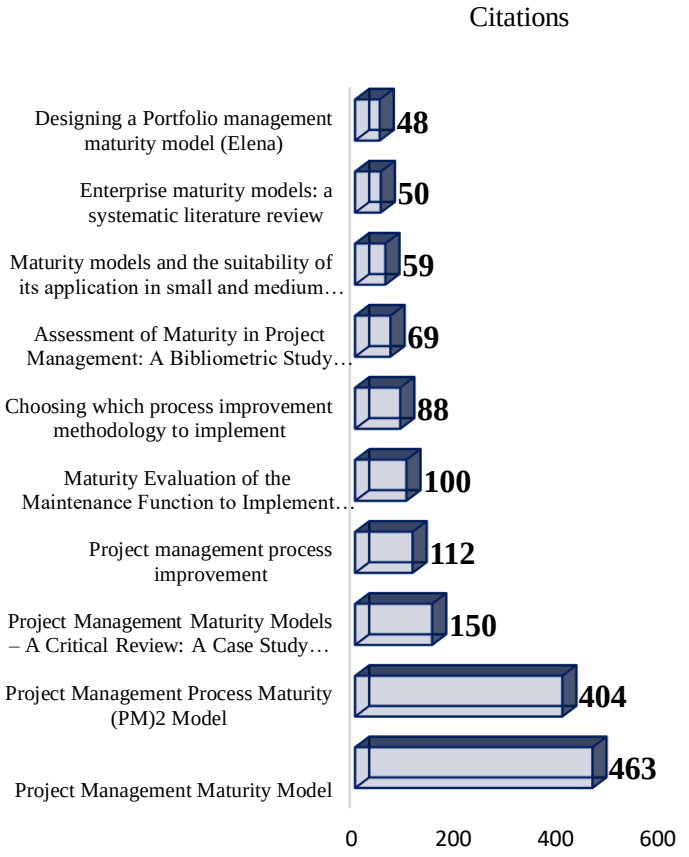

Fig. 5. Ranking of PMMM publications.

3.2 Qualitative analysis

The objective of the qualitative analysis is to provide an in-depth examination of relevant publications on project management maturity models, exploring various aspects and approaches. This includes analyzing keywords to identify trends and areas of focus, the limitation of maturity

model usage to large enterprises due to their resources and a detailed summary of studies and methodologies proposed in different publications. The studies review practical cases and adapted models to assess and improve maturity in different types of organizations, from large companies to SMEs, highlighting challenges, benefits, and recommendations for the effective implementation of these models.

3.2.1 Keywords of publications

Fig. 7 shows a cloud diagram of the keywords contained in the 32 articles identified as relevant. The words that were repeated the most are shown with a larger size, and the words that were not repeated as often, but were key, are shown with a smaller size.

Fig. 7. Keywords of publications.

3.2.2 General overview of project management maturity models

It was also identified that maturity models emerge as a proposal to improve the quality of software development because these models help to systematize processes and guarantee reproducibility within the application area. Subsequently, the models were applied to the areas that had a great impact on software development. In this case, project management was recognized as fundamental because commonly every development process is conceptualized as a project, which has a beginning, a process, and an end.

After reading and analyzing each of the publications, 12 project management maturity models were identified (OPM3, P3M3, CP3M, CIM3, PMMM, KPM3, MMGP, PM2, NPM3, PM2TOM2, P2MM, and P2CMM). Thanks to this approach of the maturity models, the project management area implemented as one of the useful tools to improve the process and identify good or bad practices that are performed within the area and determine the status concerning the ideal. The models use questionnaires as a method of evaluation to determine according to their results the level of maturity

of project management. In some cases, the models present 5 maturity levels and in others 4, however, in general, the models do not present a wide difference between the proposed levels.

The use of project management maturity models is mostly limited to large companies because they have financial and human resources that allow them to better evaluate their level of maturity and, for this reason, SMEs are limited in their use. The World Economic Forum has recognized that SMEs currently represent between 90 and 98% of the total number of companies in the world [10]. SMEs have an important role in the industry because many times these types of companies are suppliers from big companies and require a good project management maturity level.

4. Classification of PMMM

4.1 Comparison of PM maturity models

The qualitative and quantitative analysis of the articles on project management maturity models allowed us to answer the research question: What are the maturity models reported in the literature? It was also found that the maturity models have been extended to different research areas (processes, people, quality, manufacturing, products, supply chains, and operations). However, although a total of 12 PMMMs were identified, not all maturity models have the same assessment approach.

The complexity of visualizing these approaches is generated because the models proposed in the literature do not explicitly describe the evaluation process. With the systematic review, it was possible to identify articles that present practical cases that describe maturity evaluation processes in some companies, which helped to visualize the differences more explicitly. To visualize the differences between the maturity models identified, a comparison in Table 1 was built. The criteria used to compare the maturity models are:

- Approach
- Domain
- Maturity levels
- Number of best practices
- Evaluation process
- Number of survey questions
- Dimensions
- Referential
- Generated by the industry/scientific community

These criteria are important to identify the important information for our approach. In the beginning, it was considered the tools used to obtain the data but was identified that the survey was the only way to get the information on the process to be assessed. Also, it was identified that the maturity models are focused on traditional project management.

Table 1 describes the identified maturity models and makes a comparison. As a result of the comparative analysis, the findings for each criterion are described as follows.

4.1.1 Approach

The approaches identified in the literature for project management maturity models are project management, the organizational performance of the project management area, construction project management, and the project management process in companies. These different approaches show that the companies recognize the process of management of the area, the role of the project management area in the company, and the project management as different entities that need a specific project management maturity model.

Table 1. Project Management Maturity Models reported in the literature.

Model	Approach	Domains	Maturity levels	Number of best practices	Evaluation process	Number of questions in the survey	Dimensions	Based on	Generated by
OPM3: Project Management Maturity Model	Project Management	Project Management Program Management Portfolio Management	Level 1: Ignorance Level 2: Medium Level 3: Maximum	600	Step 1: Preparation for the evaluation Step 2: Assessment Step 3: Improvement plan Step 4: Implement improvement Step 5: Repeat the process	150 (Self-assessment)	1.- Domains 2.- Process improvement steps	PMBOK	Industry
CP3M V5.0: Colombian Project Management Maturity Model	Project Management	Project Management Program Management Portfolio Management	Level 1: Inconsistency Level 2: Planning and Control Level 3: Integration Level 4: Strategic alignment Level 5: Innovation and optimization	Not identified	Step 1: Process Inventory Step 2: Evaluation scheduling Step 3: Organization/ Project Characterization Step 4: Assessment of the level of formalization of practices Step 5: Information processing Step 6: Definition of process capability level Step 7: Maturity level definition Step 8: Analysis and presentation of results	The evaluation method is based on the criteria established for each maturity level	1.- PMBOK 2.- Strategic alignment 3.- Learning 4.- Adaptability 5.- Life Cycle	PMBOK	Scientific Community
MMGP: Project Management Maturity Model- Darci Prado	Project Management	Project Management	Level 1: Initial Level 2: Knowledge Level 3: Standardized Level 4: Managed Level 5: Optimized	Not identified	Not identified	40	1.- Strategic alignment 2.- Behavioral competence Organizational structure 4.- Computerization 5.- Methodology 6.- Technical competence	PMBOK	Scientific Community
NPM3: National Project Management Maturity Model	Project Management	Project Management	Level 1: Emerging Level 2: Developing Level 3: Adolescent Level 4: Maturity	Not identified	Not identified	The number of questions for the maturity assessment is not explicitly described	Not identified	Not identified	Scientific Community
PM2TOM2: Project management methods and tools-oriented maturity model	Project Management	Project Management	1.- Low Management Maturity Level 2.- Lower Medium Management Maturity Level 3.- Medium Management Maturity Level 4.- Advanced Management Maturity Level 5.- High Management Maturity Level	Not used, the model uses 43 methods and tools to assess	Step 1: Collection of data in the organization carry out the projects Step 2: Analysis of the data obtained using the model designed Step 3: Evaluation of project management maturity Step 4: Use of the evaluation results	The number of questions for the maturity assessment is not explicitly described	1.- Time management 2.- Resource management 3.- Cost management 4.- Risk management 5.- Scope Management 6.- Organizational support of the project 7.-Staff training, and project management support based on literature review	Based on the literature review	Scientific Community
P2MM: Prince 2 maturity model	Project Management	Project Management Program Managemen	1.- Awareness of the process 2.- Repeatable process 3.- Defined process	Not identified	Not identified	The number of questions for the maturity assessment	1.- Management Control 2.- Benefits Management	Prince 2	Scientific Community

		t Portfolio Management	4.- Managed process 5.- Optimized process			is not explicitly described.	3.- Financial Management 4.- Stakeholder Engagement 5.- Risk Management 6.- Organizational Governance 7.- Resource Management		
P2CMM: Portfolio Management Maturity Model	Project Management	Project Management	1.- Cognitive level 2.- Repeatable level 3.- Management level 4.- Integration level 5.- Continuous level	This model merges 45 sub-processes of PRINCE2 into 25 sub-processes	The authors describe a process to use the data after the evaluation and describe the type of questionnaire used	The number of questions for the maturity assessment is not explicitly described.	1.-Starting Up a project 2.- Initiation a project 3.- Directing a project 4.- Controlling a stage 5.- Managing product delivery 6.-Managing stage boundaries 7.- Closing a project 8.- Planning	Prince 2	Government
P3M3: Program and Project Management Maturity Model	Organizational performance of the project management area	Project Management Program Management Portfolio Management	Level 1: process knowledge Level 2: a repeatable process Level 3: defined Process Level 4: managed process Level 5: optimized process	Not identified	Step 1: Planning the assessment Step 2: Selection of the P3M3 model to be used Step 3: Establishing the scope Step 4: Selecting the data structure Step 5: Selecting the approach Step 6: Planning the checklist Step 7: Understanding results Step 8: Improving planning	9 (Self-assessment)	Not identified	Not identified	Industry
PMMM: PM Solutions Project Management Maturity Model	Project management process in companies	Project Management Program Management Portfolio Management	Level 1: Initial process Level 2: Structured and standardized process Level 3: Organizational standards and institutionalized processes Level 4: Process managed Level 5: Process optimized	Not identified	Step 1: Analyze the status of the company Step 2: Characterization of the company's practices Step 3: Analysis of surveys built based on PMMM Step 4: Determination of maturity level	52	1.- Scope management 2.- Time management 3.- Cost management	PMBOK	Industry / Scientific Community
KPM3: Kerzner Project Management Maturity Model	Project management process in companies	Project Management Program Management Portfolio Management	Level 1: Common language Level 2: Common process Level 3: Unique methodology Level 4: Benchmarking Level 5: Continuous Improvement	Not identified	Step 1: Analyze the current status of the company Step 2: Characterization of the company's practices Step 3: Analysis of surveys built based on PMMM Step 4: Determination of maturity level	183	Not identified	CMMM	Scientific Community
PM2: Project Management Process Maturity Model	Project management process in companies	Project Management	Level 1: Basic Project Management Process Level 2: Individual project planning Level 3: Systematic project planning and control Level 4: Multi-project integration planning and control	Not identified	Not identified	148	Not identified	Not identified	Scientific Community

			Level 5: Continuous improvement of the project management process						
CIM3: Construction Industry Macro Maturity Model	Construction project management	Project Management	Level 1: Immaturity (0) Level 2: Immaturity (1/3) Level 3: Traditional maturity (2/3) Level 4: Maturity (1)	They propose key practices which are generated with the objective of achieving the organizational objective. For this reason, maturity levels are established based on the existence of key practices	Step 1: Establishing the importance of key practice areas Step 2: Organizational capability	The evaluation method considers the assessment of the existence of key practices	1.- Cost 2.- Quality 3.- Health and safety 4.- Human resources	CMMM	Industry

4.1.2 Domains

The different domains identified are project management, program management, and portfolio management. According to [35], Project management is defined as the application of knowledge, abilities, and tools to project activities to accomplish the requirements. Program management also is defined as the application of knowledge, abilities, and tools to a program's activities to complete it and get benefits by managing program components together. Finally, Portfolio management is defined as the central management of one or more portfolios to achieve strategic objectives. Considering these definitions provided by the PMBOK, the different domains of project management are considered by the scientific community and industry to create the models.

4.1.3 Maturity Levels

Project management maturity levels are considered as the steps that organizations must climb to position themselves in terms of project management practices. This positioning allows for identifying the status and the improvement plan needed to reach higher levels. In general, maturity models contemplate 5 maturity levels. From the comparison, it was identified that 75% of the identified models present 5 maturity levels, 17% present 4 maturity levels, and 8% present 3 maturity levels.

4.1.4 Number of best practices

The practices of project management are the number of activities related and aligned to achieve the project objectives. Some of the maturity models consider the best practices described by manuals or referential to establish a maturity level and to create surveys to assess maturity.

Considering the Project management maturity models identified in this research, 8% of the models describe the number of best practices considered, 67% of the models do not describe the best practices considered, and 25% of the models describe an alternative criterion considered (processes, method, and tools).

4.1.5 Evaluation process

The evaluation process is the description of the steps required to assess the enterprises. Normally, the Project management maturity models describe the criterion that needs to be considered in the assessment, and many times the survey is proposed. However, the vast majority (proposed by industry) do not explicitly describe the process that must be followed to perform the maturity assessment. In this research, the evaluation process was identified in the articles that apply a specific maturity model in a case study.

4.1.6 Number of questions in the survey

The surveys have an important role in the project management maturity models, due to this being the principal tool to obtain data from the enterprises. Some of the maturity models offer a list of questions that are used to apply the questionaries and make a self-evaluation of the maturity. The self-evaluation is the action of applying a questionary in the enterprise without contracting an external to perform the maturity assessment. This term helps to identify that there are two different ways to perform a project maturity assessment, on one side the self-evaluation and on the other the external evaluation. In Table 1, 50% of the models identified describe the number of questions and the other 50% of the models do not describe the number of questions and neither the content of the questions.

4.1.7 Dimensions (Knowledge areas)

The knowledge areas or dimensions are defined in [35] as an area identified in project management that is determined by the knowledge requirements and described in terms of its component process, practices, inputs, outputs, tools, and techniques. The maturity models consider the dimensions to select what areas of project management going to evaluate and generate the questions. Considering the comparison in Table 1, the maturity models describe at list the time, resource, scope, quality, and risk as principal dimensions considered for the assessment. However, there are some other dimensions mentioned such as organizational governance, financial management, staff training, and others.

4.1.8 Referential

The PMBOK, Prince 2, CMMM, and literature review are the main referential considered by the Project management maturity models identified in Table 1. For the maturity models to be relevant the selection of the referential to generate the model due to here is described the best practices, domains, and approaches. These references provide a strong scientific base for the maturity model but many times this is a limitation when a new version drops.

4.1.9 Generated by the industry or the scientific community

It was identified that the scientific community and the industry are the main suppliers of the project management maturity models. Also, the government identified the proposed maturity model. This helps to understand why many Project management maturity models describe with more detail the steps to assess the maturity, the questions, and also the requirements. The models that are proposed by the industry don't explain explicitly the evaluation process due to they look to contact the enterprises to perform this assessment. The models proposed by the scientific community are focused in proportionate the major quantity possible of information for the people that implement the proposal. This means that there are two main purposes for generating a model: the consulting business and the academic validation.

4.2 Suggested Classification

The different approaches make it possible to generate a suggested classification that groups the different models according to their objectives. This section shows the classification proposed after analyzing the publications selected as relevant to the systematic review of project management maturity models. Fig. 8 presents the classification of project management maturity models according to their approach.

4.2.1 Project Management

The models in this category are focused on measuring the maturity of the projects. In this case, the models in this category have the following objectives:

- OPM3: This standard defines a methodology for implementing and improving OPM. It comprises a five-step iterative cycle that emphasizes evaluation and continuous improvement. In the broadest sense, OPM3® is a maturity model.
- CP3M V5.0: CP3M© has been established as a formal instrument to measure the maturity of an organization's project management.
- MMGP: The MMGP model was created to help the project management team of the Instituto de Desenvolvimento Gerencial (INDG), currently Falconi Consultores de Resultado, in the evaluation of the maturity status of the organizations that hire it.
- NPM3: The NPM3 model was developed to increase the maturity of organizational project management in national contexts.
- PM2TOM2: The PM2TOM2 model was created to evaluate the project management maturity based on the assessment of the usage of project management tools and methods in each stage of the project life cycle.
- P2MM: the P2MM model was created to provide a framework to evaluate the actual adoption of the method PRINCE2 and provide improvement plans based on industry best practices.
- P2CMM: The P2CMM model considers the PRINCE2 approach to make a qualitative evaluation of the process of project management and operation considering an evaluation index system.

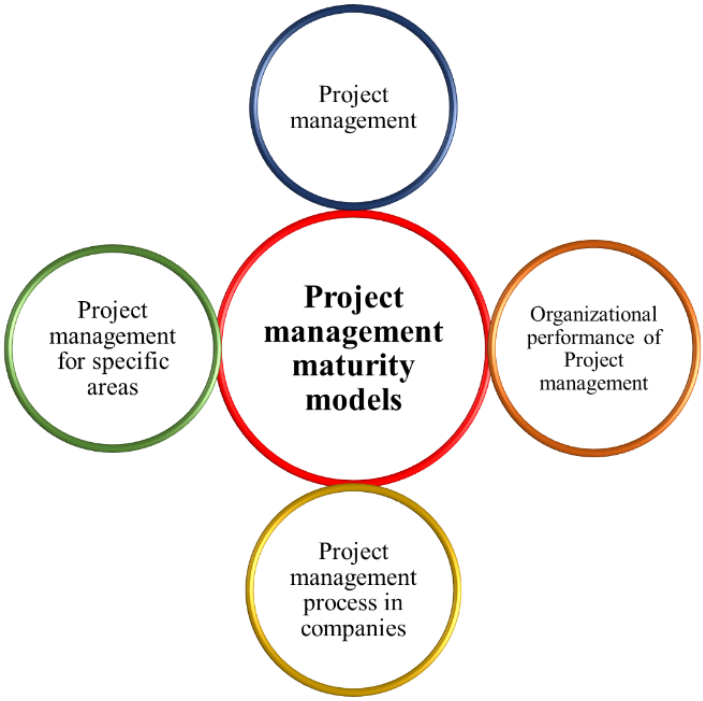

Fig. 8. Classification of project management maturity models.

4.2.2 Organizational project management performance

The model identified in this category is focused on evaluating the organizational performance of the project management area. That is, it specifically seeks to determine how well or poorly the project management area interacts with the impacted areas. The identified model has the following objective:

- P3M3: Framework to evaluate and benchmark your organization's current performance and develop improvement plans.

4.2.3 Project management process in companies

The models that fall into this category are focused on evaluating the project management process in companies to determine if the project management process is performed according to the best practices described in each model. The models in this category have the following general objectives.

- PMMM: The PMMM model aims to develop organizational performance within companies. This model uses the areas of knowledge proposed by the PMI to have more specific measures.
- KPM3: The KPM3 was created for developing the organizational capabilities and culture to incorporate project management practices into the organization's processes and procedures.
- PM2: Integrate previous project management practices, processes, and maturity models to improve the effectiveness of project management in the organization. organization.

4.2.4 Area-specific project management models

In this category, some models were generated for a specific area related to project management. In such a case, the model identified has the following objective:

- CIM3: The objectives of CIM3 are to model the construction industry maturity at the macro level to provide project performance indicators; to provide a context in which to interpret project performance; to allow comparisons between various regions, and to provide guidance on the construction industry performance improvement initiatives.

5. Future directions

Project management maturity models, despite their great usefulness in the conduct of assessments, have some important limitations in their use for organizations that do not have the necessary resources or organizational structure to implement them. In addition to these limitations, organizations face a difficult challenge in determining how to perform the assessments without a step-by-step guide describing how to perform the assessment process.

The generation of project management maturity model ontologies can help provide a conceptual understanding of the assessment process and even the relevance of the assessment. Although project management maturity models are implemented using surveys as a tool to extract information from the process, they require a trained staff and a group of people in charge of applying them. This tool is effective for companies that have the budget for continuous improvement. When this is not the case, it becomes a limitation in its applicability. For this reason, it is considered necessary to generate another tool to extract information from the project management process that does not require highly trained personnel or many resources to extract information from the process.

Likewise, it has been observed that some project management maturity models generated by the industry do not detail the maturity assessment process; they only limit themselves to explaining what the assessment criteria are, in this case, the good project management practices that should be carried out. The literature describes some case studies of some maturity models that could help implement maturity assessments.

6. Discussion

The interest of this systematic review was to identify the project management maturity models reported in the literature. To ensure the reproducibility of the present research, the systematic review

methodology of [4] was selected and the steps to perform the systematic review focused on identifying project management maturity models were described.

In this review, articles published between 2020-2021 were considered and the search engines Google Scholar and Worldwide Science were used. The repositories Science Direct, IEEE Xplore, ACM Digital Library, and SciElo, among others, were also considered. The quality criteria considered were article title, keywords, number of citations, year of publication, language, and availability. As a result, 26 maturity models were identified, focused on processes, software, human resources, quality, project management, manufacturing, products, and supply chain. Of the total number of models identified, only 12 are project management, maturity models. The identified models were grouped according to their objective: a) project management (OPM3, CP3M V5.0, MMGP, NPM3, PM2TOM2, P2MM, and P2CMM), b) organizational performance of project management (P3M3), c) project management process in companies (PMMM, KPM3, PM2) and d) project management models for specific areas (CIM3).

However, another review of the state of the art published in 2022 [36], was identified in the literature, focused on providing recommendations through the analysis of project management maturity models to provide recommendations for selecting or generating a project management maturity model. This review took into account articles published up to 2022, retrieved from the Scopus and Web of Science repositories. The inclusion and exclusion criteria for selecting relevant articles were rank, article citation index, and application rank. The authors propose to group the maturity models into three groups: a) Maturity Models of leading PM Organizations (OPM3, IPMA Delta Model, P3M3, and P2MM), b) Most cited and validated historical Maturity Models (CMMI, PM2, KPMMM, PMMM, and PMM), c) More recent maturity models (NPM3, MMM, and SPM3).

To compare this work with the work of [36], we found that the proposed classification of project management maturity models focuses on grouping maturity models according to their relevance and complexity. This classification is interesting if the objective is to show the most relevant project management maturity models considering specific criteria such as complexity, year of publication, organization, maturity levels, and domain.

Instead, our proposal is focused on grouping maturity models considering criteria such as approach, domain, maturity levels, number of best practices, evaluation process, number of survey questions, dimensions, and referential, generated by the industry/ scientific community. These criteria were selected because the main challenge that enterprises face when implementing a maturity model is the evaluation process. This process is not described in an explicit way in the literature. One of the aims of this systematic review was to identify the evaluation process for each model to provide the steps described to implement the maturity model of project management in the enterprise.

Normally the maturity models are implemented by project managers and personnel involved in the process of project management. For this reason, providing a complexity evaluation before the managers consider their available resources and structure is not viable. Each enterprise has different needs, and several resources available destined to improve the process, and size.

Project management maturity models use surveys as an assessment tool to extract information. This tool involves the use of a large amount of financial and human resources, as well as a full understanding of the project management process. If companies require resources and knowledge to implement it, will maturity models be applicable to all types of companies? To answer this question, we will discuss the challenges faced by SMEs to implement the models: 1) Limited financial resources, 2) Untrained personnel, 3) Difficulty in using surveys as an assessment method, 4) Ambiguity in the assessment process, 5) Difficulty in choosing the most appropriate model.

The use of manuals or references (i.e., PMBOK) for generating project management maturity models tends to lose validity when a new version is generated. Therefore, the generation of project management maturity models from the analysis of the literature in which current and future trends on project management are considered can increase the time of use of these models.

7. Conclusions

This article presents the origins of maturity models, the models reported in the literature, and the maturity models of the specific area of project management, which in turn have different approaches despite being in the same area.

The systematic review involved a total of 4 repositories and 2 search engines in which a total of 1423 articles were reviewed by title and keywords. After applying the inclusion and exclusion criteria, only 32 articles were identified as relevant. As a result of the systematic review and analysis of the articles, a classification according to their focus was proposed: maturity models focused on project management (7), maturity models focused on the organizational performance of project management (1), project management process maturity models (3) and finally, project management maturity models specifically designed to evaluate a single type of project (1).

The importance of maturity models is increased by the fact that nowadays all companies are trying to be more competitive and gain an advantage, which pushes them to continuously adopt new tools and technologies that help them to improve their processes and make them more effective and efficient. For future work, it is recommended to conduct a comparative analysis of the project management maturity models of each category to determine which are more efficient according to each approach. This will help academics and project managers select the most appropriate maturity model for their organization.

References

[1]. L. Torres, “A contingency view on the effect of project management maturity on perceived performance,” Ph.D Dissertation, Business School SKEMA, Lile, 2014.

[2]. J. Garzás, C. M. Fernández, and M. Piattini, “Una aplicación de la norma ISO/IEC 15504 para la evaluación por niveles de madurez de Pymes y pequeños equipos de desarrollo”, Revista Española de Innovación, Calidad e Ingeniería del Software, vol. 5, no. 2, pp. 88-98, Jul. 2009.

[3]. Felipe Sánchez-Garzón, “Supporting the transformation of a company’s project management by elaborating an invariant-based project management maturity model and a causal predictive model between maturity criteria and project performance”, P.H.D Dissertation, Lorraine Université, Nancy, 2019.

[4]. B. Kitchenham and S. Charters, “Guidelines for performing Systematic Literature Reviews in Software Engineering”, 2007.

[5]. A. González, A. Sandoval, and B. Heredia, “Elaboración de planes de entrenamiento cruzado a personal clave en proyectos: el caso de una empresa de ingeniería”, Revista ingeniería de construcción, vol. 33, no. 3, Dec. 2018, doi:10.4067/S0718-50732018000300205.

[6]. Á. Cuadros López, J. A. Morales Viveros, and A.B. Rojas Melendez, “Propuesta metodológica para medir el nivel de madurez de la gestión de proyectos en empresas de ingeniería”, Revista EIA, vol. 14, no. 27, Sep. 2017, doi: 10.24050/reia.v14i27.808.

[7]. E. Pérez-Mergarejo, I. Pérez-Vergara, and Y. Rodríguez-Ruíz, “Modelos de madurez y su idoneidad para aplicar en pequeñas y medianas empresas”, Ingeniería Industrial, vol. XXXV, no. 2, pp. 146–158, 2014, [Online]. Available: https://www.redalyc.org/articulo.oa?id=36043 3597004.

[8]. F. F. Espinosa and G. E. Salinas, “Evaluación de la Madurez de la Función Mantenimiento para Implementar Innovaciones en su Gestión”, Información tecnológica, vol. 21, no. 3, 2010, doi: 10.4067/S0718-07642010000300002.

[9]. M. V. Jacquez-Hernández and V. G. López Torre, “Modelos de evaluación de la madurez y preparación hacia la Industria 4.0: una revisión de literatura”, Ingeniería Industrial. Actualidad y Nuevas Tendencias, vol. VI, no. 20, pp. 61– 78, 2018, [Online]. Available: https://www.redalyc.org/articulo.oa?id=21505 7003004.

[10]. Prado Palacio and Leidy Johanna, “Grado de madurez en gestión de proyectos de una empresa constructora de vivienda en Santiago de Cali: caso de Buenavista constructora y promotora S.A.S”, Revista Espacios, vol. 40, no. 43, pp. 20–33, 2019, [Online]. Available: https://bibliotecadigital.univalle.edu.co/handle/ 10893/15226

[11]. Ó. Rubiano Ovalle and A. Cuadros Lopez, “Estado de la Gerencia De Proyectos En Pymes Del Sector Artes Gráficas y Propuestas de Lineamientos para su Mejoramiento”, (State of Project Management in SMEs of the Printing Sector and Proposed Guidelines for Improvement), 2012.

[12]. J. Shan and R. Lu, “Research on Application of Project Management Maturity Model in Risk Management of Electrical Engineering”, E3S Web of Conferences, vol. 218, Dec. 2020, doi: 10.1051/e3sconf/202021802040.
[13]. D. Yao, R. Zhou, and T. Fan, “Research on maturity of engineering project informatization management—As an example of Anhui Sanjian Engineering Co., LTD”, IOP Conf Ser Earth Environ Sci, vol. 267, p. 042144, 2019, doi: 10.1088/1755-1315/267/4/042144.
[14]. R. Morlhon, R. Pellerin, and M. Bourgault,“Building Information Modeling Implementation through Maturity Evaluation and Critical Success Factors Management”, Procedia Technology, vol. 16, 2014, doi: 10.1016/j.protcy.2014.10.127.
[15]. T.-C. Lin and K. J. Wang, “Project-based maturity assessment model for smart transformation in Taiwanese enterprises”, PLoS One, vol. 16, no. 7, Jul. 2021, doi: 10.1371/journal.pone.0254522.
[16]. F. Sanchez, E. Bonjour, J.-P. Micaelli, and D. Monticolo, “An Approach Based on Bayesian Network for Improving Project Management Maturity: An Application to Reduce Cost Overrun Risks in Engineering Projects”, Comput Ind, vol. 119, Aug. 2020, doi: 10.1016/j.compind.2020.103227.
[17]. F. Backlund, D. Chronéer, and E. Sundqvist, “Project Management Maturity Models – A Critical Review”, Procedia Soc Behav Sci, vol. 119, pp. 837–846, Mar. 2014, doi: 10.1016/j.sbspro.2014.03.094.
[18]. H. Tahri and O. Drissi-Kaitouni, “New Design for Calculating Project Management Maturity (PMM)”, Procedia Soc Behav Sci, vol. 181, pp. 171–177, May 2015, doi: 10.1016/j.sbspro.2015.04.878.
[19]. A. J. Christoph and S. Konrad, “Project Complexity as an Influence Factor on the Balance of Costs and Benefits in Project Management Maturity Modeling”, Procedia Soc Behav Sci, vol. 119, pp. 162–171, Mar. 2014, doi: 10.1016/j.sbspro.2014.03.020.
[20]. A. Miklosik, “Improving Project Management Performance through Capability Maturity Measurement”, Procedia Economics and Finance, vol. 30, pp. 522–530, 2015, doi: 10.1016/S2212-5671(15)01264-2.
[21]. Y. H. Kwak and C. W. Ibbs, “Project Management Process Maturity (PM)2 Model”, Journal of Management in Engineering, vol. 18, no. 3, pp. 150–155, Jul. 2002, doi:10.1061/(ASCE)0742-597X (2002)18:3(150).
[22]. A.-L. Mesquida and A. Mas, “A project management improvement program according to ISO/IEC 29110 and PMBOK®”, Journal of Software: Evolution and Process, vol. 26, no. 9, pp. 846–854, Sep. 2014, doi: 10.1002/smr.1665.
[23]. M. Gershon, “Choosing Which Process Improvement Methodology to Implement”, The Journal of Applied Business and Economics, vol. 10, no. 5, p. 61, 2010.
[24]. Robert K. Wysocki, Project Management Process Improvement. Norwood: ARTECH HOUSE, INC, 2004.
[25]. H. K. Mittermaier and H. Steyn, “Project management maturity: An assessment of maturity for developing pilot plants”, South African Journal of Industrial Engineering, vol. 20, no. 1, pp. 95–107, 2009.
[26]. T. F. de Souza and C. F. S. Gomes, “Assessment of Maturity in Project Management: A Bibliometric Study of Main Models”, Procedia Comput Sci, vol. 55, pp. 92–101,2015, doi: 10.1016/j.procs.2015.07. 012.
[27]. J. C. Viana and C. M. de M. Mota, “Enhancing Organizational Project Management Maturity: a framework based on the value focused thinking model”, Production, vol. 26, no. 2, pp. 313–329, Nov. 2015, doi: 10.1590/0103- 6513.1699 13.
[28]. S. Nikkhou, K. Taghizadeh, and S. Hajiyakhchali, “Designing a Portfolio Management Maturity Model (Elena)”, Procedia Soc Behav Sci, vol. 226, pp. 318–325, Jul. 2016, doi: 10.1016/j.sbspro.2016. 06.194.
[29]. N. Williams, N. P. Ferdinand, and R. Croft, “Project management maturity in the age of big data”, International Journal of Managing Projects in Business, vol. 7, no. 2, pp. 311–317, Apr. 2014, doi: 10.11 08/IJMPB-01-2014-0001.
[30]. F. Y. Hernández, R. I. Laguado, and J. P. Rodriguez, “Maturity analysis in project management in Colombian universities”, J Phys Conf Ser, vol. 1126, p. 012055, Nov. 2018, doi: 10.1088/1742-6596/1126/1/012 055.
[31]. D. Seelhofer and C. O. Graf, “National project management maturity: A conceptual framework”, Central European Business Review, vol. 7, no. 2, p. 1, 2018.
[32]. L. De Souza Scotelano, R. Dalvo Pereira da Conceição, U. Da Costa Leonídio, and C. Silva de Jesus, “Project management maturity model: the case in an automotive industry in Brazil”, Brazilian Journal of Operations & Production Management, vol. 14, no. 4, pp. 500–507, Dec.2017, doi: 10.14488/BJOPM.2017.v14. n4.a6.
[33]. K. Jana and T. Libena, “Proposal and Verification of Project Management Methods and Tools Oriented Maturity Model”, Journal of Management and Projects, vol. 9, no. 1, 2018.

[34]. R. Silva, N. Duarte, T. Barros, and G. Fernandes, "Project Management Maturity: Case study analysis using OPM3® model in manufacturing industry", in 2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC), IEEE, Jun. 2019, pp. 1–8. doi: 10.1109/ICE.2019.8792586.

[35]. I. Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 7th ed. Newton Square, Pennsylvania: Project Management Institute, Inc., 2021.

[36]. E. Fabbro and S. Tonchia, "Project Management Maturity Models: Literature Review and New Developments", The Journal of Modern Project Management, vol. 8, no. 3, pp. 34–45, May 2022.

Информация об авторах / Information about authors

Хорхе Франсиско РУИС-ЛОПЕС учится в аспирантуре факультета программирования Национального центра исследований и технологических разработок (Мексика).

Jorge Francisco RUIZ-LOPEZ – Doctoral student in Computer Science at the Computer Science Department of the National Center of Research and Technological Development in Mexico.

Хавьер ОРТИС-ЭРНАНДЕС имеет степень PhD по автоматизации и программированию, штатный профессор факультета программирования Национального центра исследований и технологических разработок (Мексика). Сфера научных интересов: цифровая трансформация, инженерия требований, моделирование бизнес-процессов.

Javier ORTIZ-HERNANDEZ – PhD in Automation and Computer Science, full professor at the Computer Science Department of the National Center of Research and Technological Development in Mexico. Research interests: digital transformation, requirements engineering, and business process modeling.

Эрик БОНЖУР – имеет степень PhD по автоматизации и промышленной инженерии, профессор. Специализируется в области системной инженерии в Национальной высшей школе инноваций и системного инжиниринга (ENSGSI, Лотарингский университет). Сфера научных интересов: системная инженерия, основанная на моделях, приемлемость инновационных решений, цифровая трансформация, управление знаниями и навыками.

Eric BONJOUR – PhD in Automation and Industrial Engineering, full Professor specialized in systems engineering at the National Graduate School of Innovation and Systems Engineering (ENSGSI, Université de Lorraine). Research interests: model-based systems engineering, acceptability of innovative solutions, digital transformation, knowledge and skills management.

Жан-Пьер МИКАЭЛЛИ имеет степень PhD по экономике промышленности от Университета Люмьер, Лион. Магистр и старший лектор по индустриальному и операционному управлению в Школе управления Лионского института управления бизнесом (Университет Жана Мулена). Научные интересы: разработка методов оценки производительности и инструментария для архитектурно сложных технических систем.

Jean-Pierre MICAELLI – PhD in Industrial Economics, Lumière University, Lyon, Master in Industrial Economics Jean Moulin University, Lyon, Senior Lecturer in Industrial and Operations Management at IAE School of Management of Lyon (Jean Moulin University), Research interests: development of performance evaluation methods and tools for the architecture of complex technical systems.

Ясмин ЭРНАНДЕС имеет степень PhD по программированию, профессор факультета программирования Национального центра исследований и технологических разработок (Мексика). Научные интересы: интеллектуальные обучающие системы, человек-машинное взаимодействие, интеллектуальный анализ данных в образовании, аффективные вычисления, машинное обучение.

Yasmín HERNÁNDEZ – PhD in Computer Science, full professor at the Computer Science Department of the National Center of Research and Technological Development in Mexico. Research interests: intelligent tutoring systems, human-computer interaction, educational data mining, affective computing, machine learning.