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Article

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Article

Assessment of Project Management Maturity Models Strengths and Weaknesses

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Abstract: The purpose of this article is to analyze the most popular maturity models in order to identify their strengths and weaknesses. Research conducted by international project management communities such as Software Engineering Institute (SEI), Project Management Institute (PMI), International Project Management Association (IPMA), Office of Government Commerce (OGC) and International Organization for Standardization (ISO) showed that organizations with high managerial maturity are more likely to achieve their planned project goals than those that do not identify and standardize their best management practices. This circumstance has encouraged scientists from all over the world to start developing various models that can measure and evaluate managerial maturity in projects. Nowadays, the variety of models created has led to considerable difficulty in understanding the strengths and weaknesses of each model. To solve this problem, the article authors conducted a critical analysis to identify the strengths and weaknesses of the most popular project management maturity models. The results obtained will be of interest to project managers, members of project teams, heads of organizations, project offices and everyone involved in the development of project activities. Based on the analysis, it was found that the most developed maturity models are based on international codes of knowledge of project management. Most maturity models ignore the presence of structural and infrastructural elements, such as a workplace, the necessary equipment and software, the availability of professional standards, instructions, regulations, etc. It was also revealed that there are no processes for assessing the effectiveness and efficiency of using the best practices in the maturity models.

Keywords: project management maturity model; project; comparative analysis; project management; management maturity level



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1. Introduction

Project Management Institute (PMI) defines project management as a body of knowledge, skills, tools and technologies that contribute to the full implementation of planned requirements (PMBOK Guide® 2017). The main goal of project management is to successfully achieve project objectives (scope, schedule, cost and quality) and meet all interested parties' expectations (Sidorov and Senchenko 2020).

Project management is not a new type of activity for people. Over the centuries, many major projects, such as the construction of the Giza Pyramid, the Great Wall of China, the Taj Mahal, the Panama Canal and many others have been implemented. During this time, knowledge of how to manage such projects so that the actual results fully coincide with the planned ones has been accumulated. This knowledge was processed, systematized and consolidated in the best project management practices around the world (PMBOK Guide® 2017; ICB IPMA 2015; PRINCE2® 2017; ISO 2018).

However, it is worth noting that despite the significant development in the field of project management, many projects are still exposed to numerous risks, the materialization of which prevents their successful completion ([The CHAOS Manifesto 2014](#)). In particular, the results of research conducted by V. S. Nikolaenko indicate that about 105 risks can materialize in any IT project, namely, 5 commercial risks, 45 compliance risks and 55 project risks. It is very important to emphasize that the average damage from one compliance risk materialization costs \$12,000 ([Nikolaenko 2018](#); [Nikolaenko 2022](#)).

J. K. Crawford claims that frequent risks materialization is a natural indicator that clearly demonstrates the immaturity of project teams and project managers ([Crawford 2007](#)).

To solve the problem of eliminating risks, many international project communities (SEI, PMI, IPMA, OGC, ISO, etc.) and leading scientists recommend using project management maturity levels and maturity models ([Crawford 2007](#); [Grant and Pennypacker 2006](#); [Backlund et al. 2014](#); [Andersen and Jessen 2003](#); [Meisner 2007](#); [Jugdev and Thomas 2002](#); [Montero 2013](#)). According to the hypothesis stated, in organizations with high managerial maturity, dangerous risks materialize less often, which significantly increases the chances to complete initiated projects successfully.

The revealed connection between project management maturity and the likelihood of successful completion has led to the creation of numerous maturity models. In particular, in their works, K. P. Grant and J. S. Pennypacker claim that about 30 maturity models have already been developed ([Grant and Pennypacker 2006](#)). F. Backlund, D. Choroner, E. Sundqvist et al. provide empirical evidence that organizations with a high level of managerial maturity are less likely to materialize dangerous risks ([Backlund et al. 2014](#); [Andersen and Jessen 2003](#); [Meisner 2007](#); [Jugdev and Thomas 2002](#); [Montero 2013](#)).

It should be noted that attempts to conduct a comparative analysis of the most popular project management maturity models were made earlier ([Khoshgoftar and Osman 2009](#); [Trocki and Bukłaha 2016](#)). However, as the critical analysis has shown, previous studies have focused mainly on superficial comparison and the search for conceptual differences between models without specifying their strengths and weaknesses. In this regard, the purpose of this article is to analyze the most popular maturity models, such as The Capability Maturity Model Integration (CMMI®), The Organizational Project Management Maturity Model (OPM3), The International Project Management Association Delta (IPMA DELTA®), The Portfolio, Program and Project Management Maturity Model (P3M3®), The Software Process Improvement and Capability Evaluation (SPICE), The Project Management Process Maturity Model (PM²), The Kerzner Project Management Maturity Model (PMMM), The Project Management Maturity Model (ProMMM) and The PM Solutions Project Management Maturity Model (PMMMsm), in order to identify their strengths and weaknesses.

The analysis of the maturity model's strengths and weaknesses included the following steps. First, the concept and methodology of applying maturity models were studied. Second, the subject area of application was defined. Third, scientific papers describing the testing of maturity models and presenting the results of implementation were analyzed. Fourth, a comparative analysis to identify strengths and weaknesses for each maturity model was conducted.

2. Conceptual Content of Project Management Maturity Models

2.1. The Capability Maturity Model Integration (CMMI®)

The Capability Maturity Model (CMM) was developed in 1987 as part of the Software Engineering Institute (SEI) project at the Carnegie-Mellon University Research Center (USA). The model was created because the US military and government structures needed a method to evaluate contractors (performers, suppliers) in the field of software development. In 2000, the model was transformed into an integrated Capability Maturity Model Integration (CMMI®) capability maturity model, which allows evaluating not only the maturity of development processes, but also other organization-level processes, including procurement, material support, etc. Since 2006, CMMI® has been separated for 3 models:

- CMMI for Development (CMMI-DEV)—the model is focused on organizations that develop software.
- CMMI for Services (CMMI-SVC)—the model is focused on organizations that provide services.
- CMMI for Acquisition (CMMI-ACQ)—the model is focused on organizations that are engaged in procurement and supply.

Version 1.3 (2010) decomposes all the activities of the organization into 22 processes, where these processes are divided into 4 groups—the process management group, the project management group, the engineering activity group and the support group.

It is worth noting separately that CMMI® offers two independent types of assessment—a power-assessment of the individual processes and an assessment of the organization maturity in general.

When assessing the individual processes power, a scale from 0 to 3 was used (Figure 1). In particular:

- Level 0. Incomplete—the process is missing or only partially running.
- Level 1. Performed—the process is performed but not standardized.
- Level 2. Managed—the process is carried out in accordance with the plan and regulations, controlled and evaluated.
- Level 3. Defined—the process is aligned with other processes in the organization so that a coherent set of processes can be created.

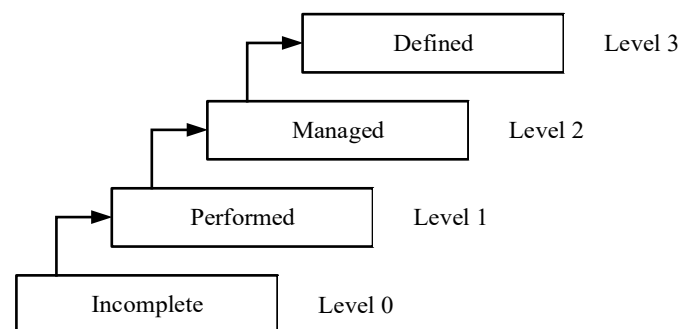


Figure 1. CMMI® Process Maturity Levels.

When assessing the organization maturity in general, a scale from one to five was used. The process areas that must be implemented by the organization were identified at each level (Figure 2). For example, to achieve Level 5 (Optimizing), an organization must implement two processes, such as Cause Analysis and Resolution and Organizational Performance Management. The organization maturity model is represented by the following levels:

- Level 1. Initial—processes are irregular, there is no systematic approach to software development.
- Level 2. Managed—the organization uses project management methodologies. The processes are well defined, but the maturity levels of the processes can vary greatly between projects.
- Level 3. Defined—processes are defined within a coherent, consistent organization's process management system.
- Level 4. Quantitatively Managed—processes are measured and controlled quantitatively.
- Level 5. Optimizing—the management focus is on innovation and continuous process improvement.

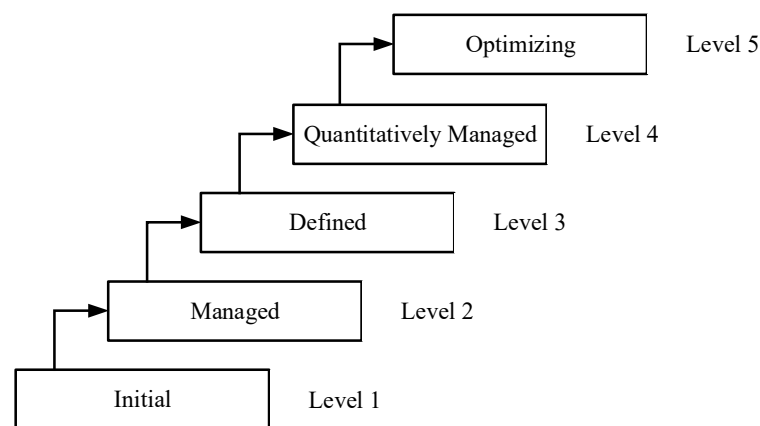


Figure 2. Organization maturity levels according to CMMI®.

Version 2.0 was released in March 2018 with significant changes (O'Neill 2018). In particular:

- The division into three models has disappeared. The CMMI® model has become single.
- A structure of 4 layers has been introduced. Specifically, a category layer (Doing, Managing, Enabling and Improving), a categorized feature area layer, the best practice area layer and a feature layer.
- The specification has become closed and paid.

2.2. The Organizational Project Management Maturity Model (OPM3)

The Organizational Project Management Maturity Model (OPM3) development started in 1998 as part of a series of standards produced by the Project Management Institute (PMI). More than 800 volunteer project management practitioners from almost all industries and disciplines from 35 countries actively participated in the research and development of OPM3. The first version of the standard was published in 2003, thereafter PMI received a large amount of feedback and comments, resulting in the publication of the OPM3 second edition in 2008.

In 2013, the third edition of the standard was released. It was maximally brought into line with the latest editions of the PMBOK® Guide and other maturity models, such as CMMI (Organizational Project Management Maturity Model (OPM3) 2013). The practical value to the organization from using OPM3 was also better articulated. The “Use of the Model” section was updated to provide the practitioner with the knowledge necessary to assess the organization’s capabilities.

OPM3 consists of three interrelated elements: knowledge, evaluation and improvement. “Knowledge” informs the organization about the best practices and other components of maturity. “Evaluation” provides an organization with an opportunity to assess its maturity. “Improvement” is the result of the assessment and allows choosing a strategy to improve the maturity of organizational management.

It is worth noting that OPM3 was designed for continuous rather than level assessment of maturity in two main dimensions. One dimension is the domains: project, program and portfolio management and organizational arrangements. Another dimension is the stages of maturity: standardization, measurement, management and continuous improvement (Figure 3). Ability improvement progress falls within these two dimensions. Capabilities are also categorized by their connection with the five project management process groups: initiating, planning, executing, controlling and completing. Thus, the total number of possible maturity measurements reaches four.

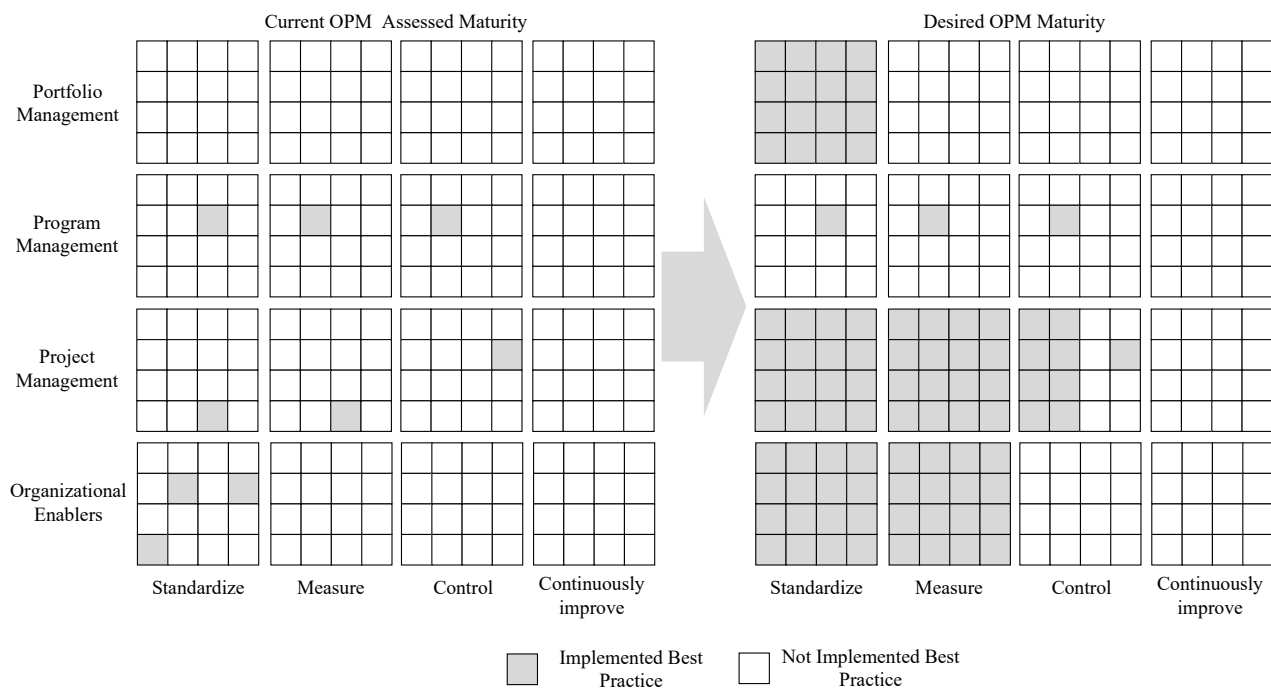


Figure 3. Assessment of current and desired maturity level according to OPM3.

2.3. The International Project Management Association Delta (IPMADELTA®)

The IPMA Delta® Project Excellence Model was developed in 2009 by the International Project Management Association (Bushuyev and Wagner 2014). The IPMA DELTA® model is based on international competency requirements for specialists, projects and organizations. To assess the level of maturity of project management, three modules were distinguished:

- **Module Individuals—I.** Within the framework of this module, the competencies of the key performers are assessed: project, program and portfolio managers, project participants, stakeholders, administrators, etc. Both professional competencies and knowledge competencies are assessed. These competencies are assessed using the IPMA Individual Competence Baseline (ICB).
- **Module Projects—P.** Within the framework of this module, project activities are directly assessed. The focus of the evaluation is on results, methods and tools. The IPMA Project Excellence Baseline® (PEB) is used to assess project management competence.
- **Module Organization—O.** Within the framework of this module, the competence of project management is assessed from the perspective of the organization, namely, how much the CEO is involved in project processes, what is the integral benefit of the organization from the project's implementation, etc. To assess the organization's competence, the IPMA Organization Competence Baseline (OCB) rules are used.

There are five levels of maturity in IPMA Delta® (Figure 4):

- **Level 1. Initial**—the level is characterized by singular achievements in the field of project management. There is no single standard for the work of personnel, which is why some employees work efficiently, some work unsatisfactorily.
- **Level 2. Defined**—the level is characterized by the presence of certain standards for managing projects, programs and project portfolios, however, management structures and processes are used non-systemically.
- **Level 3. Standardized**—the level is characterized by the incomplete and non-integrated application of management processes, structures and standards.
- **Level 4. Managed**—the level is characterized by the full and integrated operation of management-controlled standards, structures and processes of management.

- Level 5. Optimized—the level is characterized by the full, controlled and constantly improving functioning of all necessary standards, structures and management processes.

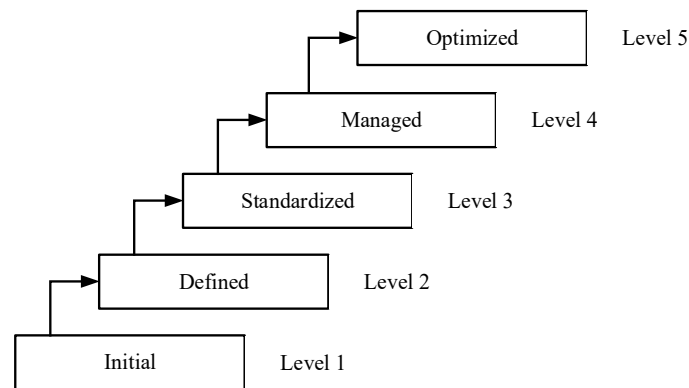


Figure 4. Maturity levels according to IPMA DELTA®.

2.4. The Portfolio, Program and Project Management Maturity Model (P3M3®)

The OGC Portfolio, Program and Project Management Maturity Model (P3M3®) was developed in 2003 by the Office of Government Commerce (OGC). P3M3® is based on the PRINCE2® project management methodology and includes (PRINCE2® 2017):

- Project Management Maturity Model (PfM3);
- Programme Management Maturity Model (PgM3);
- Project Management Maturity Model (PjM3).

Based on PRINCE2®, simplified P3M3® maturity models have also been developed:

- PRINCE2 Maturity Model (P2MM);
- Project Management Maturity Model (P1M3);
- Programme and Project Management Maturity Model (P2M3).

The P3M3® model includes five levels of project management maturity (Figure 5):

- Level 1. Initial—projects are managed without standardized procedures and control systems.
- Level 2. Repeatable—organization implements projects on its own resources. Minimal process standardization is used.
- Level 3. Defined—organization has its own project management processes that do not change.
- Level 4. Managed—the organization has specific management metrics for all projects that are suitable for predicting the future state.
- Level 5. Optimized—the organization is in a continuous process of improving project management using a proactive approach.

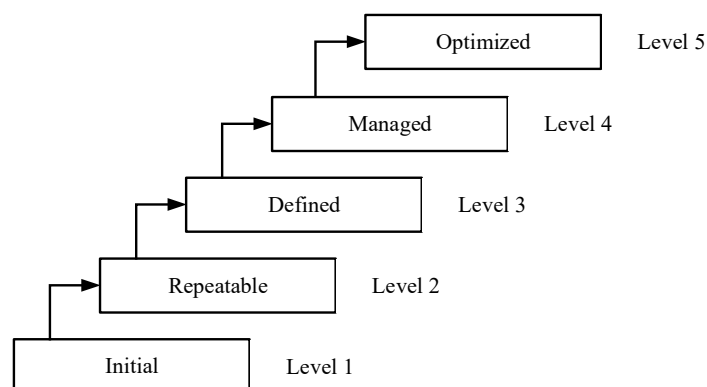


Figure 5. Maturity levels according to P3M3®.

2.5. The Software Process Improvement and Capability Evaluation (SPICE)

By the acronym SPICE, two different models for assessing and improving managerial maturity are known. The first, Structured/Standardized Process Improvement for Construction Enterprises, was created in the University of Salford with funding from the UK Department of Environment, Transport and the Regions in 2000. It has gained some notoriety in the construction and infrastructure management sectors of the organization.

However, the best-known model is SPICE, that created as a series of ISO/IEC 15504 and 330(XX) standards. At the time of creation, the abbreviation SPICE meant Software Process Improvement and Capability Evaluation, but soon the name changed into Software Process Improvement and Capability Etermination. The project was initiated in 1993 and the first standard in the ISO/IEC 15504 series was published in 1998. The development of SPICE was largely motivated by the success of CMM/CMML, and both models evidently influenced each other.

Similar to CMML, ISO/IEC 15504 proposes assessing process capability (ISO 15504-2) and organizational maturity (ISO 15504-7) separately. Specific processes are not introduced in the standard; instead, reference is made to the ISO/IEC 12207 standard, which defines life cycle processes. Process capabilities are rated on a scale of 0 to 5:

- Level 0. Incomplete—where the process is not implemented or could not reach its destination.
- Level 1. Performed—where the process has somehow reached its destination.
- Level 2. Managed—where the process is managed (planned, regulated, monitored) and its work products are properly installed, controlled and maintained.
- Level 3. Established—where the process is carried out using certain methods and infrastructure that allow achieving the desired outputs.
- Level 4. Predictable—where quantitative goals for the implementation of the process are set, the results of measuring the degree of goals achievement are collected and analyzed.
- Level 5. Optimized—where the process is improved continuously to achieve relevant current and planned business goals.

The ISO/IEC TR 15504-7 standard appeared in 2008. It set up six levels of organizational maturity:

- Level 0. Immature.
- Level 1. Basic.
- Level 2. Managed.
- Level 3. Established.
- Level 4. Predictable.
- Level 5. Innovating.

In 2009, it was decided to replace the ISO/IEC 15504 series of standards with the new ISO/IEC 330(XX) series from 33001 to 33099. The first standard of the new series—ISO/IEC TR 33014:2013—was released in 2013, and another six standards (33001, 33002, 33003, 33004, 33020, 33063) were released in 2015. The new series was a development of the previous one and can be considered as a further definition of the SPICE model.

The new version introduced six levels of process abilities (Figure 6):

- Level 0. Incomplete—the process is not implemented or does not meet its goal.
- Level 1. Performed—the process achieves its goal.
- Level 2. Managed—the process is planned, monitored and corrected; the results of its work are established, monitored and updated accordingly.
- Level 3. Established—the process is implemented on the base of methods and infrastructure; thus, it could bring appropriate results.
- Level 4. Predictable—the process is carried out in a predictable manner within specified limits in order to achieve the desired results. To achieve this goal, quantitative control parameters are identified, measurement data is collected and analyzed in order

to identify and explain the causes of discrepancies, and corrective actions are taken to work out the causes of discrepancies.

- Level 5. Innovating—the process is continuously improved to reflect ongoing changes in accordance with the organization’s business goals.

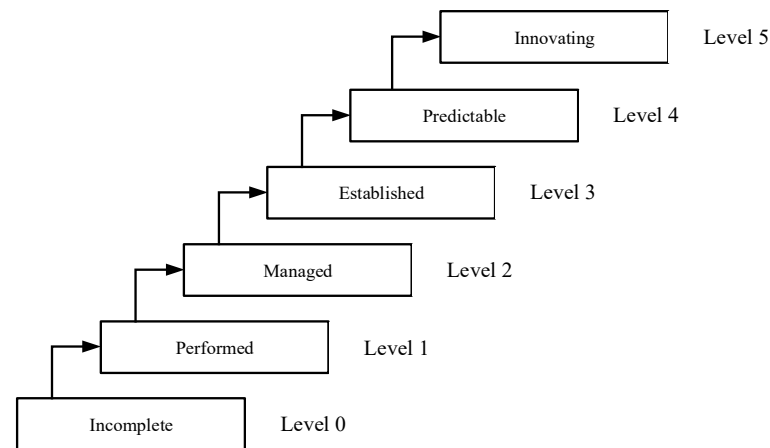


Figure 6. Maturity levels according to SPICE.

2.6. The Project Management Process Maturity Model (PM²)

The Project Management Process Maturity Model (PM²) was developed by Y. H. Kwak and C. W. Ibbs 1997 (Kwak and Ibbs 2002). The model was revised and expanded in 2002. PM² is based on the international set of PMBOK® Guide project management rules, namely the areas of project management knowledge.

The model is the basis for assessing and determining the current levels of maturity of project management in the organization and illustrates steps to improve the efficiency of project management (Ibbs and Kwak 1997). PM² separates project management processes and practices, allowing to identify strengths and weaknesses of project management and focus on weaknesses to achieve a higher maturity level. The model provides a systematic and step-by-step approach to increase the maturity of project management in an organization using five levels (Figure 7):

- Level 1. Ad hoc—main project management processes.
- Level 2. Planned—individual project planning.
- Level 3. Managed at Project Level—systematic planning and monitoring of the project.
- Level 4. Managed at Corporate Level—integrated multi project planning and monitoring.
- Level 5. Continuous Learning—continuous improvement of project management processes.

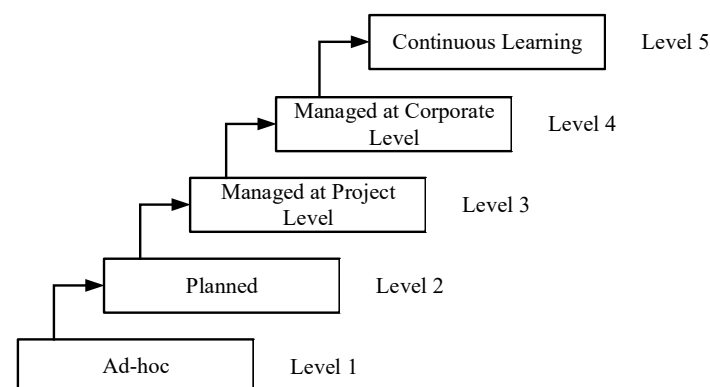


Figure 7. Maturity levels according to PM².

2.7. The Kerzner Project Management Maturity Model (PMMM)

The Kerzner Project Management Maturity Model (PMMM) was developed by H. Kerzner (The Kerzner Approach[®]) in 2001 (Kerzner 2001). According to Kerzner, achieving exceptional project management results requires a certain level of maturity (Figure 8):

- Level 1. Common Language—the organization recognizes the importance of project management and the need to master the basic knowledge of project management. Employees of the organization learn the terminology and language of project management.
- Level 2. Common Process—the organization recognizes the importance of defining and developing common processes so that the success of one project can be replicated by others.
- Level 3. Singular Methodology—the organization recognizes the importance of synergy in bringing all the methodologies used in the corporation into one where project management gains central significance.
- Level 4. Benchmarking—there is an awareness that it is necessary to improve corporate processes if the organization wants to maintain its position. Benchmarking is carried out continuously.
- Level 5. Continuous Improvement—at this level, the organization evaluates the information obtained in the course of benchmarking and uses this information to develop a unified methodology.

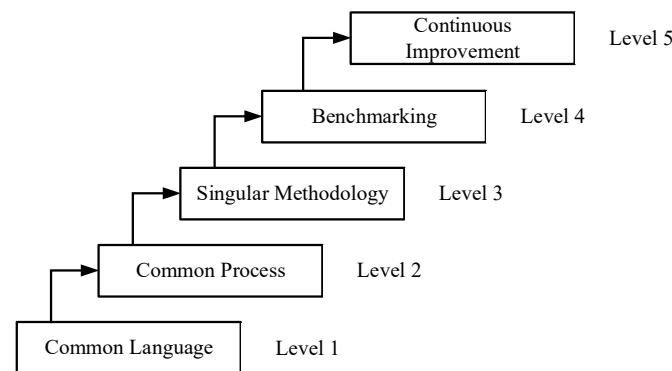


Figure 8. Maturity levels according to PMMM.

2.8. The Project Management Maturity Model (ProMMM)

The Project Management Maturity Model (ProMMM) was developed by D. Hilson in 2003 (Hilson 2003). The concept of a maturity model is based on benchmarking, i.e., on the process of identifying and adapting existing examples of the effective functioning of an organization. Benchmarking includes evaluation and comparison processes. The structure of ProMMM was taken from such models as the Capability Maturity Model (CMM) and Excellence Model from the European Foundation for Quality Management (EFQM 1999). The ProMMM model includes the following levels (Figure 9):

- Level 1. Naive—the organization does not know the cost of using the project activities. There is no project management structure. Insufficient attention is paid to possible threats.
- Level 2. Novice—the organization begins to experiment with project management, but the main processes are not formal, although the financial benefits of using project activities are much greater than at Level 1.
- Level 3. Normalized—at this level, project activities directly affect the organization's business activities. All key management processes are formalized.
- Level 4. Natural—at this level, the organization has a developed corporate culture based on the best practices.

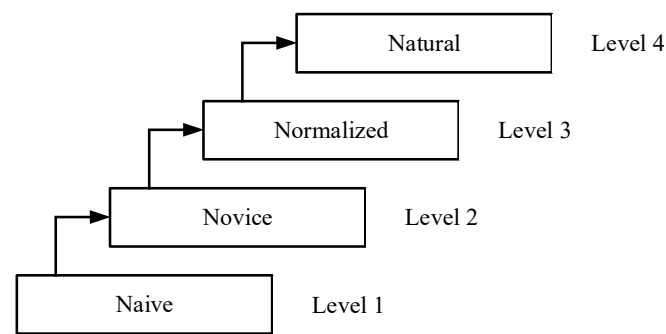


Figure 9. Maturity levels according to ProMMM.

2.9. The PM Solutions Project Management Maturity Model (PMMMsm)

The PM Solutions Project Management Maturity Model (PMMMsm) was developed by PM Solution and J. K. Crawford in 2007 (Crawford 2007). The PMMMsm model is based on the international project management body of knowledge PMBOK® Guide, in particular on project management knowledge areas. Through research, Crawford found that the best project management practices described in the PMBOK® Guide can be fully implemented and at the proper quality level only by “heroic” project managers. Among the main reasons Crawford identifies:

1. Lack of management tools prioritization in the PMBOK® Guide. From each area of expertise, project managers are given multiple approaches, methods and tools that blur their focus.
2. PMBOK® Guide equally evaluates the importance of knowledge areas and their information content. Crawford subdivides knowledge areas into core areas (content management, cost, schedule, quality) that make the greatest contribution to the successful completion of projects and auxiliary areas (communications, risk, resource management, etc.).
3. New project managers need at least 10–15 years of continuous practice to reach the level of “heroic” project managers.

On this base, the concept of a gradual transition from “immature” management in knowledge areas to “mature” management was proposed and divided into five levels (Figure 10):

- Level 1. Initial Process—there are no established standards in project management. Project documents are drawn up freely and one-time-only. Measuring the effectiveness and efficiency of design work is carried out spontaneously. Each member of the project team can define the concept of “project”, but these definitions will not coincide with each other.
- Level 2. Structured Process and Standards—management is based on the best practices, but they are not fixed at the level of organization standards. The management of the organization supports the development of project management but does not provide consistent and systematic work in this regard. There are no people responsible for improvements. Metrics have been developed to track project cost, schedule and labor productivity, but the data is collected and processed manually.
- Level 3. Organizational Standards and Institutionalized Process—all project processes are anchored in the internal standards of the organization. Clients and end users are active and integral members of the project team. All projects use the same management standards. The organization’s management regularly reviews proposals to improve internal standards.
- Level 4. Managed Process—project management is based on the past experience and lessons learned. Project information is integrated with the organization’s corporate systems. The management of the organization is clearly aware of its role in the field

of project management. Internal standards are differentiated by types, sizes and complexity of projects.

- Level 5. Optimizing Process—project management activities are continuously improving. Experience is drawn from each new situation and used to improve project management processes, standards and project documentation.

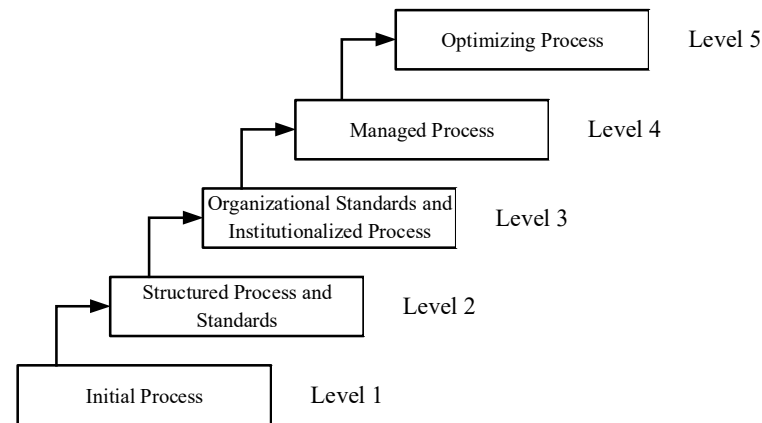


Figure 10. Maturity levels according to PMMMsm.

3. Analysis of Strengths and Weaknesses of Maturity Models

The conducted research made it possible to critically examine the nine most popular project management maturity models in the world. The identified strengths and weaknesses of the most popular maturity models are presented in Table 1. The results of a comparative analysis of the most popular maturity models are presented in Appendix A.

It should be noted that the authors of this article conducted the research in terms of identifying empirical evidence that clearly shows the positive effects for an organization when moving from one level of maturity to another, in addition to a critical analysis of strengths, weaknesses and a comparative analysis. In particular:

- A. F. Bay and M. Skitmore review the application of the PMMM model in Indonesia (Bay and Skitmore 2006). Their research involved 143 respondents who believed that a high level of maturity is necessary for suppliers and contractors (69%), business consultants (57%), investment companies (72%), manufacturing (75%), service industries (42%) and financial institutions (40%). Respondents note that if the maturity level of organizations that are engaged in these sectors of the economy is low, then they will be exposed to numerous risks.
- A.V. Polkovnikov and O. N. Ilina in their study use the PMMM model to determine the maturity level in Russian organizations (Polkovnikov and Ilina 2014). The study involved 140 organizations. According to the results, there are no level 4 and level 5 organizations among the respondents. The remaining organizations were distributed in the following proportions: Level 1—58 organizations, Level 2—57 organizations, Level 3—25 organizations.
- C. Demir and I. Kocabas describe the application of the PMMM model for educational institutions in Turkey (Demir and Kocabas 2010). According to the results of the study, Level 4 and Level 5 are elusive goals for educational institutions. However, it should be noted that these claims are not empirically supported.
- D. Ofori and E. W. Deffor reviewed the PMMM model in Ghana (Ofori and Deffor 2013). More than 200 respondents took part in the survey. Respondents believe that a high maturity level is very important for private organizations, government organizations and non-profit organizations. Research in Ghana has shown that the majority of private and public organizations have an average maturity level (Level 2 and Level 3).

- K. P. Grant and J. S. Pennypacker use the PMMMsm model in their studies. The study involved 126 respondents located in North America. According to the studies, Level 1 includes 13.7%, Level 2—53.2%, Level 3—19.4%, Level 4—7.3% and Level 5—6.5%.

Table 1. Strengths and weaknesses of maturity models.

Maturity Model Name	Strengths	Weaknesses
CMMI®	<ol style="list-style-type: none"> 1. Recognition of CMMI® certifications by the business community. 2. CMMI® is a universal maturity model, thus it could be used with various project management practices and methodologies (PMBOK® Guide, PRINCE2®, etc.). 3. Openness of the specification. 4. Long period of use and large community, providing organizations to share experience and determine answers to difficult questions. 	<ol style="list-style-type: none"> 1. Large organizations combine all three models of CMMI-DEV, CMMI-SVC and CMMI-ACQ. Practice has shown that the division of CMMI® into three models is redundant. 2. The US Department of Defense no longer oversees CMMI®. CMMI® has lost support and guidance from its original sponsor and customer. 3. Management activity in CMMI® is presented non-systemically. For example, project management functions such as communication management or stakeholder management are not identified. 4. There is no evidence of an economic benefit from using CMMI®. 5. CMMI® is difficult to integrate with Agile methodologies. Such integration requires special knowledge, skills, personnel and technologies.
OPM3	<ol style="list-style-type: none"> 1. Universality. The OPM3 model can be applied to any company. 2. Complexity. Both a separate project/program and a set of projects/programs that form a portfolio of projects are evaluated. 3. Practical justification. The model is based on the best practices; theoretical judgments are confirmed by the experience of numerous organizations. 4. Identification of potential. The OPM3 model can positively influence the formation of new abilities to achieve the planned result. 5. Tools for quantitative justification of increasing the organization's maturity. 6. The OPM3 model is flexible, scalable and supports organizations of different types, sizes, complexity and geographic locations. 7. A detailed description of a large number of elements and processes involved in the model and influencing it. 8. Detailed description of the elements and processes of self-improvement. 	<ol style="list-style-type: none"> 1. Difficult to apply in practice, since a significant part of the assessment methodology—maturity conditions—has not been published and provided to specialists, thus it has led to serious accusations against PMI. 2. Questionnaire assessment is controversial and even misleading when compared to using maturity conditions that are not available currently.
IPMA DELTA®	<ol style="list-style-type: none"> 1. Consistency with international standards ICB, PEB and OCB. 2. Allows measuring in three areas, in particular, from the position of the project manager's competencies, from the position of the organization's competencies, from the position of the competencies of project activities. 3. There is a systematic approach. 	<ol style="list-style-type: none"> 1. There are no processes for evaluating the effectiveness and efficiency of using the best practices. The IPMA DELTA® model does not provide the identification and implementation of the best management practices, which, in turn, makes it much more difficult to move to a higher level of maturity.

Table 1. Cont.

Maturity Model Name	Strengths	Weaknesses
P3M3 [®]	<ol style="list-style-type: none"> 1. Consistency with the international PRINCE2[®] standard. 2. Maturity assessment of the key project management processes. The P3M3[®] model considers the maturity of 32 processes such as management control, benefit management, financial management, stakeholder management, risk management, organizational management, resource management and others. 3. Measuring the maturity of project, program and portfolio management. 	<ol style="list-style-type: none"> 1. Lack of a systematic approach. Each process is considered as separate, i.e., not connected with other processes. 2. There are no structural and infrastructural elements by which the management of the organization can influence the level of project management maturity. The model assumes that the transition to a new level of maturity is possible only in cases where the management of the organization is directly involved in the development of project management. However, in the descriptive part of the P3M3[®] model, the activities and functions of the organization's management are not formalized. 3. There are no processes for evaluating the effectiveness and efficiency of using the best practices. The P3M3[®] model does not provide for the identification and implementation of the best management practices, which, in turn, makes it much more difficult to move to higher levels of maturity. 4. There are no processes for the creation and development of a project management culture. The P3M3[®] model is based on the concept of continuous improvement, but this process is impossible without the formation and development of an appropriate corporate culture of project management in the organization.
SPICE	<ol style="list-style-type: none"> 1. The SPICE model has the status of an international standard; in many states it has been adapted and adopted as a national standard. 2. The SPICE model is regularly updated and revised. 3. There are adaptations of the SPICE model to specific industries (automotive, medical, space). 	<ol style="list-style-type: none"> 1. Materials on the SPICE model are not freely available. 2. The SPICE model itself does not contain a reference set of processes and must rely on external reference models. 3. The SPICE model is heavily focused on assessing the maturity of processes, there is no assessment of the organization maturity level in the 330(XX) series.
PM ²	<ol style="list-style-type: none"> 1. Consistency with the international standard PMBOK[®] Guide. 2. Assessing the maturity of each area of knowledge. A differentiated approach allows visual evaluation of the strengths and weaknesses in each area of knowledge. 3. Systematic and incremental approach to increasing maturity. 	<ol style="list-style-type: none"> 1. There are no structural and infrastructural elements, which the management of the organization can use to influence the maturity level of project management. 2. There is no description of the improvement process at level 5. 3. There is insufficient completeness of the model description. Internal and external factors affecting the maturity of processes and project management in general are not defined. 4. No integration with industry standards. The PM2 model does not take into account the impact of industry standards and other regulations that can slow or even block the transition to a higher level of management.

Table 1. Cont.

Maturity Model Name	Strengths	Weaknesses
PMMM	<ol style="list-style-type: none"> 1. The possibility of self-assessment. In his writings, Kerzner offers a series of self-assessment questions for each maturity level. 	<ol style="list-style-type: none"> 1. Not aligned with international project management standards. 2. Lack of a systematic approach. Kerzner considers the maturity of project management from the perspective of an organization, without analyzing the activities and maturity of project managers and other members of project teams. 3. There are no structural and infrastructural elements by which the management of the organization can influence the maturity level of project management. The model assumes that the transition to a new maturity level is possible only in cases where the management of the organization is directly involved in the development of project management. However, in the descriptive part of the PMMM model, the activities and functions of the organization's management are not formalized. 4. There are no processes for evaluating the effectiveness and efficiency of the best practices use. The PMMM model does not provide identification and use of the best management practices, which, in turn, makes it much more difficult to move to higher levels of maturity. 5. There are no processes for the creation and development of a project management culture. The PMMM model is based on the concept of continuous improvement, but this process is impossible without the formation and development of an appropriate corporate culture of project management in the organization.
ProMMM	<ol style="list-style-type: none"> 1. Corporate culture. In his writings, Hilson says that many organizations often make the same mistake: believing that employees will acquire career development courses will increase the project management maturity. According to Hilson, this process is useless if the organization does not have a mature corporate culture. 2. Management processes. According to Hilson, processes that take place in the projects' key criterion of maturity. 3. Use of the best practices. The best practices are based on the experience of predecessors, which, according to Hilson, indicates a high level of maturity. 	<ol style="list-style-type: none"> 1. The ProMMM model is not aligned with international project management standards. 2. Lack of a systematic approach. Hilson considers project management maturity from the perspective of an organization, without taking into account the performance and maturity of project managers and other members of project teams. 3. There are no structural and infrastructural elements by which the management of the organization can influence the project management maturity level. The model assumes that the transition to a new level of maturity is possible only in cases where the management of the organization is directly involved in the development of project management. 4. There are no processes for evaluating the effectiveness and efficiency of using the best practices. The ProMMM model does not provide the identification and use of the best management practices, which, in turn, makes it much more difficult to move to higher levels of maturity.

Table 1. Cont.

Maturity Model Name	Strengths	Weaknesses
PMMMsm	<ol style="list-style-type: none"> 1. Consistency with the international standard PMBOK® Guide. 2. Assessing the maturity of each area of knowledge. A differentiated approach allows visually evaluating the strengths and weaknesses in each area of knowledge. 	<ol style="list-style-type: none"> 1. There are no structural and infrastructural elements by which the management of the organization can influence the maturity level of project management. The model assumes that the transition to a new maturity level is possible only in cases where the management of the organization is directly involved in the development of project management. However, in the descriptive part of the PMMM model, the activities and functions of the organization's management are not formalized. 2. Level 5 is based on assumptions, not facts. It involves the use of certain automation systems and quantitative methods, which can be controversial, since automation systems, perhaps in a simplified form, can be used at previous levels. 3. Conceptual similarity of Level 3 and Level 4. The process of developing internal project management standards involves unified management in all projects of the organization and, as a result, the creation of a unified management information system. 4. No integration with industry standards. The PMMMsm model does not take into account the impact of industry standards and other regulations that can slow down or even block the transition to a higher level of management. 5. Lack of a systematic approach. The proposed components of each area of knowledge are aimed at project managers but are not focused on the management of the organization. 6. The level of maturity is determined by the least mature area of knowledge. The concept of measuring each area of knowledge suggests that it is possible that the maturity of one area of knowledge will be higher than another, and therefore, it may be difficult to determine the maturity level. To solve this problem, the PMMMsm model determines the maturity level for the least mature area of knowledge.

As the analysis has shown, in general, scientists refer only to the identification of maturity levels in organizations and do not consider such important questions as: "Is there an increase in profit when the level of maturity increases?", "How does the likelihood of project success changes with the maturity level increase?" and "What are the problems in moving an organization from one level to another?".

4. Conclusions

After a critical analysis of the most popular project management maturity models, the authors of the article made the following conclusions:

1. The most developed models are based on international project management codes of knowledge (ISO, PMBOK® Guide, PMCD, PRINCE2®, etc.), which is a signifi-

- cant advantage for maturity models such as OPM3, IPMA DELTA®, P3M3® and PMMMsm.
2. The majority of maturity models do not take into account the presence of structural and infrastructural elements, such as a workplace, the necessary equipment and software, the availability of professional standards, instructions, regulations, etc. Project activities are often viewed from the perspective of an organization, but the work of project managers, project participants teams and project business processes are overlooked.
 3. There are no processes for evaluating the effectiveness and efficiency of using the best practices. As a rule, maturity models are not aimed at identifying the best management practices, which, generally, are developed by the organization in the process of implementing projects and solving problems that arise in the process of implementation.
 4. The considered models do not take into account the influence of corporate culture (except for the ProMMM model). It is worth noting that the corporate culture of an organization can both stimulate the improvement of project management, and, on the contrary, contribute to its deterioration.
 5. The maturity models developers in sufficient depth and detail describe the processes, technologies, competencies, documents, etc., that should be present at the lowest maturity levels. However, as soon as it comes to a higher maturity level, the authors tend to describe only the conceptual content. This may indicate that there is no practical content for the upper levels.
 6. Thus, based on the analysis of the nine most popular project management maturity models, it can be concluded that contractors (performers, suppliers) with a high level of project management maturity ensure the successful achievement of planned goals due to the high maturity of employees, the availability of necessary processes, quality documents, a developed corporate culture of project management based on the best group and individual practices, as well as mechanisms that eliminate the materialization of universal and special risks (Nikolaenko and Sidorov 2023). In this regard, it is logical to assume that the project management maturity assessment is a tool for identifying the best contractor (performer, supplier) who can guarantee the creation of the desired product, successfully complete any project and faithfully fulfill all obligations under the contract.

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Appendix A

Table A1. Comparative analysis of the most popular maturity models.

Criterion	Name of Project Management Maturity Model								
	CMMI®	OPM3	IPMA DELTA®	P3M3®	SPICE	PM ²	PMMM	ProMMM	PMMMsm
Developer	SEI	PMI	IPMA	OGC	ISO	Kwak Y.H. и Ibbs C.W.	Kerzner H.	HilsonD.	PM Solution Crawford K.J.
Suitable for evaluation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Suitable for analysis of strengths and weaknesses	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Suitable for project management improvement	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector	IT	For all sectors	For all sectors	For all sectors	IT, auto, space, medicine	For all sectors	For all sectors	For all sectors	For all sectors
Process reference model	Yes, 22 processes	No	No	Yes, 32 processes	No	No	No	No	No
Knowledge domain reference model	No	No	Yes, ICB, contains 46 elements of competence	No	No	Yes, 9 fields of knowledge	No	No	Yes, 10 fields of knowledge
Reference model for the best management practices	No	Yes, 586 best practices and 2400 abilities for projects, programs and portfolios	No	No	No	No	No	No	No
Number of maturity levels	1–3	0–1 (presence or lack of the best practice)	1–5	1–5	0–5	1–5	1–5	1–4	1–5
Based on a body of knowledge of the project management best practices	–	PMBOK® Guide The Standard for Program Management, The Standard for Portfolio Management, PMCD	ICB, OCB, PEB	PRINCE2®	ISO standards	PMBOK® Guide	—	—	PMBOK® Guide
Creation date of the first version	2000	2003	ICB (1999)	2003	1998	1997	2001	2003	2007
Creation date of the latest version	2018	2013	ICB (2015), OCB (2016), PEB (2016)	2006	2015	2002	—	—	2015

Table A1. *Cont.*

Criterion	Name of Project Management Maturity Model								
	CMMI®	OPM3	IPMA DELTA®	P3M3®	SPICE	PM ²	PMMM	ProMMM	PMMMsm
The process of determining the maturity level of project management is described	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
The process of determining the maturity level of program management is described	No	Yes	No	Yes	No	No	No	No	No
The process of determining the maturity level of portfolio is described management	No	Yes	No	Yes	No	No	No	No	No
Certification	Yes Class A, B and C	No	Yes Level A, B, C and D	Yes	Yes	No	No	No	Yes

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