Digital Transformation Maturity Model

Igor Ilin, Alexandra Borremans, Anastasia Levina, and Manfred Esser

Abstract Currently, digitalization has become a key engine for the development of all industries. More and more enterprises are focusing on the digitalization of their processes and the introduction of digital services. However, the transition from business to digital is quite complex and requires a gradual transition. This chapter raises questions of the maturity of various enterprises and their processes, as well as criteria and attributes for assessing maturity. In addition, a comparative analysis of some of the existing maturity models is carried out. As a result of the study, a five-level model for assessing the maturity of digital enterprises and transformation in them is presented, which was developed on the basis of modern maturity models, such as CMMI, OPM3, and others. Moreover, the levels of maturity and the criteria for their achievement, as well as the stages of transition between them, are described.

Keywords Maturity model · Digital transformation · Digitalization · Digital maturity · Company assessment

1 Introduction

Nowadays, the question of enterprises' digital maturity is quite relevant in the modern developing world, where digitalization, business transformation, and the introduction of the latest IT technologies have come to the fore. The tendency of the information community to qualitatively change the management of enterprises determines the development of the economy, an increase in labor efficiency and an improvement in the quality of life. Companies need to understand how to conduct

I. Ilin · A. Borremans · A. Levina (✉)
Graduate School of Business Engineering, Peter the Great Saint-Petersburg Polytechnic University, St. Petersburg, Russia

M. Esser
Get IT, Grevenbroich, Germany

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business in a changing environment, what strategies and management methods to use in order to maintain their competitiveness in the future.

All companies are at different stages of their development and have different business processes, so there is no single algorithm for transformation. It is necessary to conduct a comprehensive analysis of the use of information technology in the activities of the company, considering both internal processes and interaction with the environment, customers, competitors, and partners.

In order to clearly understand which processes and models need transformation, at what stage of development the company is now, they use such a concept as "digital maturity."

2 Methods

To achieve the goals of this chapter, information from open sources was analyzed on modern approaches to assessing the maturity of enterprises, their main levels. Moreover, the existing approaches to the assessment of processes, IT, business, and IT harmonization were analyzed.

According to experts, digital maturity is a cumulative assessment of the level of development of companies in several important areas of digital transformation, such as digitization of business processes, digital infrastructure, data-driven management, the use of customer orientation principles and product value management, R&D and creation of new products, digital culture, and digital partnership (Colli et al., 2019).

In other words, the digital maturity of an enterprise is the level of its readiness to properly respond to digital innovations in the company's processes.

The maturity of a company can be thought of as milestones that also have some variation but have common features.

Having determined the level of maturity of the company in the field of digital transformation, it is possible already at the first stage to form a list of changes in the organization to adapt it to a changing world, both in the external and in the internal environments. Achieving the desired level is possible only with a clear description of the further strategy for achieving the required state.

Let us introduce a definition of the concept of a maturity model. According to the ISO standard, the maturity model is a model that reflects the elements necessary for efficient processes and describes the path of a gradual improvement from immature processes to regulated, mature processes with higher quality and efficiency. In contrast, the maturity of an organization's project management refers to the organization's ability to select projects and manage them in the most efficient way to support the achievement of its strategic objectives (Al-Qutaish & Abran, 2011).

Various models for assessing maturity exists:

- SW CMM
- Integrated model CMMI
- ISO 15504 standard

- Model of maturity COBIT 4.1 (COBIT Process Assessment Model, PAM)
- SPICE (Software Process Improvement and Capability determination) model
- PMMM (Project Management Maturity Model)
- OPM3 model (PMI community)
- etc.

Let us take a closer look at some of them to get a general picture of the existing methodologies for determining the maturity of companies.

2.1 Capability Maturity Model

The most popular model is CMM (Capability Maturity Model for Software), which describes the maturity of software development processes in enterprises, developed by the Software Engineering Institute (USA). The success of the idea lies in the ease of understanding, the practicality of applying the model, and effective advancement from one level to another with significant changes in product quality for the better. This model is focused on optimizing the price–performance ratio (Paulk, 2009).

2.2 Capability Maturity Model Integration

In the process of development, the model was refined and received the name CMMI (Capability Maturity Model Integration), which differs in some details, but retains the basic principles of CMM, discreteness of maturity gradations, focus on the project business (Team, 2002). Maturity levels according to the CMMI model are as follows: 1—initial, 2—controlled, 3—definite, 4—quantitatively controlled, and 5—optimized. In Table 1, comparison of SW CMM and CMMI is presented.

The integration of the models resulted in a five-tier methodology for determining the maturity of enterprises:

- Level 1—Initial. The key concept is Heroism. It is characterized by unpredictable, poorly controlled processes that are reactive in nature. The success of the project is determined by the heroism of the staff and the qualifications of individual employees. Projects are often out of budget, results do not meet expectations, and are of poor quality.

Table 1 SW CMM and CMMI comparison

№.	SW CMM	CMMI
1	Elementary	Elementary
2	Repeatable	Managed
3	Definite	Definite
4	Managed	Quantitatively managed
5	Optimizable	Optimizable

- Level 2—Managed. Project and requirements management. All processes in the company are planned, they are constantly monitored and controlled. Stakeholders are committed in advance and are aware of the state of the product being developed at any given time. The generated requirements are almost completely consistent with the results of the project and have the proper quality in accordance with the standards and goals of the company.
- Level 3—Defined. Process engineering. Drawing up a unified system of approaches of the organization to the standard processes in the company. Each project is considered as a set of general processes, described earlier in the provisions, which are finalized and improved depending on their tasks. The processes and procedures for their adaptation have a formal rigorous form. Based on the standards, senior management sets the objectives of the processes and monitors their achievement.
- Level 4—Quantitatively Managed. Process and product quality. At this level, the company determines the quantitative characteristics of the quality and performance of processes. Methods of statistical analysis and data processing are applied. Indicators that deviate from the norm are being investigated to prevent such occurrences in the future. Data analytics allows you to predict the execution of processes not only qualitatively, but also quantitatively. The results obtained are stored in databases and are used by the management to make decisions on process management.
- Level 5—Optimizing. Continuous process improvement. The company is trying to improve the processes taking place during the project. This is due to the constant comparison of old quantitative indicators with new ones. Employees can monitor the results and independently optimize their activities (Henriques, 2018).

2.3 COBIT 4.1

The COBIT 4.1 maturity model initially turned out to be difficult to implement in practice and did not provide a definite understanding of the state of the company. So, the processes could have signs of different levels, not even going in a row, which also happened with the attributes, making it difficult to assess the level at which the company is located. This led to the loss of a holistic view of her digital maturity (Brand & Boonen, 2007).

2.4 ISO / IEC 15504

The model was improved and became based on the international standard ISO / IEC 15504 “Information technology—process assessment.” International Standard defines process evaluation as a complete process optimization program or as part

Table 2 ISO / IEC 15504 levels

Level	Process attributes	Rating score
Level 0	Process initiation	–
Level 1	Process implementation	Mainly or completely
Level 2	– Process implementation – Implementation management – Work product management	– Completely – Mainly or completely – Mainly or completely
Level 3	– Process implementation – Implementation management – Work product management – Process definition – Process deployment	– Completely – Completely – Completely – Mainly or completely – Mainly or completely
Level 4	– Process implementation – Implementation management – Work product management – Process definition – Process deployment – Process measurement – Process control	– Completely – Completely – Completely – Completely – Completely – Mainly or completely – Mainly or completely
Level 5	– Process implementation – Implementation management – Work product management – Process definition – Process deployment – Process measurement – Process control – Process innovation – Process optimization	– Completely – Completely – Completely – Completely – Completely – Completely – Completely – Mainly or completely – Mainly or completely

of the process capability. Optimizing processes means continually increasing performance and applying sustainable practices across an organization. Determination of process capabilities according to the standard—correct representation of potential capabilities from ongoing processes (Mesquida et al., 2012, p. 15504).

This standard also presupposes five levels of digital maturity of the company, which directly depends on the maturity of the processes taking place inside (Table 2).

These levels are the following:

- Level 0. Incomplete process. When processes are underway, but have not yet reached it. There is no single basis for systematic approaches to standard processes.
- Level 1. Implemented process. Achievement of the processes of the final stage of their purpose without the use of special management methods.
- Level 2. Guided process. The processes carried out are planned in advance, then subsequently regulated. The processes are monitored, the compliance of the developed product or service with the assigned goals is checked.
- Level 3. Established process. A base of basic processes is being formed, which are standardized and have common control algorithms. The described processes

are used at all stages of the project, but are individually modified in the course of implementation for the purpose of the product being developed.
- Level 4. Predictable process. The results of the processes at this stage are predicted and known in advance. Achievement of certain results is easily controlled and monitored.
- Level 5. Optimization process. Predictable processes are constantly being improved to achieve the set business goals (El Emam & Birk, 2000, p. 15504).

The levels are arranged in such a way that it is impossible to skip or slip through one of them, the transition through the levels is carried out in order. If the company decides to skip several levels, then the simultaneous implementation of several optimization tools can lead to unpredictable consequences, jeopardizing the entire project activities of the company. Each level of maturity forms the basis for the rational and efficient implementation of processes at the following levels. However, organizations can use and benefit from the implementation of processes that are associated with higher levels of maturity than those achieved. All maturity changes do not have to be consistent.

The levels are determined by the achievement of the process attributes.

N—Not achieved—0–15% achievement.
H—Partially achieved—15–50% achievement.
B—Mainly achieved—50–85% achievement.
P—Fully achieved—85–100% achievement.

2.5 SPICE

Basic concepts of the SPICE maturity model (ISO / IEC 15504 standard) are:

- Practice—An activity that introduces contribution to the objectives of the process to increase its capabilities.
- Process—A set of interrelated or interacting activities, transforming inputs into outputs.
- Process assessment attribute—A measurable characteristic of the process capability (Mitasiunas & Novickis, 2011).

Unlike CMMI, the SPICE maturity model is implemented in only one version—continuous representation. Therefore, SPICE defines only the concept of "level of opportunity," which corresponds to the scale of assessing the possibility separately the processes taken, and, as a consequence, does not allow make an assessment of the organization's software development process as a whole. Model maturity SPICE describes 6 levels of capability. To reach a particular maturity level, certain process attributes need to be realized in order to meet the desired level requirements. For all processes, the standard defines 9 different attributes.

SPICE Model Capability Level List:

Table 3 Comparison of SPICE and CMM

SPICE	CMM
Two-dimensional structure	Sequential, one-dimensional structure
Allows flexibility in developing an improvement strategy	Contains a predefined development path
Opportunity levels for every process	One maturity level for all process
Results need to be simplified	Results are easy to understand
Results are very detailed	Simplified results

- Level 0—Process not running
- Level 1—Process in progress
  - Measurement of process performance
- Level 2—Guided process
  - 2.1 Performance management
  - 2.2 Product Creation Management
- Level 3—Established process
  - 3.1 Documenting the process
  - 3.2 Tracking process resources
- Level 4—Predictable process
  - 4.1 Process measurement
  - 4.2 Process control
- Level 5—Optimization Process
  - 5.1 Process change
  - 5.2 Continuous improvement

Despite the fact that the SPICE standard has absorbed the best from a number of other standards, it has not become a simple amalgamation of them. In order to show how SPICE differs from its predecessors, it is advisable to compare SPICE and other well-known standards (Laksono et al., 2019) (Table 3).

Maturity methodologies of process approaches are constantly changing and new models such as OPM3 (Project Management Institute, PMI) model and BPMM appear.

2.6 Project Management Maturity Model

The Kerzner Project Management Maturity Model (PMMM) is a qualitative assessment of the levels of project management maturity and consists of 5 levels (Kerzner, 2019).

The model assumes that many levels are required and detectable, but the order of transition from one level to another will remain unchanged.

Maturity model levels are the following:

- Level 1—Terminology. At this level, the organization realizes the importance of project management and the need to deeply master the basic knowledge of project management and study the terminology that accompanies it.
- Level 2—General processes. 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—Unified methodology. The organization recognizes the importance of synergies that arise from integrating project management with other methodologies (quality management, process management, etc.).
- Level 4—Benchmarking. There is a realization that it is necessary to improve corporate processes if the corporation wants to maintain its superiority over competitors.
- Level 5—Continuous improvement. At this level, the company evaluates the information obtained in the course of benchmarking, and must decide whether this information will be used in the expansion (development) of a unified methodology (Faifr, 2020).

2.7 Organizational Project Management Maturity Model

OPM3 (Organizational Project Management Maturity Model) is an organizational project management maturity model. A standard for assessing the maturity of project management organizations, published in 2003 by the American Project Management Institute (PMI). The standard's goal is to identify problems in the project management process and define a strategy for other employees to carry out operations (Farrokh & Mansur, 2013).

OPM3 standard consists of three main elements:

- Knowledge of what is project management in an organization, how to determine the level of maturity of project management, and what are the best practices in PM.
- Evaluation (assessment) of the current level of maturity of project management.
- Means for improving project management processes to achieve a higher level of maturity.

OPM3 includes:

- Body of knowledge—A book describing the basic concepts and structure of the standard, the content of the model itself and the procedure for its use.
- The best practices base is a database and tools presented in electronic form. The base is structured into three domains (project portfolio, program, and project) and four levels of project formalization (processes are standardized, measurable,

controlled, and optimized). In addition, the base of best practices includes the so-called OE (Organizational Enablers), which are necessary for the organization to maintain the processes and organizational structure of project management (Bento et al., 2019, p. 3).

2.8 BPMM

The BPMM standard provides details on how to use its maturity model in practice. Including the description of 30 groups of processes, the creation and management of which will allow the organization to go from the first level to the fifth. Each group of processes is assigned a certain level of process maturity (starting with the second) and the area of application of efforts (thread). Thus, it is possible to track how each group of processes evolves as the level of process maturity increases (Kneuper, 2018).

All approaches have their own characteristics and different criteria, so they need a detailed analysis before applying.

3 Results

In order to clearly understand at what level the company is located, special attributes of maturity are applied. Using a general approach to assessing the health of companies, usually from 5 to 8 elements are identified. Key ones are presented below:

1. Buyers.

   Provide an experience where customers see your organization as a digital partner and use their preferred communication channels to manage their future offline.

2. Strategy.

   It focuses on how companies change or act to increase their competitive advantage through digital initiatives; is integrated into the overall business strategy.

3. Technology.

   It supports the success of the digital strategy, helping to create, process, store, protect, and share data to meet customer needs at low cost and overhead.

4. Operations.

   Execution and development of processes and activities using digital technologies for strategic management and increasing the efficiency and effectiveness of the company.

5. Culture.

Define and develop an organizational culture with leadership and talent processes to support the development of the digital maturity curve.

The state of each element allows you to give a complete picture of the state of the company as a whole (Maydanova & Ilin, 2019).

Not all companies have full knowledge of the digital spectrum, so such a comprehensive assessment provides an understanding of possible growth concepts, the introduction of new technologies, and methods for improving customer service. Knowing where the company is located, as well as its capabilities and needs, help determine a successful strategy (Ilin et al., 2020).

This model corresponds to a certain scale of attributes, with the help of which the state of maturity of the company is assessed.

Despite the high variety of methodologies and the development of new models, they are all built in such a way that it is impossible to miss any level of maturity, the transition through the levels is carried out in sequence. If the company decides to skip several levels, then the simultaneous implementation of several optimization tools can lead to unpredictable consequences, jeopardizing the entire project activities of the company. Each maturity level is the basis for the rational and effective implementation of processes at subsequent levels.

If we consider the Russian market, then for complete digitalization Russian companies do not have the maturity of current business processes and qualified specialists (Zaychenko et al., 2018).

The introduction of new technologies can lead to significant changes in work processes, an increase in the qualifications of employees, the development of previously unused skills that require constant optimization and understanding of all the nuances and complexities of unforeseen technological problems. Assessment of the maturity of the process helps to understand how the processes are manageable, controlled, optimized. Each company in the process of its growth goes through certain stages, characterized by different cultural, management, and strategic characteristics.

There is a strong link between the transition from process maturity to digital. A company's readiness for technological transformation is determined by an assessment of the level of compliance with fundamental processes and their management, methods of using the accumulated information. Determining the level of maturity of the management system, one can characterize the stage of the company's readiness for digital transformation, identify the company's potential for development, choose the direction of modernization and growth.

It can be noted that a company, a company that works effectively and efficiently, achieves a stable state in the global market and has a high index of readiness for digital transformation (Borremans et al., 2018). The management of such companies is able to identify weaknesses that need improvements and innovations through IT technologies, organize monitoring of changes in the environment, increase satisfaction of the needs and expectations of stakeholders, and structure goals.

Based on the methodologies described earlier, a model of digital maturity of companies was formed, which, by analogy with the process, also includes 5 levels (Table 4).

Based on the previously described methodologies, a model of digital maturity of companies was formed, which, by analogy with the process, also includes 5 levels (Fig. 1):

- Level 0. Basic infrastructure. Technologies that do not give business effects by themselves, but are necessary for the introduction of advanced technologies.
- Level 1. Computerization. The process is automated by any IT system. Entering data into the system is carried out manually.
- Level 2. Connectivity. Operational data of the process enter the system automatically, without human intervention. Adjacent systems are integrated. The control action is carried out remotely.
- Level 3. Transparency. Key process indicators are visualized and tracked in real time.
- Level 4. Predictiveness. Predictive systems have been introduced to predict the future state.
- Level 5. Adaptability. Systems have been introduced that have a corrective effect on equipment either independently or within a corporate system to maximize efficiency.

To achieve the highest level or move from one to the other, two approaches were identified.

The first of them is the replication of existing developments and technologies. It is assumed that the company is using basic digital tools that give positive results, or there are best practices for future implementation with a high level of versatility that can be applied to most standardized enterprise processes.

This approach requires the transformation of the processes in individual production sections of the enterprise. It should be remembered that they can have different levels of maturity at the same time. Thus, there is a transformation based on the replication of digital tools that have been introduced and need to be improved, or have been considered by the management as planned implementations with a certain result for the enterprise.

A second approach to the improvement and implementation of IT technologies in enterprises is proposed, which takes as a basis a detailed analysis of processes down to operational activities. New modern technologies are taken as the basis for optimization. Thus, the output is a detailed program for the digital transformation of the main problematic processes to improve the efficiency of the enterprise.

It should be noted that both approaches are practically applicable and are chosen by the company depending on its transformation objectives and the level of digital maturity. One more feature can be noted—this is the application of the described approaches to digital transformation at the same time, analyzing both the instrumental basis of the company and the internal business processes.

Moreover, when assessing the digital maturity of an enterprise, it is important to consider and develop the following attributes:

Table 4 Digital maturity of a company

Maturity level	Processes	Technologies	Employees
Level 5	– Development of processes for autonomous decision making by systems. – Development of processes for regular forecasting and planning of future production.	– Integration with external data of suppliers and buyers. – Using artificial intelligence systems.	– Developing a culture of continuous improvement and innovation. – Implementation of responsible persons for the corresponding direction of predictive analytics and adaptability.
Level 4	– Development of audit processes for historical and current data and the use of the information obtained for optimization. – Introduction of procedures for regular optimization initiatives.	– Real-time implementation of activity analysis systems that automatically perform analytics, generate warnings, and recommendations. – Implementation of digital twins for prototyping and optimization testing.	– Organization of cross-functional sessions and data exchange sessions to work on urgent problems and optimization methods based on new data. – Attracting additional data analysts.
Level 3	– Formalization of data flow management processes. – Creation of processes for active exchange of knowledge and data between all project participants. – Creation of a cross-functional data exchange network.	– Improving data accuracy, reducing the amount of useless information. – Implementation of data mining systems. – Integration of systems for data exchange.	– Training employees to work with system data, various devices, and interfaces. – Development of "Digital" skills. – Development of a culture of knowledge management.
Level 2	– Formalization of the implementation of the "digital factory." – Processes for attracting external actors to ensure connectivity.	– Elaboration of directions of integration of existing systems and technologies with future elements of the "digital factory." – Formation of a single information space and data streams, connection of systems.	– Involvement of employees in the development of a target vision. – Separation of roles and areas of responsibility, attraction of employees with competencies in business, IT, and production.
Level 1	– Elimination of paper forms and media, execution of processes through system interfaces. – Data transfer automation.	– Implementation of basic production and enterprise management systems. – Integration of systems for automatic data transfer.	– Employees trained to work with systems in their area of responsibility.

(continued)

Table 4 (continued)

Maturity level	Processes	Technologies	Employees
Level 0	– There is no direct influence on the processes.	– Creation of infrastructure for subsequent implementations of industrial Wi-Fi, local networks.	– Employees do not need additional digital competencies.

Fig. 1 Levels of digital maturity (Source: authors' creation)

- Digital culture—An organizational culture that supports continuous improvement and innovation processes.
- Human Resources—Employees with the skills needed to be successful in a digital environment.
- Processes—Optimized business processes, as well as their constant analysis and monitoring, as well as the application of process management practices.
- Digital products—Digital solutions for business.
- Models—Constantly updated models, valid and included in the activity processes.
- Data—Data available in real time with the required level of security, complete and high-quality for making management decisions.
- Infrastructure and Tools—Modern and digital infrastructure to enable cross-device connectivity and integration (Dubgorn et al., 2019).

4 Conclusion and Discussion

The basis for the rapid transformation of a business is specific and understandable goals, adjusted to changes, and strengthening of positions among competitors, improving the quality of customer service.

This research examined several models for assessing the maturity of an enterprise. The challenge for every organization is to move from a lower tier to a higher tier in order to maintain competitiveness, increase productivity, and improve the quality of the products or services being developed.

In this work, an analogy was drawn between the process model of the enterprise maturity level with the digital one. Five levels of digital maturity have been identified, such as:

- Level 0. Basic infrastructure.
- Level 1. Computerization.
- Level 2. Connectivity.
- Level 3. Transparency.
- Level 4. Predictiveness.
- Level 5. Adaptability.

Moreover, digital transformation approaches have been reviewed. The first one is based on replication of existing digital tools on the enterprise. The second—on the detailed analysis of processes down to operational activities. Understanding the current level of digital maturity is important for planning digital transformation activities for an enterprise to migrate to a target image.

Thus, knowledge about the level of digital maturity, assessment of readiness for digital transformation, the use of certain approaches to optimize activities help the management in choosing management decisions for a successful business.

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