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Assessment of transport enterprise readiness for digital transformation

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Abstract

In the era of Industry 4.0, in order to remain competitive, companies need to adapt to change through digital transformation. The effectiveness of the transformation of companies directly depends on their readiness for such a transition. The article describes an approach to assessing the readiness of a transport enterprise for digital transformation. As part of the readiness assessment, the following work was carried out: assessment of the maturity of management processes, analysis of processes according to the level of readiness for automation and assessment of the competencies and skills of the company's employees to use modern digital technologies and solutions. The research methodology is based on the application of the CMMI concept - a methodological approach to assessing maturity, which combines maturity models of various areas of the enterprise.

Keywords: digital transformation; digital maturity; maturity assessment methodology; transport; automation; digital competencies

1. Introduction

The transformation of the manufacturing industry involves radical changes - business models are changing, new companies are emerging, well-known brands with a long history disappear if they did not have time to embark on the path of digital transformation. The path of these transformations has led to the next technological milestone, the formation of the concept of Industry 4.0, which is also called the concept of "Smart Manufacturing". By "4.0" we mean that the potential revolutionary impact of this trend is a direct continuation of the three previous industrial revolu-tions. Since 2011, initiatives have emerged around the world to bring together indus-trial manufacturing, digital

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technology and the Internet. A characteristic feature of Industry 4.0 is fully automated production, where all processes are controlled in real time and considering changing external conditions.

The effectiveness of the digital transformation of companies performing digital transformation depends on the accompaniment of the digital transformation process with the parallel improvement of management, which is directly related to the proactive management of the operation and its top management. Thus, a company grows by an average of 26% if technology and new management methods are used together. If only to improve management, without resorting to digital technologies, then the profits of firms grow by 9%. If company invests only in technology, forgetting about the necessary changes in management, the profit does not grow at all, but falls by 11% (Garifullin, Zyabrikov, 2018).

Large Russian companies have already embarked on the path of digital transformation. However, most of them do not yet have a comprehensive digitalization program - companies are implementing portfolio of pilot projects to implement separate and often disparate digital solutions. Most often, companies understand this as an implemented portfolio of pilot projects in the absence of a long-term action plan with an understanding of the target state of the organization. This approach makes it possible to assess the applicability of certain digital solutions in practice, but often leads to a shift in emphasis on secondary tasks, dispersal of resources and a point transformation of business processes. For full-scale digitalization, it is necessary to improve (optimize) the maturity of current business processes, to increase the competence of personnel. All activities need to be combined into a single plan or roadmap for digital transformation.

The issues of the methodology of digital transformation of enterprises are considered by many authors (Mugge et al., 2020; Baiyere et al., 2020; Kotarba, 2018; Oztemel, Gursev, 2020; Büchi et al., 2020; Verhoef et al., 2021).

The main obstacles to digital transformation that Russian companies face are the lack of maturity of current business processes and the lack of necessary skills and competencies of employees.

Several approaches are known to assess the readiness for Industry 4.0 of an enterprise.

The "Industry 4.0 Maturity Index" methodology is the development of the Industrie 4.0 Maturity Center design center, created on the basis of the German Academy of Technical Sciences (Acatech) (Industry 4.0 Maturity Index, https://www.acatech.de/wpcontent/uploads/2018/03/acatech_STUDIE_rus_Maturity_Index_WEB.pdf, (accessed 14.07.2021)).

Organizational Digital Manufacturing Maturity Model - ODM3 (Digital Manufacturing Company Maturity Model) developed by AUTODESK Inc. and the Moscow School of Management SKOLKOVO.

Maturity model DREAMY (English Digital REadiness Assessment MaturitY model - a model for assessing readiness for digital transformation), based on the principles of CMMI (Capability Maturity Model Integration - the integration of maturity models), which defines the technological areas of digital transformation of a manufacturing company (Macchi, Fumagalli, 2013). In establishing the model, the chain of activities that create added value through the management of the production cycle was taken into account. The model focuses on production processes, which are grouped into five main areas of activity: design and engineering, production management, quality management, maintenance, logistics management.

The main goal of these methods is to help enterprises determine at what stage of digitalization development they are at the moment and correctly build a strategy for the transition to Industry 4.0. A preliminary assessment of the feasibility of applying these methods showed that, to accomplish the research tasks, these approaches will not allow obtaining useful results that would become the basis for preparing a digital transformation plan, taking into account the objectives of digitalization to be achieved.

The task of digital transformation in this study is to assess the readiness of a transport enterprise for operational digitalization, which means the introduction of digital technologies and services to improve the efficiency of management (administrative) business processes of an enterprise within the existing business model. It is necessary to assess the readiness of enterprise management processes for digital transformation.

The solution to this problem provides for the following works:

- Assessment of the maturity of management processes: organizational planning, financial management, accounting and management accounting and reporting, personnel management, procurement, inventory.
- Analysis of processes according to the level of readiness for automation.
- Assessment of the competencies and skills of the company's employees to use modern digital technologies and solutions.

To assess the readiness of enterprise management processes for digital transformation, it is necessary to solve the following tasks.

1. Explore approaches to formalizing business processes, select reference models and define a description template.
2. Carry out modeling and describe the management processes of the enterprise.
3. Assess the maturity of the processes described and identify strengths and weaknesses.
4. Assess the maturity of process automation.
5. Develop an action plan and roadmap for digital transformation.

2. Methods

The research methodology is based on the application of the concept of CMMI - Capability Maturity Model Integration - a methodological approach to assessing maturity, which combines the maturity models of various areas of the enterprise. The standard IDEF0, GOST 15504 are used. When choosing the areas of digitalization and the procedure for automating the directions of the production enterprise's activities, the following were used: the methodology "Index of maturity of Industry 4.0" (developed by the design center Industrie 4.0 Maturity Center); Manufacturing Enterprise Digital Transformation Manual (AUTODESK Inc.); maturity model DREAMY.

The key task of the work is to assess the state of the enterprise's administrative processes using the concept of "maturity" based on the recommendations of GOST R 15504-2009. This estimate assumes the description of the processes proceeding from the “AS-IS” state, taking into account the Customer's proposals for improving the processes, which do not affect the changes in the current organizational structure of the enterprise. In accordance with the CMM (Capability Maturity Model), defined in the GOST R 15504 standard, there are five levels of process maturity, determined depending on the measured ratings of the process attributes.

Description of the business processes of the enterprise are carried out on the basis of the form - Business process card. In describing the processes, documents of the enterprise are used, as well as regulations, job descriptions, etc.

To assess the level of maturity of business processes, the approach described in GOST 15504 was used. 5 levels of maturity are allocated.

Level 0: Incomplete process - the level of evidence of systematic possession of at least one of the following process attributes is absent or insufficient.

Level 1: Performed process- Executable process achieves clearly identified results.

Level 2: Managed process - the process being performed is carried out under a certain target procedure of the organization (i.e. some organizational cycle is supported - the process is planned, tracked, analyzed and configured).

Level 3: Established process - the previously described repeatable process is performed on the basis of a standard process-model, based on recognized principles of management and achievement of results.

Level 4: Predictable process - a controlled process runs within specified quantitative limits.

Level 5: Optimizing process - a predictable process dynamically adapts and changes in order to effectively meet the current and projected business goals of the company.

Each of the levels is revealed by a set of attributes, and those - by a set of metrics that reveal the essence of the attributes.

For each process, it is necessary to determine the location in accordance with the implemented metrics. If the process is implemented as presented in the attribute metric, then we assign the process a label 1, otherwise - 0. The sum of the labels (1 and 0) is the absolute process score. The relative process rating is calculated by dividing the absolute rating by the total number of metrics corresponding to the level. Then we determine the level of maturity according to the rating scale proposed in the standard. Processes that are at a certain level of maturity are simultaneously at a lower level. Thus, the process implemented at Level 3 must be implemented at both Level 2 and Level 1. Table 1 shows the rating scale, where the corresponding values are marked with letters.

Table 1. Scale of ratings of process achievement of its result

Marker	Definition	Achievement criterion, %
N	Not achieved	0-15

P	Partially achieved	15-50
L	Largely achieved	50%-85%
F	Fully achieved	85%-100%

The same metrics are used to assess the maturity index of the company's personnel.

The following approach is used to assess the Maturity Index. Each process is assigned labels: 1 if the maturity level is marked L or F, and 0 otherwise. The process maturity index is calculated as the sum of the labels divided by the number of levels (5), maturity level 0 is not considered.

To assess the readiness of the process for automation (use of automated control systems), their detailing was performed using attributes and metrics. The detailing result is shown in Table 2.

Table 2. Maturity levels, attributes and metrics for automation readiness

Maturity level	Attributes	Metrics
0 Paper	Paper	Process does not use information technology for its implementation
1 Initial	Initial automation	The process is carried out using information technology: computer hardware, MS Office level software
2 Performed	Execution of the process using automated solutions	To implement the process, systems and services are used that exclude the presence of paper carriers
		corporate data is entered and managed through system interfaces without duplication
3 Managed	Process control with automated solutions	The process is carried out using an automated enterprise management system
		The automated system is customized according to the enterprise process
	Definition of the automation process	The implementation of the process using an automated system is reflected in the enterprise standards
		The automated process is integrated with other automated processes in the enterprise
4 Predictable	Process measurement	To assess the results of the implementation of the process, the services of the automated process are used
		Activity analysis is carried out on the basis of big data analysis technologies, which automatically generate reports and recommendations in real time
		Changes to the automated system are planned
5 Optimizing	Process innovation and optimization	The efficiency of the enterprise process is significantly increased due to its automation
		Changing enterprise processes is carried out by changing its automated implementations
		Integration with external data marts of suppliers and buyers
		Using artificial intelligence systems for forecasting, diagnostics and recommendations

To determine the readiness of an enterprise for digital transformation (operational digitalization), it is necessary to assess the competencies and skills of the enterprise employees to use modern digital technologies and solutions. One of the obstacles to digital transformation is insufficient competence and knowledge of employees (Tsifrovaya transformatsiya v Rossii, 2018, https://komanda-a.pro/blog/dtr_2018, (accessed 14.07.2021); Gileva, 2019). According to the results of the studies (more than 300 enterprises from 15 industries), it was revealed that 64.1% are insufficient competencies and knowledge and 60.9% are lack of qualified personnel (Gileva, 2019).

Table 3 shows a fragment of this model for assessing the readiness of personnel for digital transformation.

Table 3. Level maturity model for assessing staff readiness for digital transformation

Maturity level	Characteristic

1. Initial: infrastructure, systems and services do not allow to get business effects from process automation	Employees don't need additional digital competencies
2. Performed: infrastructure consolidated, basic automation systems implemented, processes formalized	Employees are trained to work with systems and services in their area of responsibility
3. Managed: the infrastructure meets the needs of enterprise management, a corporate management system is implemented, processes are managed and controlled	Development of a culture of knowledge management; separation of roles and areas of responsibility in accordance with digital skills; attracting employees with competencies in data analysis and artificial intelligence
4. Predictable: a single corporate information space has been created, systems and services automatically generate reports and forecasts in real time, the state of processes is predictable	Involvement of employees in the development of a target vision; training employees to work with data systems, various tools for extracting and analyzing data
5. Optimizing: infrastructure, systems and services adapt to the needs of the enterprise, process management is digitized	Development of a culture of continuous improvement and innovation; appointment of those responsible for a certain direction of predictive analytics and adaptability based on AI systems

3. Results

3.1. Assessment the level of maturity of processes

The assessment of the level of maturity of the processes of the transport enterprise was carried out in accordance with the assessment methodology developed within the framework of this project, based on the standard GOST R ISO / IEC 15504-2-2009. For each management process, process models were built in the IDEF0 notation, the process maturity was assessed, strengths and weaknesses were identified, the process automation maturity was assessed, activities were formed, a plan and roadmap for digital transformation was developed, including the timing and cost of the activities.

One of the studied processes was the A2 process "Personnel and payroll management", which at the enterprise is represented by the following sub-processes:

A2.1. Personnel planning and recruiting
A2.2. Personnel development
A2.3. Personnel accounting
A2.4. Payroll preparation
A2.5. Reporting and analysis

Analysis of the business process “Personnel management and payroll” and its sub-processes allowed us to obtain an assessment of the level of maturity (Fig. 1). Each subprocess was compared with the maturity level metric (from 0 to 5) and recorded in the corresponding cell, if the metric characterizes the analyzed subprocess, otherwise the subprocess was not recorded in the cell. An example is shown in Fig. 1.

Attributes	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
Incomplete process						
the process is not implemented or could not reach its destination	A2.2					
Process implementation						
the process has reached its definite outputs		A2.1; A2.3; A2.4; A2.5				
Implementation management						
the objectives of the process are identified			A2.1; A2.3; A2.4; A2.5			
the implementation of the process is planned and monitored			A2.1; A2.3; A2.4; A2.5			
the implementation of the process is adjusted to fit the plans			A2.1; A2.3; A2.4; A2.5			
responsibilities and authorities for the implementation of the process are defined, allocated and communicated			A2.1; A2.3; A2.4; A2.5			
resources and information necessary to carry out the process are identified, available, allocated and used			A2.1; A2.3; A2.4; A2.5			
the interfaces between the parties involved are managed to ensure both effective communication and a clear allocation of responsibilities						

Fig. 1. Assessment of the level of maturity of the process.

For each sub-process, the number of associated metrics was calculated, which correlated with the total number of metrics at a given maturity level, according to the methodology developed in this study (see Table 2). The resulting ratio was expressed in percent and in accordance with the rating scale they were labeled “N”, “P”, “L” or “F” (Table 4). The final rating assessments of the achievement of the attributes of all subprocesses of the business process “Human resource management and payroll” were the main ones for calculating the maturity index. The maturity index, as well as the assessment of the level of maturity, was calculated on the basis of the methodology proposed during the implementation of the study (Table 2), as the ratio of the number of tags “L” and “F” to the number of maturity levels (5), expressed as a percentage (Table 4).

Table 4. Fragment of the table "Rating assessments of subprocesses A2 “Human resources management and payroll”

№	Subprocess name	Maturity level					Maturity index, %
		Incomplete	Performed	Managed	Predictable	Optimizing	
A2	HR management and payroll						44%
A2.1	Planning and recruiting	L	L	P	N	N	40%
A2.1.1	Personnel planning	F	F	L	N	N	
A2.1.2	Staff recruitment	F	F	L	N	N	
A2.1.3	Maintaining the staffing table	N	N	N	N	N	

Based on the ratings of the A2 subprocesses, Human Resources Management and Payroll, the following conclusions were drawn:

1. Subprocess A2.1 “Planning and selection of personnel” according to the cumulative estimates of the five levels of maturity has reached an index value of 40%.
2. Subprocess A2.2 “Personnel development” according to the aggregate estimates of the five maturity levels reached the index value of 0%.
3. Subprocess A2.3 “Personnel accounting” according to the aggregate estimates of the five levels of maturity has reached the index value of 60%.
4. Sub-process A2.4 “Payroll preparation” based on cumulative estimates of five levels of maturity has reached the index value of 60%.
5. Sub-process A2.5 “Reporting and analysis” on the aggregate assessments of the five maturity levels reached an index value of 60%.

General process index A2 “Human resource management and payroll” based on aggregate estimates of five maturity levels reached an index value of 44% (Fig. 2)

Subprocesses A2.1 “Planning and recruiting”, A2.3 “Personnel accounting”, A2.4 “Payroll preparation”, A2.5 “Reporting and analysis” have reached level 3 (Managed process).

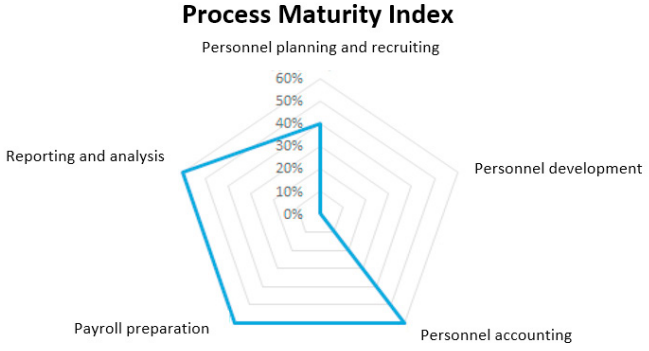

Fig. 2. Process Maturity Index A2 Human Resources and Payroll.

3.2. Assessment of the level of maturity of process automation

To analyze the levels of maturity of process automation, the same approach was used as for assessing the level of maturity and business processes. Maturity levels were marked taking into account the scale, according to the developed methodology (see Table 2).

Based on the ratings of the A2 subprocesses, “Human Resources Management and Payroll”, the following conclusions were drawn: Processes A2.1 “Planning and Recruitment”, A2.5 “Reporting and Analysis” have partially reached maturity level 1 (Initial). Process A2.3 “Human Resources” have reached automation maturity level 2 (Performed). Process A2.4 “Payroll preparation” has reached the 3rd level of automation maturity (Managed).

3.3. Assessment of digital competencies of employees of the enterprise.

To determine the level of maturity of the company's personnel, it was necessary, to assess their digital competencies. To assess the digital competencies of employees of the enterprise's departments, a test questionnaire was compiled with two blocks of questions. The first block assesses the knowledge and skills of the employee, the second block assesses the employee's motivation to acquire new knowledge and skills in the field of infocommunication technologies.

The results of the survey showed that among the respondents there are no employees who do not understand the importance, do not try to apply and develop digital competencies.

A high degree of digital competencies, interest in its development and effective use was demonstrated by 52% of the interviewed employees. In 37% of respondents, digital competencies is constantly manifested, which allows the employee to use it for problems solving. Digital competencies is manifested to a limited extent in the form of individual elements in 11% of the interviewed employees. For 30% of employees (16 people) who use specialized software in their work, competence is constantly manifested. 70% (38 people) have a high degree of competence.

As for motivation, 89% believe that timely introduction of technologies is necessary for successful work, 70% try to use available technologies as much as possible, 78% prefer to use modern information technologies regardless of the employer (Kiykova, 2021).

Table 5 shows the ratings and the maturity index of the personnel of the enterprise.

Table 5. Fragment of the table “Levels and maturity index of personnel of the enterprise.”

Indicator	Level					Maturity index, %
	1	2	3	4	5	
Staff	F	L	N	N	N	40%
Employees don't need additional digital competencies	F					
Employees are trained to work with systems and services in their area of responsibility		L				
Developing a culture of knowledge management			N			

Based on the results of the survey, it can be concluded that employees who use specialized software are trained to work with systems and services that are in their area of responsibility, which corresponds to maturity level 2. At the time of the study, 43% of employees had specialized software used in the analyzed processes.

4. Discussion

The goal of digital transformation ("TO-BE" state) was defined by the Customer as the implementation of a corporate information system for managing administrative processes based on 1C: ERP. In accordance with the developed maturity model, this means that in all studied areas, the enterprise must move to a state not lower than the third level of maturity. For each area of digitalization, a list of activities with an expert assessment of the cost and timing of their implementation is proposed. Activities are grouped into three stages - preparatory, main, and final. The activities at the stages are shown in Table 6.

Table 6. Fragment of the table of the list of activities.

Preparatory		Main		Final	
Event	Result	Event	Result	Event	Result
Personnel					
Development and approval of a list of requirements for digital competencies of employees for each of the positions	Approved list of requirements for digital competencies	Testing personnel for digital competencies assessment	List of employees for training	Implementation of a system of planned training for all tasks based on digitalization	Scheduled personnel learning Personnel with the necessary digital competencies

Based on the analysis, a roadmap for digital transformation was formed, which includes three stages of one year each. The stages have quarterly scheduling and contain a list of activities.

5. Conclusion

The study applied a process-based approach to the formation of a digital transformation plan, which implies a progressive movement from the initial state "as-is" to the state "TO-BE". The initial state, which is the starting point for digital transformation, was determined in the study for two areas through the assessment of private maturity indices: processes (51%) and personnel (40%.)

To determine the readiness of an enterprise for digital transformation, it is proposed to assess the maturity of processes, the level of readiness of processes for automation, an assessment of the personnel maturity index and its readiness to use modern digital technologies. For readiness for digital transformation, it is necessary that all employees involved in the modernized processes are trained to work with specialized software and hardware and have the appropriate motivation.

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