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DEVELOPING E-MATURITY MODEL FOR MUNICIPAL PROJECT AND PROGRAM MANAGEMENT SYSTEM

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The role and importance of information and communication technologies (ICT) in city management are analyzed. It is substantiated that the digital component of municipal management is an important element of a sustainable city and ensures the expansion of citizens' access to basic services. Modeling the assessment of the electronic maturity of the management office of municipal digitalization projects is considered through the prism of the technological maturity model of I. Kendall and K. Rollins. A matrix for assessing the electronic maturity of municipal e-projects, represented by project management knowledge areas and digital ICT characteristics of electronic maturity, has been developed.

The results of digital maturity modeling are discussed on the example of the Municipal e-Project Management Office (PMO_{eM}). Eight levels of PMO_{eM} maturity are proposed: «I – PMO_{eM} is able to effectively implement information service projects»; «II – PMO_{eM} analyzes the organizational aspects of the online services of the municipality»; «III – PMO_{eM} develops ways to effectively implement online services»; «IV – PMO_{eM} requires a high level of e-government maturity, opening «fast access» of citizens to e-services»; «V – municipality staff as members of the project team (PMO_{eM}) ensures the progress of functional efficiency of city smart services»; «VI – PMO_{eM} is able to provide the vast majority of municipal services using ICT tools»; «VII – PMO_{eM} provides an expanded range of smart services»; «VIII – all municipal services are provided under the maximum mainstreaming of ICT». The proposed assessment tool will allow the PMO_{eM} directorate and the top management of IT organizations to conduct a self-assessment of progress in the digital management of municipal e-projects, e-programs and select the actions necessary to move to a higher level of e-maturity

Keywords: e-government, municipal digital office, e-maturity, digitalization, e-project management

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1. Introduction

In general, the trend towards the development of electronic city models in the direction of developing IT technologies (Information Technologies, IT) for human resource management and social capital development («digital city» – «intelligent city» – «smart city») is noted in recent studies. Smart City focuses on whether residents are satisfied with IT capabilities in solving their everyday problems. In particular, the Institute of Management Development (IMD), in collaboration with the Singapore University of Technology and Design (SUTD), has presented the world ranking of smart cities 2020 with a focus on the analysis of the technological support of cities in «COVID-19 times» [1]. The 2020 Smart City Index confirmed the hypothesis that cities with advanced technologies are better able to cope with the challenges of the pandemic. It is important that among the key areas of the index, apart from health and safety, mobility, activities, opportunities, «governance» is also highlighted.

At the same time, the development of urban e-government is not linear, and it often demonstrates unstable functioning. The «intelligence» of cities is measured not only by advances in technology, but also by the specifics of citizens' perception of electronic services. As a result, bridging the gap between the priorities of municipal authorities and members of the local community is becoming an important task in municipal e-government projects. It should be noted that municipalities widely use project management tools, but there is a difference in the quality of their processes and the progress achieved. The reason for such inconsistencies are the differences in the e-maturity of municipalities, as well as their institutional parameters and applied city digital models [2, 3].

In such a situation, attention to the work of project offices in municipalities, as important actors in the implementation of sustainable development strategies, is increasing. Currently, the search for tools for municipalities to develop effective solutions in a complex urban environment is underway. ICTs can improve the level of municipal service delivery, the transparency of local governance and, in general, have a positive impact on the competitiveness and well-being of the urban community. ICT also contribute to improved participatory governance, efficiency and accountability of urban policies, provided that such tools are used properly [4].

The municipalities are making progress in stages, taking into account the complexity of electronic projects. E-government at the local level is developing depending on the nature of the organizational and technical environment. Researchers are attempting to analyze the relevant processes and practitioners are trying to determine at what stage cities are compared with others. Comparing municipal e-government practices can be extremely helpful as it provides benchmarks for measuring progress. The stages of e-government implementation are being gradually standardized. This allows municipalities to adopt strategic plans for deploying e-government projects. At the same time, municipalities are progressing at different rates. Some e-government programs are technologically complex, but they are not well integrated. Other e-government programs are simple to integrate, but they are not technologically integrated enough. Therefore, the question of how to take into account and provide a two-dimensional space for the development of electronic control is being actualized.

Increasingly, municipalities are guided by e-maturity models in the development of e-government projects. The maturity model is a conceptual framework that defines how to implement e-government projects in stages. That is why scientific and practical developments for assessing the maturity of digital municipal governance are becoming extremely valuable. However, municipalities face organizational and technological difficulties in applying maturity models. In such situations, local initiatives require the establishment and functioning of the central digital office. This directs the focus of research attention to assessing the maturity of municipal project management offices. Thus, the development of multilevel models of urban e-government maturity is an urgent epistemological problem that requires integrated solutions.

2. Literature review and problem statement

The paper [5] presents the results of research on the evaluation of e-government projects in developing countries. The «weak points» in the implemented projects are shown in terms of sustainable development strategies, efficient use of resources (economic, technological, human, and time). The result of this study was the integration of parameters of e-government services into the e-maturity model: «economic efficiency», «time saving», «effort spent». At the same time, there is a certain epistemological uncertainty regarding the modeling of electronic maturity on the basis of detailed stages. This, in turn, determines the feasibility of conducting research on the development of alternative e-maturity models.

The parameters of evaluation of e-government projects are analyzed in [6]. The interrelation of different components («ease of use», «usefulness», «user satisfaction», «maturity of websites») is shown. The result of this study was the delineation of the dominant theoretical direction for the improvement of project activities in the field of e-government in the parameters of «operational efficiency» and «quality of services and quality of information». But the issues related to overcoming the one-dimensionality of electronic maturity assessment remained unresolved. This may be due to the objective difficulties associated with the unresolved problem of methodological coordination of e-government projects with e-maturity models. An option to overcome these difficulties can be the development of a two-dimensional model of electronic maturity that combines the features of the project management system with information technology.

It is worth noting that in order for e-government initiatives to have meaningful results, several determinants of success that affect the development of e-government should be considered. That is why the theoretical and methodological basis of this study is the model of assessment of digital municipal government, proposed by the United Nations (UN). It covers five important components (security and privacy, ease of use, content, services and citizen participation) [4]. This study evaluates municipal websites in terms of the level of digitalization of municipal services and digital democracy. The level of implementation of e-government management tools is assessed based on special methods that are used to compile the corresponding city ratings.

The researchers refer to the analysis of different contexts of electronic city management programs, taking into account, on the one hand, the position in the global index, on the other – national characteristics of cities' readiness for electronic management. For example, the stages and determinants of global cities' e-government were studied using two analytical methods in [7]. Cluster analysis is used to build a city typology that reflects the level of «sophistry» of e-government. The time series regression method is used to identify the factors influencing the stages of e-government development in municipalities. As a result of this study, the trajectory for the relevant benchmarking processes is outlined: from e-government to smart management. At the same time, there is a need for further research to identify the specifics of the stages of municipal e-government development.

It is noted that such functional parameters as «dissemination of information», «interactive functions», «e-commerce functions», «e-democracy» are used to assess the e-government of municipalities [8]. In the light of current trends in increasing the flexibility and accessibility of web technologies, the ability of municipalities to integrate data is analyzed. The disadvantages in current approaches to the development of municipal websites are identified (excessive organizational complexity of information retrieval, insufficient interactivity and customer orientation). The use of the latest technology also requires an increase in organizational and management capabilities. Therefore, the need to develop ethodological approaches to the assessment of municipalities from the standpoint of new requirements for «reference» e-government is articulated.

The factors that motivate or prevent IT employees of municipalities to implement technological innovations are studied in [9]. Technological innovations are considered in the context of implementation of municipal projects and programs to improve the efficiency and effectiveness of the service delivery system. The authors propose to use a mixed multivariate analysis of data on e-services of municipalities. The factors that encourage or inhibit innovation are examined using a mixed methodological approach (including interviews with city officials and multivariate analysis of a new data set on municipal e-government services). The problem of electronic maturity of municipal government is analyzed in correlation with modern requirements for local self-government in [10]. It also investigated the factors explaining the significant discrepancy among municipalities in the provision of digital services to citizens. In particular, the demographic characteristics of the city, such as population density, older and younger age groups, had a significant impact on the level of e-government.

The researchers [11] identify key aspects of success that influence e-government development. It is argued that one of the biggest challenges to e-governance is the digital divide between different stakeholder groups, as well as the nature of the use of IT tools. The result of this study allowed classifying municipalities according to their e-government index, as well as establishing a baseline for identifying aspects affecting the development of municipal e-government (funding, geographic location, demographic resources, etc.).

The logical-system analysis was carried out to study different approaches to monitoring the level of electronic municipal services in [12]. Researchers contextualize the multitude of e-government studies in European post-communist countries and highlight the need for greater openness and accountability of e-government. In particular, it is emphasized that tools for measuring the level of citizens' involvement in decision-making are being developed to assess the electronic governance of cities. For example, the results of using geoinformation methods for the management of security parameters of urban areas and infrastructure (on the ArcGISOnline platform) are presented in [13]. By GIS mapping (mapping using geographic information systems) of citizens' needs in a safe space, separate layers of the interactive map of the city were compiled.

Two directions of urban electronic transformations are outlined in [14], namely: the first is the automation of all processes of the city's life, the second is the constant improvement of the citizens' quality of life. At the same time, the risks of using ICT in participatory management (involving citizens in management decision-making processes) are noted. The factors that hinder the development of e-government at the local level are also analyzed, with special attention paid to the risks that accompany the process of introducing e-democracy (for example, online voting). A critical analysis of modern approaches to the development of international indices of electronic maturity of management was carried out in [15], and the system of their criteria was analyzed. It is proposed to use a weighting system instead of the system of average weight measurement of electronic development to measure progress in e-governance.

In general, the authors see the need to improve the assessment of e-government at the local level in the direction of improving the quality of municipal services. The researchers also note that e-government is formed under the influence of structural features of the social, cultural and political environment. In particular, the paper [16] outlines the environment of municipal government as a set of specific external and internal factors that limit or accelerate the development of digital technologies. The matrix of ICT tools for managing urban programs and projects has been developed taking into account the Digital City, Intelligent City and Smart City models. «Critical Success Factors» were analyzed to implement more mature project management in [17]. It is proposed to apply approaches based on SWOT (Strength, Weakness, Opportunity, and Threat) analysis to improve the relevant processes in municipalities. The necessary data obtained by interviewing a group of experts are presented in the form of a block diagram of project design and implementation procedures and are demonstrated taking into account the strategic approach to management.

It is also noted [18] that any model of electronic city management, in terms of project management, provides for the operation of a municipal digital office for the implementation of city programs and projects. The digital segment is considered as a tool for managing sustainable urban development programs to expand citizens' access to relevant municipal services. Project Management Office (PMO) models are developed by integrating many organizational and technical parameters. It is proposed to use a conceptual model to assess the maturity of the municipal digital office [19]. Maturity models of the municipal digital office are considered as part of e-government transformation and represented by a number of discrete stages of maturity in the direction of progress from lower stages to higher ones. The main focus in the assessment of e-municipal government is given to official websites of cities. It was found that municipal administration remains the dominant trend in the development of digital governance in many cities. At the same time, participatory e-government and the involvement of citizens in governance are much less developed.

An analysis of the current level of research on e-government in municipalities suggests the lack of effective tools to assess their maturity. After all, international city indices prove that there is a big difference between municipalities in using electronic services.

3. The aim and objectives of the study

The aim of the study is to develop a comprehensive toolkit for identifying the level of electronic maturity of the municipal government system using a project-oriented approach. This will enable digital municipal offices to build trajectories to improve the quality of the management system.

The objectives to achieve the aim are defined:

– to systematize the integration of the digital component into the contextual parameters of ten project management knowledge areas (integration, scope, time, cost, quality, resource, communications, risk, procurement, stakeholder management);

– to develop a methodology for assessing the e-maturity of the municipal management system based on the results of assessing the quality of the most important strategic e-projects and e-programs for sustainable development of the city.

4. Methodology

The methodological prism of the research is integrative, based on the application of a systematic approach within the framework of modern project management methodologies, namely the model of I. Kendall and K. Rollins [19].

This study is a scientific attempt to test the hypothesis of the existence of a specific correlation between information technology and effectiveness of the urban project and program management system in terms of stakeholder satisfaction. The city's project management system becomes more efficient if the municipality applies a wide range of IT tools.

The tools of mathematical modeling are used to test the hypothesis, as well as methods of multi-criteria evaluation and optimization in conditions of varying degrees of certainty of the source information. The use of digital focus in the context of project management methodology has allowed developing a qualitatively new model for assessing electronic maturity (e-maturity).

5. E-maturity assessment model for the municipal project and program management system

5. 1. Integration of the digital component into the contextual parameters of project management knowledge areas to assess the e-maturity of the municipal project office

The conceptual model of assessing the e-maturity of the municipal digital office is based on a complete table of qualitative content characteristics of different aspects of the relevant management activities. An attempt to extrapolate the digital component to the context parameters of project management knowledge areas was made to assess the electronic maturity of the PMO [15]. The full array of characteristics for assessing the e-maturity of the municipal e-project and e-program management system (Municipal e-Project Management Office, PMO_{eM}) are presented in Table 1. The following approach is proposed to increase the efficiency of this model in terms of time and computing resources.

It is necessary to limit ourselves to a sufficiently short sliding time «window» in the study (including only the last 12 months). In this case, it is possible to take into account rapid permanent changes in actual input data. It is important to rank the selected number k_{max} of the latest strategic e-projects and e-programs in descending order of importance, which is characterized by a positive priority indicator. The level j_{pr} of e-maturity that is expected to achieve should be specified based on actual circumstances. In this case, it is proposed to consider only a given minimum permissible number k_j of the most important e-projects and e-programs for each j-th level.

The following is accepted: $k_1=3$; $k_j=k_{j-1}+1$, $j=\overline{2,n}$, n – the total number of e-maturity levels of the PMO_{eM}. It is proposed to start the calculation precisely by studying the correspondence of a set of expert data to the requirements of the expected j-th level of e-maturity, $j=j_{pr}$. It is obvious that the predicted level j_{pr} of electronic maturity must correspond to the condition $k_{j_{pr}} \le k_{max}$.

Table 1

PMO_{eM} *e*-maturity level evaluation

Project Management Knowledge Areas [20]	ICT characteristics of PMO_{eM} e-maturity
1	2
Level – PMO_{eM} is able to effectively implement information service projects	
Project Integration Management	1. 1. There are no standards and tools to manage the development of online services. The municipality uses GIS tools informally, selectively to perform certain functions
Project Scope Management	1. 2. There is no clear understanding and control of the development of urban online services
Project Schedule Management	1. 3. Teams of executors of city e-projects are isolated from each other. There is no data on the workload of teams and their individual members
Project Cost Management	1. 4. Expenditures on e-projects are not included in city programs and are not financed from the city budget. The mayor (as responsible for all city programs) does not receive relevant reports on the implementation of e-projects and e-programs
Project Quality Management	1. 5. Stakeholder requirements (including beneficiaries) for the city's online service have not been identified
Project Resource Management	1. 6. Executors of city Internet services are subordinated to heads of municipal services, functional divisions. Their level of ICT use is unknown. Executors of city online services start and finish e-projects later than planned, and also constantly «fight» for funding for e-projects
Project Communications Management	1. 7. There are no standard forms of reporting on the level of e-government, as well as the development of online services
Project Risk Management	1. 8. Development risks of online services are not the subject of special attention
Project Procurement Management	1. 9. Providers and contractors of online services, digital technologies are not perceived as mandatory members of the management team of city projects, programs, services
Project Stakeholder Management	1. 10. There are no standard forms of reporting on identifying all electronic/digital government/management stakeholders
Level II – PMO_{eM} analyzes the organizational aspects of the online services of the municipality	
Project Integration Management	2. 1. «Cost» and «time» criteria are used to monitor/manage e-projects of municipal online services
Project Scope Management	2. 2. Technical specifications for Internet services are developed by a separate department (PMO_{eM}). Functional requirements of e-projects are outlined, there is no detail, exact data/parameters
Project Schedule Management	2. 3. E-projects are integrated into the architecture of sustainable development programs of the city
Project Cost Management	2. 4. Funding for e-projects to create online services is included in the city's budget program for the current year
Project Quality Management	2. 5. PMO_{eM} mentors demonstrate a willingness to identify stakeholder needs for municipal online services

Continuation of Table 1

1	2
Project Resource Management	2. 6. The role of municipal functional staff in providing specific online services is not clearly defined. The PMO_{eM} is empowered to assist municipal functional units to identify customer needs. The PMO_{eM} has been appointed an ICT and GIS expert to develop and support the city's strategically important online services
Project Communications Management	2. 7. The municipality monitors the level of e-government as well as develops online services
Project Risk Management	2. 8. The main risks of managing the development of online services have been identified
Project Procurement Management	2. 9. «Deadlines» are used for suppliers and contractors of ICT, GIS, online services, digital technologies
Project Stakeholder Management	2. 10. A register of beneficiaries of online services and digital technologies is developed. Special attention is paid to the needs of people in vulnerable situations (women, children, people with disabilities and the elderly)
Level III – PMO_{eM} develops ways to effectively implement online services	
Project Integration Management	3. 1. The e-development management team (PMO_{eM} mentors and functional managers of the municipality) uses standard procedures at meetings to identify opportunities and threats to online services
Project Scope Management	3. 2. Functional requirements for smart services are reflected in the components of electronic services. The processes of documenting a smart service are partially accompanied by the use of GIS tools
Project Schedule Management	3. 3. Managers and functional managers of the municipality use the PMO_{eM} as a source of information to accelerate work on e-service projects. There are known opportunities to reduce the duration and minimize threats to complete strategically important e-projects
Project Cost Management	3. 4. Financial indicators of e-projects are monitored monthly. It is also possible to determine the cost of e-portfolio
Project Quality Management	3. 5. The e-development management team ($PMO_{e\text{-}M}$ and functional managers of the municipality) is aimed at meeting the needs of beneficiaries in smart services
Project Resource Management	3. 6. The e-development management team (development director and functional managers of the municipality) is focused on meeting customers' needs that affect the achievement of the Sustainable Urban Development Goals. Team members learn and develop their new vision/attitude, take into account the speed of personal work and try to stay on the «critical path» of the e-project on which they work
Project Communications Management	3. 7. The municipality holds regular meetings to monitor the level of development of online services. Ways to improve the management of urban online services on the GIS platform have been developed
Project Risk Management	3. 8. There are opportunities to strengthen the response to risk management of urban online services on the GIS platform
Project Procurement Management	3. 9. ICT/GIS contractors report on the progress of orders on a monthly basis. There are requirements for long-term supply/support/maintenance and other work that is on the «critical path» of the e-project
Project Stakeholder Management	3. 10. The e-development management team (development director and functional managers of the municipality) determines the main requirements and expectations, the degree of influence of each group of stakeholders
Level IV – PMO_{eM} requires a high level of e-government maturity, opening «fast access» of citizens to e-services	
Project Integration Management	4. 1. Standard change management procedures have been developed and e-government indicators are monitored. E-government indicators meet the City's Sustainable Development Goals and are displayed in relevant databases. Various GIS content layers have been developed and are available on the Internet
Project Scope Management	4. 2. The relationship between the content of different types of smart services has been determined. GIS-layers are the basis for creating various online services
Project Schedule Management	4. 3. Implementation of all important e-projects is monitored. Delays in the schedule of e-projects are revealed
Project Cost Management	4. 4. E-project and e-program managers (PMO_{eM} director) understand how the reduction (or increase) in the duration of projects affects the overall financial performance of the city budget
Project Quality Management	4. 5. The e-development management team (director of development and functionality management of the municipality) is aware of the specific needs of beneficiaries in smart services
Project Resource Management	4. 6. The e-development management team (development director and municipal managers) demonstrates the ability to adjust the completion dates of both individual e-projects and e-programs, and e-portfolios. Control over all types of resources (human, financial, etc.) is carried out using on-line services and automated systems
Project Communications Management	4. 7. E-project and e-program managers are aware of the status of all municipal e-projects and e-programs in the e-portfolio and the relationships between them. Necessary information is available on-line
Project Risk Management	4. 8. Response plans for technical circumstances (server congestion, Internet coverage, etc.) have been developed. Evaluation of the effectiveness of digitalization recommendations of «corrective action» and «preventive action» is carried out
Project Procurement Management	4. 9. Problems with Internet providers and electronic service contractors have been identified. There is a register/database of responsible and reliable suppliers and contractors
Project Stakeholder Management	4. 10. Standard processes of client-oriented stakeholder management have been developed: «Identification of social groups of stakeholders», «Identification of stakeholder needs», «Mediation/conflict of interests management of different social groups», «Developing client-oriented solutions», etc.

Continuation of Table 1

1	2
Level V – municipality staff as members of the project team (PMO_{eM}) ensure the progress of functional efficiency of city smart services	
Project Integration Management	5. 1. The number of IT specialists in e-project management has increased. Digital tools are used at all stages of e-government of municipal projects and programs. Improving the efficiency of e-government indicators is in line with the sustainable urban development goals, as well as up-to-date databases. New GIS multi-content layers are being developed and updated and available on the Internet
Project Scope Management	5. 2. The e-development management team (development director and functional managers of the municipality) works and is responsible for e-project portfolios
Project Schedule Management	5. 3. The e-development management team (development director and functional managers of the municipality) works and is responsible for the results of the e-project portfolio. Some started e-projects have been suspended
Project Cost Management	5. 4. Suppliers and e-development management team (development director and functional managers of the municipality) are aware of the impact of the city budget on financial performance
Project Quality Management	5. 5. The e-development management team (director of development and functionality management of the municipality) has determined the criteria (visions) that contribute to achieving the expected results. The interaction of the PMO_{eM} with municipality departments is well established
Project Resource Management	5. 6. The PMO_{eM} ensures differentiation of all municipal e-projects and e-programs according to strategic objectives (sustainable urban development). The e-development management team has information on available strategic resources of the municipality and clearly adheres to the requirement to effectively use resources for e-projects and e-programs (with added value, achieving a positive synergy effect)
Project Communications Management	5. 7. The PMO_{eM} reports to the mayor, the city council on operational plans for the development of online services, smart services, e-projects, e-programs. Information about online services, smart services, e-projects/programs is available to all stakeholders (including resident users)
Project Risk Management	5. 8. Digital risk management is a mandatory component of reporting on the status of e-projects and e-programs. The PMO_{eM}, sponsors, functional managers of the municipality support the reduction of risks due to the use of digital technologies
Project Procurement Management	5. 9. ISPs and e-service contractors on their own initiative make efforts for early delivery of critical online services, smart services, e-projects, e-programs
Project Stakeholder Management	5. 10. Customer-oriented participation of the PMO_{eM} with all project stakeholders throughout the e-project life cycle is developed. Increased support and minimized resistance of all social stakeholder groups
Level VI – PMO_{eM} is able to provide the vast majority of municipal services using ICT tools	
Project Integration Management	6. 1. E-planning processes ensure a balance of content, implementation schedules and resource provision of municipal projects (without reloading the PMO_{eM}). Improving the efficiency of e-government meets the goals of sustainable urban development, relevant databases. New GIS multi-content layers are being developed and updated and available on the Internet
Project Scope Management	6. 2. Some e-projects are implemented faster than planned (with better content)
Project Schedule Management	6. 3. Some e-projects are completed ahead of schedule (earlier than planned)
Project Cost Management	6. 4. The e-development management team (development director and functional managers of the municipality) has the right to dispose of at least 10 % of the city budget for the implementation of smart services
Project Quality Management	6. 5. Quality problems of municipal smart services are identified, resolved and documented in a timely manner. The PMO_{eM} forms an archive of quality management practices of municipal smart services
Project Resource Management	6. 6. A clear allocation of resources by e-project and e-program portfolios has been made and resource portfolios have been formed. The PMO_{eM} manages resources without overload and downtime
Project Communications Management	6. 7. E-project and e-program managers receive the information necessary to identify opportunities that will accelerate the completion of projects/programs in a timely manner
Project Risk Management	6. 8. Performer teams of e-projects and e-programs have competencies for the prevention of risks related to the use of digital technologies for municipal services
Project Procurement Management	6. 9. Internet service providers (ISPs) and electronic service contractors use the PMO_{eM} techniques and tools that are consistent with the strategy of sustainable urban development
Project Stakeholder Management	6. 10. Predicting customer-oriented stakeholder behavior allows the PMO_{eM} to act proactively. Most social groups of beneficiaries are supporters of online services, smart services, e-projects, e-programs
Level VII – PMO_{eM} provides an expanded range of smart services	
Project Integration Management	7. 1. The process of choosing the composition of e-projects is formalized, and it is followed by the entire e-development management team (PMO_{eM} and functional managers of the municipality). The e-development management team uses a unified methodology. Indicators of e-government, sustainable urban development, updating of databases are high. New GIS layers are being developed, and existing multi-content GIS layers, which are already available on the Internet, are being updated
Project Scope Management	7. 2. The e-development management team (PMO_{eM} and functional managers of the municipality) apply their knowledge of the interdependence between e-projects to fully provide the content of online services

Continuation of Table 1

1	2
Project Schedule Management	7. 3. Each of the e-project managers and functional managers of the municipality knows its workload taking into account the priority of e-projects. Strategic e-projects are not a reason to delay other e-projects
Project Cost Management	7. 4. The e-development management team (PMO_{eM} and functional managers of the municipality) considers the costs of all e-projects included in the e-portfolio of the municipality. The e-development management team solves the issue of balancing the costs of ICT, GIS, smart technologies and the quality of online services (whether the needs of different socio-economic categories of the city's residents are taken into account)
Project Quality Management	7. 5. Quality criteria and quality management tools developed by the PMO_{eM} are used by municipality departments that support online services, smart services, and e-projects
Project Resource Management	7. 6. A multi-vector approach to assessing the PMO_{eM} performance has been introduced. Both internal (municipality staff) and external clients of online services and smart services are involved in developing solutions to reduce the time of e-projects
Project Communications Management	7. 7. Human resource intensity, as well as consistency with the e-project and e-program portfolios, is increasing. The number of inconsistencies of tasks related to the resource use and automation of inefficient processes has significantly decreased
Project Risk Management	7. 8. Digital technologies are integrated into all city projects and programs of the municipality, which allows to quickly include online services, smart services in all interconnected e-projects and resource provision
Project Procurement Management	7. 9. ISPs and e-service contractors support planning processes for online services, smart services, e-projects, and also apply PMO_{eM} techniques and tools
Project Stakeholder Management	7. 10. Customer-centric stakeholder management is supported primarily through online services. Socially-sensitive expectations of stakeholders are implemented in the results and products of e-projects and e-programs – smart services
Level VIII – all municipal services are provided under the maximum mainstreaming of ICT	
Project Integration Management	8. 1. The «mature» process of e-project management is integrated into the architecture of all municipal programs, as well as continuous benchmarking is carried out
Project Scope Management	8. 2. All strategic goals of electronic development of the municipality have been achieved. Progress in achieving the City's Sustainable Development Goals is defined
Project Schedule Management	8. 3. More than 95 % of e-projects are completed on time. 10 % of e-projects are completed ahead of schedule (earlier than planned)
Project Cost Management	8. 4. The e-development management team (PMO_{eM} and functional managers of the municipality) is actively involved in the redistribution of released («extra») budget funds of some e-projects among other e-projects (which have a deficit in financing)
Project Quality Management	8. 5. The municipality has implemented a process of continuous improvement of the quality of online services, smart services, e-projects using statistical control methods (online feedback) to identify more effective ways to improve quality
Project Resource Management	8. 6. The intensity of use of all resources is consistently high. The $PMO_{e\text{-}M}$ implements a large number of e-projects/e-programs/e-portfolios without attracting additional resources
Project Communications Management	8. 7. All stakeholders understand and approve the correlation between the e-project portfolios, goals, resources and assets of the municipality. Employees are actively initiating proposals to expand and improve online services, smart services, as well as clarify the content of the e-project/e-program portfolio
Project Risk Management	8. 8. The e-project portfolio of the municipality is balanced. The problems of one e-project do not significantly affect the digital performance/value of other e-projects and e-programs
Project Procurement Management	8. 9. ISPs, electronic service contractors, PMO_{eM} use unified ICT, procurement approaches/procedures in e-projects and e-portfolios
Project Stakeholder Management	8. 10. The process of customer-oriented management of all stakeholders is mature. Processes of continuous improvement of customer-oriented stakeholder involvement strategies have been implemented throughout the life cycle of the e-project and e-program. The results of more than 95 % of e-projects and e-programs satisfy social needs, requirements, expectations of stakeholders, and 10 % – exceed

The PMO_{eM}, in order to apply this model, should select the most important strategic e-projects and e-programs that have been implemented recently (within the last 12 months). In this case, all k_{max} selected e-projects and e-programs of the municipal management system are ranked in descending order of importance, which is characterized by a positive priority. It is assumed that a high level of e-maturity of the system as a whole should be based on a larger volume of priority inputs while rejecting less important ones.

As the maturity level of projects and programs increases, it is proposed to increase the number k_j of projects for sampling. The sampling procedure is carried out by averaging the input estimates of the possible j-th level of e-maturity of the municipal management system. It is assumed that the higher the maturity level of projects, the more projects should be included in the assessment (Table 2).

The implementation of the model (Table 1) in specific municipal practices requires clear mathematical formalization and development of a detailed application methodology. The complex structural-logical hierarchy of the objects of the input concept and ways of their transformation can be adequately reflected by the conceptual apparatus of matrix algebra.

Table 2

Minimum number of e-projects/e-programs in the sample to assess the $PMO_{e\text{-}M}$ e-maturity

Level of e-maturity	I	II	III	IV	V	VI	VII	VIII
Minimum number k_j of e-projects, e-programs in the sample	3	4	5	6	7	8	9	10

The obtained mathematical representations include both rank variables describing the distinguished characteristics of achieving e-maturity in quantitative form, and constant coefficients. The coefficients serve as a means of accounting for the mutual influence of various indicators and importance of their contribution to the final result of monitoring the e-maturity of the municipal digital office.

5. 2. Development of a methodology for assessing the e-maturity of the municipal management system

The lack of clear guidelines, the variety of possible ways to computerize management and the significant uncertainty of specific situations limit the use of formal numerical-analytical methods of applied statistical analysis and classification, as well as determine the priority involvement of the expert community. The need to increase the objectivity of expert evaluation, reproducibility of its results, simplification of relevant procedures determines the basis for applying modern methods of computer modeling and optimization. There is a need for a detailed schematization of input data processing and formation of generalized e-maturity criteria, convincing and understandable to specialists in municipal government.

A multilayer technique for the synthesis of a mathematical model for the integrated assessment of the electronic maturity of the PMO_{eM} digital office, which includes five layers, as well as its operation, is proposed.

The first layer involves the implementation of the initial survey of the organization under study, collection and display of selected input information and recording the predicted j_{pr}-th level of e-maturity. First, the scale of measurements is agreed; the whole set of e-projects and e-programs is detected and those to be studied are selected. The last step is a direct determination of the matrix of input expert values of digital maturity indicators (indices) in terms of project management knowledge areas and setting the expertly expected level of e-maturity.

The second layer provides for the initial expert formation of classification matrix tools for processing input data. First, target matrices of the limit values of the classification ranges of the share of values of each input indicator of digital maturity in the total volume of the corresponding activity are agreed. They collectively represent PMO_{eM} maturity in terms of various levels and areas of project management knowledge. Next, the matrix of weights of importance of these e-maturity indicators and the matrix of priority indicators of selected strategic e-projects and e-programs are formed.

The third layer provides for intermediate processing of input data and classification tools. Initially, the scaling of weights and the formation of a matrix of normalized weights of e-maturity indicators are carried out. Next, an ordered matrix of priority indicators is obtained by introducing a descending order. In the last step, matrices of weighted values of the output indicators of digital maturity are formed for each area of project management knowledge in terms of e-maturity levels of the PMO_{eM}.

The fourth layer involves the calculation of a generalized (integrated – in the terminology adopted in this area [21]) estimate, weighted according to the relevant requirements and priorities of e-projects, as well as the corresponding specific value of e-maturity, for each level of PMO_{eM} e-maturity. The corresponding integrated estimate of e-maturity and its specific value are found in the cycle of calculations $j=\overline{1,n}$, where n – the total number of e-maturity levels, for each j-th level of PMO_{eM} e-maturity using weighted outputs for k_j most important e-projects and e-programs.

The fifth layer involves finding the optimal estimate j_r of the achieved level of e-maturity with mandatory compliance with the lower limits of the relevant classification ranges and graphical display of research results. A consistent search for the optimal estimate j_r of the achieved e-maturity level as the highest is carried out starting from the expected j_{pr}-th level. To do this, the minimum value $\Delta_{\min}^{(s)}$ of standard deviation of the initial values from the midpoints $\Delta_j^{(s)}$ of the respective classification ranges is achieved provided that the lower limits are met. Computer visualization in the form of a profilogram of the general position of the set of optimal values of the initial electronic maturity indicators within the classification ranges is used to display the structure of the results obtained.

The context of this layer provides for a detailed subject analysis of input data, target values and resulting values in terms of prospects for choosing ways to increase the level of PMO_{eM} e-maturity and improve expert procedures.

The following designations were introduced:

– D – weighted integrated estimate (integrated index) of the electronic maturity of the digital office;

– d – specific value of the weighted integrated estimate (specific integrated index) of the electronic maturity of the digital office;

– m – total number of project management knowledge areas (selected clusters of elements of content characteristics of digital management), $m=10$;

– n – total number of PMO_{eM} e-maturity levels, $n=8$;

– $k_{\max}$ – total number of e-projects and e-programs selected for consideration, $k_{\max}=10$;

– $A=(a_k)$ – matrix of priority indicators of the selected strategic e-projects and e-programs, sorted in descending order of values;

– a_k – additional priority indicator of the k-th e-project (e-program) $\left(k=\overline{1,k_{\max}}\right)$;

– $X=(x_{ik})$ – matrix of input indicators of e-maturity of the digital office in the context of all selected e-projects (e-programs) and project management knowledge areas;

– x_{ik} – input indicator (index) of the electronic maturity of the digital office in the context of the k-th project $\left(k=\overline{1,k_{\max}}\right)$, which corresponds to the i-th project management knowledge area $\left(i=\overline{1,m}\right)$ and reflects its characteristics;

– $W=(w_{ij})$ – matrix of normalized weights of PMO_{eM} e-maturity;

– w_{ij} – normalized non-negative weight of the indicator x_i of e-maturity of the digital office, which corresponds to the i-th project management knowledge area according to the requirements of the j-th level of PMO_{eM} e-maturity ($i=\overline{1,m}$; $j=\overline{1,n}$), which satisfies the rationing:

$$\sum_{i=1}^{m} w_{ij}=1, \quad j=\overline{1,n}, \tag{1}$$

$Y=(y_{ij})$ – matrix of weighted output indicators of the electronic maturity of the digital office in terms of both project management knowledge areas and PMO_{eM} e-maturity levels; y_{ij} – initial indicator of the electronic maturity of the digital office, weighted both by priority indicators of the respective k_j projects and by the requirements of the i-th level of PMO_{eM} e-maturity, which corresponds to the i-th project management knowledge area ($i=\overline{1,m}$; $j=\overline{1,n}$), which is calculated by the formula:

$$y_{ij} = mw_{ij}\frac{\sum_{k=1}^{k_j} a_k x_{ik}}{\sum_{k=1}^{k_j} a_k}, \quad i=\overline{1,m}, \quad j=\overline{1,n}, \tag{2}$$

$Z^{(\min)} = \left(Z_{ij}^{(\min)}\right)$ and $Z^{(\max)} = \left(Z_{ij}^{(\max)}\right)$ – target matrices of the lower $Z_{ij}^{\min}$ and upper $Z_{ij}^{\max}$ limits of the classification ranges $\left[Z_{i1}^{(\min)};Z_{i1}^{(\max)}\right]$, $\left[Z_{i2}^{(\min)};Z_{i2}^{(\max)}\right]$, ..., $\left[Z_{in}^{(\min)};Z_{in}^{(\max)}\right]$ $\left(i=\overline{1,m}\right)$ of the share of the maximum possible input value $s_{\max}$ of each e-maturity indicator in the total activity, which corresponds to the i-th project management knowledge area in terms of the j-th level of PMO_{eM} e-maturity ($i=\overline{1,m}$; $j=\overline{1,n}$), and the values of $Z_{ij}^{\min}$ and $Z_{ij}^{\max}$ are related by the condition of completeness and continuity:

$$0 = Z_{i1}^{(\min)} \le Z_{i1}^{(\max)} = Z_{i2}^{(\min)} \le Z_{i2}^{(\max)} =$$
$$= Z_{i3}^{(\min)} \le \ldots \le Z_{in}^{(\max)} = 1,\ i=\overline{1,m}. \tag{3}$$

The target value of the weighted integrated estimate $D_j^{(c)}$ of e-maturity for the j-th level of PMO_{eM} e-maturity and its corresponding specific value $d_j^{(c)}$ are determined by the formulas:

$$D_j^{(c)} = md_j^{(c)},$$
$$d_j^{(c)} = (1/2)s_{\max}\sum_{i=1}^{m} w_{ij}\left(z_{ij}^{(\min)} + z_{ij}^{(\max)}\right),\quad j=\overline{1,n}. \tag{4}$$

An obvious characteristic of both the sequence of target values of the weighted integrated e-maturity estimate and the sequence of its specific values is the monotony of growth. The life cycle (trajectory) of the development of PMO_{eM} e-maturity, starting from the input «zero» level, has the following form:

0→I→II→III→...→VIII,

where «revolutionary» jumps of separate intermediate levels are allowed.

There is a positive synergy of successive transitions from a lower level to a higher one, which is characterized by parameters s_j defined as:

$$s_j = \frac{\left|d_j^{(c)} - d_{j-1}^{(c)}\right|}{\left(d_{j-1}^{(c)} + d_j^{(c)}\right)},\quad j=\overline{1,n}, \tag{5}$$

where $d_0^{(c)} = 0$.

The initial value of the integrated estimate D_j, weighted according to the requirements of the j-th level of PMO_{eM} e-maturity and its corresponding specific value d_j are calculated by the formulas:

$$D_j = md_j,\ d_j = (1/m)\sum_{i=1}^{m} y_{ij},\quad j=\overline{1,n}. \tag{6}$$

Calculation of the absolute deviations $\Delta_{ij}^{(y)}$ of the initial indicators y_{ij} of electronic maturity from the means of the corresponding classification ranges, weighted according to the requirements of the j-th level of PMO_{eM} e-maturity, for each project management knowledge area in terms of digital maturity levels is carried out by the formula:

$$\Delta_{ij}^{(y)} = \left|y_{ij} - \left(\frac{1}{2}\right)ms_{\max}w_{ij}\left(z_{ij}^{(\min)} + z_{ij}^{(\max)}\right)\right|,$$
$$i=\overline{1,m},\quad j=\overline{1,n}. \tag{7}$$

Calculation of the average quadratic deviations $\Delta_j^{(s)}$ of e-maturity indicators y_{ij} for each j-th level of PMO_{eM} e-maturity $\left(j=\overline{1,n}\right)$, weighted according to the requirements of the j-th level of PMO_{eM} e-maturity, for all project management knowledge areas is performed by the formula:

$$\Delta_j^{(s)} = \sqrt{\frac{1}{m}\sum_{i=1}^{m}\Delta_{ij}^{(y)2}},\quad j=\overline{1,n}. \tag{8}$$

It is proposed to evaluate each input indicator x_{ik} ($i=\overline{1,m}$; $k=\overline{1,k_{\max}}$) of e-maturity of the digital office as a characteristic of the inclusion of the digital component in the relevant management segment of implementation of the respective e-project (e-program) on a continuous scale in the range [0; 3] with four reference markers. Marker «0» – complete noncompliance of the inclusion characteristics (in the absolute absence of digital elements or no need at all, when the corresponding indicator x_i=0 can be considered as a fictitious value). Marker «1» – low compliance (introduction of individual digital elements). Marker «2» – average compliance (moderate systemic implementation of ICT). Marker «3» – high compliance (full digitalization). Thus, the maximum possible input value $s_{\max}$ of each e-maturity indicator in terms of maturity levels and knowledge areas is defined as the upper range of the scale: $s_{\max}$=3.

It is proposed to evaluate the input priority indicators a_k $\left(k=\overline{1,k_{\max}}\right)$ of e-projects (e-programs) on a discrete scale in the range [1; 10] with a unit sampling step.

For experimental research, m=10 and n=8, $k_{\max}$=10.

It should be noted that, according to the currently accepted structure of the matrix of initial indicators $Y=(y_{ij})$, the lowest first level of PMO_{eM} e-maturity corresponds to the presence of only the following three non-zero values of initial e-maturity indicators – y_{61}, y_{71} and $y_{10\,1}$.

Table 3 reflects the currently accepted generalized structure of the matrix $W=(w_{ij})$ of normalized weights of PMO_{eM} e-maturity indicators and shows their values found according to expert evaluation.

The currently accepted generalized structure of the matrices $Z^{(\min)}$ and $Z^{(\max)}$ of the lower and upper limits of the classification ranges of the share of the values of each e-maturity indicator in the total activity is shown in Tables 4, 5. Each of these indicators reflects the degree of application of digital technologies in the project management knowledge areas according to the e-maturity level, and their values are determined by expert evaluation.

Table 6 reflects the target values of the weighted integrated estimate $D_j^{(c)}$ and its corresponding specific value $d_j^{(c)}$ for the j-th level of PMO_{eM} e-maturity, which are calculated based on the data obtained (Tables 4, 5).

Table 3

Matrix $W=(w_{ij})$ of normalized weights of PMO_{eM} e-maturity indicators

Project Management Knowledge Areas	PMO_{eM} e-maturity level							
	I	II	III	IV	V	VI	VII	VIII
1. Project Integration Management	0	0.15	0.12	0.12	0.12	0.12	0.12	0.12
2. Project Scope Management	0	0.05	0.09	0.09	0.1	0.1	0.1	0.1
3. Project Schedule Management	0	0.1	0.1	0.1	0.09	0.09	0.09	0.09
4. Project Cost Management	0	0.1	0.1	0.1	0.09	0.09	0.09	0.09
5. Project Quality Management	0	0.05	0.09	0.1	0.11	0.11	0.11	0.12
6. Project Resource Management	0.4	0.13	0.1	0.09	0.09	0.09	0.09	0.09
7. Project Communications Management	0.35	0.1	0.09	0.1	0.1	0.1	0.1	0.09
8. Project Risk Management	0	0.1	0.1	0.09	0.09	0.09	0.09	0.09
9. Project Procurement Management	0	0.1	0.11	0.1	0.1	0.1	0.09	0.09
10. Project Stakeholder Management	0.25	0.12	0.1	0.11	0.11	0.11	0.12	0.12
Σ	1	1	1	1	1	1	1	1

Table 4

Matrix $Z^{(min)}$ of the lower limits of the classification ranges of the share of PMO_{eM} values of each indicator of application of digital technologies in the project management knowledge areas in the total activity according to e-maturity levels

Project Management Knowledge Areas	PMO_{eM} e-maturity level							
	I	II	III	IV	V	VI	VII	VIII
1. Project Integration Management	0	0	0.25	0.5	0.7	0.9	1	1
2 Project Scope Management	0	0	0.3	0.45	0.6	0.8	1	1
3. Project Schedule Management	0	0	0.25	0.5	0.8	1	1	1
4. Project Cost Management	0	0	0.25	0.4	0.6	0.8	0.9	1
5. Project Quality Management	0	0	0.25	0.5	0.75	1	1	1
6. Project Resource Management	0	0.15	0.3	0.45	0.6	0.7	0.8	0.9
7. Project Communications Management	0	0.15	0.3	0.45	0.6	0.7	0.8	0.9
8. Project Risk Management	0	0	0.15	0.25	0.5	0.7	0.9	1
9. Project Procurement Management	0	0	0.15	0.4	0.6	0.8	1	1
10. Project Stakeholder Management	0	0.15	0.3	0.5	0.7	0.8	0.9	1

Table 5

Matrix $Z^{(max)}$ of the upper limits of the classification ranges of the share of PMO_{eM} values of each indicator of application of digital technologies in project management processes (knowledge areas) in the total activity according to e-maturity levels

Project Management Knowledge Areas	PMO_{eM} e-maturity level							
	I	II	III	IV	V	VI	VII	VIII
1. Project Integration Management	0	0.25	0.5	0.7	0.9	1	1	1
2. Project Scope Management	0	0.3	0.45	0.6	0.8	1	1	1
3. Project Schedule Management	0	0.25	0.5	0.8	1	1	1	1
4. Project Cost Management	0	0.25	0.4	0.6	0.8	0.9	1	1
5. Project Quality Management	0	0.25	0.5	0.75	1	1	1	1
6. Project Resource Management	0.15	0.3	0.45	0.6	0.7	0.8	0.9	1
7. Project Communications Management	0.15	0.3	0.45	0.6	0.7	0.8	0.9	1
8. Project Risk Management	0	0.15	0.25	0.5	0.7	0.9	1	1
9. Project Procurement Management	0	0.15	0.4	0.6	0.8	1	1	1
10. Project Stakeholder Management	0.15	0.3	0.5	0.7	0.8	0.9	1	1

Table 6

Target value of the weighted integrated estimate $D_j^{(c)}$ of e-maturity for the j-th level of PMO_{eM} e-maturity and its corresponding specific value $d_j^{(c)}$

Levels of e-maturity, j	I	II	III	IV	V	VI	VII	VIII
Target specific value of weighted integrated maturity estimate, $d_j^{(c)}$	0.225	0.453	1.032	1.698	2.208	2.637	2.871	2.973
Target value of weighted integrated estimate, $D_j^{(c)}$	2.25	4.53	10.32	16.98	22.08	26.37	28.71	29.73

The data in Tables 3–5 allow finding the minimum $y_{ij}^{(\inf)}$ and maximum $y_{ij}^{(\sup)}$ possible values of each output indicator y_{ij} of the electronic maturity of the digital office, based on the accepted rating scale. The indicator y_{ij} corresponds to the i-th project management knowledge area according to the requirements of the j-th level of PMO_{eM} e-maturity ($i=\overline{1,m}$; $j=\overline{1,n}$). It is proposed to accept restrictions by the cases of the presence of at least a minimum nonzero value $s_{\min}=1$ of each input indicator x_{ik}, except for fictitious ones, and take the upper range of the scale $s_{\max}=3$ as the maximum value of each input indicator x_{ik}:

$$y_{ij}^{(\inf)} = mw_{ij}z_{ij}^{(\min)}s_{\min},$$
$$y_{ij}^{(\sup)} = mw_{ij}z_{ij}^{(\max)}s_{\max}, \quad i=\overline{1,m}, \quad j=\overline{1,n}. \quad (9)$$

The results of the calculations are shown in Tables 7, 8, where the minimum values are rounded «with a shortage», and the maximum values – «with an excess» of up to three significant decimal places.

The optimal estimate j_r of the achieved level of e-maturity of the digital office under study is defined as the highest step j provided that the restrictions are unconditionally met:

$$k_j \le k_{\max};\ d_j \ge d_j^{(c)};\ y_{ij} \ge w_{ij}z_{ij}^{\min},\ i=\overline{1,m}. \quad (10)$$

The minimum value $\Delta_{\min}^{(s)}$ of the standard deviation $\Delta_j^{(s)}$ of the initial values y_{ij} is reached:

$$\Delta_{\min}^{(s)} = \min_j \Delta_j^{(s)}. \quad (11)$$

It is important to rely on the ranking of the selected number of $k_{\max}$ e-projects (e-programs) in descending order of priority indicators and the monotonically increasing nature of the sequence $d_j^{(c)}$, $j=\overline{1,n}$ of the target specific values of the weighted integrated estimate of e-maturity. An iterative procedure for assessing the digital maturity of the office begins with a study of the correspondence of a set of expert data to the requirements of the expected j-th e-maturity level $j=j_{pr}$, provided that the constraints are strictly met (10).

Table 7

Matrix of the minimum possible values $y_{ij}^{(\inf)}$ of the initial indicators of e-maturity of the digital office in terms of both project management knowledge areas and PMO_{eM} e-maturity levels

Project Management Knowledge Areas	PMO_{eM} e-maturity level							
	I	II	III	IV	V	VI	VII	VIII
1. Project Integration Management	0	0	0.30	0.60	0.84	1.08	1.20	1.20
2. Project Scope Management	0	0	0.27	0.41	0.60	0.80	1.00	1.00
3. Project Schedule Management	0	0	0.25	0.50	0.72	0.90	0.90	0.90
4. Project Cost Management	0	0	0.25	0.40	0.54	0.72	0.81	0.90
5. Project Quality Management	0	0	0.23	0.50	0.83	1.10	1.10	1.20
6. Project Resource Management	0	0.20	0.30	0.41	0.54	0.63	0.72	0.81
7. Project Communications Management	0	0.15	0.27	0.45	0.06	0.70	0.80	0.81
8. Project Risk Management	0	0	0.15	0.23	0.45	0.63	0.81	0.90
9. Project Procurement Management	0	0	1.17	0.40	0.60	0.80	0.90	0.90
10. Project Stakeholder Management	0	0.18	0.30	0.55	0.77	0.88	1.08	1.20

Table 8

Matrix of the maximum possible values $y_{ij}^{(\sup)}$ of the initial indicators of e-maturity of the digital office in terms of both project management knowledge areas and PMO_{eM} e-maturity levels

Project Management Knowledge Areas	PMO_{eM} e-maturity level							
	I	II	III	IV	V	VI	VII	VIII
1. Project Integration Management	0	1.13	1.80	2.52	3.24	3.60	3.60	3.60
2 Project Scope Management	0	0.45	1.22	1.62	2.40	3.00	3.00	3.00
3. Project Schedule Management	0	0.75	1.50	2.40	2.70	2.70	2.70	2.70
4. Project Cost Management	0	0.75	1.20	1.80	2.16	2.43	2.70	2.70
5. Project Quality Management	0	0.38	1.35	2.25	3.30	3.30	3.30	3.60
6. Project Resource Management	1.80	1.17	1.35	1.62	1.89	2.16	2.43	2.70
7. Project Communications Management	1.58	0.90	1.22	1.80	2.10	2.40	2.70	2.70
8. Project Risk Management	0	0.45	0.75	1.35	1.89	2.43	2.70	2.70
9. Project Procurement Management	0	0.45	1.32	1.80	2.40	3.00	2.70	2.70
10. Project Stakeholder Management	1.13	1.08	1.50	2.31	2.64	2.97	3.60	3.60

There are two possible cases:

1) if for the current j-th level of e-maturity, the correspondence to which is investigated, at least one of inequalities (10) is violated, then it is necessary to consistently descend one step below $j:=j-1$ until conditions (10) are met, with the obvious restriction $j\geq 0$;

2) if for the current level of e-maturity, all conditions (10) are satisfied, then it is necessary to consistently rise one step above $j:=j+1$ until inequalities (10) are fulfilled, with the obvious restriction $j\leq n$.

Next, the values of the criterion (11) for the found j-th and previous $j-1$-st level of e-maturity are compared. As the optimal estimate j_r of the achieved e-maturity level, the value j or $j-1$ is taken, which corresponds to the lower value of the criterion (11). Then d_{j_r} is taken as the achieved specific value of the integrated estimate of e-maturity. Accordingly, the achieved value D_{j_r} of the integrated estimate (index) of electronic maturity, which is considered as a global criterion for measuring the PMO_{eM} e-maturity, is determined by the equality $D_{j_r}=md_{j_r}$.

The dynamics of the progress of the digital office in electronic maturity is characterized by the following pair of indicators:

$$\alpha_1=\frac{\left|d_{j_r}-d_{j_r-1}\right|}{\left(d_{j_r}+d_{j_r-1}\right)},\quad \alpha_2=\frac{\left|d_{j_r}-d_{j_r+1}\right|}{\left(d_{j_r}+d_{j_r+1}\right)}, \qquad (12)$$

where $d_0=0$, which corresponds to the lack of digital developments. The preservation of the growth rate of digital maturity is observed under the condition $d_{n+1}=2d_n-d_{n-1}$.

Visualization of a detailed analysis of the e-maturity level achieved by the digital office is used. The general position of the set of optimal values $y_{ij_{opt}}$ $\left(i=\overline{1,m}\right)$ of the initial e-maturity indicators among the sets of the lower $z_{ij}^{(\min)}$ and upper $z_{ij}^{(\max)}$ limits of the classification ranges is presented as profilograms (Fig. 1).

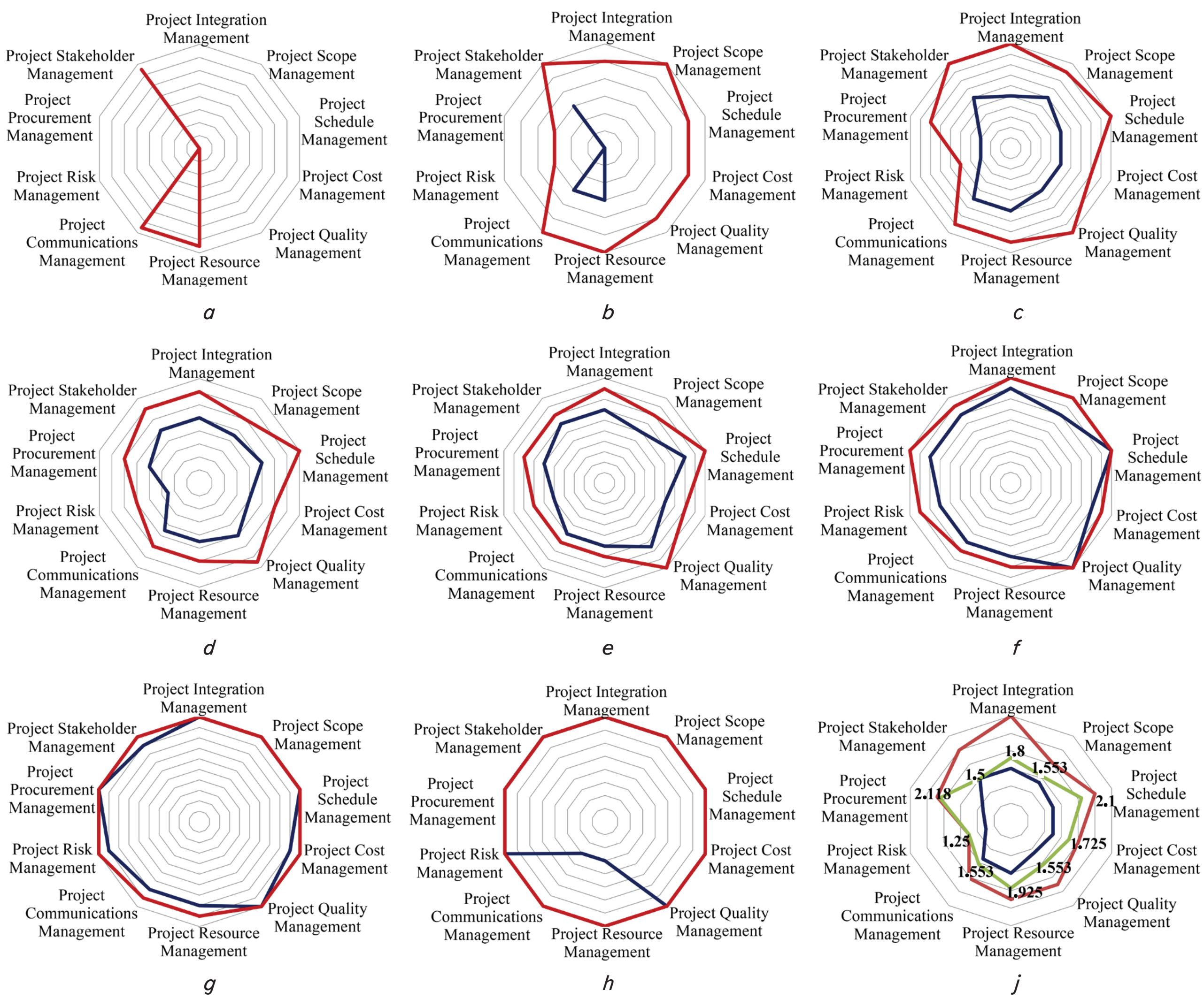

Fig. 1. Profilogram of optimal values of initial e-maturity indicators within the corresponding classification ranges: *a* – profilogram of the lower limits of the classification ranges of the I e-maturity level; *b* – profilogram of the lower limits of the classification ranges of the II e-maturity level; *c* – profilogram of the lower limits of the classification ranges of the III e-maturity level; *d* – profilogram of the lower limits of the classification ranges of the IV e-maturity level; *e* – profilogram of the lower limits of the classification ranges of the V e-maturity level; *f* – profilogram of the lower limits of the classification ranges of the VI e-maturity level; *g* – profilogram of the lower limits of the classification ranges of the VII e-maturity level; *h* – profilogram of the lower limits of the classification ranges of the VIII e-maturity level; *j* – example of a profilogram of weighted initial indicators for the found optimal estimate of e-maturity level (III e-maturity level)

6. Discussion of the results of modeling the assessment of PMO_{eM} e-maturity

The developed methodology for assessing the PMO_{eM} e-maturity should become an important tool for improving the management system of municipal e-projects and e-programs. The use of qualitative characteristics of PMO_{eM} e-maturity (Table 1) allows for self-assessment of the municipality at eight levels. Thus, eight «control points» of the trajectory of improving the quality of the municipal management system are outlined.

This author's approach defines the levels of electronic maturity in more detail than the generally accepted three-level approach («digital city»→«intelligent city»→«smart city»). And the use of mathematical tools (1)–(10) can formalize decision making under varying degrees of certainty of the initial information. The proposed mathematical apparatus is basic, it can be supplemented, developed in accordance with the conditions and specifics of a particular municipality.

The application of the developed analytical tools will be useful in project activities of IT departments of municipalities responsible for implementing digital technologies in the provision of services to citizens.

At the same time, the author's approach requires further scientific and practical development, both in the direction of working with specific data and expanding analytical capabilities.

The empirical basis for further research should be analytical reports on the functioning of PMO_{eM} in individual municipalities. This involves conducting detailed control measurements (assessment) to identify indicators of electronic activity and its provision. A promising area of relevant theoretical research may be the use of fuzzy sets.

The systematic application of the proposed toolkit for indicating digital maturity will allow municipalities to take into account relevant external factors when developing effective measures for increasing the PMO_{eM} e-maturity.

7. Conclusions

1. The digital context of municipal government and international approaches to the assessment/rating of smart cities are outlined. The basic model of assessing the electronic maturity of the project management office of municipal digitalization is presented through the prism of the technological maturity model of I. Kendall and K. Rollins. Digital strategies for managing municipal services are considered in conjunction with the requirements of prompt response to dynamic signals from the administrative and social environment (including the needs of citizens), unfolding in the perspective of the basic stages of e-maturity development. This methodological approach allows forming a qualitative context of electronic municipal services at a higher e-maturity level.

The maturity assessment matrix for the PMO_{eM} has been developed, which is represented by project management knowledge areas and digital ICT characteristics of e-maturity. Eight levels of PMO_{eM} maturity have been determined: «I – PMO_{eM} is able to effectively implement information services projects»; «II – PMO_{eM} analyzes the organizational aspects of the online services of the municipality»; «III – PMO_{eM} develops ways to effectively implement online services»; «IV – PMO_{eM} requires a high level of e-government maturity, opening «fast access» of citizens to e-services»; «V – municipality staff as members of the project team (PMO_{eM}) ensures the progress of the functional efficiency of city smart services»; «VI – PMO_{eM} is able to provide the vast majority of municipal services using ICT tools»; «VII – PMO_{eM} provides an expanded range of smart services»; «VIII – all municipal services are provided under the maximum mainstreaming of ICT». Thus, the architecture of possible evolution of the municipal government system through the implementation of e-projects and e-programs is built.

2. The mathematical model and methodology for working with it to determine the level of electronic maturity reached by the investigated digital office and analyze its individual components are developed. The ability to vary expert values of weights, priority indicators and allowable input estimates of e-maturity in terms of both sub-indices and micro-indices, allows analyzing the ways to improve the digital maturity of PMO_{eM}, predicting the limits of the worst and best estimates of digital maturity, controlling external expert monitoring and efficiency of using investment resources for digitalization by means of computational experiment.

This model allows assessing the current degree of e-maturity of similar other management structures by transferring the obtained expert values of weights to new objects, as well as determining the place of the studied digital office among them, based on the results.

The developed tools can be used by PMO_{eM} directorates and senior management of IT organizations to independently assess the progress in the digital management of municipal e-projects, e-programs in general and individual components, as well as to choose the optimal range of actions needed to move to a higher level of e-maturity.

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