Стаття присвячена розробці методу електронного планування проєктів створення та надання інформаційних ресурсів, та принципів впровадження інструментів електронного проектного менеджменту в діяльність проектно-орієнтованих підприємств. Описано систему PrimaDoc-T, в якій реалізовано функції автоматичного планування проектів, розподілу процесів обробки документації (інформації) по проектам, ведення проектного архіву документів та наведено результати її використання

Ключові слова: електронний проектний менеджмент, електронний менеджер проектів, мета-методологія, управління ресурсами

Статья посвящена разработке метода электронного планирования проектов создания и предоставления информационных ресурсов и принципов внедрения инструментов электронного проектного менеджмента в деятельность проектно-ориентированных предприятий. Описана система PrimaDoc-T, в которой реализованы функции автоматического планирования проектов, распределения процессов обработки документации (информации) по проектам, ведение проектного архива документов и приведены результаты ее использования

Ключевые слова: электронный проектный менеджмент, электронный менеджер проектов, мета-методология, управление ресурсами

DEVELOPMENT OF PRINCIPLES AND METHOD OF ELECTRONIC PROJECT MANAGEMENT

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1. Introduction

Modern project management trends are directed to becoming independent of the geographical or technological location of information technology or users. Project management virtual offices [1, 2] and project planning and control cloud technologies [3–5] confirm that.

Project management automation should be the next step at project management information technology development. In this case, information systems will be rather a decision-making instrument than an instrument for decision making. With total automation, information technology can substitute some human (project participant) functions, e. g. project plan creation and its execution control, human resource management, project time management, etc. Because of the reduction of human influence on project implementation, the probability of getting the desired result with proper implementation time, quality, and cost grows.

Sure, complex technical-organizational systems like most of projects cannot be managed by computers yet. But management of simpler projects, like information resource creation and provision projects (IRCPP) at enterprises and organizations could be automated to a greater extent [6, 7], and in this way, starts electronic project management (e-PM) [7].

Today, neither Project Management Book of Knowledge (PMBOK), nor other project management methodologies [8–10] take up electronic project management issues. It is evident that electronic project management methodology creation should move simultaneously with management methods and tools creation.

So, the conclusion is that there is a topical problem of development of scientific and practical instruments of electronic management for information resource creation and provision projects.

2. Literature review and problem statement

In the publications researched [11–13], the development and implementation of electronic project management at enterprises are investigated. For example, in [11] electron-

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ic project management is considered as application code development control but not as project management. In [12], the authors define the electronic project management as project information and project documentation storage without the information management function. In [13], e-PM is a web instrument, which creates the common working environment for designing and construction projects and allows the project teams to consolidate the planning, design, procurement, and construction in a sole system. The system like that is supplementary without providing management decisions. The above-mentioned systems are not used for enterprise information resources management. This problem is researched in [14, 15], where the way information and communication technologies can support information management at enterprise projects is described. However, these researches consider information management as a project process, but not as a separate project, which should be managed.

On the other hand, electronic management can be represented with virtual project management. In [16–18], *virtual project management* is defined as a system providing the virtual teams with the facilities to collaborate for some time to achieve a specific goal. The virtual teams have extra skills and a common goal, have interdependent activity goals, and share the approach to the work, which they all are responsible for [19]. So, virtual project management is a common working space for effective project teams collaboration.

In the above-mentioned publications, electronic project management is a tool used for simplifying project team work and it doesn't automate project management. Also, electronic project management is not considered to be used for enterprise information management. So, after scientific works analysis, it is concluded that for today the area of management automation of information resource creation and provision projects-using electronic project management is free for scientific research and development.

3. The aim and objectives of the study

The aim of this work is the development of electronic management models and methods of information resource creation and provision projects and development of approaches to implementation of electronic project management at project-oriented enterprises.

To achieve the aim, the following tasks must be executed:
– to propose the principles of implementation of electronic project management at project-oriented enterprises;
– to propose the method of automatic planning of information resource creation and provision projects;
– to propose the tools of electronic project manager functions implementation in project management systems.

4. The principles of electronic project management deployment in project-oriented enterprises

As it follows from the analysis, electronic project management is given sufficient attention in publications. It was mentioned that e-PM cannot be created yet for all projects. Therefore, only projects that are clearly formalized at least for planning and execution control tasks are considered. These are enterprise information resources creation projects.

Since the research is devoted to the creation of electronic project management technology, it is reasonable to provide the definition of the main concepts. Let's also consider the principles of e-PM implementation in project-oriented enterprises. The technology core will be automatic management tools (electronic project manager) of information resource creation and provision projects.

Definition 1. Information resource (IR) is data, knowledge, messages, facts, ideas, concepts that change the consumer behavior and received from project-oriented enterprise information systems as the result of operational or project activities or from the external environment and used outside of the sources.

One should differentiate the concepts of information resource and information product. An information resource is what is consumed by employees of the enterprise or information systems during the performance of management or operational functions, for example, knowledge. An information product is what is produced by these employees or information systems [20].

Definition 2. Electronic project management (e-PM) is a kind of project management having the main management process being implemented in computer software and information environment without humans [7].

Definition 3. Electronic project manager (e-M) is a software and information system implementing project management in e-PM automatically [7].

While e-PM is a project management technology, e-M is a tool of making project decisions that are an e-PM part.

Definition 4. Information resource creation and provision project (IRCPP) is an information creation project e-PM with the goal to satisfy information demands of users or information systems with creating and providing the information resource in a convenient way [6].

Electronic project management implementation has some peculiarities because some management functions are transferred to a virtual environment and get under automatic control. For instance, these peculiarities are:
– management functions are distributed between traditional management ways (using common methodologies like PMBOK, P2M, Scrum, etc.) and functions being executed automatically in automatic tools;
– need for creation of project management tools using the electronic project manager;
– project teams have to be taught not only the project management, but also the collaboration with the electronic project manager.

So, electronic project management implementation should be considered at the intersection of management functions and automation functions. Therefore, e-PM implementation requires enterprise employees to change the way they are used to do their work. The integrated and systematic approach is needed that includes the development of appropriate implementation strategy and plan of management tools of projects with e-PM elements taking into account all enterprise features and its information infrastructure. The following is proposed for that:

1. Creating an add-on that would provide integration of project management methodologies (PMBOK, P2M, PRINCE-2) and information systems and technology creation methodologies (Scrum, Kanban, DSDM, XP). This add-on should be a system of principles, approaches, models, structures, and schemes of implementation of management tools of projects with e-PM elements.

2. Creating an electronic project management technology containing electronic project management tools that are implemented more effectively in an automatic mode without human intervention (electronic project manager).

Such technology will be the basement for effective interaction of e-M tools with the IRCPP team on the base of clear rules (instructions) on project management functions implementation. The interaction scheme is depicted in Fig. 1.
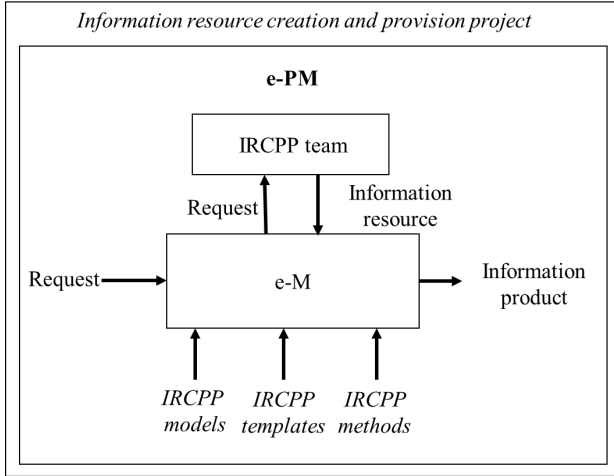

Fig. 1. Interaction scheme in e-PM

Some explanations to Fig. 1:
– *Request* is addressing e-M to obtain an information resource;
– *IRCPP team* is a group of people involved in creation and provision of an information resource;
– *IRCPP model* is a conceptual presentation of information resource creation and provision project being based on definite classification features;
– *IRCPP template* is an example of information resource creation and provision project that was implemented before and matches the current project model;
– *IRCPP methods* are a set of rules and actions necessary for information resource creation and provision project management.

Fig. 2 includes the main IRCPP management methods that can be implemented in e-M.
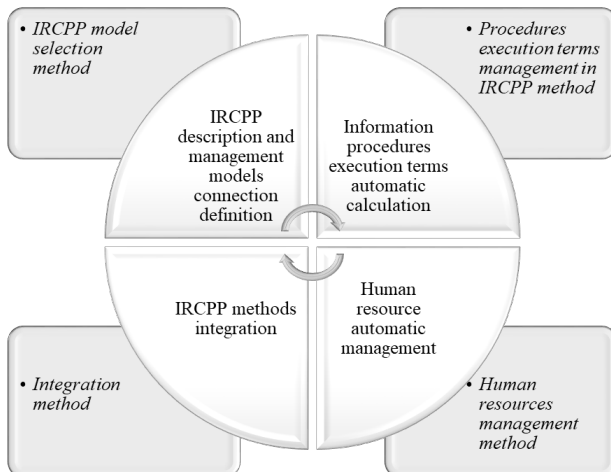

Fig. 2. IRCPP management methods

In the following section, the main method of e-M basement is considered. This is the method of procedures execution terms management in IRCPP.

5. Method of procedures execution terms management in information resource creation and provision projects

Information resource creation and provision projects are characterized by a clear formalization of actions on obtaining and processing information. These actions (procedures) are repeated in different projects. And if the workers execute these procedures for a long time, they get good skills at that. This makes the procedures execution time much shorter and improves quality. Therefore, when evaluating the terms of an information resource creation and provision project execution, it is important to take into account the role executor person and the way this role was executed before.

So, an IRCPP peculiarity is that procedures execution duration may be significantly different depending on the executor person. Therefore, the "work execution duration" concept being used often in traditional project management is not quite suitable in IRCPP.

The method is proposed that allows "compressing" or "stretching" the IRCPP execution depending both on the due date and human resources assigned for the procedures execution.

Let us consider the method proposed:
1. Select the most productive human resources (human resources that make the work the fastest) for project works roles.
2. Set the iteration number $N=0$.
3. Set the initial duration of information procedures execution

$$\forall I_j^C : \tau_j^{(0)},$$

where I_j^C is an information procedure; $\tau_j^{(0)}$ is the initial execution duration of an information procedure I_j^C.

4. Calculate the execution time of the whole project for N iteration. The traditional methods (critical way, critical chains, PERT, etc.) are used.

5. If the calculated project execution time does not exceed the due date ($t_{sch}^{(N)} \le t_{due}$), the calculation is over.

6. Calculate the compression coefficient of the work that must be executed for information procedures implementation:

$$\beta^{(N)} = \frac{t_{due} - t_0}{t_{sch}^{(N)} - t_0},$$

where t_{due} is the due date for obtaining the information resource; $t_{sch}^{(0)}$ is the estimated deadline for the project; t_0 is the project start time; β is the work compression coefficient.

7. Increment the iteration number ($N=N+1$).

8. Set priority for every information procedure that will determine the execution time immutability:

$$0 \le \alpha_j^{(N)} \le 1,$$

where $\alpha_j^{(N)}$ is the immutability coefficient of the execution time of the procedure I_j^C (information procedure priority) in N iteration.

The coefficient determines if it is possible to reduce the procedure duration. And if possible, how much this duration can be reduced in comparison with other procedures. If $\alpha_j^{(N)} = 1$, then it is not reasonable to reduce the procedure execution duration. If

$$\alpha_j^{(N)} = 0,$$

then the execution duration is reduced proportionally to the calculated coefficient β.

9. Calculation of the information procedures execution duration for iteration N:

$$\tau_j^{(N)} = \tau_j^{(N-1)} \cdot \left(\left(1 - \alpha_j^{(N)}\right) \cdot \beta + \alpha_j^{(N)} \right),$$

where $\tau_j^{(N)}$ is the information procedure execution duration for iteration N; $\tau_j^{(N-1)}$ is the information procedure execution duration for iteration $N-1$.

10. Calculate the execution duration of the whole project for iteration N. If the calcul ated project execution duration is not greater than the policy duration ($t_{sch}^{(N)} \le t_{due}$), then the calculation is over.

11. Go to item 7.

This method allows the electronic project manager to make the automatic calculation of execution time for both separate information procedures and the project in the whole. And it allows shortening (if necessary) the execution time of information procedures, for which implementation of the management functions of tasks execution terms in the procedure itself is possible. The execution time of "hard", immutable procedures cannot be changed. For instance, those that are executed in an automatic mode in computers and have execution time that can be neither increased, nor reduced.

Let's consider an example of using this method.

It is necessary to obtain some information resource R_1. This information resource creation and provision project P_1 has a linear model (Fig. 3). It begins in 0 time moment. The project due date $t_{due} = 9$.
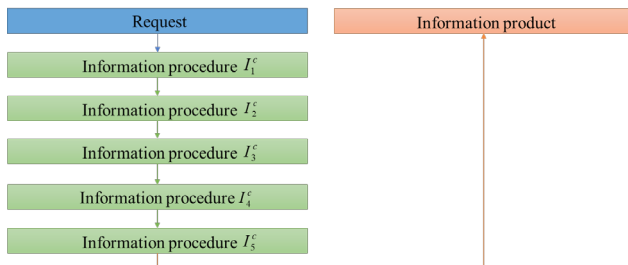

Fig. 3. Information resource creation and provision project model

1. Setting zero iteration ($N=0$).

2. Defining the initial duration of every information procedure:

$$\tau_1^{(0)} = 1, \tau_2^{(0)} = 5, \tau_3^{(0)} = 3, \tau_4^{(0)} = 1, \tau_5^{(0)} = 2,$$

where $\tau_1^{(0)}$ is the initial execution duration of the information procedure I_1^C; $\tau_2^{(0)}$ is the initial execution duration of the information procedure I_2^C; $\tau_3^{(0)}$ is the initial execution duration of the information procedure I_3^C; $\tau_4^{(0)}$ is the initial execution duration of the information procedure I_4^C; $\tau_5^{(0)}$ is the initial execution duration of the information procedure I_5^C.

Procedures number $K=5$.

1. Calculation of the project finish scheduled date:

$$t_{sch}^{(0)} = t_0 + \tau_1^{(0)} + \tau_2^{(0)} + \tau_3^{(0)} + \tau_4^{(0)} + \tau_5^{(0)} =$$
$$= 1 + 5 + 3 + 1 + 2 = 12.$$

2. For the project P_1, the due date is less than the scheduled date (9<12), therefore, the calculations are continued.

3. Calculation of the schedule compression coefficient of the works that should be executed for information procedures implementation:

$$\beta = \frac{t_{due} - t_0}{t_{sch}^{(0)} - t_0} = \frac{9 - 0}{12 - 0} = 0,75.$$

4. Increment the iteration number $N=1$.

4. 1. Setting information procedures priorities (Table 1).

Table 1

Iteration 1. Information procedures priorities

Procedure	Duration	Priority
I_1^C	1	0.8
I_2^C	5	0
I_3^C	3	1
I_4^C	1	0.5
I_5^C	2	0.4

4. 2. Calculation of the information procedures execution duration for iteration 1 (Table 2):

$$\tau_j^{(1)} = \tau_j^{(0)} \cdot \left(\left(1 - \alpha_j^{(1)}\right) \cdot \beta + \alpha_j^{(1)} \right).$$

Table 2

Iteration 1. Calculation of the information procedures execution duration

Procedure	Duration	Priority	New duration
I_1^C	1	0.8	0.95
I_2^C	5	0	3.75
I_3^C	3	1	3
I_4^C	1	0.5	0.875
I_5^C	2	0.4	1.7

4. 3. Calculation of the new project duration:

$$t_{sch}^{(1)} = t_0 + \tau_1^{(1)} + \tau_2^{(1)} + \tau_3^{(1)} + \tau_4^{(1)} + \tau_5^{(1)} =$$
$$= 0 + 0,95 + 3,75 + 3 + 0,875 + 1,7 = 10,275.$$

4. 4. Compare the due and scheduled project date. The due date is less than the scheduled date (9<10.275). Go to the next iteration.

5. Increment the iteration number $N=2$.

5. 1. Set the priority for every information procedure. In particular, reduce it for the procedure I_3^C (Table 3).

Table 3

Iteration 2. Priorities for information procedures

Procedure	Duration	Priority
I_1^C	1	0.8
I_2^C	5	0
I_3^C	3	0.8
I_4^C	1	0.5
I_5^C	2	0.4

5. 2. Calculation of the information procedures execution duration for iteration 2 (Table 4):

$$\tau_j^{(2)} = \tau_j^{(1)} \cdot \left(\left(1 - \alpha_j^{(2)} \right) \cdot \beta + \alpha_j^{(2)} \right).$$

Table 4

Iteration 2. Calculation of the information procedures execution duration

Procedure	Duration	Priority	New duration
I_1^C	0.95	0.8	0.92625
I_2^C	3.75	0	2.8125
I_3^C	3	0.8	2.85
I_4^C	0.875	0.5	0.765625
I_5^C	1.7	0.4	1.4875

5. 3. Calculation of the scheduled project execution date:

$$t_{sch}^{(2)} = t_0 + \tau_1^{(2)} + \tau_2^{(2)} + \tau_3^{(2)} + \tau_4^{(2)} + \tau_5^{(2)} =$$
$$= 0 + 0,92625 + 2,8125 + 2,85 +$$
$$+ 0,765625 + 1,4875 = 8,841875.$$

5. 4. The due date is greater than the scheduled date (9>8.841875). The calculation is over.

6. Calculation of the information procedure execution term is over.

The presented method can be used both for information resource creation and provision projects planning and electronic document flow management. In this case, the method is used for calculating the documents processing time by correspondents using the work statistical features and actions execution due date written in the documents. For example, if a contract must be agreed upon by various company services within 5 days, but upon statistical characteristics of correspondents this can be done in 7 days, this method allows calculating the scheduled date of the work of every unit on this document. Moreover, the priorities can be formed automatically, based on how timely these documents were processed before.

Let us consider the system, which contained electronic project management implementation.

6. Information resources management system PrimaDoc-T

The electronic project management system is implemented in the information management system PrimaDoc-T (Fig. 4). Its main component is the system electronic administrator. It works as an electronic project manager.

PrimaDoc-T is a solution based on LINUX and PostgreSQL DBMS. Its goal is the creation and implementation of projects related to obtaining and providing the information to interested parties. It can be used both as an electronic document management system and a system for managing information on projects (archive, documents, IRCPP).

PrimaDoc-T functions:

– Working with input, internal, and output IRCPP documents;

– IRCPP documents automatic registration (the user sets the registration order and rules);

– Encrypting IRCPP documents location and file names (on user demand any information in the system can be encrypted);

– Logging all actions of IRCPP participators. Log discovers who and when made any action in the system. The log is accessible for viewing only to the administrator;

– IRCPP documents automatic distribution by categories: executed, not executed, closed, created, templates, canceled.
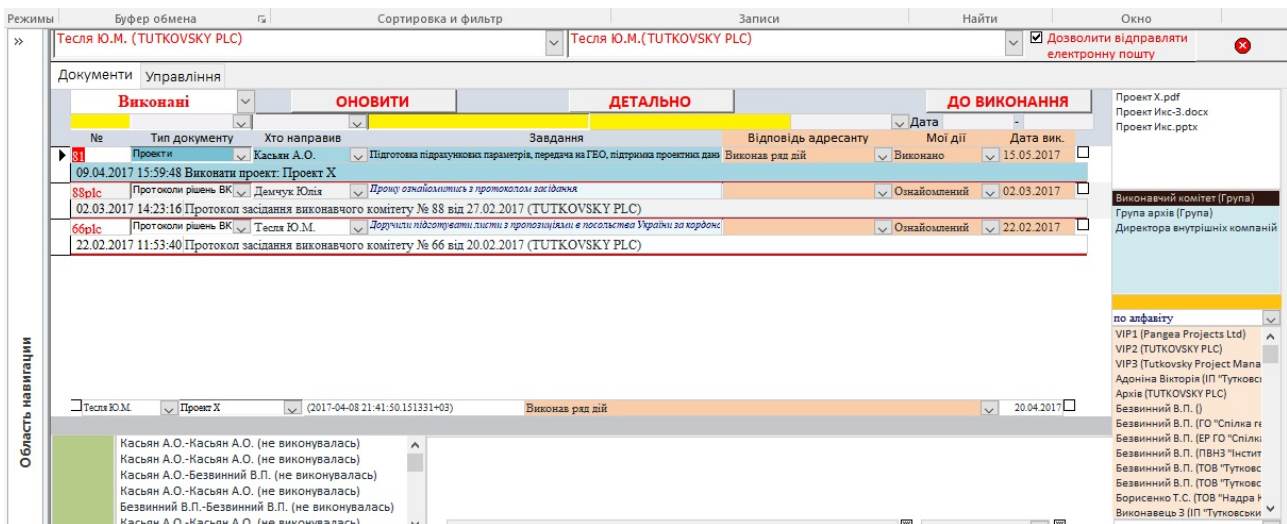

Fig. 4. Information system PrimaDoc-T window

PrimaDoc-T capabilities:

1. e-M plans the order and terms of IRCPP procedures execution.

2. It controls the procedures execution during forming the information resource.

3. It processes both paper and electronic input documents (electronic letters are automatically uploaded into the system and are redirected as the system documents to the correspondents set by the user).

4. All intermediate information resources (stage by stage information processing with forming the resource being transferred to the next correspondent) are constantly in control of the system. It is controlled who, when and what did with the information (even if a user only opened a document for viewing and did nothing else with it).

5. Diagnostic of the system information database (who did something wrong and what was that).

6. All actions in the system are logged (even opening a document without changing it).

7. It is always possible to get the system work logs filtered for managers, owners, correspondents on: how many documents he or she emitted or received, how much documents he or she reviewed, executed, etc.).

8. e-M can duplicate each task in the procedure with an e-mail to the performer.

9. Offline work with the archive of documents on projects and organizations is possible (detached from the process where the documents were created).

10. If the manager wishes, his or her secretary can work with the documents. In this case, the secretary works with his or her own login and password.

11. Managing hundreds of projects at initiation, planning, and implementation stages. This feature is realized by the installed project templates [21].

During PrimaDoc-T operation, the following effects were discovered:

1. The time of search for the needed document reduced.

2. The control over the documents state and projects information content improved. The procedures implementation time is controlled by the system. Information on "deviations" is automatically transferred to the administrator and other stakeholders.

3. A clear structure of the information archive was created. This allows integrating or refining the project or enterprise information resource while moving on the document tree.

4. All information is encoded. It can be accessed by authorized users. Login is possible only with a personal password that cannot be discovered even by the administrator.

5. The system works with the user local cache. The server is connected only at the time of sending or receiving information.

6. The system allows transferring some project management functions in a virtual environment. In this environment, the documents, project implementation stages, archive data, administration procedures are integrated.

7. Discussion of the results of the application of electronic project management methods.

The method of electronic planning of information resource creation and provision projects and the principles of implementation of electronic project management instru-

ments in project-oriented enterprise activities are proposed. Project teams' participation in the implementation of many typical management functions often leads to delays in decision making because of the team members interaction on information interchange, coordination of interests and actions. The proposed automatic implementation of project management functions reducing the losses related to such interactions and accelerating decision making in information resources creation and provision projects. Understanding that electronic project management implementation is complicated and different from traditional methodologies of project management, the principles of electronic project management tools implementation at project-oriented enterprises based on the integration of traditional project management methodologies (PMBOK, P2M, PRINCE-2) and information systems and technology creation methodologies (Scrum, Kanban, DSDM, XP) are proposed. This approach allows automating most of the project management functions in electronic project management technology and making project teams free of repeated management functions.

The main advantage of this research is the development of project management instruments in a new direction, namely electronic project management.

One more research advantage is practical implementation of the theoretical part. PrimaDoc-T software system was created with the implementation of the functions of automatic project planning, project documentation (information) processing processes distribution, project documents archive maintaining. This system has allowed automating a set of functions on project documents management. In particular, the creation of an electronic storage of project information, its updating, use, including the distribution of authorization and different filters. It provided a convenient toolset for project management. Besides, the unit of automatic planning and control over the IRCPP execution in the company projects management process is implemented. This makes the project managers free of performing the functions related to information provision procedures administration.

The research disadvantage is that it is related to only one project type: information resources creation and provision projects. But it is so because the task is very complicated. Creation of the electronic project manager for all types of projects is not possible for today.

The research on the electronic project manager creation for one kind of projects is a continuation of previous research of the authors relating the creation of project resources management systems (PRP-system). The basis of this new system class are enterprises and organizations information resources that are aimed at the effective management of projects and programs.

The results confirm the prospects of the chosen project management development way, in particular, the increasing automation not only in information processing processes but also project management processes. In the future, it is planned to extend the proposed approach on other project classes and to develop and implement the methods of administration and control of projects and programs in the electronic project manager.

8. Conclusions

1. The principles of electronic project management implementation in project-oriented enterprises is proposed.

The conceptual basis of electronic project management is created. It is used both for the development of the principles of electronic project management implementation in project-oriented enterprises and for the development of electronic management tools of information resources creation and provision projects.

2. The method for automatic planning of information resources creation and provision projects is developed. It is based on the calculation of works execution terms with selecting the template that best matches the task and automatic compression and stretching of individual works depending on the performance efficiency and given due dates. It is shown that the method allows "compressing" and "stretching" information resources creation and provision projects

time depending both on due dates and on those work resources that are assigned to perform various project procedures. It is shown that this method allows compressing (if needed) the execution time of those information procedures, for which the implementation of the management functions of work execution terms in the procedure itself is possible.

3. Based on the integration of the traditional project management methodologies (PMBOK, P2M, PRINCE-2) with information systems and technologies creation methodologies (Scrum, Kanban, DSDM, XP), the functional structure of the electronic project manager in the enterprise information management system PrimaDoc-T is proposed. The estimation of the PrimaDoc-T system industrial exploitation results is given.

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