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COMPLEX IT PROJECT MANAGEMENT INFORMATION SYSTEM

I. Putii, P. Teslenko. Інформаційна система управління складними IT-проектами. Статтю присвячено розробці концепції та архітектури інформаційної системи управління складними IT-проектами, що забезпечує автоматизоване виявлення, аналіз і зниження невизначеності в умовах високої складності реалізації проектів. Показано, що сучасні IT-проекти характеризуються високим рівнем динаміки, технологічної новизни, мультидисциплінарністю та великою кількістю взаємопов'язаних елементів. В таких проектах складність проявляється не лише у масштабі чи кількості компонентів, а насамперед у взаємозалежності технічних, організаційних і поведінкових факторів. Це ускладнює передбачення результатів і знижує ефективність класичних методів управління. Сформульовано проблему — відсутність системного підходу до управління невизначеністю, яка виникає внаслідок складності реалізації IT-проектів та безпосередньо впливає на їх успішність. Показано, що складність доцільно розглядати як складність реалізації, яка охоплює технологічні, організаційні, комунікаційні, часові та поведінкові аспекти проекту. Саме вони формують джерело невизначеності, що унеможливає стабільне прогнозування результатів і створює ризики зриву термінів або невідповідності очікуванням замовника. Для системного подолання цієї проблеми запропоновано метод управління складними IT-проектами, що базується на ідеї послідовного зниження невизначеності. Метод реалізовано у вигляді етапів: виявлення зон невизначеності, формування гіпотез, перевірка їх ефективності через Spike, PoC або R&D-експерименти, подальший рефакторинг процесів управління та оновлення плану проекту. Розроблено структуру інформаційної системи управління складними IT-проектами, яка включає дев'ять модулів і забезпечує повну автоматизацію циклу управління. Система використовує інструменти обробки природної мови, багатокритеріального аналізу, машинного навчання та предиктивної аналітики для формування управлінських рішень на основі даних. Реалізовано логічну архітектуру з замкненим адаптивним контуром, що забезпечує безперервне вдосконалення управлінських дій і стабілізацію стану проекту. Впровадження запропонованої системи дозволить мінімізувати вплив людського фактору, підвищити прогнозованість і забезпечити кероване зниження невизначеності, що є критично важливим для успішного завершення складних IT-проектів.

Ключові слова: складний IT-проект, невизначеність, предиктивна аналітика, Spike, Proof of Concept, рефакторинг управління, метод управління складними IT-проектами, інформаційна система управління складними IT-проектами

I. Putii, P. Teslenko. Complex IT project management information system. The article is devoted to the development of the concept and architecture of an information system for managing complex IT projects, which provides automated detection, analysis and reduction of uncertainty in conditions of high complexity of project implementation. It is shown that modern IT projects are characterized by a high level of dynamics, technological novelty, multidisciplinary nature and a large number of interconnected elements. In such projects, complexity is manifested not only in the scale or number of components, but primarily in the interdependence of technical, organizational and behavioral factors. This complicates the prediction of results and reduces the effectiveness of classical management methods. The problem is formulated – the lack of a systematic approach to managing uncertainty, which arises as a result of the complexity of implementing IT projects and directly affects their success. It is shown that complexity should be considered as the complexity of implementation, which covers technological, organizational, communication, time and behavioral aspects of the project. They form a source of uncertainty, which makes it impossible to predict results stably and creates risks of missing deadlines or not meeting customer expectations. To systematically overcome this problem, a method for managing complex IT projects has been proposed, based on the idea of sequentially reducing uncertainty. The method is implemented in the form of stages: identifying areas of uncertainty, forming hypotheses, testing their effectiveness through Spike, PoC or R&D experiments, further refactoring of management processes and updating the project plan. The structure of an information system for managing complex IT projects has been developed, which includes nine modules and provides full automation of the management cycle. The system uses natural language processing tools, multi-criteria analysis, machine learning and predictive analytics to form management decisions based on data. A logical architecture with a closed adaptive loop has been implemented, which ensures continuous improvement of management actions and stabilization of the project state. The implementation of the proposed system will minimize the impact of the human factor, increase predictability and ensure a controlled reduction in uncertainty, which is critically important for the successful completion of complex IT projects.

Keywords: complex IT project, uncertainty, predictive analytics, Spike, Proof of Concept, management refactoring, complex IT project management method, complex IT project management information system

1. Introduction

Modern IT projects are characterized by high dynamics of development, multidisciplinary and a significant number of interrelated elements. Complex IT projects are understood to be those that simultaneously combine technological innovation, integration of heterogeneous systems, changing requirements and interdependence of teams, i.e. complexity of implementation including the need for scientific research [1]. In such projects, it is impossible to fully predict the behaviour of the system or the consequences of decisions made, since each change at one level can create chain effects at others. The complexity here is not limited to the number of components or scale; it is systemic in nature –

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technical, organisational, communicational, temporal, and behavioural.

Technological complexity arises when a project is based on new or unstable technologies for which there are no established development or testing practices yet. Organisational complexity is related to the distribution of responsibilities between departments, developers and stakeholders, who often have different priorities and visions of the outcome. Communication complexity manifests itself in a large number of information exchange channels, which complicates the control of requirements integrity and team synchronisation. Time complexity arises from the multi-level dependencies between tasks and the high variability of plans, where the results of one stage significantly affect the feasibility of the next. Finally, behavioural complexity arises from the human factor: different experiences of team members, differing understandings of goals, or resistance to change.

The combination of these types of complexity creates significant uncertainty, which is the main threat to the successful completion of complex IT projects. Uncertainty in requirements, time estimates, code quality, or technical limitations directly increases the risks of missed deadlines, reduced quality, or failure to meet customer expectations [2]. It cannot be completely eliminated, but it can be systematically managed to reduce its impact on critical project elements.

To this end, the software development industry uses tools such as Spike, Proof of Concept (PoC), and research and development experiments (R&D experiments) [1].

Spike is used for short-term research into an unknown technological problem – it is a quick experiment that answers a narrow technical question without creating a complete product. Proof of Concept is broader in nature and aims to test the viability of an idea or architectural solution in a controlled environment, demonstrating that the concept can be implemented in practice. Research and development work differs in scale and depth – it is a stage at which a hypothesis is tested in conditions close to real life, involving a full cycle of development, testing, and evaluation of results [3]. The main difference between them lies in the depth of analysis and the degree of influence on the further architecture of the project: Spike answers the question “is it possible”, PoC – “how exactly to do it”, and R&D work – “how to integrate it into the system without risk”.

However, in most organisations, such actions are performed sporadically and without integration into the overall management system, which leads to a loss of connection between research and the actual state of the project. For systematic, rather than random, uncertainty management, a conceptual model for managing complex IT projects [4] and a method for forming hypotheses for complex IT projects [5] have been developed.

This model is based on the principle of cyclicity: identifying areas of uncertainty, forming hypotheses for action, testing their effectiveness, refactoring management processes, and adapting the project plan. Refactoring here acts as a separate management procedure – changing internal processes, roles, communications, or plans based on confirmed experimental results, which allows you to maintain flexibility without losing controllability. That is why it is advisable to integrate it as a separate module in the structure of the information system for managing complex IT projects – instead of the “classic” plan adaptation module, which now performs the functions of management refactoring.

Based on this conceptual model and method, it is envisaged to create an information system (IS) for managing complex IT projects that automates all stages of this cycle – from data collection to evaluation of refactoring results. Using analytical models, natural language processing algorithms, and machine learning elements, such a system eliminates the influence of the human factor, minimises the risks of additional errors in decision-making, and ensures a controlled, predictable reduction in uncertainty. Its implementation should ensure control over the execution of complex IT projects and increase the likelihood of successful completion even in unstable project conditions.

2. Analysis of literature data and problem statement

Article [6] examines the evolution of approaches to managing complex projects from classical to modern integrated methodologies. The author interprets a complex project as a multi-level system with numerous interdependencies, where a change in one element affects the entire structure. The main problem highlighted by the researcher is the lack of a single methodological standard capable of taking into account the different conditions of project implementation, which leads to ineffective management and wrong decisions. The proposed solution is to use hybrid management models that combine the advantages of network planning, CPM and PERT, as well as the use of information technology to simulate project implementation scenarios.

In article [7], a complex project is described as part of a program portfolio operating in a highly turbulent external and internal environment. The authors point to a key management problem: the mismatch between methodologies and the level of project complexity. When a company uses the same approaches for different types of projects, a “manual control effect” arises, which reduces efficiency and manageability. The solution proposed is a dual adaptive control system that simultaneously controls the object and learns based on accumulated information, i.e., combines the principles of adaptive control and self-organisation.

The authors [8] define a complex IT project as a multifunctional process with a high level of risk, rapid changes in requirements, and the need for constant adaptation. The main management problem lies in budget, resource, and time constraints, while at the same time ensuring flexibility. The authors propose a hybrid methodology that integrates Agile and Waterfall, supplemented by mathematical modelling and simulation to optimise resource allocation and increase the adaptability of the management system.

In the monograph “Project Management: Theory, Practice, Information Technology” (O. Zatchko, A. Ivanusa, D. Kobilkin, 2019) [9], complex projects are considered through the prism of information support. The authors emphasise that the complexity of modern projects requires instrumental support – the use of software tools such as MS Project to coordinate resources, deadlines and risks. The lack of a unified information environment for coordinating technical and management processes is identified as a problem. The proposed solution is to integrate the classic PMBOK and P2M methodologies with digital management platforms that ensure transparency and systematic control.

In the study “Succeeding Against the Odds: Project Management in Complex IT Scenarios” [10], a complex project is viewed as a system with a large number of nonlinear relationships, where each management decision creates a reverse effect. The author emphasises that the main problem lies in the loss of controllability due to information overload and inconsistency between teams. This leads to missed deadlines, incorrect prioritisation of tasks, and duplication of work. The proposed solution is to implement a digital knowledge management system that accumulates information from all project subsystems (Jira, GitLab, Confluence) and provides cognitive support for managerial decisions.

In article [11], complex projects are described as innovative ecosystems that combine research (R&D) and production phases. The authors point to the problem of the gap between innovation management and project management: in R&D projects, complexity arises due to the unpredictability of results and constantly changing parameters. This complicates resource and schedule planning. The proposed solution is to integrate innovation management models with Agile methods and create digital twins to simulate possible project development scenarios. The information system described in the article supports risk forecasting and automatic assessment of the technological maturity of solutions.

In contrast, the authors [12] emphasise that complex projects in the digital environment are characterised by a high level of dynamism and unpredictability. The main problem is the lack of connection between digital tools and management decision-making processes. As a result, digital systems record data but do not generate instructions for action. The authors propose the concept of “data-driven management”, i.e., the creation of a management system that not only aggregates data but also uses analytics to predict problem areas and suggest courses of action. The system involves the use of predictive analytics and artificial intelligence algorithms to assess the progress of IT projects.

In the 2020 article “Definitions, Characteristics and Measures of IT Project Complexity – Systematic Review” [13], project complexity is defined by five groups of factors: structural, technological, organisational, project uncertainty and dynamic. The authors analysed more than 100 literature sources and point out that the main problem of management lies in the subjective perception of complexity — the lack of uniform criteria for measuring it. This leads to even experienced managers underestimating the level of risk. As a solution, they propose creating a Project Complexity Index metric and integrating it into management information systems for automated monitoring of project complexity.

Next, we note the journal *Research-Technology Management* [14], which contains numerous publications where complex projects are defined as interdisciplinary R&D initiatives with high uncertainty of technological results. The main problem is the lack of connection between research and commercialisation of results, which leads to a loss of innovative potential. The authors emphasise the need to create knowledge management systems that combine managerial and technical processes, ensuring the tracking of hypotheses, experiments and decisions within a single digital environment.

The article “A Hybrid Agent-Based and System Dynamics Framework for Modelling Project Execution and Technology Maturity in Early-Stage R&D” [15] is devoted to modelling complex R&D projects. The authors define complexity as the result of the interaction of people, technologies and management processes. The main problem is the inability to predict the trajectory of technology development in the early stages. A hybrid agent-system model is proposed, which combines the behavioural patterns of agents (developers, managers, customers) with the dynamics of technological maturity development. The model is implemented as an information system for forecasting time, costs and risk of failure.

It should be noted that the ISO 21500 – Guidance on Project Management [16] standard does not contain a separate definition of a complex project. It uses the general term “project”, described as “a unique process consisting of controlled tasks with a defined beginning and end”. However, in the context of the document, it is noted that “some projects may be more complex due to their scale, number of stakeholders, or technical novelty”. Thus, the standard only points to the existence of complexity as a factor that complicates management, but does not offer a specific tool for assessing or overcoming it.

The authors of all the articles reviewed agree that the main problem in managing complex projects is not only technical multi-levelness, but also methodological inconsistency. They propose a transition to hybrid, adaptive, or information-supported management systems capable of responding dynamically to changes and reducing the level of uncertainty, which is a prerequisite for the success of modern complex IT projects. Based on the review and analysis of the literature, we note that there is a need to develop an IS that automates human-dependent processes of identifying project uncertainty, analysing it, and forming measures to reduce this uncertainty in order to ensure the successful completion of a complex IT project.

3. Purpose and objectives of the study

The purpose of the study is to develop a method for managing complex IT projects, which is the basis for creating a logical representation of the corresponding information system, the implementation of which ensures a constant reduction in the level of uncertainty and increased manageability of IT project implementation.

To achieve this goal, tasks are solved that are related to the identification of project uncertainties, their analysis, and the formulation of project decisions that should lead to a reduction in these uncertainties.

4. Justification of the method for managing complex IT projects

The proposed method for managing complex IT projects is based on a conceptual model for managing complex IT projects involving research and development, supplemented by three key tools: a hypothesis formation canvas, a two-stage hypothesis filtering method, and a refactoring method for managing IT projects.

Classic project management stages, such as initiation, requirements and team formation, feasibility verification, and role distribution, are not included in the method [17]. This article provides a detailed sequence of stages, starting with the identification of areas of project uncertainty and ending with the refactoring of the management structure.

The first stage is the identification of areas of uncertainty. Based on natural language processing (NLP) technology, content units are automatically extracted: problems, risks, contradictions, and gaps in experience, skills, etc. Next, a problem base is formed, i.e., where there is uncertainty or where risks of complexity are observed.

Problem signals are extracted from backlog, Jira, Confluence, Service Desk, etc. The NLP module forms the Problem Base and classifies records by category (functional, UX, security, architecture, etc.).

The second stage is the formation of hypotheses based on the hypothesis formation method canvas [5]. Each area of uncertainty is described in the structure: problem – hypothesis – expected result – verification criteria – resources. This standardises the general representation of the problem and formalises assumptions for further verification. Hypotheses structured in this way are stored in the Hypothesis Management System (HMS) knowledge base, where they are grouped by semantic connections or technological directions.

Each problem is converted into a hypothesis using the “If... then... because...” template, and a database of hypotheses (HMS Knowledge Base) is created.

The third stage is a two-stage filtering of hypotheses. This ensures that only those that are of high value to the project and can be implemented in practice are selected. The first filter assesses the impact of the problem on strategic goals using the MCDA (Multi-Criteria Decision Analysis) model, which calculates an integral importance index. It takes into account the impact, risk, scale, and number of stakeholders. The second filter evaluates feasibility through an index that includes time, financial, and resource constraints. Hypotheses with low index values are automatically filtered out as redundant or irrational.

The MCDA calculates the Feasibility_Index as a measure of feasibility, resulting in only relevant hypotheses being retained.

The fourth stage is hypothesis testing, during which either Spikes, Proof of Concept, or research and development work is carried out. This allows hypotheses to be confirmed or refuted in practice and also allows the effectiveness of solutions to be tested. Each hypothesis is given a status – confirmed, rejected, or requiring further research. This allows you to track progress and keep a history of decisions made.

A short experiment is created for each hypothesis. The results are stored in HMS with an indication of their status.

The fifth stage is refactoring IT project management, which is the basis of the method's adaptability. Here, areas for improvement are identified and directions for further research and recommendations for subsequent stages are determined. A cycle of invariant verification is initiated as a mechanism to ensure that the basic parameters of the project, such as the goal, main tasks and constraints, remain unchanged even after management changes are made.

Refactoring is the adaptation of management processes (not code). The invariant verification cycle ensures that the project's goal, key tasks, and constraints remain unchanged.

The sixth stage is updating the management structure. This involves transferring the results of refactoring to the operational project management model. The stage includes updating the backlog, sprint plans, communication schemes, and roles. All changes are documented and evaluated using comparative metrics.

All changes are recorded in the management system (Jira, Azure DevOps). The backlog is updated and sprint plans are adjusted automatically.

The final stage is cyclical HMS self-learning. The system accumulates data on hypotheses, research, and refactoring results and predicts new areas of uncertainty using machine learning methods. This creates a closed adaptive loop in which each cycle not only reduces uncertainty but also increases the maturity of the management system.

The developed method integrates scientific thinking, complex project management models, and automation into a single management structure and becomes the basis for the development of a management information system for complex IT projects.

5. Development of an IS for managing complex IT projects

The implementation of the information system is based on the concept of adaptive management of complex IT projects. The main idea is a cyclical process of identifying uncertainties, forming hypotheses for their elimination, verifying the proposed actions, and adapting the management plan based on the results obtained. This approach allows for a continuous reduction in the level of uncertainty, keeping the project in a predictable and controllable state.

To implement this vision, an information system structure has been proposed, the logical representation of which is shown in Figure 1. The structure includes the following modules:

- data collection and consolidation module;
- uncertainty and complexity identification module;
- module for forming management hypotheses;
- hypothesis evaluation and prioritisation module;
- hypothesis implementation (verification) module;
- module for evaluating results and controlling uncertainty reduction;
- module for adapting the management plan (refactoring);
- cyclicality and re-analysis module;
- manager's analytical panel.

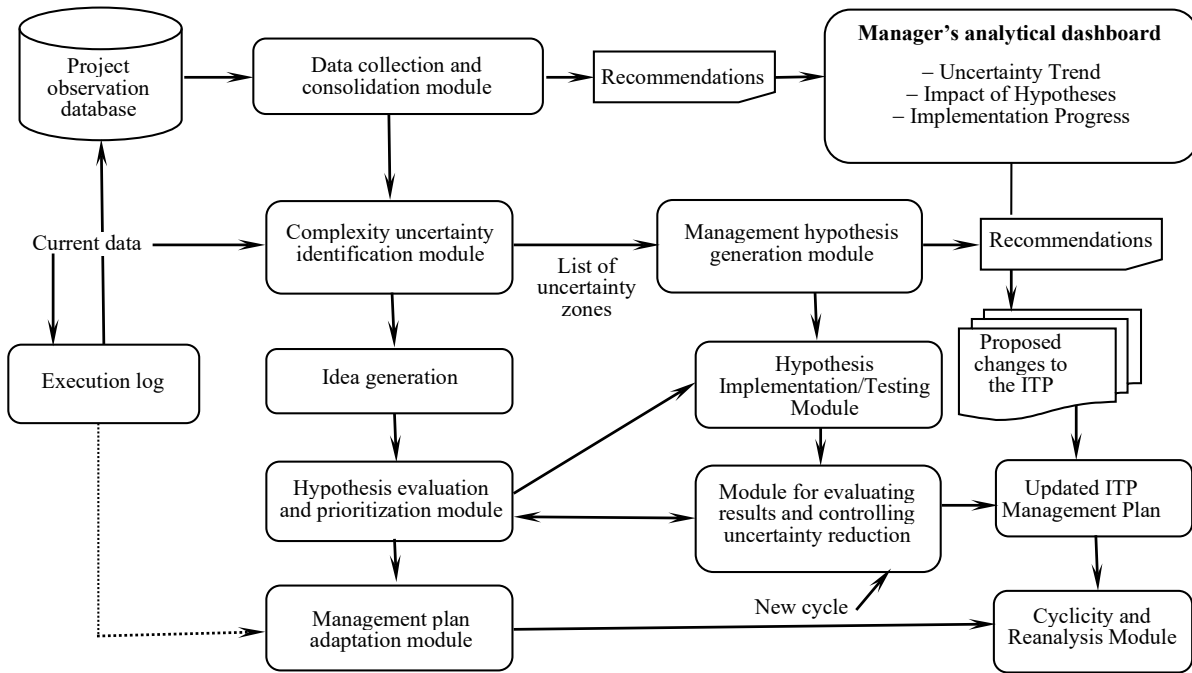


Fig. 1. Diagram of the logical representation of information system modules
The figure shows ITP as an IT project

The data collection module aggregates information from Jira, Git, Confluence, CI/CD logs, and QA reports in JSON format and forms a project observation database. Based on this, the uncertainty identification module uses NLP and clustering to identify problem areas – incomplete requirements, risky changes, unknown technology, or abnormal delays. These areas are transferred to the hypothesis formation module, which creates formalised records in the form of “if... then... because...” templates, suggesting options for action, such as Spike research or Proof of Concept. The next module evaluates and prioritises hypotheses using multi-criteria decision analysis (MCDA) methods, forming a list of the most important ones for implementation. The hypothesis implementation module tracks the execution of these actions, collecting data on resources used, time spent, and execution statuses. Next, the results evaluation module analyses whether uncertainty has decreased using the “Uncertainty Index” and “Risk Δ ” metrics. If the changes have had a positive effect, the adaptation module automatically updates the management plan – backlog, roles, sprints, priorities. All changes are fed into the cyclicity module, which initiates a new management cycle for the next stage.

The project manager’s analytical panel aggregates all results in the form of an interactive dashboard, which displays uncertainty trends, the impact of implemented hypotheses, and the current progress of the project. It is the main decision-making tool at the management level.

The figure shows the logical connections between the system modules. The data flow starts from the project observation base, from which information is sent to the uncertainty identification and analysis modules. The results are then transferred to the hypothesis formation, evaluation, and implementation blocks, after which the effectiveness of the actions is assessed. The updated management plan is submitted to the manager’s analytical panel and returned to the system to start a new cycle. Thus, the IS structure implements a closed adaptive control loop for complex IT projects, in which each stage is a logical continuation of the previous one, ensuring a constant reduction in the level of uncertainty and increasing the manageability of the project.

6. Conclusions

Managing complex IT projects requires a new approach that goes beyond traditional methodologies. The complexity of modern IT projects is determined not only by technical or organisational factors, but above all by the dynamic relationships between people, technologies and the project environment, which has been interpreted as complexity of execution. Research shows that the key reason for failure in such projects is the accumulation of uncertainty arising from unstable requirements, lack of reliable estimates, limited team experience, or high technology novelty. It is uncertainty that is not

systematically controlled that becomes the main source of risk, complicating the prediction of results and reducing the likelihood of successful completion of such IT projects. Therefore, this article focused on reducing uncertainty as a central management goal.

A review of the literature showed that to overcome this problem in the management of complex IT projects, Spike, Proof of Concept, and research and development practices are being actively implemented. Spike allows you to quickly test a technical hypothesis or train a team, PoC demonstrates the viability of an idea, and R&D research ensures its practical implementation. At the same time, their independent use is usually episodic and not integrated into the management system, which reduces the effect of the knowledge gained. To ensure a cyclical and controlled reduction of uncertainty, a formalised approach is needed that can combine research activities with management processes.

Within the framework of this study, a method for managing complex IT projects has been developed, based on a conceptual model that covers the entire cycle: identifying uncertainties, forming hypotheses, testing their effectiveness, refactoring management processes, and adapting the plan. Refactoring is proposed as a separate element of the model, replacing the traditional stage of adapting the management plan. This allows for the continuous improvement of project organisational structures, communication schemes, and management approaches without losing project stability.

Based on this method, an information system for managing complex IT projects has been developed, which automates the processes of identifying, analysing, and eliminating uncertainties. The system includes nine interconnected modules that form a closed adaptive management loop. It combines natural language processing (NLP) tools, multi-criteria analysis (MCDA), machine learning, and predictive analytics algorithms that allow risks to be assessed before they actually occur. A key feature of the system is its ability to self-learn – after each management cycle, it accumulates experience and improves the accuracy of its forecasts and recommendations.

Thus, the proposed approach forms a new paradigm for managing complex IT projects, in which the main focus is not on fixing deviations, but on actively preventing risks through controlled reduction of uncertainty. Integrating the described model into project management practice will increase the predictability, adaptability, and sustainability of IT projects even in conditions of technological novelty and organisational turbulence.

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