

## METHODOLOGIES AND VISUALIZATION TOOLS OF EFFECTIVE PROJECT MANAGEMENT

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**Abstract:** In the article reflections on graphical methods and techniques used in improving project management are presented. Based on the conducted research, was noted that in the majority of informatics tools, the creation methods of Gantt's Chart and network techniques are being used, that allow graphs' presentation showing project's schedule task, where the time is a primary variable. It is not possible, by the model of graphics technology used in other areas, such as in medicine, cartography and architecture, browse simultaneously on several project's levels a number of parameters, which are together in specific relationships and dependencies, that have an impact on decision-making by the project manager and appropriate course of the subsequent stages, which in turn will ensure the achievement of adopted objective.

**Key words:** project management, network techniques CPM, PERT, GERT, infographics, volumetric visualization, rendering

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### Introduction

The response to dynamic changes in the present day and dealing with a huge amount of information, excessive markets' requirements, finding new production, service and cost reserves, is the searching for new methods of Polish and Romanian organizations management, regardless of industry and its size. Recently, in the organizations of these countries, the concept of project management system deserves recognition of. Interest in the projects' implementation has increased since Poland and Romania entered to the European Union, and especially since 2008, when the possibility for greater use of financial support from EU funds for Polish and Romanian companies reconstruction and modernization, has arisen. The need to search for new methods and tools for managing business entities has increased the importance of projects' implementation and realization.

The main factors justifying the use of project management techniques to improve organization management are: the struggle with competitors, forcing the introduction on the market more and more personalized products and services dedicated to limited groups of customers, innovative solutions and technologies in production and service area implementation, the need for innovative reorganization of management methods in the pursuit of teamwork, joint problem solving

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and responsibility for the company's future (Głodziński and Marciniak, 2016). Interdisciplinarity and complexity of the project management system, especially in company's modernization, is associated with uncertainty and risk. To reduce it, and at the same time streamline next stages of the project, tools that increase the likelihood of success should be used. The verified solution in many fields of research are graphic methods and data and information presentation techniques, which use humans perceptual abilities for rapid association and irregularities perception of observed picture, streamline complex analysis, drawing conclusions and making decisions.

### **Project Management System Concept Basis of Strategic Planning**

From the beginning of time, people are involved in projects, concerning many activities that fascinate till today. Structures that without the use of specialized equipment have been built in the III BC are admirable and till today amaze not only its appearance but also the ability of builders in the field of management components such as planning, organizing and controlling the implementation of the project on such a large scale. The following pyramids: Pyramid of Djoser at Saqqara next to Memphis city, Cheops pyramid, Chefren pyramid, Mykerinos Pyramid of Giza in Egypt and many more other buildings of this type, built in the following centuries BC, for example in Sudan, Mexico and Peru (Nicholas and Steyn, 2012).

A major building achievement was the oldest city from the VIII BC century, Tell Qaramel located in Syria, consisted of circles, each of which belonged to one family group. Explorers of the city – the Warsaw University staff – stated that each ancestral district was built of stone and silt, and in the center was a tower, and around it houses with a base of supplies have been built. There were extensive, bicameral, with a fireplace and internal walls and was hard to describe them as a primitive. To successfully completed projects can be included, among others Wall of China – defense system consisting of natural dams, the network of forts and watchtowers or Angkor Wat in Cambodia – the largest ecclesiastical building in the world, architectural jewel of the championship perspective and proportions ([www.national-geografic.pl](http://www.national-geografic.pl)).

Both in ancient era and in subsequent builder's periods the project management system on a large scale was well-known (Nicholas and Steyn, 2012; Kautz, et al., 2016). Since the beginning of the twentieth century, the development of the project management system concept was connected with the need for complex projects realization that require modern methods. To cope with then political – economic demands, the interest in the use of general systems theory, the basics of which was formulated in 1932 by Ludwig von Bertalanffy, Austrian biologist and philosopher, has grown. He believed that a systemic approach is to understand the individual elements making up the phenomenon or problem, and the capture of the relationship and interaction between these elements, together with the identification

of all factors that streamline or inhibit the final success achievement (Bertalanffy, 1984).

It can be concluded then that a systemic approach to project management is not an invention of the last century; it was only recalled and disseminated in connection with its preferred aspects of the activities of economic entities having problems with adaptation in a complex and turbulent environment. Any project's realization, that in the current reality does not concern the selected tasks only, but company's entire operating activities, takes place in a particular environment, the parameters of which have a significant impact on its ultimate success. Response to the growing pace of changes in the modern world is the growing interest in issues related to the effective project management, treated as a strategic force intensifying the possibilities and opportunities of each company. It should be noted that companies which put on permanent development, providing a satisfactory position on the international markets, tend to design the implementation of its activities, which transform into an organization managed by the projects, based on the paradigms of knowledge management and customer-oriented management concept as well (Gareis, 1991; Sense and Antoni, 2003; Tabor, 2015; Asnina et al., 2014).

This type of business is characterized by high flexibility in all operating areas, which is useful and beneficial in modern reality, but very risky. Entities oriented at project management must have the ability to synchronize the dynamic transformation of the environment, changing requirements and expectations of customers with an internal reorganization of perfecting steps to achieve the adopted goals and achieve the desired effects, offsetting the growing in such cases risk. That is why organizations characterized by the project maturity must operate at the system level, which determines the choice of appropriate and modern methods, technologies and tools to support project management, and consequently generates the knowledge necessary in perspective management of the company through the project.

### **Methods and Methodologies in Project Management System**

Project's definitions commonly found in the literature of a subject are relatively intuitive; both have many similarities and differences, which do not provide unambiguous formulation of this concept. Generally it can be said that the project is organized activities characterized by complexity, uniqueness, clarity, creativity and innovation, using modern methods and tools to improve their planning and realization within the specified constraints of time, cost, resource and cultural, in order to meet the stakeholders' needs and expectations. For the purpose of determining the project's goals, an S.M.A.R.T mnemonic rule is being used. Subsequent letters characterize the features of adopted targets, namely (Jałocha, 2011; Prywata, 2010):

- S – specific – clearly and specific defined objectives,
- M – measurable – to determine that the achieved adopted goal should be measurable,

- A – achievable, ambitious – achievable and ambitious, performed works and activities cannot be routine, but should require creative and innovative activities, leading to success,
- R – realistic – project’s goals should be realistic, in order to assess the final result,
- T – time bound – project’s realization and goals achievement are limited by timeframe.

The concepts of project and project management are related to each other by factors relating to the use of skills and deepen their knowledge in the field of efficient implementation of subsequent stages with the participation of qualified participants and the use of appropriate methods and tools improving the planned activities implementation. The first innovative management methods were usually created and designated for the military. By streamlining the planning and control processes, the American project „Manhattan”, for the construction of the atomic bomb, which since the use of non-destructive use of nuclear energy by successive modern techniques and technologies and innovative management methods gave rise to the next complex projects in all fields of social life, was completed in 1945. According to the proverb saying that "necessity is the mother of invention", new management methods to improve successful realization of various projects have been created. The most important projects, which have contributed to improvement of further project management methods, are illustrated in Figure 1.

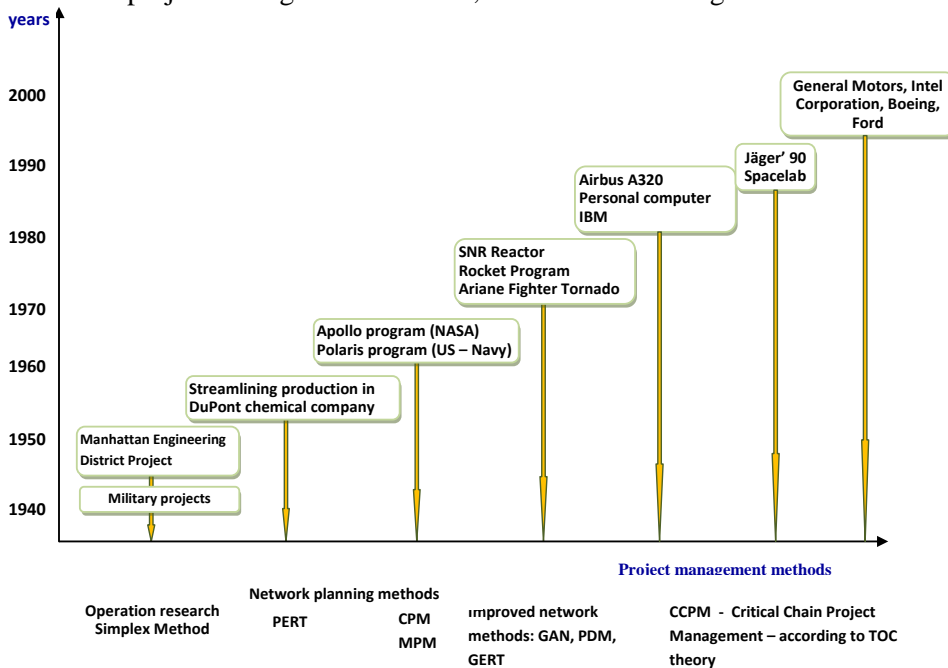


Figure 1. Evolution and improvement of project management methods (Own work based on: Litke, 1995; Nicholas and Steyn, 2008)

The presented methods of solving problems in project management are the basis for creating various kinds of methodologies adequate to the nature of the realizing projects. With the development of the project management theory as a scientific discipline, many solutions to facilitate the manager's work and all project participants have been created. Depending on the project's size and complexity, it may take the form of various methodological models, namely: cascading, incremental, evolutionary, spiral model and prototyping (Szyjewski, 2004).

In general, the methodologies, described in the literature as a set of methods, principles and techniques, determining consistent and logical approach to project management, improving and providing instructions for performing the following tasks and activities, from the planning stage through the intermediate stages until the final result, that achieve the intended purpose, can be divided into traditional, characterized by clearly defined goals and ways of achieving them and alternative as well. The latter depending on the approach to the course of the project concept include adaptive methodologies with a specific purpose, but without concrete methods to achieve them, and agile and extreme methodologies, with the priorities of methods' adaptation, techniques, and final results to the changing needs of stakeholders and environmental conditions. In contrast, depending on the industry and company' types performing the project, applicable methodologies are divided into (Wierzejski, 2014):

- universal – the most popular on an international scale, described as generally accepted standards,
- specialized – designed for specific projects covering the corporate and industry methodologies.

Traditional methodologies most commonly used in project management, and classified for universal are: PMI methodical standard (*Project Management Institute*) and PRINCE2.

The first one is a set of best practices in project management in the form of a guide (*A Guide to the Project Management Body of Knowledge*) – PMBOK, based on experience and analysis of a wide variety of cases occurring in company's different areas and operating conditions. Included subject pertains to knowledge in a field: integration management, project's scope management, time and deadlines management, cost management, project quality management, human resources management, communication management, risk management, supply management. The structure of the PMI methodology complements the matrix of correlations of forty-two processes and techniques relevant to the undertaken subject, necessary to manage the successive phases of the project (Nicholas and Steyn, 2008).

Another popular methodology described as a universal one, and that belongs to the traditional is PRINCE2 (*Projects IN Controlled Environments*), the name of which points to the ability to deliver successful projects in a controlled environment. The British Crown is owner of this methodology, which transferred its administration to the CCTA organization (*Central Computer and Telecommunications Agency*), transformed in later years into the OGC (*Office of Government Commerce*).

In 2013 the company AXELOS Ltd an ownership took over. A set of PRINCE2 standards is the result of the evolution of PROMPT methodology, developed in the seventies the twentieth century by Simpact Systems Ltd. for the purpose of creating information systems for UK Government. This is the concept of project management, which includes detailed instructions on how to plan, organize, manage and control projects, and having in mind the continuous knowledge fulfillment and innovative solutions application to improve the effective implementation of the following processes. The principles of methodology are elements building its foundations on: the legitimacy of the business project, clear definition of roles and responsibilities, stages management, focusing on products, to adapt to the project's environment and the tolerance introduction for the most important parameters – time, costs, benefits and quality of results (*Managing Successful...*, 2009; Wyrozębki, 2011).

In addition to the universal methodologies, sets of rules implementing specific projects called specialist ones can be identified. These include the industry and company methodologies. The first of them are adapted to the specific characteristics of the various countries' economic departments, concerning: Mining industry, manufacturing, construction, transport, finance and insurance, communication with ICT technologies. Methodologies on innovative information technologies, which, due to the key role in every economic area, are the largest group. To the most popular industry methodologies include as follows (Sroka, 2015; Wierzejski, 2014; Chrapko, 2012; DSDM, 2007; *The Values...*):

- *Code of Practice for Project Management and Development* – Code of practice for construction project management and this industry development, developed and published for the first time in 1992 in the UK by the CIOB (*Chartered Institute of Building*).
- HERMES (*Management and Execution of Projects in Information and Communication Technologies*) – an example of a harmonized approach to the projects' implementation in the Swiss public offices, schools and universities. The methodology is especially designed for project management by public administration units at all levels of territorial organization of the state. Developed by the Swiss Federal Administration and continuously modified, streamlines the projects' realization in the areas of: modern information and communication technologies deployment, management of projects financed from public sources and rapid response to the identified needs of customers and the environment.
- Methodology of municipal project management developed by the German Bundesministerium für Forschung und Technologie (Wyrozębki, 2012).
- SSADM (*Structured Systems Analysis and Design Method*) – structural methodology developed by the UK Office OGC (*Office of Government Commerce*) in order to improve the analysis, specification and design of information systems. Widely used standard in the UK public and private sectors. Used and treated as an unofficial standard in Spain and Portugal.

- RUP (*Rational Unified Process*) – classic project management methodology developed by Rational Software Corporation, now owned by IBM. It includes flexible practices of modern software development adapted and expanded adequately to the needs of a particular organization.
- Agile methodologies, formed the basis of the Manifesto for Agile Software Development, developed in 2001, in a Snowbird holiday resort, in the United States by an international group of supporters of the agile new approach to information project management. The most common methodologies in this group are: SCRUM with an iterative character, providing another valuable function as a growth product called "sprints," caring for a high level of self-organization and team motivation; DSDM (*Dynamic Systems Development Method*), developed in the late 90s of twentieth century in the UK as the most structured with fast programming and business advantage achievements attitude; XP (*Extreme Programming*) based to maximize the personal and business values assuming reasonable cost, with a high level of self-discipline, teamwork skills and knowledge. Also methodologies such as Evo (*Evolutionary Project Management*) methodology designed and developed by Tom Gilb from the 80s of twentieth century, used in defining and measuring the business value of both small and large companies such as: Intel, Citibank, HP, IBM ([www.gilb.com](http://www.gilb.com)); AgilePM (*Agile Project Management*) – manual and certification based on a DSDM Atern designed for project manager combining AgilePM with PRINCE2 and ITIL (*Information Technology Infrastructure Library*) standards; XPrince (*Extreme Programming in Controlled Environments*) – methodology developed by J. Nawrocki, from the Institute of Informatics, Poznan University of Technology, the purpose of this methodology is the balance between agility and discipline, the use of traditional principles of project management. XPrince is based on three other methodologies: XP, PRINCE2 and Rational Unified Process (Mastalerz, 2015), are also worth to note.

Company's methodologies adapt project management to the individual needs of specific organization. Despite the high cost of building this type of standards they are justified in the case of very specific, individual projects, not undertaken by other organizations. They are often adapted from universal or industry or own authors methodologies, because usually taken matter concerning scientific, technical and innovative solutions, is deeply known only by the organization's employees. The examples of corporate methodologies are as follows:

- NASA Programm and Project Management streamlining the realization of complicated and complex task burdened with extraordinary risk, but having a national priority. It is a set of procedures and rules of special projects, programs and tasks management in order to achieve the desired results within a certain time, within the framework of the financial resources in line with the programmatic, institutional and technical commitments (Juchnowicz, 2011).

- PCP Produkt Creation Process applied to the innovative products and services development. The methodology supports activities of Building Trust Sika international company, which produces high quality products in the field of construction chemicals and the Royal Philips Electronics Dutch manufacturer of consumer electronics ([www.sika.com](http://www.sika.com)).
- The methodology of European Space Projects Management ASTRA developed by SES (*Societe Eurpeenne des Satellites*). Currently used to manage a group of 50 geostationary satellites providing satellite communications for data transmission and telecommunications (Wyrozębski, 2012).
- The ASAP (*Accelerated SAP*) methodology by SAP company is a set of tested practices and models of informatics solutions implementation (Kale, 2001).
- Author methodologies: the methodology of investment project management developed by german specialists B. Aggteleky and N. Bajny, MLPP methodology (*Lent's Method for Projects' Conduction*) and BFPM methodology (*Business Focused Project Management*) by authors of E. Frigenti and D. Comninos (Kale, 2001).

Particularly important elements of project management are efficient communication and fast flow of information between stakeholders and effective analysis and presentation of information to improve decision-making process. A preferred solution in this regard is the use and proper use of modern tools to optimize the implementation of further steps in the context of the whole project. Innovative methods and tools that provide access to flexibly updated information and knowledge resources are worth to note. They allow for the treatment of complex issues comprehensively, resulting in a holistic look at the processes of project management and decision-making. The significant role play concepts enabling observation and thorough analysis of the existing phenomena and anticipation of various events and situations with using the legible ways of presenting discovered information and knowledge to the managers and decision-makers, with warning against threats at the same time. The most effective techniques in this field are visual methods of presenting information in multidimensional spaces with the possibility of making a different kind of simulations leading to reasonable and rational activities.

### **Project Management Techniques**

Only every sixth organization, excluding informatics companies, begins to apply or is inclined to use flexible agile methodologies. First of all, there are companies that previously used PRINCE2 methodology and its clearly defined framework combines with the flexibility and speed of agile's response. Research and analysis have covered also the types of techniques used to improve the implementation and monitoring of project's activities within the adopted methodologies, used by software developers to streamline project management. During the verification, specified and systematized the ones that are the most popular and most frequently



used. In the first stage of the project generating and problems' solving is carried out, with the help of chosen heuristics methods. Listed in the figure above, techniques are used in the aftermath of each other, for example ANKOT method to the idea's classification after the brainstorming, or in a combination of several methods with the efficient "playing with words" method, metaphorical thinking or the antytemat method, which stimulates the discovery of innovative ideas and their solutions enriched by graphics associations and multimedia creativeness.

In the next stages, adequately to the project's type and complexity, techniques to improve the implementation of individual tasks and works, leading to the project's completion and transfer the results to the user, are used.

The selected techniques are implemented using informatics tools to optimize communication in both, the project team and between all stakeholders, which increase the quality of collaboration and streamline the creation of new knowledge necessary in the implementation of the next projects. The necessity of continuous monitoring and adjustment of how to perform the following tasks and work to ongoing changes in the environment requires the coordination through the use of graphical tools that most effectively appeal to the man imagination.

### **Visual Project Management**

Visualization is an important issue in solving the decision-making problems during the project tasks' execution, especially in a situation when the teamwork's importance is growing. Awareness of the synergies importance, the ability to problem-solving and decision-making in a team and proper communication are the conditioning aspects of achieving success by the team.

In contrast to the working group, in which the manager focuses in its hands decision-making, the team is a group of people with complementary skills, connected by the desire to achieve the target and support each other in their activities. The team makes decisions based on the knowledge and experience of all persons belonging to it, which leads to find better solutions than a single decision (*Stwórz zespół z ikrą...*, 2006). In this context, visualization should be treated as a process of encoding information in the form of a variety of images, which stimulate the imagination and creative thinking leading to finding the best solutions for existing problems.

The tables are most frequently used in the creation of: correlation matrix; risk project that includes various types of risks sheet, the probability of their occurrence, the degree of risk, risk's consequences estimation and proposals for remedial action; statement of cash flow positions with attached commentary; its performance estimation (Pietras and Szmit, 2003), and many reports in the next phases of the project, including the final reporting, summaries and archiving of acquired knowledge.

The above form of information presentation is supplemented by various types of graphs, clearly exposing the profile of the existing dangers and decision trees determining the choice of the best solutions. In further stages of the project's

realization a hierarchical tree structure WBS (*Work Breakdown Structure*) are being used in order to develop labor division in the company, in combination with the checklist in the form of text questions, checking the completeness of the information obtained as well as the Gantt chart tracing execution time of each task and the burden of the project's participants.

With the complex and extensive projects, the above methods do not allow for accurate planning of runtime actions or to identify critical tasks. Then networks methods can be used, which in a sequential manner with the help of arrows and circles, symbolizing activities and events already carried out or have already started, depict the course of the entire project in the identification of actions delay, so critical activities, which duration is equal to the difference the moment of occurrence of the final and initial event, what allows to determine the critical path. Selected graphical tools usually used together, have many advantages and suited for simple projects, but fail in the management of complex and difficult projects, where a large amount of processed information related to the numerous tasks and big amount of employees, causes a lack of logic depending of further activities, the resulted images of information presentation, despite supporting information technologies, are too complex and therefore difficult to read and unclear. Based on the conducted research, the biggest difficulty is to create a flexible schedule, which could be modified on the fly, adequately to the kind of change in the organization and its environment. Another problem is the proper construction of information presentation clearly speaking to the recipient. Therefore it is worth to consider how many information the graph is able to convey, if it is properly matched to the types of possessed information and occurring phenomena, or so popular techniques and graphical tools used for decades, are used effectively in terms of used colors, types of images, photos and text forms (Leach, 2016). It is also important to assess consistently applied by managers, information visualization techniques relating to task plans schedules and their implementation in terms of quantity and choice. In addition to Gantt charts, network diagrams, regular tables and Excel basic static charts, innovative solutions, which, among others, include animations and dynamic simulations, specialized forms of imaging called infographics or volumetric visualization that assure photorealistic, interactive visualizations called rendering are not adapted.

## **Conclusion**

In the current economic reality, every company should strive to achieve the status of the intelligent knowledge-based organization. Increasing complexity and complication of project management processes, causes the necessity of developing and supplementing the methodologies used by modern methods and techniques to improve the generation of critical information and increasing the source of knowledge for decision-making processes at every stage of the project. The most useful methods are those that appeal to the imagination of stakeholders, and especially to decision-makers, stimulating creative activities and creative thinking.

Tools positively influence the perceptions of people are called as visualization. Properly selected tools provide opportunities for effective exchange of valuable information among the project's participants and its clear presentation, which increases the likelihood of accuracy of decision-making and to improve the creativity and innovation in the field of activity of the project. The greatest achievements provide infotechnology use at every stage of the project to visually manage and control the proper flow of information and knowledge.

Information visualization tools integrated with organization's information technology, improve quickly browse the databases of information and knowledge and its transparent mapping according with diverse and necessary criteria to ensure effective management of documents and sending clear, unambiguous results of analyzes and reports on the implementation of the next stages of the project, as well as observation of changes in the environment, playing a significant role in decision-making processes. Using the information visualization at the same time a lot of events to predict future periods can be visualized, it is easy to distinguish stable processes from critical ones. The transition from conventional, ie, verbal and tabular information presentation for dynamic visualization, make it easier to pick up and synthesizes information, that meets its functions, affecting the reduction of uncertainty, minimize errors, and the quality and speed of decision-making at the elimination of risk.

To sum up, the key to success is the accurate planning of the project in terms of organization and the selection of appropriate methodologies and techniques to improve the implementation and control of all tasks. To a large extent this is dependent on the competence of the manager, who should combine qualities innovator, manager and efficient coordinator of the whole project, and strive to implement and make appropriate use of the latest scientific advances to improve the management of the project at every stage. Information visualization is a technique that holds unlimited potential to support complex decision-making processes. However, currently it still requires a lot of research improving existing tools and exploring new possibilities for the use of the telematics's achievements in order to increase their value in the real world of project managers facing with bigger and bigger amount of problems.

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## METODOLOGIE I NARZĘDZIA WIZUALIZACJI SKUTECZNEGO ZARZĄDZANIA PROJEKTAMI

**Streszczenie:** W artykule przedstawiono rozważania na temat graficznych metod i technik stosowanych w usprawnieniu zarządzania projektami. Na podstawie przeprowadzonych badań zauważono, że w większości narzędzi informatycznych wykorzystywane są metody tworzenia diagramów Henry'ego Gantta i technik sieciowych, pozwalających na prezentację wykresów ukazujących harmonogram zadań w projekcie, gdzie podstawową zmienną jest czas. Nie ma możliwości, wzorem technologii graficznych stosowanych w innych dziedzinach jak np. w medycynie, kartografii czy architekturze, przeglądania jednocześnie na kilku poziomach projektu, wielu parametrów, będących ze sobą w określonych relacjach i zależnościach, a mających wpływ na podejmowanie decyzji przez kierownika projektu i właściwy przebieg kolejnych etapów, co z kolei zapewni osiągnięcie zamierzonego celu.

**Słowa kluczowe:** zarządzanie projektem, techniki sieciowe CPM, PERT, GERT, infografika, wizualizacja wolumetryczna, rendering

### 選擇方法和可視化工具作為有效項目管理的基礎

**摘要:** 在文章中介紹了用於改進項目管理的圖形方法和技術的反思。基於進行的研究，注意到在大多數信息工具中，亨利甘特的圖表和網絡技術的創建方法正在使用，允許圖表顯示項目的日程表任務，其中時間是主要變量。通過在其他領域中使用的圖形技術模型，例如在醫學，製圖學和建築學中，不可能同時在幾個項目的層次上瀏覽許多參數，這些參數一起在特定的關係和依賴性中，項目經理的決策和後續階段的適當課程，這反過來將確保實現已通過的目標。

**關鍵詞:** 項目管理，數據和信息可視化方法和技術，甘特圖，網絡技術CPM，PERT，GERT，圖表，體積可視化，渲染