

## A STUDY ON MULTI-PROJECT MANAGEMENT IN THE MINING AND GEOLOGY SECTOR IN SERBIA: A CASE ANALYSIS

T. Stanković<sup>1#</sup>, T. Radojević<sup>2</sup>, I. Jovanović<sup>1</sup>

<sup>1</sup>Mining and Metallurgy Institute Bor, Bor, Serbia

<sup>2</sup>University Singidunum, Belgrade, Serbia

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### Abstract

This paper describes the basic concept of multi-project management in the science and research organizations in Serbia and worldwide. A brief discussion was held on the sources of funding for these projects, and several proposed solutions to problems that may arise in the management of projects in the field of mining, were considered from the perspective of worldwide practice. An overview of completed projects in the field of mining and geology in the period from 2010 to 2023 is given using the example of a case study of a selected scientific and research organization, the Bor Mining and Metallurgy Institute, by type and number of projects and sources of funding. A brief analysis of the success of multi-project management in this institution was carried out. Considering the years of project development, it was determined it was found that the greatest success of multi-project management has been achieved in the last five years, which indicates the good business strategy of the Institute. The financing structure has shown that the largest number of projects in this institution, in the given period was financed by the private sector, i.e. the Chinese mining company Serbia Zijin Copper Bor (formerly RTB Bor).

**Key words:** multi-project management, financing, project, portfolio, case study.

### 1. Introduction

#### 1.1. General concept of the multi-project management in the scientific and research organizations

The concept of multi-project management is found in the organizations dealing with different fields of activity and having in common that their portfolio consists of not just one, but several projects that form the basis of their business. The scientific and research organizations are typical representatives of such organizations. Their business activities are carried out precisely through the development and implementation of numerous projects of various types, depending on the field for which they are registered. For the effective management of numerous and diverse projects, it is not enough for a scientific and research organization to have the staff, organization and other prerequisites for the successful management of individual projects, the prerequisites for implementation of the multi-project management must also be in place [1].

The concept of multi-project management is an important factor in integrating the key functions of any organization, especially a science and research organization [2]. According to Levine, 2005 [3] multi-project management is a comprehensive system, i.e. the management principle of a large number of projects (portfolio) as an integrated whole of all projects of a scientific and research institution, and all with the aim of realizing its tasks and vision [3]. At the same time, the project management, i.e. management of individual projects, is one of the essential components of the multi-project management model [4]. In this context, the established and effective project management process is an essential prerequisite for introduction and implementation the multi-project management process in the organization.

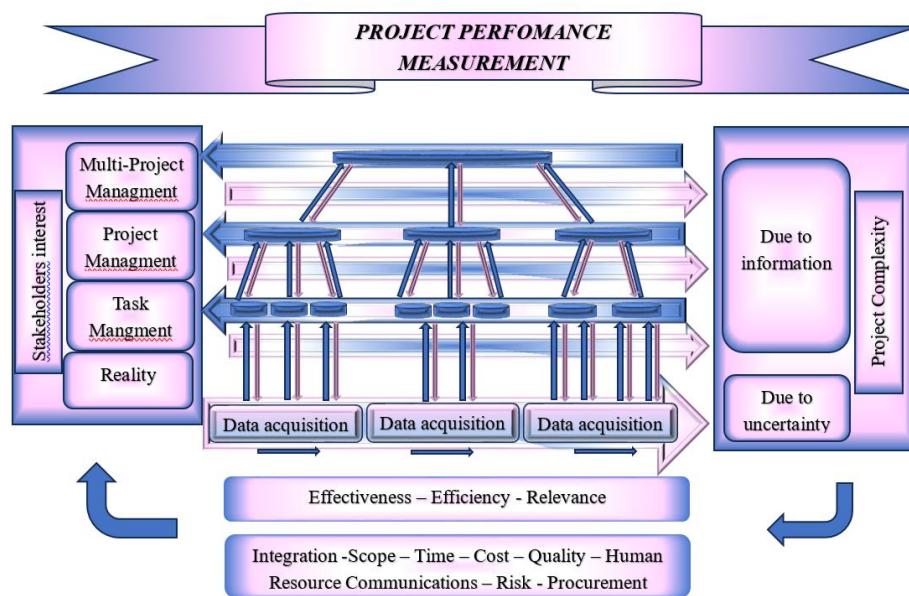
When projects are selected for implementation in the organization (as a phase of multi-project management), they move from the competence of multi-project management to the competence of project management (see Figure 1) [5]. These facts point out

how the management of individual projects and multi-project management are the related and mutually dependent processes [6]. The specific culture and values of the employees are also very important in an organization that introduces and implements the multi-project management. Some of the specific cultural values of a multi-project organization, in the context of adopting the concept of multi-project management, are the following:

- Projects are seen as strategically important elements that, on the one hand, enable the implementation of business strategy, and on the

other, influence the business strategy;

- Autonomy and self-organization of the projects is enabled by the top management;
- Leadership implies the ability to recognize the vision and strategy of the organization, but also to connect them with the organization projects;
- Continuous development and survival of the organization should be based on the projects;
- Project management is not considered as a competence and qualification of the specific professionals, but is most closely related to the general management and all its owners [7, 8, 9].



**Figure 1** Project implementation measurement hierarchy

Based on a well-developed model, the multi-project management process is introduced and implemented in ten steps in accordance with the generally accepted world PMI (Project Management Institute) standards for project portfolio management: (1) categorization; (2) identification of opportunities and needs; (3) evaluation of options; (4) selection; (5) prioritization; (6) portfolio optimization and adjustment; (7) authorization; (8) implementation and planning of projects; (9) portfolio status reporting; (10) portfolio improvement [10].

### 1.2. Project financing in the scientific research organizations

The portfolio of the scientific and research organization projects is mainly dominated by the so-

called R&D (*Research and Development*) projects, i.e. the scientific and research development projects that include a wide range of activities with the aim of knowledge improvement, development the new technologies and improvement the existing products or processes [11]. These projects are very demanding in terms of the scope and investment period. These are expensive and long-term projects that require the stable and long-term financing in terms of providing the funds needed to implement the project. The sources of funding for the science and research projects can be internal or external, depending on which science and research organizations carrying them out. The internal funding sources are the resources of organization itself and include the use of profits, reserves, sale of assets or reinvestment of income into projects. External funding is

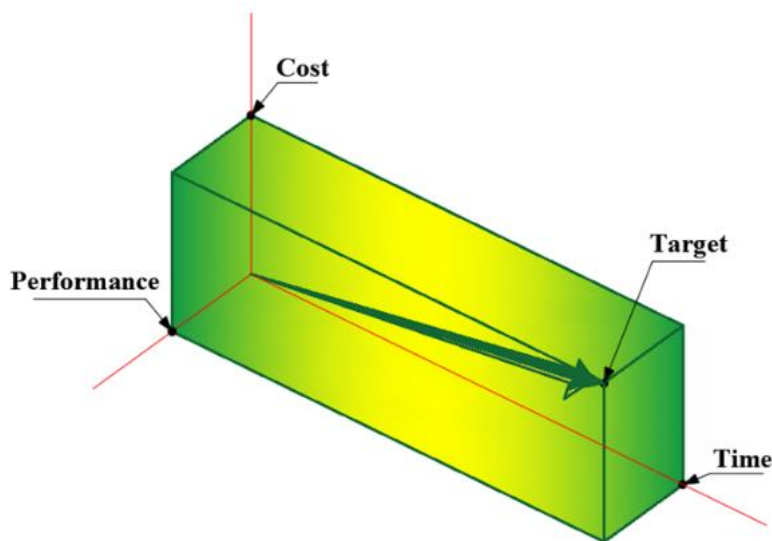
a type of funding where funds are requested from sources outside the organization. The external funding sources in the broadest sense can be: the profit organizations, the government, the private non-profit sector, international funds and others [12].

In addition to the R&D projects, many scientific and research organizations are engaged in the development of projects for commercial purposes, mainly funded by the profit-making companies.

## 2. Multi-project management in mining

Nicholas and Steyn [13] stated that the goal of any

project is to hit a three-dimensional target: complete the work for a customer or end-user in accordance with the budget, schedule, and performance requirements. They proposed the concept of project goal as a target point in the three-dimensional space (see Figure 2), where the budget represents the total project costs, schedule is the time period specified for finishing all demanding tasks, and performance requirements are related to the "project end-item, deliverables, or final result, including necessary attributes of the final product or service, technological specifications, quality and quantity measures, and whatever else is important to the customer or end-user [13].

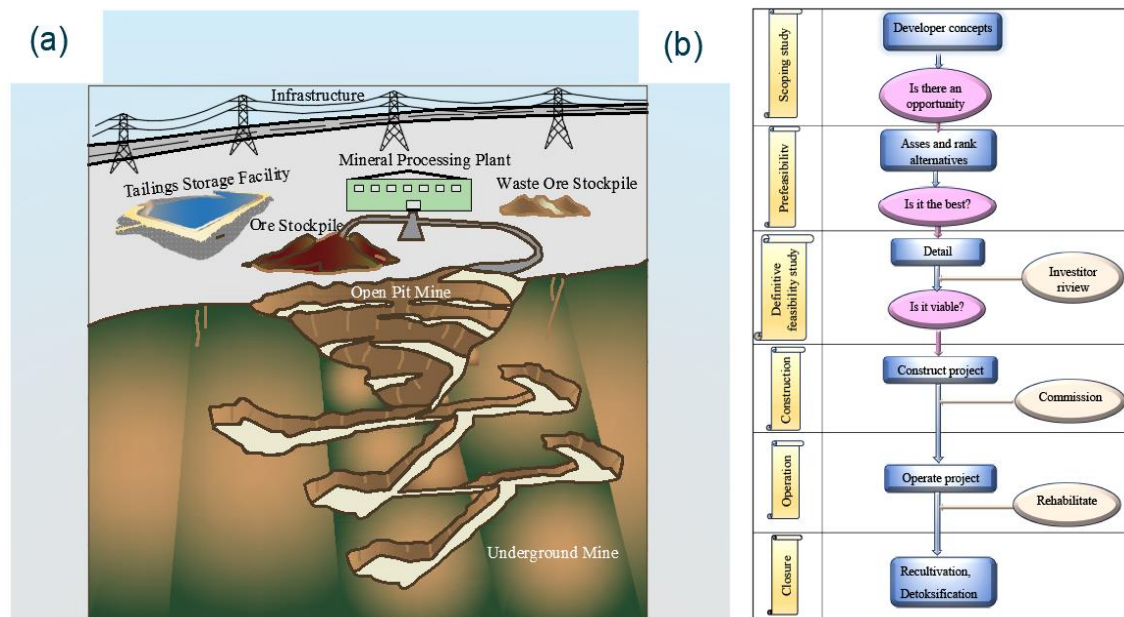


**Figure 2** Project target represented through three dimensions

In order to achieve this goal, especially when it comes to the management of multiple projects, it is necessary to see all the influential factors that may be important for the success of each project implementation. According to Riesener et al., 2023 [14] the critical success factors in the multi-project management are: (1) competence and skills management; (2) identification of bottleneck resources; (3) limitation of ongoing projects; (4) consideration of economic aspects due to project delays; (5) use of cycles or cadence; (6) flexibility; (7) decision support by the digital tools (& AI); (8) realistic project planning and (9) global controlling of the multi-project environment. It is also believed that the risk management belongs to this list [14].

Knowledge of critical factors is of great importance

for multi-project management in general, and especially in the mining sector, where a large number of scientific disciplines are interwoven within the framework of various types of mining projects, ranging from the scientific and exploratory ones to the projects, developed for the economic issues, such as: Geology, geomechanics, exploitation, mineral processing and processing technology, construction, mechanical engineering, electrical engineering, automation, environmental protection, occupational safety, economic analysis, etc. For example, the design and construction of a mine, processing plant and infrastructure represent a very complex and risky business endeavor, with a large number of steps that need to be taken during the various phases of research and design (see Figure 3) [15].



**Figure 3** Schematic view of a mine design:  
(a) Representative mining project facilities (b) Mining project development framework

## 2.1. Challenges and solutions

By considering, identifying and optimizing the effect of critical factors in all of the above phases, given in Figure 3 (where each of these project phases serves an important purpose and requires a specific set of management skills [16]), it is possible to achieve the successful multi-project management in the area of mining [17]. Various researchers give suggestions on how to improve the project company performances as effectively as possible and to overcome some of the problems arising during development of this project type.

High competency and skill management enable the good project performances [14]. Litvinenko et al. 2022 [18] stated that the level of professional competence, education and technical, managerial and leadership skills of the mining company engineers represent the equivalent of a trust in such activities of the company, its development and ability to meet the environmental, social and governance principles and sustainable development goals [18]. Kowszyk et al., 2023 [19] described how the management conflict in the mines from four Latin American countries (Chile, Mexico, Brazil and Peru) can have a negative impact on the social, environmental and economic circumstances [19].

According to Riesener et al., 2023 [14], the identification of bottleneck resources in the multi-project environment is not easy due to a high complexity, but usually the employees with special skills represent the bottleneck resources [14]. For this reason, a mining company approach to human resource management policy is very important. Rubbers, 2020 [20] gave an example of the human resource management policy of the new mining projects in the Congolese Copperbelt [20]. Recognizing the resource bottlenecks and seeking the optimal resource allocation scheme is crucial to achieve the overall optimization of the project schedule and resource arrangement [21].

In the multi-project management, it is very important to keep the number of ongoing projects under control (not to run too many projects at once), and the probability of timely project completion can be usually increased by setting an appropriate project buffer [14, 22, 23]. Therefore, the project company must also predict the solution of the multi-project scheduling problem and consider the economic aspect (potential reduction of profit), if penalties are to be paid due to the project delays [14, 24]. As an important step in the multi-project management strategy, Riesener et al., 2023 [14] recommend working in fixed cycles (cadences) that "create a flow and improve the planning accuracy".

The use of various digital tools (including artificial intelligence methods) to aid management decision making, is highly desirable considering the mining institutions involved in planning [25, 26]. There is a whole range of the project management software on the market that can be used for this purpose [27]. Also, a potential of artificial intelligence to contribute to the effectiveness of the project management is not negligible [14]. For example, Ben Kraiem et al., [28] proposed the machine learning algorithms to select the appropriate project management methodology. Zhang et al., 2020 [29], described a deep neural network-based ant colony optimization algorithm for estimation the capital costs of the mining projects which can be used in development of the mining projects.

Simultaneous multiple-project management in the research institutions can be very difficult, short-period and high-risked. It is very important to select the appropriate projects and also to rank them according to the mission, orientation and plan of strategic development [21]. Flexibility and realistic project planning play an important role in this strategy [14].

Mastering the multi-project environment and risk management are crucial for any project success. According to Santos et al., 2023 [30], the project control involves monitoring the progress and performance of the project, controlling the expected results and taking the necessary corrective actions if there is a deviation from the original plan [30]. On the other hand, the mining projects are exposed to a high risk due to the complexity, size, uncertainty and high cost [31, 32]. Importance of the risk management in the mining projects is described through several practical examples. For example, Chinbat, 2011 [31] provides an extensive analysis of the risk management process in the mining projects, based on practical experience from Mongolia, until Badri et al., 2013 [33] proposes a risk management methodology in the underground mining projects in Quebec, Canada. Jiskani et al., 2022 [34] and Kamel et al., 2023 [35] combine a risk analysis for mining projects with artificial intelligence. Other also describe the problem of risk and uncertainty in the mining projects in different countries - Germany [36], Turkey [37] and Gabon [38].

## **2.2. Multi-project management and financing of the projects in the scientific and research organizations in Serbia**

Considering the multi-project management, the

scientific and research organizations, as well as the business companies in Serbia have undergone many trials and challenges over the past decades. The fact is that the transition period in Serbia towards Europe and the world is still ongoing, so the challenges facing the scientific and research organizations, dealing with the multi-project management, are specific. Factors affecting the multi-project management in the science and research organizations in Serbia are:

1. Limited resources - Science and research organizations in Serbia often face limited financial resources for research, including funds, equipment and employees, which can be challenging and stressful.
2. Administration and regulations - Science organizations in Serbia often have to navigate complex bureaucratic processes in order to obtain funding and other resources for their research projects. This can slow down the decision-making and project deadlines.
3. Brain drain - Serbia is facing a significant brain drain. Many highly qualified researchers are leaving the country to find better opportunities abroad. This can lead to a shortage of experienced researchers, making it difficult to effectively manage the numerous research or economic projects.
4. Lack of collaboration and communication - Collaborative research is crucial for scientific progress, but scientific organizations in Serbia often struggle with cooperation due to the limited resources and competition for funding. This can make managing multiple projects that require collaboration between different teams and departments a challenge [39, 1].

The aforementioned statements generally apply to all sectors, including mining. To overcome these challenges, the scientific organizations in Serbia need to implement effective project management practices that prioritize resource allocation, communication, and collaboration. The effective project management tools, including project management software, can help organizations to manage the multiple projects more efficiently and meet their research goals. In addition, more intensive cooperation and partnership with the other organizations in Serbia and abroad can help to the scientific organizations in Serbia to gain access to the resources and expertise for the effective multi-project management [40].

The project funding models are used in the scientific and research institutes in the field of mining to provide

the funding for research projects related to mining. These projects may include the research, development and optimization of mining processes and technologies, as well as the environmental and social impact assessments.

Some of the project funding models that can be used in mining science and research organizations are:

1. Grants from government agencies, non-profit organizations and private foundations to support their research projects;
2. Corporate funding - mining companies can provide funding to academic and research organizations to conduct the research related to mining processes and technologies;
3. Joint ventures - the scientific and research organizations can partner with the mining companies or other organizations to carry out the mining-related research projects;
4. Public-private partnerships - where public sector entities can provide funding and regulatory support, while private sector entities can provide technical expertise;
5. Corporate partnerships - where mining companies can partner with the scientific and research organizations in order to fund the research projects that align with their business objectives;
6. Donations from individuals or organizations can provide funding for scientific research;
7. Consortia - this approach involves the formation of consortia for joint funding and project management [40].

It is important for research organizations to carefully evaluate the advantages and disadvantages of each funding model and choose the one that best suits their needs.

### 3. A case analysis

The Mining and Metallurgy Institute Bor (abbreviated to MMI Bor) is presented as an example of a scientific and research organization in Serbia that successfully manages multiple projects in the field of mining.

The Mining and Metallurgy Institute Bor is a scientific and research institution, owned by the Republic of Serbia in the fields of research, design, production and processing of mineral raw materials. Today, the MMI is a leader in the country and one of the most important institutions in Southeast Europe with its human and technical capacities and financial stability. It also represents one of the most important supporters of

scientific and research development in the field of mining.

The MMI Bor, as a part of its scientific and research activities, develops the scientific and research projects in the fields of geology and mining and conducts research in the field of exploitation of deposits and preparation of metallic and non-metallic mineral raw materials [41].

In addition to scientific and research work the Institute realizes the preparation of expertise and studies, pre-investment and investment studies and projects, investment programs, investment-technical documentation, project studies and other investment documentation for the implementation of investment works in the country and abroad, in the field of geology and mining, which are of interest to the Republic, the region and local self-government, as well as within the scope of work in the field of environmental protection and ecology (recycling of waste and other materials) [41].

The period from 2010 to 2023 was selected to analyze the success of the multi-project management in the MMI Bor. The number of completed projects was defined by the type and year of development (or the start of implementation, in the case of the scientific and research projects), taking into account all the realized projects in the field of mining and geology. The study includes projects prepared in the form of investment and technical documentation in accordance with the Law on Mining and Geological Explorations ("Official Gazette of RS", No. 101/2015, 95/2018 - other laws and 40/2021), then technological research in the field of mineral processing, environmental impact studies related to mining facilities, as well as scientific and research projects from the national and international cooperation programs. Figure 4 shows the type and number of projects by year of development/implementation. Figure 5 shows the percentage share of projects by year of development/implementation. The presented data were obtained from the MMI archive.

For the purpose of clarification, Table 1 describes each type of project documentation in more detail.

Over the last 14 years, the Institute has been involved in the development a total of 146 different types of projects in the field of mining and geology. Based on the data from Figures 4 and 5, it can be clearly seen that the progress has been made in the field of multi-project management in the MMI Bor over the last 5 years. In the observed period from 2010 to 2023, 50% of the projects were developed in the last 5 years, compared to the

previous nine-year period 2010-2018, in which 50% of the projects were also placed in the mining and geology field. This means that the MMI has almost doubled the production of project documentation in the last 5 years, which speaks for a good organization and adequately implemented rules of the multi-project management. It should be added that the MMI employs highly skilled staff in the fields of mining, geology, mechanical engineering, electrical engineering, construction and economics with a modern software support for development all types of projects.

Besides the employees, software tools are also available for modelling and designing in fields of geology, underground and open pit mining, mineral processing, pyrometallurgy, electrometallurgy, refining, mechanical and electrical engineering, automation engineering, civil engineering, development and

application of hardware and software, industrial informatics, etc. Some of the licenced software programs in the field of mining and geology that MMI has at its disposal are GEMCOM v 6.1.4.; MINEX v 5.2.1.; MINESCHED; SLOPE/W)

Some of the efficiency factors that have contributed to the increase in the number of successfully placed projects in the last 5 years of the Institute's work are:

- introduction of even more modern software tools that enable more efficient and faster problem solving,
- employment of qualified personnel,
- good work organization and well-thought-out prioritization of projects on the time scale,
- good employee motivation and improvement of working conditions (working environment and financial moment).

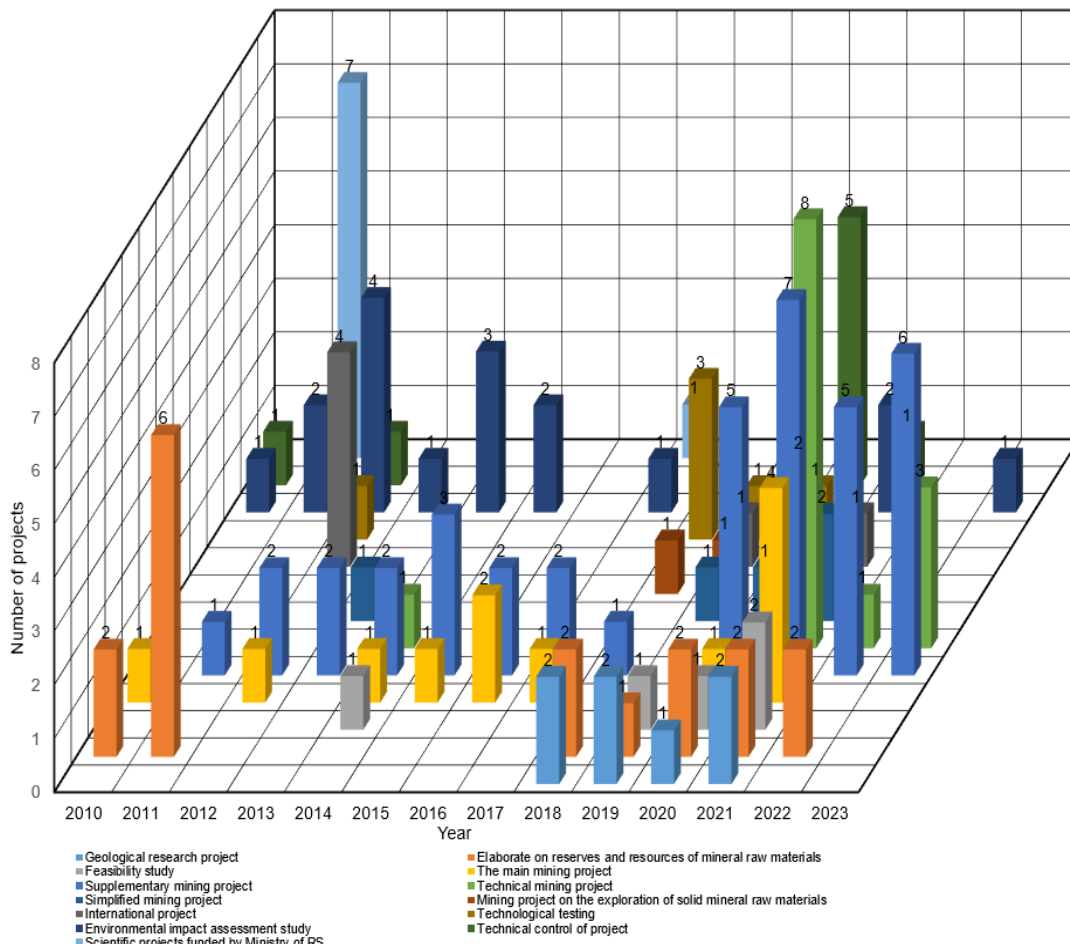


Figure 4 Type and number of projects developed/implemented in the MMI Bor in the period from 2010 to 2023

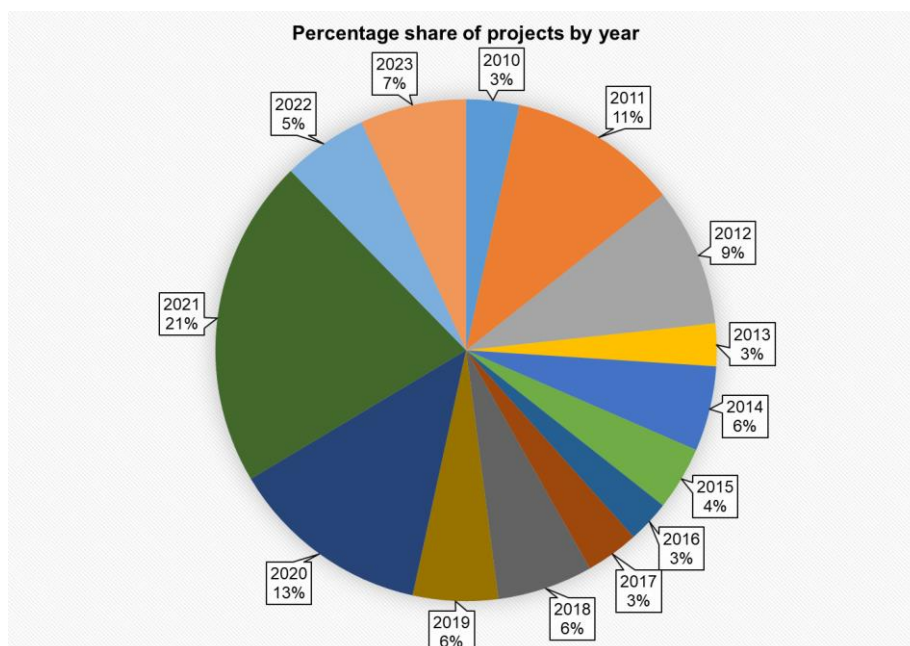


Figure 5 Percentage share of projects by year in MMI Bor

Table 1 Description of project documentation

|  |  |
|--|--|
| Geological research project                                      | Describes geological and mineralogical characteristics of the research area, classification and categorization of mineral reserves.  |
| Elaborate on reserves and resources of mineral raw materials     | Document on the results of geological research of a specific deposit of mineral raw materials, the quantities and quality of researched raw materials or resources, their classification, technical possibilities and exploitation conditions, as well as the expected economic effects. |
| Feasibility study  | Describes the conditions and conceptual solution of the method of exploitation and preparation of mineral raw materials.   |
| The main mining project  | The project of exploitation, maintenance and construction of new underground and surface mines as well as facilities for the processing of mineral raw materials.  |
| Supplementary mining project                                     | Project that is created for deviations from the main mining project.   |
| Technical mining project   | Project that is prepared in accordance with the main and supplementary mining project for the technological operations of mining works.  |
| Simplified mining project  | For all minor deviations from the adopted technical solutions processed in the technical project.  |
| Mining project on the exploration of solid mineral raw materials | The project on the basis of which mining works are carried out within the approved project of geological research.   |
| International project  | A scientific research project that involves international cooperation.   |
| Technological testing  | Laboratory experimental research in the field of mineral processing.   |
| Environmental impact assessment study                            | Analyzes and evaluates the quality of environmental factors and their sensitivity in a certain area.   |
| Technical control of project                                     | Includes control of the project in terms of compliance with the law and other regulations in the field of mining.  |
| Scientific projects funded by Ministry of RS                     | Project from the scientific research programs funded by the Ministry of RS.  |



The educational structure of MMI Bor is very specific in the context of motivation for organizational change and project development. It is an employee structure that requires a particularly sophisticated and balanced approach when it comes to motivation for ongoing work activities and projects as well as for planned organizational changes. That is why such an organization creates and nurtures special organizational communication, culture and special human resources management, as special aspects of motivating employees to work and change [42].

The management at MMI Bor is quite stimulating in terms of motivating employees to work and change. The activities that receive the most attention, in order to maintain and increase employee motivation, are employee development and rewarding. Regarding remuneration in MMI Bor, material rewards in the form

of salaries presuppose opportunities for the development of employees and their advancement in scientific, research and professional titles. This means that the management of this organization, both materially but largely by intangible rewards, motivates its employees [42].

The projects in the MMI Bor are financed by the profitable third parties from the country and abroad (considering the preparation of investment and technical documentation), then by the Ministries of the Republic of Serbia (national scientific and research projects), as well as by the European Union (international scientific and research projects). Figure 6 shows the type and number of projects by the type of financing. Figure 7 shows the percentage share of projects by the type of financing. Data on the amount of finance were not available.

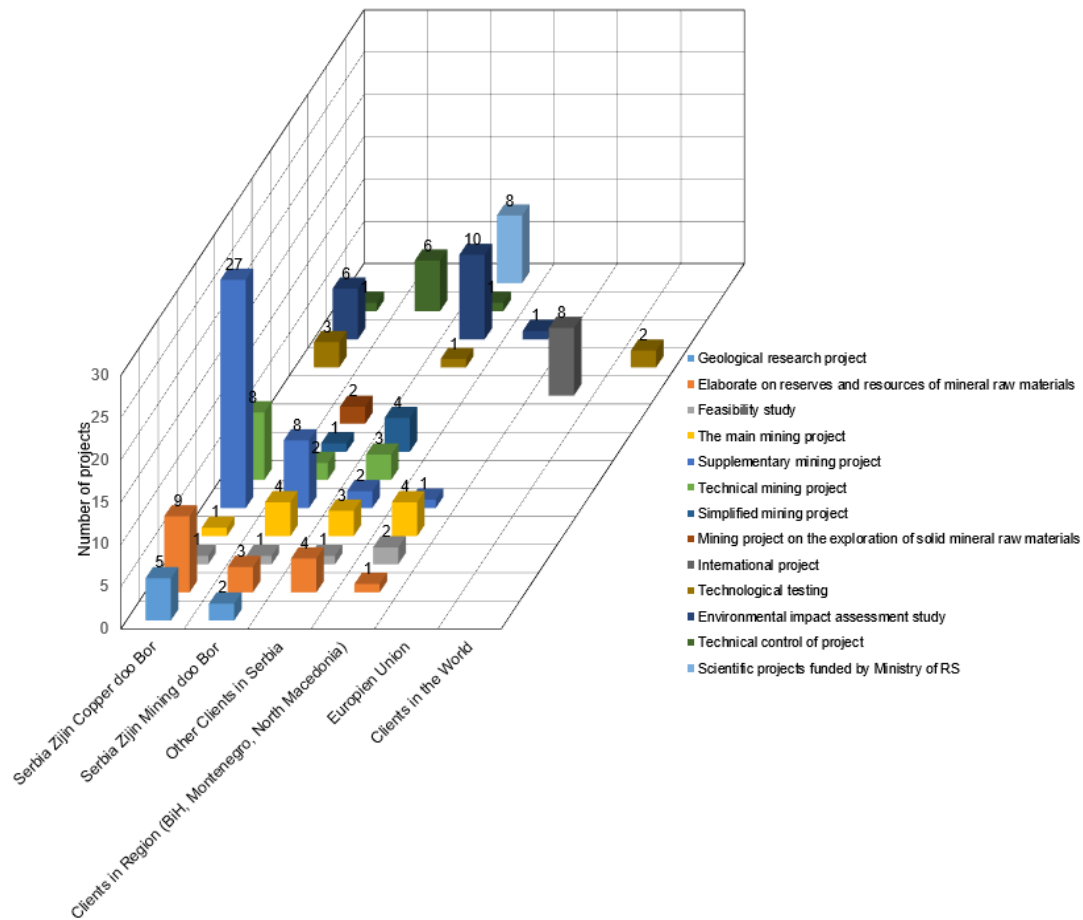
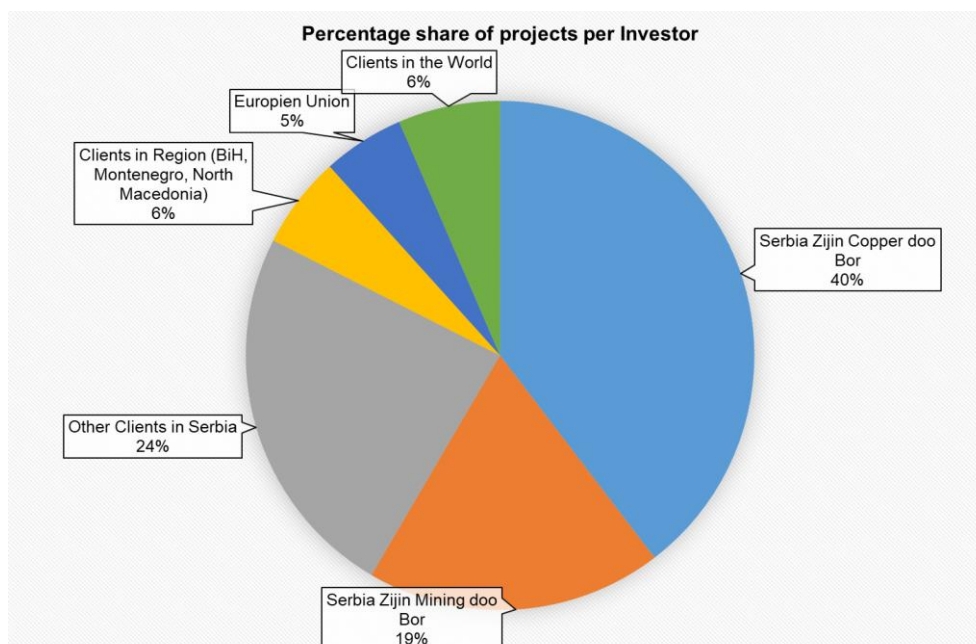


Figure 6 Type and number of projects developed/implemented in the MMI according to the type of financing in the period from 2010 to 2023



**Figure 7** Percentage share of projects in the MMI Bor by type of financing in the period from 2010 to 2023

Figures 6 and 7 show that the largest number of projects, implemented in the period from 2010 to 2023 in MMI Bor, was financed by the third parties, namely the company Zijin Copper doo Bor (former Mining and Smelting Basin Bor) and Zijin Mining doo Bor. This is expected when taking into account the strategic policy of the company Zijin, which is aimed to increase the capacity of all mines in the Bor region. In addition, a significant percentage is occupied by the investors from the Republic of Serbia (24%). Regarding the other types of investments, the business policy of the MMI is aimed at increasing the number of scientific and research projects, financed by the Republic of Serbia and European Union, as well as the number of projects developed for the clients from the countries of the region, Europe and world.

#### 4. Conclusion

The basic concept of the multi-project management is given within the framework of presented research, as well as an overview of influential factors on the multi-project management in the scientific and research organizations dealing with mining.

The Mining and Metallurgy Institute Bor is presented as an example of a domestic scientific and research institution that successfully deals with the multi-project

management. Based on conducted research, the following conclusions can be drawn:

- The concept of multi-project management is found in the organizations that have in common a large number of projects in their portfolio on which their business is based.
- On the basis of a well-developed model, the introduction and implementation of the multi-project management process is carried out according to the defined steps in accordance with the generally accepted PMI world standards.
- In order to implement the successful multi-project management, it is necessary to consider, identify and optimize the impact of a whole range of critical factors in all phases of the project development.
- By integrating scientific research into the management of multiple projects, organizations from the mining sector can improve decision-making processes, reduce risks, improve project performance and promote sustainability.
- The Mining and Metallurgy Institute Bor is a leading institution in Serbia engaged in scientific and research and design in the field of geology, exploitation and processing of mineral raw materials. The project activity of the Institute is presented for the period from 2010 to 2023.

- In the future, the presented MMI model can help both project managers and financiers, to make funding decisions based on resource allocation info, develop risk mitigation strategies and introduce better safety measures and environmental monitoring systems.

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## STUDIJA O VIŠESTRUKOM UPRAVLJANJU PROJEKTIMA U SEKTORU RUDARSTVA I GEOLOGIJE U SRBIJI: ANALIZA SLUČAJA

T. Stanković<sup>1#</sup>, T. Radojević<sup>2</sup>, I. Jovanović<sup>1</sup>

<sup>1</sup>Institut za rudarstvo i metalurgiju Bor, Bor, Srbija

<sup>2</sup>Univerzitet Singidunum, Beograd, Srbija

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### Izvod

Ovaj rad opisuje osnovni koncept višestrukog upravljanja projektima u naučnim i istraživačkim organizacijama u Srbiji i širom sveta. U radu se kratko razmatraju izvori finansiranja ovih projekata, a analizirano je nekoliko predloženih rešenja problema koji se mogu javiti u upravljanju projektima u oblasti rudarstva, iz perspektive svetske prakse. Prikazan je pregled realizovanih projekata u oblasti rudarstva i geologije u periodu od 2010. do 2023. godine na primeru studije slučaja izabrane naučnoistraživačke organizacije, Instituta za rudarstvo i metalurgiju Bor, po vrsti i broju projekata i izvorima finansiranja. Izvršena je kratka analiza uspešnosti višestrukog upravljanja projektima u ovoj instituciji. Uzimajući u obzir godine razvoja projekata, utvrđeno je da je najveći uspeh višestrukog upravljanja projektima postignut u poslednjih pet godina, što ukazuje na dobru poslovnu strategiju Instituta. Struktura finansiranja pokazala je da je najveći broj projekata u ovoj instituciji, u datom periodu, finansiran od strane privatnog sektora, odnosno kineske rudarske kompanije Serbia Zijin Copper Bor (ranije RTB Bor).

**Ključne reči:** višestruko upravljanje projektima, finansiranje, projekat, portfolio, studija slučaja.

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