SmartMiner
SUPPORT SYSTEMS FOR SMART, ERGONOMIC AND SUSTAINABLE MINING MACHINERY WORKPLACES

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# 46th AIM Conference 2024

**Garmisch-Partenkirchen, Germany,**

**September 6, 2024**

# Industrial Engineering Solutions for Smart, Ergonomic and Sustainable Mining Machinery Workplaces: Short Overview of SmartMiner Project

**Vesna Spasojević Brkić**

**University of Belgrade, Faculty of Mechanical Engineering, Industrial Engineering Department**

**Kraljice Marije 16, 11120 Belgrade, Serbia**

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# Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces

## *SmartMiner*

Participating Scientific and Research Organizations (SROs) :

1. **Faculty of Mechanical Engineering; University of Belgrade (FMEUB)**
2. **Technical Faculty in Bor; University of Belgrade (TF Bor)**
3. **Innovation Center, Faculty of Mechanical Engineering; University of Belgrade (ICMF)**

Principal Investigator (PI): **dr Vesna Spasojević Brkić, full professor, FMEUB**

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# SmartMiner focus

- SmartMiner focus - the current problems of the **mining industry**
- SmartMiner offers smart solutions how increase **productivity, safety and sustainability** through **a paradigm shift towards combining a human-centric approach with business strategy in a way that is based on data and analytics**.
- SmartMiner will allow **mining companies to become reliable partners for increasing the prosperity index in society.**

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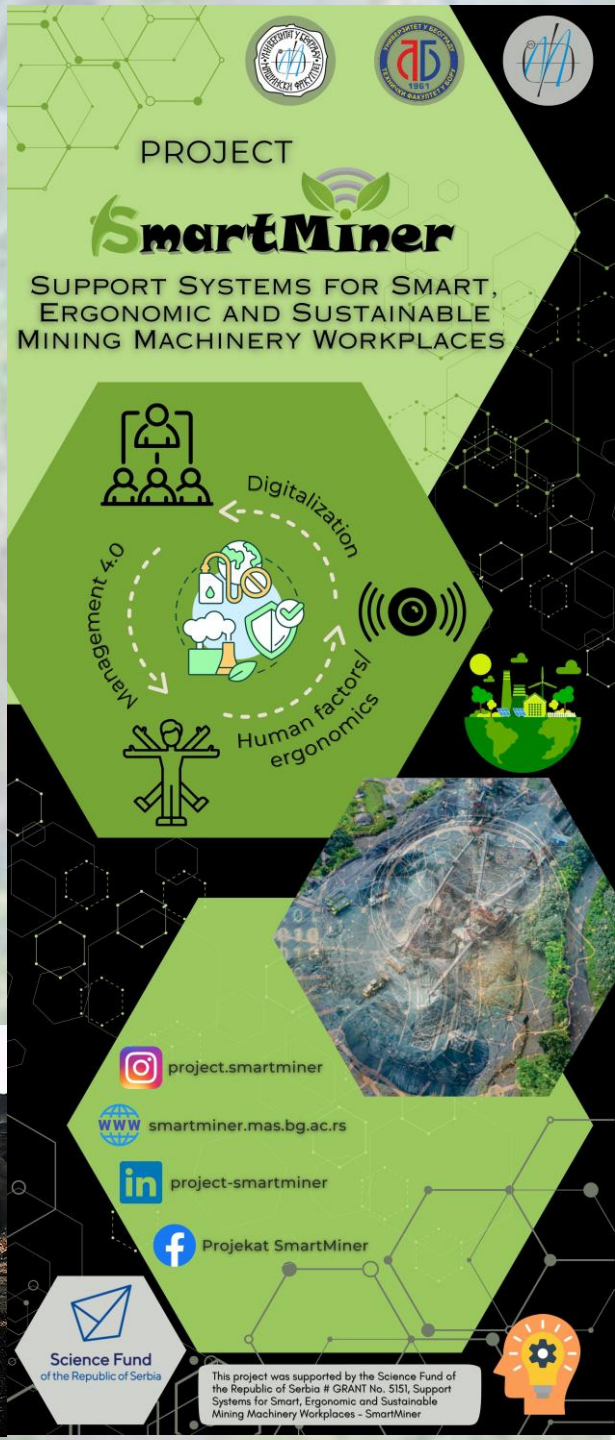

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# SmartMiner aims...

... to give a scientifically based answers to the following questions:

- Are the stoppages of mining machines primarily caused by technical-technological causes and is there a hidden potential in human and/or organizational factors to solve pollution and safety problems?
- How to improve productivity of mining machines through greater satisfaction and high motivation of users (operators) and improved work organization?
- How to improve safety in the operation of mining machines and prevent environmental degradation, population displacement and constant conflicts in the environment?
- How to further reduce the operating costs of mining machines?
- How to solve the challenges related to the extended life of exploitation of mining machinery and increase energy efficiency?
- How to make the mining industry a reliable partner for the development of wealth and prosperity in society?

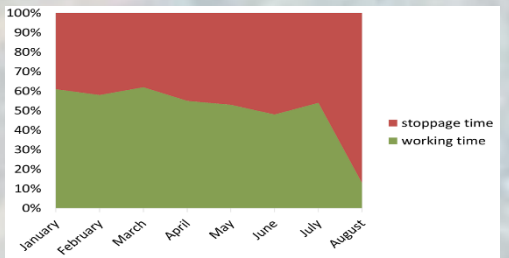


Figure 1. Working and stoppage time of BWE

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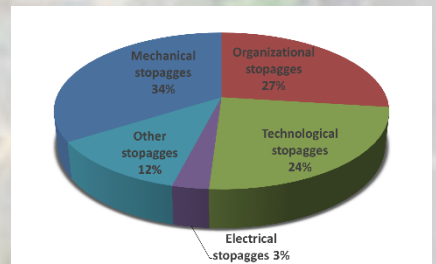


Figure 2. Types of stoppages of BWE

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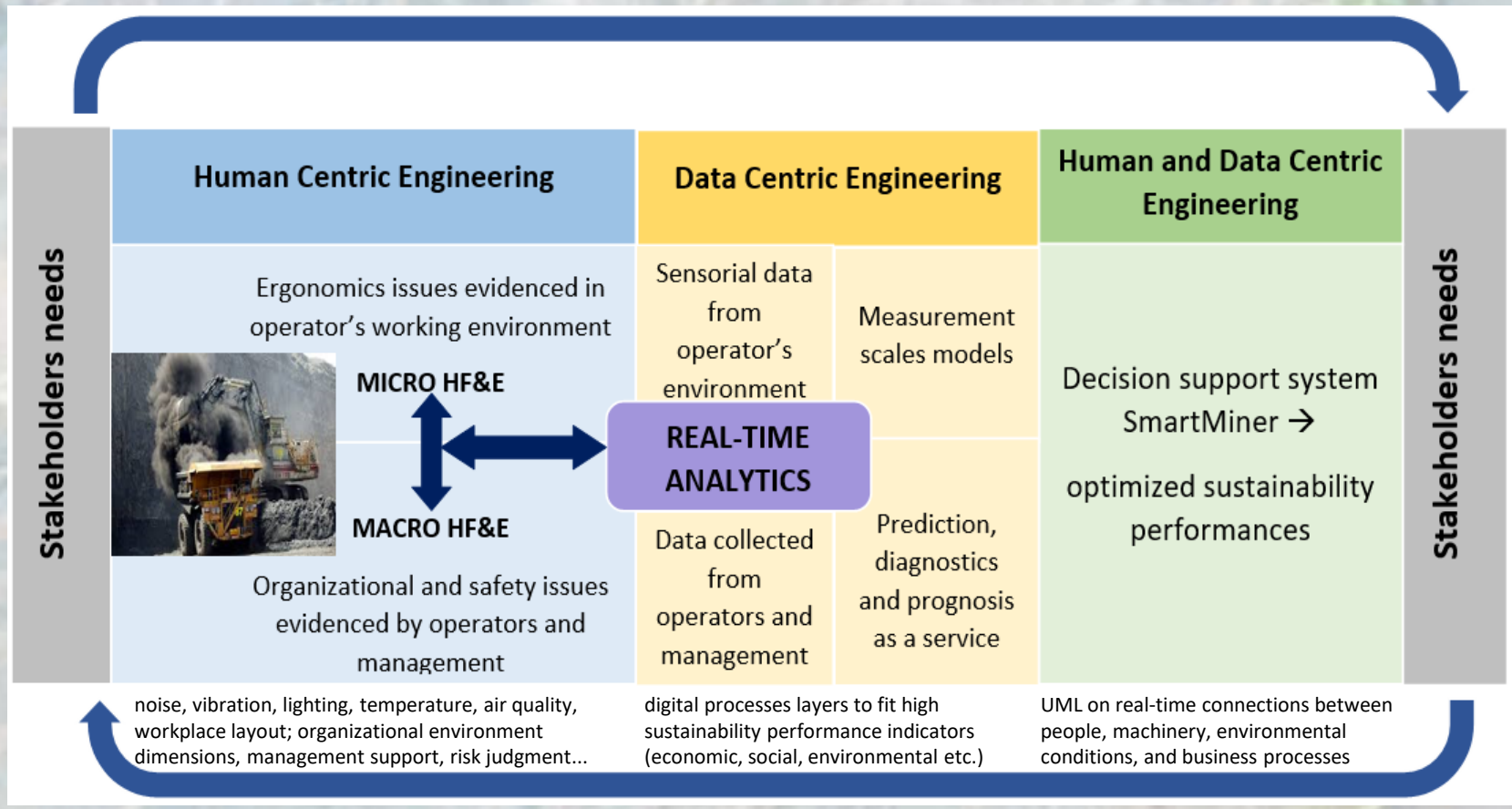
# SmartMiner concept in a nutshell

*"Human will be always in center, and we should keep it so."*

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# SmartMiner hypothesis

**H0:** Necessary step between operator 4.0&5.0 and society 5.0 is “management 4.0”, which means human (and his environment) in the center and raising environmental quality through micro (physical environment) and macro environment levels (organizational environment).

**H1:** Level of necessary digitalization and automation of mining machinery workplace depends on contextual factors – primarily on human and organizational factors.

**H2:** It is possible to prototype innovative support systems: 1. Operator’s ergonomic adjustment system, serving to solve human factors issues and 2. Smart multi-sensorial operator aid system and software system structural description model as constituent, serving to solve both human and organizational factors issues. Both prototypes are prerequisite parts of commercial Decision Support System.

**H3:** If level of HF/E, digitalization and automation and contextual factors are aligned, high value of sustainability index must be achieved.

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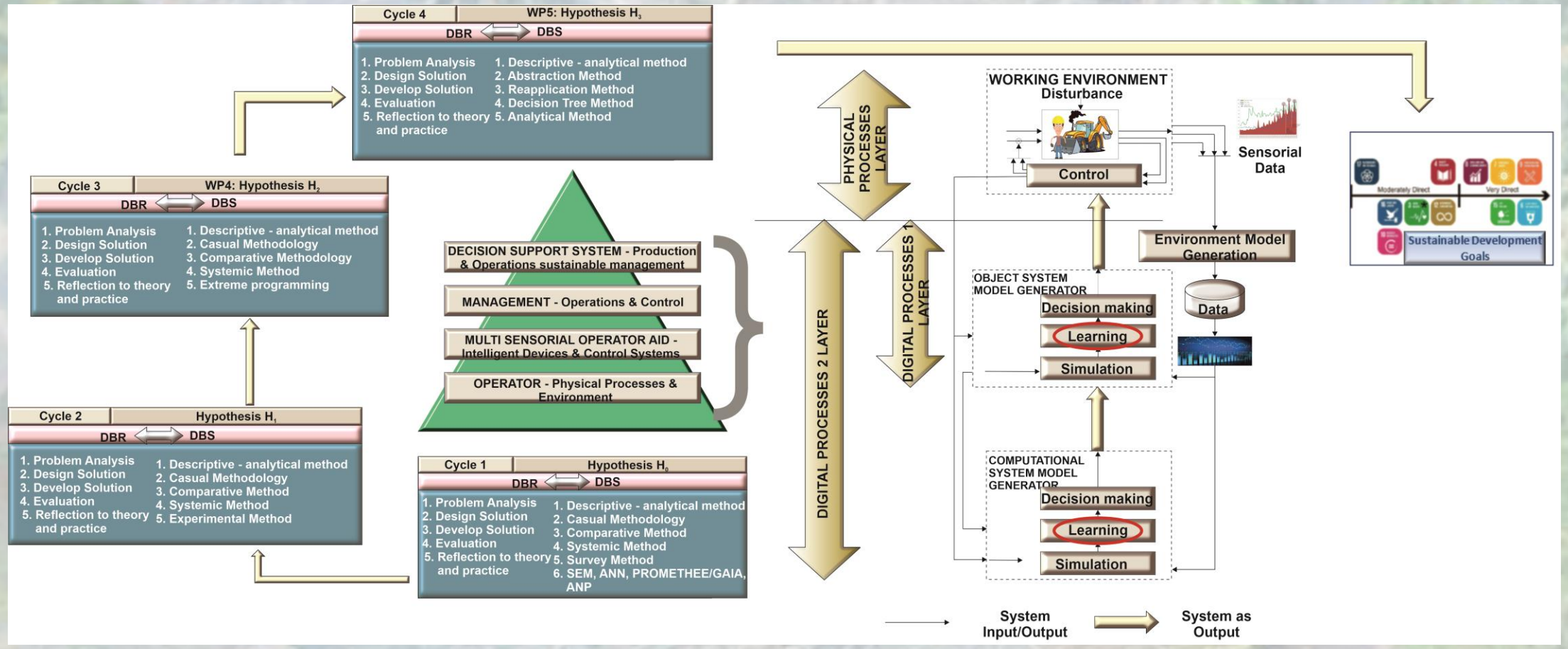
# SmartMiner methodology paradigm

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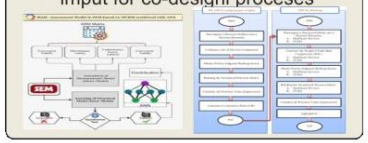
Efficiency
Environment
Trust
Safety
NEEDS UNMET

COMMERCIALIZATION

Decision support system for all organizational levels
New decision system concept
Context-specific multisensorial mining machinery operator aid model
SmartMiner MAIN OBJECTIVES

WP1
Project Management & Coordination
STRATEGY
MEASURE
ORGANIZE
Project Coordinator
ANALYZE
EXECUTE
DEVELOP

WP2
User/Operator & Stakeholders' needs - imput for co-designl proceses



WP5
Dissemination ONE STOP SHOP & Stakeholders Colaboration

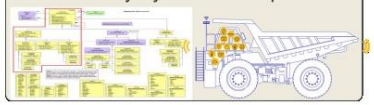
DECISION SUPPORT SYSTEM - Production & Operations sustainable management
MANAGEMENT - Operations & Control
MULTI SENSORIAL OPERATOR AID - Intelligent Devices & Control Systems
OPERATOR - Physical Processes & Environment & HF/E

PHYSICAL PROCESSES LAYER
DIGITAL PROCESSES 1 LAYER
DIGITAL PROCESSES 2 LAYER

WORKING ENVIRONMENT
Disturbance
Control
Sensorial Data
Anthropometric Design Data
Environment Model Generation
OBJECT SYSTEM MODEL GENERATOR
Decision making
Learning
Simulation
Data
COMPUTATIONAL SYSTEM MODEL GENERATOR
Decision making
Learning
Simulation
Sustainable Development Goals
System Input/Output
System as Output

WP3
Development of Multisensonal Operator Aid System

WP4
Smart, Ergonomic & Sustainable Mining Machinery System Development



Not ergonomic
Not smart
CURRENT SOLUTIONS
Not sustainable

Suttounding pollution
Societal acceptance
Low productivity
Employees health care
UNSOLVED ISSUES
Numerous accidents
Numerous maintenance problems

UNSOLVED PROBLEMS
Statistical Analysis & Data Mining
Cyber- phisical system modeling and programming
Ind.Eng. & Manag. Tools
Interdisciplinary
Human Factors and Ergonomics
CSR Co-management Practice

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# SmartMiner and stakeholders

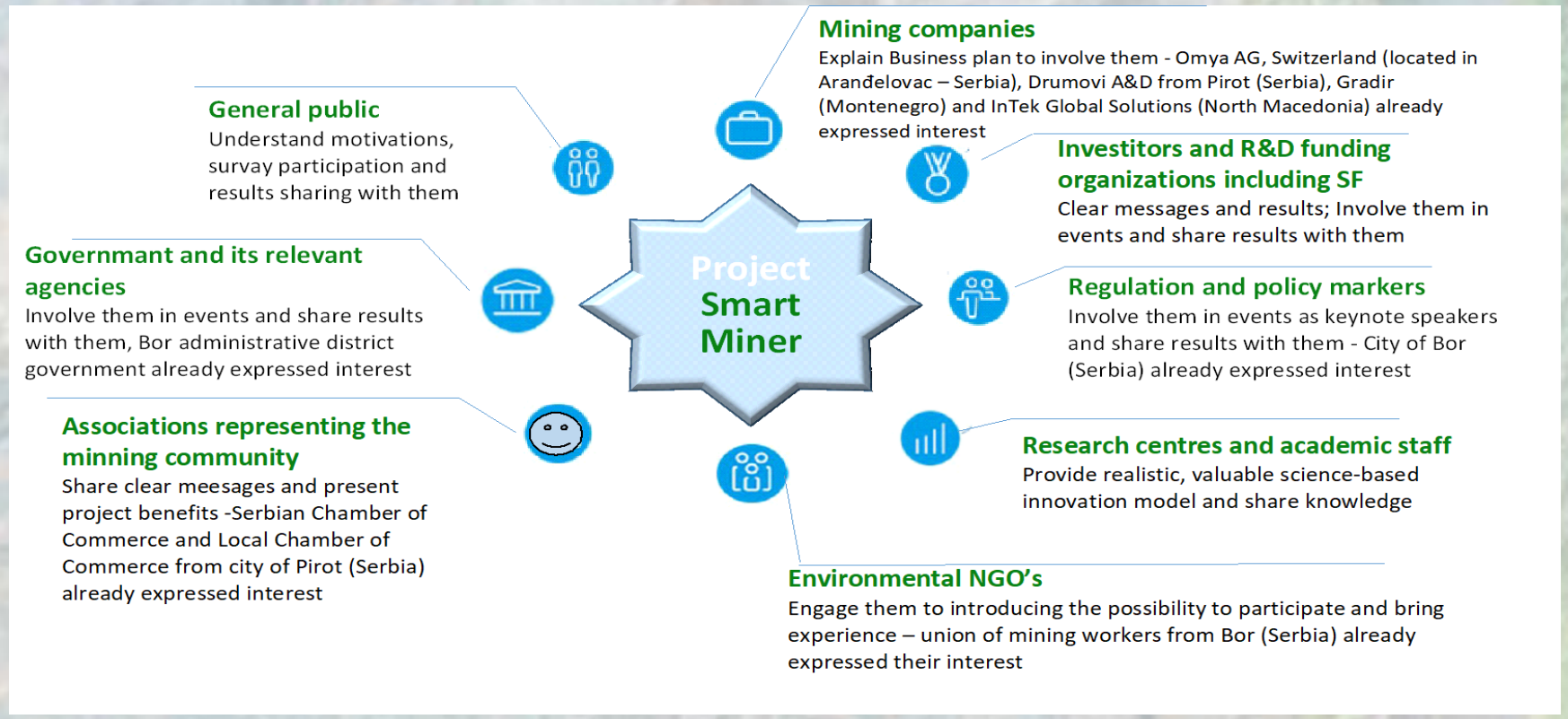


Figure 3. Additional stakeholders "attraction strategies"

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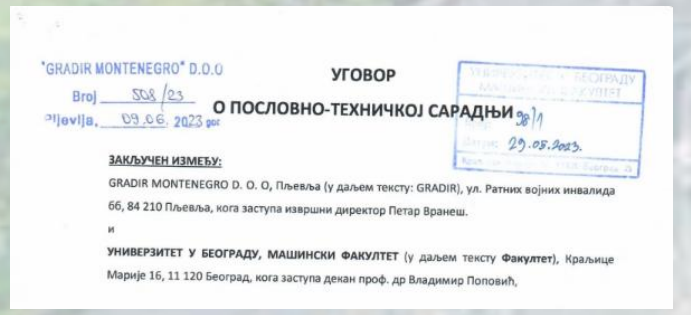
# SmartMiner: Agreements with Stakeholders



"GRADIR MONTENEGRO" D.O.O

**УГОВОР**

Broj 508/23

Pljevlja, 09.06.2023 god

**О ПОСЛОВНО-ТЕХНИЧКОЈ САРАДЊИ** 98/1

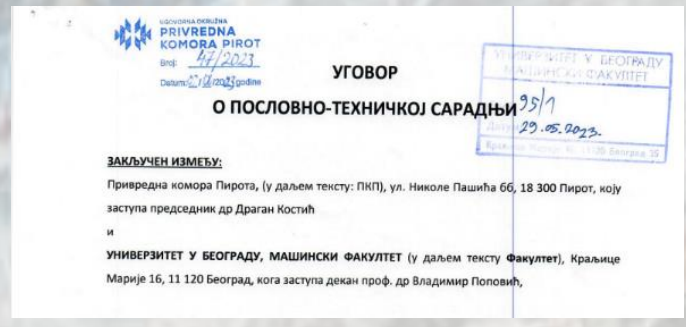
29.05.2023.

**ЗАКЉУЧЕН ИЗМЕЂУ:**

GRADIR MONTENEGRO D. O. O, Пљевља (у даљем тексту: GRADIR), ул. Ратних војних инвалида 6б, 84 210 Пљевља, кога заступа извршни директор Петар Вранеш.

и

**УНИВЕРЗИТЕТ У БЕОГРАДУ, МАШИНСКИ ФАКУЛТЕТ** (у даљем тексту **Факултет**), Краљице Марије 16, 11 120 Београд, кога заступа декан проф. др Владимир Поповић,



ПРИВРЕДНА КОМОРА ПИРОТ

Broj: 47/2023

Datum: 22/12/2023 godine

**УГОВОР**

**О ПОСЛОВНО-ТЕХНИЧКОЈ САРАДЊИ** 95/1

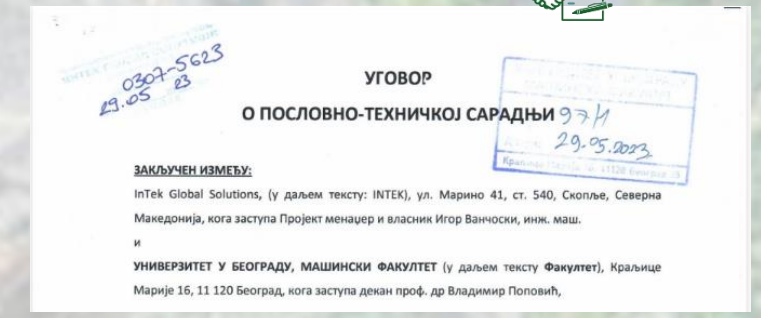
29.05.2023.

**ЗАКЉУЧЕН ИЗМЕЂУ:**

Привредна комора Пирота, (у даљем тексту: ПКП), ул. Николе Пашића 6б, 18 300 Пирот, коју заступа председник др Драган Костић

и

**УНИВЕРЗИТЕТ У БЕОГРАДУ, МАШИНСКИ ФАКУЛТЕТ** (у даљем тексту **Факултет**), Краљице Марије 16, 11 120 Београд, кога заступа декан проф. др Владимир Поповић,



0307-5623

29.05 23

**УГОВОР**

**О ПОСЛОВНО-ТЕХНИЧКОЈ САРАДЊИ** 97/1

29.05.2023.

**ЗАКЉУЧЕН ИЗМЕЂУ:**

InTek Global Solutions, (у даљем тексту: INTEK), ул. Марино 41, ст. 540, Скопље, Северна Македонија, кога заступа Пројект менаџер и власник Игор Ванчоски, инж. маш.

и

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DRUMOVI A&D D.O.O.

Broj 89/13/1

09.07.2023 god.

PIROT

**УГОВОР**

**О ПОСЛОВНО-ТЕХНИЧКОЈ САРАДЊИ** 96/1

29.05.2023

**ЗАКЉУЧЕН ИЗМЕЂУ:**

Друмови А&Д д.о.о. Пирот, (у даљем тексту: ДРУМОВИ), адреса насеље Гњилан 2 бб, 18 300 Пирот, кога заступа директор Гордана Панић.

и

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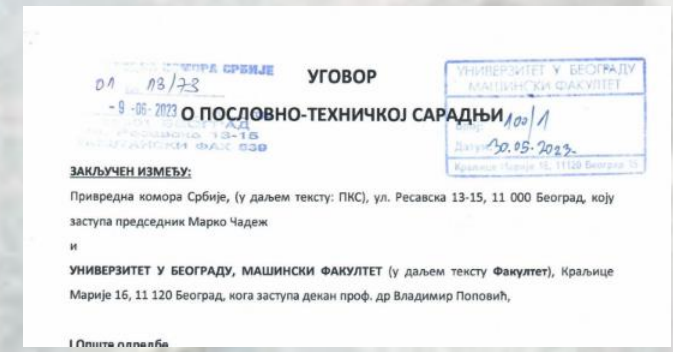

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-9-06-2023

**УГОВОР**

**О ПОСЛОВНО-ТЕХНИЧКОЈ САРАДЊИ** 100/1

30.05.2023.

**ЗАКЉУЧЕН ИЗМЕЂУ:**

Привредна комора Србије, (у даљем тексту: ПКС), ул. Ресавска 13-15, 11 000 Београд, коју заступа председник Марко Чадеж

и

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I Општа одредбе

РЕПУБЛИКА СРБИЈА
ГРАДСКА УПРАВА - БОР

Број: ГИ2-1/2023-II/01

18 JUL 2023

БОР

**УГОВОР**

**О ПОСЛОВНО-ТЕХНИЧКОЈ САРАДЊИ**

УНИВЕРЗИТЕТ У БЕОГРАДУ
ТЕХНИЧКИ ФАКУЛТЕТ У БОРУ

Број: II/7-474

30.06.2023 год.

ПОШТАНСКИ ФАХ 50

**ЗАКЉУЧЕН ИЗМЕЂУ:**

**Града Бора,** матични број :07208529, ПИБ: 100568330 , ул. Моше Пијаде 3, 19 210 Бор, кога заступа градоначелник Александар Миликић, дипл. инж. инд. Информатике ( у даљем тексту: ГРАД БОР)

и

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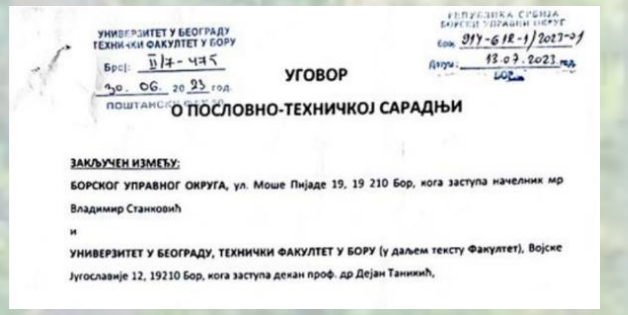

УНИВЕРЗИТЕТ У БЕОГРАДУ
ТЕХНИЧКИ ФАКУЛТЕТ У БОРУ

Број: II/7-475

30.06.2023 год.

ПОШТАНСКИ ФАХ 50

РЕПУБЛИКА СРБИЈА
БОРСКИ УПРАВНИ ОКРУГ

Број: 917-618-1/2023-01

Датум: 13.07.2023 год.

БОР

**УГОВОР**

**О ПОСЛОВНО-ТЕХНИЧКОЈ САРАДЊИ**

**ЗАКЉУЧЕН ИЗМЕЂУ:**

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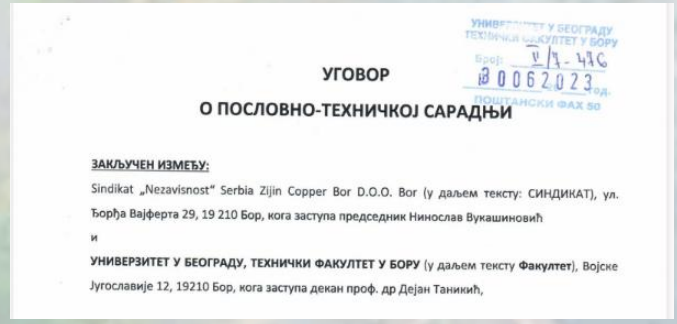

УНИВЕРЗИТЕТ У БЕОГРАДУ
ТЕХНИЧКИ ФАКУЛТЕТ У БОРУ

Број: V/7-476

30.06.2023 год.

ПОШТАНСКИ ФАХ 50

**УГОВОР**

**О ПОСЛОВНО-ТЕХНИЧКОЈ САРАДЊИ**

**ЗАКЉУЧЕН ИЗМЕЂУ:**

Sindikat „Nezavisnost" Serbia Zijin Copper Bor D.O.O. Bor (у даљем тексту: СИНДИКАТ), ул. Ђорђа Вајферта 29, 19 210 Бор, кога заступа председник Нинослав Вукашиновић

и

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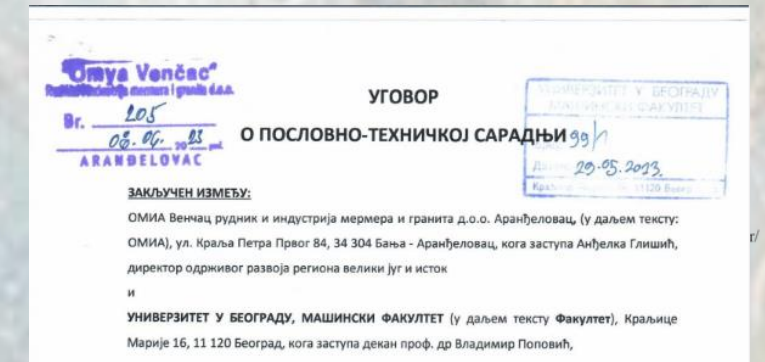

"Omya Venčac"

Br. 205

06.06.2023

ARANĐELOVAC

**УГОВОР**

**О ПОСЛОВНО-ТЕХНИЧКОЈ САРАДЊИ** 99/1

29.05.2023.

**ЗАКЉУЧЕН ИЗМЕЂУ:**

ОМИА Венчац рудник и индустрија мермера и гранита д.о.о. Аранђеловац, (у даљем тексту: ОМИА), ул. Краља Петра Првог 84, 34 304 Бања - Аранђеловац, кога заступа Анђелка Глишић, директор одрживог развоја региона велики југ и исток

и

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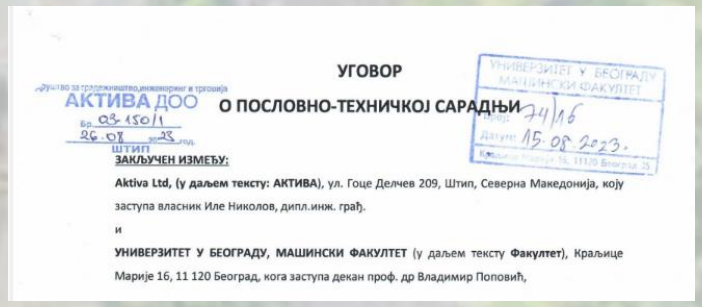

**УГОВОР**

**О ПОСЛОВНО-ТЕХНИЧКОЈ САРАДЊИ** 74/16

15.08.2023.

АКТИВА ДОО

Бр. 03-150/1

26.08.2023 год.

ШТИП

**ЗАКЉУЧЕН ИЗМЕЂУ:**

**Aktiva Ltd, (у даљем тексту: АКТИВА),** ул. Гоце Делчев 209, Штип, Северна Македонија, коју заступа власник Иле Николов, дипл.инж. грађ.

и

**УНИВЕРЗИТЕТ У БЕОГРАДУ, МАШИНСКИ ФАКУЛТЕТ** (у даљем тексту **Факултет**), Краљице Марије 16, 11 120 Београд, кога заступа декан проф. др Владимир Поповић,

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**Finally, SmartMiner is "one-of-a-kind"** :

1. It addresses the major problem of today's mining industry – its' **productivity and sustainability by paradigm shift** to combining a human-centric engineering approach with business strategy rooted in data and analytics.
2. It will influence two crucial and correlated factors: **improve safety and reduce pollution**.
3. It **starts and ends with real industry problems** solved by cyclical DBR&DBS approach, which implies continual improvement.
4. It will provide solution in the right way which **integrates individuals, their tasks, smart tools and technologies, physical environment and the organization** as the only way leading to sustainable solution.
5. It addresses **all stakeholders' and beneficiaries' groups** – research, academia, industry, unions, public sector...
6. Competent SmartMiner **team** mobilizes 15 researchers and 4 esteemed, top external experts from Germany, USA, the most cited scientist in the region and in the country.
7. It will provide **PCT protected technology development** and **tangible results** through its scientific groundbreaking objectives fulfillment based on HF/E and Artificial Intelligence merged into mining machinery operator micro and macro environment to translate data and signals into a language understandable by human users in manner to transform an operational setting from machine-centered to human-centered.
8. Its results have both national and international significance and **huge potential for future extensions**.

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Projekat SmartMiner
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SUPPORT SYSTEMS FOR SMART, ERGONOMIC AND SUSTAINABLE MINING MACHINERY WORKPLACES

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# SmartMiner workpackages

| WP No | WP title | WP Lead SRO's acronym |
|---|---|---|
| WP1 | Project management and coordination | FMEUB |
| WP2 | User/operator and stakeholders' issues, requirements and needs – inputs for co-design process | TF Bor |
| WP3 | Development of context-specific multi-sensorial mining machinery operator aid system | FMEUB |
| WP4 | Smart, Ergonomic and Sustainable Mining Machinery Workplaces System development | FMEUB |
| WP5 | Dissemination activities and stakeholders' collaboration | FMEUB |

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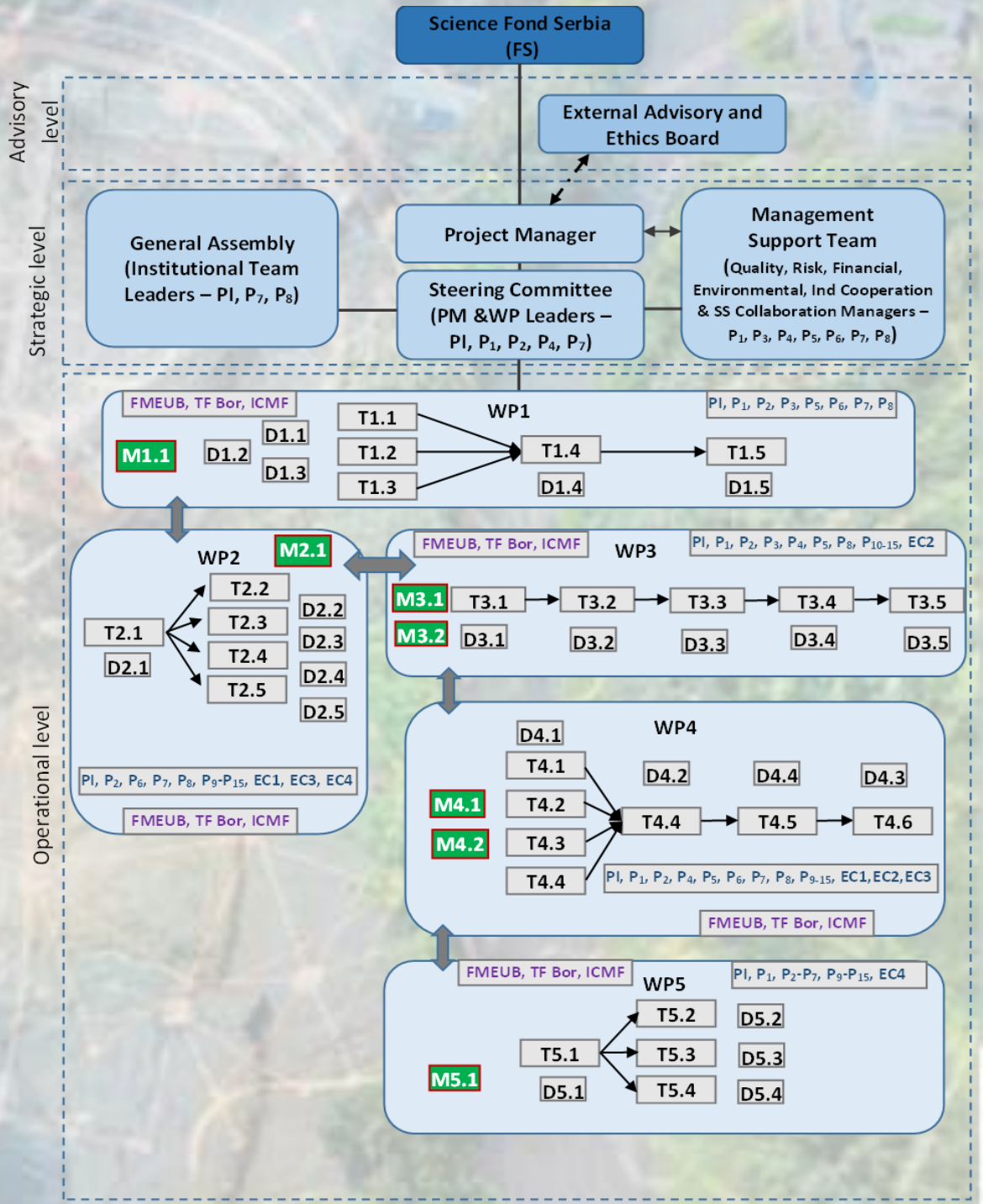
# SmartMiner organisational structure, tasks and deliverables

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# SmartMiner work plan

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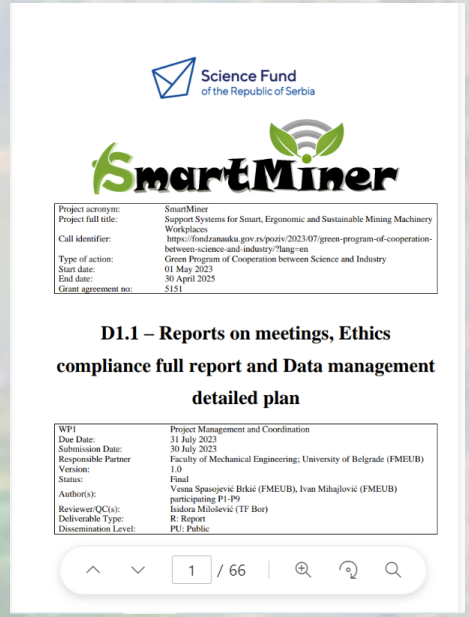
# WP1:Project management and coordination

D1.1. Reports on meetings, Ethics compliance full report and Data management detailed plan – month 3 (updated regularly)

D1.2 Project Management Plan – describes project management structure and general decision-making procedures to ensure the high quality and low risk levels of day-to-day project management – month 3

D1.3 Periodic Activity Report – each year - month 12,24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SmartMiner

| | |
|---|---|
| Project acronym: | SmartMiner |
| Project full title: | Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces |
| Call identifier: | https://fondzanauku.gov.rs/poziv/2023/07/green-program-of-cooperation-between-science-and-industry/?lang=en |
| Type of action: | Green Program of Cooperation between Science and Industry |
| Start date: | 01 May 2023 |
| End date: | 30 April 2025 |
| Grant agreement no: | 5151 |

**D1.1 – Reports on meetings, Ethics compliance full report and Data management detailed plan**

| | |
|---|---|
| WP1 | Project Management and Coordination |
| Due Date: | 31 July 2023 |
| Submission Date: | 30 July 2023 |
| Responsible Partner | Faculty of Mechanical Engineering; University of Belgrade (FMEUB) |
| Version: | 1.0 |
| Status: | Final |
| Author(s): | Vesna Spasojević Brkić (FMEUB), Ivan Mihajlović (FMEUB) participating P1-P9 |
| Reviewer/QC(s): | Isidora Milošević (TF Bor) |
| Deliverable Type: | R: Report |
| Dissemination Level: | PU: Public |

1 / 66

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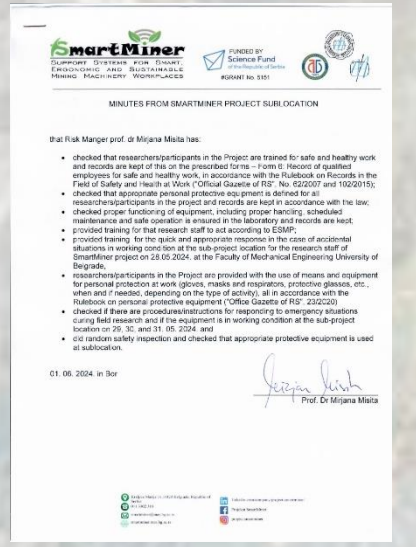
#GRANT No. 5151

САГЛАСНОСТ

Место: Бухаревац, Мајур, Бор
Датум: 01.06.2024.

Сагласност лице
(Руководилац радарске станице)

Сагласност директора
(Руководилац пројекта)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MINUTES FROM SMARTMINER PROJECT SUBLOCATION

that Risk Manger prof. dr Mirjana Misita has:

- checked that researchers/participants in the Project are trained for safe and healthy work and records are kept of this on the prescribed forms – Form 0: Record of qualified employees for safe and healthy work, in accordance with the Rulebook on Records in the Field of Safety and Health at Work ("Official Gazette of RS", No. 62/2007 and 102/2015);
- checked that appropriate personal protective equipment is defined for all researchers/participants in the project and records are kept in accordance with the law;
- checked proper functioning of equipment, including proper handling, scheduled maintenance and safe operation is ensured in the laboratory and records are kept;
- provided training for that research staff to act according to ESMP;
- provided training for the quick and appropriate response in the case of accidental situations in working condition at the sub-project location for the research staff of SmartMiner project on 28.05.2024. at the Faculty of Mechanical Engineering University of Belgrade,
- researchers/participants in the Project are provided with the use of means and equipment for personal protection at work (gloves, masks and respirators, protective glasses, etc., when and if needed, depending on the type of activity), all in accordance with the Rulebook on personal protective equipment ("Office Gazette of RS", 23/2020)
- checked if there are procedures/instructions for responding to emergency situations during field research and if the equipment is in working condition at the sub-project location on 29, 30, and 31. 05. 2024. and
- did random safety inspection and checked that appropriate protective equipment is used at sublocation.

01. 06. 2024. in Bor

Prof. Dr Mirjana Misita


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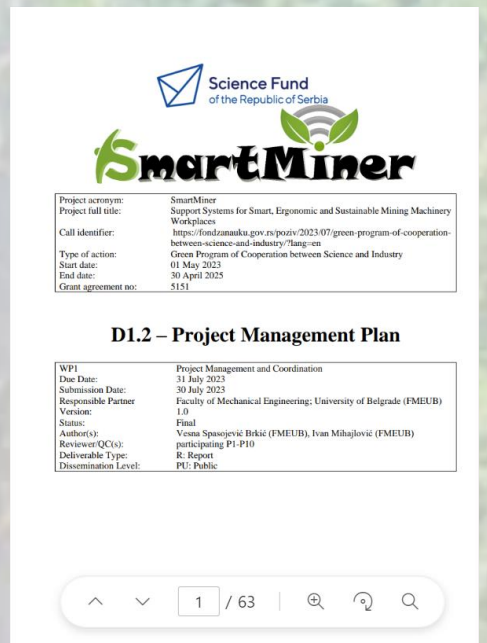
Science Fund of the Republic of Serbia

SmartMiner

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| Project acronym: | SmartMiner |
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| Type of action: | Green Program of Cooperation between Science and Industry |
| Start date: | 01 May 2023 |
| End date: | 30 April 2025 |
| Grant agreement no: | 5151 |

**D1.2 – Project Management Plan**

| | |
|---|---|
| WP1 | Project Management and Coordination |
| Due Date: | 31 July 2023 |
| Submission Date: | 30 July 2023 |
| Responsible Partner | Faculty of Mechanical Engineering; University of Belgrade (FMEUB) |
| Version: | 1.0 |
| Status: | Final |
| Author(s): | Vesna Spasojević Brkić (FMEUB), Ivan Mihajlović (FMEUB) |
| Reviewer/QC(s): | participating P1-P10 |
| Deliverable Type: | R: Report |
| Dissemination Level: | PU: Public |

1 / 63

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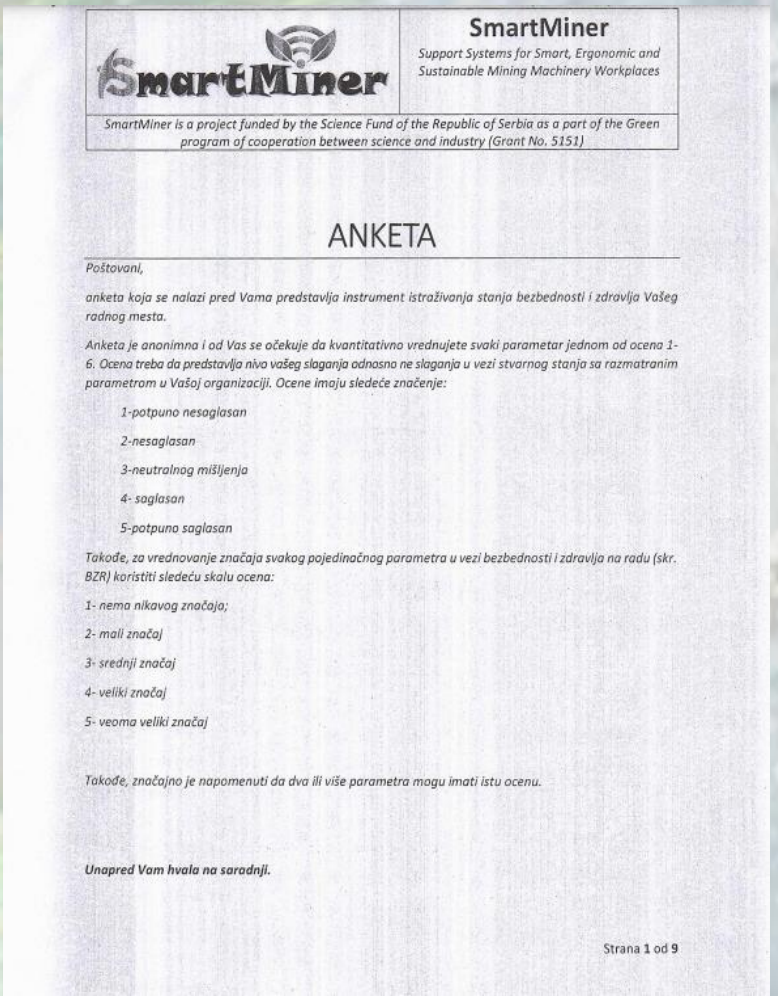
# WP1:Project management and coordination: examples

Operator/Foreman
Top or middle level manager
Mining machinery operator



SmartMiner
*Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces*

*SmartMiner is a project funded by the Science Fund of the Republic of Serbia as a part of the Green program of cooperation between science and industry (Grant No. 5151)*

## ANKETA

*Poštovani,*

*anketa koja se nalazi pred Vama predstavlja instrument istraživanja stanja bezbednosti i zdravlja Vašeg radnog mesta.*

*Anketa je anonimna i od Vas se očekuje da kvantitativno vrednujete svaki parametar jednom od ocena 1-6. Ocena treba da predstavlja nivo vašeg slaganja odnosno ne slaganja u vezi stvarnog stanja sa razmatranim parametrom u Vašoj organizaciji. Ocene imaju sledeće značenje:*

*1-potpuno nesaglasan*

*2-nesaglasan*

*3-neutralnog mišljenja*

*4- saglasan*

*5-potpuno saglasan*

*Takođe, za vrednovanje značaja svakog pojedinačnog parametra u vezi bezbednosti i zdravlja na radu (skr. BZR) koristiti sledeću skalu ocena:*

*1- nema nikavog značaja;*

*2- mali značaj*

*3- srednji značaj*

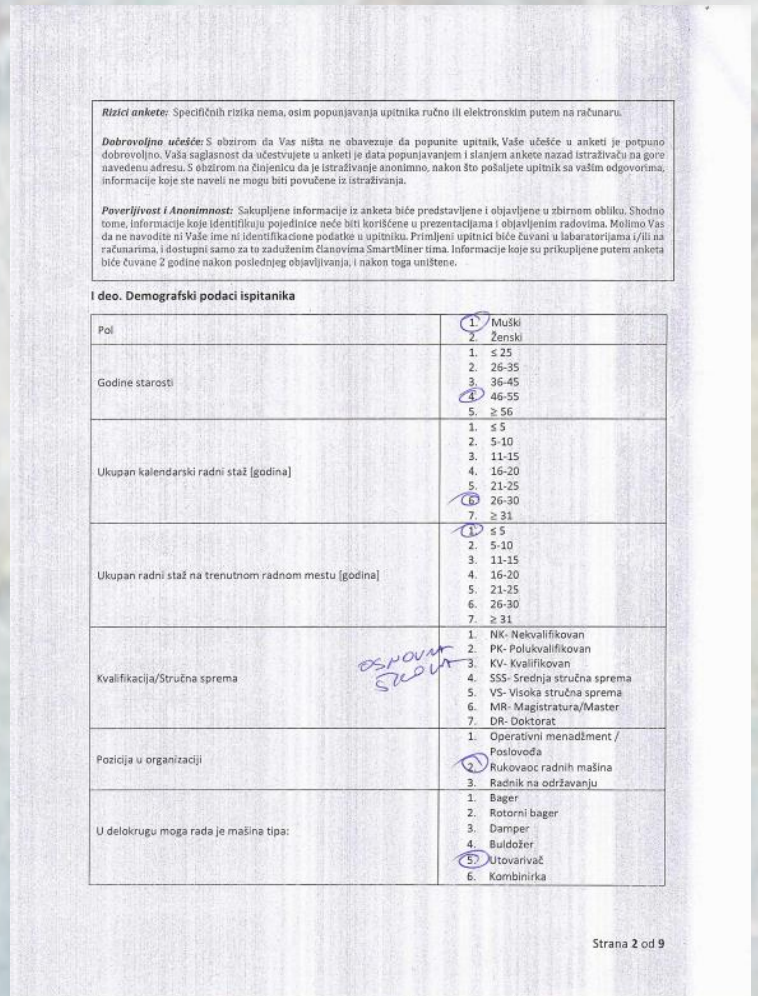
*4- veliki značaj*

*5- veoma veliki značaj*

*Takođe, značajno je napomenuti da dva ili više parametra mogu imati istu ocenu.*

***Unapred Vam hvala na saradnji.***

Strana 1 od 9



***Rizici ankete:*** Specifičnih rizika nema, osim popunjavanja upitnika ručno ili elektronskim putem na računaru.

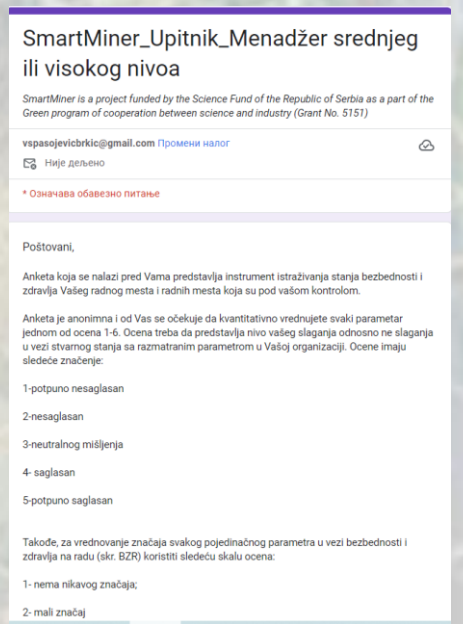
***Dobrovoljno učešće:*** S obzirom da Vas ništa ne obavezuje da popunite upitnik, Vaše učešće u anketi je potpuno dobrovoljno. Vaša saglasnost da učestvujete u anketi je data popunjavanjem i slanjem ankete nazad istraživaču na gore navedenu adresu. S obzirom na činjenicu da je istraživanje anonimno, nakon što pošaljete upitnik sa vašim odgovorima, informacije koje ste naveli ne mogu biti povučene iz istraživanja.

***Poverljivost i Anonimnost:*** Sakupljene informacije iz anketa biće predstavljene i objavljene u zbirnom obliku. Shodno tome, informacije koje identifikuju pojedinice neće biti korišćene u prezentacijama i objavljenim radovima. Molimo Vas da ne navodite ni Vaše ime ni identifikacione podatke u upitniku. Primljeni upitnici biće čuvani u labaratorijama i/ili na računarima, i dostupni samo za to zaduženim članovima SmartMiner tima. Informacije koje su prikupljene putem anketa biće čuvane 2 godine nakon poslednjeg objavljivanja, i nakon toga uništene.

**I deo. Demografski podaci ispitanika**

| | |
|---|---|
| Pol | 1. Muški<br>2. Ženski |
| Godine starosti | 1. ≤ 25<br>2. 26-35<br>3. 36-45<br>4. 46-55<br>5. ≥ 56 |
| Ukupan kalendarski radni staž [godina] | 1. ≤ 5<br>2. 5-10<br>3. 11-15<br>4. 16-20<br>5. 21-25<br>6. 26-30<br>7. ≥ 31 |
| Ukupan radni staž na trenutnom radnom mestu [godina] | 1. ≤ 5<br>2. 5-10<br>3. 11-15<br>4. 16-20<br>5. 21-25<br>6. 26-30<br>7. ≥ 31 |
| Kvalifikacija/Stručna sprema | 1. NK- Nekvalifikovan<br>2. PK- Polukvalifikovan<br>3. KV- Kvalifikovan<br>4. SSS- Srednja stručna sprema<br>5. VS- Visoka stručna sprema<br>6. MR- Magistratura/Master<br>7. DR- Doktorat |
| Pozicija u organizaciji | 1. Operativni menadžment / Poslovođa<br>2. Rukovaoc radnih mašina<br>3. Radnik na održavanju |
| U delokrugu moga rada je mašina tipa: | 1. Bager<br>2. Rotorni bager<br>3. Damper<br>4. Buldožer<br>5. Utovarivač<br>6. Kombinirka |

Strana 2 od 9



SmartMiner_Upitnik_Menadžer srednjeg ili visokog nivoa

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vspasojevicbrkic@gmail.com Промени налог

Није дељено

* Означава обавезно питање

Poštovani,

Anketa koja se nalazi pred Vama predstavlja instrument istraživanja stanja bezbednosti i zdravlja Vašeg radnog mesta i radnih mesta koja su pod vašom kontrolom.

Anketa je anonimna i od Vas se očekuje da kvantitativno vrednujete svaki parametar jednom od ocena 1-6. Ocena treba da predstavlja nivo vašeg slaganja odnosno ne slaganja u vezi stvarnog stanja sa razmatranim parametrom u Vašoj organizaciji. Ocene imaju sledeće značenje:

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3-neutralnog mišljenja

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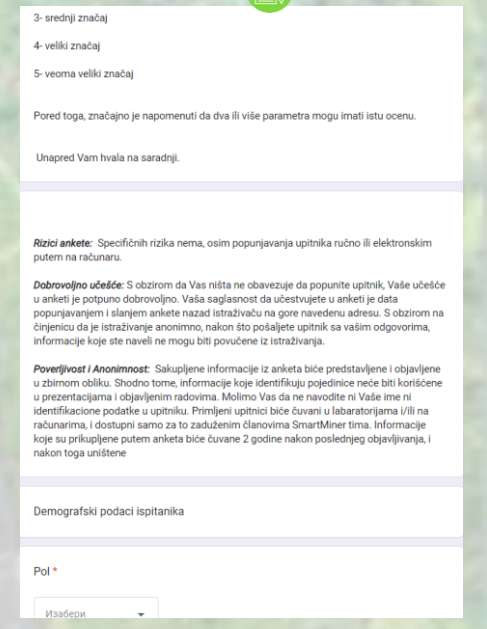
2- mali značaj



3- srednji značaj

4- veliki značaj

5- veoma veliki značaj

Pored toga, značajno je napomenuti da dva ili više parametra mogu imati istu ocenu.

Unapred Vam hvala na saradnji.

***Rizici ankete:*** Specifičnih rizika nema, osim popunjavanja upitnika ručno ili elektronskim putem na računaru.

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Demografski podaci ispitanika

Pol *

Изабери

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# WP2:User/operator and stakeholders' issues, requirements and needs – inputs for co-design process

D2.1. Initial workshop with stakeholders – report – month 3

D2.2. Data collected using questionnaire to assess mining machinery operators' anthropometric measurements and opinion on the workplace factors / interview set of questions upon need, measurement scales development and statistical data analysis – database - month 6

D2.3. Data collected using questionnaire to assess management opinion on safety climate, organizational factors and sustainability performance/ interview set of questions upon need, measurement scales development and statistical data analysis – database - month 7

D2.4. Structural equations model (SEM) covering interconnections of all assessed groups of factors – modeling report - month 9

D2.5. Basic decision tree developed based on PROMETHEE/ GAIA ranking and AHP-ANP prioritization – month 12

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# WP2:User/operator and stakeholders' issues, requirements and needs – inputs for co-design process

D2.1. Initial workshop with stakeholders – report – month 3

Science Fund of the Republic of Serbia

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| Type of action: | Green Program of Cooperation between Science and Industry |
| Start date: | 01 May 2023 |
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| Grant agreement no: | 5151 |

**D2.1 – Initial workshop with stakeholders**

| | |
|---|---|
| WP2 | User/operator and stakeholders' issues, requirements and needs – inputs for co-design process |
| Due Date: | 31 July 2023 |
| Submission Date: | 30 July 2023 |
| Responsible Partner | Technical faculty in Bor; University of Belgrade (TF Bor) |
| Version: | 1.0 |
| Status: | Final |
| Author(s): | Đorđe Nikolić (TF Bor), Isidora Milošević (TF Bor), Anđelka Stojanović (TF Bor), Participating PI,P2,P5-P14 |
| Reviewer/QC(s): | Vesna Spasojević Brkić (FMEUB) |
| Deliverable Type: | R: Report |
| Dissemination Level: | PU: Public |

1 / 36

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**AGENDA**

**October 3rd, 2023, room 514**

11:00 Opening of the meeting
11:05 Prof. Dr Vesna Spasojević Brkić: SmartMiner Concept and Methodology
11:35 Prof. Dr Ivan Mihajlović: Collaboration with stakeholders in SmartMiner – plans and actions
12:05 Coffee break
12:20 Prof. Dr. Eckard Helmers: Zero (carbon) emission mobility based on Life Cycle impacts
13:00 Discussions
13:30 Wrap-up and next engagements
14:00 End of the meeting, group photo and lunch

**October 4th, 2023, room 514**

12:00 Opening of the meeting
12:05 Prof. Dr Eckard Helmers: Institutional carbon footprinting and how to sustain the world
14:00 End of the meeting, group photo, and lunch

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SUPPORT SYSTEMS FOR SMART, ERGONOMIC AND SUSTAINABLE MINING MACHINERY WORKPLACES

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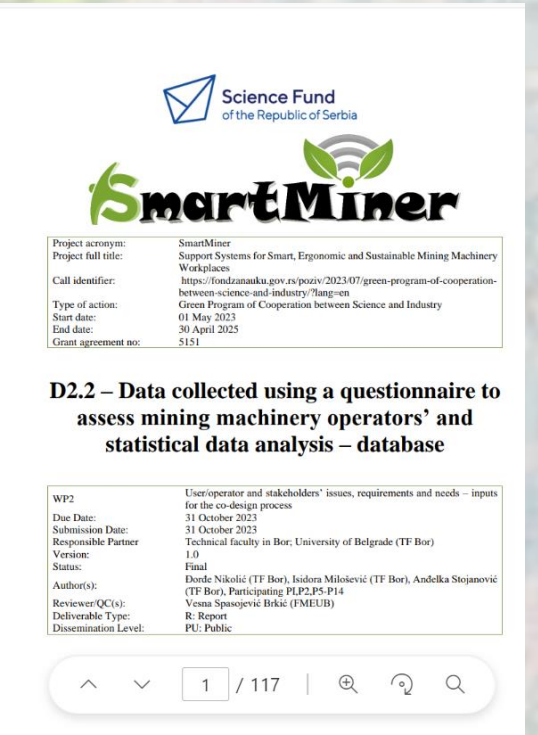
#GRANT No. 5151

# WP2:User/operator and stakeholders' issues, requirements and needs – inputs for co-design process

D2.2. Data collected using questionnaire to assess mining machinery operators' opinion on the workplace factors / interview set of questions upon need, measurement scales development and statistical data analysis – database - month 6


Science Fund of the Republic of Serbia

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|---|---|
| Project acronym: | SmartMiner |
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| Type of action: | Green Program of Cooperation between Science and Industry |
| Start date: | 01 May 2023 |
| End date: | 30 April 2025 |
| Grant agreement no: | 5151 |

**D2.2 – Data collected using a questionnaire to assess mining machinery operators' and statistical data analysis – database**

| | |
|---|---|
| WP2 | User/operator and stakeholders' issues, requirements and needs – inputs for the co-design process |
| Due Date: | 31 October 2023 |
| Submission Date: | 31 October 2023 |
| Responsible Partner | Technical faculty in Bor; University of Belgrade (TF Bor) |
| Version: | 1.0 |
| Status: | Final |
| Author(s): | Đorđe Nikolić (TF Bor), Isidora Milošević (TF Bor), Anđelka Stojanović (TF Bor), Participating PLP2,P5-P14 |
| Reviewer/QC(s): | Vesna Spasojević Brkić (FMEUB) |
| Deliverable Type: | R: Report |
| Dissemination Level: | PU: Public |

1 / 117

SmartMiner

ANKETA ZA RUKOVAOCE RUDARSKE MEHANIZACIJE

*Poštovani, anketa*
*koja se nalazi pred Vama je anonimna i predstavlja instrument istraživanja stanja ergonomske prilagođenosti Vašeg radnog mesta.* ***Unapred Vam hvala na saradnji.***

***Rizici ankete:*** *Specifičnih rizika nema, osim popunjavanja upitnika ručno ili elektronskim putem na računaru.*
***Dobrovoljno učešće:*** *S obzirom da Vas ništa ne obavezuje da popunite upitnik, Vaše učešće u anketi je potpuno dobrovoljno. Vaša saglasnost da učestvujete u anketi je data popunjavanjem i slanjem ankete nazad istraživaču na gore navedenu adresu. S obzirom na činjenicu da je istraživanje anonimno, nakon što pošaljete upitnik sa vašim odgovorima, informacije koje ste naveli ne mogu biti povučene iz istraživanja.*
***Poverljivost i Anonimnost:*** *Sakupljene informacije iz anketa biće predstavljene i objavljene u zbirnom obliku. Shodno tome, informacije koje identifikuju pojedinice neće biti korišćene u prezentacijama i objavljenim radovima. Molimo Vas da ne navodite ni Vaše ime ni identifikacione podatke u upitniku. Primljeni upitnici biće čuvani u labaratorijama i/ili na računarima, i dostupni samo za to zaduženim članovima SmartMiner tima. Informacije koje su prikupljene putem anketa biće čuvane 2 godine nakon poslednjeg objavljivanja, i nakon toga uništene.*

3. Data collected ..... 6
4. Results of research ..... 15
4.1. Operators attitude related to the workplace safety ..... 15
4.1.1. Respondents opinions by questions ..... 15
Group 1. Technical factors assessment ..... 15
Group 2. Human factors assessment ..... 22
Group 3. Organizational factors assessment ..... 29
Group 4. Sustainability factors assessment ..... 47
4.1.2. Exploratory factor analysis (EFA) ..... 52
4.2. Operators attitude related to the workplace ergonomics ..... 66
4.2.1. Respondents opinions by questions ..... 66
4.2.2. Exploratory factor analysis (EFA) ..... 112
5. Responsibility assignment ..... 116

Sample size: 460 and 114

**Table 1. The result of the factor analysis for the assessment of technical factors**

| | | Assessment of the actual situation in the organization | | | | |
|---|---|---|---|---|---|---|
| ***Factor*** | ***Item*** | ***Factor loading*** | ***Eigenvalue*** | ***Variance explained*** | ***KMO*** | ***Cronbach's α*** |
| Work equipment | 1. Collective protective equipment (fire extinguishers, gas and ventilation parameters meters...) are correct and present at my workplace. | .710 | 4.969 | 70.992 | .924 | .931 |
| | 2. Work equipment and work machines are appropriate for the work operations I perform at my workplace. | .885 | | | | |
| | 3. Work equipment and work machines are regularly controlled and inspected by the authorities. | .884 | | | | |
| | 4. The work equipment I use is correct, safe and modern. | .837 | | | | |
| | 5. Personal protective equipment for work is comfortable and does not bother me while I work. | .896 | | | | |

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# WP2:User/operator and stakeholders' issues, requirements and needs – inputs for co-design process

D2.3. Data collected using questionnaire to assess management opinion on safety climate, organizational factors and sustainability performance/ interview set of questions upon need, measurement scales development and statistical data analysis – database - month 7

Science Fund of the Republic of Serbia

SmartMiner

| | |
|---|---|
| Project acronym: | SmartMiner |
| Project full title: | Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces |
| Call identifier: | https://fondzanauku.gov.rs/poziv/2023/07/green-program-of-cooperation-between-science-and-industry/?lang=en |
| Type of action: | Green Program of Cooperation between Science and Industry |
| Start date: | 01 May 2023 |
| End date: | 30 April 2025 |
| Grant agreement no: | 5151 |

**D2.3 – Data collected using a questionnaire to assess managers in mining industry and statistical data analysis – database**

| | |
|---|---|
| WP2 | User/operator and stakeholders' issues, requirements and needs – inputs for the co-design process |
| Due Date: | 30 November 2023 |
| Submission Date: | 30 November 2023 |
| Responsible Partner | Technical faculty in Bor; University of Belgrade (TF Bor) |
| Version: | 1.0 |
| Status: | Final |
| Author(s): | Đorđe Nikolić (TF Bor), Isidora Milošević (TF Bor), Andelka Stojanović (TF Bor), Participating PI,P2,P5-P14 |
| Reviewer/QC(s): | Vesna Spasojević Brkić (FMEUB) |
| Deliverable Type: | R: Report |
| Dissemination Level: | PU: Public |

1 / 68

| | Timestamp | Pol | Godine starosti | Ukupan kalendarski rad | Ukupan radni staž na tr | Kvalifikacija/Stručna spr | Vaša pozicija u organizi | U toku moje karijere ne | Povreda je okarakter |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 10/9/2023 10:40:20 | Muški | 46-55 | 26-30 | 5 godina ili manje | VS- Visoka stručna spr | Menadžment najvišeg n | Nije | |
| 3 | 10/9/2023 10:47:20 | Muški | 46-55 | 26-30 | 5 godina ili manje | DR- Doktorat | Menadžment najvišeg n | Nije | |
| 4 | 10/17/2023 11:16:35 | Muški | 46-55 | 21-25 | 11-15 | SSS- Srednja stručna s | Option 3 | Jeste | Teška |
| 5 | 10/17/2023 11:26:32 | Ženski | 26-35 | 5 godina ili manje | 5 godina ili manje | MR- Magistratura/Mast | Option 3 | Nije | |
| 6 | 10/17/2023 12:01:17 | Muški | 56 i više godina | 31 ili više godina | 11-15 | MR- Magistratura/Mast | Menadžment najvišeg n | Jeste | Laka |
| 7 | 10/17/2023 13:36:54 | Ženski | 26-35 | 5-10 | 5 godina ili manje | VS- Visoka stručna spr | Srednji nivo menadžme | Nije | |
| 8 | 10/18/2023 0:00:27 | Ženski | 36-45 | 11-15 | 11-15 | MR- Magistratura/Mast | Menadžment najvišeg n | Jeste | Teška |
| 9 | 10/19/2023 14:02:23 | Muški | 36-45 | 11-15 | 5-10 | VS- Visoka stručna spr | Srednji nivo menadžme | Nije | |
| 10 | 10/20/2023 7:34:06 | Muški | 46-55 | 21-25 | 11-15 | MR- Magistratura/Mast | Option 3 | Jeste | Teška |
| 11 | 10/23/2023 18:31:56 | Muški | 25 ili manje godina | 5 godina ili manje | 5 godina ili manje | MR- Magistratura/Mast | Option 3 | Nije | |
| 12 | 10/23/2023 18:55:15 | Muški | 36-45 | 16-20 | 5 godina ili manje | VS- Visoka stručna spr | Option 3 | Nije | |
| 13 | 10/23/2023 19:14:14 | Muški | 46-55 | 26-30 | 11-15 | SSS- Srednja stručna s | Option 3 | Jeste | Laka |
| 14 | 10/23/2023 19:31:12 | Muški | 46-55 | 16-20 | 5-10 | SSS- Srednja stručna s | Option 3 | Jeste | Laka |
| 15 | 10/23/2023 19:41:26 | Muški | 46-55 | 31 ili više godina | 31 ili više godina | SSS- Srednja stručna s | Option 3 | Nije | |
| 16 | 10/23/2023 19:55:26 | Muški | 46-55 | 16-20 | 5-10 | VS- Visoka stručna spr | Option 3 | Nije | |
| 17 | 10/23/2023 20:10:58 | Muški | 46-55 | 21-25 | 21-25 | MR- Magistratura/Mast | Option 3 | Nije | |
| 18 | 10/23/2023 20:20:32 | Muški | 56 i više godina | 31 ili više godina | 5 godina ili manje | VS- Visoka stručna spr | Option 3 | Nije | |
| 19 | 10/23/2023 20:47:13 | | 36-45 | 16-20 | 11-15 | VS- Visoka stručna spr | Option 3 | Nije | |
| 20 | 10/23/2023 20:57:48 | Muški | 56 i više godina | 31 ili više godina | 31 ili više godina | SSS- Srednja stručna s | Option 3 | Nije | |

Sample size: 160

| | | | | | |
|---|---|---|---|---|---|
| | 4. Corrective action is always taken when management is told about unsafe practices. | .930 | | | |
| | 5. In my workplace, managers/supervisors show interest in my safety. | .844 | | | |
| | 7. Managers and supervisors express concern if safety procedures are not adhered to. | .836 | | | |
| | 3. In my workplace, management turns a blind eye to safety issues | .920 | 1.061 | 15.162 | |
| | 6. Management acts only after accidents have occurred. | .939 | | | |
| | | | *cumulative* | 83.995 | |
| Rules and procedures on safety at work | 1. Certain safety rules and procedures do not have to be followed in order to do the job safely. | .980 | 2.889 | 96.303 | .778 .981 |
| | 2. Certain rules and procedures regarding safety and health at work are not practical. | .986 | | | |
| | 3. Sometimes it is necessary to deviate from safety requirements for the sake of production. | .978 | | | |
| Encouraging employees to improve safety at work | 1. I am involved in informing about important security issues. | .927 | 1.718 | 85.913 | .500 .829 |
| | 2. I deal with issues of safety at work. | .927 | | | |

**Table 8. The result of the factor analysis for the assessment of the importance of sustainability factor**

| | | Assessment of the importance of parameters related to safety and health at work | | | | |
|---|---|---|---|---|---|---|
| *Factor* | **Item** | *Factor loading* | *Eigenvalue* | *Variance explained* | *KMO* | *Crombach's α* |
| | 1. There are good interpersonal relations in the organization and teamwork is valued | .792 | 6.997 | 63.607 | .815 | .939 |

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# WP2:User/operator and stakeholders' issues, requirements and needs – inputs for co-design process

D2.4. Structural equations model (SEM) covering interconnections of all assessed groups of factors – modeling report - month 9

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SmartMiner

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|---|---|
| Project acronym: | SmartMiner |
| Project full title: | Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces |
| Call identifier: | https://fondzanauku.gov.rs/poziv/2023/07/green-program-of-cooperation-between-science-and-industry/?lang=en |
| Type of action: | Green Program of Cooperation between Science and Industry |
| Start date: | 01 May 2023 |
| End date: | 30 April 2025 |
| Grant agreement no: | 5151 |

**D2.4 – Structural equations model (SEM) covering interconnections of all assessed groups of factors – modeling report**

| | |
|---|---|
| WP2 | User/operator and stakeholders' issues, requirements and needs – inputs for the co-design process |
| Due Date: | 31 January 2024 |
| Submission Date: | 31 January 2024 |
| Responsible Partner | Technical faculty in Bor; University of Belgrade (TF Bor) |
| Version: | 1.0 |
| Status: | Final |
| Author(s): | Đorđe Nikolić (TF Bor), Isidora Milošević (TF Bor), Anđelka Stojanović (TF Bor), Participating PLP2,P5-P14 |
| Reviewer/QC(s): | Vesna Spasojević Brkić (FMEUB) |
| Deliverable Type: | R: Report |
| Dissemination Level: | PU: Public |

1 / 30

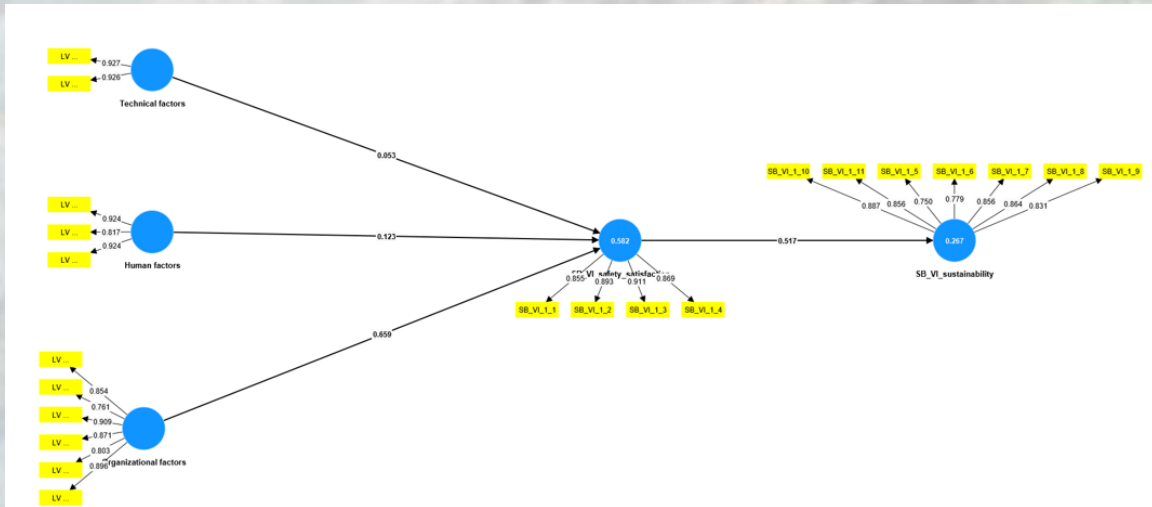


Figure 3. Structural model in PLS

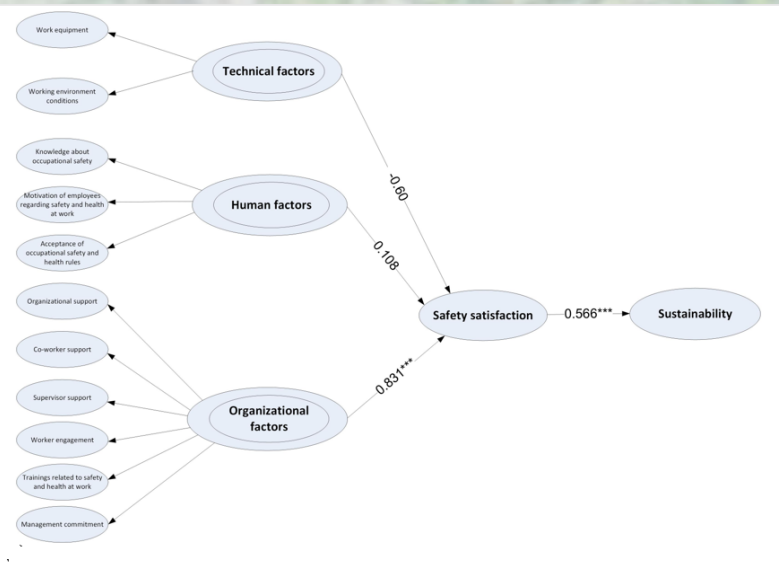


Figure 2. Structural model in AMOS

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# WP2:User/operator and stakeholders' issues, requirements and needs – inputs for co-design process

## D2.5. Basic decision tree developed based on PROMETHEE/ GAIA ranking and AHP-ANP prioritization – month 12

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|---|---|
| Project acronym: | SmartMiner |
| Project full title: | Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces |
| Call identifier: | https://fondzanauku.gov.rs/poziv/2023/07/green-program-of-cooperation-between-science-and-industry/?lang=en |
| Type of action: | Green Program of Cooperation between Science and Industry |
| Start date: | 01 May 2023 |
| End date: | 30 April 2025 |
| Grant agreement no: | 5151 |

### D2.5 – Basic decision tree developed based on MCDM ranking techniques

| | |
|---|---|
| WP2 | User/operator and stakeholders' issues, requirements and needs – inputs for the co-design process |
| Due Date: | 30 April 2024 |
| Submission Date: | 30 April 2024 |
| Responsible Partner | Technical faculty in Bor; University of Belgrade (TF Bor) |
| Version: | 1.0 |
| Status: | Final |
| Author(s): | Đorđe Nikolić (TF Bor), Isidora Milošević (TF Bor), Anđelka Stojanović (TF Bor), Participating PI,P2,P5-P14 |
| Reviewer/QC(s): | Vesna Spasojević Brkić (FMEUB) |
| Deliverable Type: | R: Report |
| Dissemination Level: | PU: Public |



**2.4. Aplication of hybrid SEM-MCDM procedure**

In order to evaluate the considered operator's workplace depending on the mining machineries they use, operator's opinions collected during the survey were used. The average evaluation scores for the seven different types of mining machineris workplaces are shown in Table 7.

*Table 7. Summary of the average scores of mining machineries workplaces conditions to each subcriterion in model (Likert's scale between 1 and 5)*

| | Human factors-subcriteria | | | Organizational factors-subcriteria | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Type of mining machinery workplace | HF_1 | HF_2 | HF_3 | OF_1 | OF_2 | OF_3 | OF_4 | OF_5 | OF_6 |
| Operator on Excavator | 4.597 | 4.784 | 4.567 | 4.448 | 4.575 | 4.556 | 4.326 | 4.423 | 4.333 |
| Operator on Rotary excavator | 4.500 | 4.350 | 4.200 | 4.000 | 4.433 | 4.189 | 3.800 | 4.250 | 4.344 |
| Operator on Dump truck | 4.600 | 4.850 | 4.500 | 4.100 | 4.600 | 4.400 | 4.200 | 4.200 | 4.320 |
| Operator on Bulldozer | 4.600 | 4.771 | 4.634 | 3.708 | 4.333 | 3.889 | 4.146 | 4.375 | 3.917 |
| Operator on Loader | 4.862 | 4.769 | 4.761 | 4.538 | 4.513 | 4.632 | 4.635 | 4.885 | 4.431 |
| Operator on Grader | 4.650 | 4.719 | 4.719 | 4.000 | 3.792 | 3.847 | 3.688 | 4.094 | 3.675 |
| Operator on Other mining machine | 4.757 | 4.828 | 4.651 | 3.964 | 4.384 | 4.031 | 3.834 | 4.090 | 3.918 |
| Subcriteria weights | 0.055 | 0.048 | 0.055 | 0.141 | 0.126 | 0.150 | 0.144 | 0.133 | 0.148 |

Based on the application of the PROMETHEE II ranking procedure, evaluation and ranking of operator's workplace condiotion is given in Table 8. The preference level function was chosen as the best solution for the description of the analyzed data. These data are qualitative essentially, and in the analysis their quantitative analogue was used (five-degree scale from one "totaly dissagree" to five "totaly agree"). The value thresholds were chosen q =0.5 (Indifference threshold) and p= 1.5 (Preference threshold), which corresponds to the scale which was used for fator evaluation by operators (Vego et al., 2008). Additionaly, Max criteria was selected based on the type of questions belonging to each subcriteria.

*Table 8. PROMETHEE II rankings*

| Type of mining machinery workplace | φ + | φ - | φ | Ranking |
|---|---|---|---|---|
| Operator on Excavator | 0.09623 | 0.00000 | 0.09623 | 2 |
| Operator on Rotary excavator | 0.02284 | 0.05595 | -0.03310 | 4 |
| Operator on Dump truck | 0.05991 | 0.01107 | 0.04884 | 3 |
| Operator on Bulldozer | 0.01049 | 0.08456 | -0.07407 | 6 |
| Operator on Loader | 0.22815 | 0.00000 | 0.22815 | 1 |
| Operator on Grader | 0.00454 | 0.20882 | -0.20427 | 7 |
| Operator on Other mining machine | 0.01049 | 0.07227 | -0.06178 | 5 |

The workplace with the highest level of safety satisfaction is represented by the Operator on Loader in the PROMETHEE II ranking order, while the workplace with the lowest ranking results is represented by the Operator on Grader.

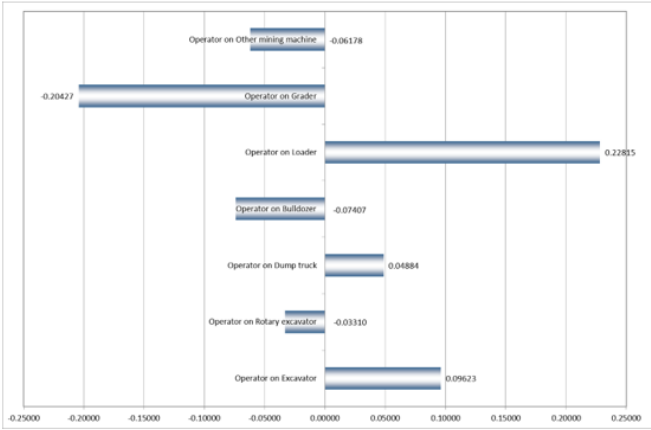


*Figure 5. PROMETHEE II net-flow results*

The weight evaluation for each criterion affects the outcome as well, because the chosen criteria are not equally important. Data on weight stability intervals for every subcriterion are shown in Table 9. Stability interval analysis is used to assess how robust the selected preference relations are. Reevaluating the input subcriteria can be done after the stability intervals have been interpreted. A large stability interval suggests that even when the parameter varies widely, the ranking order remains constant. The weights stability intervals analysis revealed that none of subcriteria were particularly unstable or had a narrow stability interval.

*Table 9. Weights stability intervals for the selected subriteria in model*

| Criteria | Subcriteria | Weight of subcriteria | Interval | |
|---|---|---|---|---|
| | | | Minimum | Maximum |
| Human factors | HF_1 | 0.055 | 0 | 1 |
| | HF_2 | 0.048 | 0 | 1 |
| | HF_3 | 0.055 | 0 | 0.2397 |
| Organizational factors | OF_1 | 0.141 | 0.1384 | 0.6647 |
| | OF_2 | 0.126 | 0 | 1 |
| | OF_3 | 0.150 | 0.1474 | 1 |
| | OF_4 | 0.144 | 0 | 0.1453 |
| | OF_5 | 0.133 | 0 | 1 |
| | OF_6 | 0.148 | 0 | 1 |

*Table 9. TOPSIS rankings*

| Type of mining machinery workplace | CCi | Ranking |
|---|---|---|
| Operator on Excavator | 0.74153 | 2 |
| Operator on Rotary excavator | 0.43966 | 4 |
| Operator on Dump truck | 0.58639 | 3 |
| Operator on Bulldozer | 0.34810 | 5 |
| Operator on Loader | 0.96231 | 1 |
| Operator on Grader | 0.16317 | 7 |
| Operator on Other mining machine | 0.31919 | 6 |

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# WP3:Development of context-specific multi-sensorial mining machinery operator aid system

D3.1. Fully functional multisensory mining machinery operator aid system established or in operating mode (TOOL which can monitor the list of the most important workplaces factors coming out of WP2) – **month 15**
D3.2. Databases design for collecting the data lines obtained from the measuring sensors and final measurement scale development for assessment of the behavioristic and safety climate indicators of each workplace, on the weekly bases – month 17
D3.3. Modeling results report- numerical and statistical models, based on MLRA and ANNs, developed for simulation of the procedures and processes on each of evaluated mining machinery workplaces – month 19
D3.4 Report on verification & validation of multi-sensorial operator aid system input / output models, based on new data lines acquisition - month 21
D3.5. Operator's ergonomic adjustment system designed and technical solution started verification procedure – month 21

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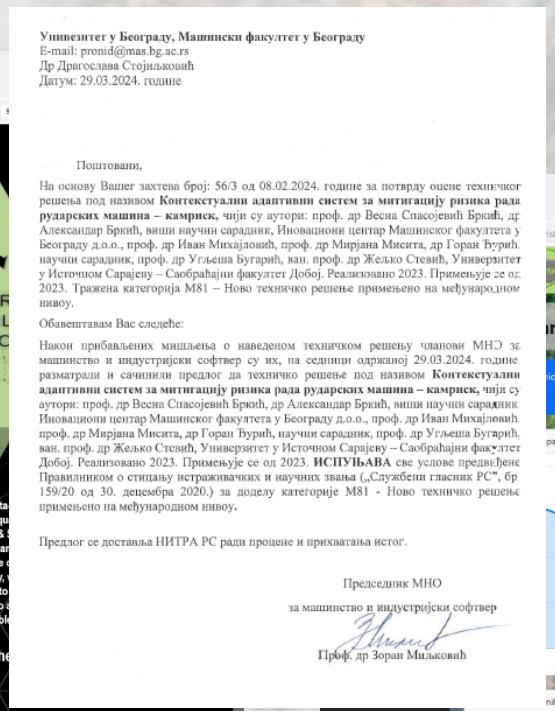
# WP3:Development of context-specific multi-sensorial mining machinery operator aid system

Technical solution M81: KAMRISK – Contextual adaptive system for mining machinery risk mitigation



**Универзитет у Београду, Машински факултет у Београду**
E-mail: pronid@mas.bg.ac.rs
Др Драгослава Стојиљковић
Датум: 29.03.2024. године

Поштовани,

На основу Вашег захтева број: 56/3 од 08.02.2024. године за потврду оцене техничког решења под називом **Контекстуални адаптивни систем за митигацију ризика рада рударских машина – камрисК**, чији су аутори: проф. др Весна Спасојевић Бркић, др Александар Бркић, виши научни сарадник, Иновациони центар Машинског факултета у Београду д.о.о., проф. др Иван Михајловић, проф. др Мирјана Мисита, др Горан Ђурић, научни сарадник, проф. др Угљеша Бугарић, ван. проф. др Желко Стевић, Универзитет у Источном Сарајеву – Саобраћајни факултет Добој. Реализовано 2023. Примењује се од 2023. Тражена категорија М81 – Ново техничко решење примењено на међународном нивоу.

Обавештавам Вас следеће:

Након прибављених мишљења о наведеном техничком решењу чланови МНО за машинство и индустријски софтвер су их, на седници одржаној 29.03.2024. године разматрали и сачинили предлог да техничко решење под називом **Контекстуални адаптивни систем за митигацију ризика рада рударских машина – камрисК**, чији су аутори: проф. др Весна Спасојевић Бркић, др Александар Бркић, виши научни сарадник Иновациони центар Машинског факултета у Београду д.о.о., проф. др Иван Михајловић, проф. др Мирјана Мисита, др Горан Ђурић, научни сарадник, проф. др Угљеша Бугарић, ван. проф. др Желко Стевић, Универзитет у Источном Сарајеву – Саобраћајни факултет Добој. Реализовано 2023. Примењује се од 2023. **ИСПУЊАВА** све услове предвиђене Правилником о стицању истраживачких и научних звања („Службени гласник РС", бр 159/20 од 30. децембра 2020.) за доделу категорије М81 - Ново техничко решење примењено на међународном нивоу.

Предлог се доставља НИТРА РС ради процене и прихватања истог.

Председник МНО
за машинство и индустријски софтвер
Проф. др Зоран Миљковић

SmartMiner

SUPPORT SYSTEMS FOR SMART, ERGONOMIC AND SUSTAINABLE MINING MACHINERY WORKPLACES

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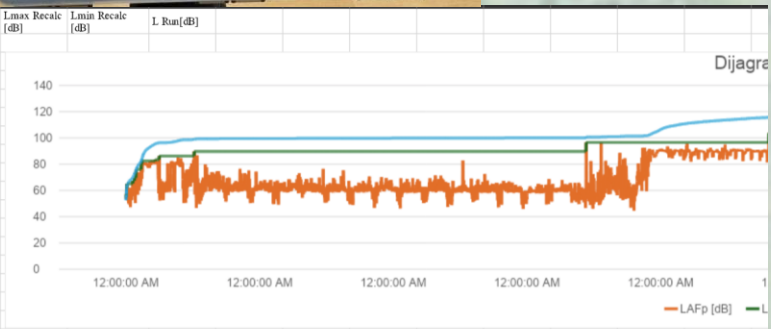
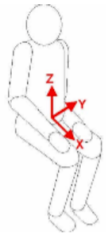
# WP3:Development of context-specific multi-sensorial mining machinery operator aid system

| Time | LAFp [dB] | LAFmax [dB] | LE [dB] | Status | Leq Recalc [dB] | Lmax Recalc [dB] | Lmin Recalc [dB] | L Run[dB] |
|---|---|---|---|---|---|---|---|---|
| 10:36:12 AM | 53,4 | 53,4 | 50,6 | | --- | | | |
| 10:36:13 AM | 54,8 | 54,8 | 52,7 | | 105,4 | | | |
| 10:36:13 AM | 54,1 | 54,8 | 54,3 | | 4,8 | | | |
| 10:36:14 AM | 53,8 | 54,8 | 54,6 | | 104,5 | | | |
| 10:36:14 AM | 57,1 | 57,1 | 56,6 | | --- | | | |
| 10:36:15 AM | 55,4 | 57,1 | 57,3 | | 0,2 | | | |
| 10:36:15 AM | 61,9 | 61,9 | 60,4 | | 52,8 | | | |
| 10:36:16 AM | 61,8 | 61,9 | 61,8 | | 0,3 | | | |
| 10:36:16 AM | 61,5 | 61,9 | 62,7 | | --- | | | |
| 10:36:17 AM | 65,1 | 65,1 | 64,1 | | --- | | | |
| 10:36:17 AM | 59,5 | 65,1 | 64,5 | | --- | | | |
| 10:36:18 AM | 58,5 | 65,1 | 64,7 | | --- | | | |
| 10:36:18 AM | 59,4 | 65,1 | 64,9 | | --- | | | |
| 10:36:19 AM | 59,3 | 65,1 | 65,2 | | 0,2 | | | |
| 10:36:19 AM | 58,8 | 65,1 | 65,3 | | 52,8 | | | |
| 10:36:20 AM | 54,5 | 65,1 | 65,3 | | 0,3 | | | |
| 10:36:20 AM | 53,9 | 65,1 | 65,4 | | --- | | | |
| 10:36:21 AM | 53,7 | 65,1 | 65,5 | | --- | | Prosečna buka: | 86,89601375 |
| 10:36:21 AM | 52,1 | 65,1 | 65,5 | | --- | | | |
| 10:36:22 AM | 55 | 65,1 | 65,7 | | --- | | | |



Calculation of Daily VDV Exposure for Whole-Body Vibrations

In accordance with: EU Directive 2002/44EC and ISO 2631-1: 1997




| | | | |
|---|---|---|---|
| **Operating person:** | Person 1 | **Activities:** | Activity 1 |
| (overwrite "Person" | Person 2 | (overwrite "Activity" | Activity 2 |
| with names) | Person 3 | with descriptive text) | Activity 3 |
| | Person 4 | | Activity 4 |
| | Person 5 | | Activity 5 |
| | Person 6 | | Activity 6 |
| | Person 7 | | Activity 7 |
| | Person 8 | | Activity 8 |
| | Person 9 | | Activity 9 |
| | Person 10 | | Activity 10 |

| | | |
|---|---|---|
| **Exposure limit value:** | 21 | m/S^1,75 |
| **Exposure action value:** | 9,1 | m/s^1,75 |

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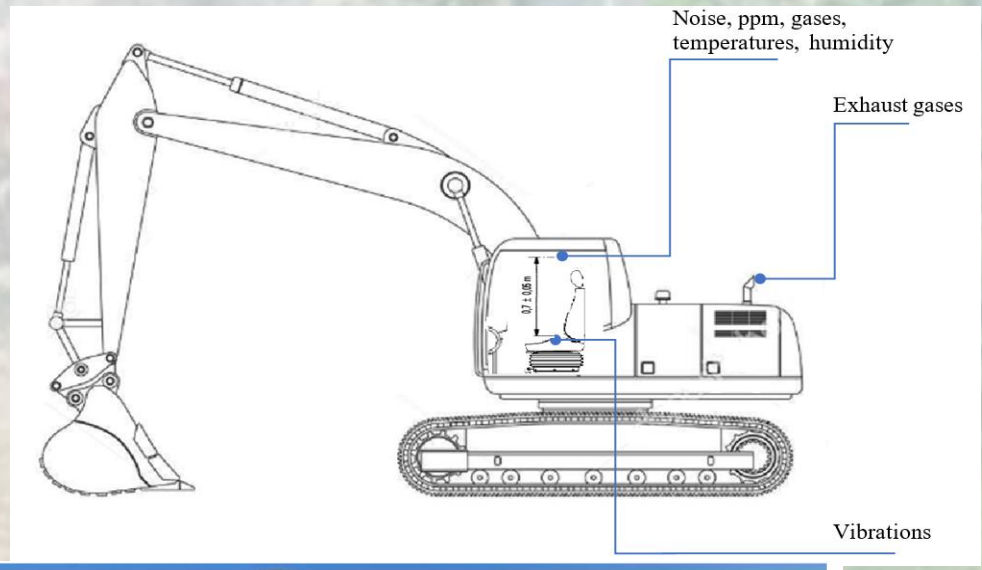
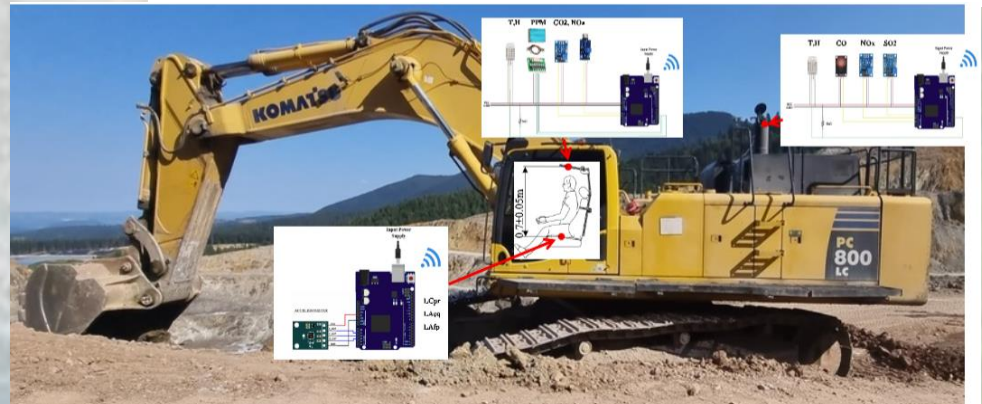
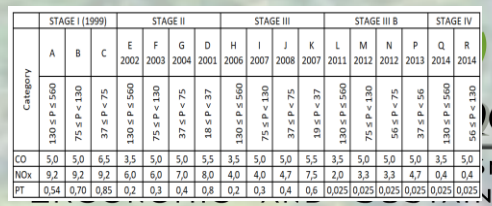
# WP3:Development of context-specific multi-sensorial mining machinery operator aid system

| Measurement instrument | Measuring variables | Calculated/Compared to |
|---|---|---|
| TROTEC PC 220 | Particle sizes:<br>0.3µm, 0.5µm, 1.0µm, 2.5µm, 5.0µm, 10µm<br>AT(°C) | • Limit value in relation to the 24-hour PM2.5 standard<br>• Limit value in relation to the annual PM2.5 standard |
| HUMAN-VIBRATION ANALYZER V31 | Move on three orthogonal axes:<br>$a_{wx}$,<br>$a_{wy}$<br>$a_{wz}$<br>$a_{w(Vec)}$<br>MTVV | • Daily exposure limit - eight hours; A(8)<br>• Daily action value of exposure - eight hours; A(8) |
| DIGITAL ALMEMO D6 SENSOR / AHLBORN ALMEMO 2590-2A/4AS | CO2 [ppm], KGVI NO2 [ppm], KGVI SO2 [ppm], CO2 [mg/m3], KGVI NO2 [mg/m3], KGVI SO2 [mg/m3] | • The limit values<br>• Short-term limit values (KGV) |
| HD2010UC/A Spectrum Analyzer Interating Sound Level Meter | LCpk – peak sound pressure value<br>LAeq – equivalent noise level<br>LAFp – sound pressure | • $p_{peak}$ - peak value of sound pressure (maximum value "C" of frequency-weighted current sound pressure)<br>• $L_{A,EX,8h}$ - daily exposure level of to noise (dB(A) in relation to the reference value of 20µPa)<br>• $L_{A,EX,15min}$ -15min level of noise exposure<br>• $L_{A,EX,8h}$ - weekly exposure level to the noise |
| TESTO 340 FLUE GAS ANALYSER FOR EMISSION MEASUREMENT | ppm CO, ppm NO, % CO2, °C FT, ppm NOx | • Limit values in relation to STAGE I...V, year of engine production and engine power |
| CREALTY CR-SCAN 01 | Operator's 3D model | • Anthropometric measurements |





| Category | STAGE I (1999) | | | STAGE II | | | | STAGE III | | | | STAGE III B | | | | STAGE IV | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | E 2002 | F 2003 | G 2004 | D 2001 | H 2006 | I 2007 | J 2008 | K 2007 | L 2011 | M 2012 | N 2012 | P 2013 | Q 2014 | R 2014 |
| | 130 ≤ P ≤ 560 | 75 ≤ P < 130 | 37 ≤ P < 75 | 130 ≤ P ≤ 560 | 75 ≤ P < 130 | 37 ≤ P < 75 | 18 ≤ P < 37 | 130 ≤ P ≤ 560 | 75 ≤ P < 130 | 37 ≤ P < 75 | 19 ≤ P < 37 | 130 ≤ P ≤ 560 | 75 ≤ P < 130 | 56 ≤ P < 75 | 37 ≤ P < 56 | 130 ≤ P ≤ 560 | 56 ≤ P < 130 |
| CO | 5,0 | 5,0 | 6,5 | 3,5 | 5,0 | 5,0 | 5,5 | 3,5 | 5,0 | 5,0 | 5,5 | 3,5 | 5,0 | 5,0 | 5,0 | 3,5 | 5,0 |
| NOx | 9,2 | 9,2 | 9,2 | 6,0 | 6,0 | 7,0 | 8,0 | 4,0 | 4,0 | 4,7 | 7,5 | 2,0 | 3,3 | 3,3 | 4,7 | 0,4 | 0,4 |
| PT | 0,54 | 0,70 | 0,85 | 0,2 | 0,3 | 0,4 | 0,8 | 0,2 | 0,3 | 0,4 | 0,6 | 0,025 | 0,025 | 0,025 | 0,025 | 0,025 | 0,025 |

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MINING MACHINERY WORKPLACES

# WP3:Development of context-specific multi-sensorial mining machinery operator aid system

| No | | | | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **Rule book/Standard** | **International standard** | **Mark** | **The limit value (GV)** | **The short-term exposure limit value (KGV)** | Mining machine 1 | Mining machine 2 | Mining machine 3 | Mining machine 4 | Mining machine 5 |
| **Machine type:** | | | | | Excavator | Excavator | Damper | Excavator | Excavator |
| **kWh:** | | | | | 123 | 180 | 250 | 370 | 370 |
| **Year:** | | | | | 2018 | 2024 | 2008 | 2017 | 2017 |
| **NOISE** | | | | | | | | | |
| • Rule book on preventive measures for safe and healthy work when exposed to noise (Official Gazette of RS No. 96/2011, 78/2015, 93/2019);<br>• Rule book on noise protection measures and norms at work in workplaces (Official Gazette of RS, No. 21/92); | *•ISO-9612-2009<br>•ISO/11201 – Acoustics – Noise emitted by machinery and equipment | **$p_{peak}$** | 140 Pa (137 dB(C) in relation to the reference value of 20 μPa); | | 133.4 | 83 | 131.5 | 106.1 | 135 |
| | | **LA,EX,8h daily** | 85 dB(A) | **LA,eq,15min** dB(A) = 70 (drive noise)/ 60 (traffic noise) | 61.08 | - | 55.099 | 53.9 | 46.11 |
| **EMISSION OF GASEOUS AND PARTICULATE POLLUTANTS FROM INTERNAL COMBUSTION ENGINES** | | | | | | | | | |
| | | g/kWh | | | STAGE IV | STAGE IV | STAGE III | STAGE IV | STAGE IV |
| | | Category | | | CATEGORY R | CATEGOR Y Q | CATEGORY L | CATEGORY Q | CATEGORY Q |
| Directive EU | ***•Directive 9768EC<br>•Directive 981053<br>•Directive 2008/50/EC •Regulation (EU) 2019/1242 | **% O2** | | | 16.33 | 17.87 | 16.00 | 16.06 | 14.06 |
| | | **CO** | | | 116.11 | 0.92 | 15.64 | 3.80 | 1.81 |
| | | **NOx** | | | 268.63 | 131.38 | 160.06 | 241.39 | 321.58 |
| | | **SO2** | | | 4.22 | 2.52 | 4.10 | 6.68 | 6.15 |
| | | **°C FT of exhouse pipe** | | | - | - | 40 | 26 | 22 |
| **INDOOR AIR QUALITY (GASES, PARTICULATE POLLUTANTS)** | | | | | | | | | |
| | | | **The limit value (LV)** | **The short-term exposure limit value (SLV)** | ppm | ppm | ppm | ppm | ppm |
| | | | mg/m³ / ppm | mg/m³ / ppm | LV / SLV | LV / SLV | LV / SLV | LV / SLV | LV / SLV |
| Rule book on preventive measures for safe and healthy work when exposed to chemical substances ("Official Gazette of RS", no. 106/2009, 117/2017 and 107/2021) | Directive 2006/15/EC (second list). | **CO2** | 9000 / 5000 | | - | 752.3 / - | 915.4 / - | 912.8 / - | 273.65 / - |
| | Direktiva 2017/164/EU (četvrta lista) | **SO2** | 1.3 / 0.5 | 2.7 / 1 | - / 0.0 | 5.5 / 13.6 | 0.0 / 0.0 | 0.0 / 0.0 | 0.4 / 0.0 |
| | Directive 2017/164/EU (fourth list). | **NO2** | 0.96 / 0.5 | 1.91 / 1 | - / 0.0 | 9.2 / 21.5 | 0.1 / 0.0 | 0.5 / 0.0 | 0.7 / 0.0 |
| | | **AP,p mbar** | | | - | 975.9 | 882.8 | 880.6 | 880.2 |
| | | | **24-hours PM2.5 standard** | **Yearly PM2.5 standard** | | | | | |
| | EPA - National Ambient Air Quality Standards (40 CFR part 50) | **2.5 μm** | 35 μg/m3 | 9μm/m3 | 43.2 / - | 15.1 / - | - / - | 31.1 / - | 0.8 / - |
| | EPA - National Ambient Air Quality Standards (40 CFR part 50) | **10 μm** | 150 μg/m3 | 9μm/m3 | 982.5 / - | 72.7 / - | - / - | 189.2 / - | 30.9 / - |
| **OUTSIDE AIR TEMPERATURE** | | | | | | | | | |
| | | **Temperature** | <+5°C | +5°C ÷ +15°C / >+15°C | 28.5 | 30 | 35 | 30 | 30 |
| Rule book on preventive measures for safe and healthy work at the workplace ("Official Gazette of RS", RS 21/2009) | | **AT(°C)** | 15-18 | 15-18 / max 28 | 33.14 | 30.21 | 28.26 | 32.15 | 27.32 |
| | | **RH(%)** | max 75 | max 75 / 28°C ? 55<br>26°C ? 60<br>24°C ? 65<br><24 ? 73 | 38.698 | 34.942 | 34.526 | 28.053 | 31.958 |
| **VIBRATION** | | | | | | | | | |
| Rule book on preventive measures for safe and healthy work when exposed to vibration ("Official Gazette of RS", no. 93/2011 and 86/2019) | ***•ISO 2631-1<br>•ISO 2631- 5<br>•ISO-2631-1978 •ISO-TR-25398-2006 Earth-moving machinery | The daily **limit** value of exposure eight hours; A(8) | 1.15 m/s2 [W/B] | | 0.26 | 0.31 | 0.53 | 0.26 | 0.40 |
| | | The daily **action** value of exposure eight hours; A(8) | 0.5 m/s2 [W/B] | | 0.26 | 0.31 | 0.53 | 0.26 | 0.40 |

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# WP5:Dissemination activities and stakeholders' collaboration

D5.1. Project website and profiles launched using logo and posters and brochures printed – month 3
D5.2. Dissemination Plan Activity Report – month 4 and Dissemination Activity Report – yearly month 12,24
D5.3. Scientific open access publications (min 2 in high impact M21/22 journals), 6 high impact conference papers, technical solution and patent application, public events and workshops (cross-section on an annual basis - month 12, 24)
D5.4 Collaboration with stakeholders' report – cross-section on an annual basis - month 12,24

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# WP5:Dissemination activities and stakeholders' collaboration

D5.1. Project website and profiles launched using logo and posters and brochures printed – month 3

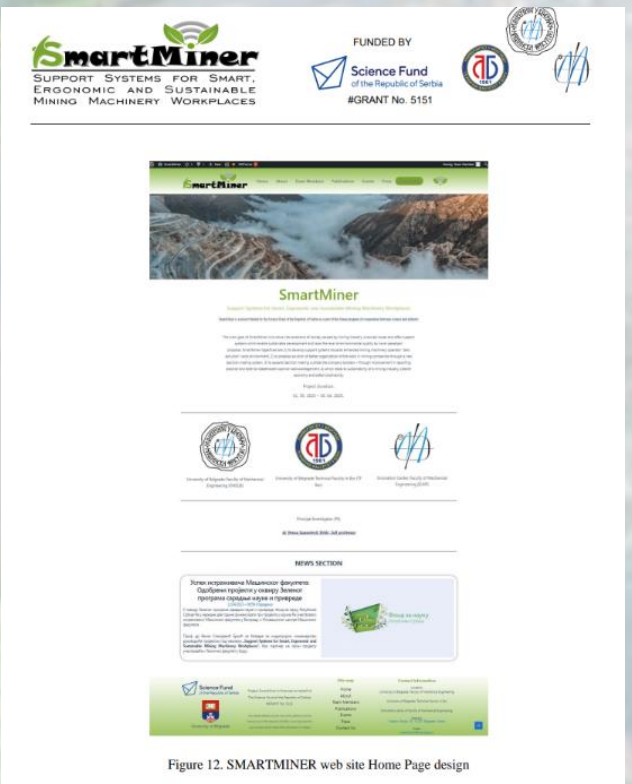



Figure 12. SMARTMINER web site Home Page design

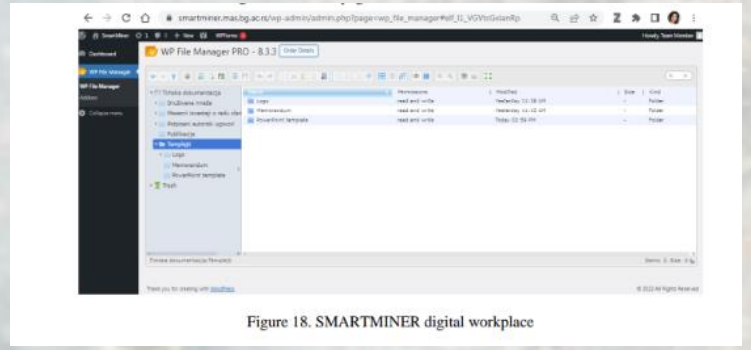



Figure 18. SMARTMINER digital workplace

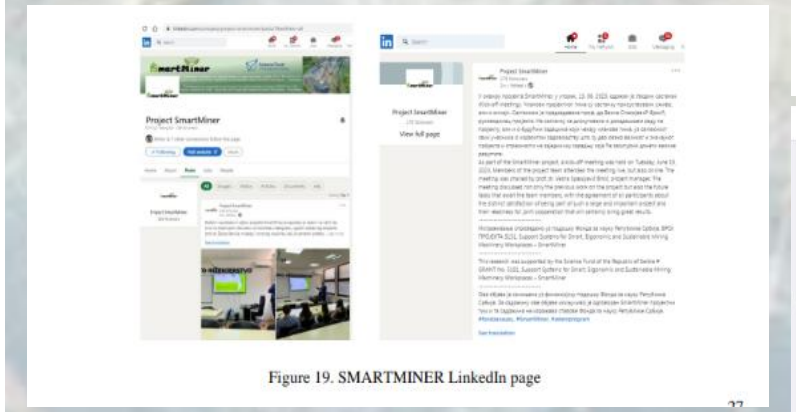



Figure 19. SMARTMINER LinkedIn page

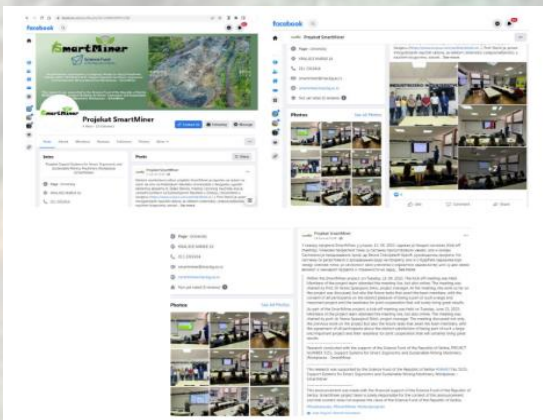
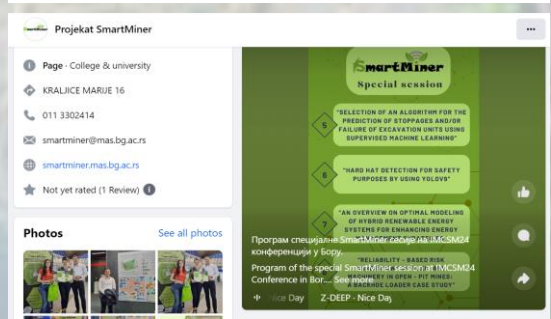



Figure 20. SMARTMINER Facebook page



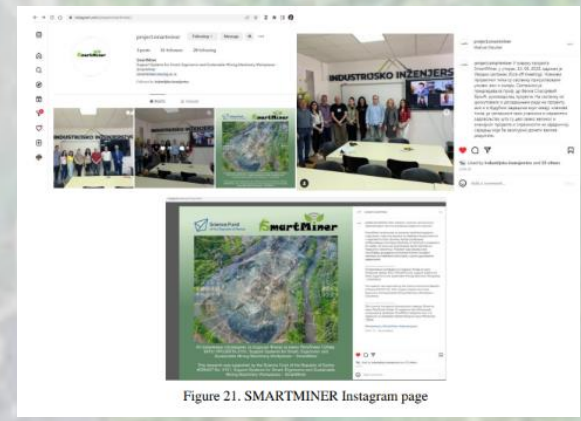
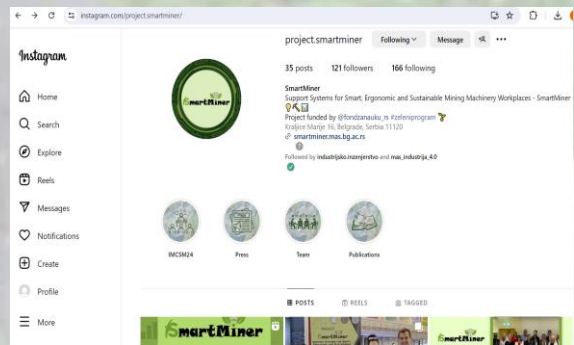




Figure 21. SMARTMINER Instagram page



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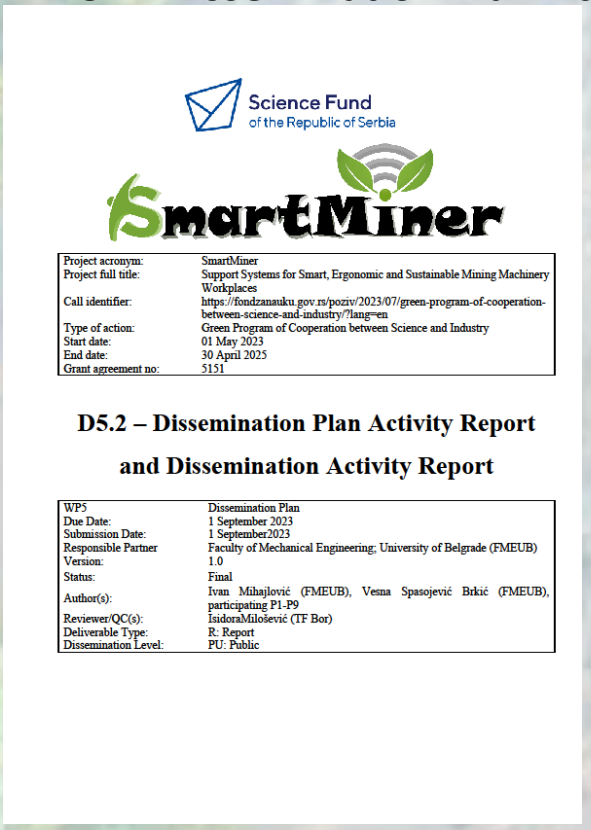
# WP5:Dissemination activities and stakeholders' collaboration

D5.2. Dissemination Plan Activity Report – month 4 and Dissemination Activity Report – yearly month 12,24



Science Fund of the Republic of Serbia

SmartMiner

| | |
|---|---|
| Project acronym: | SmartMiner |
| Project full title: | Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces |
| Call identifier: | https://fondzanauku.gov.rs/poziv/2023/07/green-program-of-cooperation-between-science-and-industry/?lang=en |
| Type of action: | Green Program of Cooperation between Science and Industry |
| Start date: | 01 May 2023 |
| End date: | 30 April 2025 |
| Grant agreement no: | 5151 |

**D5.2 – Dissemination Plan Activity Report and Dissemination Activity Report**

| | |
|---|---|
| WP5 | Dissemination Plan |
| Due Date: | 1 September 2023 |
| Submission Date: | 1 September2023 |
| Responsible Partner | Faculty of Mechanical Engineering, University of Belgrade (FMEUB) |
| Version: | 1.0 |
| Status: | Final |
| Author(s): | Ivan Mihajlović (FMEUB), Vesna Spasojević Brkić (FMEUB), participating P1-P9 |
| Reviewer/QC(s): | IsidoraMilošević (TF Bor) |
| Deliverable Type: | R: Report |
| Dissemination Level: | PU: Public |

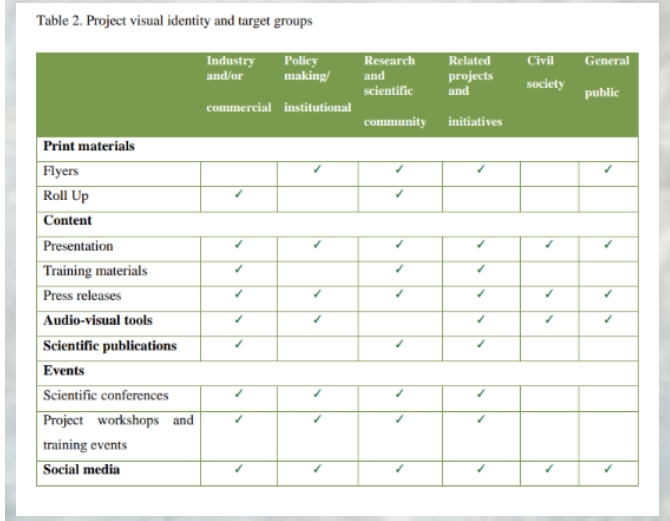


Table 2. Project visual identity and target groups

| | Industry and/or commercial | Policy making/ institutional | Research and scientific community | Related projects and initiatives | Civil society | General public |
|---|---|---|---|---|---|---|
| **Print materials** | | | | | | |
| Flyers | | ✓ | ✓ | ✓ | | ✓ |
| Roll Up | ✓ | | ✓ | | | |
| **Content** | | | | | | |
| Presentation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Training materials | ✓ | | ✓ | ✓ | | |
| Press releases | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Audio-visual tools** | ✓ | ✓ | | ✓ | ✓ | ✓ |
| **Scientific publications** | ✓ | | ✓ | ✓ | | |
| **Events** | | | | | | |
| Scientific conferences | ✓ | ✓ | ✓ | ✓ | | |
| Project workshops and training events | ✓ | ✓ | ✓ | ✓ | | |
| **Social media** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

- 2 stakeholders engagement workshops
- 1 press release in POLITIKA
- 2 TV releases – RTS and TV Bor
- 8 Advisory&Ethics Board meetings
- 1 special session at conference with 10 papers dedicated to SmartMiner project
- Till now 24 published papers
- 1 technical solution M81

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SmartMiner
SUPPORT SYSTEMS FOR SMART, ERGONOMIC AND SUSTAINABLE MINING MACHINERY WORKPLACES

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# WP5:Dissemination activities and stakeholders' collaboration

D5.3. Scientific open access publications (min 2 in high impact M21/22 journals), 6 high impact conference papers, technical solution and patent application, public events and workshops (cross-section on an annual basis - month 12, 24)

- 2 stakeholders engagement workshops
- 1 press release in POLITIKA
- 2 TV releases – RTS and TV Bor
- 8 Advisory&Ethics Board meetings

ПОЛИТИКА

Мени

Sreda, 27.09.2023. u 14:07

Jasna Petrović-Stojanović

„SmartMiner" projekat na Mašinskom fakultetu

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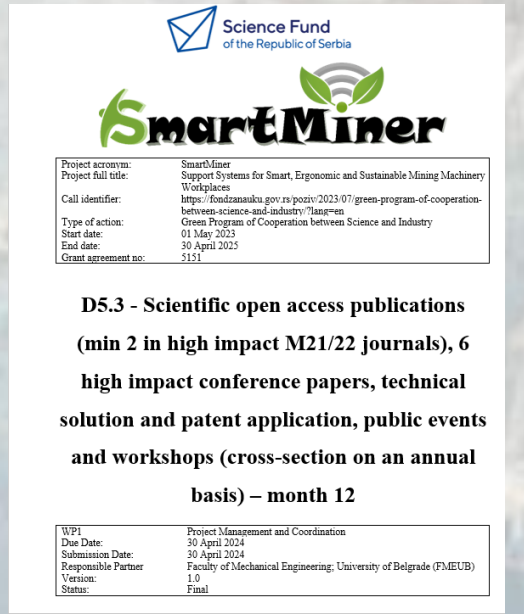
# WP5:Dissemination activities and stakeholders' collaboration

D5.3. Scientific open access publications (min 2 in high impact M21/22 journals), 6 high impact conference papers, technical solution and patent application, public events and workshops (cross-section on an annual basis - month 12, 24)

- Planned results 2 M21/22, 1 technical solution, 6 M33, 1 patent
- Till now 24 published (1 M22,1 M23,1 M31,1 M51,20 M33) and 1 technical solution M81
- In review 2 high impact papers -1 M21 and 2 M22



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SmartMiner

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| Project acronym: | SmartMiner |
| Project full title: | Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces |
| Call identifier: | https://fondzanauku.gov.rs/poziv/2023/07/green-program-of-cooperation-between-science-and-industry/?lang=en |
| Type of action: | Green Program of Cooperation between Science and Industry |
| Start date: | 01 May 2023 |
| End date: | 30 April 2025 |
| Grant agreement no: | 5151 |

**D5.3 - Scientific open access publications (min 2 in high impact M21/22 journals), 6 high impact conference papers, technical solution and patent application, public events and workshops (cross-section on an annual basis) – month 12**

| | |
|---|---|
| WP1 | Project Management and Coordination |
| Due Date: | 30 April 2024 |
| Submission Date: | 30 April 2024 |
| Responsible Partner | Faculty of Mechanical Engineering; University of Belgrade (FMEUB) |
| Version: | 1.0 |
| Status: | Final |

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# WP5:Dissemination activities and stakeholders' collaboration

D5.3. Scientific open access publications (min 2 in high impact M21/22 journals), 6 high impact conference papers, technical solution and patent application, public events and workshops (cross-section on an annual basis - month 12, 24)

- 1 special session at conference with 10 papers dedicated to SmartMiner project

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# WP5:Dissemination activities and stakeholders' collaboration

D5.4 Collaboration with stakeholders' report – cross-section on an annual basis - month 12,24

Science Fund of the Republic of Serbia

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| Project acronym: | SmartMiner |
| Project full title: | Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces |
| Call identifier: | https://fondzanauku.gov.rs/poziv/2023/07/green-program-of-cooperation-between-science-and-industry/?lang=en |
| Type of action: | Green Program of Cooperation between Science and Industry |
| Start date: | 01 May 2023 |
| End date: | 30 April 2025 |
| Grant agreement no: | 5151 |

**D5.4 - Collaboration with stakeholders' report – cross-section on an annual basis – month 12**

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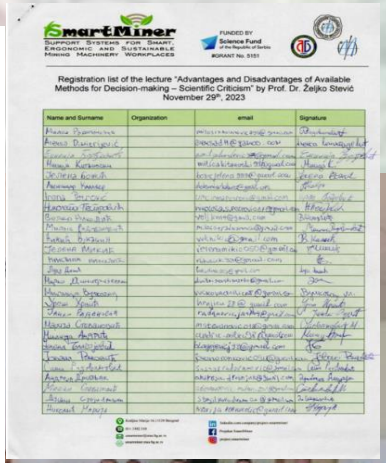
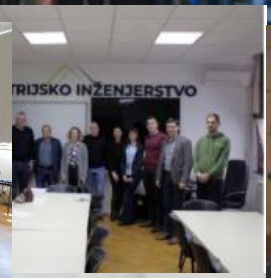
|---|---|
| WP1 | Project Management and Coordination |
| Due Date: | 30 April 2024 |
| Submission Date: | 30 April 2024 |
| Responsible Partner | Faculty of Mechanical Engineering; University of Belgrade (FMEUB) |
| Version: | 1.0 |
| Status: | Final |
| Author(s): | Vesna Spasojević Brkić (FMEUB), participating P1-P14 |
| Reviewer/QC(s): | Isidora Milošević (TF Bor) |
| Deliverable Type: | R: Report |
| Dissemination Level: | PU: Public |

1 / 77





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# SmartMiner impact

## GLOBAL IMPACT

- New and different paradigm
- Environmentaly and socially sustainable workplaces due to paradigm shift
- Solutions considering operator & society 5.0 concepts and HF/E
- Change of stakeholders mindset
- Global impact on the society, economy, industry, climate change, environment, biodiversity, helthcare, education and other aspects of social development ➡ higher human development index value all over the world
- Concept transfer to other industries

## STRATEGIC (MID-TERM) IMPACT

- Improved industrial safety and economic benefits
- Improved working conditions - efficient and green operation of mining machinery
- New, sustainable solution offered with short time-to-market
- Opens development of specific scientific interdisciplinary fields
- Mining companies become as trusted partners for the development of wealth and prosperity in the society

## OPERATION LEVEL IMPACT

- Productivity increase at workplace by 10-30%
- Production increase by 10-20%
- Higher energy efficiency and major pollutants emissions decrease by 100 tons/y per machine
- 15 % lower incidence rates

## NATIONAL LEVEL IMPACT

- New, specific scientific, interdisciplinary field is born in Serbia
- Boath open access and IP protected results: two publications in high impact M21/22 journals, six on the conferences and technical solution and patent
- increase number of companies, GDP, and employment
- motivating policy makers to harmonize sustainability policies

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# 46th AIM Conference 2024

## Thank you for your kind attention

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