

# INTERNATIONAL COMPETENCE CENTRE FOR MINING-ENGINEERING EDUCATION UNDER THE AUSPICES OF UNESCO



AUSTRIAN BRANCH  
AT MONTANUNIVERSITÄT LEOBEN



LEOBEN 20.-22. JANUARY 2020  
EXPERT FORUM  
on Digitalisation in the Raw Materials Sector

EVENT

CONFERENCE

## TABLE OF CONTENTS

About the event.....	4
Welcome from the host institution.....	6
Special welcome to our guests from SPMU and EC.....	8
Welcome from EIT Raw Materials.....	10
Digitalisation, an integral part of the Lighthouse Sustainable Discovery &Supply	12
Agenda.....	14
Selected speakers	
Yuriy Zhukovskiy, SPMU.....	18
Digital competences as the basis for sustainable development of the RM sector	
Debby DeRoover, European Commission .....	20
Raw Materials in Horizon 2020 and Horizon Europe	
Michael Haschke, DMT' .....	22
Industry needs & priorities for digitalisation in the raw materials sector	
Andrea Bartoli, Worldsensing .....	23
Worldsensing journey from idea to success	
Uwe Restner, Sandvik.....	24
Digitalisation in mine tunnel development	

Wolfgang Walcher, Robotic Eyes.....	25
Making human labour easier, more productive and safer with Robotic Eyes	
Fran Espada, Hovering Solutions.....	26
Flying robots for underground 3D mapping	
Luca Piovano, UPM.....	27
Extended reality and data Visualisation experiences in mining and other activities	
Markus Häupl, Abaut .....	28
Artificial intelligence image recognition, pattern analysis, machine learning	
Richard Gloaguen, HZDR .....	30
Digitalisation in exploration using machine learning	
Paul O’Leary, MUL.....	31
Digital twins for monitoring, evaluation of ground quality, processes & machines	
Phillipp Hartlieb, MUL .....	32
Improving performance by measurement and digital analysis of mining processes	
Project presentation: MiRe Books.....	34
Start-up and business corner.....	35
Abaut, Robotic Eyes, MiRe Books, Metheore, Mecorad, KGHM Cuprum	
Thesis awards.....	36

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AUSTRIA - LEOBEN  
20.1.-22.1.2020

Arts Exhibition Centre & Museum

Exploration, mining and mineral processing involves the collection and analysis of vast quantities of data from various scales of observation and over variable timeframes.

As the digitalisation of the sector is progressing, artificial intelligence (AI), machine learning (ML), deep learning (DL), augmented/virtual reality (AR/VR) and data integration solutions are increasingly being used to collect, analyse and manage data and visualise content in real time in variable contexts.

AI, ML, DL, AR, VR and data integration were therefore the topics of the **FIRST EXPERT FORUM OF THE EIT RAWMATERIALS SUSTAINABLE**

**DISCOVERY AND SUPPLY LIGHTHOUSE.** Generally speaking, lighthouses are large-scale and long-term innovation initiatives of the **European Institute of Innovation & Technology (EIT)**, namely the **Raw Materials Knowledge and Innovation Community**, that address critical and specific raw materials challenges for Europe. They provide guidance for innovation projects that create smart solutions along the entire raw materials value chain for a sustainable future.

Taking place in the heart of Leoben, at the Arts Exhibition Centre & Museum, this expert forum was for people actively researching, developing and employing digital solutions in exploration, mining and mineral processing – universities, research & technology organisations, companies and start-ups.

The Expert Forum is an excellent opportunity to meet key stakeholders, discuss common development successes and challenges, as well as learn from each other's successes and failures to develop new smart solutions.





**The International Competence Centre for Mining-Engineering Education under the auspices of UNESCO as the Austrian Branch at Montanuniversität Leoben, co-organised this event.**

Established in December 2019, its mission is to support UNESCO’s global priorities of sustainable development by creating conditions for excellence and the continuous education of qualified specialists for the mining sector. The Austrian branch in Leoben, has given priority to the topics of sustainability, the global supply of raw materials and raw materials policy.

In this context in cooperation with partner universities and organisations, the Competence Centre seeks to work towards a more sustainable raw materials sector. As digitalisation in the sector progresses, such joint events enable key

stakeholders to come together, discuss trends, identify industry needs and innovative solutions and establish networks for project and strategic alliances.

The interest in, and the success of the event – **more than 130 participants from over 20 different countries** - show the importance of the topic and the need for future cooperation.

Creating opportunities for such dialogues and knowledge exchange is of paramount importance for the industry to enhance main operations and in sustaining its social license to operate.

The Competence Centre aims to maintain contact between various stakeholders and will continue to organise such activities in the future.



MOSER PETER

VICE-RECTOR, MUL

WELCOME  
FROM THE HOST INSTITUTION

„Welcome at Montanuniversität Leoben (MUL), where 4,000 students and around 1,000 employees are committed to the vision of the “**Circular Economy**” based on the sustainable management of resources all along the economic cycle from cradle to grave.

A sustainable materials flow from geology, mining, processing, metallurgy to materials, design, energy, to recycling back into the production processes is part of all of our activities in education and research.

I am glad to say that last week, one of our PhD students successfully defended a PhD in the field of metal mining & planetary boundaries.

The Sustainable Development Goals (SDGs) and their connection to the raw materials and the circular economy vision are a very important strategy in our work.

We cover both education and research in these areas; a strong point thereby is working in larger international networks, like e.g. international study programmes (with English as the language of education), participation in H2020 pro-

grammes and ERC grants.

In December 2019, MUL signed a contract with **UNESCO** and the St. Petersburg Mining Uni-

versity to establish an **International Education and Research Center in the field of Raw Materials**. Also within this initiative, MUL covers the areas of responsible sourcing for materials and energy efficient production processes and products of low impact and high quality.

A lighthouse of our work is EIT Raw Materials, in which, as a core partner, we were already highly active in the preparation phase and since the start.

If I am not mistaken, we worked on around 40 EIT Raw Materials-related projects so far and these have had an enormous impact on our research and education field.



„We work on responsible sourcing for materials and energy efficient production processes and products of low impact and high quality.

We do not only look at sectorial impacts but try to design “sustainable circular systems” in terms of their overall impact, of course knowing that material and process efficiency never can get to 100 %.“

However, it was not just the direct participation in these projects that significantly stimulated our development towards sustainable resources activities; it was also the contact with a huge number of new partners working in all of the various sectors of raw materials that triggered a lot of new creative thinking, especially through exchange and discussion with people, quite often with different views and ideas.

A key to the future development is certainly the digitalisation in the raw materials sector, the topic that concerns us here today and tomorrow. Several research projects during the previous years have shown, that we still do not fully understand the complexity of a lot of processes in the raw materials sector.

I strongly believe that the full understanding of the complexity of processes especially, among others, in terms of interaction, impact and efficiency, is a very important point towards the design of sustainable systems. Digitalisation will certainly contribute a lot to this.

I thank you for coming to Leoben, showing

interest in our work and participating in this event. I hope you will go home with a lot of new impressions and ideas for future sustainable development. I also hope that you will find a bit of free time to share your thoughts and discuss your ideas with colleagues over a good glass of carbon-neutrally brewed Gösser beer.

Lastly, I would like to thank

- EIT RM with Andreas Klossek and his team for giving MUL the opportunity to host this event;
- Patrick Nadoll for managing the preparation work together with Hanno, the ECLC team Kristoph, Sylvia, Antonis, Markus and all the others;
- The local team from the Ressources Innovation Center Leoben (RIC), headed by Susanne Feiel and her great team with Hanno, Owain, all Annas, Magdalena, Gloria, Stefanie, Manuel, Marinella, Mariaelena, Patrick, Marlène, Marie-Theres and Omar.

Enjoy your time in Leoben!

Glück auf!“

A SPECIAL WELCOME TO OUR GUESTS ...



FROM SAINT PETERSBURG MINING UNIVERSITY  
WITHIN OUR COOPERATION IN THE  
INTERNATIONAL COMPETENCE CENTRE FOR MINING-ENGINEERING EDUCATION  
UNDER THE AUSPICES OF UNESCO





FROM THE EUROPEAN COMMISSION

DG GROW

INTERNAL MARKET, INDUSTRY, ENTREPRENEURSHIP AND SMEs

# ANDREAS KLOSSEK

INTERIM CEO, COO, MANAGING DIRECTOR, EIT RAW MATERIALS



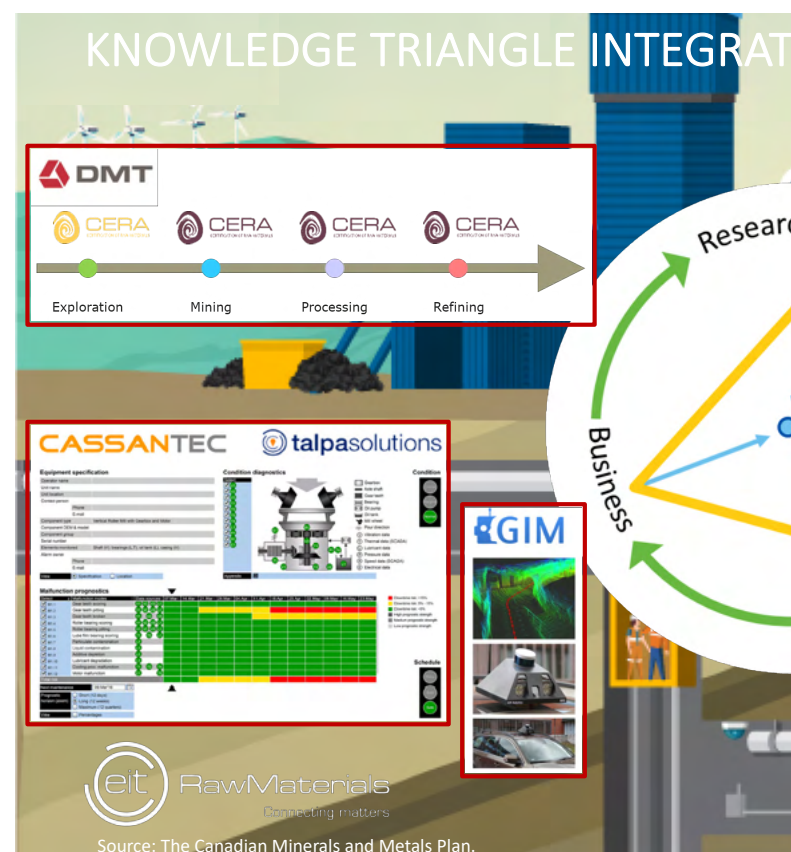
Andreas Klossek has been with the EIT RawMaterials since the beginning in 2014. Before that, he managed large R&D networks and public private partnerships (PPPs) in the energy and raw

materials sectors. His vast experience, together with his PhD in business administration, makes Mr. Klossek a highly valuable contact in these fields.

„Developing raw materials into a major strength for Europe“ is the vision of EIT RawMaterials. Along the value chain, sustainable competitiveness of the European minerals, metals and materials sector should be enabled. To achieve these aims it is important that innovation, education and entrepreneurship are promoted. Along with an integration of knowledge from industry, higher education and research, whereby stakeholders from the entire value chain of raw materials must be involved. EIT RawMate-

## WELCOME TO THE EVENT DIGITALISATION IN THE RAW MATERIALS SECTOR

rials‘ focus is on increasing resource efficiency, improving processes and products, supporting the introduction of new and innovative technologies, as well as rethinking the current linear economic model and achieving a circular approach. Furthermore, increasing human capital in the raw materials sector and promoting entrepreneurial education at all levels are additional priorities.




„EIT RawMaterials supports the digital transformation in many different ways by integrating all sides of the knowledge triangle: education, research and business.“

**EXPERT FORUM: DIGITALISATION IN THE RAW MATERIALS SECTOR**

The event will connect experts to:

- discuss overall **trends**
- identify **industry needs** and **innovative solutions**
- **network** for a project and strategic alliances
- meet with digital natives – **the next generation of raw materials professionals**
- provide information on **funding opportunities**




The digital transformation of the raw materials industry includes data integration, automation and autonomous technology, virtual and augmented reality, artificial intelligence & machine learning, blockchain technology for certification, maintenance and safety mechanisms, and goes beyond Industry 4.0 in many cases.

**MINING 4.0 – EXAMPLE MINING 4.0**



cases.

EIT RawMaterials supports this transformation in many different ways: EIT-funded education programmes such as DIM ESEE or MiReBooks provide training for the digital world; more than 130 start-ups have been supported, and many industry research projects have been and are being conducted successfully.

Furthermore, by organising events such as the Expert Forum relevant stakeholders in the raw materials community can meet, discuss, share knowledge and network, thus working together on our common goal - developing raw materials into a major strength for Europe.

PATRICK NADOLL

SENIOR ADVISOR - EIT RAW MATERIALS

## DIGITALISATION AS AN INTEGRAL PART OF THE LIGHTHOUSE SUSTAINABLE DISCOVERY AND SUPPLY



**EIT RawMaterials** runs three lighthouse programmes:

- 1) “Raw materials and circular societies,”
- 2) “Sustainable materials for future mobility” and
- 3) “Sustainable discovery and supply”.

These lighthouse programmes are large-scale and long-term innovation initiatives that address critical and specific raw materials challenges for Europe.

The sustainable discovery and supply lighthouse focuses on the importance of Europe’s resource potential and the role of primary raw materials as key enablers for a more sustainable

future.

Mining today faces numerous challenges such as increasing depths, decreasing ore grades, an overall low acceptance and a lack of investments.

Exploration needs to cover various scales of observation aided by machine learning - from satellite data to nano-scale geochemistry - to identify additional mineral potential.

Digital solutions in exploration, mining and processing offer smart and cost-effective solutions to improve the accuracy of geological models, increase safety and efficiency and optimise processes along the entire value chain.

Hence, digitalisation of the mining sector is one of the key focus areas of EIT RawMaterials.



„Sustainability starts with Europe’s resource potential. What we need are digital solutions that are fit for purpose, smart and efficient, as well as safe and reliable.“

## EIT RAWMATERIALS LIGHTHOUSES



## THE FUTURE



© Dr Kash Shiranda

Dr Kash Shiranda, Futurist

www.mineconnector.com

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REGISTRATION AND LIGHT LUNCH

12:00

Welcome. *Main Auditorium.*

Chaired by Patrick Nadoll, *EIT RawMaterials*

13:50

Welcome to the event

Andreas Klosek, *Interim CEO, COO, Managing Director, EIT RawMaterials*

14:00

Welcome from the hosting institution

Prof. Dr Peter Moser, *Montanuniversität Leoben*

14:05

Digitalisation as an integral part of the Lighthouse Sustainable Discovery and Supply

Patrick Nadoll, *Senior Advisor – Exploration and Resource Assessment, EIT RawMaterials*

Block 1: **Setting the Current Scene. Main Auditorium**

Chaired by Hanno Bertagnolli, *Montanuniversität Leoben*

14:30

Overview of Eramet AI

Joseph Pellegrino, *Eramet*

14:45

AI – image recognition, pattern analysis, machine learning

Markus Häupl, *ABAUT*

15:00

Optimum use of AI and ML for mineral exploration in a digitalised society – opportunities and challenges

Thorikild Maak Rasmussen, *Luleå University of Technology*

15:15

Digital solutions and machine learning platforms for applied mineralogy and petrology

Tomáš Hrtška, *Czech Academy of Science*

15:30

Improving performance by measurement and digital analysis of mining processes

Philipp Hartlieb, *Montanuniversität Leoben*

15:45

CERA Blockchain Solution

Valentina Dietrich, *Montanuniversität Leoben*

16:00

Panel

Block 2: **Digital Challenges & Success Stories in Specific Application Areas. Main Auditorium**

Chaired by Krzysztof Kubacki, *EIT RawMaterials*

17:00

Digitalization in Exploration: from imaging sensor integration to data fusion using machine learning

Richard Gloaguen, *Helmholtz-Zentrum Dresden-Rossendorf*

17:15

Digital exploration: Machine learning and public geodata for mineral prospectivity mapping in Finland

Vesa Nykänen, *Geological Survey of Finland*

17:30

Digitalization in mine tunnel development

Uwe Restner, *Sandvik*

17:45

Advanced data analytics for mining and mineral processing applications

Sergii Anufriev, *KGHM Cuprum*

18:00

Digital twins for monitoring and evaluation of ground quality, processes and machines

Paul O'Leary, *Montanuniversität Leoben*

18:15

Panel

8:30

**NETWORKING COFFEE & DIGITAL TRADESHOW**

**PARALLEL SESSIONS**

**PARALLEL SESSION 1. Tower Room**

9:00

MireBooks I

9:15

MireBooks II

9:30

MireBooks III

9:45

MireBooks IV

**PARALLEL SESSION 2: Thesis Awards & Digital Natives. Main Auditorium**

Chaired by Fabio Ferri, *EIT RawMaterials*

8:50

Introduction  
Fabio Ferri, *EIT RawMaterials*

9:00

Award Winner Master Category:  
Textural and Mineralogical Characterization of Li-pegmatite Deposit: Using Microanalytical and Image Analysis to Link Micro and Macro Properties of Spodumene in Drill Cores  
Juan Sebastian Guiral V, *Luleå University of Technology*

9:10

Award Winner Master Category:  
Virtual Underground Training Environment  
Jakub Jastrzębski, *Aalto University*

9:20

Award Winner PhD Category:  
The Hämmerlein skarn-greisen deposit in the Erzgebirge (Germany) - Analysis, geomaterialogy and pre-concentration of a compositionally complex and fine-grained ore deposit  
Marius Kern, *TU Bergakademie Freiberg*

9:30

Award Winner PhD Category:  
Computational Methods and Strategies for Geometallurgy  
Pierre-Henri Koch, *Luleå University of Technology*

9:40

Extended Reality and Data Visualization experiences in mining and other activities  
Luca Piovano, *CeDint - UPM*

9:55

Panel & Awards Ceremony

**Block 3: Disruptive Start-Ups in the Raw Materials Sector. Main Auditorium**

Chaired by Antonis Politis, *EIT RawMaterials*

10:45

Gold mining 4.0  
Mathias Cherbuin, *CyanoGuard AG*

10:55

Worldsensing Journey - From Idea to Success  
Andrea Bartoli, *Worldsensing*

11:05

Making Human Labor Easier, more Productive and Safer with Robotic Eyes  
Wolfgang Waicher, *Robotic Eyes*

11:15

High precision measurement & optimization under harshest conditions  
Marc Banzac, *Mecorad GmbH*

11:25

Digitization Solutions: Ventilation-on-Demand  
Giorgos Papanagiotakis, *Emphasis DigiWorld*

11:35

Flying Robotics for Underground 3D Mapping  
Fran Espada, *Hovering Solutions*

11:45

Metheore: Measure to Manage  
Arpitsingh Parmar, *Metheore*

11:55

Panel

**Block 4: Future Developments & Responsibilities. Main Auditorium**

Chaired by Massimo Gasparon, *EIT RawMaterials*

13:30

Digitalisation in the raw materials sector - A European Commission perspective  
Debby DeRoover, *European Commission, DG Grow*

13:45

Mineral Intelligence for Europe? - Where we are, where we are going, connection to EIT RM  
Špela Kumelj, *Geological Survey of Slovenia*

14:00

Industry Needs & Priorities for Digitalisation in the Raw Materials Sector  
Michael Haschke, *DMT*

14:15

Operational Intelligence - A mandatory step for Sustainability  
Andrea Bartoli, *Worldsensing*

14:30

If data is eating the world, who is eating the data?  
Mirko Liebetrau, *Talpasolutions*

14:45

Upscaling mineral exploration through field augmented reality: The FARMIN project  
Tobias Kampmann, *Luleå University of Technology*

15:00

Digital competences as the basis for sustainable development of the raw materials sector  
Yury Zhukovskij, *St.Petersburg Mining University*

15:15

Panel







## YURIY ZHUKOVSKIY

DIRECTOR, RESEARCH CENTER FOR DIGITAL TECHNOLOGIES, SPMU

DIGITAL COMPETENCES AS THE BASIS  
FOR SUSTAINABLE DEVELOPMENT OF THE RAW MATERIALS SECTOR

Nowadays, it is clear that the digital transformation of the mining industry is not just an empty phrase, but rather a process of change. Every step of our work and every process in the industry is subject to these changes.

It is necessary to get ready for the upcoming developments by transforming our educational system from an individual point of view to a multidisciplinary approach in problem solving.

At **Saint Petersburg Mining University**, traditional education and research are transformed into more contemporary processes by means of the digital transformation of routine work:

The Educational Research Centre for Digital Technologies was created one year ago and has already achieved a lot; for example, a work group of young and enthusiastic professionals from different branches of the mining industry was established. The aim is to solve complex projects and educate all interested students in the field of digital technologies, be it artificial intelligence, big data, AR or VR, predictive maintenance, etc.



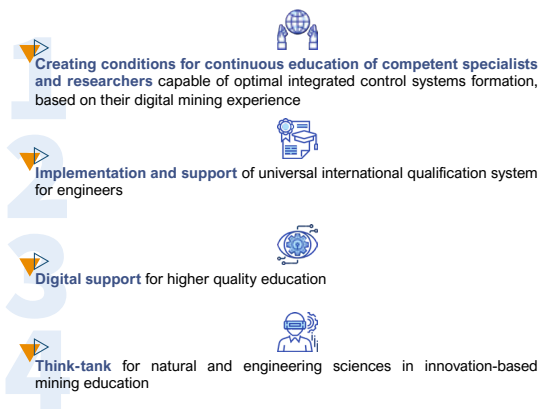
„Our scope is to ensure the creation of conditions for continuous education of competent specialists and researchers. In combining our efforts and through international cooperation we will be able to achieve our goal step by step.“

With the establishment of the **International Competence Centre for Mining-Engineering Education under the auspices of UNESCO**, three leading universities in the raw materials and mining sector,

- Montanuniversität Leoben,
- TU Bergakademie Freiberg and
- Saint Petersburg Mining University,

collaborate and work jointly on a common goal, aligned with the **UN Sustainable Development Goals**: to ensure the creation of conditions for continuous education of competent specialists and researchers and favour international cooperation in this field.

Mutually developed concept with the UNESCO Competence Centre:



THE PURPOSE OF STUDYING TOMORROW: I KNOW HOW MY UNIQUE KNOWLEDGE WILL HELP SOLVE THE COMMON PROBLEM FOR US ALL



Transformation is consistent with the UN sustainable development goals:



Technologies for five levels of digital transformation:

1. Technical transformation
2. Transformation of business processes
3. Transformation in regulation
4. Transformation of the energy structure
5. Transformation in management

Key qualities of the enterprise industry 4.0:

1. Speed
2. Flexibility
3. Quality
4. Efficiency
5. Security



1. Digitalization
  2. Decarbonization
  3. Decentralization
- 3 "D" formed in Europe in 2017.

4. Depend - the increasing information and technological dependence of the production, transportation and use of various types of energy from each other.
  5. Decrease - the trend not only of energy consumption reducing, but also of all types of resources and materials, reducing the amount of waste and their increasing involvement in recycling.
- These proposals developed by Saint-Petersburg Mining University in 2019.

DEBBY DEROOVER

H 2020/HORIZON EUROPE TEAM LEADER FOR DG GROW, EC

RAW MATERIALS IN HORIZON 2020 AND HORIZON EUROPE



One of the six headline ambitions for Europe set out by Commission President Ursula von der Leyen is “A Europe fit for the digital age”. Digital technologies applied in an ethical and secure manner are key enablers for tackling the societal challenges we are facing today.

However, digital applications require a large amount of critical raw materials, as do clean technologies for climate neutrality.

Ensuring a secure, sustainable, responsibly-sourced supply from a diversity of sources, as well as strategic autonomy of the EU for these materials, are crucial.

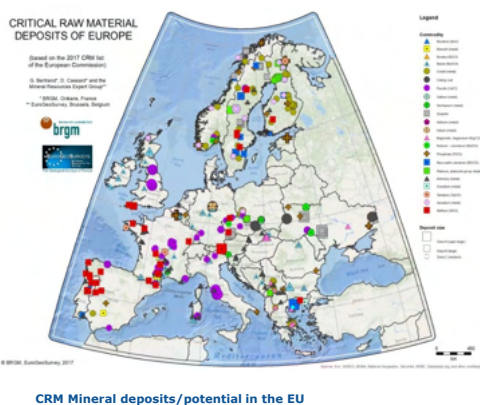
Under the current R&I Framework Programme Horizon 2020, the Commission has funded several raw materials topics with digital aspects, such as innovative solutions for the substitution of critical raw materials in electronic devices.

We have supported research and innovation on digital solutions, helping to avoid exposure of workers in dangerous situations and increasing the efficiency of mining operations.

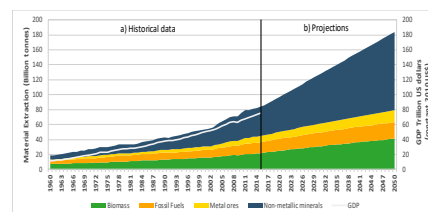
**The Commission** aims to continue in this line to make the digital transition of the raw materials sector a success, in cooperation with universities, industrial sector representatives, innovators, small and large companies and civil society.

Why raw materials matter?

- 1 **Impact** on all value chains and economy
- 2 **Transition** to a low carbon and circular economy
- 3 **Increase** of raw materials demand
- 4 **Race for resources**



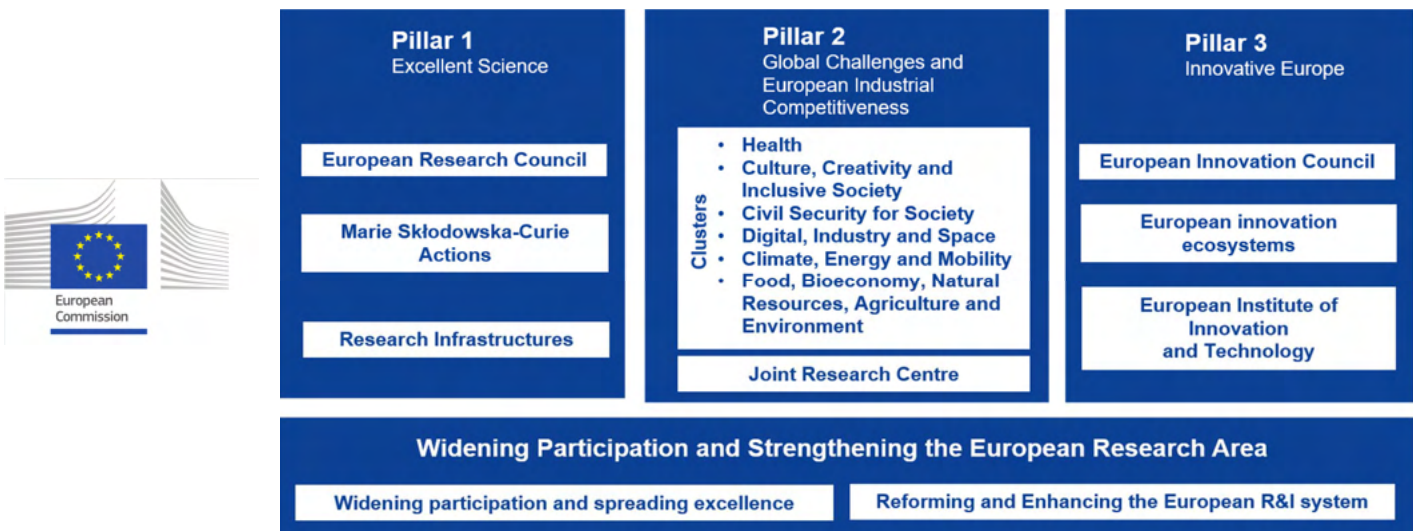
CRM Mineral deposits/potential in the EU



Global material extraction by resource type  
Source: Raw materials Scoreboard 2018 in prep., UNEP, World Bank

“Access to resources is also a strategic security question for Europe’s ambition to deliver the Green Deal. Ensuring the supply of sustainable raw materials, in particular of critical raw materials necessary for clean technologies, digital, space and defence applications, by diversifying supply from both primary and secondary sources, is therefore one of the prerequisites to make this transition happen.”

Preliminary structure Horizon Europe



**New solutions for the sustainable production of raw materials**

- New exploration technologies
- Innovative mining: smart, alternative, deep sea
- Raw materials innovation for the circular economy: sustainable processing/refining, reuse, recycling and recovery schemes
- Substitution of CRMs and scarce materials

**Raw materials policy support actions**

- Responsible sourcing of raw materials in global value chains
- Primary raw materials policy
- Waste policy
- Knowledge base



„Events like the Expert Forum are crucial to exchange knowledge and innovative ideas and learn about the raw materials actors’ needs.“

MICHAEL HASCHKE

DIRECTOR INNOVATION & EU RELATIONS, DMT

## INDUSTRY NEEDS & PRIORITIES FOR DIGITALISATION IN THE RAW MATERIALS SECTOR



Many companies already reap the benefits of digitalisation. For instance, KOMATSU's autonomous 200t haulage truck increased mine safety, efficiency and productivity by more than 20% and reduced fuel consumption.

The visionary "digital mine" will include unmanned mining for maximum safety and enhanced productivity, material tracking systems for mine waste and tailings materials, monitoring and re-processing, and IoT-based real-time processing. Optimised predictive maintenance will be safer, faster and more cost-saving. Mixed reality will

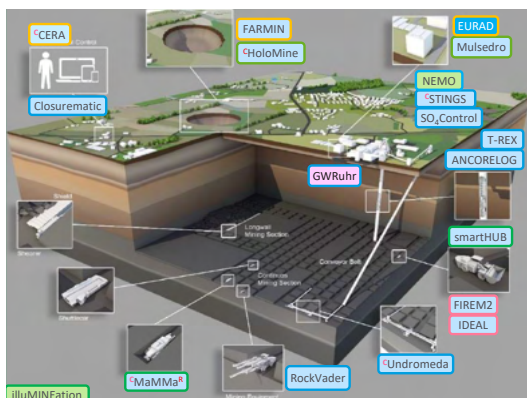
be the high-tech communication tool.

Digitalisation remains the common denominator of technological innovation in the raw materials sector.

The explosive growth of data, and emergence of powerful AI & machine learning tools will reveal correlations and unlock insights in data to drive new value and opportunities, as the primary catalyst for progress and disruption in the 2020s.

Tech intensity, i.e. an organisation's rate of technology adaption along with its ability to build its own digital capabilities, will determine an organisation's future.

The „Digital Mine“



ANDREA BARTOLI

HEAD OF BUSINESS DEVELOPMENT, WORLDSENSING

WORLDSENSING'S JOURNEY FROM IDEA TO SUCCESS

**Worldsensing** is a Spanish company founded in 2008, which then designed and developed the first smart sensor system to monitor avalanches.

Since then, this data collection hardware and software has been applied to many other fields, including mining. The Loadsensing solution is now used in over 90 countries and by global mining companies.

This success is mostly due to an innovation-centred company culture, that can be summarised as follows:



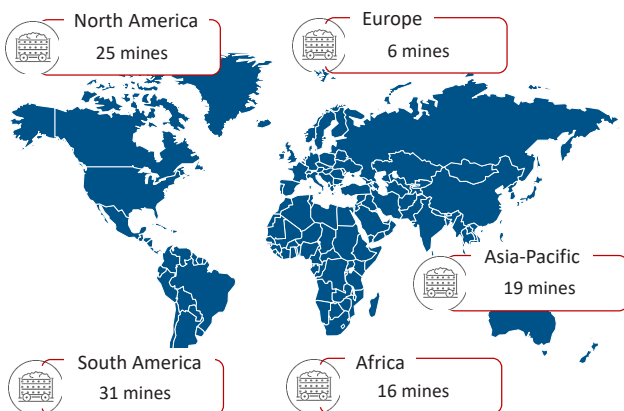
„The business idea is very important, but it is just the first step.“

„Understanding your costumers is a must, but understanding your business is also key for success.“

„Failures are part of the scale-up journey, and a company's culture is the first secret to overcoming challenges.“



Loadsensing is deployed across more than 60 countries and 70+ sites of global mining leaders



UWE RESTNER

PRODUCT LINE &amp; SALES SUPPORT MANAGER, SANDVIK

## DIGITALISATION IN MINE TUNNEL DEVELOPMENT



**Sandvik** produces a range of drilling, loading and cutting machines for mining tunnel development. To increase productivity, cost efficiency and safety, various steps of digitalisation and mechanisation are applied.

In his presentation, Uwe Restner highlighted some critical elements of mechanisation and machine-human interaction:

Autonomously operating loading machines have been in operation for many years already in underground mines in Australia and South America. Proximity detection becomes very critical when personnel work with remote-controlled or autonomous machines.

Another aspect of mechanisation is the combination of a number of sub-systems in a highly complex mining machine like the bolter miner. The total system availability, for instance, is the low-figure product of ten individually high numbers.

Digitalisation applications such as 3D radars for machine navigation, automatic profile drilling or cutting can be applied to increase tunnel performance and safety.



WOLFGANG WALCHER

CEO, ROBOTIC EYES

MAKING HUMAN LABOUR EASIER,  
MORE PRODUCTIVE AND SAFER WITH ROBOTIC EYES

Three Microsoft veterans created **Robotic Eyes** four years ago when they realised the potential of augmented reality.

They set off to unleash the power of “reverse augmented reality”, scanning the real world and creating digital twins.

This concept has many applications, especially in situations where there is no room for human error.

It helps avoid, detect and fix human errors using AR and reverse AR to constantly align plans and instructions with the physical world. Holograms are placed in the right areas to present construction projects in a real-world context.

This technology can be used for shaft inspection, machine inspection, planning, training, maintenance planning and documentation.



„The EIT Expert Forum was a great opportunity for Robotic Eyes to meet partners and customers alike, as well as present our latest developments and contributions to multiple EIT projects.

The fact that Robotic Eyes technology was mentioned and recognised in several presentations shows once more the importance of these efforts to make human labour easier, safer and more productive. Advancing methods for machine inspection and mine inspections with augmented reality-based mobile solutions will greatly benefit mine operation and safety.“

The fact that Robotic Eyes technology was mentioned and recognised in several presentations shows once more the importance of these efforts to make human labour easier, safer and more productive. Advancing methods for machine inspection and mine inspections with augmented reality-based mobile solutions will greatly benefit mine operation and safety.“



FRAN ESPADA

CEO AND FOUNDER, HOVERING SOLUTIONS

## FLYING ROBOTS FOR UNDERGROUND 3D MAPPING

The autonomous flying robots produced by **Hovering Solutions** are able to capture data in scenarios such as ore passes or tunnels. The resulting information on the autonomous underground explorations are 3D models including real-time point-cloud visualisation for a fast in-situ assessment, as well as high density 3D-models provided in standard file formats, including high-definition textures of rock surfaces.

Point clouds are combined with geolocation information to provide absolute geoinformation to the models, useful for underground survey

work, while textured models allow geologists and engineers to analyse the surface status and use the information in rock mechanics analysis to prevent future problems.

The autonomous robotic solution is currently being used in different sectors such as underground mining, utilities, hydropower plants and civil construction, among others.

The flying platform is equipped with lasers and other sensors to allow indoor positioning and avoid collisions with objects and tunnel walls.



LUCA PIOVANO

POST-DOC RESEARCHER UPM MADRID

EXTENDED REALITY AND DATA VISUALISATION EXPERIENCES IN MINING AND OTHER ACTIVITIES



„The vast availability of data creates high expectations. However, to use data wisely, we have to understand what they are, what they represent in the real world, their features and issues (e.g. variability and uncertainty) and what context to interpret them in.“

Virtual and mixed reality offer many application benefits or monitoring environments, e.g. increasing the situational awareness of security operators over a monitored area. They are also ideal for highly specialised training and virtual mock-ups of situations, as well as for measuring the physiological response of the user under stress situations. In mining education, real environments can be modelled and content created on demand.

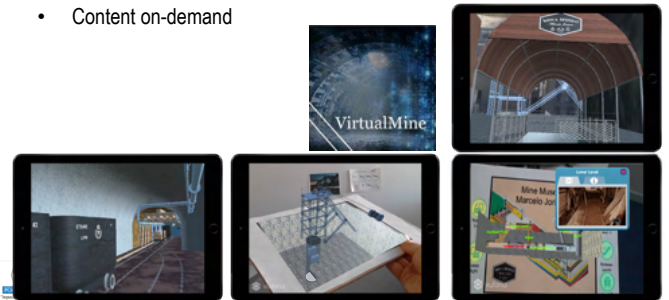
VR assists in decision making, for instance by providing ad-hoc dashboards and actionable in-

sights.

People’s skills need to be augmented to properly use and understand VR/AR technologies, data AND visualisation domains. Then, it will be possible to integrate new technologies into traditional workflows.

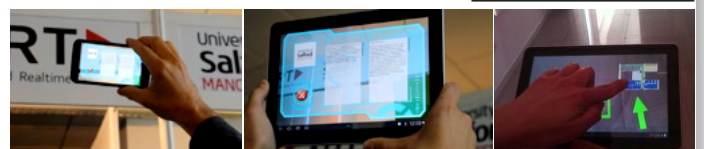
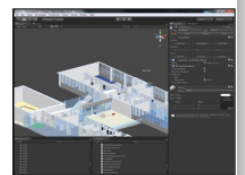
Applications to show mining-related content for students and museum visitors:

- Modeling of real environments and elements;
- Active interactions and navigation (VR, natural interaction);
- Content on-demand



Mixed reality platform to provide value-added services during real events or situations:

- Route planning for indoor environments (no GPS);
- Show information in AR;
- Possible applications:
  - tourism exhibition;
  - emergence handling



## MARKUS HÄUPL

## COO AND CO-FOUNDER ABAUT

## ARTIFICIAL INTELLIGENCE

## IMAGE RECOGNITION, PATTERN ANALYSIS, MACHINE LEARNING



The mining industry is under-digitalised and therefore a great optimisation potential is lost, as organisations fail to have real time

actionable insights into their operations. This is putting them under pressure to improve their activity, to make better use of resources and thus control rises in costs.

**abaut** is a technology provider that offers an innovative digital solution for mining performance analytics based on AI, IoT and embedded systems, that brings transparency into the operations of mining companies and reveal their performance optimisation potential.

**abaut** has developed plug&play OEM-independent sensors and a camera system that collects near real time, accurate and comprehensive data generated by mining operations, that is then analysed and evaluated with the help of machine learning algorithms, in order to

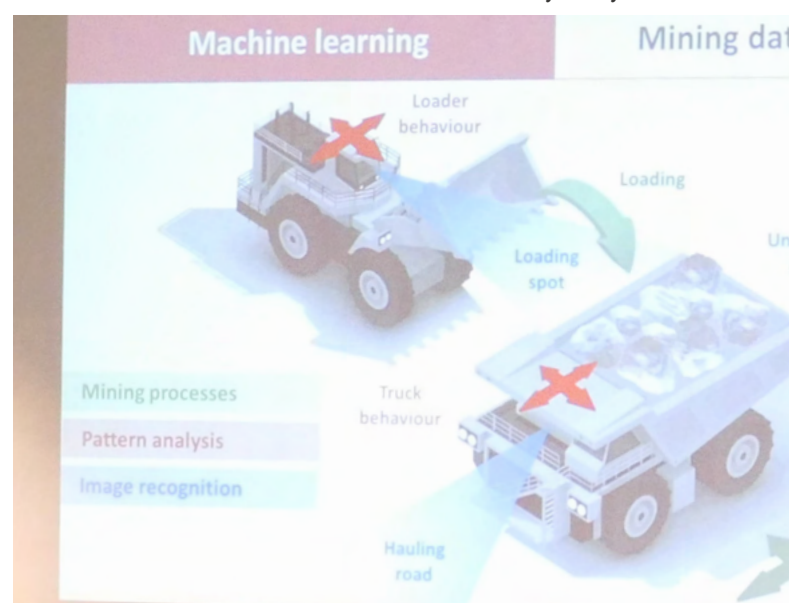
- recognise machinery activity patterns and the

interaction between machines partnering in a mining process (e.g. loading and unloading)

- track material mass flow (extracted ore vs. waste rock)
- estimate efforts/energy consumed in the mining process and
- evaluate the performance of the entire mining operation according to specific KPIs.

The customers receive a detailed description of the status-quo of their operations (from the overview up to very detailed views of single events) that creates the basis for meaningful business decisions.

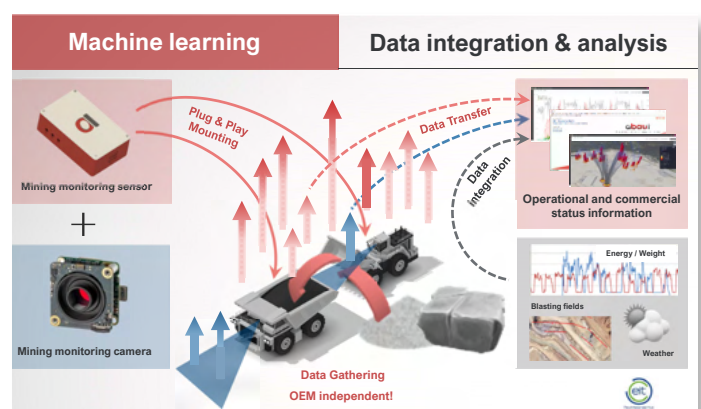
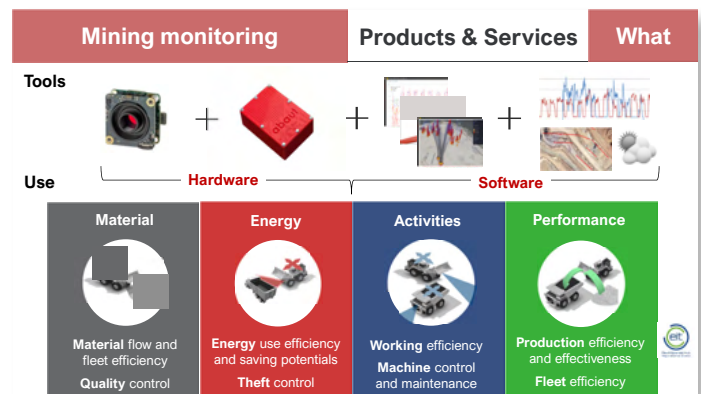
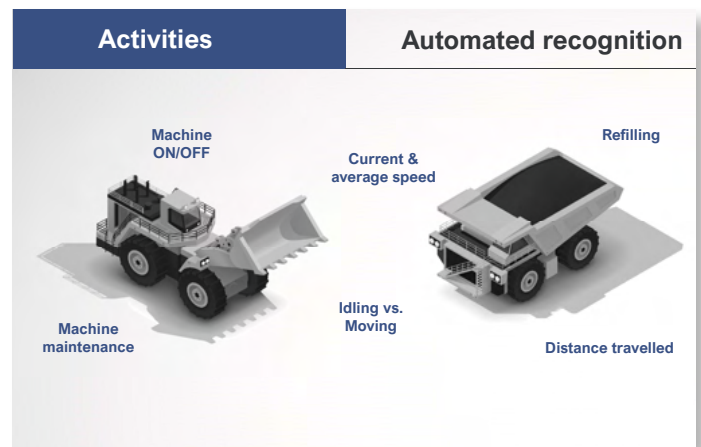
The solution does not interfere in any way with



„Besides the fact that events such as the Expert Forum offer the appropriate context for networking, alligning demand with supply, partnering and promotion, we consider that the main opportunity is to communicate about the innovation that we bring to the industry, in order to facilitate its acceptance and build trust.“

the regular operations, the installation is plug-and-play and the hardware part used for data collection is compatible with all types of machinery (OEM-independent). It can be implemented in any mining company, independent of the fleet size, operations configuration, working environment and organisational structure, as it is modular and easily scalable to include all particular cases.

**abaut** helps customers gain a competitive advantage by making use of a resource that is overseen most of the time – the knowledge of their operations.



RICHARD GLOAGUEN

HEAD OF THE DIVISION EXPLORATION TECHNOLOGY, HZDR

## DIGITALISATION IN EXPLORATION: FROM IMAGING SENSOR INTEGRATION TO DATA FUSION USING MACHINE LEARNING



The Helmholtz-Zentrum Freiberg recently developed innovative solutions at the intersection between remote sensing, machine learning, and the raw materials sector.

This was made possible by designing advanced machine learning-based algorithms for the identification and classification of areas with high mineral potential, using satellite-, drone-, and ground-based data and measurements.

Machine learning classification and feature extraction techniques are developed to map minerals in a large set of samples or geological surfaces.

To perform advanced supervised machine learning approaches, labelled samples are required. Several approaches for remote sensing, outcrop imaging and drill-core scanning have been developed to support the geologists. With the multi-source collection of spectroscopy data, hyperclouds are created that allow detailed mineralogical studies of mineral deposits.

**HZDR**  
HELMHOLTZ ZENTRUM  
DRESDEN ROSSENDORF

PAUL O'LEARY

HEAD OF CHAIR OF AUTOMATION, MU LEOBEN

## DIGITAL TWINS FOR MONITORING AND EVALUATION OF GROUND QUALITY, PROCESSES AND MACHINES

Technology has evolved dramatically during the last 50 years. Compared with the computer used for guidance of the Apollo mission in 1969, today's computers have 1,000,000 times the computing power and memory.

„But: It is not a question of technology, but a question of what we do with the technology!“

And, more importantly, what do we do with the vast amount of data we collect?

What can we learn from metadata?

What exists and what do we know?

Are there limitations on knowledge?

With the aid of digital twins, a real-time comparison of observation and simulation is possible, as demonstrated in the simulation of the excavation stages in an underground metro station in London.

With the right tools, data analysis can assist in life-time optimisation of machines and incident analysis. Given an incident with a plant or machinery, we can investigate the cause. This is important for both liability and guarantee reasons. Financially this has proved to be one of the most important issues.



**Digitalization and CPS at the Chair of Automation**

Recent and current projects

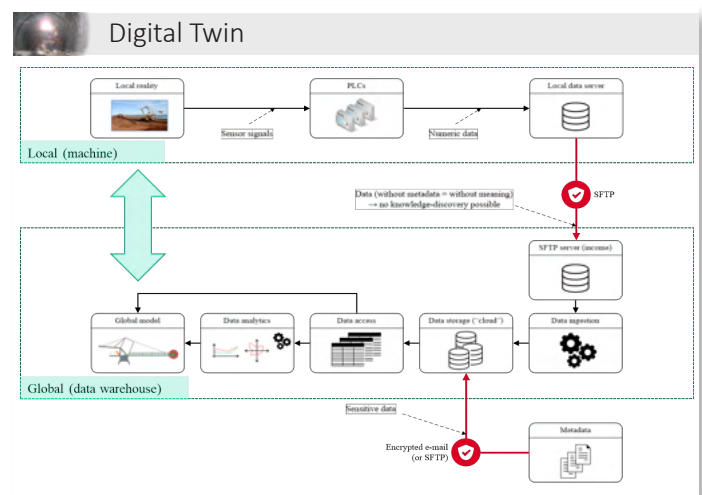
Three selected examples

Bucket wheel reclaimer: life time optimization

Bucket wheel excavator, incident analysis.

Tunnelling: real-time comparison of observation and simulation.

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 automation.unileoben.ac.at 2 Paul.oleary@unileoben.ac.at



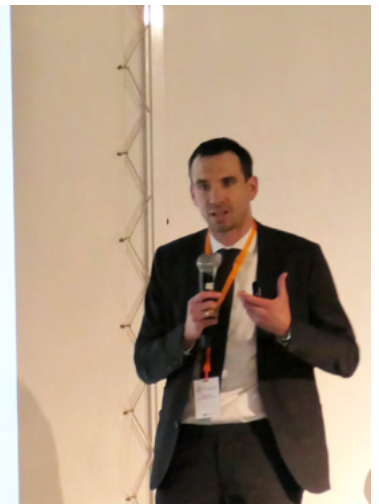
PHILLIPP HARTLIEB

SENIOR RESEARCHER, MU LEOBEN

IMPROVING PERFORMANCE  
BY MEASUREMENT AND DIGITAL ANALYSIS OF MINING PROCESSES

When you can measure what you are speaking about, and express it in numbers, you know something about it; But when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind.

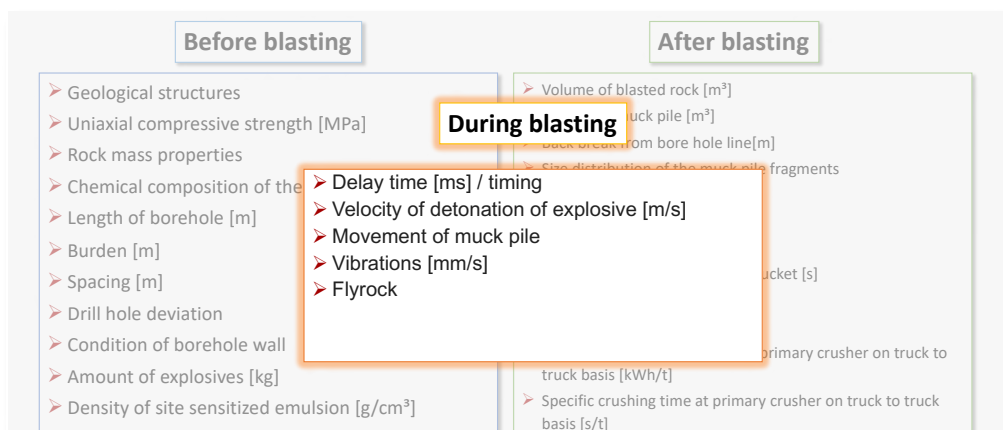
Lord Kelvin (1824-1907)



Knowledge of operational parameters is of vital importance in every mining operation. Only this allows for the best possible control of the process, including fleet management, quality control, cost savings and

productivity improvements.

During the EU H2020-funded SLIM project, Montanuniversität Leoben developed such a dataset, enabling the mine management to take the right decisions.

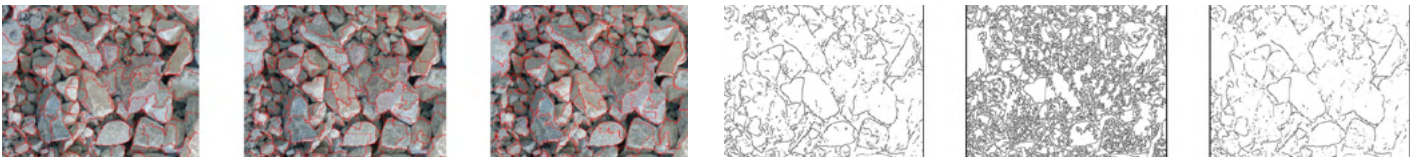


What can be measured?

KPI Definition



„The Expert Forum was a great opportunity to present the findings to a relevant audience and discuss the problems and technological challenges with interested peers.“

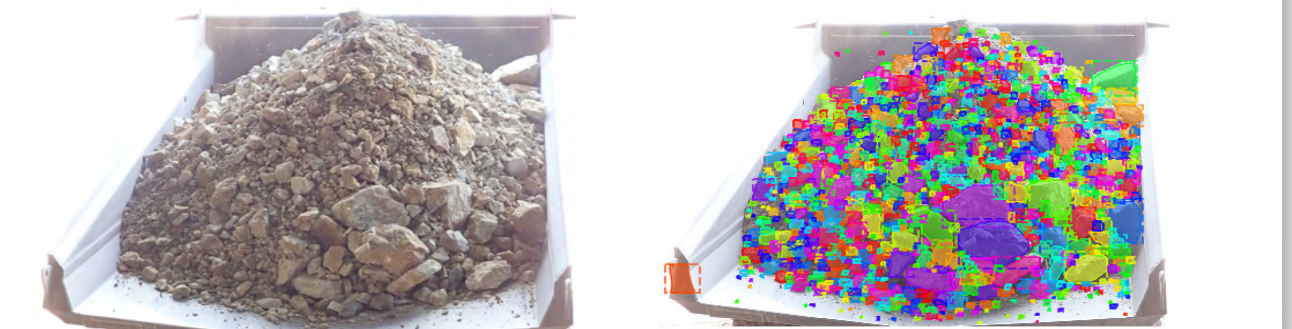


This dataset comprises aerial images of blast sites and the muckpiles after blasting, enabling the 3D modelling of geotechnical structures, precise definition and planning of drill-holes, and evaluation of muckpile characteristics (mainly grain size distribution). Additionally, innovative systems based on artificial intelligence algorithms have been developed and used to automatically track and record the loading parameters

of the wheel-loader (loading and manoeuvring time) and link these data to the respective truck loads and energy consumption of the primary crusher. Altogether, this semi-automated approach enables almost 100% reliability when gathering and analysing these management and design relevant parameters (e.g the connection of drilling precision, loading time and energy consumption).

Blast analysis

- New fragmentation algorithm based in Deep learning, machine intelligence Mask R-CNN (regional convolutional neural network)



# MiReBooks

In the education project **MiReBooks** (Mixed Reality Handbooks for mining education), funded by the EIT RawMaterials, Europe's leading mining universities of Leoben, Freiberg, Aachen, Lulea and Tallinn have partnered up with a number of research institutions and industry partners to create a series of virtual & augmented Reality based (=mixed reality, MR) interactive mining handbooks as the new digital standard for higher mining education across Europe.



This project aims to close the gap between the new digital natives' generation and the old learning methods still used at universities. Furthermore, mining is a very complex topic; students need to learn and understand 3-dimensional concepts difficult to realise without the right visualisation tools. On top of this, mines are not always accessible for universities.



With MiReBooks complex issues in mining are no longer a challenging barrier for learning progress and students complete their studies with a more thorough comprehension of their discipline. The array of possible industrial mine environment examples that students can be immersed into becomes endless and thus the industry will receive graduates that are familiarised in-depth with a holistic view on the industrial context. Students will enter the job market skilled as digital natives and highly influence the way the industry will work and develop in this way in the future.

Technically, the MiReBooks-assisted lectures will include smartphones with a special app that allows the students to trigger additional information (3D images, videos) from augmented illustrations within MiReBooks textbooks. In addition, with virtual reality goggles, they will be able to immerse themselves in a virtual mining environment/3D-filmed sequence of a real mine process.

In 2019, the new learning concept was tested and accepted by the users (professors and students); the structure of the book was also defined and the alpha version of the software that makes this whole experience possible was created.

In 2020, it is the moment to populate the book with content, both written text and digital content (360° videos, 3D models...). The models and videos will be created and/or provided by the industry partners in the consortium: Epiroc, KGHM Cuprum, LKAB and some other mines that participate as subcontractors, such as, VA Erzberg.



START-UP AND BUSINESS CORNER - SHOWROOM



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ment



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for Geometallurgy



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in the Erzgebirge (Germany) – Analysis,  
geometallurgy and pre-concentration of  
compositionally complex and fine-grai-  
ned ore deposit

## LIST OF ABBREVIATIONS

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3D	three-dimensional
AI	Artificial intelligence
AR	Augmented reality
CEO	Chief executive officer
COO	Chief operating officer
DG Grow	Directorate-General of the European Commission for Internal Market, Industry, Entrepreneurship and SMEs
DL	Deep learning
EC	European Commission
EIT	European Institute of Innovation & Technology
ERC	European Research Council
EU	European Union
HZDR	Helmholtz Zentrum Dresden Rossendorf
IoT	Internet of things
KPI	Key performance indicator
ML	Machine learning
MUL	Montanuniversität Leoben
OEM	Original equipment manufacturer
R&D	Research & Development
RM	Raw materials
SME	Small and mid-sized enterprise
SPMU	Saint Petersburg Mining University
UPM	Universidad Politécnica de Madrid



## **Impressum**

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Montanuniversität Leoben

Excerpts of presentations: respective speaker

