Survey for participants:

Tools for Mining Information Modelling – MineBIM use cases

10.11.2023, Jyrki Salmi

University of Oulu, Finland

9-10 November BARCELONA 2023

3RD MINING 4.0 ROADMAP FOR THE FUTURE

Speaker: Jyrki Salmi

- **Academic present:**

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  Civil engineering unit, Digital Construction and Mining research area

  - Doctoral researcher (PhD student), since Feb 2021, completion in autumn 2025
  - Research director, Digitalization and automation of mining

- **Industrial background:**

  Master of Science in Mining and Process Engineering 1995 from Aalto University in Helsinki.
  26 years of work history from Outokumpu company's Kemi and Hitura mines.

  - Has worked in numerous positions from Summer intern to Vice president of the mine and Head of mine deepening project.
  - Special expertise in mine planning, data processing, information management and information systems, mining automation, digitalisation, strategy planning and managerial work.

- **Visionary - Enabler - Researcher**

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9-10 November BARCELONA 2023

Part A - Presentation

10th Now 2023

“Tools for Mining Information Modelling – MineBIM use cases”

- **MINES:** Digitalisation, data management and needs.
- **BIM:** High-quality 3D models with semantic information, incorporating graphical and non-graphical data through object-oriented programming
- **MineBIM:** An emerging technology with the potential to enhance safety, efficiency, and sustainability in mining operations
- **Integration:** Utilizes data points in 3D information models to connect all related information to surfaces, solids, and voids. Fundamentals and use cases of the MineBIM.

Survey for participants

Part B – Round table

9th Now 2023

“How can BIM benefit the mining industry by reducing operating costs and increasing efficiency across the mine lifecycle?”

- This informative and interactive round table discussion will provide participants with a **deeper understanding** of BIM's applications, implications, and opportunities for the mining industry.
- The focus of the discussion will be on **how BIM can benefit the mining industry** by reducing operating costs and increasing efficiency throughout the life cycle of a mine.
- There will be several **interactive exercises** to ensure that each participant can relate to the practical applications of MIM for their organisation.

Digitalization process in mining

Development steps for the mine of the future must be taken

1. in digitalization and automation to increase productivity,
2. in monitoring the mining environment and events to improve efficiency and safety, and
3. in understanding the big picture to improve business and responsibility.

The digital mining industry also needs to consider

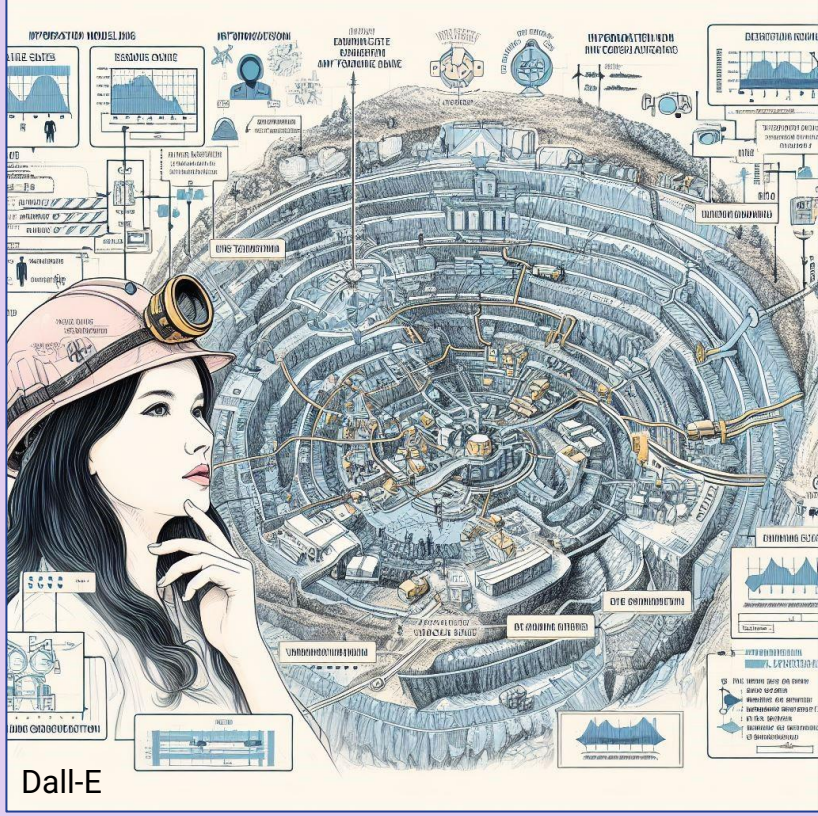
1. technical and organisational digital capabilities,
2. reliability of information, and
3. understanding the value of information.

Dall-E: “3D model of an underground mine loaded with information where information is flowing from one place to another”

How to manage all the data flows and information?

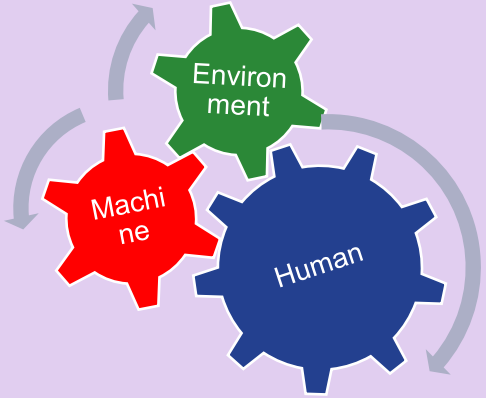
- In mining, the value of data has traditionally not been identified in many places in the data production and processing chain.
- Which information is useful? = Traditional bigdata problem. => The relevant information shall be specified.
- Mixed data is needed to manage workflows based on data-driven decision-making. Who needs what information and when?

➢ You need to define which dataflows you want to manage and in which context.


Dall-E

In **Human - Environment - Machine** interaction there are **8** manageable dataflows!

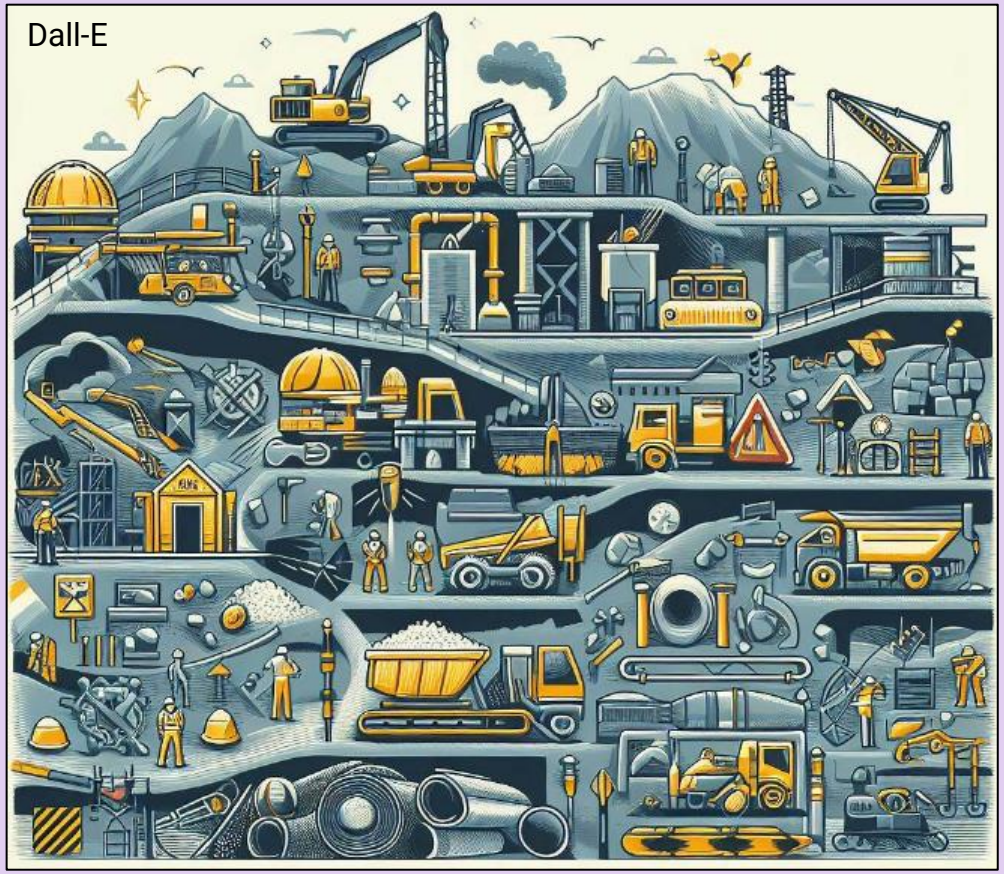
Human-to-human		
From human to machine	From human to environment	From environment to human
From machine to human	From machine to environment	From environment to machine
Machine-to-machine		



Declarations:
- Machine i.e., mobile or fixed machinery or apparatus.
- Environment i.e., physical, digital or virtual operating environment including data storages and visualization tools.

What is important for a mine operator? What are the needs of mines?

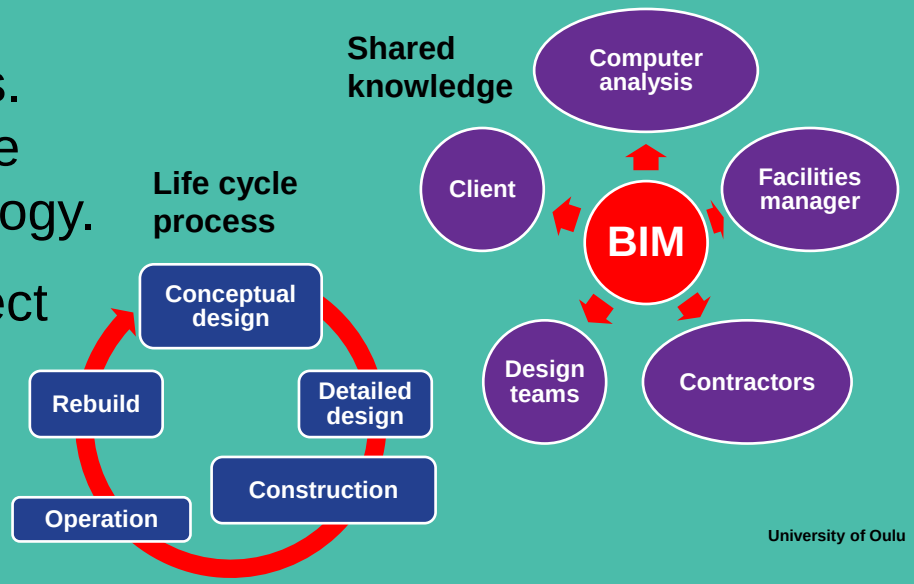
- Main objectives are safety, productivity, efficiency, and general waste reduction.
- Time delays, unnecessary work and poor quality must be eliminated; and risks, operating costs and wastes reduced.
- Up-to-date information management, real-time monitoring and decision-making throughout the process. Are we ready to start the next work?
- The biggest operational benefit for mining companies is how to keep to planned schedules? Costs of late starts of production can be significant.



BIM (Building Information Modeling)

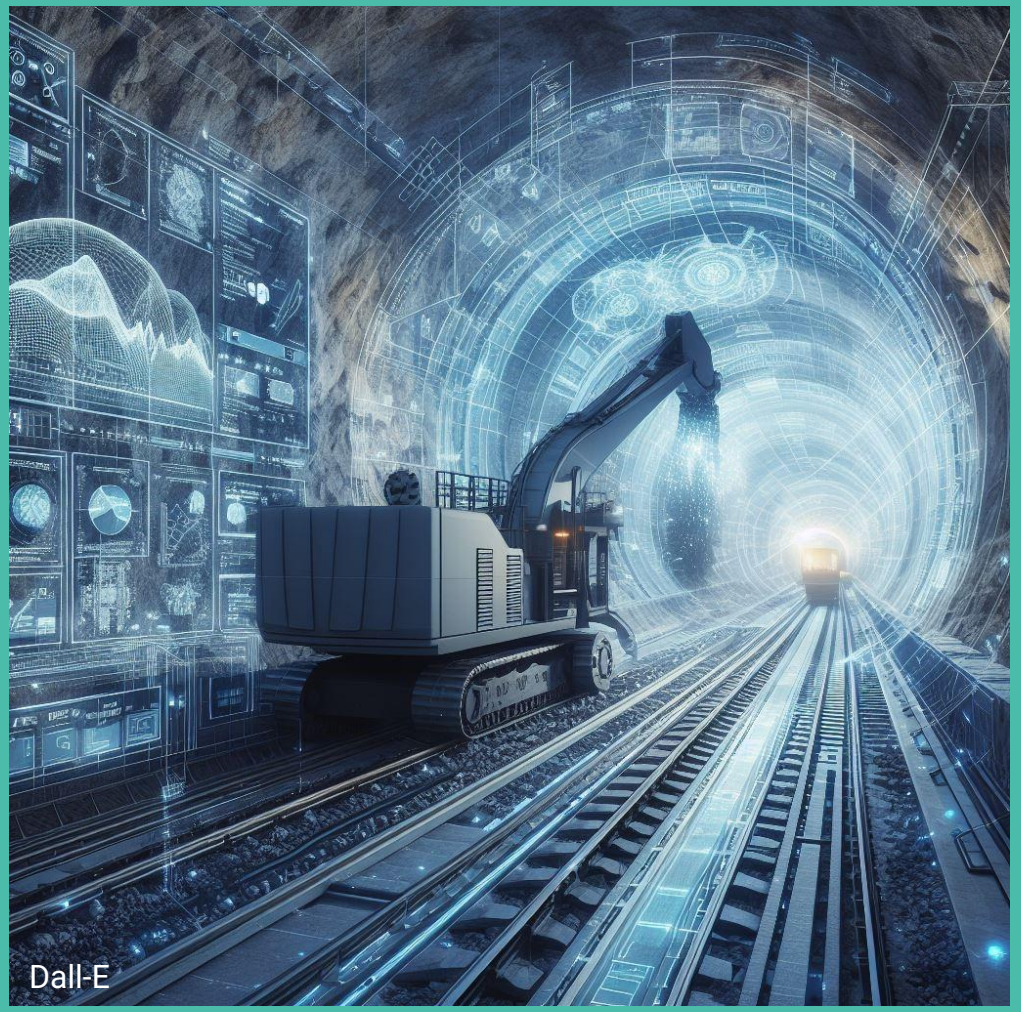
- BIM technology covers the entire AEC industry (Architecture, Engineering, Constructions):
  - ✓ Building construction (residential buildings, public buildings, airports, hospitals, etc.),
  - ✓ Infrastructure (roads, railways), and
  - ✓ Engineering facilities (bridges, tunnels, power plants, but also off-shore facilities or power grids)
- Each of these industries has its own specifics and challenges. They also often use various software to design or manage the model. They are at different levels of adoption of BIM technology.
- However, the basis and assumptions of BIM technology project development are similar.

The International Standards Organization (ISO) 19650 series, which is commonly used in the tunneling industry, defines BIM as *"The use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions."*



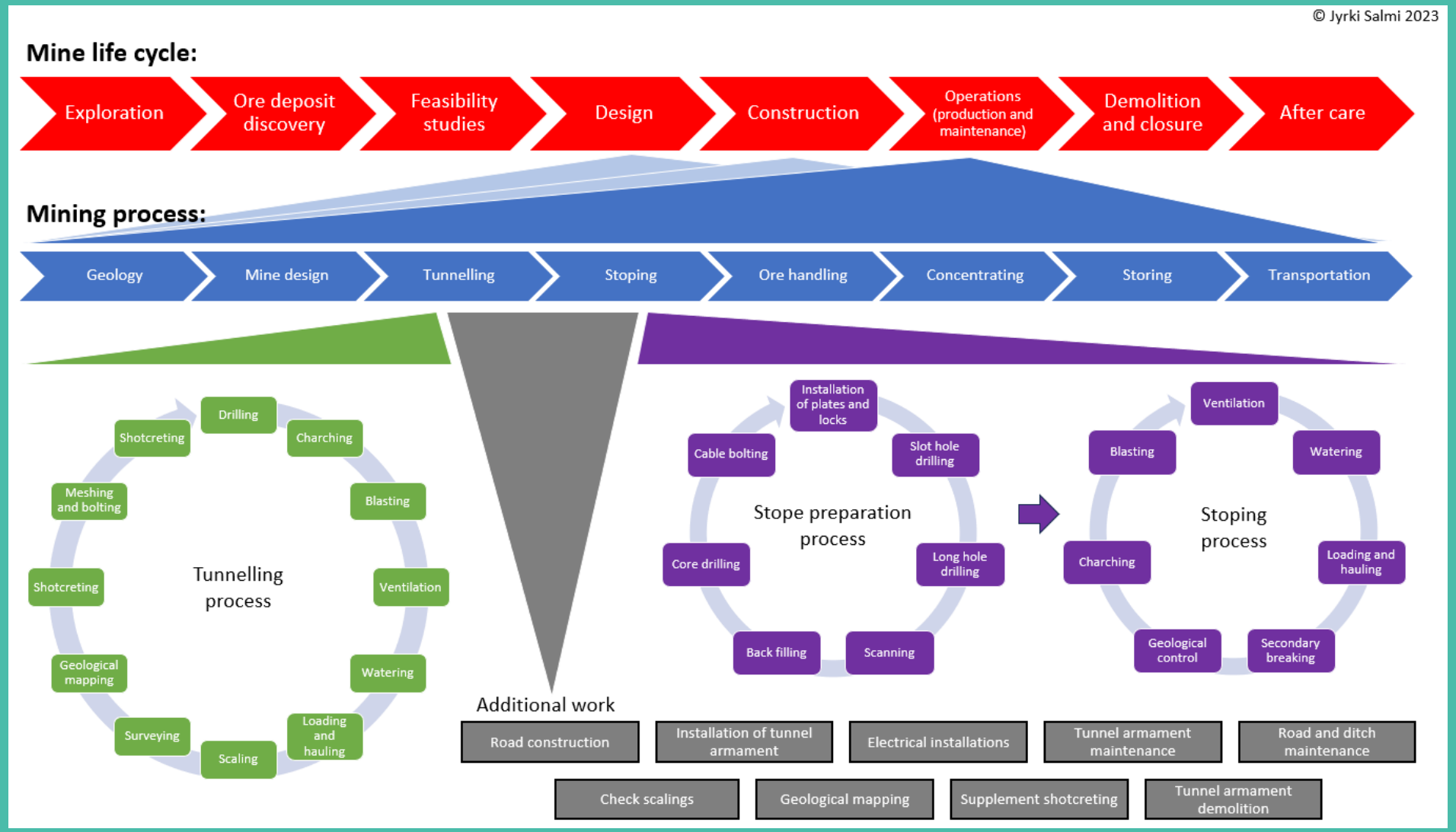
What about BIM in mining?

- In mining, there is clear evidence that **data flows** from design and construction handover to operation and maintenance take place in the mining industry just as they do in all industries.
- **It's not just called BIM** in the mining industry – the term hasn't appeared to the same extent as it has in the construction industry and now especially in the infrastructure construction industry.
- It probably doesn't help that the abbreviation for BIM contains the word Building. Rather, it should be MIM (Mining Information Modeling). But the name doesn't matter – it still means the same thing – **a smart model of something that will soon come true**.


Dall-E

There are huge overlapping processes in mining

- BIM can be applied from a single small part of the mining process to the entire life cycle of the mine.
- BIM can be applied to various work phases, work machines and process equipment.
- BIM is most useful when the entire process from design to maintenance is based on BIM.



BIM benefits in mining

- ✓ With BIM, information is not destroyed at any stage of the process, but collected and stored in to models continuously i.e., increasing and developing the information pool and flow: data-information-knowledge-wisdom.
- ✓ Lean and sustainable development go well with information management and BIM.
- ✓ BIM enables the utilization of large amounts of data, real-time data processing and digital twinning.
- ✓ BIM enables collaboration and improves transparency of information between project partners, such as owners, engineers, and contractors.
- ✓ BIM provides a dynamic and digital mining environment.
- ✓ BIM fills a technology gap in the development of machine automation in a mining environment.

The two main benefits of BIM in mining are:

1. Coordination of disciplines
2. Asset management (ore rather than tunnels)

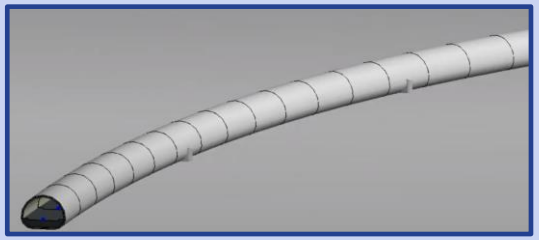
The two main values of BIM in mining are:

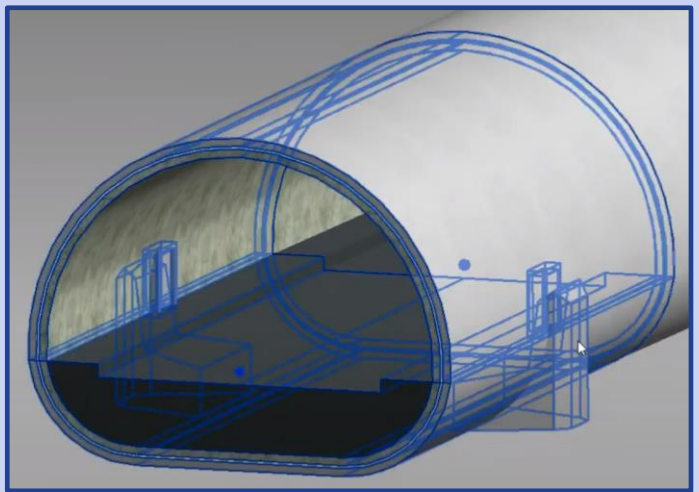
1. Visualization
2. Interface management

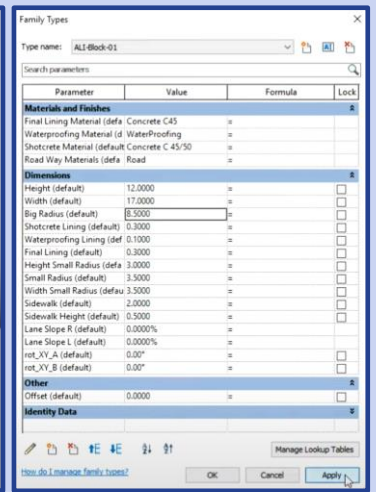
What are the BIM barriers in mining?

- The mining sector is more profit-driven than the infrastructure or other construction sectors.
- Mining is a private industry, unlike state-controlled infrastructure where the government can say what to do and how.
- For BIM, it is vital that the information is available to everyone and is not in the closed systems of different OEMs.
- The lack of awareness is primarily related to the value and best practices generated by BIM in the implementation of BIM in a mining project.
- There is a need to define what the value of BIM is in general and what its value is in a particular project.
- Standardization of BIM for the mining industry needs to be developed.

BIM use cases in mining







BIM use cases in mining

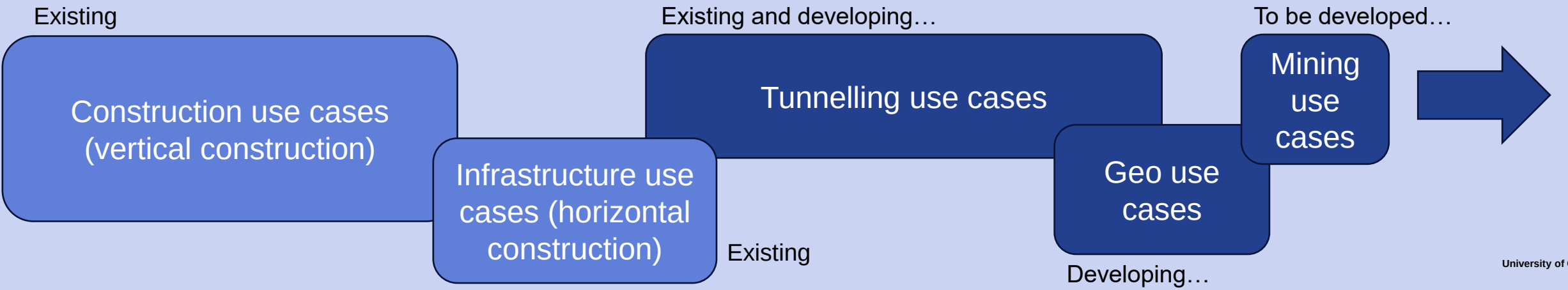
The two obvious main use cases of BIM in mining are:

1. **Constructability use cases**

   Refers to the assessment and assurance of the quality of design and implementation to ensure that the planned construction can be built efficiently, cost-effectively, and safely.

2. **Operational use cases**

   Refers to the practical applications or scenarios in which a particular technology is actively employed and utilized in daily operations or real-world situations.



Constructability use cases for BIM in mining?

What ChatGPT 3.5 tells you…

1. **Tunnel and Shaft Construction:** BIM can be used to create 3D models of tunnels and shafts, ensuring that the design is constructible and that geological conditions are considered.
2. **Blast Design and Safety:** BIM can assist in planning blasts and ensuring that the designs take into account safety measures, such as blast barriers, ventilation, and access points.
3. **Underground Infrastructure:** BIM helps in the design and construction of underground infrastructure, such as tunnels, mine shafts, and ore handling systems.
4. **Material Handling Facilities:** BIM supports the design of material handling facilities, optimizing the layout for efficient ore and waste material movement.
5. **Plant and Processing Facilities:** BIM can be applied to the design and construction of processing plants, helping with equipment placement and infrastructure layout.
6. **Structural Integrity:** BIM ensures the structural integrity of constructed elements, minimizing the risk of collapses and hazards.
7. **Construction Sequencing:** BIM helps in planning the sequence of construction activities, ensuring that they are executed in the most efficient order.
8. **Safety Measures:** BIM can model and plan safety measures and equipment placements, such as safety chambers, fire suppression systems, and escape routes.
9. **Logistics and Material Flow:** BIM optimizes the logistics and material flow within mining operations, reducing congestion and improving efficiency.
10. **Excavation and Earthwork:** BIM assists in the planning of excavation and earthwork activities, ensuring that the design is feasible and can be executed safely.
11. **Borehole and Drilling Design:** BIM can be applied to borehole and drilling design, ensuring that drilling activities are constructible and accurate.
12. **Environmental Mitigation:** BIM helps plan and implement environmental mitigation measures, such as water management and land reclamation, ensuring they are constructible and effective.
13. **Quality Control:** BIM can be used for quality control during construction, ensuring that the constructed elements adhere to design specifications.
14. **Regulatory Compliance:** BIM helps ensure that construction activities comply with regulatory requirements and permits, reducing the risk of compliance issues.
15. **Site Access and Traffic Management:** BIM assists in planning site access and traffic management, optimizing routes for vehicles and personnel.

Operational use cases for BIM in mining?

What ChatGPT 3.5 tells you…

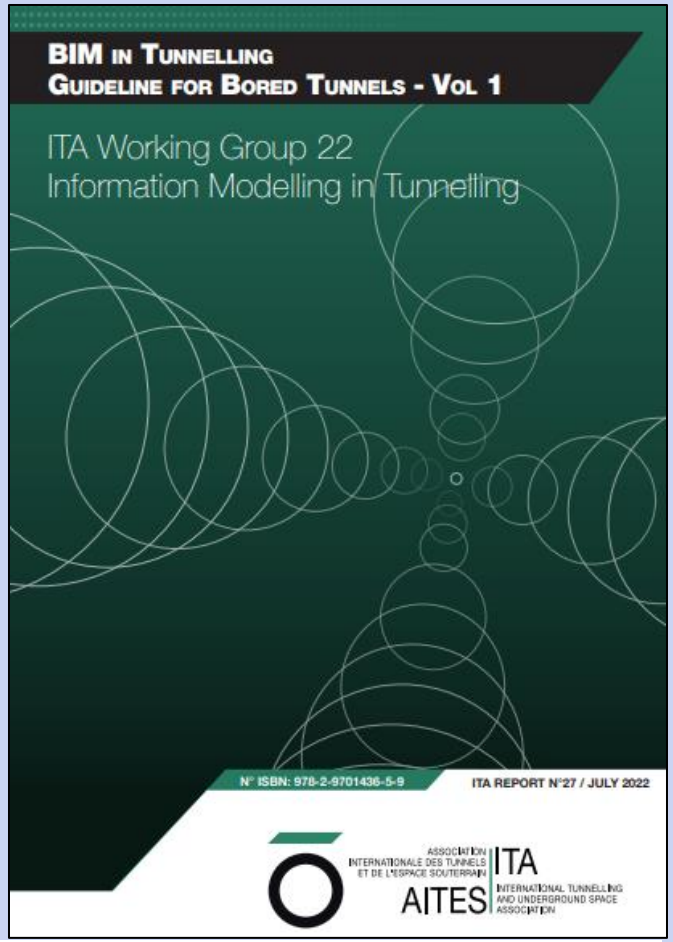
1. **Daily Mine Planning:** BIM can be used to create accurate 3D models of the mine site, helping with daily mine planning, such as determining ore locations, material quantities, and equipment placement.
2. **Blast Design:** BIM assists in designing controlled explosions or blasts by simulating and visualizing the impact of the blast on the surrounding environment and infrastructure.
3. **Asset Management:** BIM helps with the management and maintenance of mining equipment and infrastructure, ensuring assets are in optimal working condition.
4. **Drilling and Blasting Optimization:** BIM is used to plan drilling and blasting operations, optimizing hole placement and explosive usage for efficient rock fragmentation.
5. **Safety Training and Simulation:** BIM can be employed for safety training and simulation exercises, allowing miners to practice responding to emergencies and hazardous situations.
6. **Environmental Monitoring:** BIM supports environmental monitoring by creating models that illustrate how mining activities impact the environment and help in assessing and mitigating potential issues.
7. **Ore Flow Management:** BIM can optimize the flow of ore from extraction points to processing plants, reducing bottlenecks and streamlining material movement.
8. **Equipment Tracking:** BIM enables real-time tracking and monitoring of mining equipment and vehicles, enhancing safety and asset utilization.
9. **Dust and Air Quality Control:** BIM can help assess and control dust and air quality in mining areas by modeling the flow of dust and pollutants.
10. **Tailings Management:** BIM is used for designing and managing tailings storage facilities, ensuring the safe containment of waste materials.
11. **Maintenance Scheduling:** BIM assists in scheduling maintenance activities by predicting when equipment will need servicing, reducing unplanned downtime.
12. **Material Handling:** BIM optimizes the design and layout of material handling systems, improving the efficiency of ore and waste movement.
13. **Resource Allocation:** BIM supports the allocation of resources, such as personnel and equipment, to specific areas or tasks, optimizing utilization.
14. **Emergency Response Planning:** BIM can be used for emergency response planning, helping miners and safety teams prepare for and respond to incidents effectively.
15. **Regulatory Compliance Reporting:** BIM helps in generating accurate reports and documentation for regulatory compliance, streamlining the reporting process.

Tunnelling BIM use cases (by ITA-AITES)

33 BIM use cases listed and described…

…from 3 source organizations (DAUB, ITA, IFC)...

…for 8 different **project stages**.



15 >> APPENDIX A – BIM USE CASES

USE CASE	DESCRIPTION	SOURCE	STRATEGIC DEFINITION	PREPARATION & BRIEFING	CONCEPTUAL & PRELIMINARY DESIGN	BASELINE REFERENCE DESIGN	DETAILED/ CONTRACTOR DESIGN				CONSTRUCTION	COMMISSIONING & HANDOVER	USE/ OPERATION
							30% Detailed Design	60% Detailed Design	90% Detailed Design	100% Detailed Design			
Design variants investigation	Variant investigation based on 3D models of the existing condition including conflict analysis	DAUB	✓	✓	✓	✓	✓						
Visualisation (public relations work)	Visualisation of the design including existing buildings and infrastructure	DAUB		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Design production environment	Design plans and plans for approval are derived in 2D from the structure model	DAUB		✓	✓	✓	✓	✓	✓	✓	✓		
Cost estimation and cost calculation	Model-based and structured quantity determination; Linking of the 3D model with cost data	DAUB		✓	✓	✓	✓	✓	✓	✓	✓		
BIM / structural / FE model co-ordination	Co-ordination of domain-specific sub-models by combining models in coordination software for detecting interferences	IFC		✓	✓	✓	✓	✓	✓	✓	✓		
Sustainability	Incorporation of sustainability parameters in the BIM model with the target to support quantifications 'for EG, carbon content' and provide data for variant investigation	WG22		✓	✓	✓	✓	✓	✓	✓	✓		
Health and safety design environment	Consideration of all safety-relevant aspects in the model, especially through the representation of the construction sequence with time; Rule-based checking of escape routes, bottlenecks, closed zones, escape and rescue possibilities;	DAUB			✓	✓	✓	✓	✓	✓	✓	✓	✓

Tunnelling vs. Mining project stages

An example of existing tunnelling project stages being converted into mining equivalents.

PROJECT STAGES										
Tunnelling conventions	STRATEGIC DEFINITION	PREPARATION & BRIEFING	CONCEPTUAL & PRELIMINARY DESIGN	BASELINE REFERENCE DESIGN	DETAILED/ CONTRACTOR DESIGN				CONSTRUCTION	COMMISSIONING & HANDOVER	USE/OPERATION
					30% Detailed Design	60% Detailed Design	90% Detailed Design	100% Detailed Design			
Mining conventions	SCOPING STUDIES	PRE-FEASIBILITY STUDIES			FEASIBILITY STUDIES				CONSTRUCTION & PRODUCTION		

Suitable BIM use cases for Construction & Production project stages in mining (1/2)

1	Visualization (public relations work)	Visualization of the design including existing buildings and infrastructure.
2	Health and safety design environment	Consideration of all safety-relevant aspects in the model, especially through the representation of the construction sequence with time; Rule-based checking of escape routes, bottlenecks, closed zones, escape and rescue possibilities; Analyses of working conditions; Consideration of environmentally relevant aspects (closed areas, hazardous substances) in the models (especially in the 4D simulation of the working sequence).
3	Surveying	To transfer geometrical constraints and input parameters from the 3D models for the structural design of underground structures ... connect existing and preconstruction condition surveys, evolve data through construction / as built etc.
4	Logistics planning	Digital planning and checking of space management, delivery possibilities, supply and disposal etc. with the model; Determination of the effects on logistic capacity of changes to the model; Simulations / variant studies of various logistic solutions incl. representation of the requirements of health and safety and environmental protection as well as time and cost effects.
5	Defects management	Documentation of defects and the corresponding remedial measures in the digital model.
6	Structure documentation	Creation of „as built“ BIM models; Documentation of the construction process with comprehensive defects management.
7	Monitoring	Monitoring of ground deformations during tunnelling.
8	Cost estimation and cost calculation	Model-based and structured quantity determination; Linking of the 3D model with cost data.
9	BIM / structural / FE model co-ordination	Co-ordination of domain-specific sub-models by combining models in coordination software for detecting interferences.
10	Sustainability	Incorporation of sustainability parameters in the BIM model with the target to support quantifications 'for EG, carbon content' and provide data for variant investigation.
11	Coordination of specialist design work	Assembly of each specialist model to one coordination model; Checking of the specialist models for collisions with other disciplines.
12	3D ground modelling	Provision of all geotechnically relevant data over the entire course of the project; Use of the data as input quantities for further use cases; Constant updating of the model as knowledge is gained.
13	GIS	Integration of GIS data into the BIM environment to improve design co-ordination and clash analysis.
14	Change management	Handling of deviations identified in construction progress controls … as well as changes during the design process.

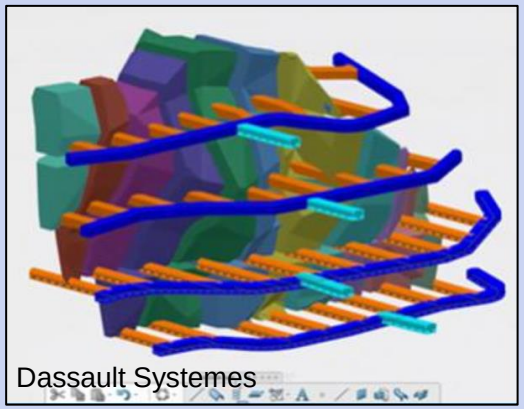
Suitable BIM use cases for Construction & Production project stages in mining (2/2)

15	Geological documentation	Assessment of geotechnical risk along tunnel route.
16	Digital Twin (in the design stage)	Creation of a coordinated workflow to set a single source of truth between digital models in the design development, e.g., between the Structural model and BIM model, Hydraulic model and BIM model.
17	Construction Scheduling	Model-based scheduling of construction; Linking of individual construction elements from the structure model with the associated activities in the schedule; Representation of the project structure in the schedule structure and the BOQ structure.
18	Quantity determination	Basis for cost estimation, tendering, billing, logistics, planning as well as during construction for billing and payment purpose.
19	Compliance management	Automated checking of compliance of the tunnel design with norms and regulations.
20	Machine guidance & control	Steering a tunnel boring machine through the ground on the basis of the as-designed tunnel axis.
21	Production of construction drawings	Working drawings, also in 2D, are generated from the structure model.
22	Construction progress control	Recording of the actual progress of construction and prompt comparison and adjustment to the intended situation; Digital documentation and stepwise recording or acceptance of construction activity by official inspector or client's construction supervisor.
23	As built documentation	Handover of the as-built model, import into Asset management systems .
24	Invoicing of construction works	Use of the model, which is promptly updated with the on-site excavation classes and any additional and/or reduced quantities of support measures, as the basis for the payment of excavation works, taking into account the associated time-related costs; Use of the "construction time model" in BIM.
25	Digital Twins (Asset Management)	Advanced asset management is expected to leverage a Digital Twin of a tunnel, in the form of a continuously updated digital mirror of the current conditions.
26	Handover to GIS	Provide the basis for regional / national transportation asset management (network level, programmatic needs analysis).
27	Use for operation and maintenance	Provision of a facility model with all relevant data for operation; Data administration and updating at a central location (database).

… and finally, two more specific MineBIM use cases:

Emptying the stope (underground mining unit)

Using assistive machine control based on the BIM model, the operator can see on the computer screen where the boundary between the stope backfill and the ore is, so that the bucket does not start digging vertically into the backfill material or leave the ore unloaded at the bottom of the stope.


Dassault Systemes

Novatron

The loading machine can be controlled either remotely or automatically. The stope loading process takes place on top of a previously backfilled stope along the entire length of the stope, which is several tens of meters long.

Human-Environment-Computer Interaction and Mixed Reality

- Imagine a **"Dark mine"** that no longer has any fixed lights nor physical markings, spray-painted survey markings, warning signs, guidance signs, road signs, traffic lights, area restriction fences, work site instructions or anything that used to convey information manually to people walking around the mine...
- All information about the mine's physical environment is stored in data warehouses and information models (**BIM**).
- You can walk around the mine with a device that allows you to see everything (**AR**) as clearly as in daylight and have access to all information and activity data related to your environment.
- Any manual information you previously saw on tunnel floors, walls, and ceilings, such as markings, warning signs, traffic lights, and area restrictions, is now processed virtually (**DT and xR**) only.
- You can see all the activity information about the surrounding equipment and selected workflows, safety instructions, and even the geological features of the surrounding rock that have been added to the physical view that you can **see in front of you** with your own eyes. Everything is always available, up-to-date and on-line.

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Thank you for listening!

Survey for participants

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