Data Management in Future Mines – Maximizing Value from Data

Mine.io Cloud Platform and Use Case in TUBAF Pilot

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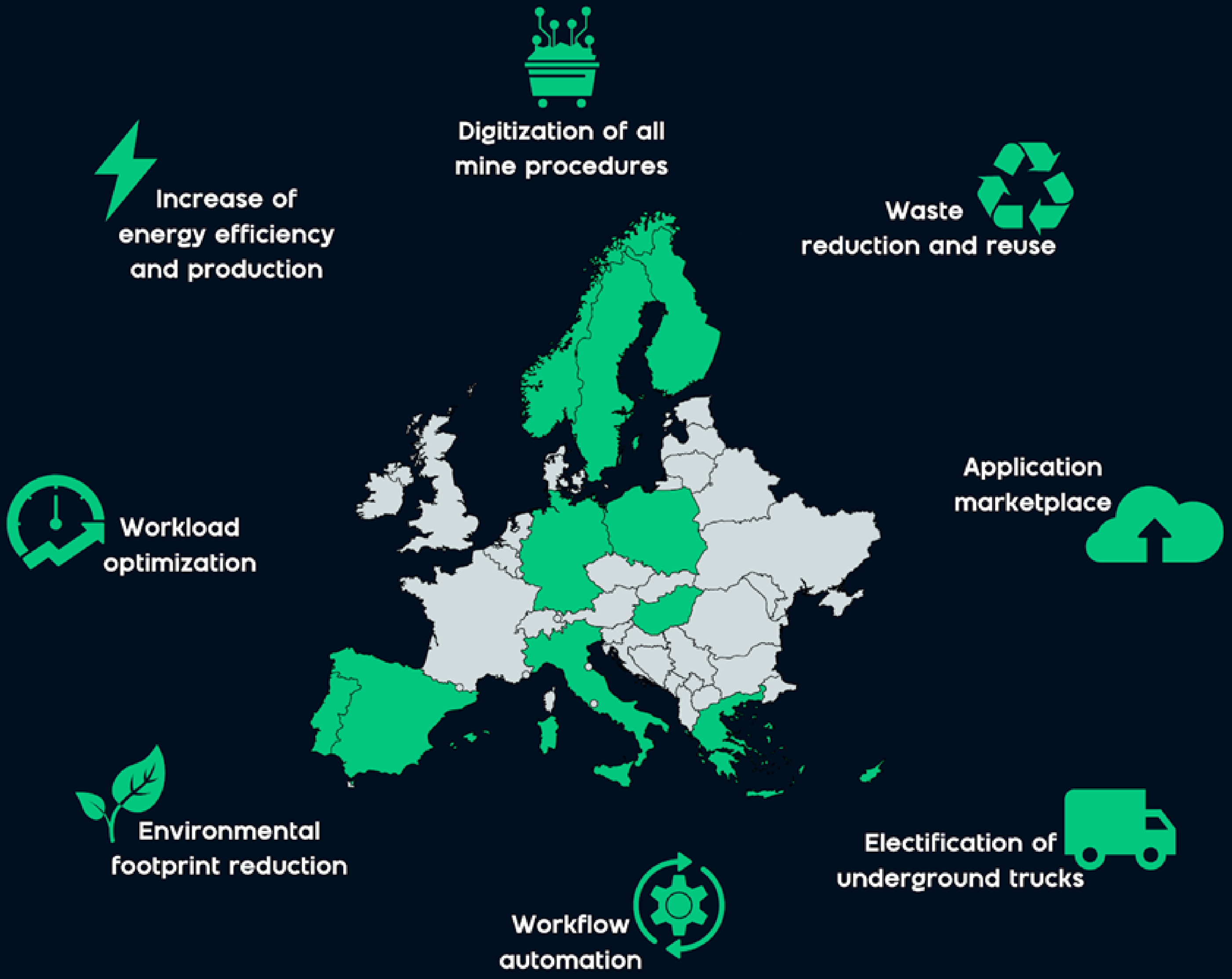
Mine.io aims to provide solutions that will build a novel mining digital ecosystem and a systemic structure for the implementation of Industry 4.0 in mining industrial environments.

- **25 partners**
- **7 pilot use cases**
- **€14M budget**
- **42 months**



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Challenges to tackle from the Mine.io Platform's perspective (*WHAT* and *WHY*)

- **Digital Maturity Challenges**: Low digital adoption due to legacy systems and outdated technologies.
- **Pilots' Diverse Needs**: Variation in requirements across different pilot needs.
- **Integration Complexity**: Technology and processes diversity hinder seamless integration.
- **Siloed Operations & Supply Chain Gaps**: Limited data exchange and sharing causing delays and inefficiencies.
- **IT/OT Convergence**: Integrating IT and OT enables a unified, data-driven decision-making environment.
- **Future Enhancements**: Focused on remote monitoring and connectivity for modernized/innovative mining.

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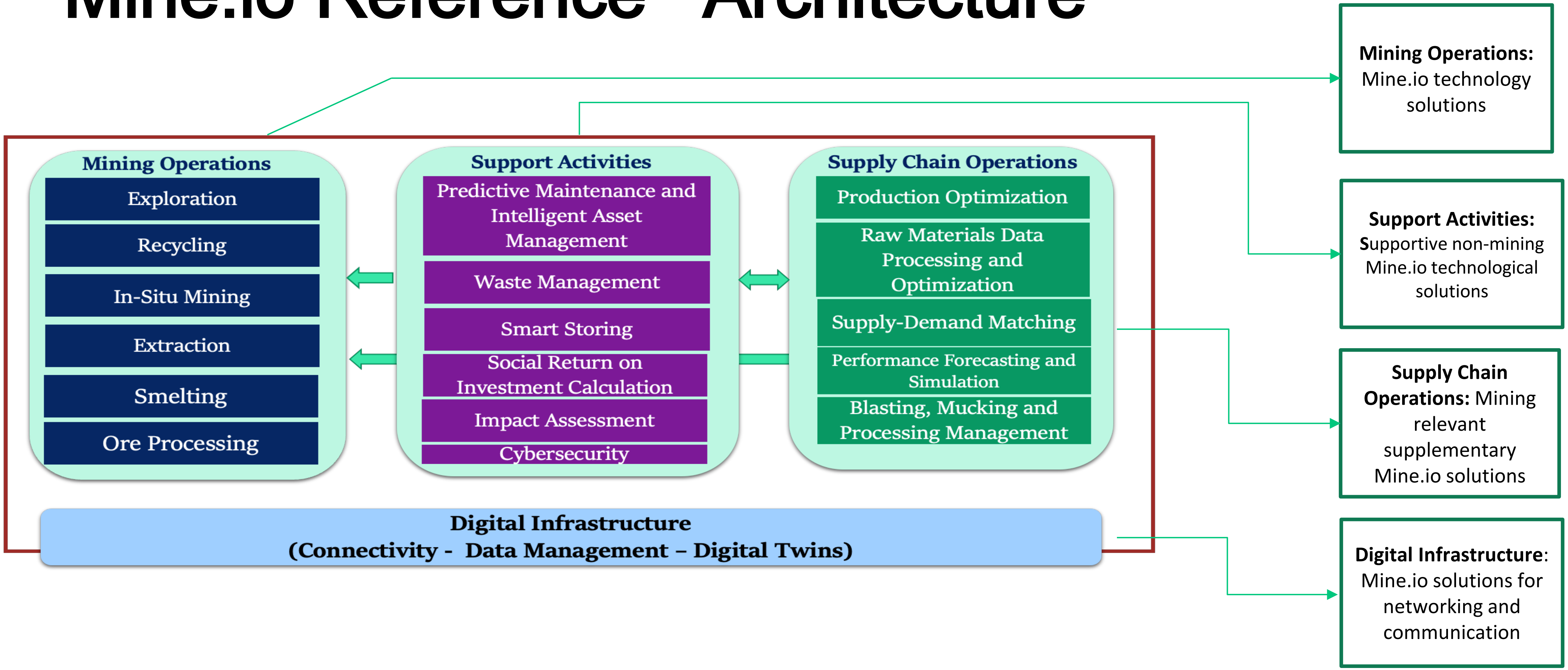
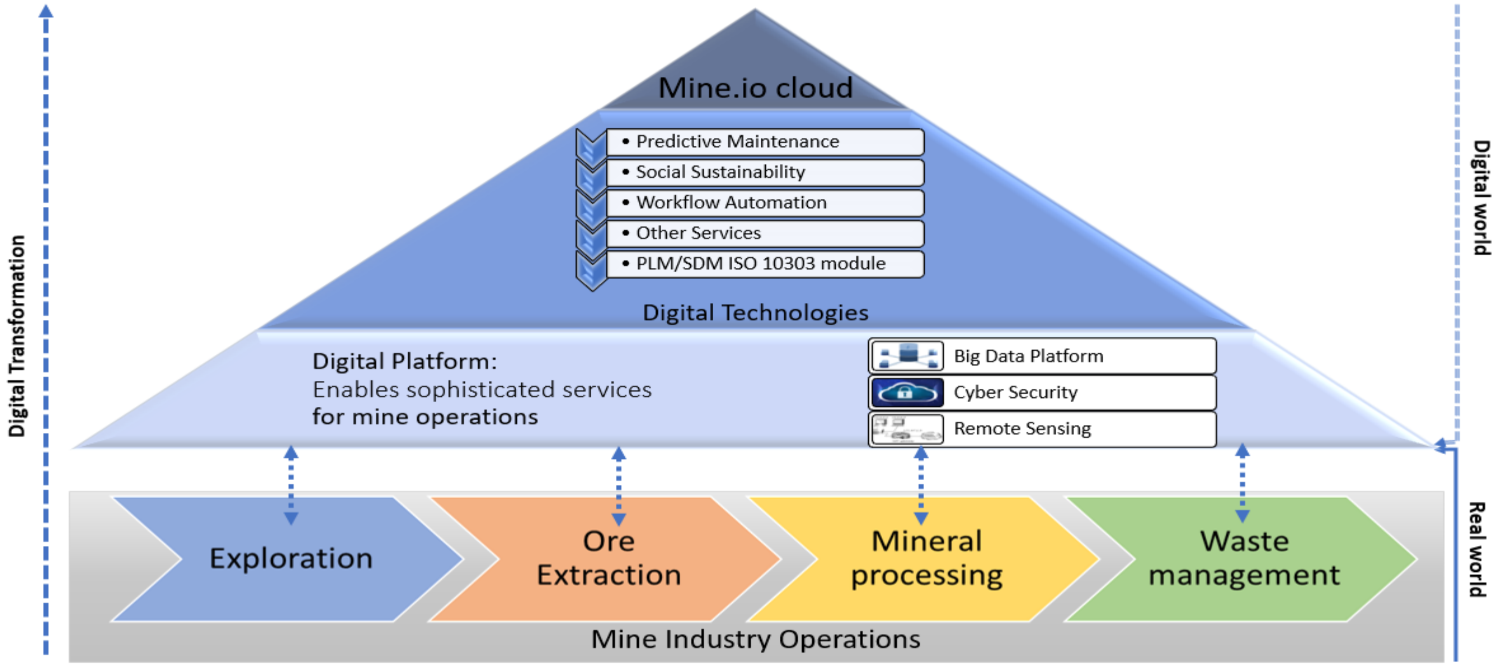
Mine.io Reference Architecture



Conceptual view of the Mine.io (*How*)

- **Digital Transformation First Approach**:
  - **Real-world** and **Digital-world** division
  - Bridge the Mining Industry Operations with the Digital Innovation
    - The Real world consisting of the main **Mining Operations**: Exploration, Ore Extraction, Mining Processing and Waste Management
    - The Digital-world is the **Mine.io Cloud**, consisting of the Digital Platform and the Digital Solutions

Mine.io Conceptual View



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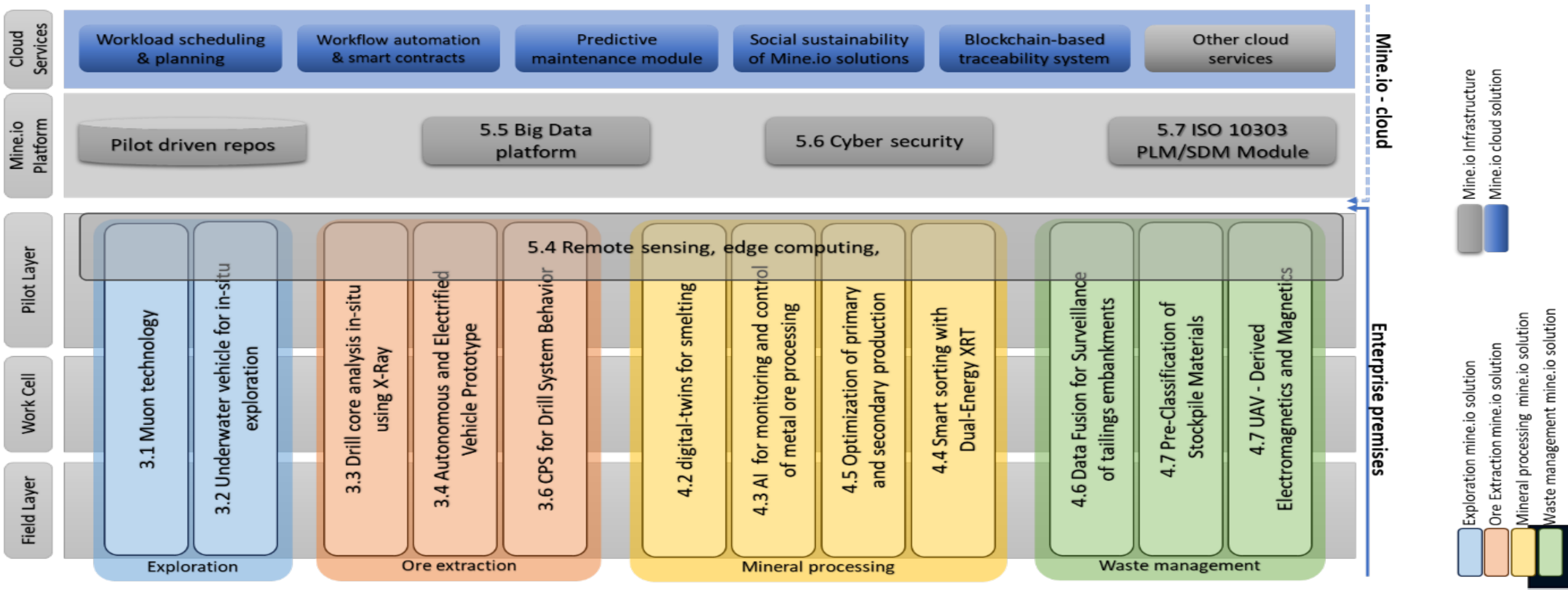
Mine.io Platform Architecture (*HOW*)

- Based on **HLRA** and the **abstraction layered approach:**
  - We divided the architecture in two main pillars (**abstraction layers**):
    - the **Enterprise premises** and
    - the **Mine.io cloud**
- Converging the **HLRA** and the **abstract layers resulted in:**
  - **clustering** the Mine.io solutions (tasks) into **Mining Operations**
  - **aligning** with the **Support Activities**, the **Supply Chain Operations,** and the **Digital Infrastructure**



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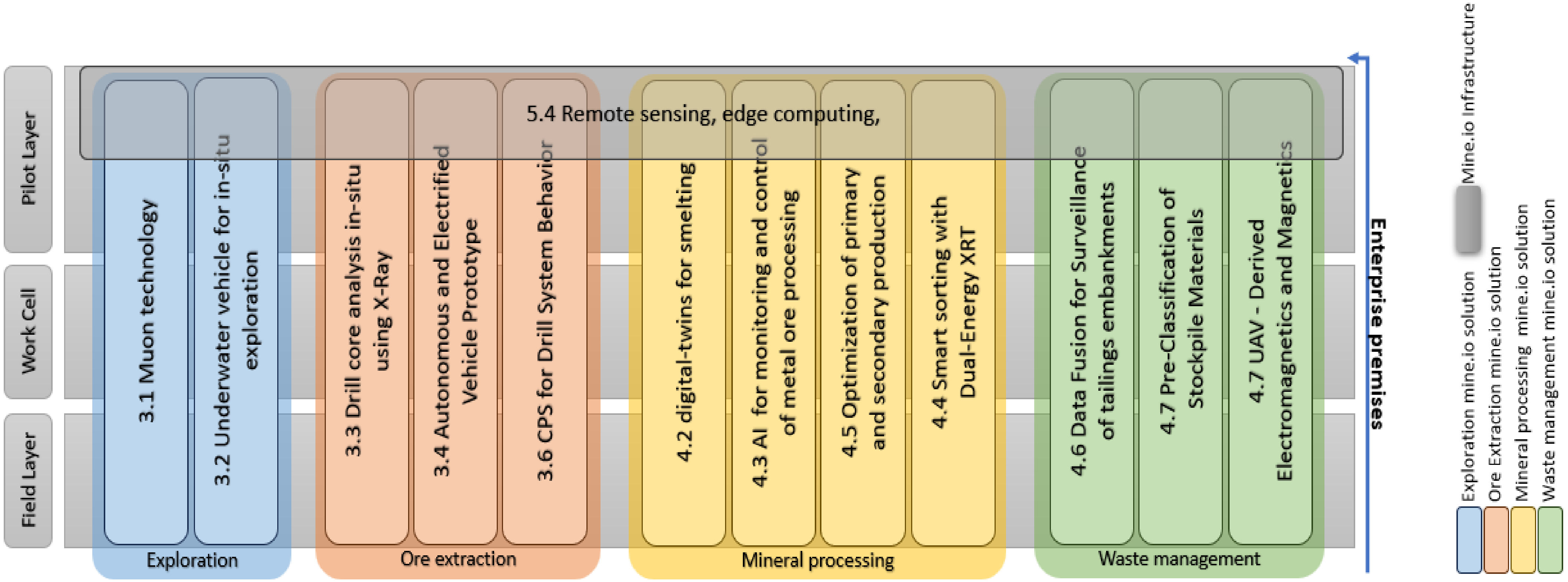
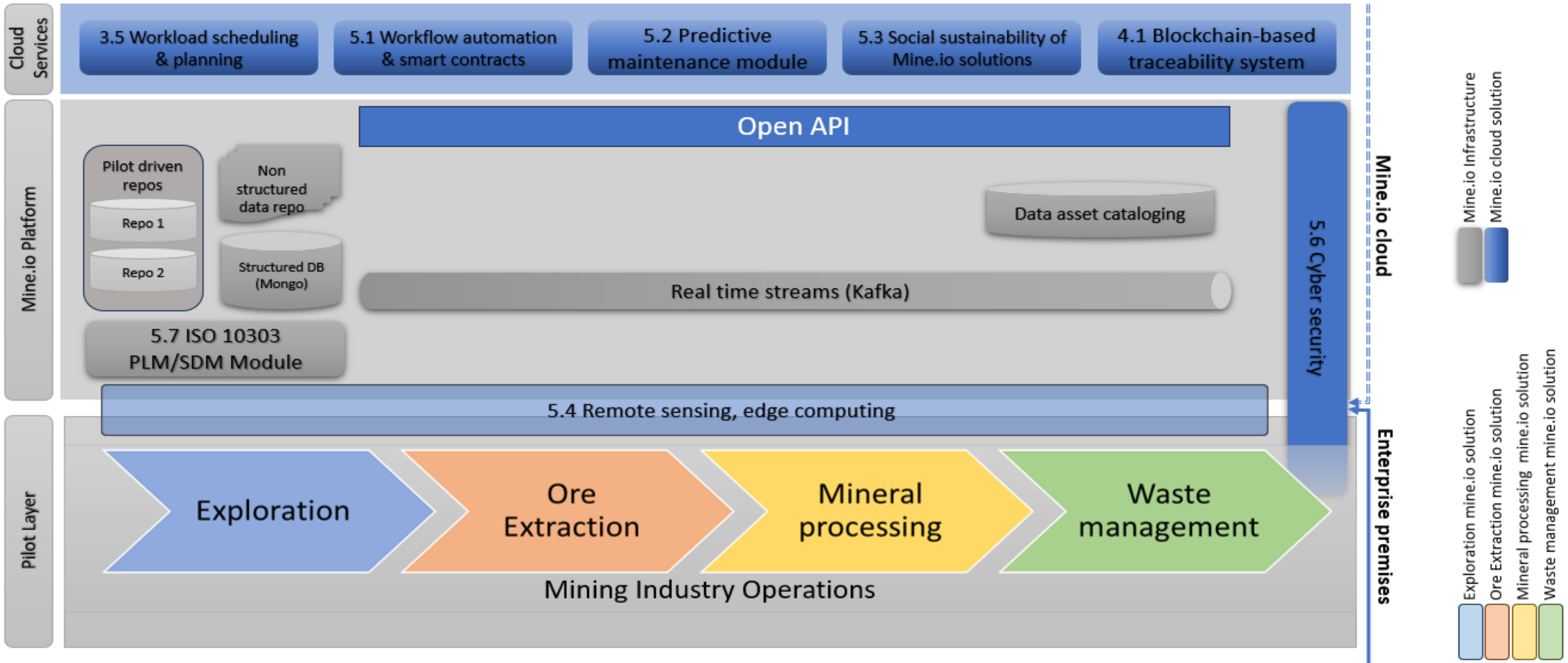
Enterprise premises ‘abstract’ layers

- Field Layer (sensors and machinery)
- Work Cell Layer (systems close to the field, involving communication with sensors, basic processing, and control), and
- Pilot Layer [middle layer between the edge devices (solutions for mine operations and remote sensing) and the Mine.io Cloud]



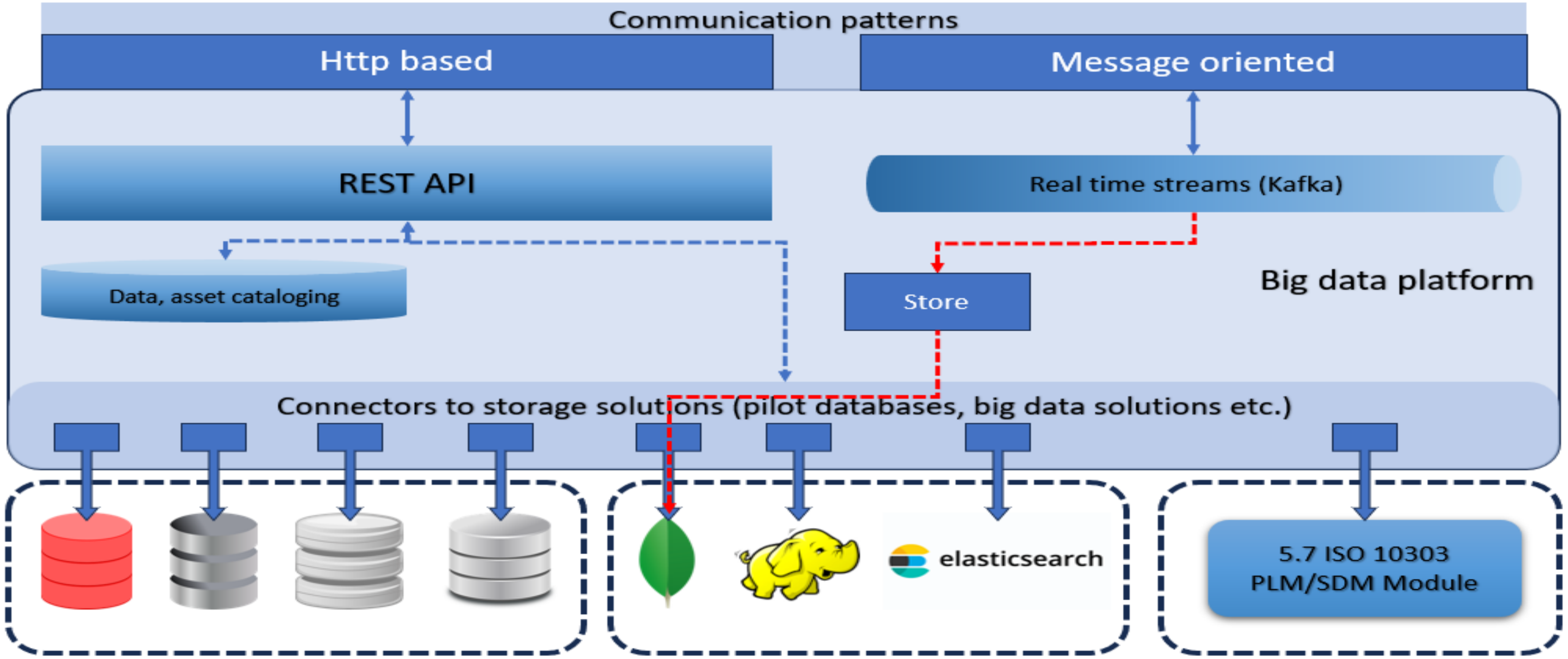
Mine.io Cloud Platform (*HOW*)

- Mine.io Cloud Services
  - Supportive non-mining cloud-based solutions
- Mine.io Platform
  - Infrastructure Elements and cloud solutions, providing the necessary hardware and networking infrastructure to deploy and operate various functionalities and cloud-based services.



Big Data Platform Architecture (*HOW*)

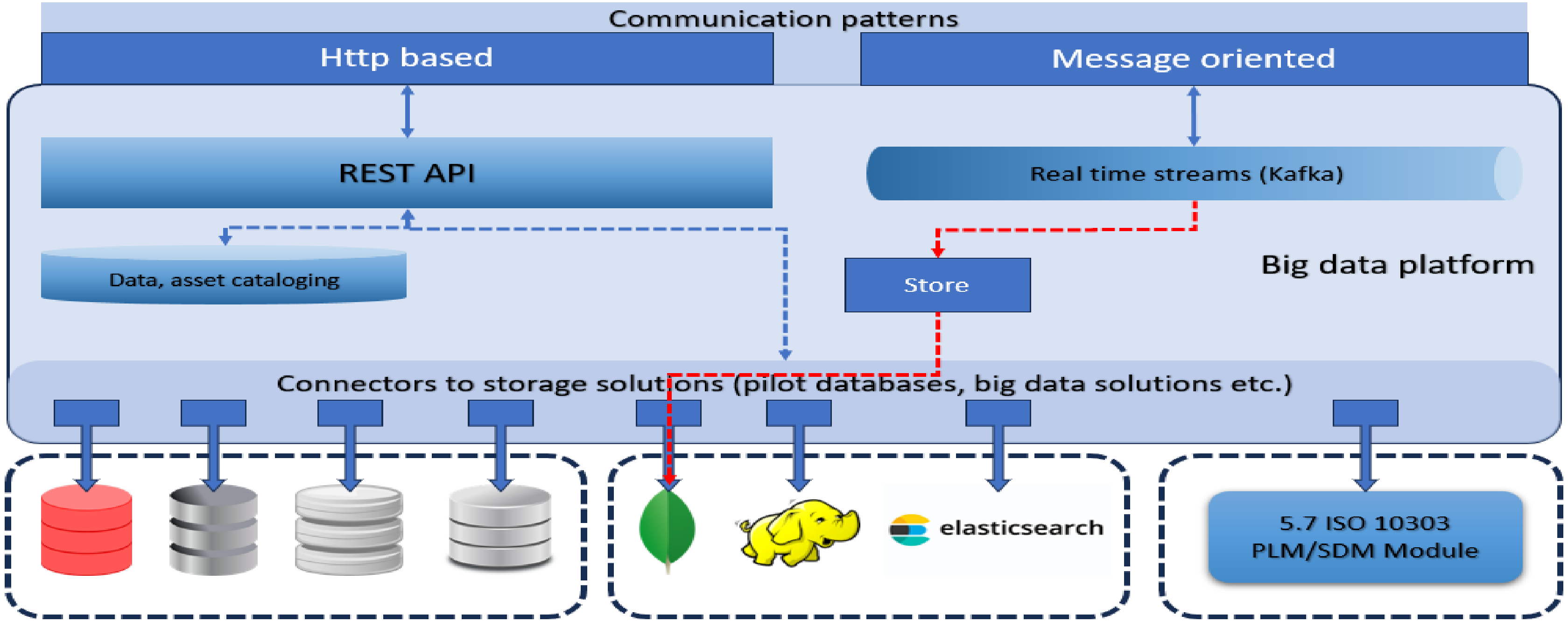
- Consists of:
  - Supported data Repositories (pre-existing and new storage solution e.g. Mongo DB, Hadoop)
  - Data asset cataloguing (indexing data, describing its type, model, and storage location)
  - Real time data streaming (handling real-time data streams, ensuring reliable data flow across systems)
  - REST API (supporting data asset management, exchange and sharing, enabling CRUD operations)
  - Connectors (enabling interoperability with various storage solutions)



Big Data Platform Integration

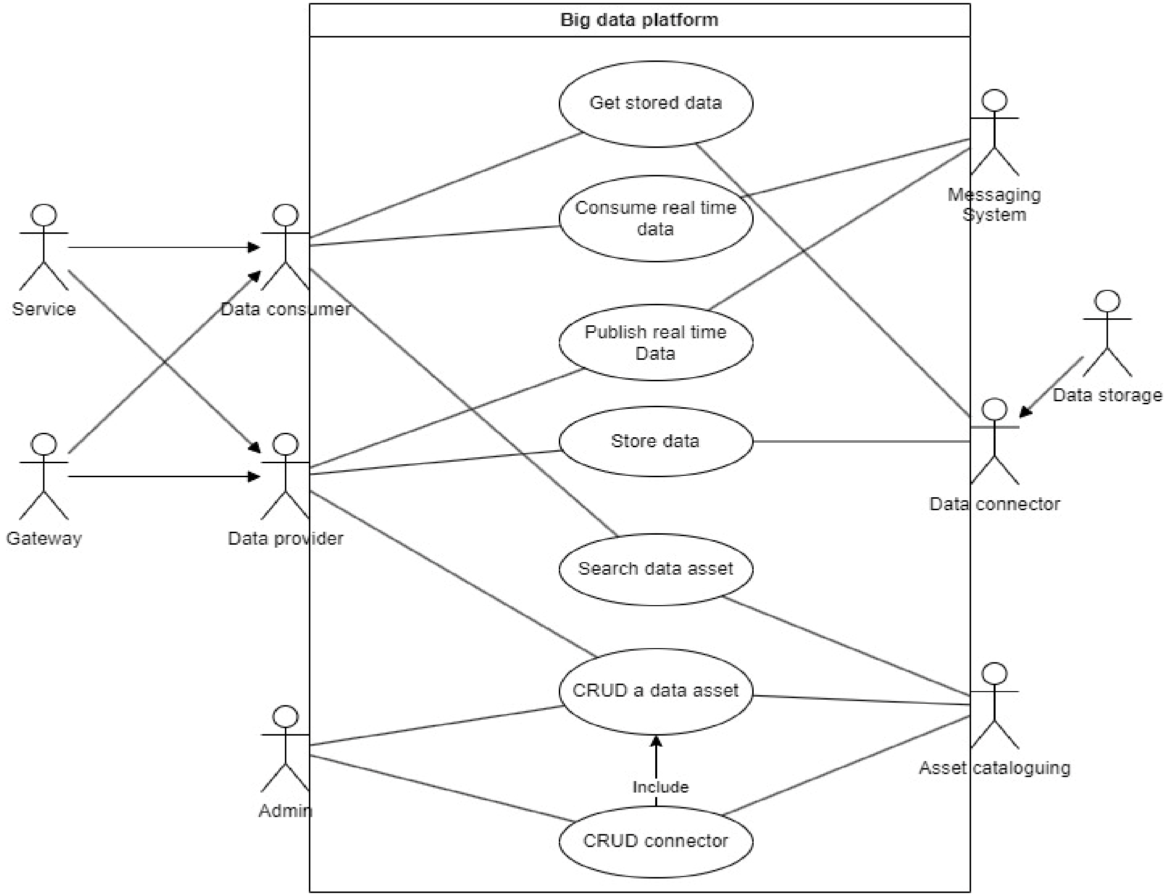
- Northbound communication layer with both Mine.io gateways and cloud services via two different integration patterns
    - Http based request – response exposed through REST API
    - Message oriented for real time streaming supported with KAFKA

- Storage solutions southbound connectivity will be managed via connectors.



Big Data Platform's (data management) Use Case View

- **Data Asset definition**
  - *CRUD connector*: Admin executes CRUD operations for new connector. => The new connector is stored to the asset cataloguing.
  - *CRUD data asset*: Admin or data producer executes CRUD operations for a new data asset. The data asset is linked with existing connector and stored to the data asset cataloguing.
  - *Search data asset*: Data consumer searches for available data assets.
- **Data storage/retrieval:**
  - *Store data*: Data producer stores data to a data storage using the connector that is linked with the data asset.
  - *Get stored data*: Data consumer requests data from a data storage.
- **Real time streaming manipulation:**
  - *Stream data*: Data producer streams real time data to the messaging system
  - *Consume data*: Data consumer subscribes and receives a real time data stream from the messaging system



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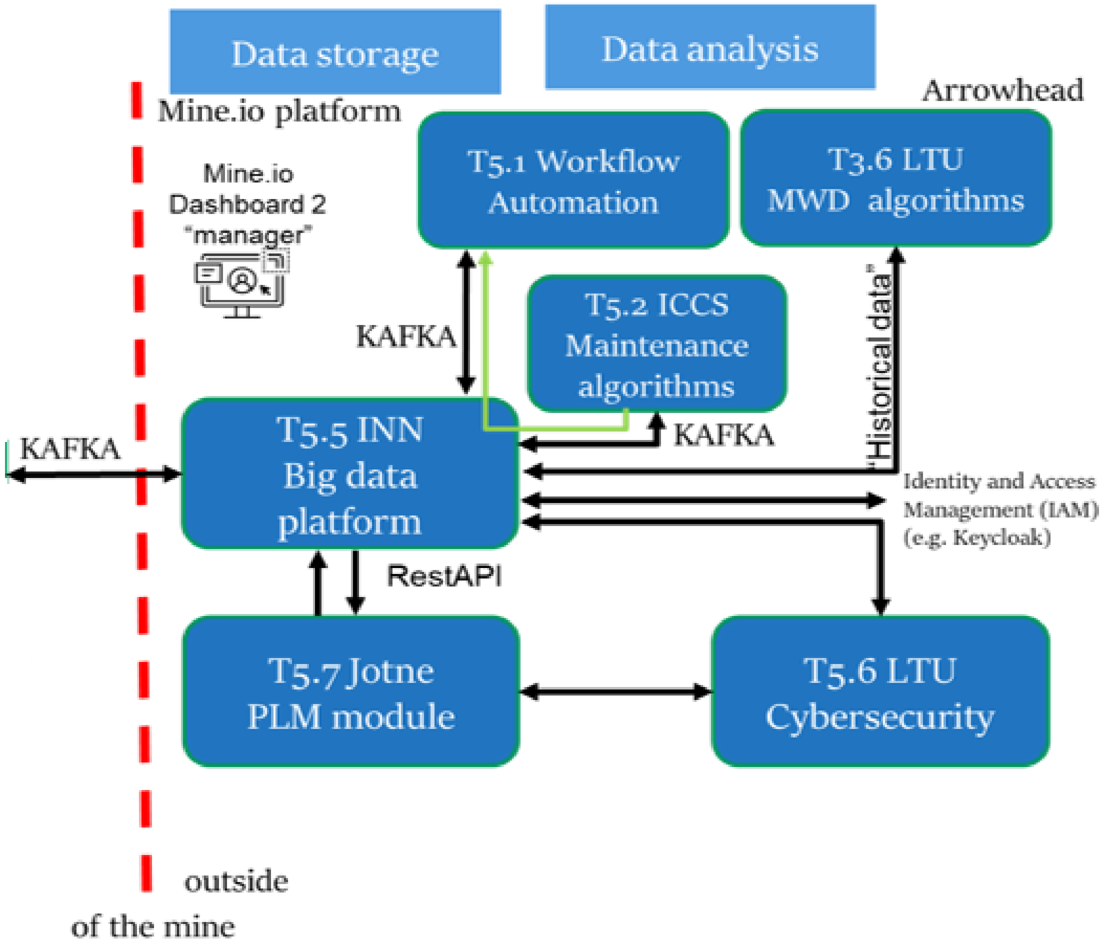
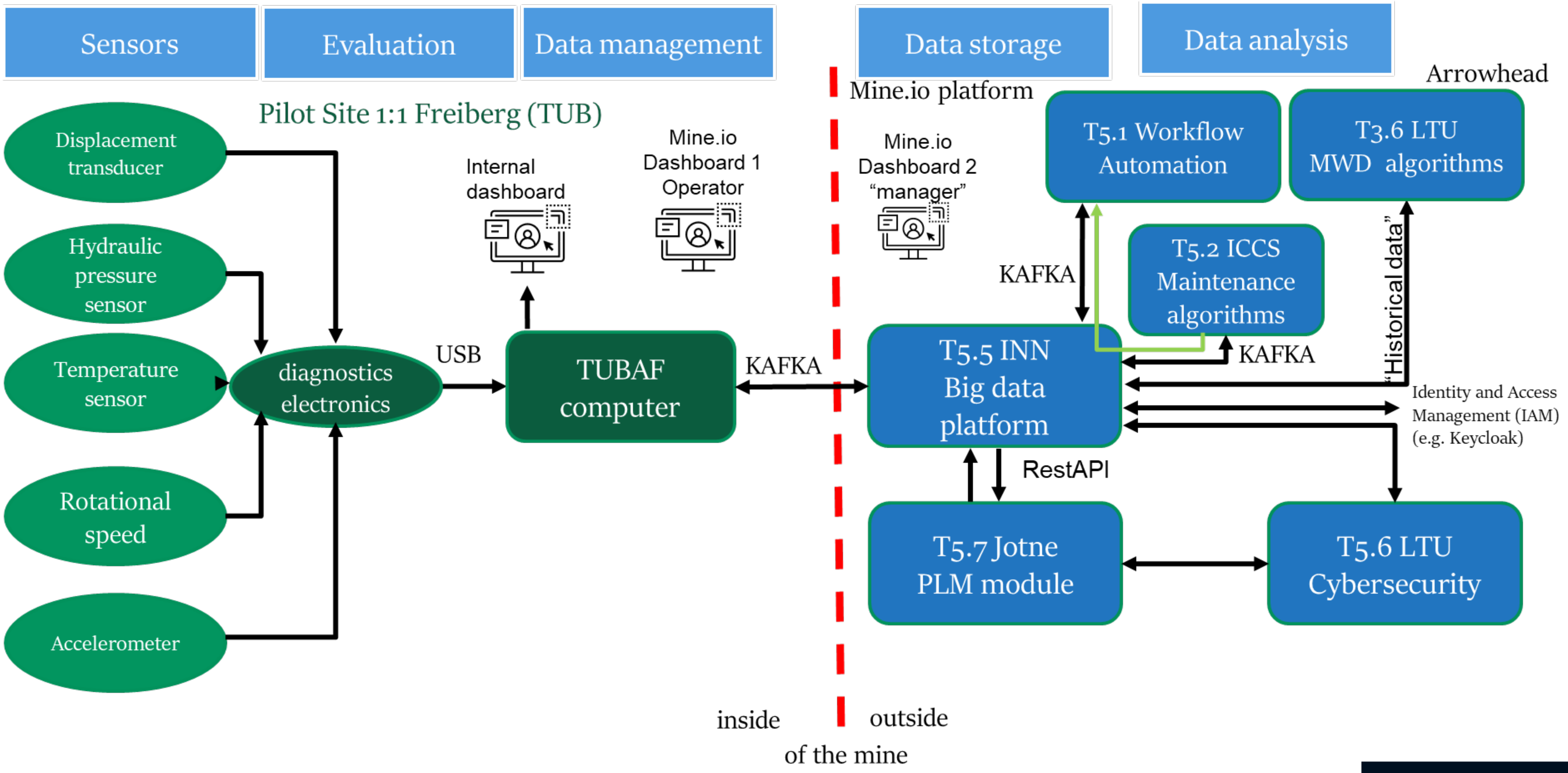
Big Data Platform’s Significance and Impact

- **Distributed data storage**
  - Big Data Platform supports multiple pilot driven data storage solutions.
- **Expandability - scalability**
  - For each new pilot, only a new connector should be implemented
- **Findability**
  - Asset cataloguing supports the indexing and the discoverability of data
- **Accessibility**
  - Data sharing with rest cloud services through an Open API
- **Interoperability**
  - Leveraging ISO 10303 through PLM module
- **Reusability**
  - Each data and metadata are clearly described in order to be reused
- **Versatility**
  - Ability of a data system, platform, or dataset to support and handle a wide variety of data types, formats, and sources
- **Security by Design**
  - Embedding security measures directly into the design and development process

Use Case of TUBAF Pilot in Freiberg Architecture




Sensors
Evaluation
Data management
Data storage
Data analysis
Pilot Site 1:1 Freiberg (TUB)
Mine.io platform
Arrowhead
Displacement transducer
Hydraulic pressure sensor
Temperature sensor
Rotational speed
Accelerometer
diagnostics electronics
USB
Internal dashboard
Mine.io Dashboard 1 Operator
TUBAF computer
KAFKA
Mine.io Dashboard 2 "manager"
T5.1 Workflow Automation
T3.6 LTU MWD algorithms
T5.2 ICCS Maintenance algorithms
KAFKA
KAFKA
"Historical data"
T5.5 INN Big data platform
Identity and Access Management (IAM) (e.g. Keycloak)
RestAPI
T5.7 Jotne PLM module
T5.6 LTU Cybersecurity
inside
outside
of the mine

Research and Education Mine Reiche Zeche (FLB)

Digitisation Drill Operations

- Equipping the Sandvik DE110 with a data logging system
  - Add sensors and data logging system to the drill rig
  - Real-time measurements and transmission to the cloud
- Operating Sandvik DE110 in the mine
  - Test drilling at well known location
  - Test drilling with different drill bits (new & used)

Digitisation Drill Operations - Objectives

- Provide the operator with detailed status information
- Increase the efficiency of the drilling process
- Get a faster learning curve for the operator
- Evaluate and analyse the rock being drilled in real time
- Analyse the wear of the drill bit in real time

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Digitisation Drill Operations – Material Evaluation During Drilling

- Using advanced tools for data filtering and normalisation
- Drilling situation evaluation through AI-supported analysis
  - Identifying the boundaries between the ore vein and the host rock
  - Identifying the rock quality (e.g., fracture zones)

Digitisation Drill Operations – Predictive Maintenance

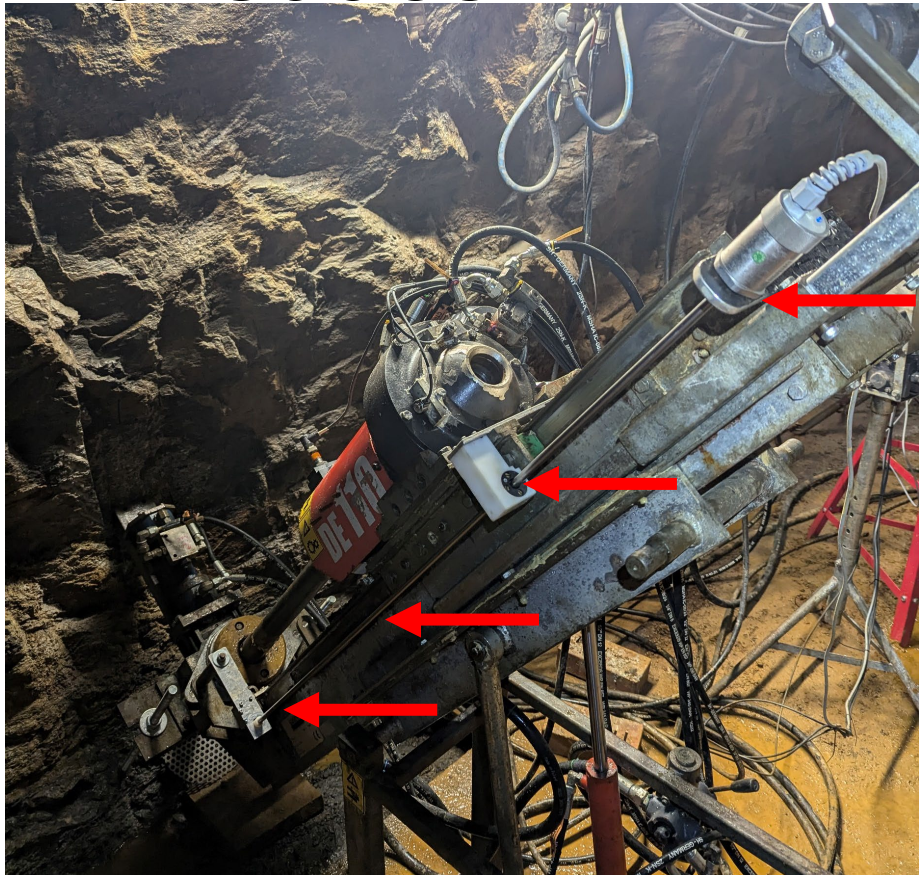
- Predictive Maintenance module is implemented in the form of
  - A machine learning analytics process development tool
  - Automated machine learning (AutoML)
  - deep learning
- Identify actual equipment degradation and predict future health status
  - detects anomalies, predicts the wear of the drill bit, and provides recommendations about maintenance actions

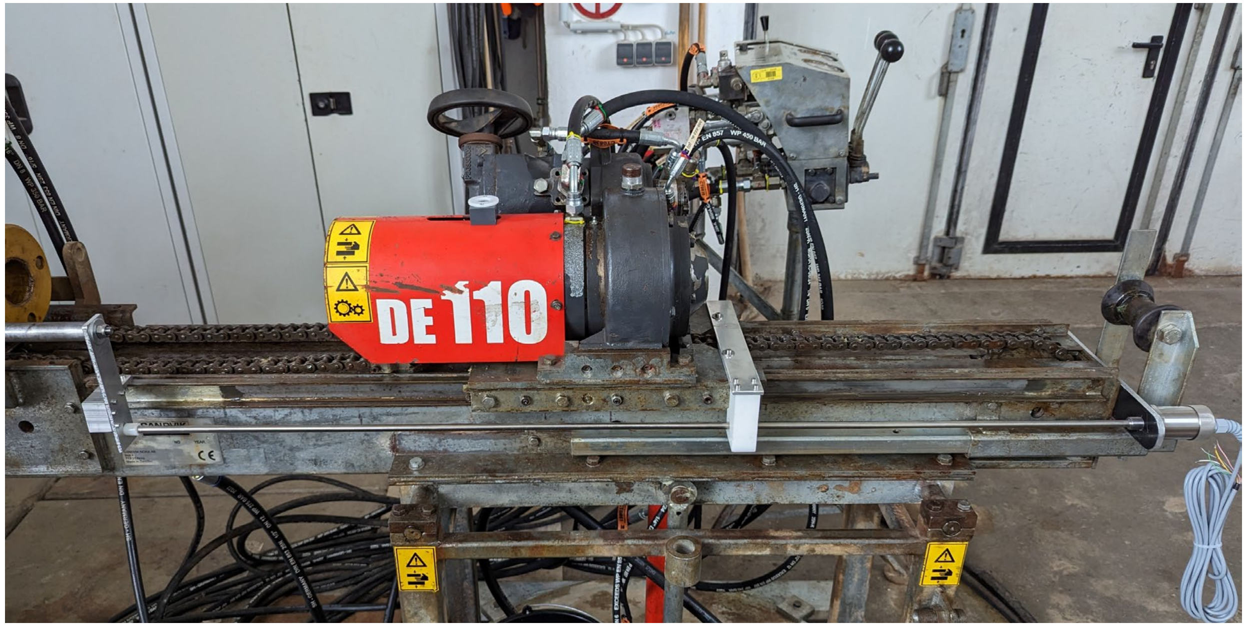
Digitisation Drill Operations

Different sensors are installed

- Displacement transducer - drilling length and speed
- Accelerometer - Drilling rig vibration
- Rotational speed - Drill rod speed
- Hydraulic pressure sensor - Hydraulic pressure on 2 circuits for the rotation unit and the bar chuck
- Temperature sensor - Temperature of the hydraulic circuit before the radiator

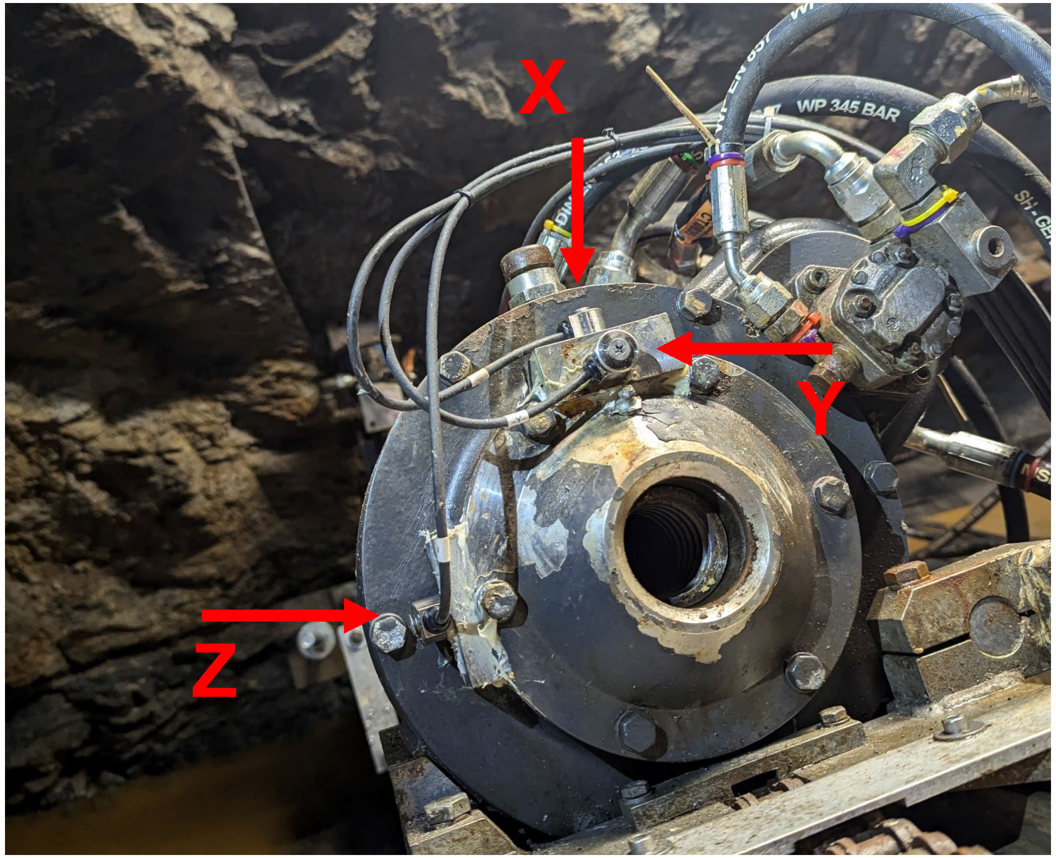
Installation of a Displacement Transducer





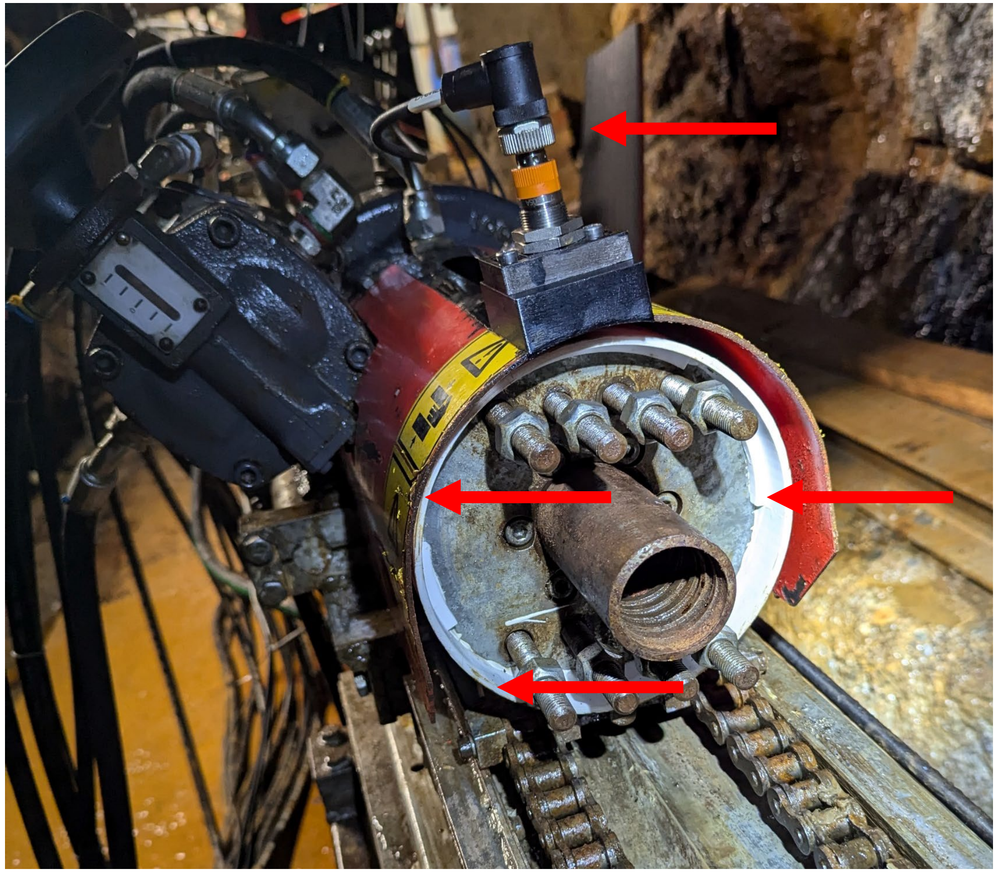
Installation of Accelerometers

- Acceleration sensors are installed
  in 3 directions

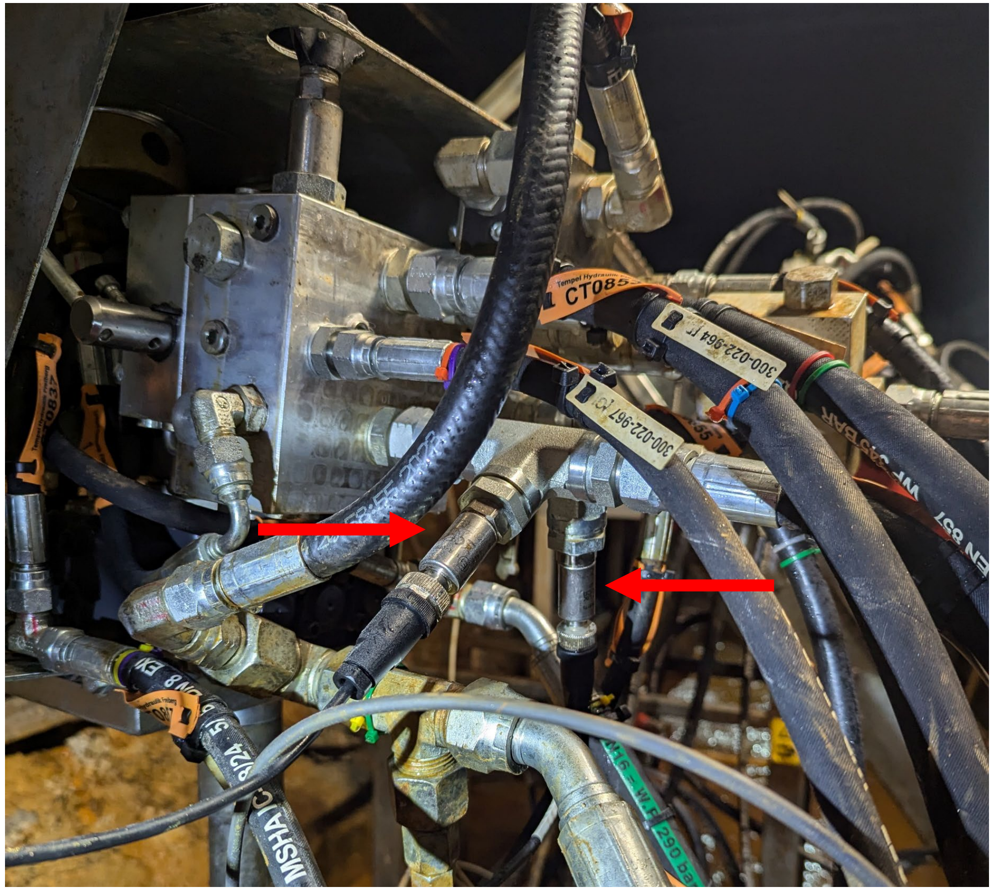


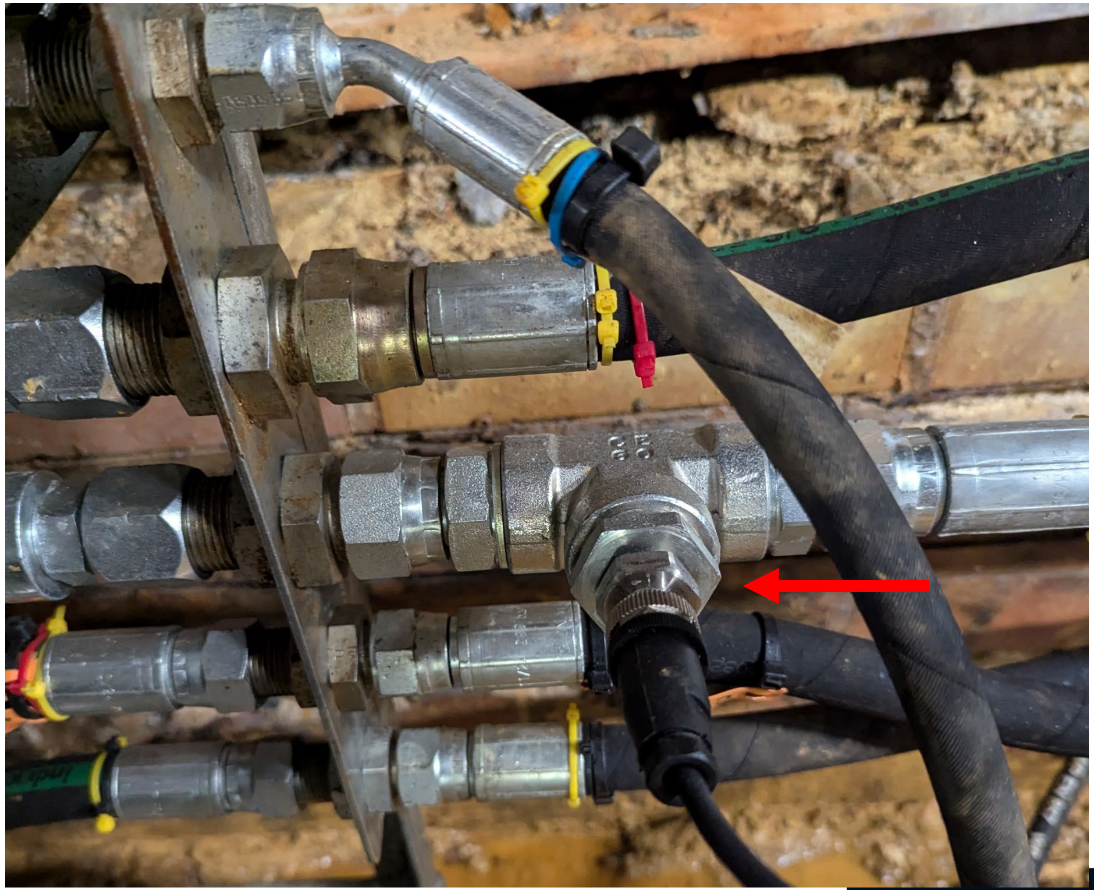
Installation of Rotational Speed Sensor

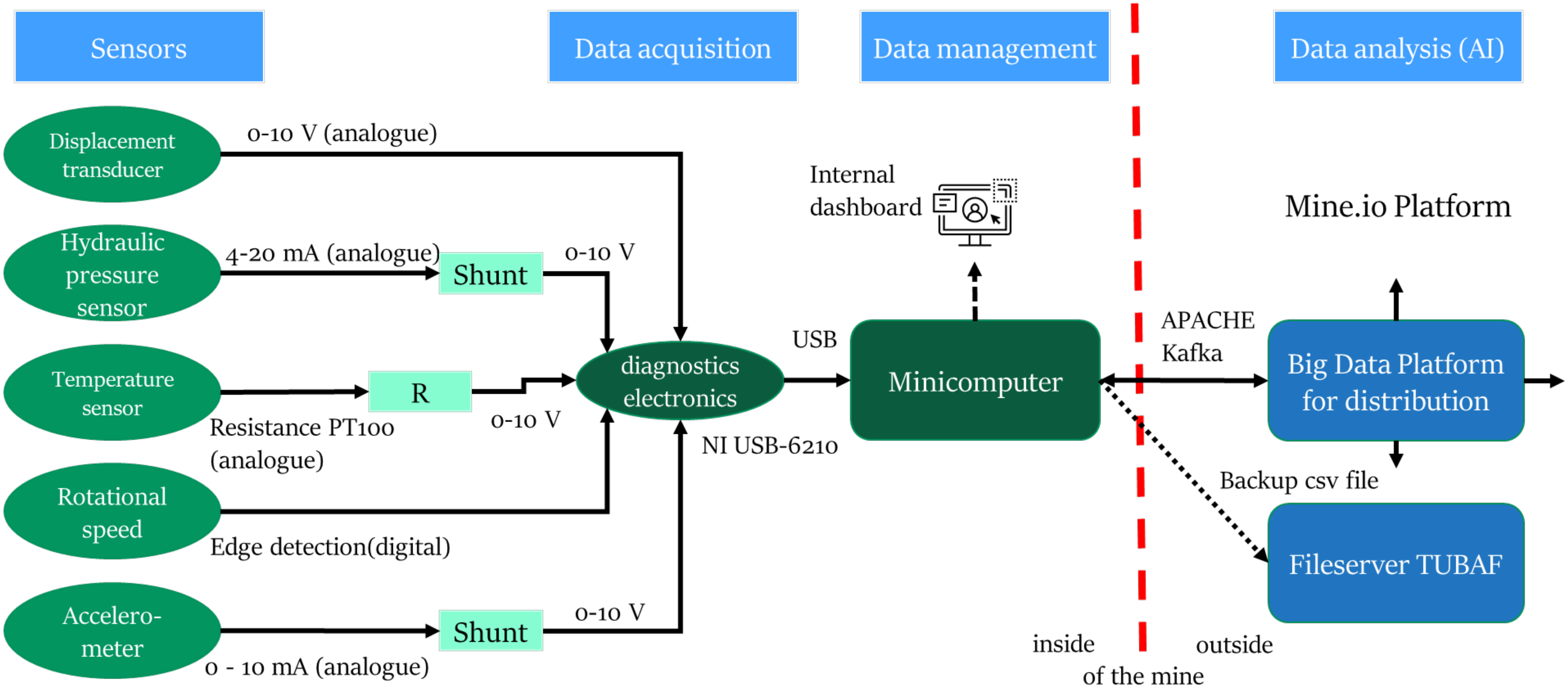
- Install the bearing less inductive rotary encoder above the rotating rotary head on the red cover
- A disk made of POM material is placed on the protruding screws with inserted metal screws and fastened
- the rotation of the disk is the magnetic signal for the transducer



Installation of Pressure and Temperature Sensors







Sensors
Data acquisition
Data management
Data analysis (AI)
Displacement transducer
0-10 V (analogue)
Hydraulic pressure sensor
4-20 mA (analogue)
Shunt
0-10 V
Temperature sensor
R
Resistance PT100 (analogue)
0-10 V
Rotational speed
Edge detection(digital)
Accelero-meter
Shunt
0-10 V
0 - 10 mA (analogue)
diagnostics electronics
NI USB-6210
USB
Internal dashboard
Minicomputer
APACHE Kafka
Mine.io Platform
Big Data Platform for distribution
Backup csv file
Fileserver TUBAF
inside
outside
of the mine

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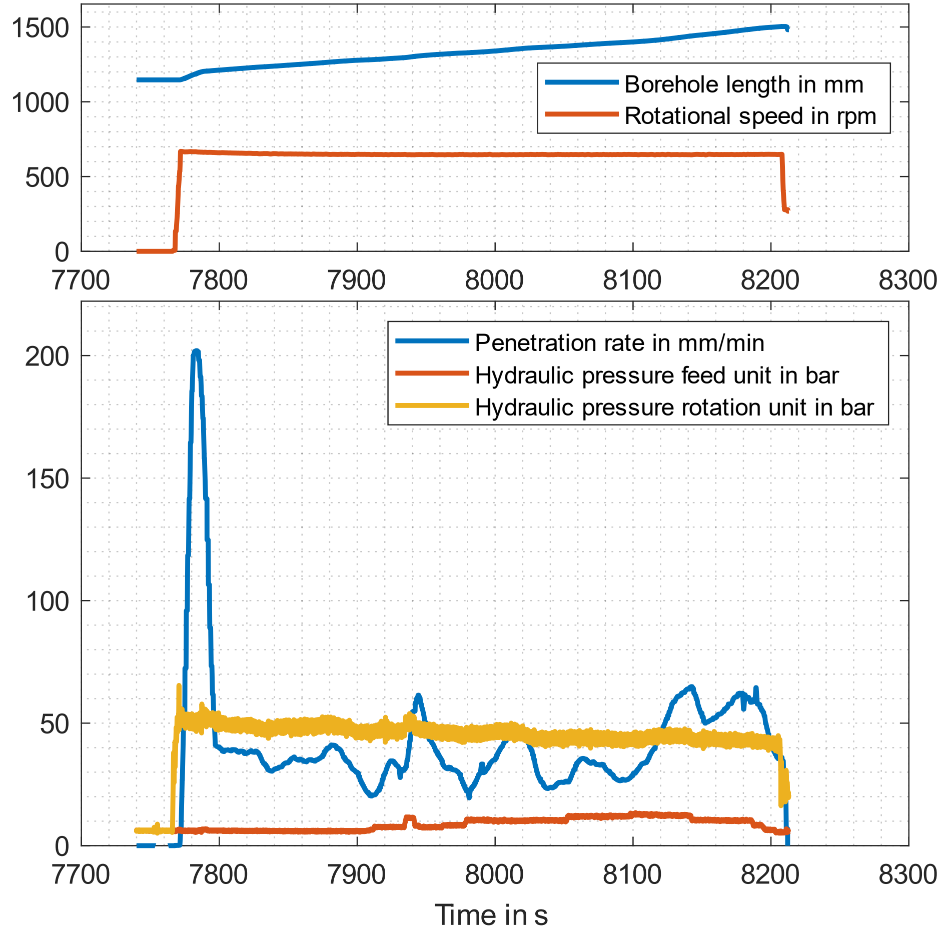
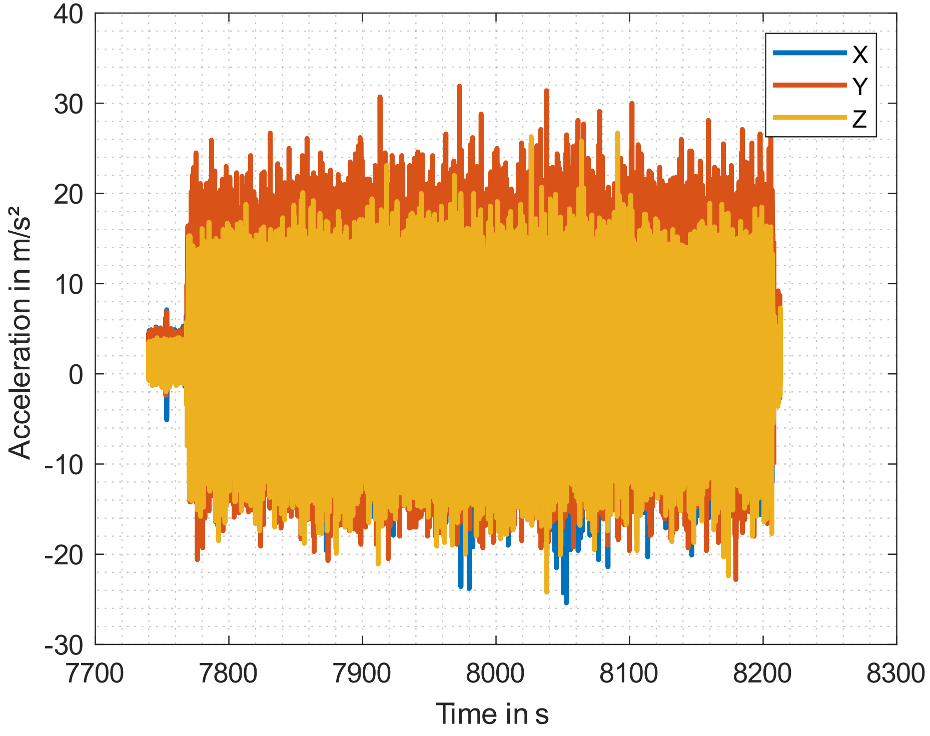
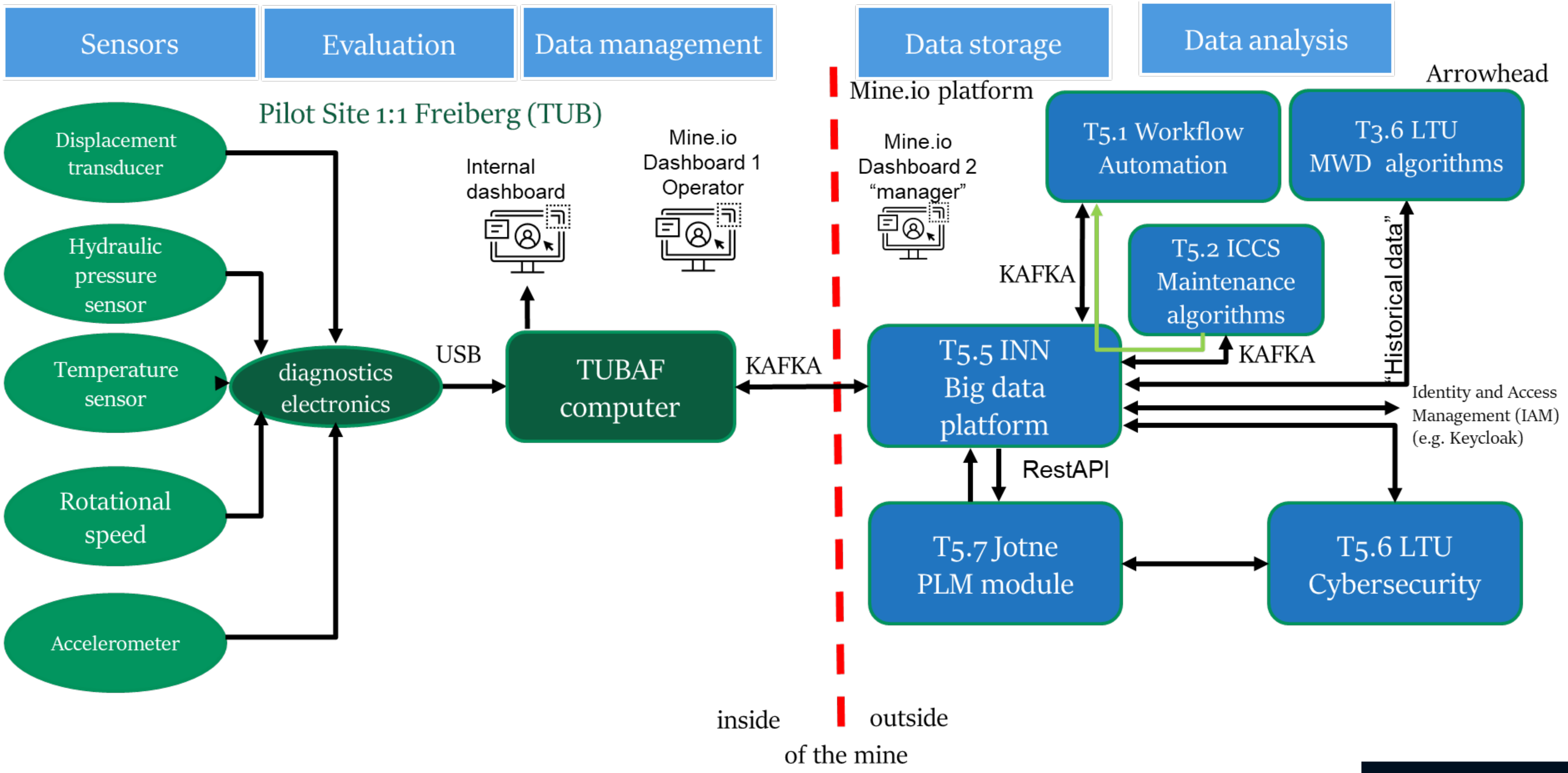
Data Analysis – First borehole



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MINE.IO

A Holistic Digital Mine 4.0 Ecosystem

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Glück Auf!

Thank you for your attention

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