REAL-TIME MINING

MOVING TOWARDS CONTINUOUS PROCESS MANAGEMENT IN MINERAL RESOURCE EXTRACTION

FUTURE MINING CONFERENCE
SYDNEY, 5TH OF NOVEMBER 2015

JÖRG BENNDORF, DELFT UNIVERSITY OF TECHNOLOGY
ON BEHALF OF THE REAL-TIME MINING CONSORTIUM

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 641989
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BACKGROUND

Potential of critical raw materials in Europe classified by deposit sizes (PROMINE)

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The main barriers to overcome for the successful economic exploitation:

- **effective grade control**, which will maximize resource potential along the whole value chain
- **minimization of handling zero-value material** introduced by dilution, thus reducing unnecessary expenditure of energy and financial resources and
- **management and control of the geological uncertainty** due to limited information available.
Main Source of Risk: Geological Uncertainty

Limited Information 1:10.000.000

Complex Geology

Tight product specifications
THE TRADITIONAL APPROACH

SILO 1
- Exploration and Data Collection

SILO 2
- Resource Modelling

SILO 3
- Mine Design
- Equipment Selection
- Reserve Estimation

SILO 4
- Production Scheduling and Operation

SILO 5
- Processing and Sale

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NEW INFORMATION POTENTIAL

Increasing Availability of Sensor Based Online Data:

• Material characterization (geo-chemical, textural and physical properties)
• Equipment performance, upstream and downstream (e.g. efficiency, down-time)
• Equipment location and material tracking (e.g. GPS, UPS)
THE REAL-TIME MINING APPROACH

Discontinuous and Intermittent Process Monitoring and Decision Making

Near-Continuous Process Control and Optimization

INNOVATION

Mine Planning and Prediction
Real-Time Resource/Reserve Model Update
Online Sensor-based Measurements

Prediction vs. Measurements

Operation of Mine Plan

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Overall objective: to develop an innovative technical solution for resource-efficient and optimal high precision/selective mining in geologically complex settings using online data.

Hypothesis: recovery can be significantly increased by changing mineral resource management from a ‘batch-type’ to a near-continuous model-based controlled activity
REAL-TIME MINING BUILDING BLOCKS

**BB 1: Sustainability and Industrial Viability Indicators**

- **Mining Machine**
  - **BB 2: Underground Positioning**
    - Positioning and inertial navigation
    - Infrastructure
  - **BB3: Sensors for Material Characterization**
    - Sensors-combinations
    - Link to ore properties (geochem, texture, mineralogical physical)
    - Representative sampling strategies
  - **BB4: Sensors for Machine Performance**
    - Machine performance measures such as cutting energy and link to material properties

**BB 5: Data Integration, Management and Visualization**

**Exploration and Mine Planning**

- **BB 6: Sequential Resource Model Update – Real Time**
  - Real-Time updating integration of exploration data and sensor information (material + machine performance sensors)

- **BB 7: Integrated Long- and Short-Term Optimization**
  - Rapid optimization of short-term sequencing and production control
  - Integrated optimization of short- and long-term planning

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EXTRACTION METHODS RTM
CYCLIC EXTRACTION

Drill Hole
Core Sample
Ore zone
Muck-pile
LHD
Ore-passage
Ore Transfer
Crusher
BIN

Control decision points
Selective Loading
Scheduling

Sensors for material characterization
Sensors for machine performance
Sensors for geo-referencing (positioning and material tracking)

Selective Loading
Scheduling

Sensors for material characterization

Bin A
Bin B
Bin C

Dispatching

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REAL-TIME MINING
REAL-TIME DATA

(Lead: RWTH Aachen)

Lead: TU Delft

Lead: SonicSampDrill

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TEST CASE 1

“Reiche Zeche” Research Mine
Freiberg, Germany

Source: Description „Test Site Mine ‚Reiche Zeche‘, Freiberg, Saxony, Germany“ provided by TU Bergakademie Freiberg

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TEST CASE 2

“Neves Corvo” Copper Mine
Portugal (Massive sulphide ore and associated stockwork zone)

Source: lundin mining

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CASE STUDY UPDATING

Grade Control (GC) Model
1. Reconcile – Extracted Blocks
2. Update – Scheduled Blocks

Extraction Performance
1. Improve production forecasts
2. Optimize control decisions (proact)
CASE STUDY UPDATING

Material Tracking/ Material Flow Simulation in the Mine


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CASE STUDY UPDATING

Mean Field

SMU scale

Simulations
CASE STUDY UPDATING

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CASE STUDY OPTIMIZATION

Forecast of process KPI's for a given extraction schedule

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CASE STUDY OPTIMIZATION

Simulation based optimization of extraction schedule to improve extraction performance
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ADVANCE WITHIN RTM

Innovation Chain Real-Time Mining

- Integrated real-time closed-loop framework for optimizing extraction in highly selective and geological complex settings
- Sensor combinations for rapid raw material characterization
- Sensors for machine performance (rock cutting)
- System integration and demonstrated real-time framework for extraction in a:
  - Rock-cutting application
  - Sonic drill application
  - Rotary drill application

- Rapid updating of mineral resource/reserve model
- Real-Time optimization of long- and short-term decisions
- Underground positioning system – TRL6
- Exploitation plan for prototype and market entry preparation

TRL 1 basic principles observed
TRL 2 technology concept formulated
TRL 3 experimental proof of concept
TRL 4 technology validated in lab
TRL 5 technology validated in relevant environment
TRL 6 technology demonstrated in relevant environment
TRL 7 system prototype demonstration in operational environment
TRL 8 system complete and qualified
TRL 9 actual system proven in operational environment
THREE TAKEAWAYS

1. Real-Time Mining is an exciting European Union funded H2020 project and integrates multiple disciplines.

2. Making best use of online production information can lead to a shift in paradigm from a batch-type to a continuous process monitoring and control and can create significant value.

3. Real-Time Mining will demonstrate this hypothesis in full industrial scale case studies (TRL 6/7).
Thank you for your attention and

Glückauf

www.realtime-mining.eu