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Development of a decision support instrument of mine–wide operations for Agnico Eagle Kittilä mine

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Outline

- Introduction of Kittilä mine
- Project background
- Study scope
- Decision support instrument for mine-wide operations
  - input
  - output
  - algorithms
- Conclusions

Introduction of Kittilä mine 1/4

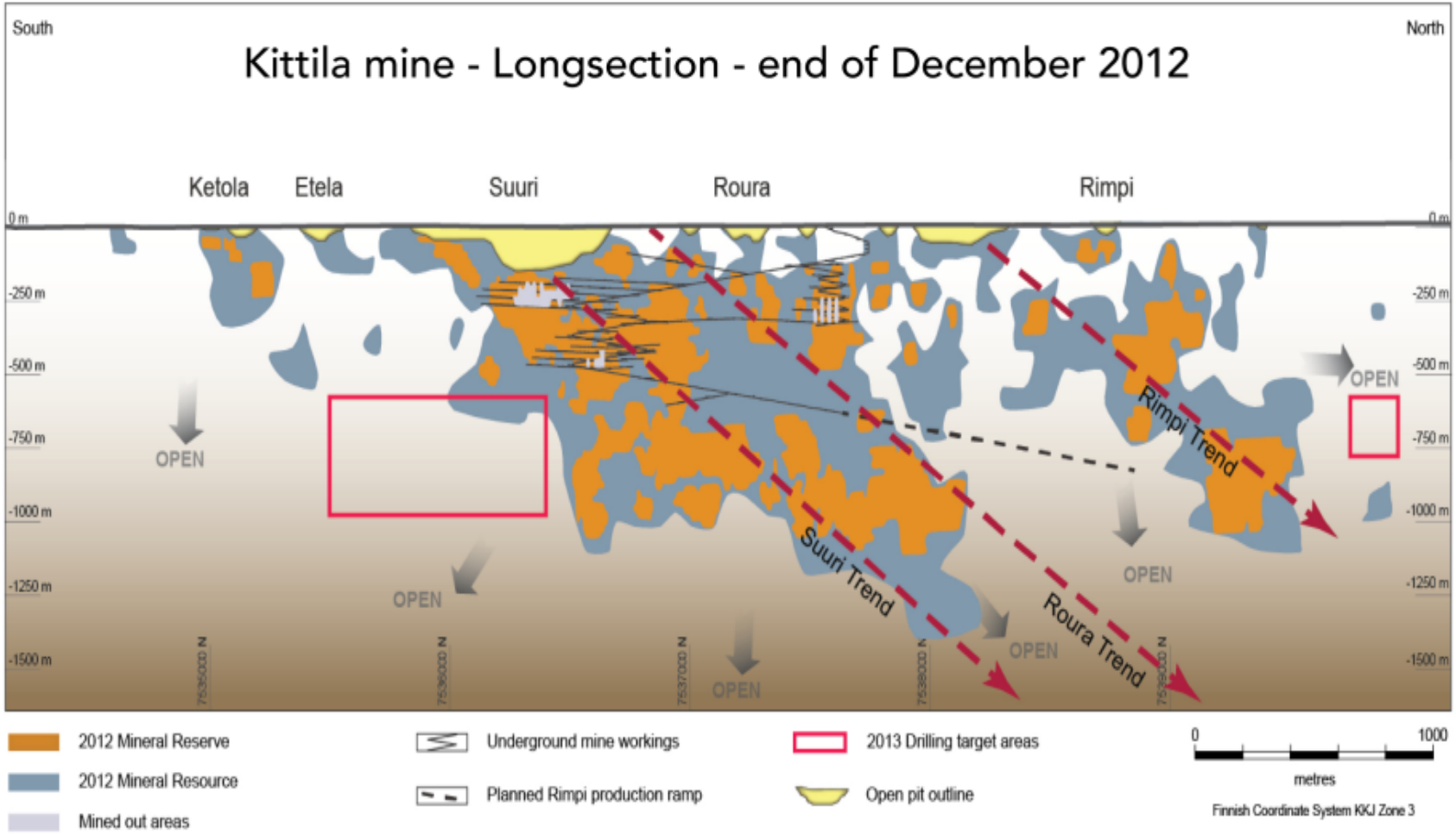
- operated by Agnico Eagle Finland Oy
  owned by Agnico Eagle Mines Ltd.
- the largest known gold deposits in the EU
- in 1st quarter 2013 (150,000 oz in 2013)
  payable gold production 43,145 oz
  with total cash cost of 624$/oz
- 3,750t/d from 2nd half 2015

Category	Au	Au(oz)	Tonnes
	(g/t)	(x000)	(x000)
Proven & Probable Reserves	4.49	4,783	33,122
Indicated Resources	2.65	669	7,854
Inferred Resources	3.88	2,366	18,966

Introduction of Kittilä mine 2/4

- to surface crusher by haul trucks via a 3 km long ramp access system
- open stoping with delayed backfill
- ca. 7 km tunnels each year
- many active stopes at the same time, long distances between each other, greater depth in future

Introduction of Kittilä mine 3/4



Introduction of Kittilä mine 4/4

- four development teams and four production teams
- working time 07:00-17:00 and 19:00-05:00
- 5d on/5d off
- ‘life of mine’ plan => annual budget plan => 18-month rolling plan => first 3-month details plan => weekly plan
- software used in mine planning and production

Deswik

AUTODESK AUTOCAD

GEMCOM INSITE™ Mine Production Management and Reconciliation

GEMCOM SURPAC™ Geology and Mine Planning

CENTURY Systems TECHNOLOGIES INC

Project background

Innovative Technologies and Concepts for the Intelligent Deep Mine of the Future

- Funded by the EC-FP7
- From Nov. 2011 to Oct. 2015
- 26 partners, incl. companies, universities and research institutes (total budget ca. 30 M€)
- 8 Work Packages
- WP 1: Mine wide information and control systems,
  - logistic and mass flow management
- Task 1.2: Mine-wide information and decision system

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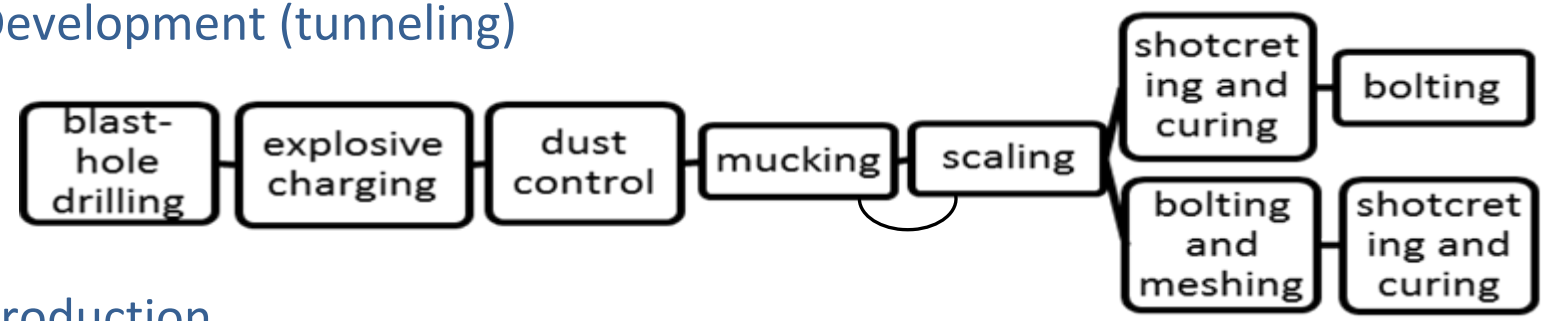
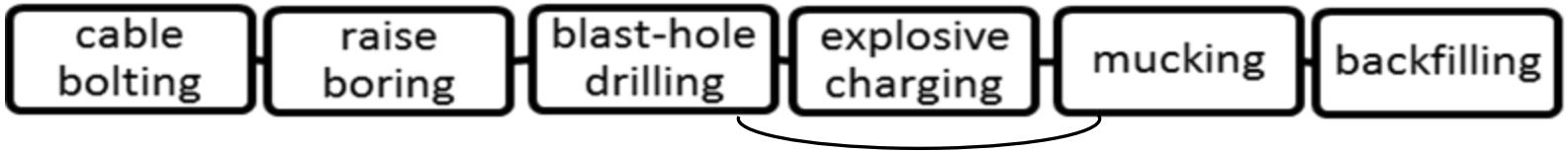
Study scope

- Hard rock underground mines
- Mining operations, incl. development and production
- The operation process in Kittilä mine

Development (tunneling)

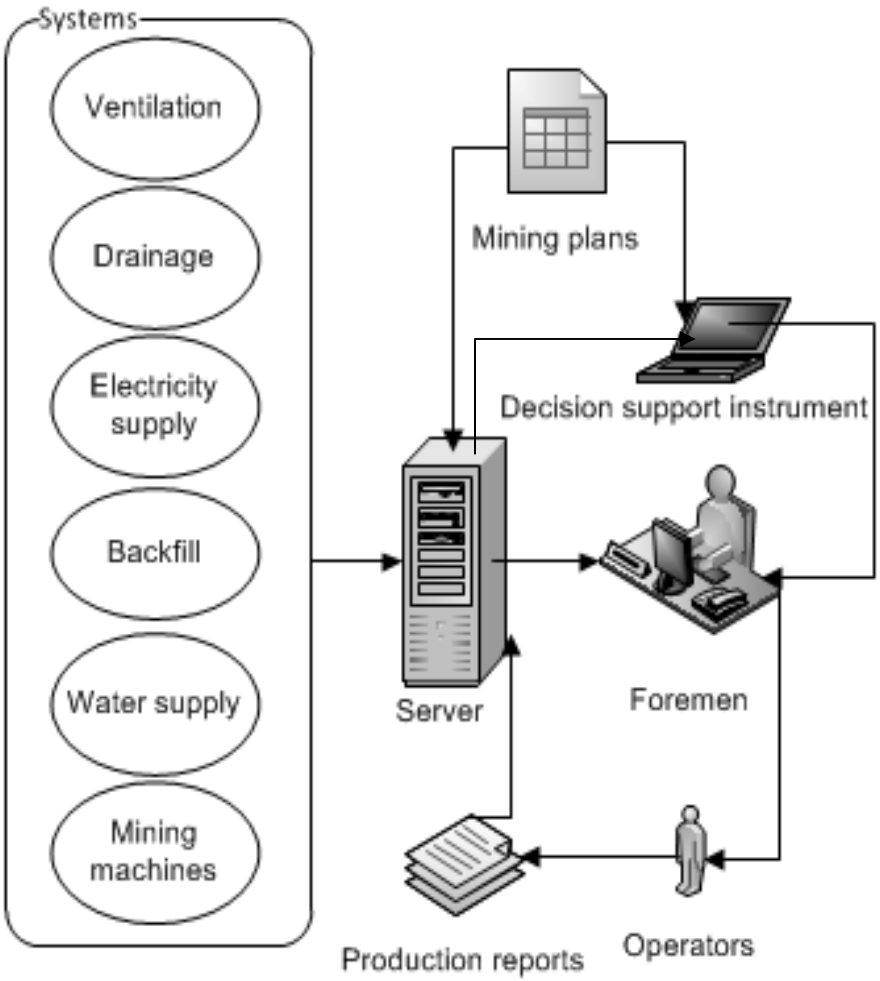


Production



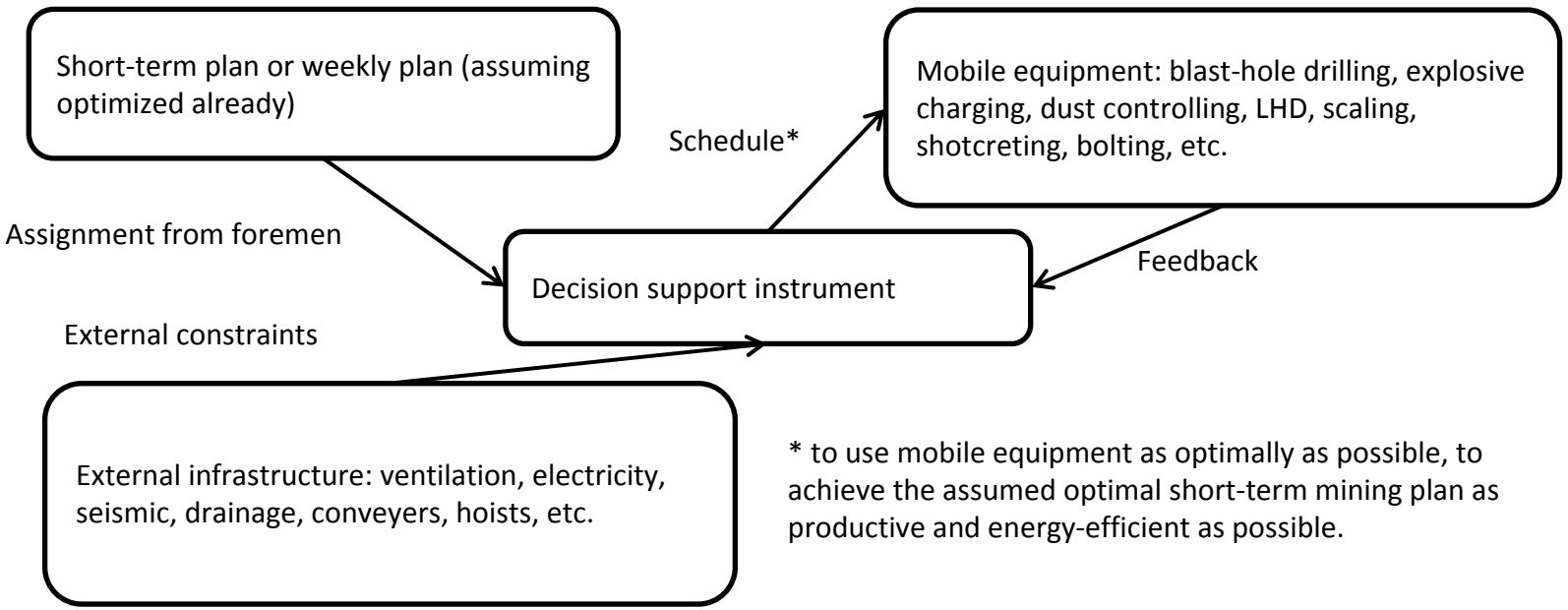
Decision support instrument for mine-wide operations 1/2

- based on mine-wide information network
- to increase production and reduce energy consumption
- to improve equipment scheduling for more flexible short-term planning
- to propose solutions in case of disturbance in operations



Decision support instrument for mine-wide operations 2/2

- key components: input, output, algorithms
- relation of decision support instrument and environment



* to use mobile equipment as optimally as possible, to achieve the assumed optimal short-term mining plan as productive and energy-efficient as possible.

Input 1/3

- weekly plan: heading (meters) and stoping (tons)
- input needs names of working faces, workloads, and spatial relation
- names and workloads imported from weekly plan spreadsheet
- spatial relations of faces ideally obtained from modeling software. However, they should be able to be input manually as well.

Input 2/3

- mobile machines' status: available or unavailable
- working parameters: e.g. vehicle speeds, fuel consumption, operating rates
- working parameters can be obtained by a statistical analysis of historic data recorded in mining asset management software

Input 3/3

External constraints (i.e. the external requirements which the decision support instrument follows):

(1) Ore production at one stope $\geqslant$ planned ore tonnage at that stope
(2) Excavation at one heading $\geqslant$ planned excavation length at that heading
(3) Total ore production per hour $\leqslant$ stockpile capacity per hour
(4) Total waste per hour $\leqslant$ wasteyard capacity per hour
(5) Feed rate on each stationary equipment $\leqslant$ capacity of that equipment
(6) Time of working for stopes and headings $\leqslant$ planned work period

- ideally, real-time data, directly imported from external infrastructure
- possibly, to input data manually (specific knowledge required)

Output

- timelines of mobile machines and other systems (e.g. ventilation, drainage) at different working faces (see Figure as below)

- can assist foremen to initiate a machine schedule and propose solutions for achieving short-term plans
- e.g., by reloading real-time data and rerunning the instrument to renew the schedule when encountering unexpected disturbances in mine operations

Basic algorithm

Example of scheduling mobile equipment when using working period as the optimizing objective

Goal: To minimize working period for a given productivity

1. •Input statistical values of operating rates of machines
   •Input distance matrix of working faces
   •Input external constraints
2. •Cluster stopes and headings which are in the same levels
3. •Calculate the time of serial operations and cyclic operations respectively for every cluster and level, under external contraints
4. •Sequence the levels and clusters
5. •Calculate timestamps, and schedule machines for stopes and headings

Conclusions

The Kittilä mine

• needs to significantly increase productivity in future, and has to reduce cost for the downtrend of gold price;

• considerably relies on mobile machines in mine operations;

• has relatively simple mine structure and processes in the current stage of its life cycle;

• has equipped with skilled engineering team, mine-wide network, data collecting and reporting system.

The decision support instrument

• requires mine-wide network;

• prefers real-time data easily accessible;

• initiates machine schedules and proposes solutions in case disturbances occur.

=> The Kittilä mine meets the requirements for the decision support instrument, and this mine is good as a test mine to implement the demonstration.

Thank you!

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Questions?

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