



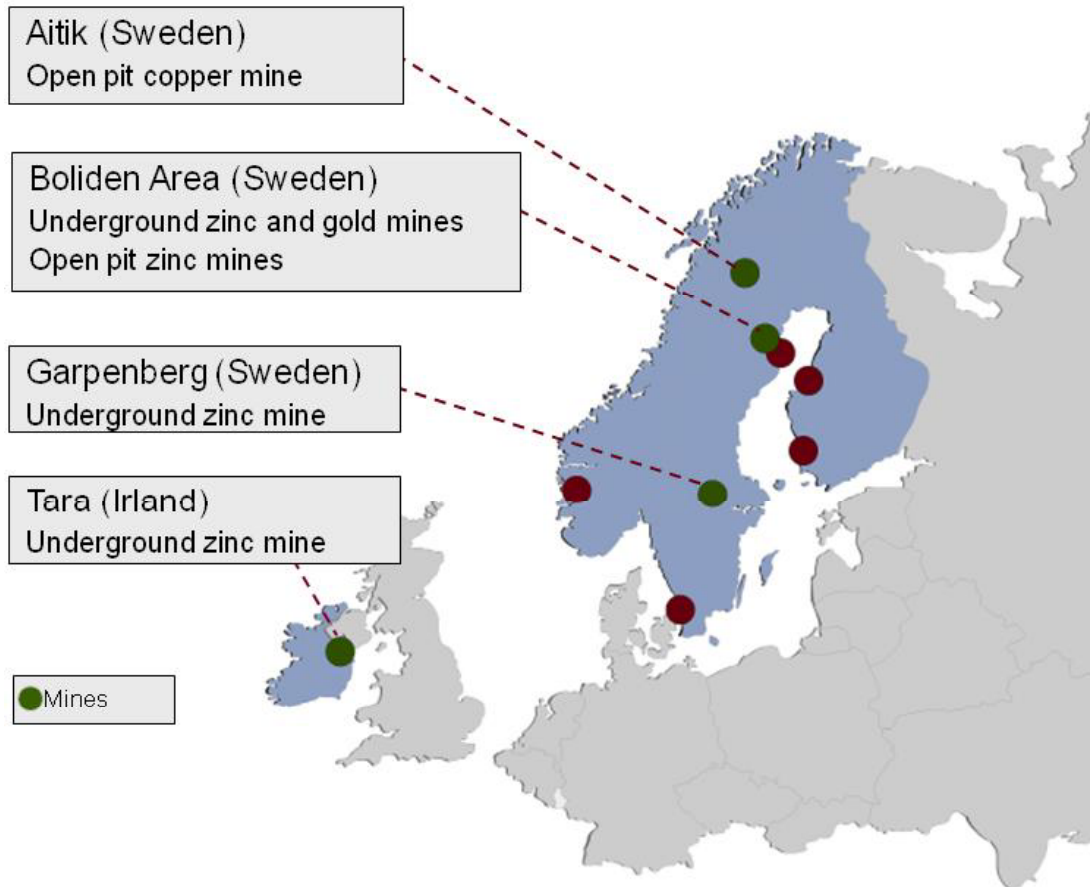
# Mines Technology

CMD 20 November 2013

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Director Technology  
Boliden Mines

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# Boliden mines



## Characteristics

Relatively small underground mines

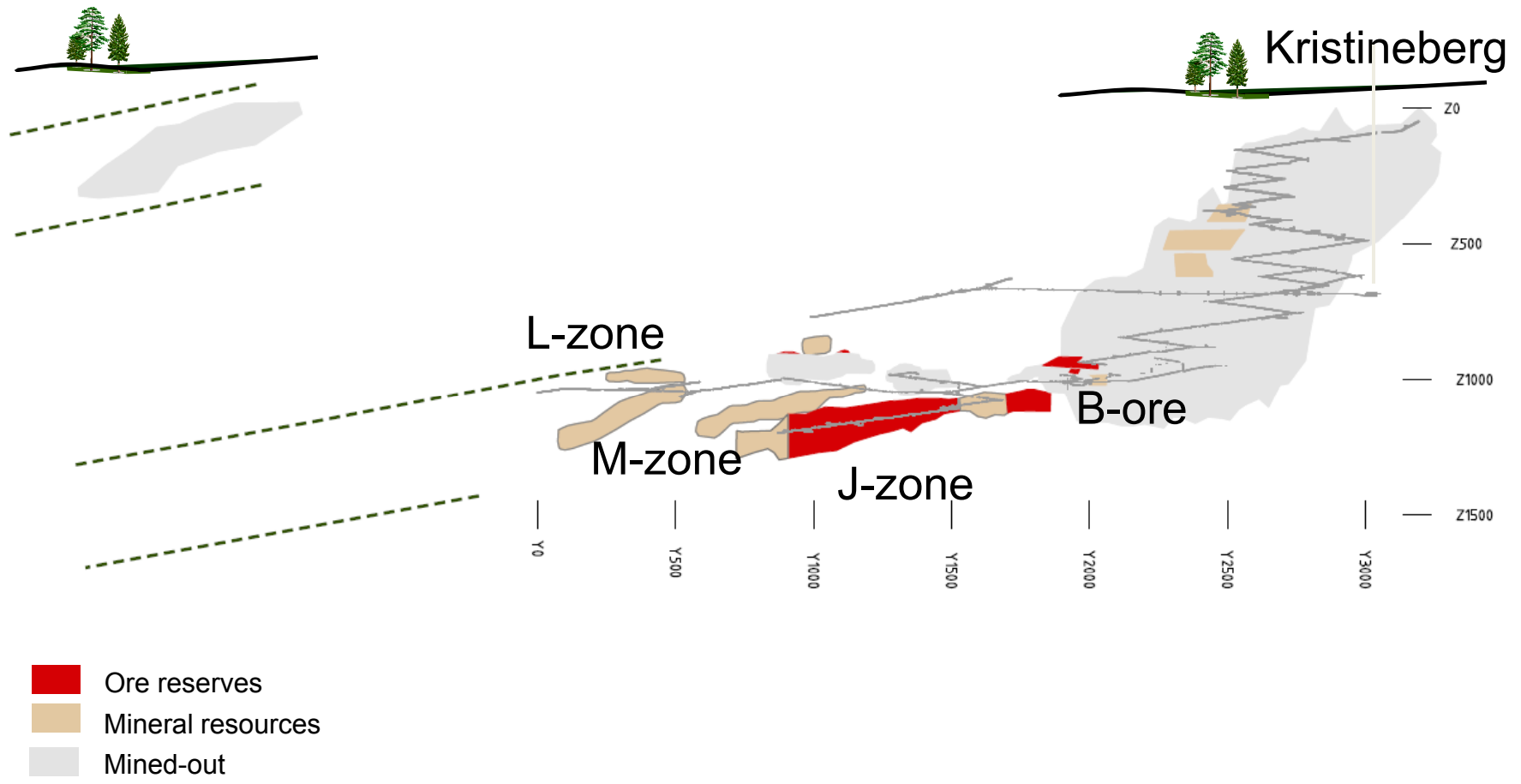
- Complex geology
- Operate at depth
- Many operation headings
- Many production units
- Extensive ore transport
- Extensive travel time u.g.

Big open pit mine

- Mega operation
- High productivity
- Low cost



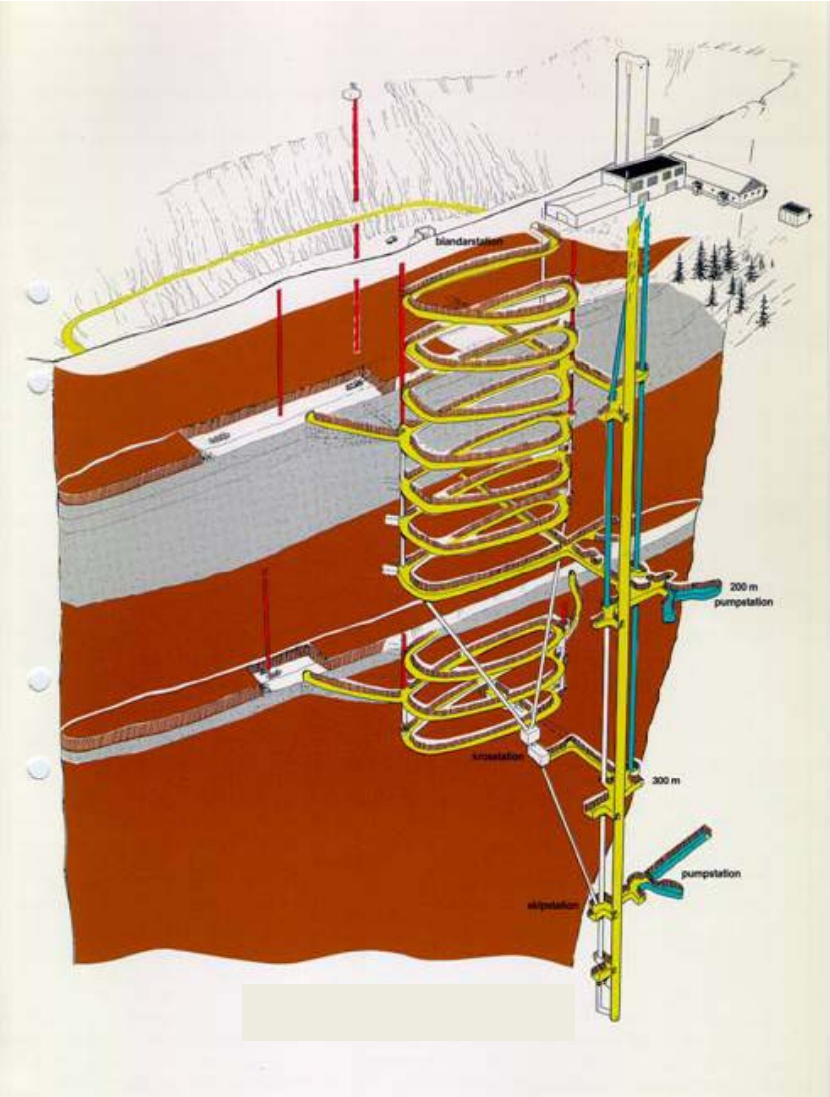
# Kristineberg mine



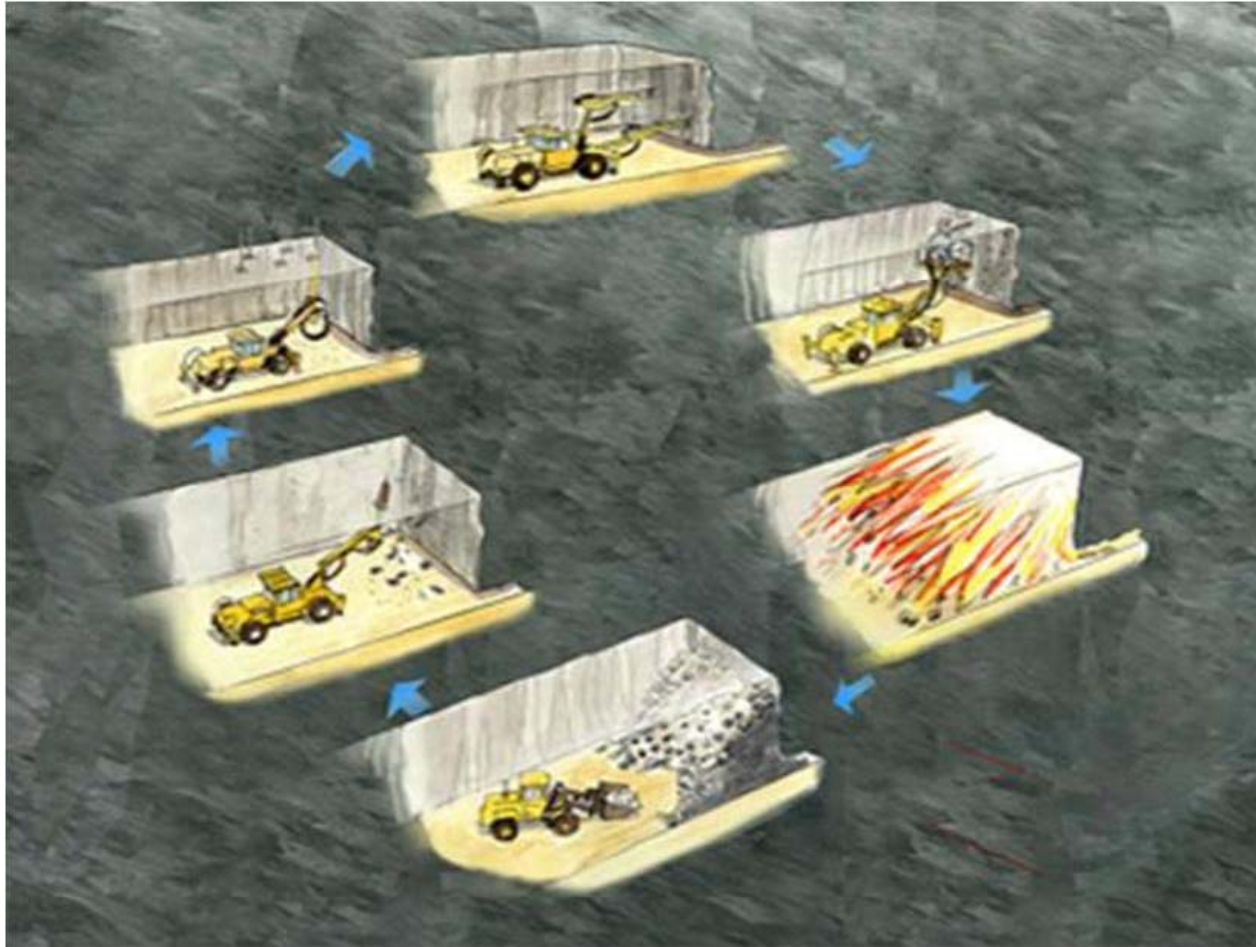
# Infrastructure size and localization



# Cut and Fill Mining



# Unit operations in an underground mine



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# Technology (T) - Mission

- Technology drives the development of mine design, methods, processes, plants, and is a corporate development resource for Boliden mines and plants
- Technology contributes to drive productivity and optimize utilization of mineral reserves by determinedly pursue R & D
- Technology is an important link in making Boliden an attractive employer for engineers and managers

# R & D

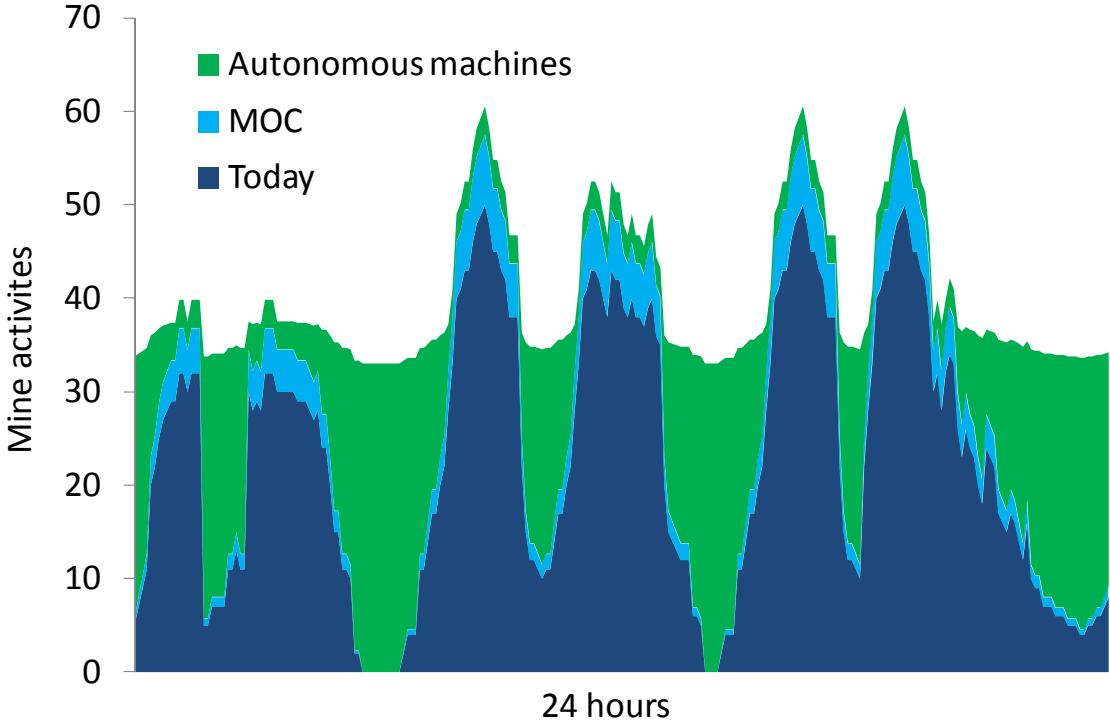
## Operational excellence – Technology key areas

- Mining
  - Mine automation
    - Communication systems, remote control, autonomous units
- Processing
  - Flotation design
    - Circuit design for higher recoveries
  - Treatment of penalty elements
    - Reduce penalty costs, better marketability, new resources
  - Process control
    - Improving recoveries/quality by real time adjustments according to ore properties





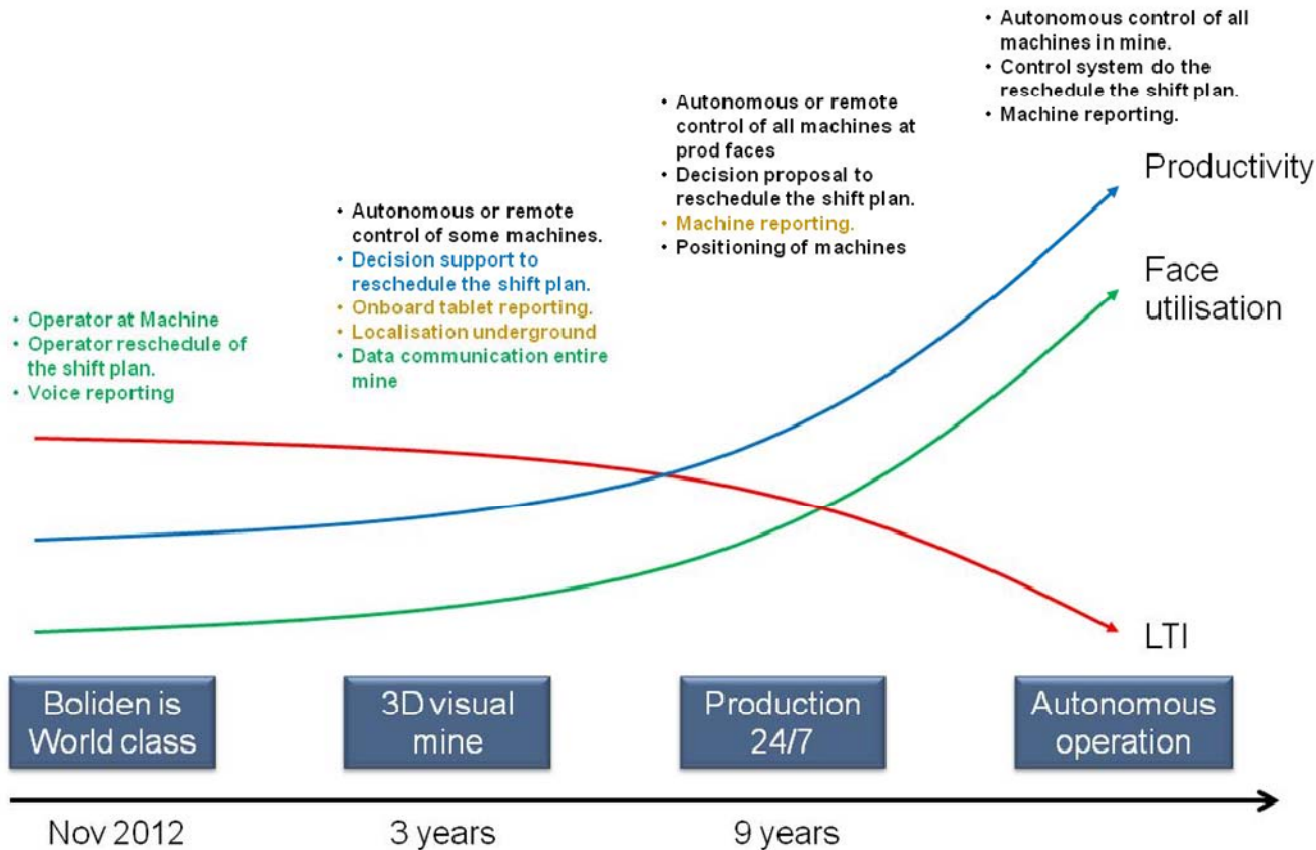
# Underground mine Production potential in 10 years



Transparent and visualised production



# Mine automation program



## Vision

Automation will move the mine into a continuous process that runs 24/7 with no operator at the production face and full visualization

## Results

- Higher safety
- Improved face utilisation
- Increased productivity
- Cost effective production

# Mine automation – 1

- World class WiFi coverage in underground mining!



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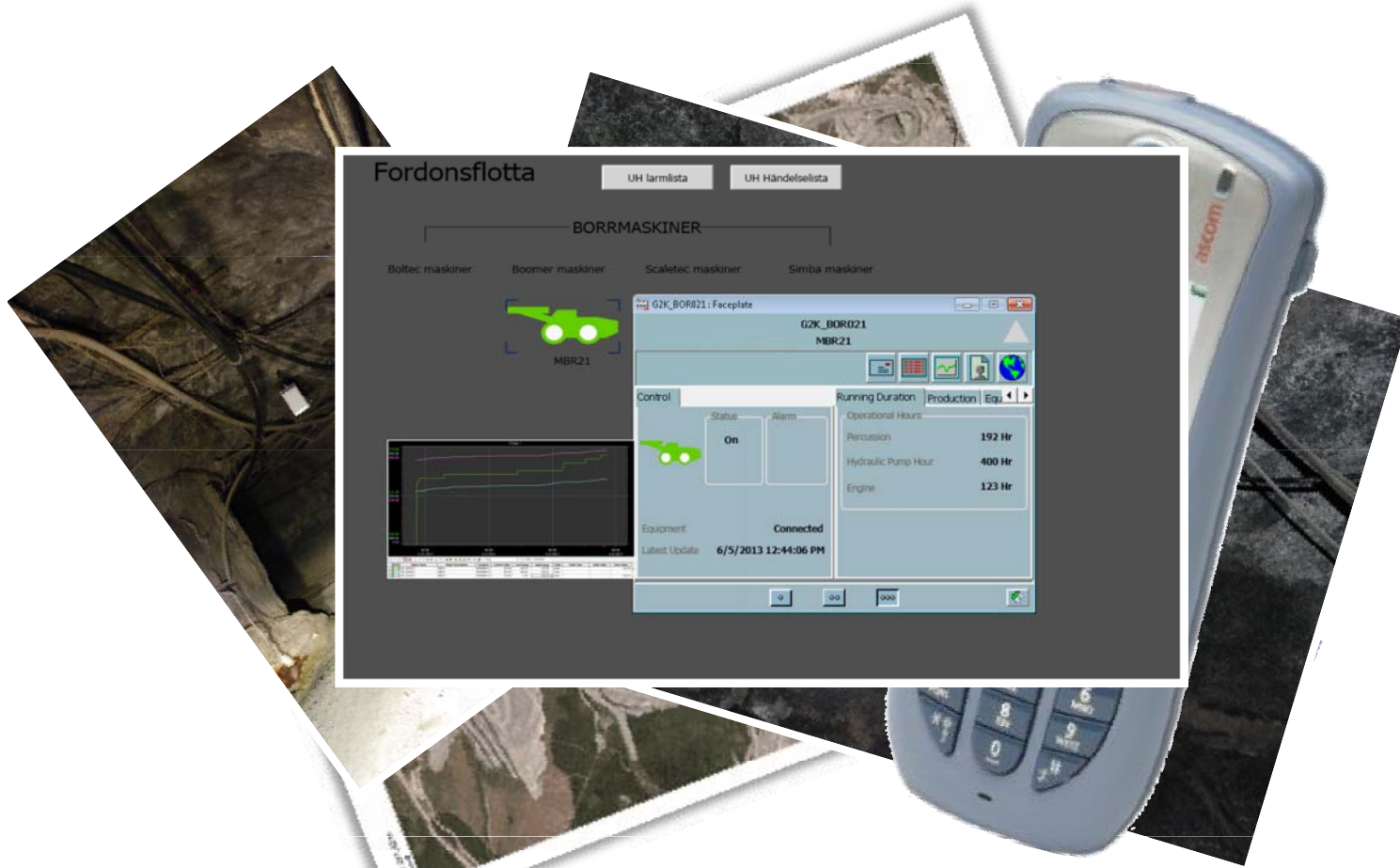
# Mine automation – 2

- Deployed voice communication over WiFi in entire underground mine!



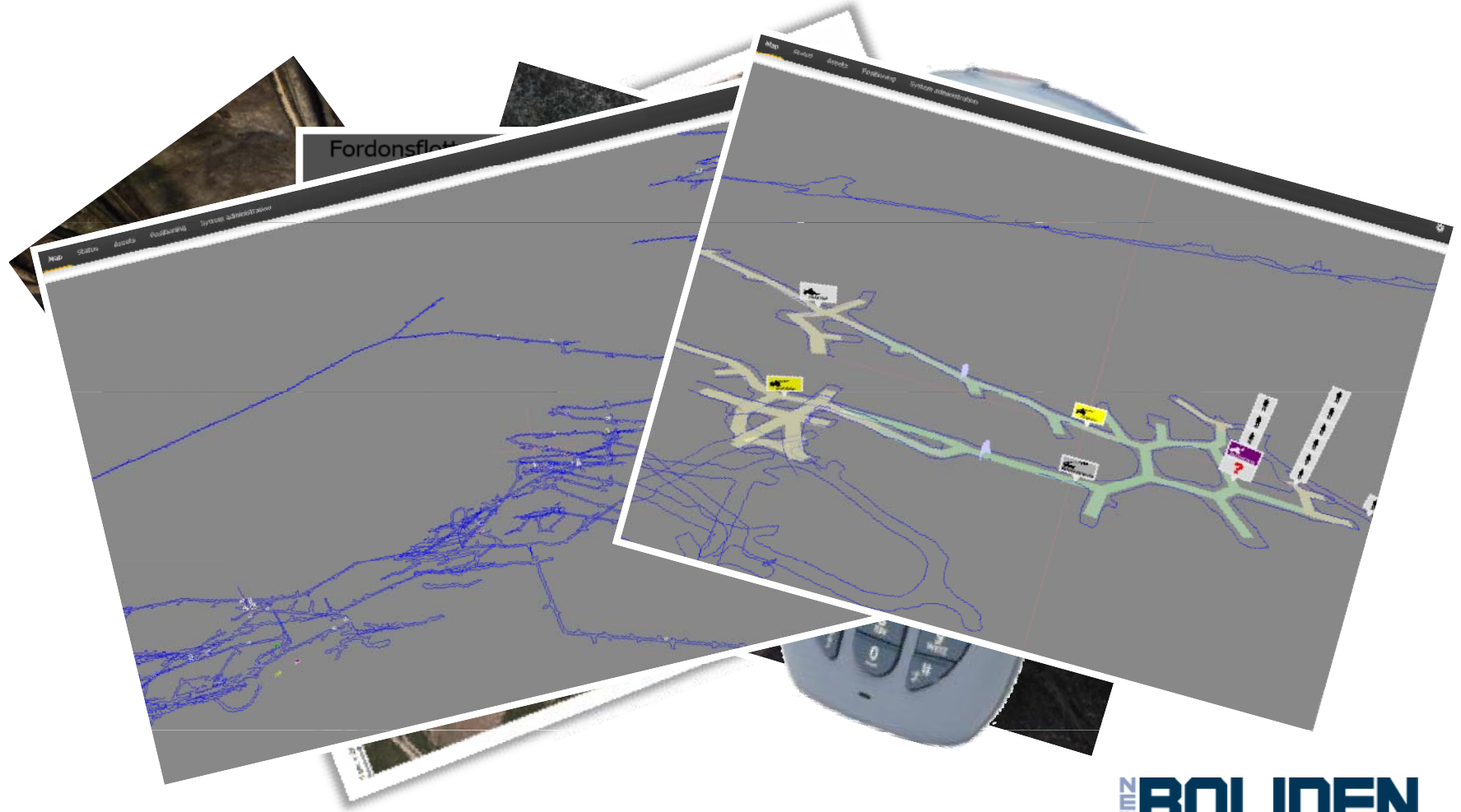
# Mine automation – 3

- Optimized maintenance with automated machine logging!



# Mine automation – 4

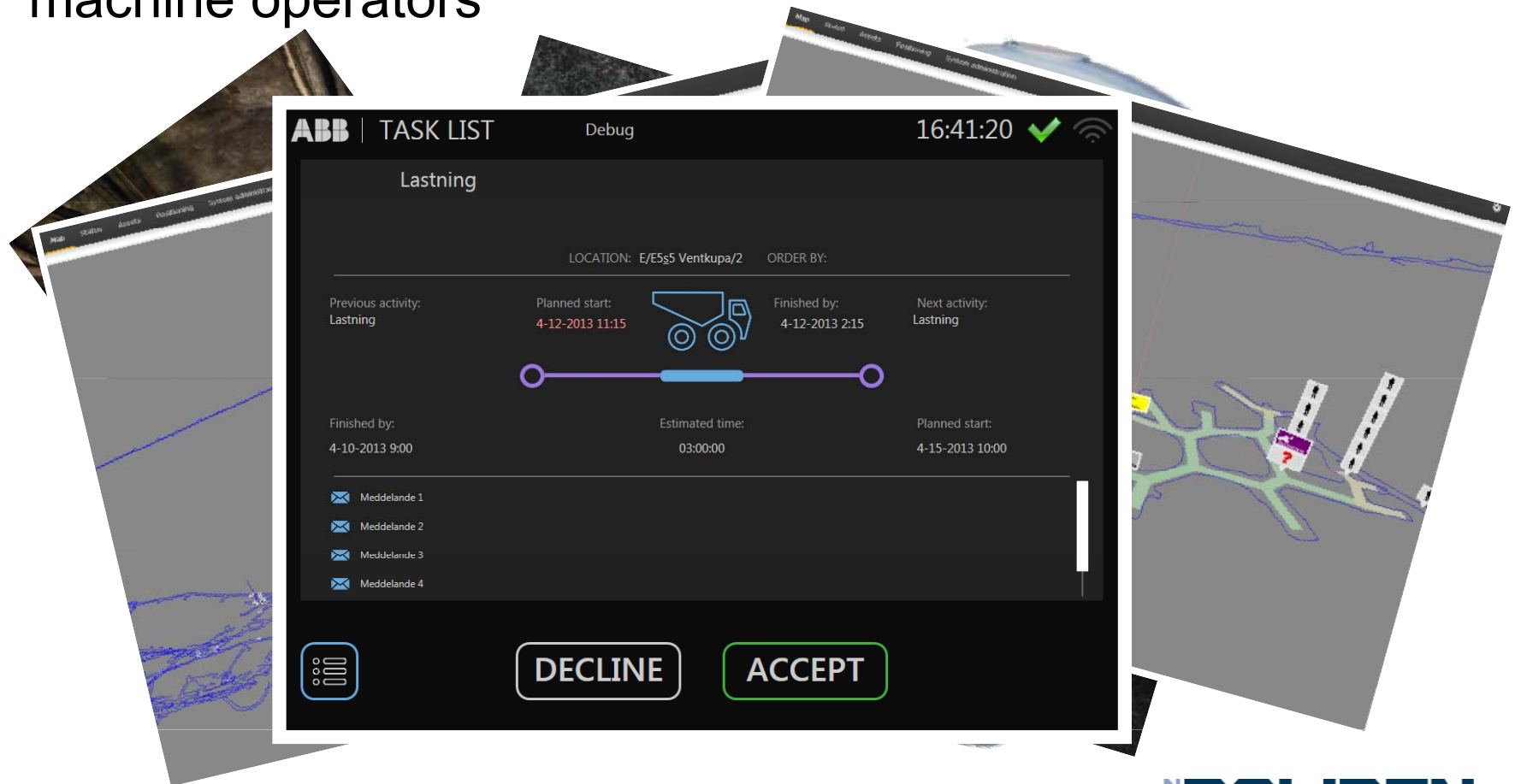
- Unique positioning of vehicles in underground mines!



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# Mine automation – 5

- Broadening the real-time planning with direct feedback from machine operators



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# Mine automation – 6

- Remote vehicles operation in mine production



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# R & D

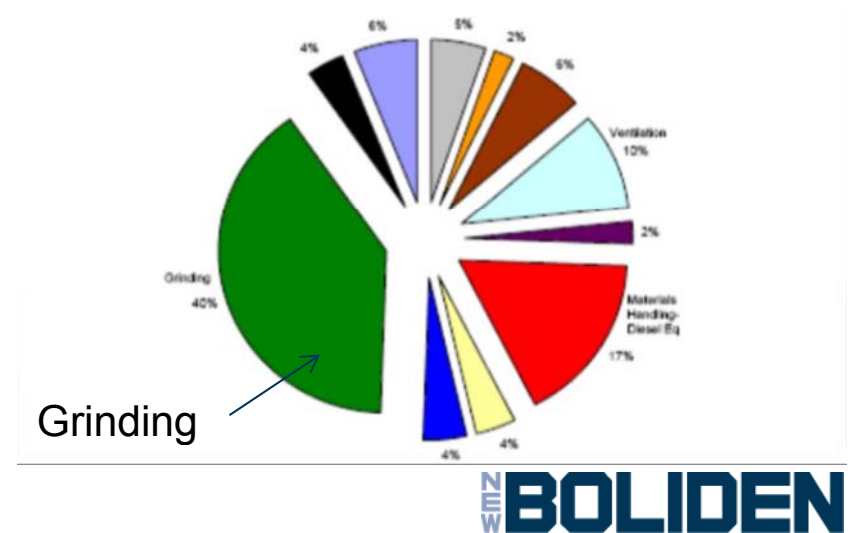
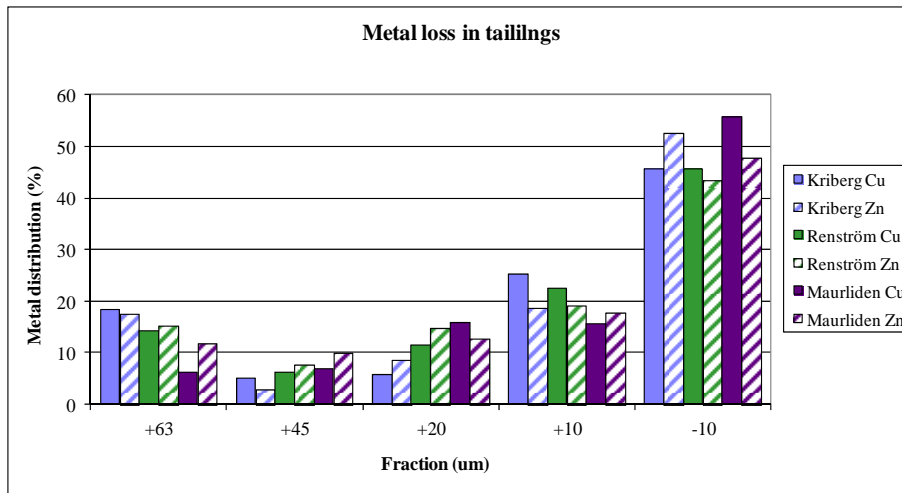
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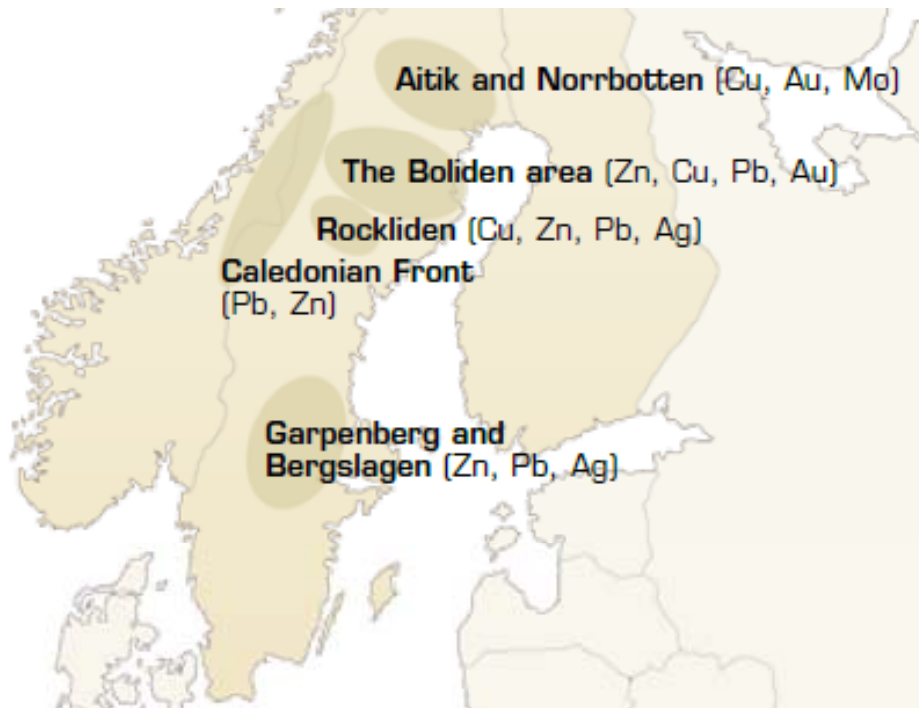
# Improved process efficiency

- Flotation
  - Fine and coarse particle flotation (always an issue...)
  - Flotation circuit design
  - More selective reagents (for instance in Cu/Pb separation)
- Grinding
  - Energy consumption (approx. 3 % of world energy cons. is used for comminution)
  - Wear (cost and availability)
- Leaching
  - Concentrate quality – More complex ores and higher levels of impurity



# R&D Challenges

More complex ores with higher levels of impurities; for example Rockliden



Typical analysis (Cu/Pb separation possible needed) :

	Ag g/t	Cu %	Zn %	Pb %	As %	Sb %	Hg %	S %
CuPb-slig	1246	20	6.2	13	0.19	1.51	0.02	32

Rockliden is about 250 km south-west from Boliden



# Sulphide Leaching

## Problem

- Future copper concentrates will have increasing levels of impurities such as antimony and arsenic
  - Cannot be treated by Boliden smelters
  - Cannot be treated by other smelters



## Vision

- Sulphide leaching for removing antimony from copper concentrates. This will allow processing of the Rockliden and Rakkejaur by Boliden smelters.
- Sulphide leaching for removing arsenic from enargite ( $\text{Cu}_3\text{AsS}_4$ ) rich copper concentrates. Many potential applications.

## Goal

- To develop sulphide leaching technology for the Rockliden copper concentrate.
  - Pilot plant testing – process data – design criteria – feasibility study

# Sulphide Leaching – 1

## Conceptual study completed in 2011

- Process design based on laboratory bench scale test work

## Results

- Around 90 % of the antimony could be removed with sulphide leaching
- Final copper concentrate had acceptable antimony concentrations for treatment at the Boliden smelter ( $\leq 0.2$  %)
- Other process alternatives investigated where not feasible



# Sulphide Leaching – 2

## Mini pilot testing completed autumn 2012

- Antimony leaching recovery confirmed
  - (90%) in closed circuit
- Water balance is important
  - Leaching (evaporation)
  - Flow sheet (waste bleed size)
- De-watering of copper concentrate an important factor in plant design

## Pre-feasibility study (ongoing)

- Antimony recovery (lab scale)
  - Precipitation (best alternative)
  - EW (possible alternative)
- Sulphide recovery (lab scale)
  - Crystallization (possible alternative)
  - Acid stripping (best alternative)



# Sulphide Leaching – 3

## Pre-feasibility study

1. To select the most promising process flowsheet
2. To provide design criteria for equipment selection and plant design
3. Piloting test work to confirm process flowsheet
  - Build and operate a pilot plant with a capacity of “1 tonne/d” at a cost of around 20 Mkr
  - A mineral processing campaign (300 t ore) will be required to produce copper concentrate (about 15 t) for the leaching pilot test
  - To confirm the operation of all the major unit operations in the leaching circuit
  - Complementary laboratory test work to confirm ancillary unit operations
4. To determine the production costs



Sodium sulphide



Antimony Powder

# Processing of Kankberg ore

## One example of successful R & D

- Process design and gold recovery are based on a pilot plant campaign 2006 and following leaching studies
- The process involves flotation to a gold/tellurium-rich copper-concentrate which thereafter is leached in the existing CIL-plant at the Boliden concentrator. One tank is modified for heating during leaching.
- A leaching plant is built for extraction of tellurium
  - Commissioned beginning of 2013



# Summary

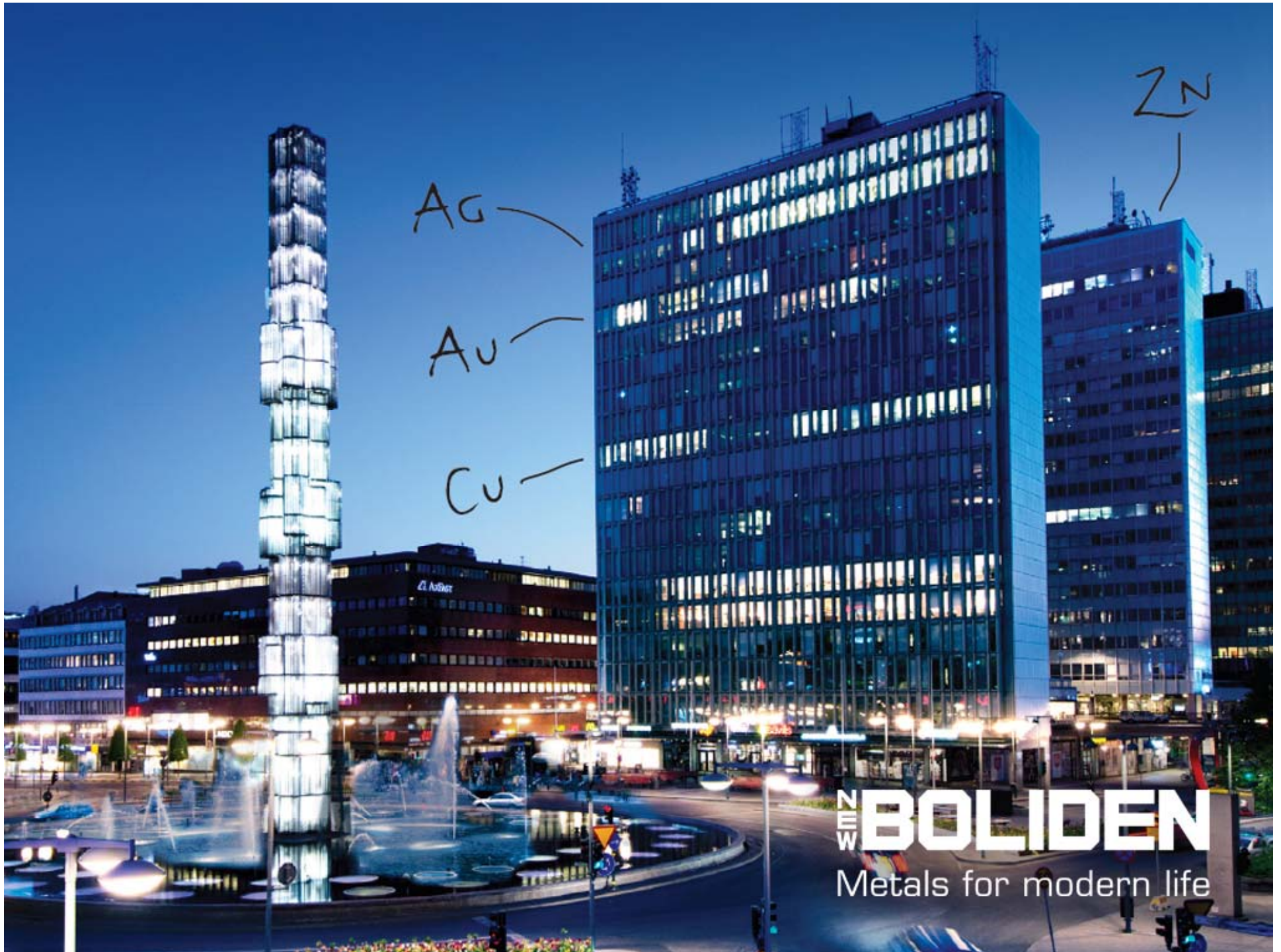
By determinedly pursue R & D in specified focus areas Boliden drive productivity and optimize utilization of mineral reserves

- ✓ Describe the problem
- ✓ Formulate vision and goal
- ✓ Carry out the development work according to Boliden project model (including pilot test)

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Ag

Au

Cu

Zn

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