Mining: The Inversion of Industry 4.0

CDO Conference Vancouver April 2018

Peter Warrian PhD
University of Toronto

Summary

- Previous CDO Work
  - Advanced Materials, Rise of Microstructural Manufacturing, Merging of Design & Manufacturing
- CDO Extractive Industries
  - Further Upstream: Digitization of Ore Bodies, Mine Operations
- Digital Value Chain from Mining to Metallurgy to Design/Manufacturing
  - Mining 4.0 vs Industry 4.0

Counter Intuitive: Mining as a Play on the Digital Economy

Mining & Digital Economy

- Productivity Paradox
  - We just had a 10 year Metals Supercycle
  - Mining Productivity Declined by 28%
  - Mining at a Tipping Technology Point: Digitization
- Mining and the Digital Economy
  - Digital Economy Needs Mining: Lots of it.
  - EV's batteries and Cobalt
  - Digitalization = Electrification = Copper
- Most of the Materials are Underground
  - Next 10 copper mines are underground mine designs

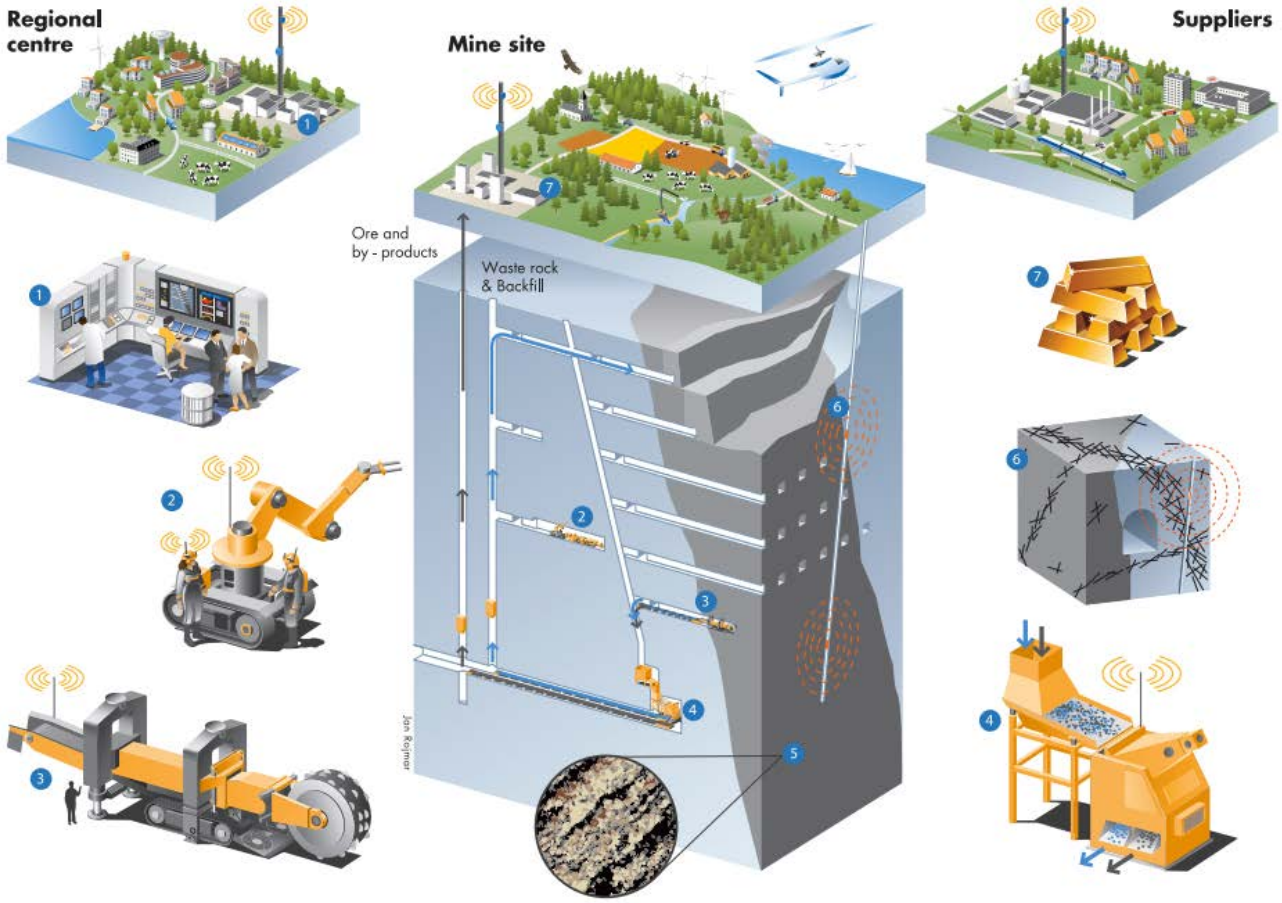
Digital Transformation: Mine Design

- Surface Mining (Open Pit)

- Underground Mining

Underground Mining Yesterday & Today

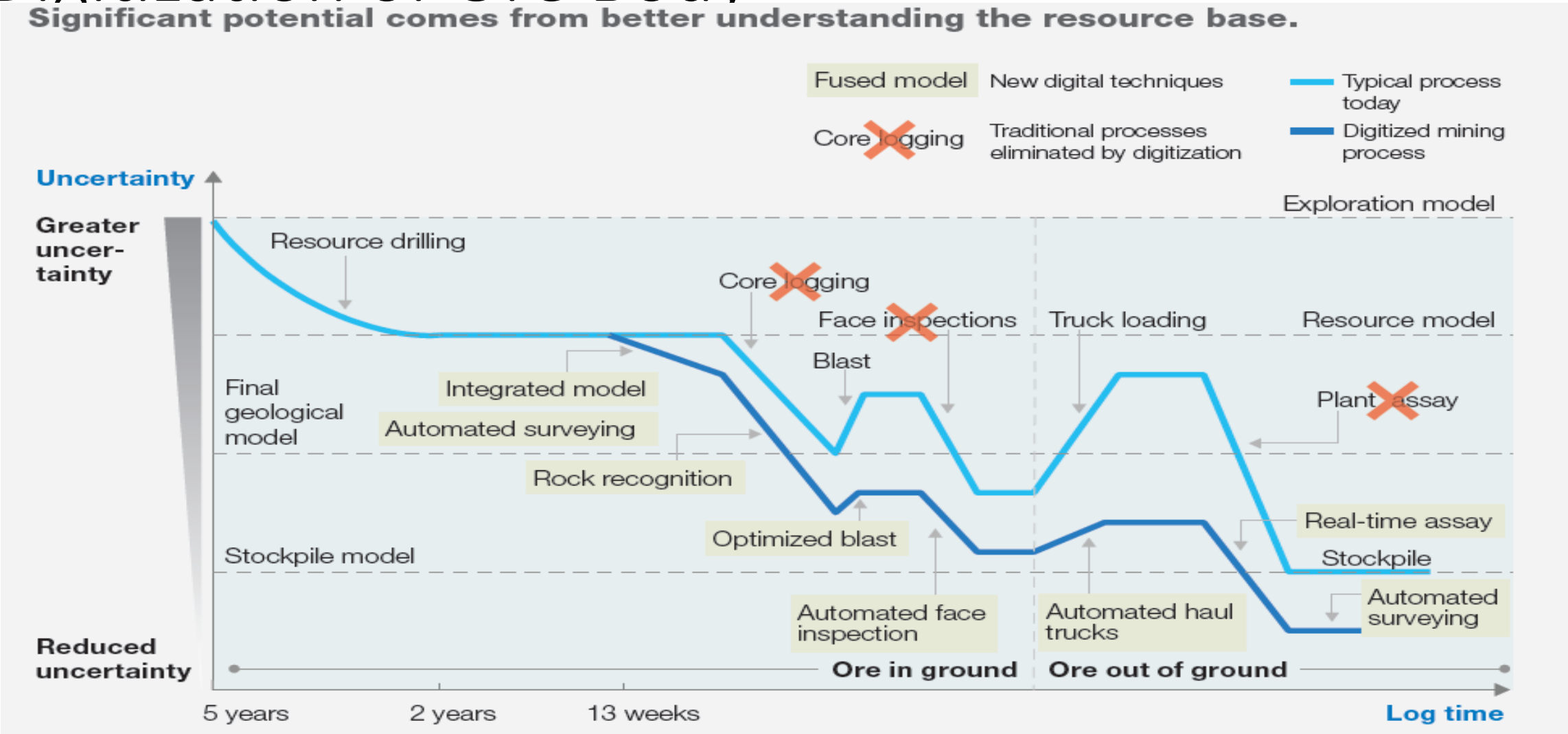
Mine of the Future



Mining Industry Technology Innovation

- Mine Operations: Lagging, Inflection Point
  - Operating Companies: Little Innovation internally
  - Equipment Manufacturers: Step improvements of bulk mining equipment
  - Supply Chain: Specialized SMEs at the margin
- Exploration and Development
  - Digitization: drones, digital imaging, quantum computing
  - Many innovative SMEs: software, sensors, digital infrastructure

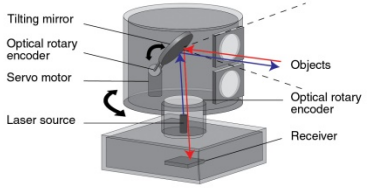
Digitization of Ore Body



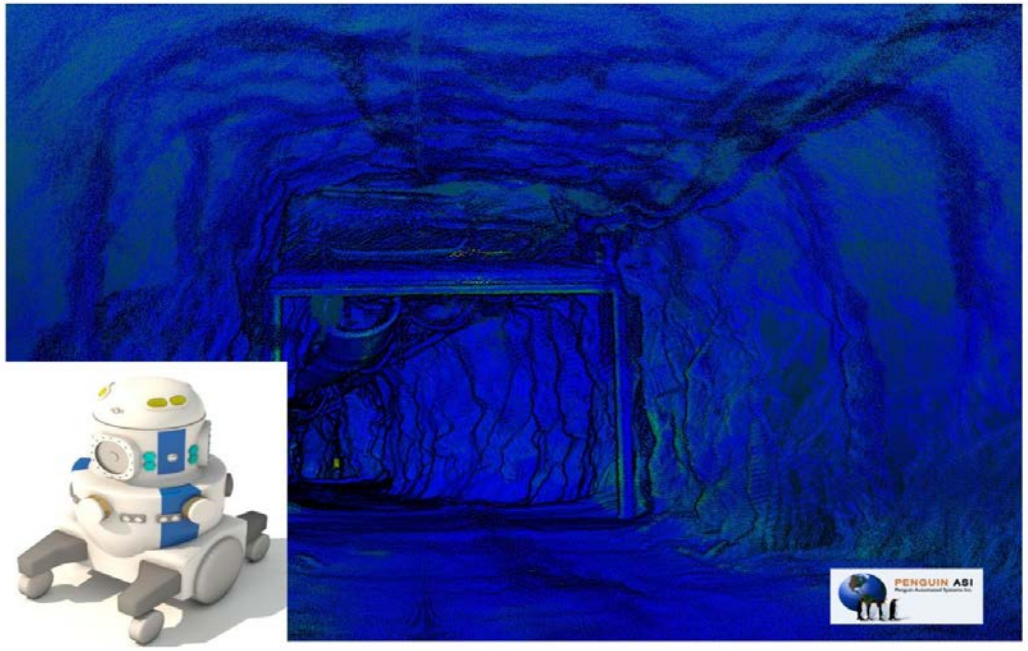
Source: Durrant-Whyte 2015

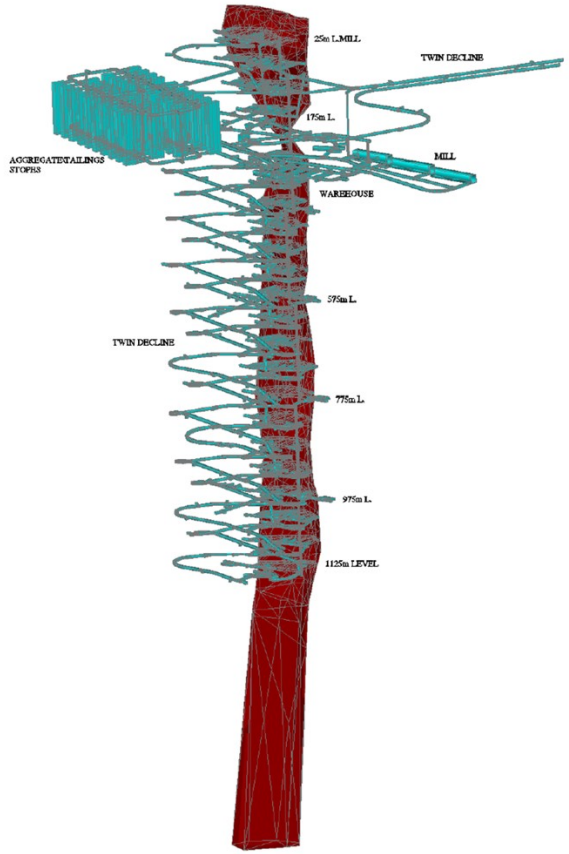
Mining by Robots Already

Underground Drones: Lidar Technology



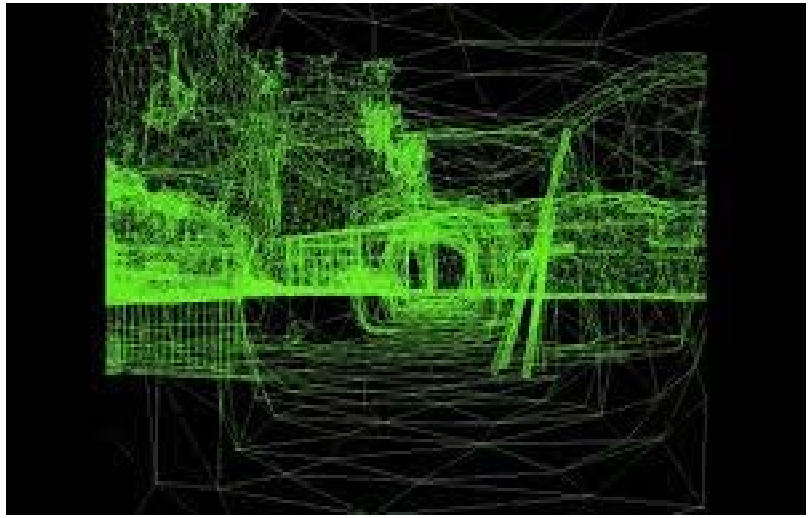
Positioning Underground





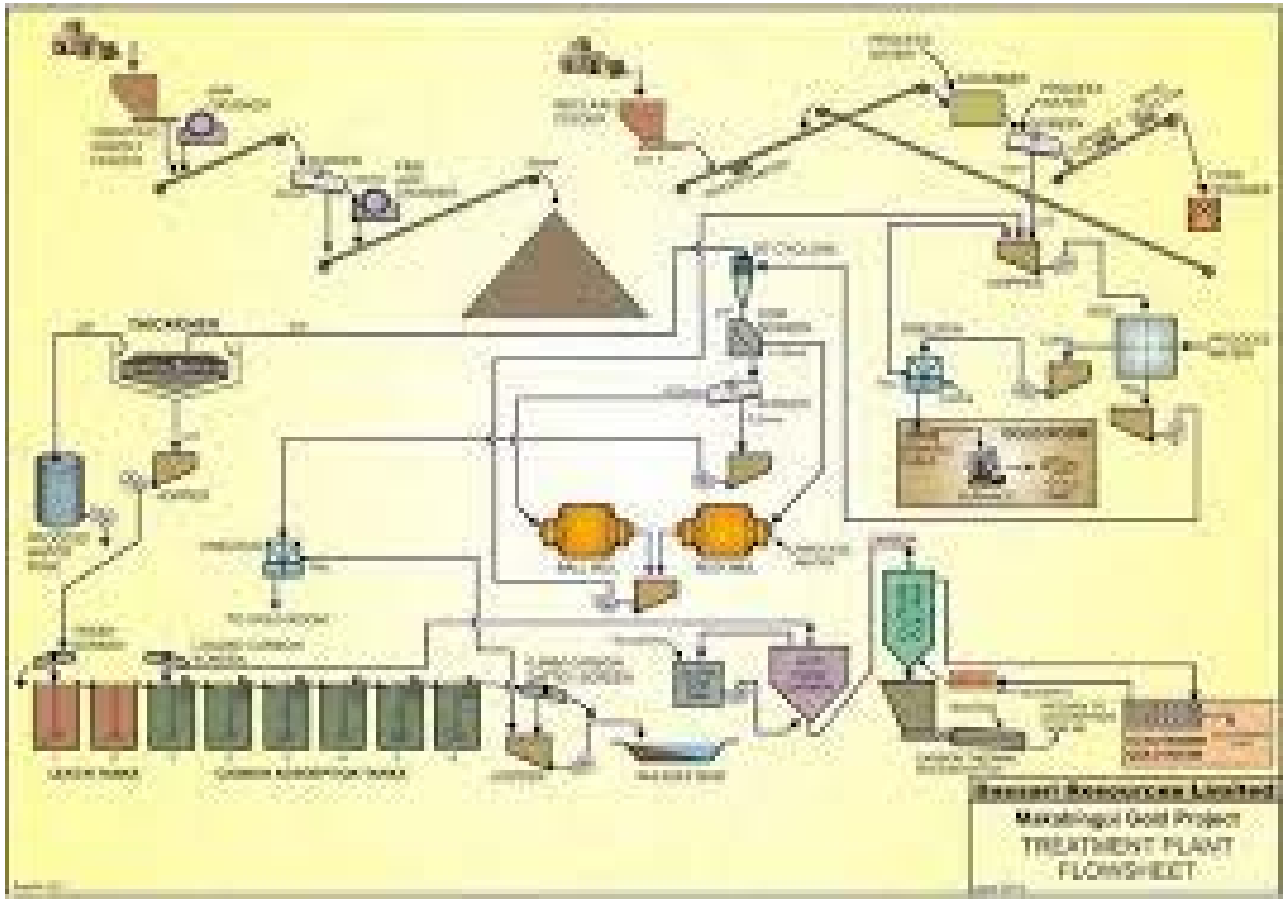
Digitized Mine Plans

PENGUIN ROBOTICS



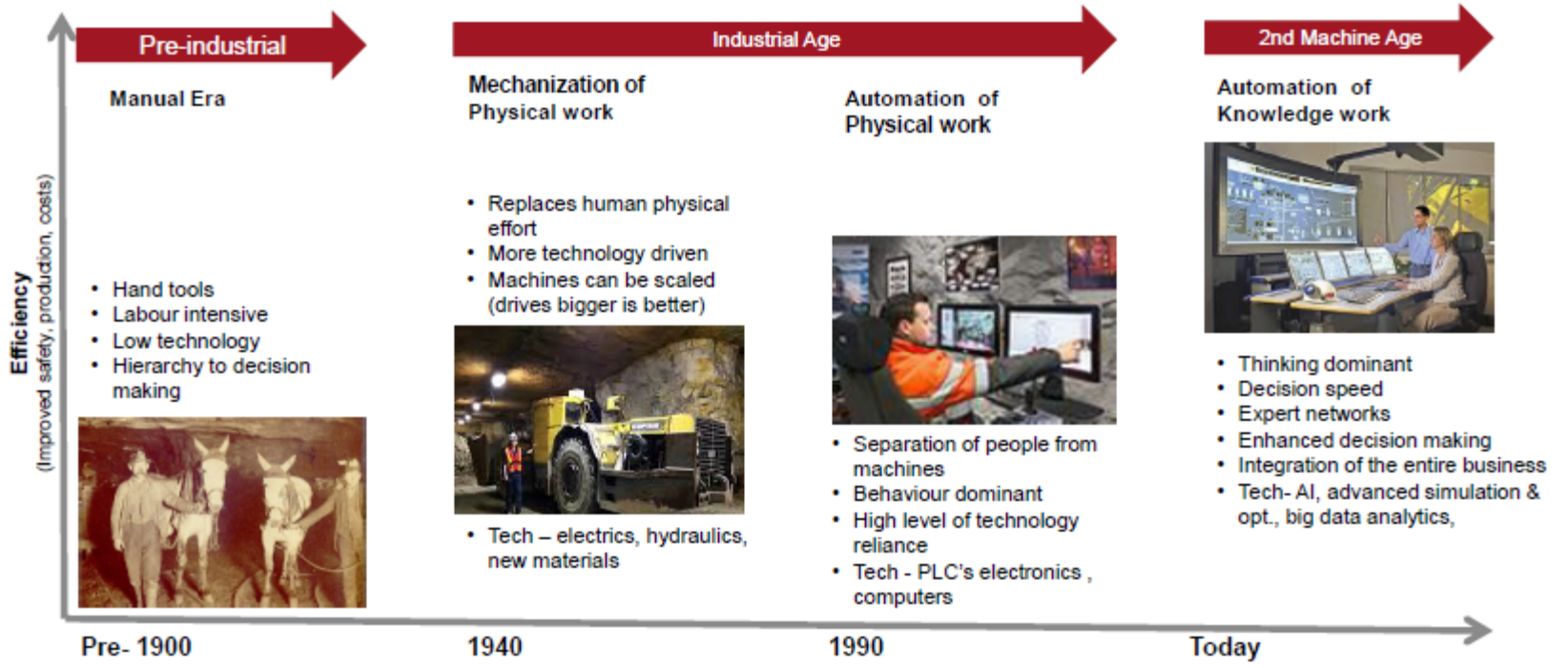
Optimization by Montreal Gaming Software

Connecting to the Metallurgy



Mining 4 and Industry 4.0 Model

Mining Company Perspective



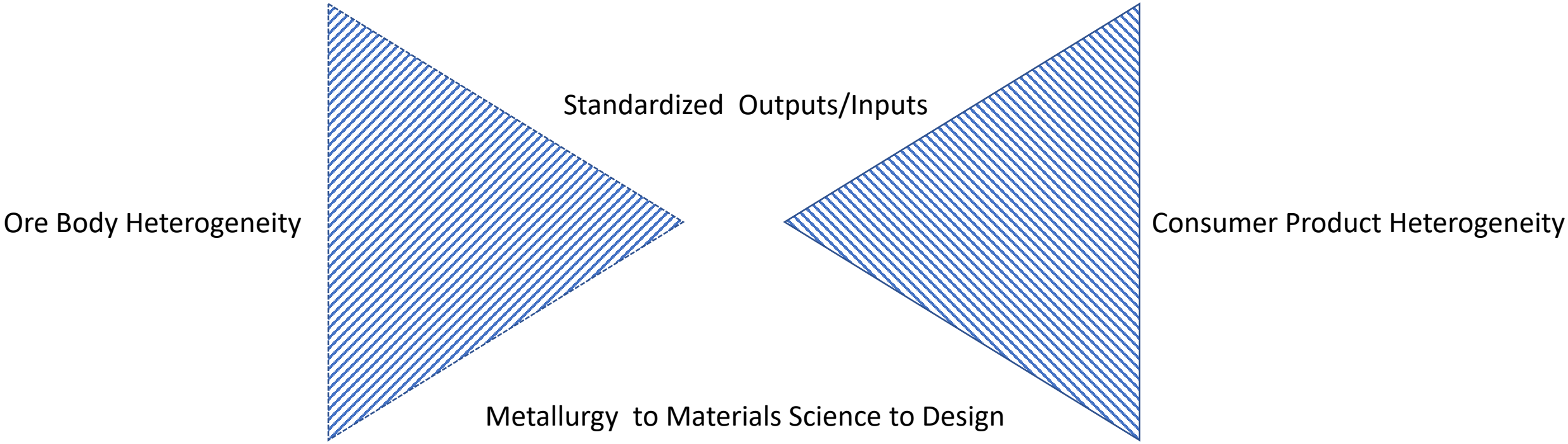
Mining 4.0: Taking the Lid Off the Mine

"Taking the lid off…"

What this was all about

- Connectivity for real-time monitoring of processes
- Improved operational control
- Optimizing plan execution & elimination of waste

Mining 4.0 vs Industry 4.0



Conclusions

- Three Technology Trajectories:
  - Mining Companies: next to nil
  - Equipment OEMs: Step Functions
  - Exploration & Development: Leading Edge of Digital Technologies
    - SMEs on the Outside: Mining Supercluster
- Technology Lead in Canada by Precious Metals Companies
  - Scale: 1500 TPD vs 10-50K TPD
  - No links to Metallurgy: Financial Economy not the Manufacturing economy
    - Mining-Metallurgy-Materials Science-Design & Manufacturing
- Policy Issue: Can’t get There from Here