UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF ENGINEERING & THE BUILT ENVIRONMENT

Wits Mining Institute

Innovation in a Time of AI?

Balancing minerals industry challenges and strategic priorities

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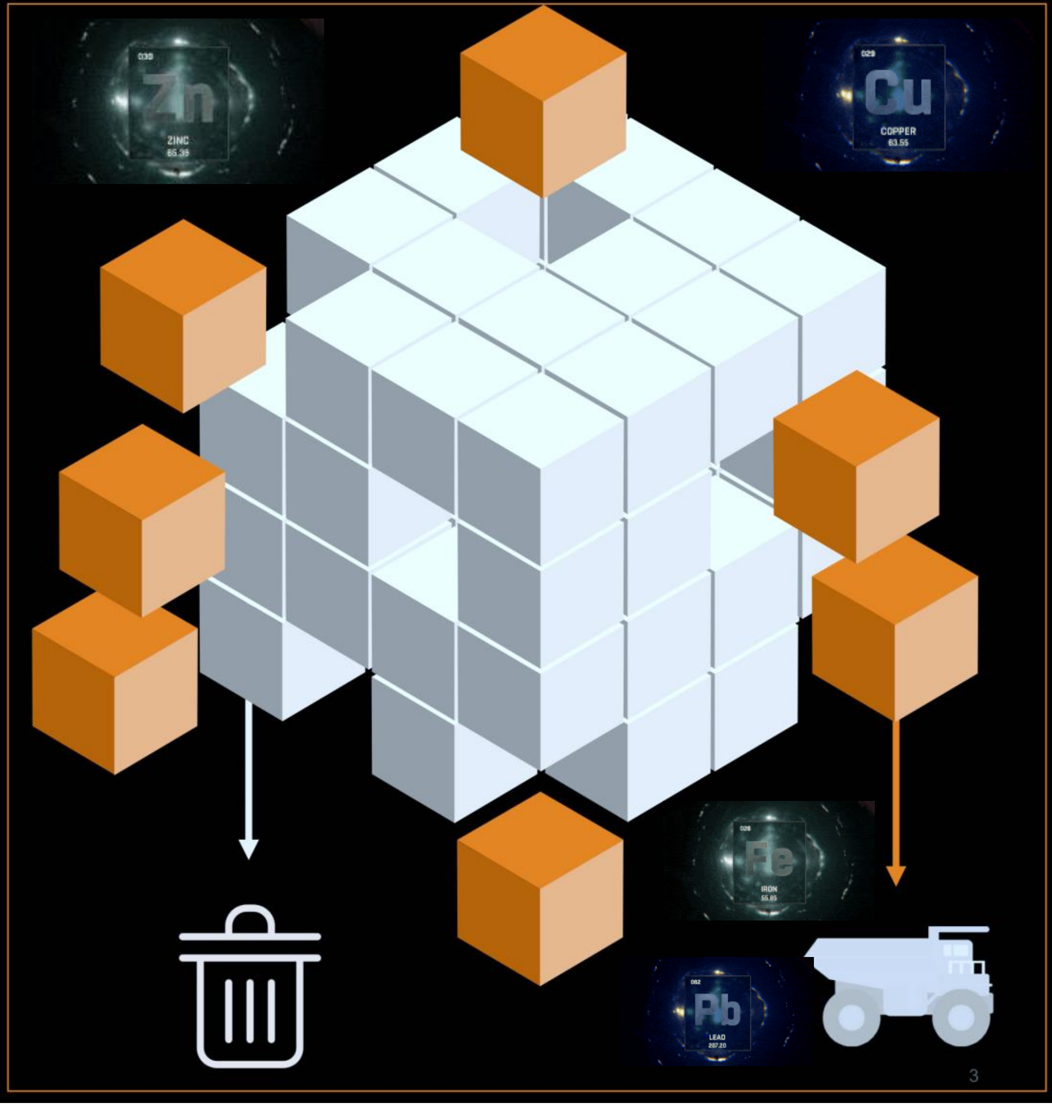


Celebrating the Strength and Love of Mothers

Happy Mother's Month!

Thank you for your endless compassion, resilience, and care

We celebrate your influence and inspiration this entire month, and always!

The era of hyper-innovation or hyper-novelty?

Extremely rapid and continuous advancements in technology and business processes facilitated by AI

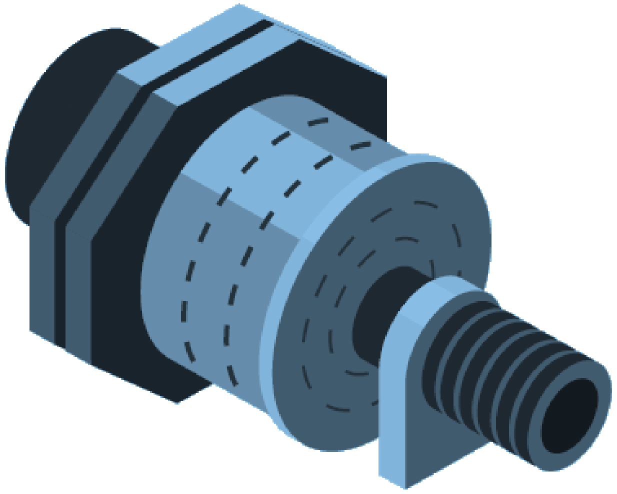
Implications for engineering design, Vendor OEMs and mining companies:

1. Shorter testing time for new tech to meet industry demands – but will this lead to underqualified solutions?
2. IP exposure to facilitate integrated compatible solutions with other OEMs – but will this lead to diminished true novelty?
3. Adapting to constantly changing standards related to safety and data security – what about regulations on AI?
4. Customised engineering solutions make it difficult to generalise solutions – same applies to AI solutions, like models.
5. Data-driven decision systems with poor QAQC – bad data in, bad AI model out.



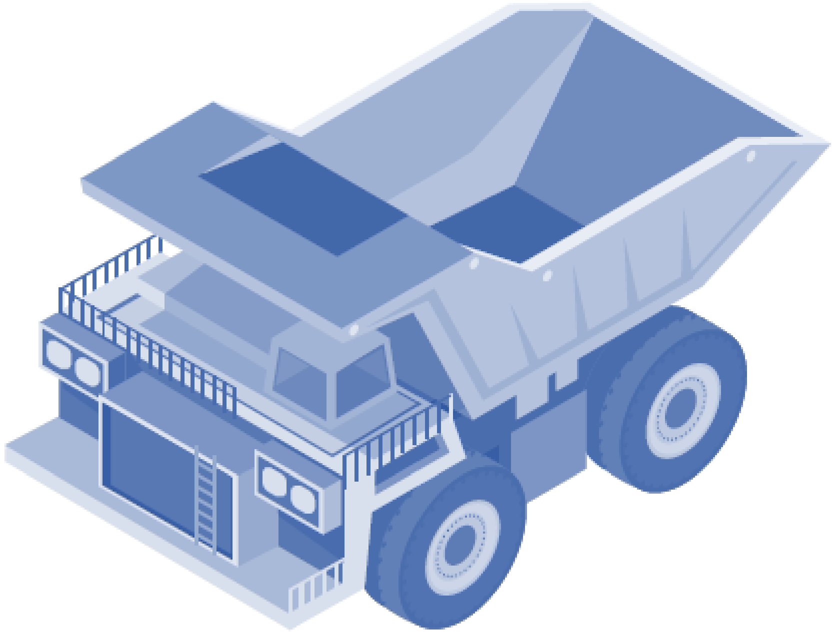

Key components of innovation in a time of AI?

AI-coupled, human-scrutinised ingenuity



Cost-effective digitalization strategy

Volume and predictive maintenance



Current mining industry innovation status

50%
still use manual tools for supply chain visibility.

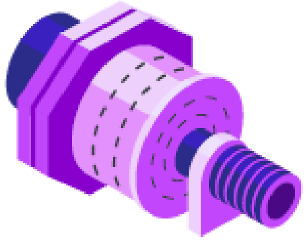
40%
still use manual tools for operational planning.

and only **10%**
see their industrial data as an asset.

accenture

Results
1. 75% less unplanned downtimes
2. 50% faster analysis and reliable decisions
3. >20% reduction in emissions

Technology adoption in mining operations



Fleet Management

- Maximize tonnage throughput and reduce unplanned fleet outages
- Track inventory and production data to improve the quality and grade of ore
- Improve maintenance planning, including scheduling and execution of work, eliminate routine inspections, and predict under-performance of mobile assets

Mining and Metallurgy

- Improve asset utilization and optimization
- Meet sustainability challenges with insight into dust generation, noise, and vibration, along with water and power consumption
- Understand material and grade in near-real time and spot market opportunities

Remote operations centre

- Arm virtual experts with continuous improvement data from maintenance, inventory, scheduling, and planning
- Improve up- and downstream visibility by accessing near-real-time operational data, anytime and anywhere
- Bring together historical asset utilization with actual production data to get a holistic view of the entire process and improve predictive maintenance

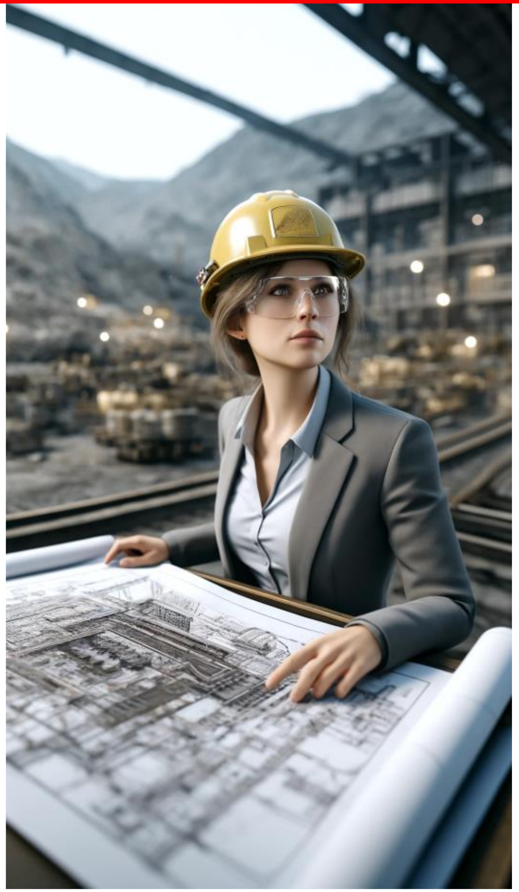
Technical challenges in the minerals industry

- Absence of technologies for rapid mine development
- Poor return on investment in mineral exploration due to lower discovery rates
- Reliance on robust oil and diesel-based machinery
- Reliance on lime for pH control in mineral processing
- Poor recycling and reuse of industrial and process water
- Absence of GPS signal in underground mines
- Dominance of cable-based communication systems
- Overemphasis on machine efficiency rather than worker expertise
- Mining contracts often lack strategies for beneficiation
- Limited examples of fully automated mines
- Incompatible fleet management technology

A model of a RDP house, UJ revealed it was built in a day using 3D printing

Engineering solutions aided by AI…

Minerals Engineers Before AI Came Out



Minerals Engineers When AI Came Out

Minerals Engineers after using AI for 5 years

The quest - turn old data into modern value using AI

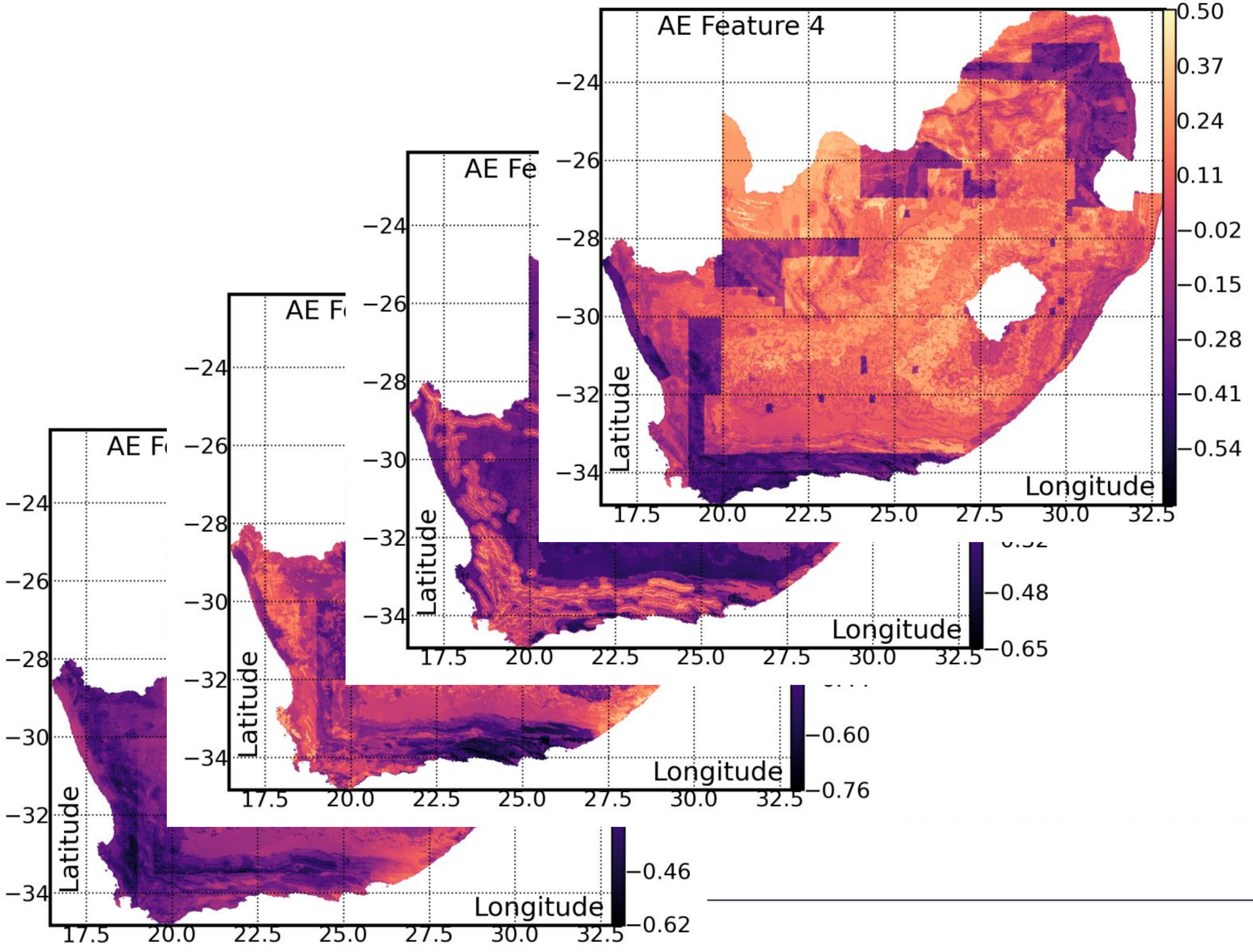
Utopian Solution

Formulate Constraints → Create Usable Models → Deploy and Explore (hard)

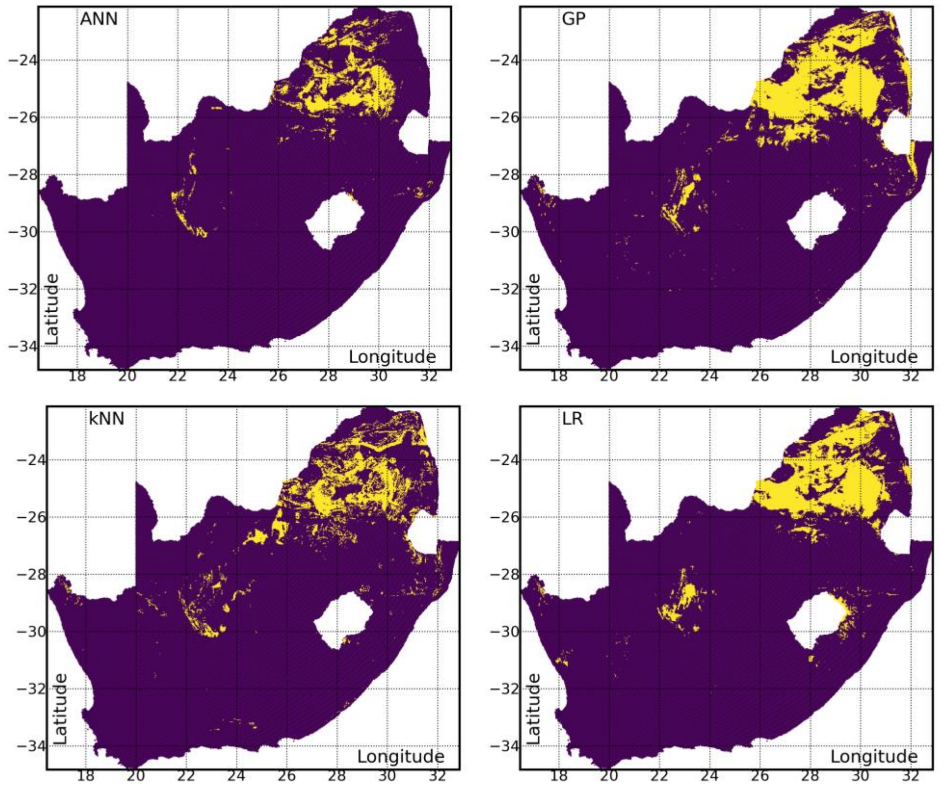
Actual Outcome

No Constraints → Unknown Trustworthiness of Models → Academic Papers (easy)

Symptom: Trustworthy and Usable Models – Which one?

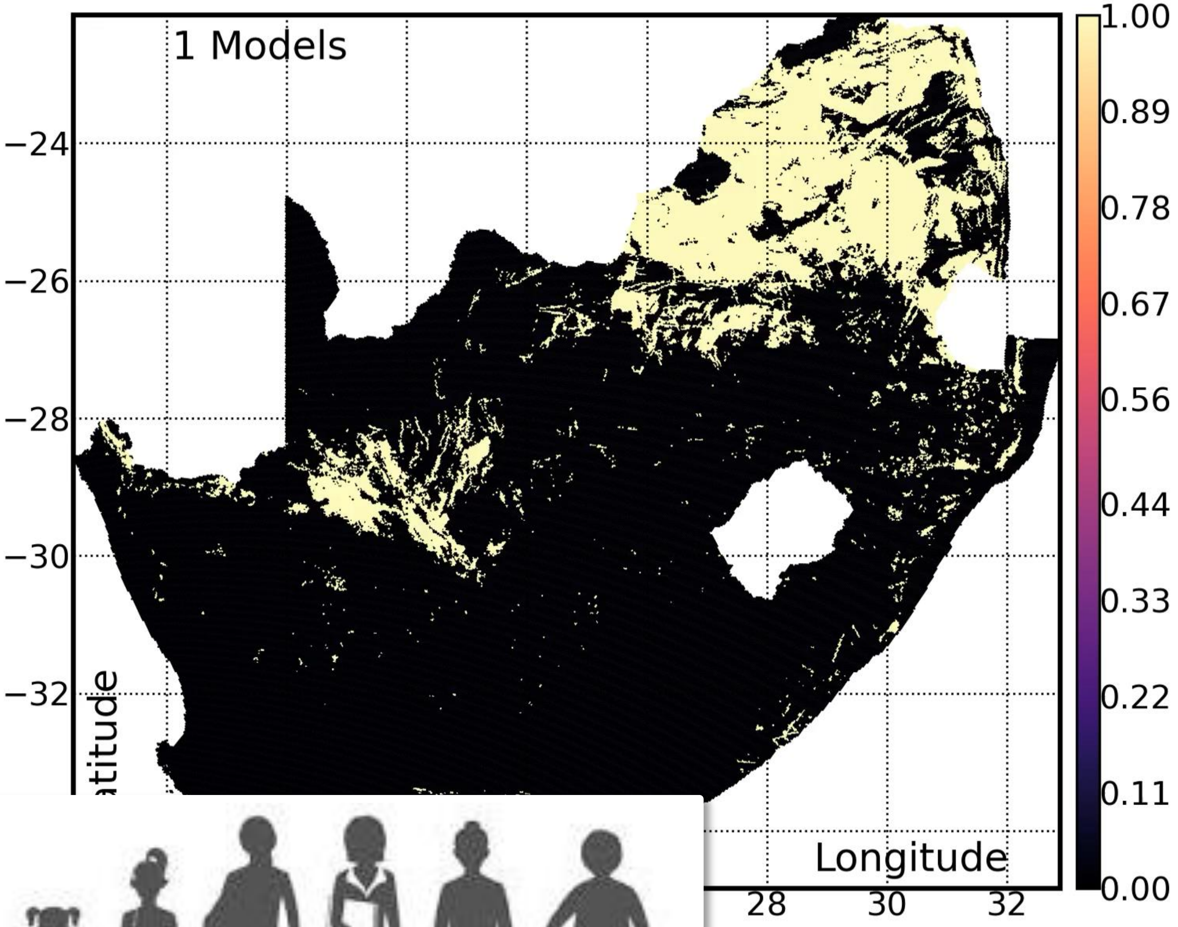


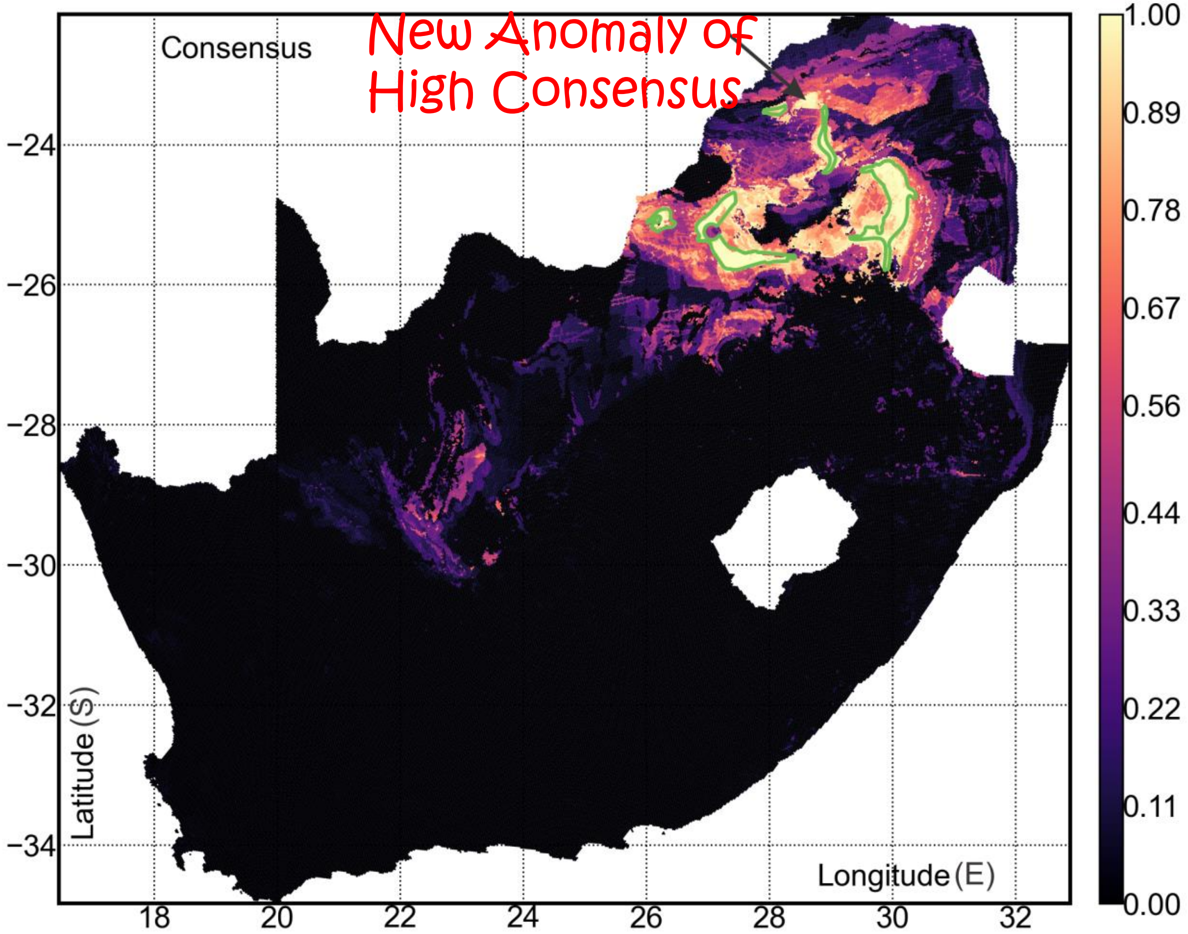
How is this any different than ChatGPT giving 100 different answers to the same question?

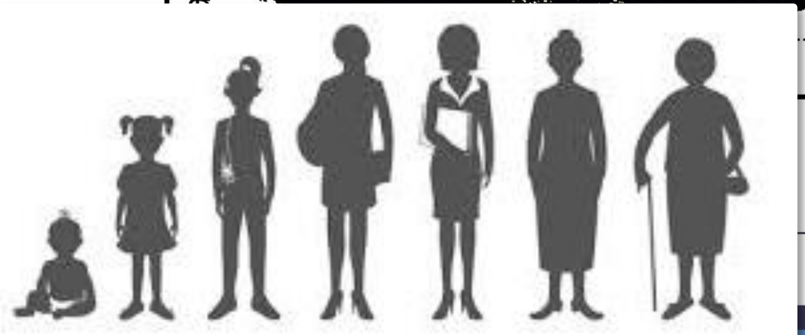


Solution: Experimental Science – Consensus Models

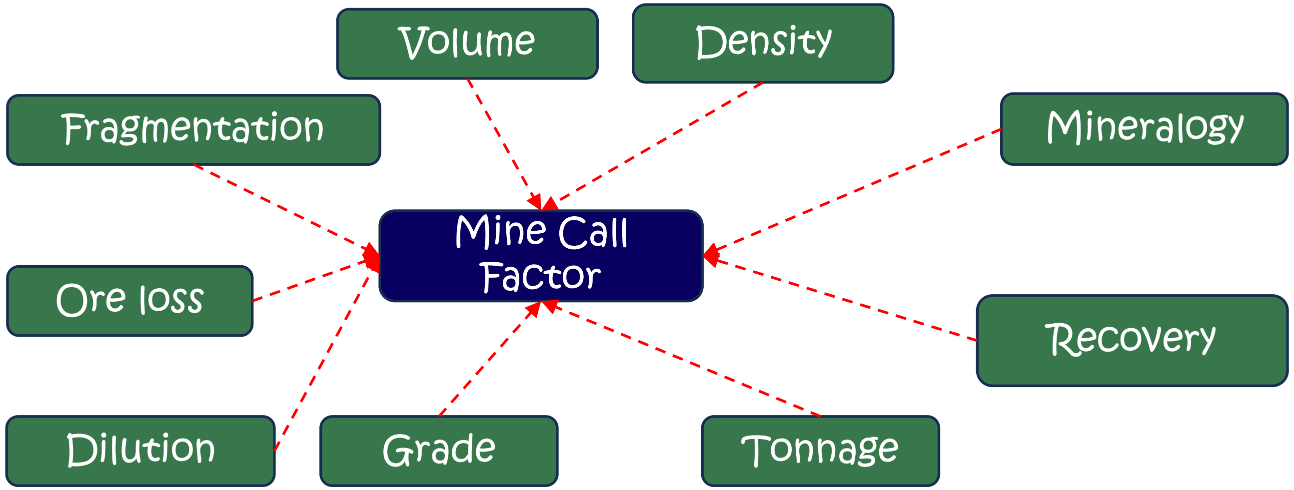
Each map is a data-driven experimental outcome -> average all experimental outcomes -> the average is the most correct

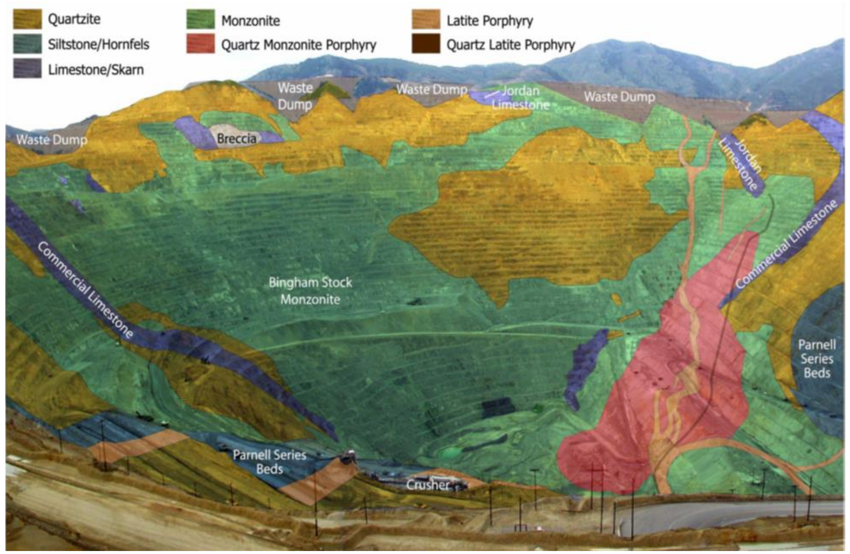






Problem: Low mill throughput and poor metal accounting



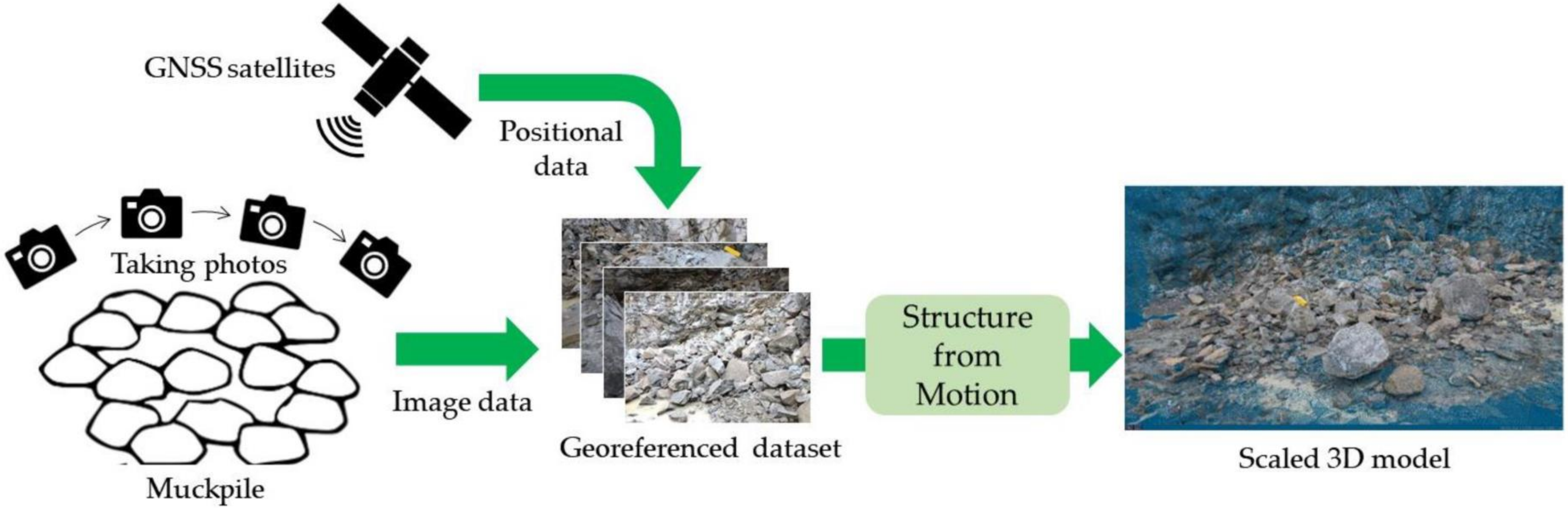


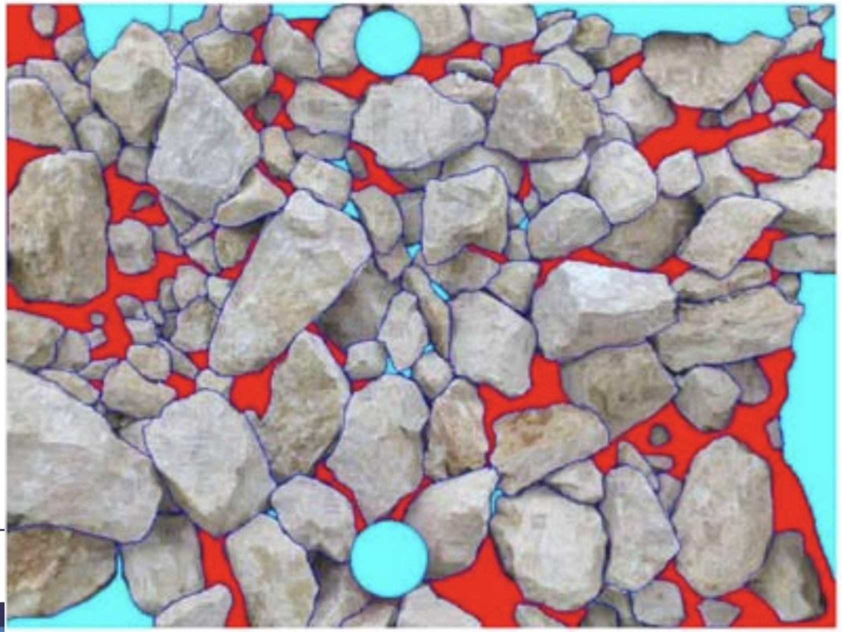
Elongated large fragments of ore

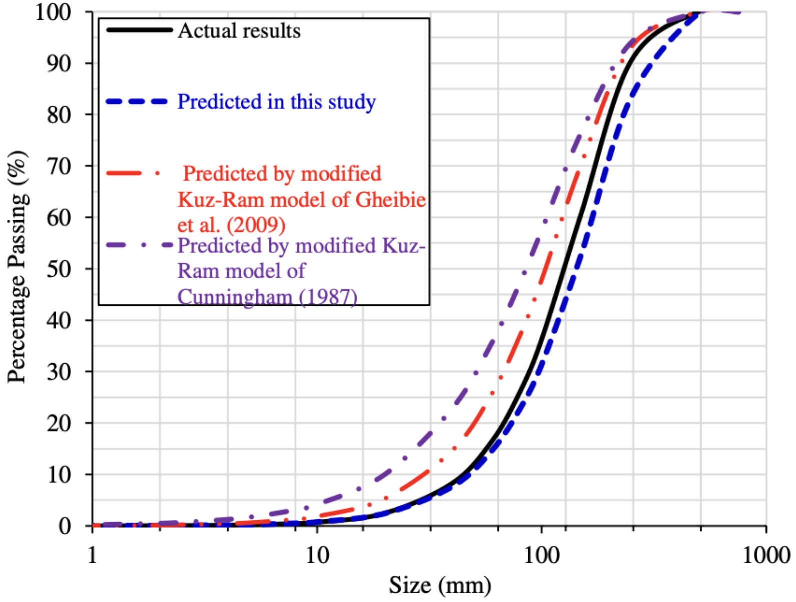
Non-uniform fragmentation

Ore stuck inside the mill

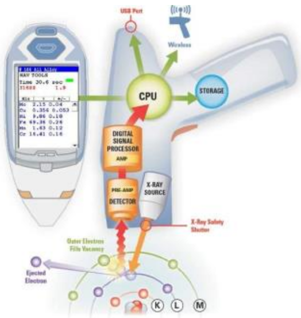
Solution: Real-time fragmentation analyzers



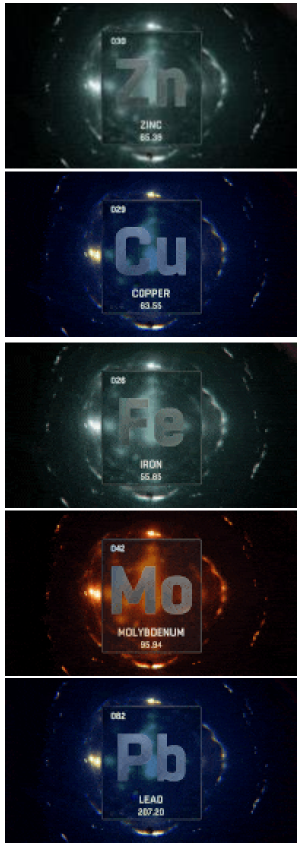


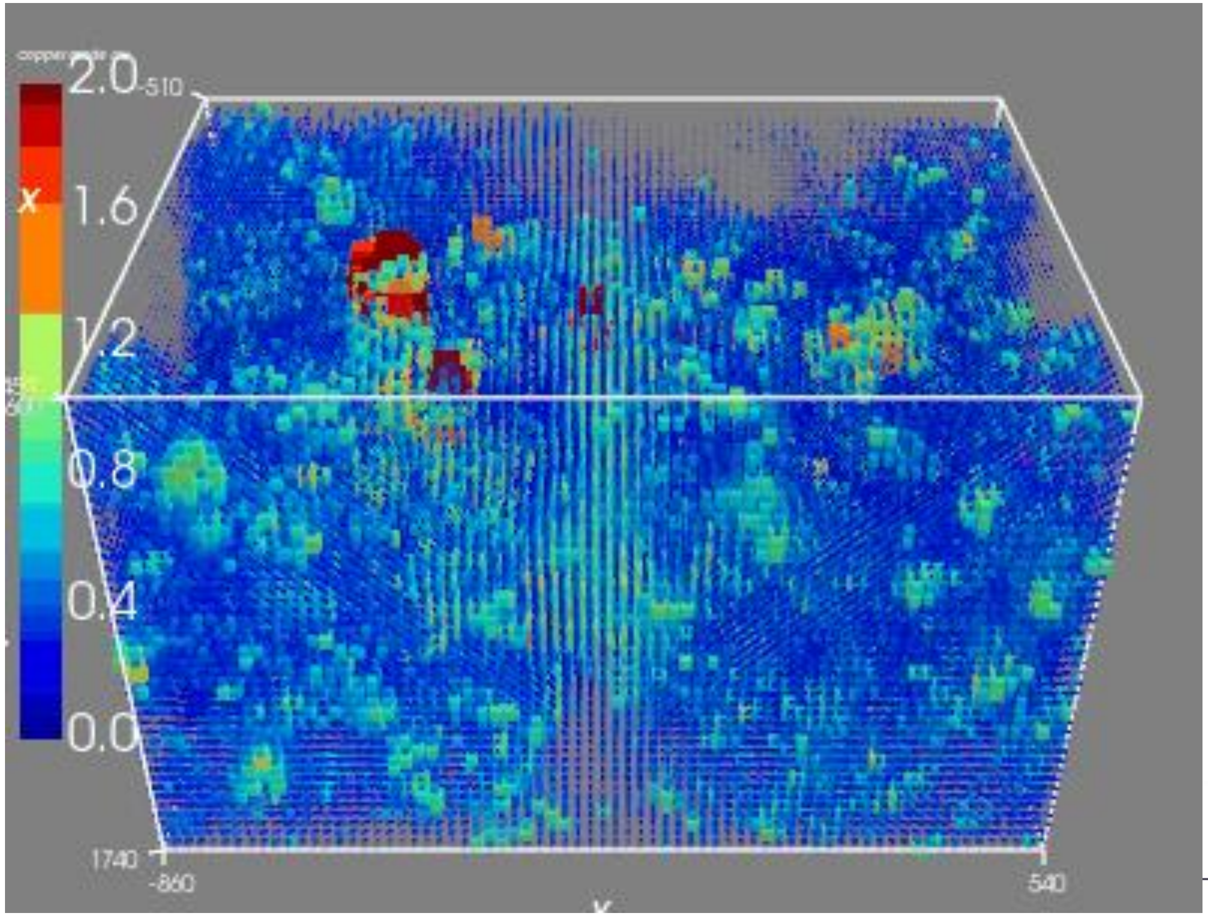


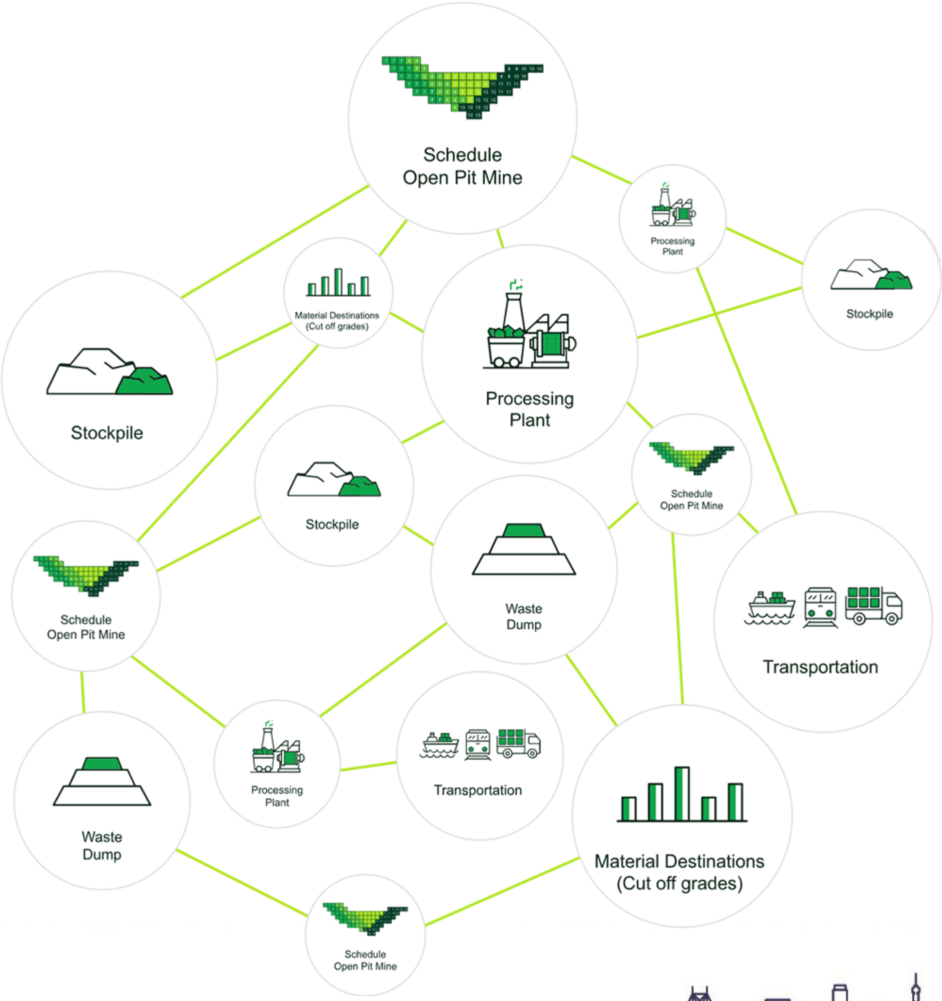
Solution: Real-time 3D grade control models



Portable elemental and hyperspectral scanners + AI







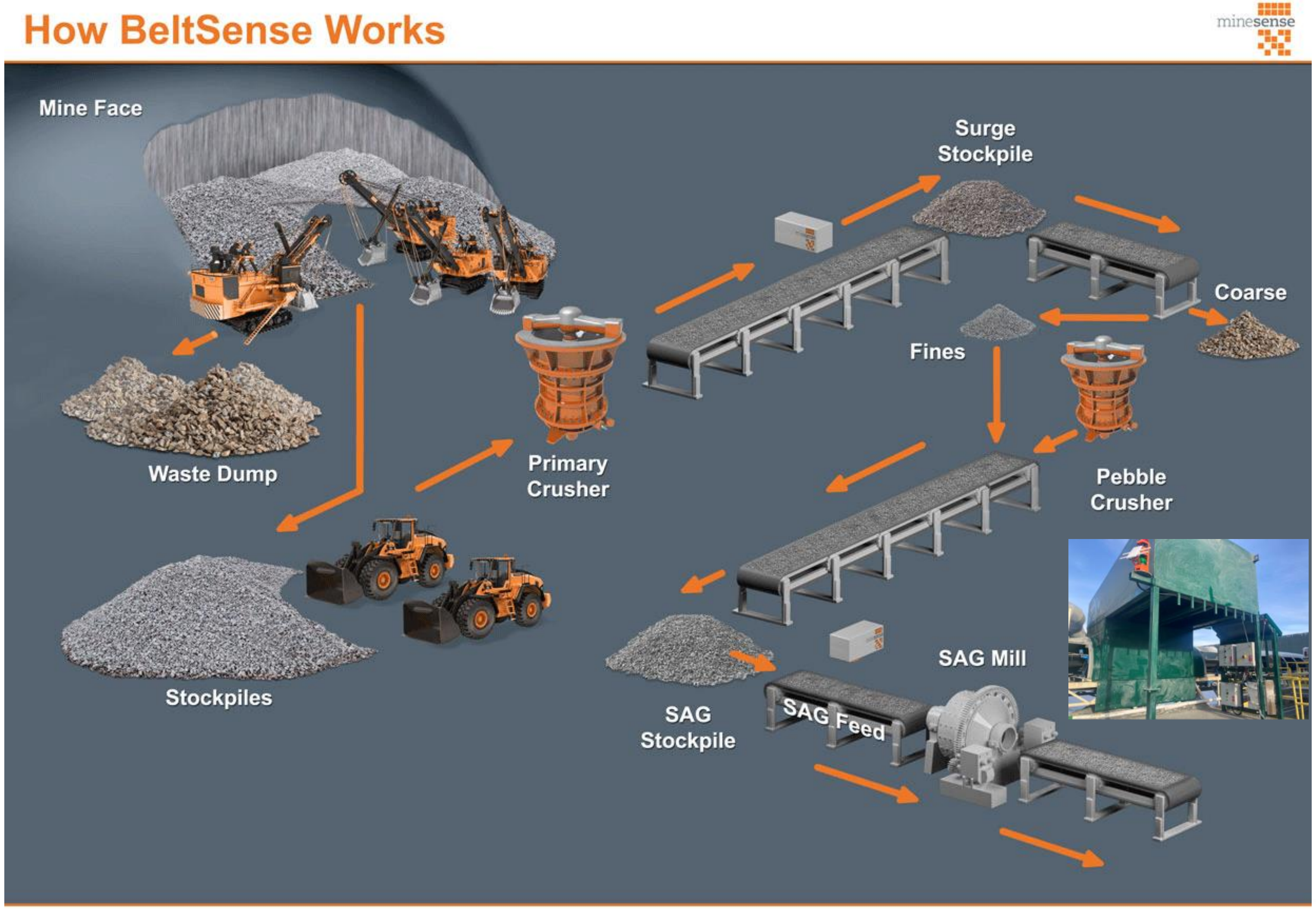
Operational Challenge: Ore sorting and classification

- Cross tramming mixing ore and waste
- Large ore sorting done at the crushing and milling stages

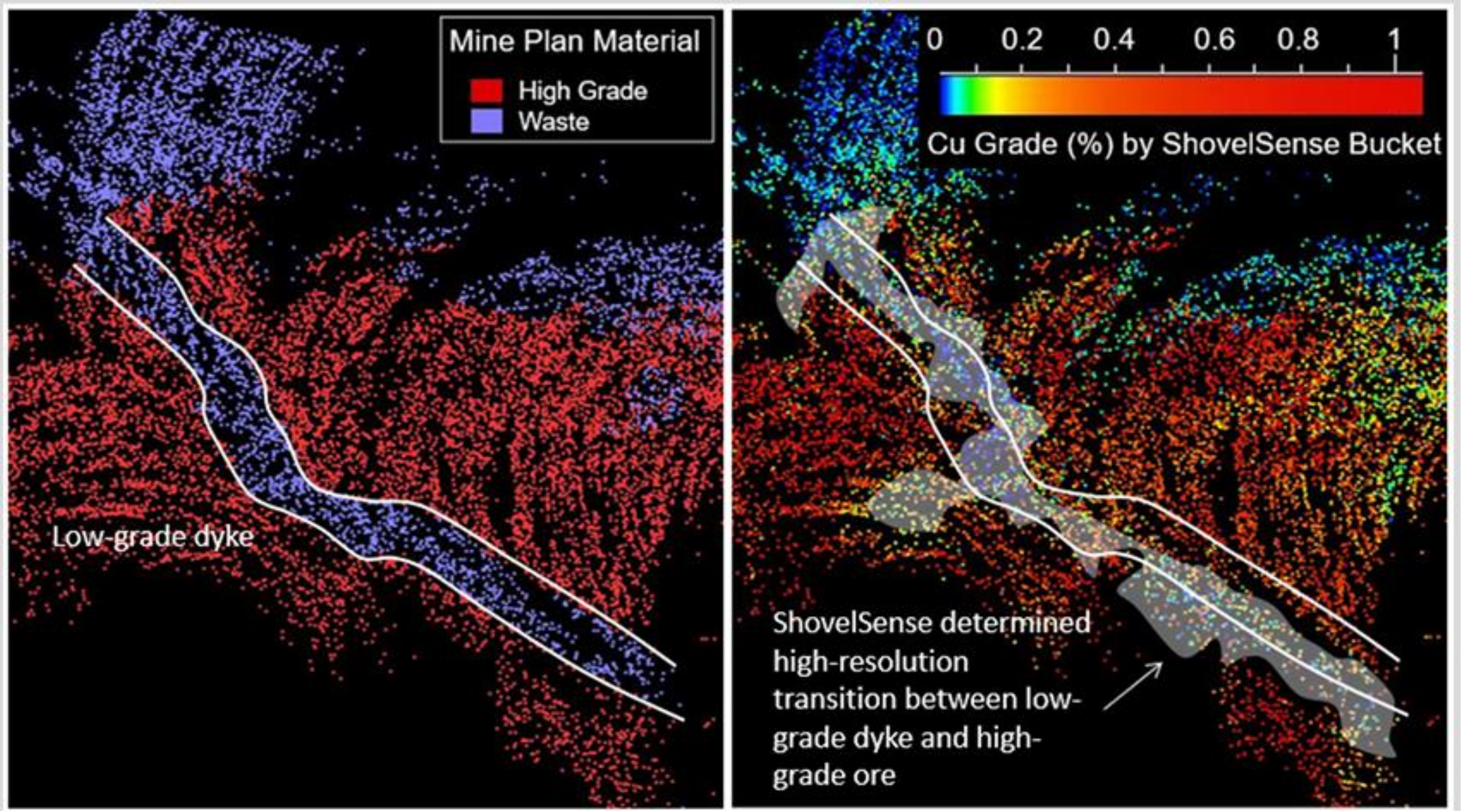
Solution: Automated ore sorting at the mining face

- → XRF sensors provide real-time grade measurements of the material in each bucket
- → Grades are averaged to the truck to inform routing decisions

Solution: Automated ore sorting at the mining face



Solution: Automated ore sorting at the mining face

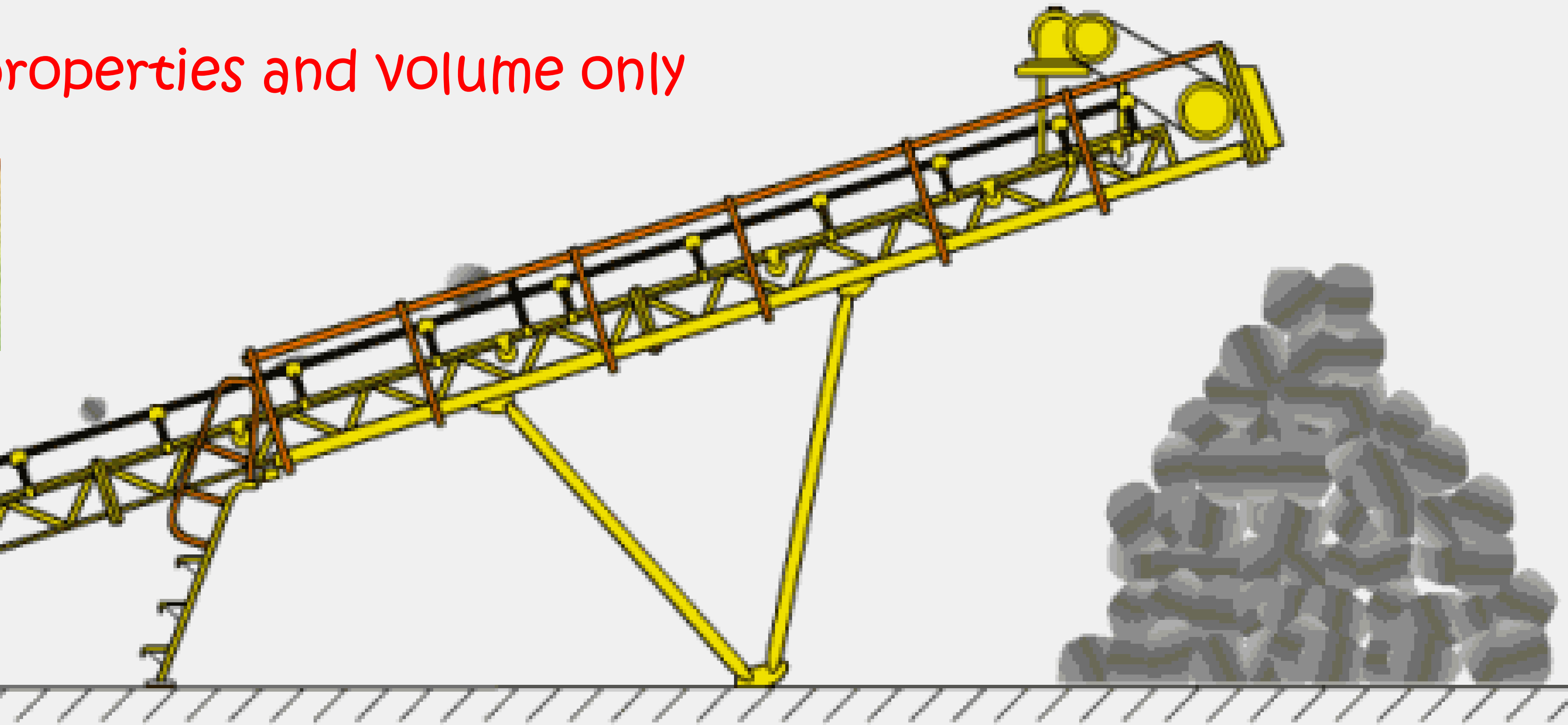
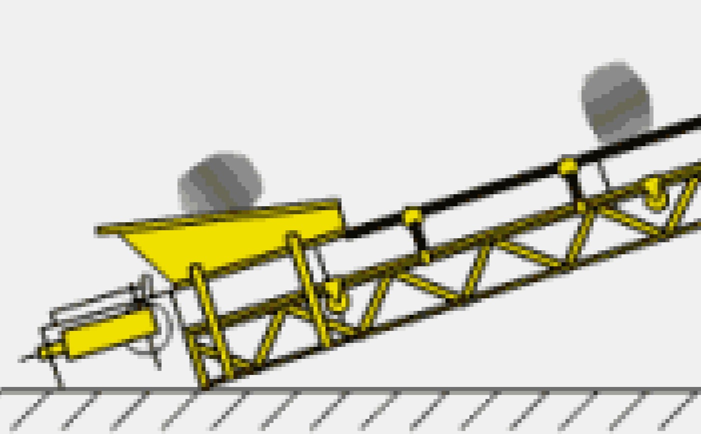


- Align with selective mining units (SMUs)
- Reconcile with geological model and mine plan
- Optimizes the life of mine
- Improve Mine call factor

Operational Challenge: Stockpile strategy

- Poor tonnage reconciliation due to high moisture content
- Inconsistent blending strategy due to sampling challenges

Lidar scan surface properties and volume only

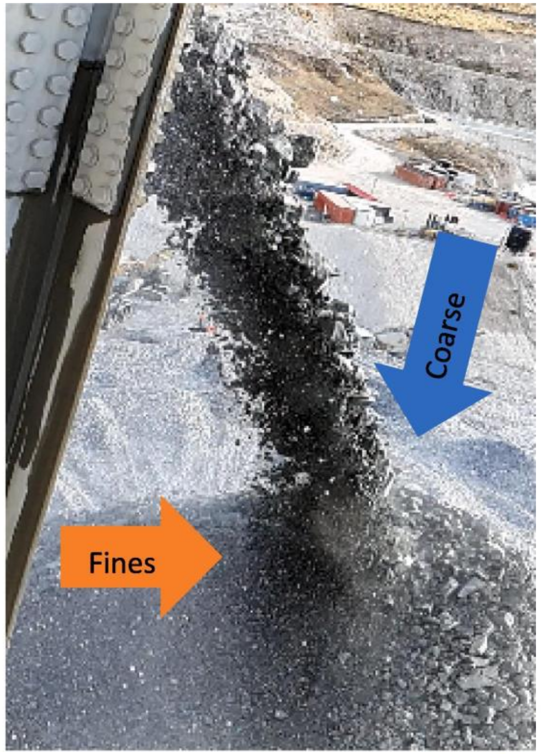
Solution: Integrated stockpile simulator

Model: Continuous Cellular Automata (CCA)

Moisture and density measurements

Trajectory segregation during stockpile stacking where fines are concentrated at the Centre of the pile while coarse material goes farther to the margins

Coarse particles on top

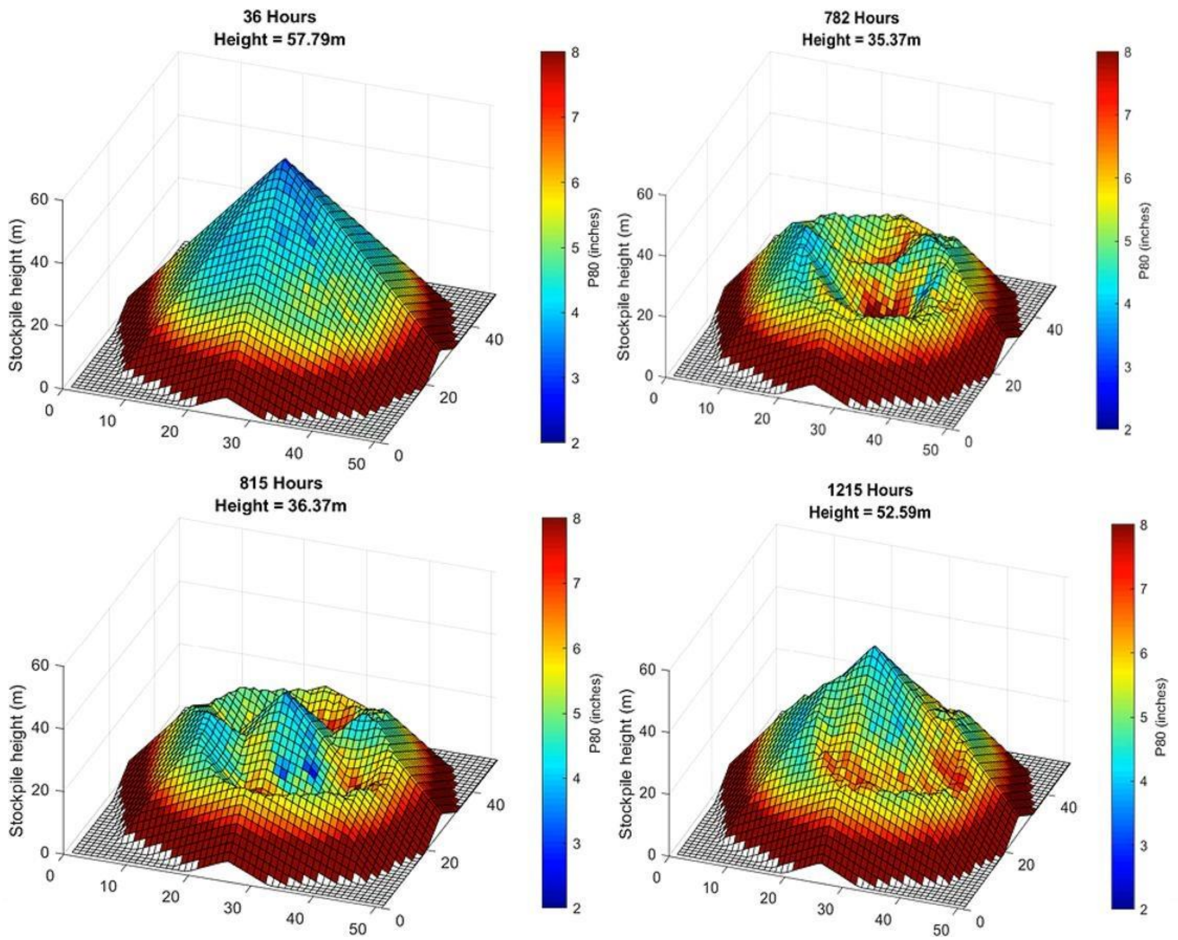


Solution: Integrated stockpile simulator

Model: Continuous Cellular Automata (CCA)

- 3D grid each cell stores multiple properties
- D50 and D80 Characteristic Size
- Each time step has 4 calculation steps:

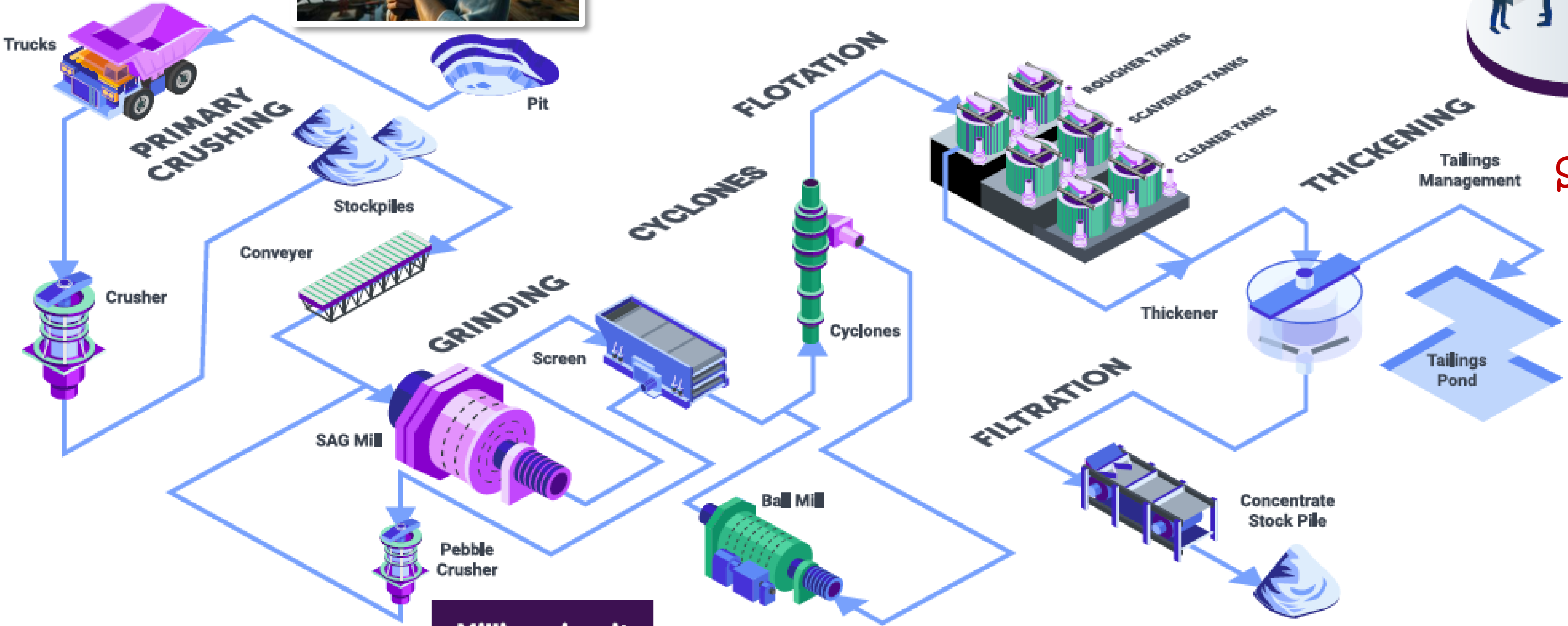
1. Feeding,
2. Discharge,
3. Void propagation and
4. Surface flow



Digital Twins and Wearable Tech

Mobile fleet

Remote operation center

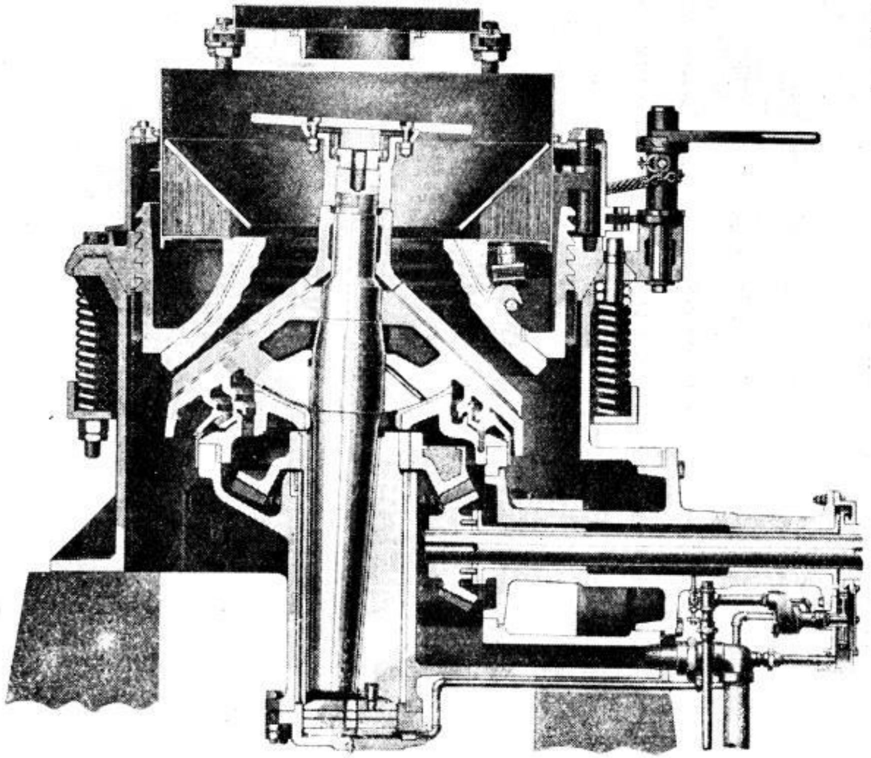


Milling circuit

Smart Vest

Innovation in Scale: Crushers

Cone crusher - key features unchanged for over 80 years (e.g., crushing chamber shape, concave, liners, tramp release springs, eccentric motion, drive etc.), as the best way to crush rock in this application was discovered a long time ago.



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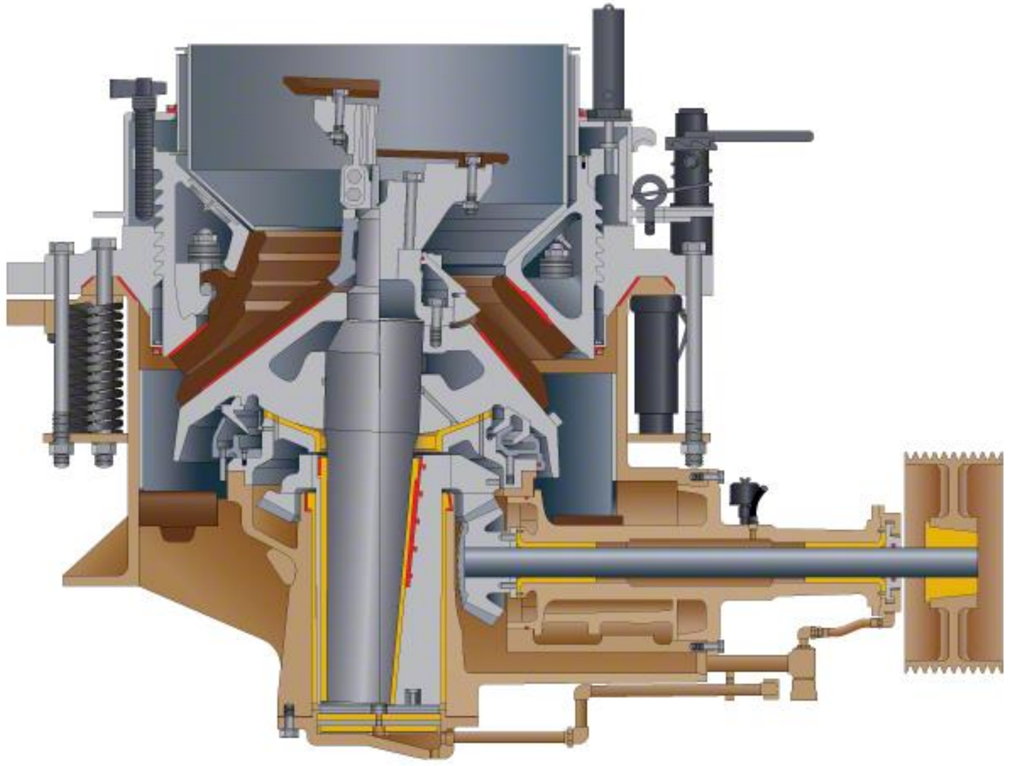
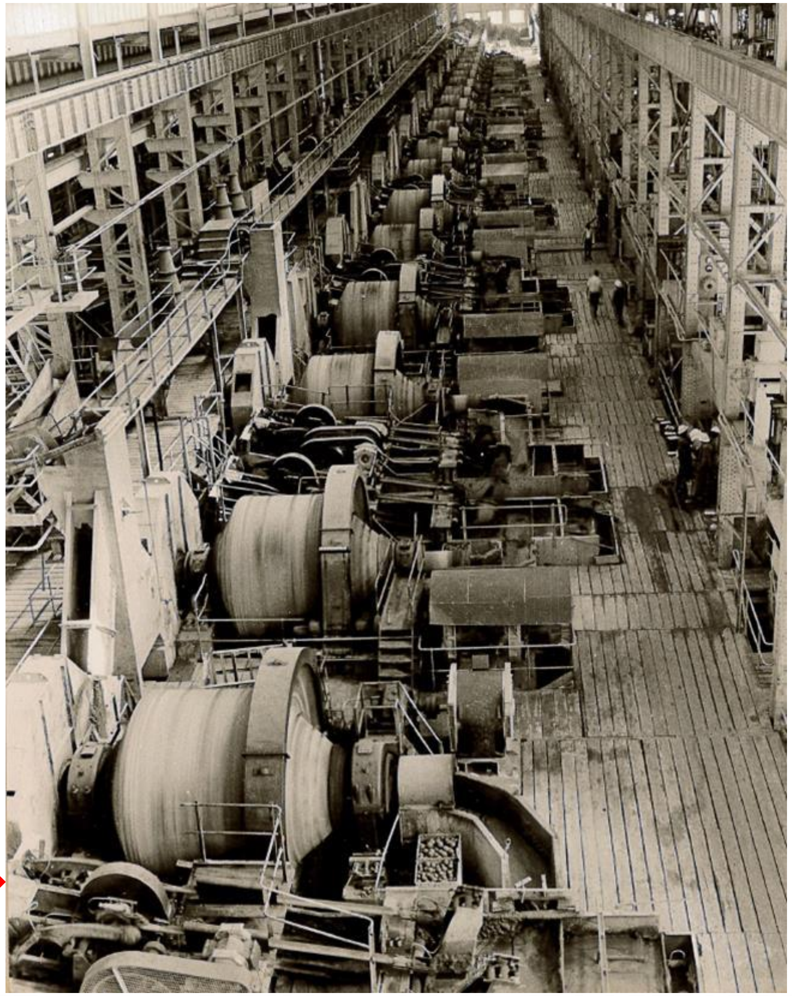


2023

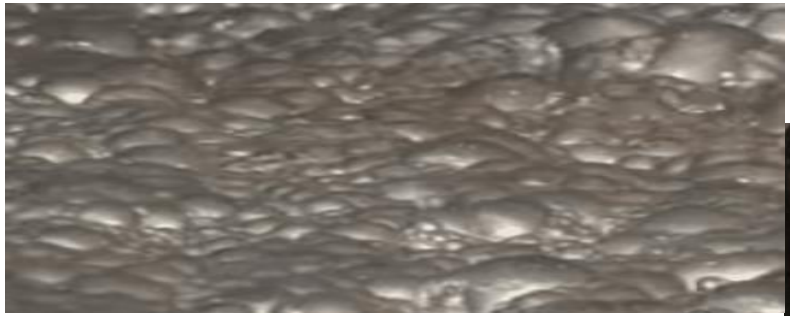
Innovation in Scale: Mills

Mills 1970s
2.7 x 2.4 m mills
Mufulira



Mills 2023: 12.3 x 10.0m 28 MW (Sino Iron, WA)

Innovation in Scale: Flotation



1959 Flotation Cell = 1.3 m^3

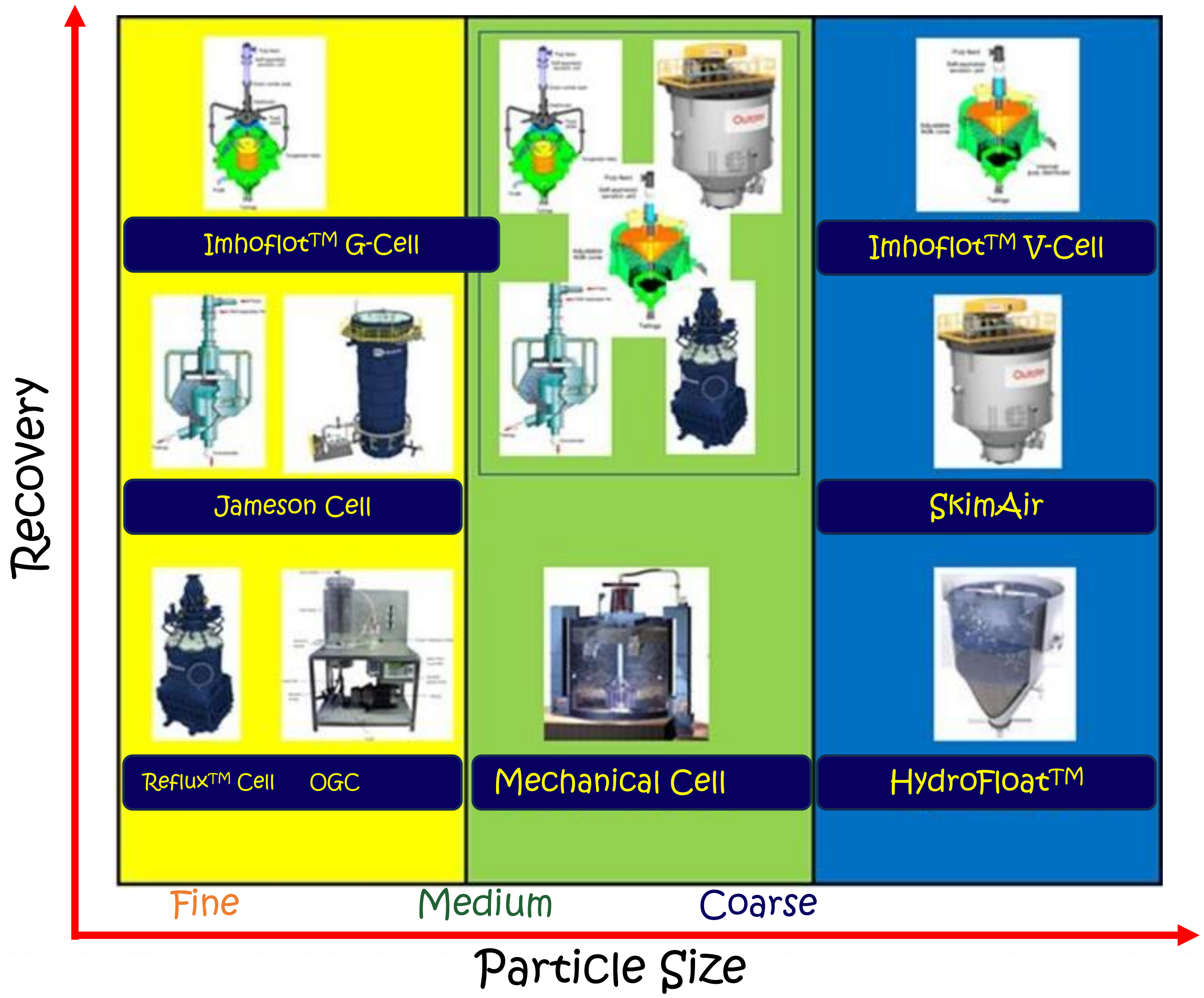
Exponential growth in size (volume) to >600 m^3 in 2023 and, by extrapolation, volumes above 1000 m^3 would be expected by 2030

FLSmidth's SuperCell™ 600 series at 600-660m^3

Innovation in Scale: Flotation

Before 1969 all flotation cells <3 m^3

- 1970 - 16 m^3 Outokumpu, Finland
- 1976 - 38 m^3 Outokumpu, Finland
- 1982 - 60 m^3 Pyhäsalmi, Finland
- 1995 - 100 m^3 Escondida, Chile
- 1997 - 150 m^3 Australia
- 1997 - 160 m^3 Chuquicamata, Chile
- 2002 - 200 m^3 Century Zinc, Australia
- 2007 - 300 m^3 Macraes, New Zealand
- 2013 - 500 m^3 Kevitsa, Finland
- 2015- 660 m^3, KGHMs Robinson copper-molybdenum mine in Ely, Nevada- USA



Lessons from the innovation in Scale

- Almost all scale development is done by vendors.
- Main drivers are OPEX/CAPEX, and competition.
- Enabling technologies important (**e.g., materials, AI+Computer-aided design (CAD)**).
- Can we increase scale indefinitely? Or are we running out of options?
- What is next?

Problem: Large GHG emissions from smelters

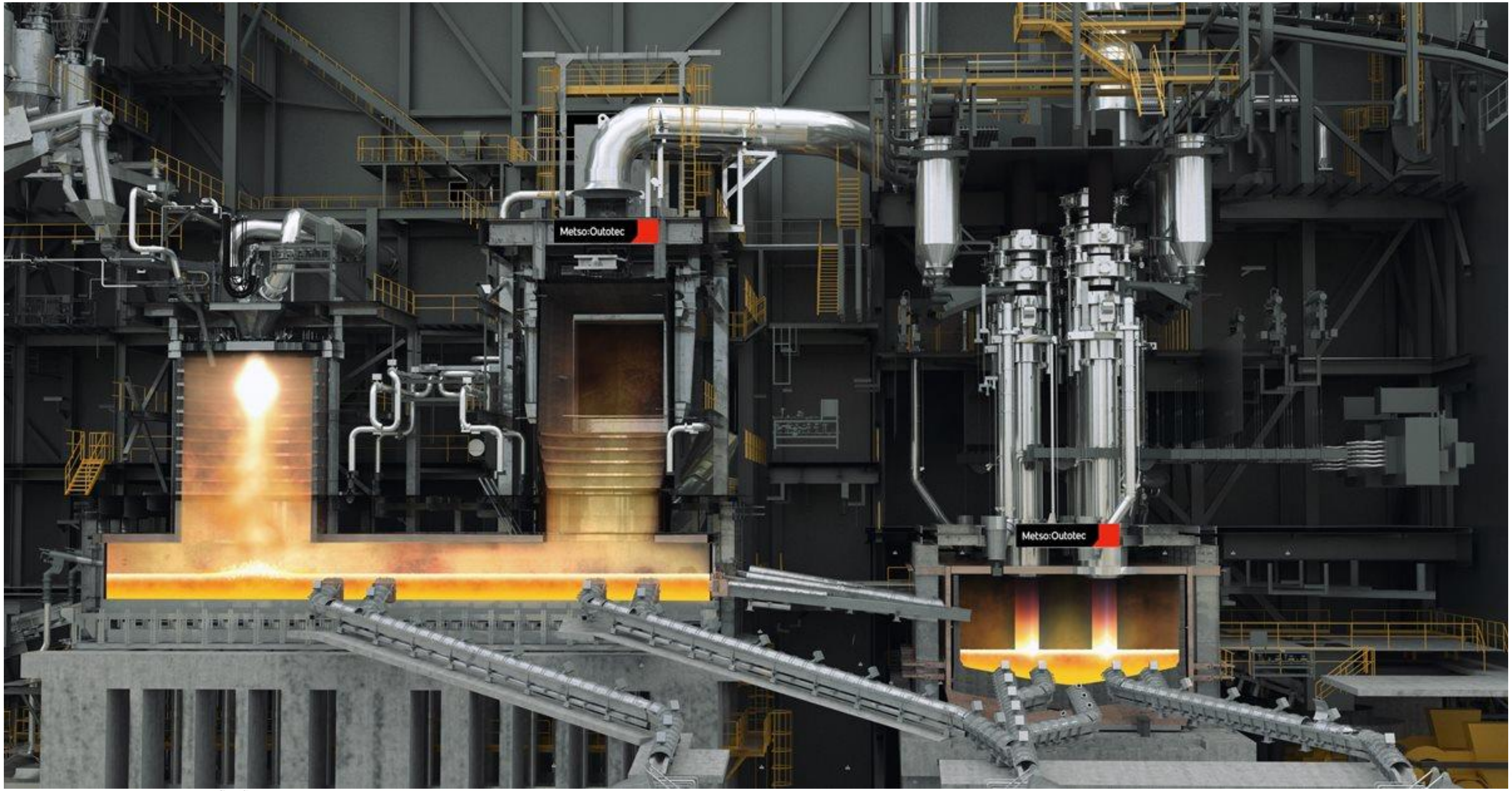
Each human per day:

- Inhales 14 kg of air each day
- Drink 2 kg of water
- Eating 1.5 kg of food.

- With each breath, we inhale necessary oxygen, but also small amounts of potentially harmful gases and small particles
- These constituents directly affect our health, even if we might not be aware of it
- Poor air quality reduces human life expectancy by more than 15 years in the most polluted cities and regions worldwide

Contributes between 7 to 10% of global CO_2 emissions

Problem: Direct reduced iron (DRI) Electric Smelter



DRI Smelting Furnace can handle large slag volumes without excess iron losses, thereby allowing the use of blast furnace-grade iron ore

Keep in mind the following…

AI has accelerated the rate of innovation and simplifies prototyping of engineering designs

Remember that:

- All (data-driven) AI relies on data, data created by humans
- Solutions created by AI do not always work and will require extensive human scrutiny and expertise-based validation
- The current generation of AI mainly infers things that are known – no true "greenfield" innovation
- Training AI using data requires humans to create innovative data

Conclusion

"Start by doing what is necessary, then what is possible, and suddenly you are doing the impossible."

— St. Francis Of Assisi