Monitor Deloitte.

Natural Resources Canada


MineRP

# Future of mining visualization

November 2020

# Developing a collaborate effort to create the Future of Mining in Canada

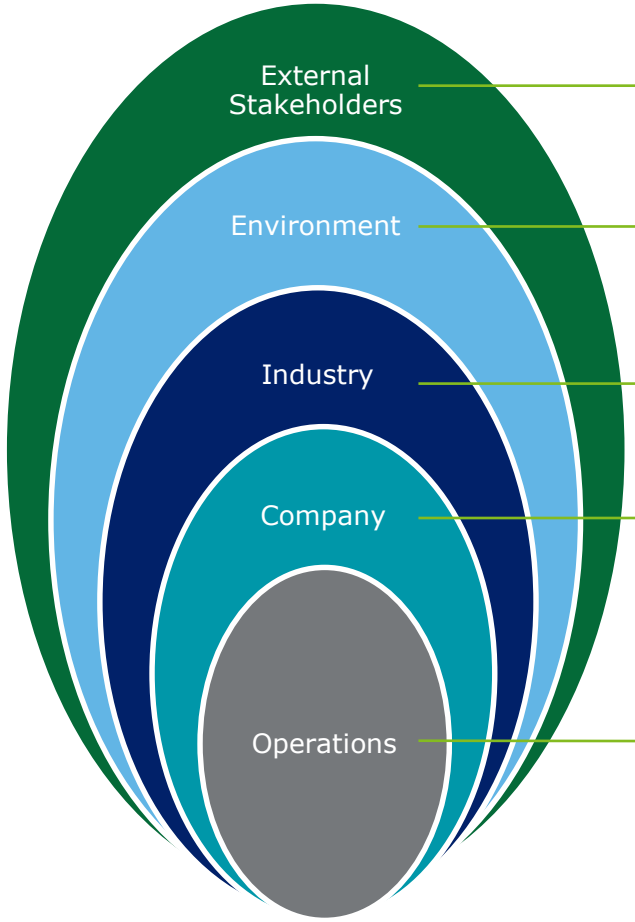
- We have a desire to transform mining? Purpose
- What should we aspire to for mining? Requirements
- What do the Future of Mining concepts look like? 3D Visualization
- Does it represent the features that we want? Desirability
- Do we believe that what we see can be possible within two decades? Feasibility
- How can we explore different options? Co-creation platform
- Which option is the best? Viability / Optimization

Focus on near surface narrow vein gold deposits

>2000 inactive projects in Canada

>1000 active projects in Canada

# All the mining issues identified during the workshop have been categorize across the following domains




| Domain | Description |
| --- | --- |
| External Stakeholders | Issues related to the community, government and the suppliers |
| Environment | Issues related to emissions, water usage and land footprint |
| Industry | Issues related to mining industry as a whole |
| Company | Issues related to the corporate culture and expectations |
| Operations | Issues related to the mine - Ore Deposit, Operations, Labor, Energy, and Capital |

# Identified key design elements of the future of mining of the targeted mine

- Changes in the approach to mine design to focus on value extraction and zero waste
- Full digitalization of operations
- Much better, more powerful and more precise exploration.
- Full cyber-physical model of the mine operations
- Integrated planning and AI-based optimization of all the elements of mine planning across all time horizons
- Modular surface infrastructure, portable systems for processing and for developing smaller ore bodies
- Ability to liberate the ore with greater precision and less waste
- Continuous operations, in situ processing and extraction where possible.
- More efficient comminution
- Increased automation, use of intelligent systems, and greater use of emerging technologies.
- Electrification of all mining activities, including liberating of ore where it makes sense
- Maximize the use of renewable sources of energy and intelligent energy management systems.
- Decarbonize across the entire value chain (Scope 1,2, and 3 emissions)
- Dry processing to limit water use
- Real-time monitoring of all activities and full transparency across all elements of the operations
- Technologies should enable greater value-add, and can differentiate the Canadian brand.

# New design principles can break tradeoffs in existing orthodoxies to help overcome many of the current mining challenges

| | Current Design Principles | New Design Principles |
|---|---|---|
| 1 | Bigger is better – Economies of scale lowers cost | Modular, scalable and flexible design and equipment to increase options over LOM |
| 2 | 364/24/7 mine operations maximize asset utilization and production | Optimize mine plans and schedules to maximize value of the mine to all stakeholders |
| 3 | Standardized processes and equipment at mines and across mines reduce cost | Customize processes and equipment to optimize value from ore body |
| 4 | Mine life is designed to maximize return on fixed investments | Increase the amount of movable assets to create value from any life of mine |
| 5 | Critical resources like labor, energy and water are readily available | Minimizing the use of critical resources is a key criteria in mine design considerations |
| 6 | Waste movement and processing has to be minimized as it decreases returns | Invest to eliminate waste as early in the value chain as possible and add value to what remains |
| 7 | License to operate requires compliance with minimum social and environmental regulations | Maximize the value to society and environment subject to achieving required returns |
| 8 | Success across each phase of the LOM requires a different focus | All decisions have to take into account the value of the integrated system over the LOM |

# Various solutions clusters become enablers of the proposed new design principles to address the challenges of mining in a meaningful way

## 1. Improve ore body knowledge

- Reduce core sampling requirement. Analyze the hole not the core
- Coil drill techniques
- Real-time analyses
- Blast hole analyses
- Ore sensing technologies at the face
- Multi-disciplinary analyses
- AI based ore body models

## 2. Integrated mine design, planning and scheduling

- Integrate all ore body data into one common platform like MineRP
- Integrate common database of all resources and capabilities
- Integrate operational planning and scheduling with financial systems to model system value

## 3. Selective Mining & In-Situ processing

- Continuous cutting machines
- High intensity blasting
- Raise bore ore cutting
- In-situ primary extraction
- Water recovery
- Backfill to leave zero waste

## 4. Alternative material handling and movement technologies

- Electric modular trucks
- Autonomous hauling
- Alternative technologies like Railveyor and Ropecon
- Multi-modal system
- Hybrid Air Vehicles to move material and equipment inter-mine

## 5. Modular mining

- Use equipment that can be assembled and disassembled on-site
- Hybrid air vehicles to transport equipment modules to sites
- Avoid road infrastructure where possible
- Removable equipment decouples equipment life from ore body lifer

## 6. Integrated operations with intelligent work environment

- Fully digitalized operations
- Digital twins of all equipment as well as full mine operations to track deviations to plan
- Predictive platforms like Predix

## 7. Automation

- Link to intelligent work place
- Remote centres to operate remote equipment. No people on site for most of the mining tasts
- Full autonomous parts of the operations
- Automate the management of renewable energy integration

## 8. Electrification & re-newable resources

- Electrification of all mining processes
- Digitally intelligent grid to enable full load control and orchestration at mine level
- Maximum penetration of renewable energy
- Use cheap energy to recycle water
- Standards required to catalyze innovation

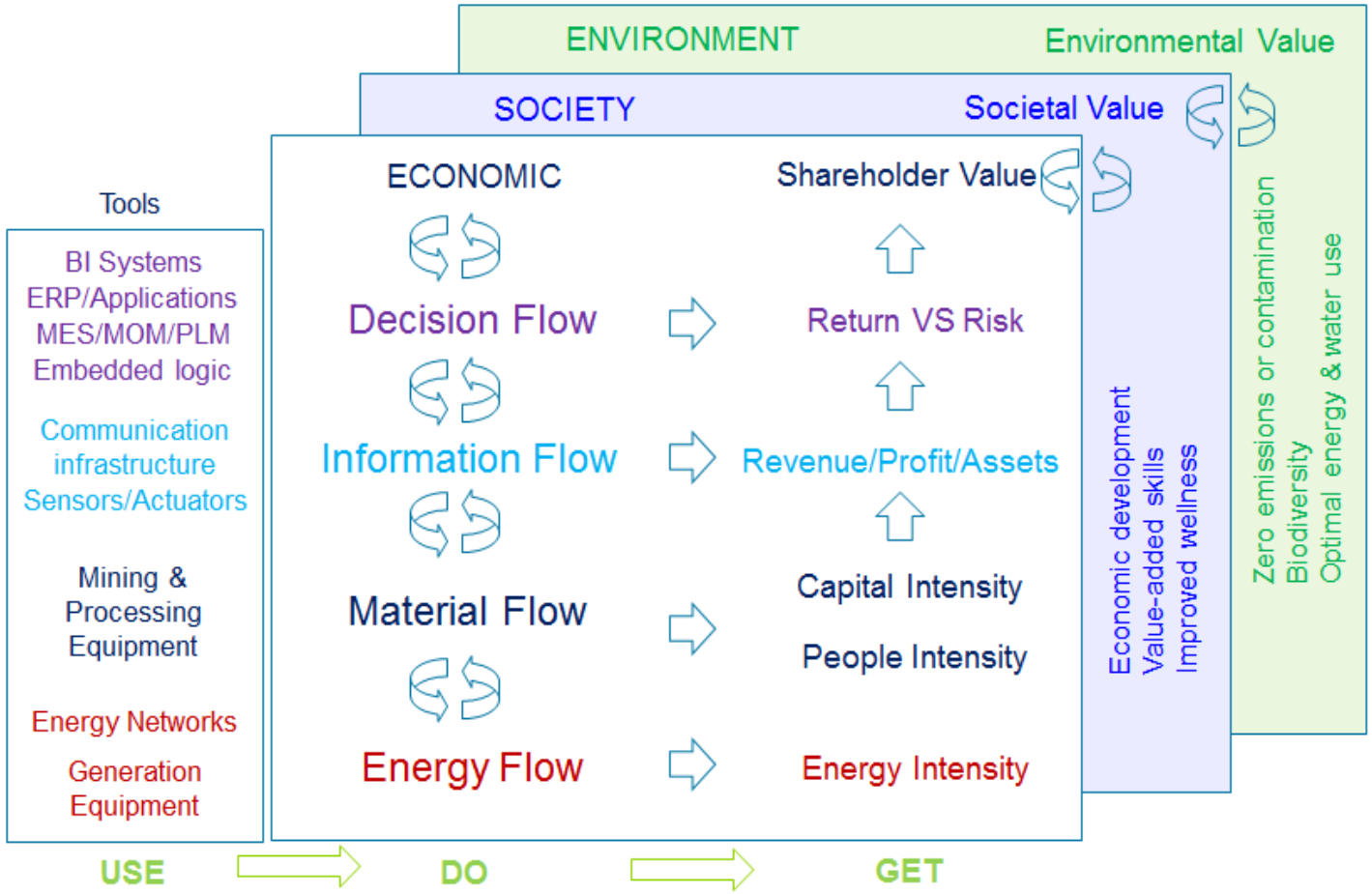
## 9. Transact more efficiently

- Use BlockChain to track ore mined throughout the value chain
- Rewards employees and partners with instant payments
- Track warranties on parts with BC individually
- Sell metals and minerals directly to end customer with BC
- Track, recycle and resell

## 10. Improve Water Treatment & Management

- Advanced purification and recycling technology like Axine.
- Digital water monitoring
- BlockChain logging of water quality
- Vacuum assisted evaporation with renewables to reduce tailing requirement

# Solution clusters is composed of different combinations of technology elements across different domains




| | | | |
|---|---|---|---|
| 5.Stakeholders | STAKEHOLDER | 5.9.S_Customer | Customers |
| | | 5.8.S_Shareholders | Shareholders |
| | | 5.7.S_Banks | Banks |
| | | 5.6.S_Politician | Politicians |
| | | 5.5.S_Community | Society/Community |
| | | 5.4.S_Regulator | Regulators |
| | | 5.3.S_Supplier | Suppliers/Partners |
| | | 5.2.S_Employee | Employees / Unions |
| | | 5.1.S_Environment | Environment (land/air/water/diversity) |

| | | | |
|---|---|---|---|
| 4.Decisions | DECISIONS | 4.6.D_Short_Long | Short/Long term |
| | | 4.5.D_Profit_Growth | Profit/Growth |
| | | 4.4.D_Risk_Return | Return/Risk |
| | | 4.3.D_Authority | Accountability/Authority |
| | | 4.2.D_Part | Part/Whole |
| | | 4.1.D_Central | Centrallized/Decentrallized |

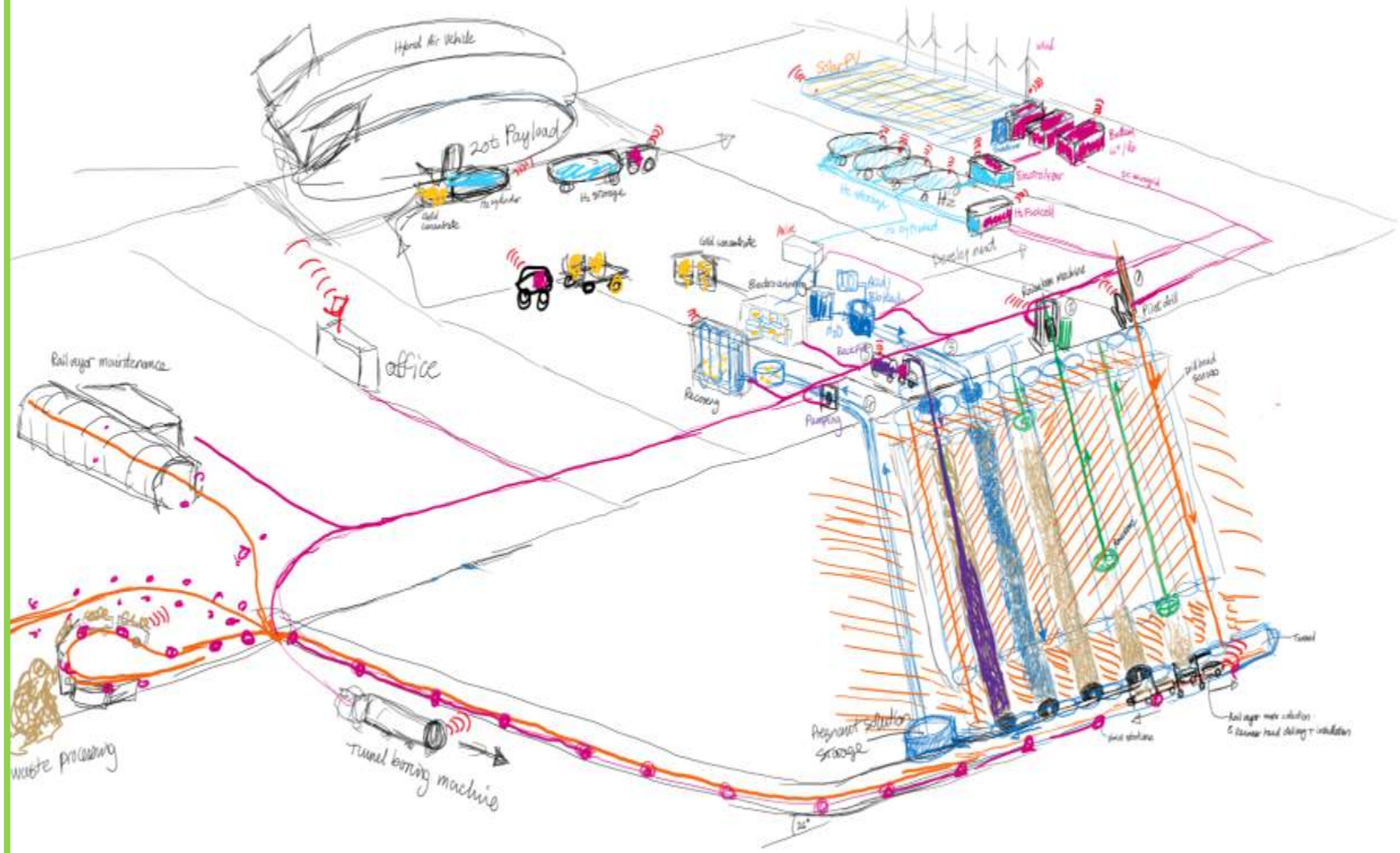
| | | | |
|---|---|---|---|
| 3.Information | INFORMATION | 3.6.I_Action | Action |
| | | 3.5.I_Optimize | Optimization |
| | | 3.4.I_Analysis | Analysis |
| | | 3.3.I_Aggregate | Aggregation |
| | | 3.2.I_Network | Networking |
| | | 3.1.I_Sensors | Sensors |

| | | | |
|---|---|---|---|
| 2.Material | MATERIAL | 2.10.M_Engineering | Engineering |
| | | 2.9.M_Maintenance | Maintenance |
| | | 2.8.M_Ops_Process | Operation: Process |
| | | 2.7.M_OpsTransport | Operations: Transport |
| | | 2.6.M_OpsSeparate | Operation: Separate |
| | | 2.5.M_OpsLiberate | Operation: Liberate |
| | | 2.4.M_OpsDetect | Operation: Detect |
| | | 2.3.M_Development | Development |
| | | 2.2.M_Exploration | Exploration |
| | | 2.1.M_Orebody | Ore body: Resource/Reserve |

| | | | |
|---|---|---|---|
| 1.Energy | ENERGY | 1.8.E_Environment | Environment |
| | | 1.7.E_Stakeholder | Stakeholder |
| | | 1.6.E_Use | Use |
| | | 1.5.E_Trans | Transport/Transmit |
| | | 1.4.E_Storage | Storage |
| | | 1.3.E_Product | Energy product |
| | | 1.2.E_Conversion | Conversion |
| | | 1.1.E_Resource | Energy resource |

# Creating a concept visualizing of the systems integration of design elements

- Modular equipment
- Fully electrified
- 100% Renewable energy
- Precision mining
- Fully automated
- Remote monitoring
- No mine camp
- No explosives
- In-situ processing
- Water recovery
- No tailings
- No waste dump
- Smallest footprint
- Zero emissions
- No road/rail infrastructure
- Daily commute
- Community engagement



# Using a flexible and versatile modeling and 3D visualization platform to create more immersive experiences to engage the various stakeholders.

NRCan

Canadian Server with access control

1 PPT: Concepts

FOM Requirements

FOM Design Concepts

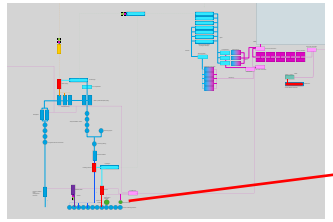
2 System element database

Structure categories/domains

Database of FOM elements

Index of model components

3 MineRP Dash: 2D



Relationship between element

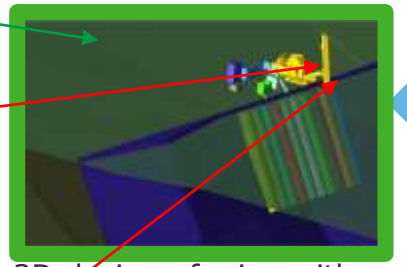
Physical layout of ecosystem

Different ecosystem layers

Hyperlink

Documents / websites / Vendors

5 MineRP Publisher: 3D



3D design of mine with orebody

360° viewing and orientation

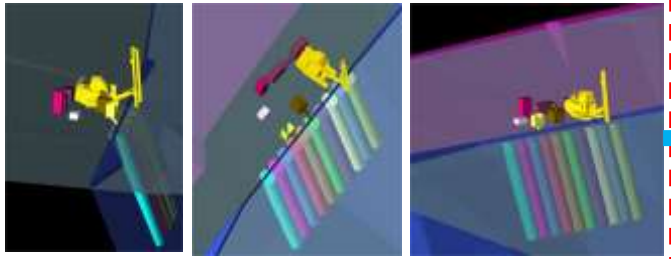
Sequencing / Animation

4 3D Object Database

3D Physical objects

Symbols / Descriptions

6 Discussion support



Static images with annotations

Dynamic animated video clips

Stakeholder collaboration

7 MineRP 3D Spatial Analyzer

Detailed mine planning

Scheduling

LOM modeling

MineRP

Deep dive

Gaming engine

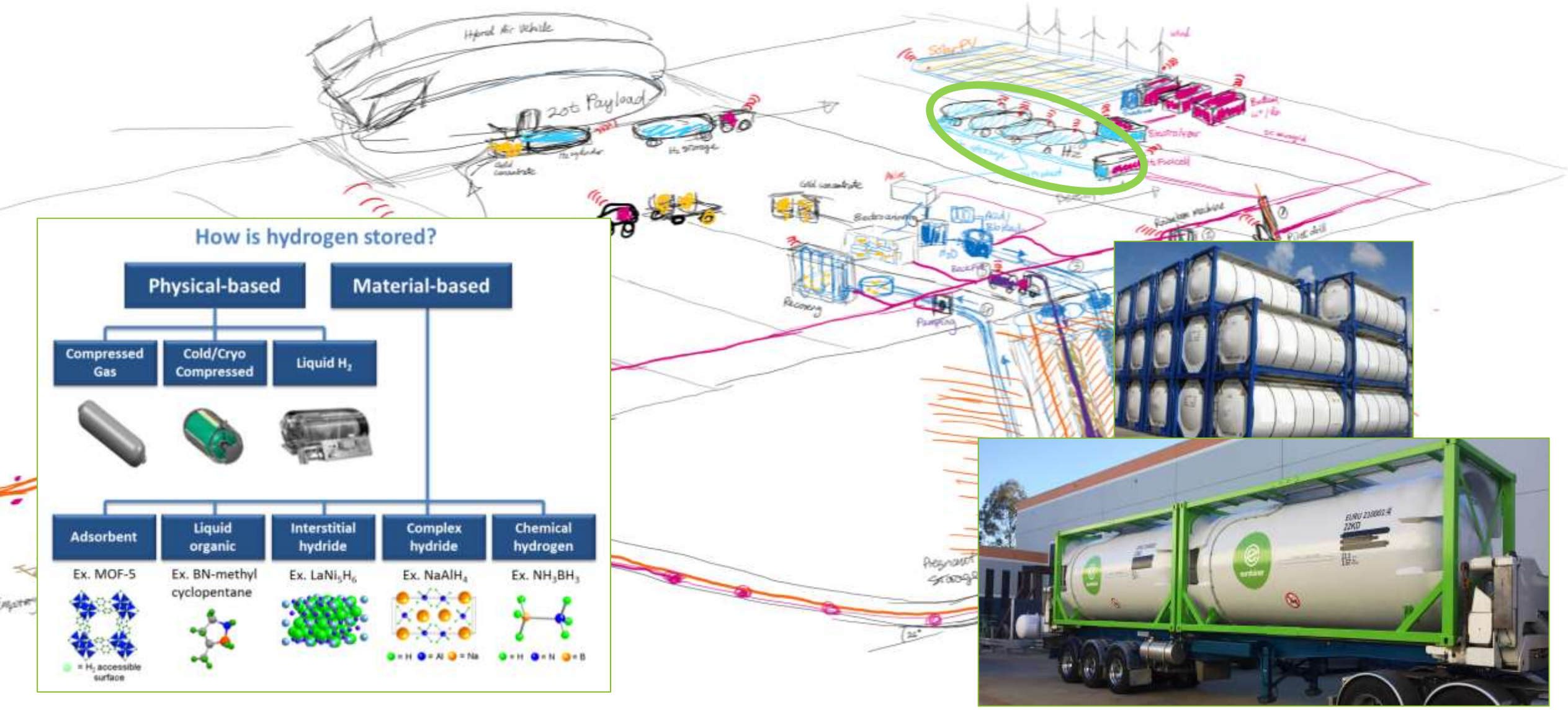
8 Virtual Reality

Immersive environment

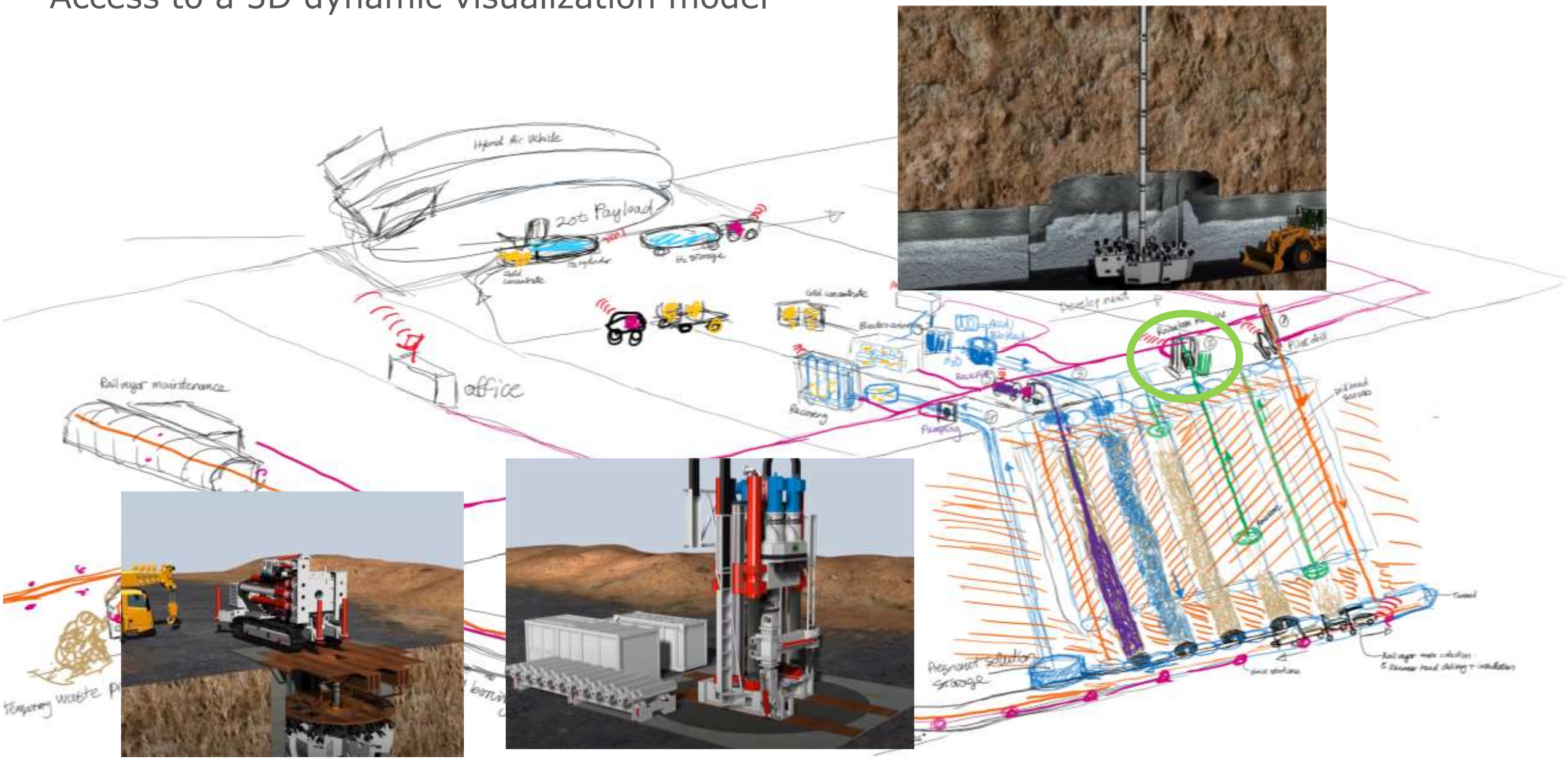
Feedback

# Access to a 3D dynamic visualization model

# Access to a 3D dynamic visualization model



# Access to a 3D dynamic visualization model




https://www.youtube.com/watch?v=pCyDS553acw