

# METS Ignited

The Industry Growth Centre  
For Australia's METS Sector

GLOBAL MINING GUIDELINES GROUP

# GMG

*Innovation  
through  
Collaboration*



— QUEENSLAND —  
**ROBOTICS**

## Industry trends in system safety: An update

**Andrew Scott**

August 2021

[www.metsignited.org](http://www.metsignited.org)



Australian Government  
Department of Industry, Science,  
Energy and Resources

Industry  
Growth  
Centres



# SAFETY SHARE

# METS Ignited is one of six Federal Government Funded Industry Growth Centres at the forefront of the Australian Government Innovation Policy



## METS Ignited collaborates with

- State and territory Governments
- Industry bodies
- Mining companies
- METS companies
- Research organisations

Supporting and growing the Australian METS sector.



# What does METS Ignited do?

Australia is recognised globally as a leader in the application of technology in the mining sector.

METS Ignited operate a series of industry events in collaboration with a range of industry partners, to ensure the sector that realise these benefits, leveraging our global industry leadership position, and to ensure that we scale and grow our future skills and capabilities nationally.

## Industry Clusters

### Industry Ecosystem

With 15 events over the past 9 months, and over 500 attendees, including world leading mining companies, researchers, and METS Companies, today there are a number of emerging clusters in the METS sector. METS Ignited can help establish your cluster initiative.

## Masterclasses

### Future Industry Skills

The Future Skills program provides a range of industry skills with a mix of different delivery models, from online content, remote facilitation, and group training sessions. The focus of the course is to deliver practical skills in data, analytics, machine learning and artificial intelligence

## Export Collab

### Market Entry

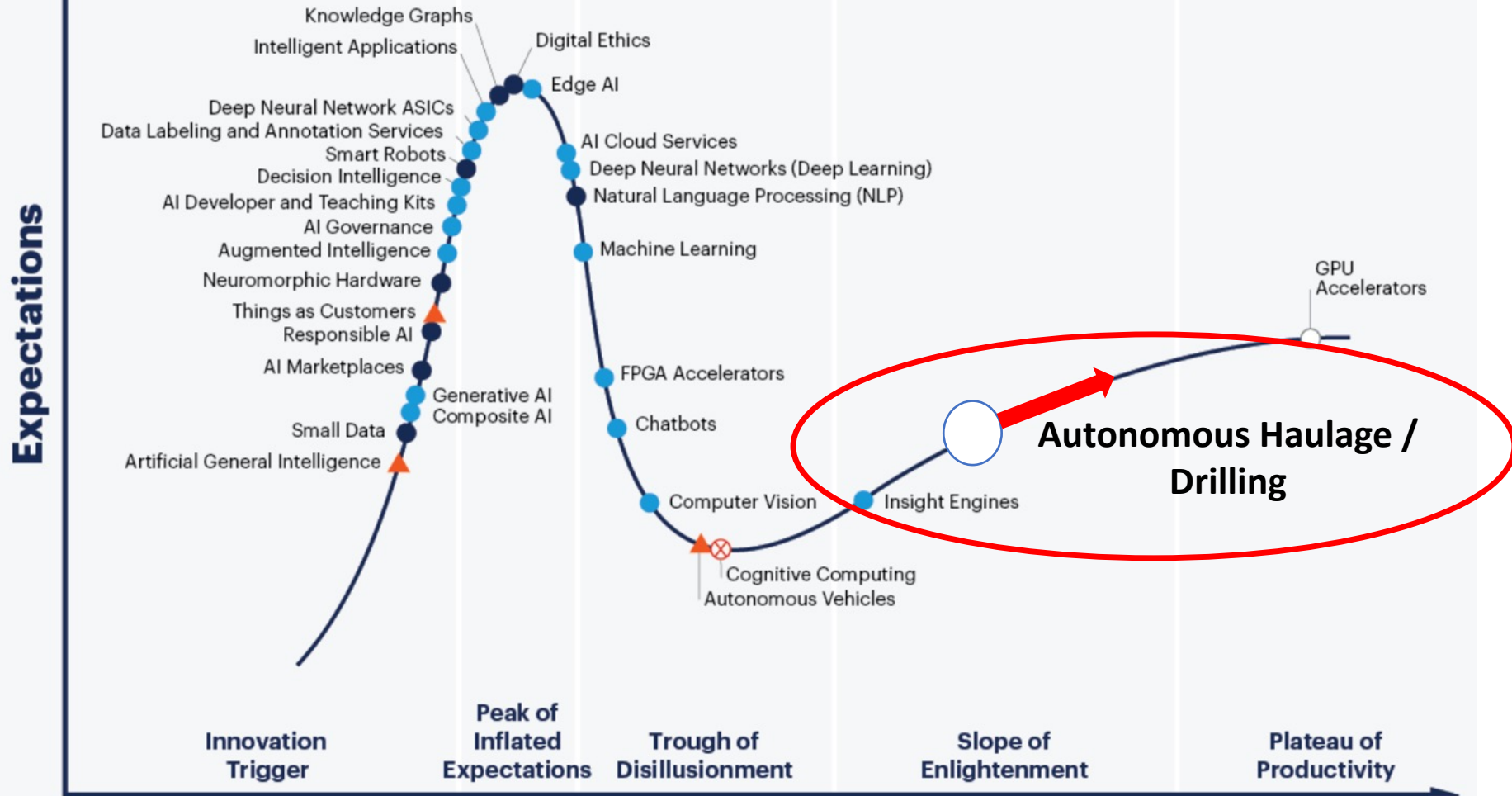
Co-ordination of multiple government and industry body programs and in-market business support such as co-working spaces, professional, networking access, introduction to relevant industry bodies, associations and potential collaborative international METS companies

## National Accelerator

### Sustainable Growth

The next phase of the Accelerator Program is the Scale Up and Take Off stream – where the program will further expand into areas of Investment Education – Managing through cycles – Dealing with Growth and Skill and Resourcing for the Future.

The resource sector is probably more prepared than most



Plateau will be reached:

○ less than 2 years

● 2 to 5 years

● 5 to 10 years

▲ more than 10 years

⊗ obsolete before plateau

As of July 2020



# Driven by Asia, the Industrial Robo-force Swells

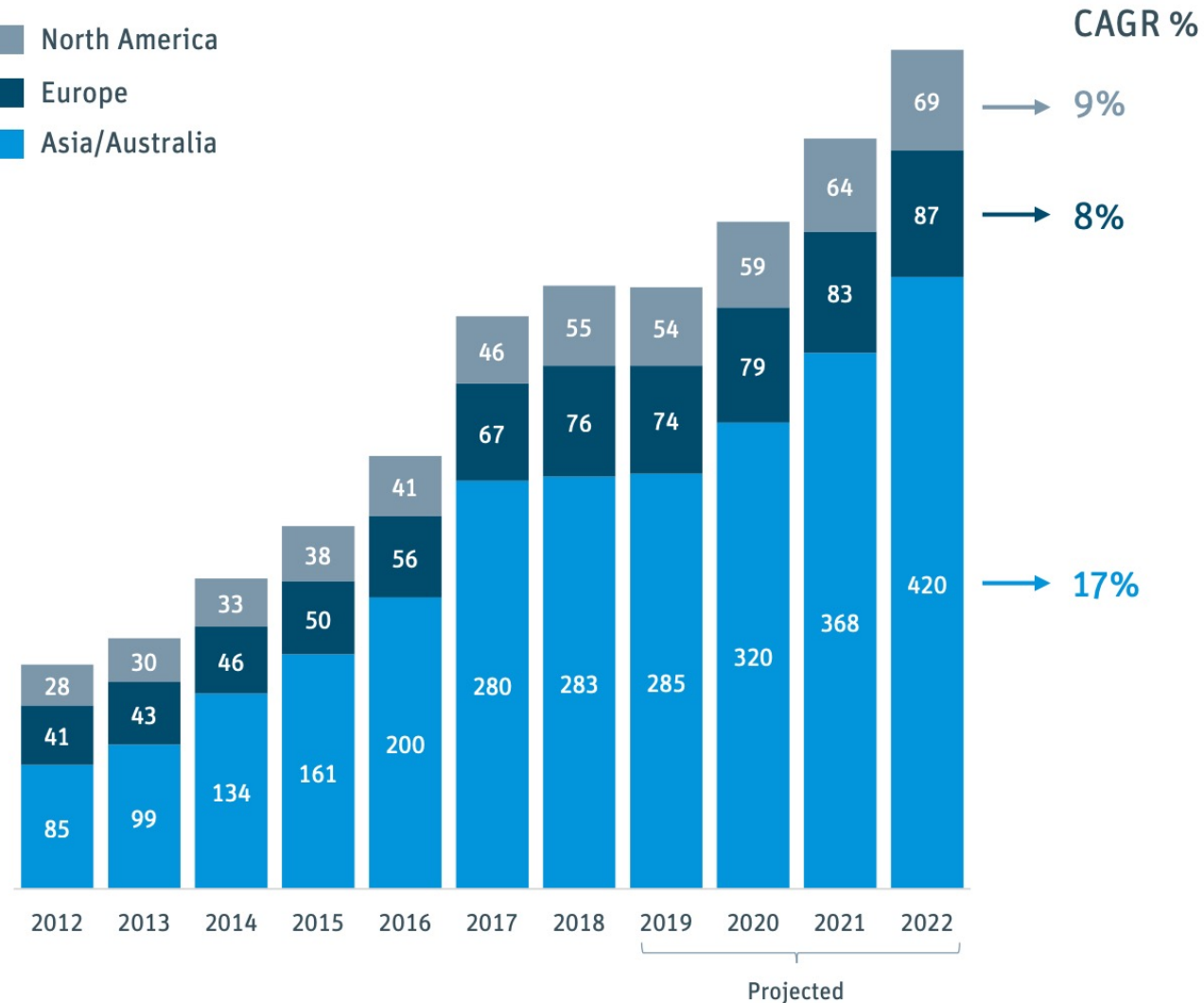
Annual installations of industrial robots have more than doubled since 2013, growing at 18% CAGR<sup>1</sup>. This is expected to slow in the next four years to 9%. China has led the way, increasing its stock of industrial robots nearly fivefold.

While impressive, this rate of growth is not tremendous. Innovating the existing stock of robots is a compelling opportunity, as is expanding that stock.

## Annual Installations of Industrial Robots by Region

Thousands of Units

- North America
- Europe
- Asia/Australia



QUEENSLAND  
ROBOTICS



# It feels like where we where back in 1995



Sensor costs  
Computational costs

AI / Tools /  
knowledge  
Acceptance /  
adoption



# Facets of **Ethical AI** in Defence



## **RESPONSIBILITY**

Who is responsible  
for AI?



## **GOVERNANCE**

How is AI controlled?



## **TRUST**

How can AI be trusted?



## **LAW**

How can AI be  
used lawfully?



## **TRACEABILITY**

How are the actions  
of AI recorded?

<https://www.dst.defence.gov.au/publication/ethical-ai>



# Robotics and Autonomous Systems – the issues

*they aren't resilient enough?*

## **Persistent Autonomy**

- managing uncertainty and unpredictability,
- persistent perception,
- multi-modal fusion,
- self-healing systems,
- assertive actuation.

*they aren't smart enough?*

## **Machine Cognition**

- machine learning,
- artificial intelligence,
- symbolic reasoning and logic,
- theory of mind,
- planning,
- decision making,
- social agents.

*people don't trust them?*

## **Human-Autonomy Integration**

- human-machine models,
- behavioural and social models,
- psychometrics,
- shared decision making,
- trust and uncertainty,
- communications and narrative.

# Robotics and Autonomous Systems – WIP

## Perception and Sensing

- resilient perception,
- scene, situation and self-understanding,
- modular low-cost intelligent sensors,
- bio-inspired sensing.

## Effectors and Platforms

- self-managing platforms,
- adaptable platforms and effectors,
- bio-inspired platforms,
- micro-systems, novel actuation,
- low observability.

## Intelligent Systems

- multi-modal, multi-platform, data fusion,
- multi-platform, multi-role decision making,
- human-system integration.



Space  
Healthcare  
Manufacturing



SMALL  
SMART  
MANY

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Mining  
Defence  
Agriculture  
Construction

[www.makerimmersion.com.au](http://www.makerimmersion.com.au)



Screenshot



Opportunities

“My Camera. Take Photo.”



realwear.



2016

HARPER ADAMS UNIVERSITY

The Hands Free Hectare project aims to cultivate a field without humans setting foot on it

**Today**

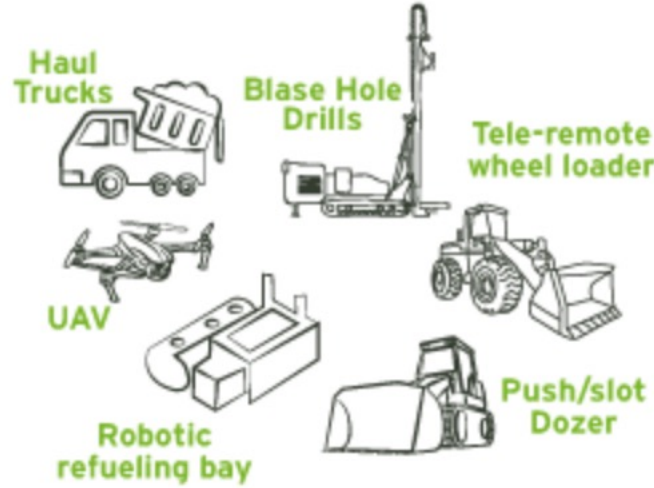


# Autonomous Mining Eco-Systems



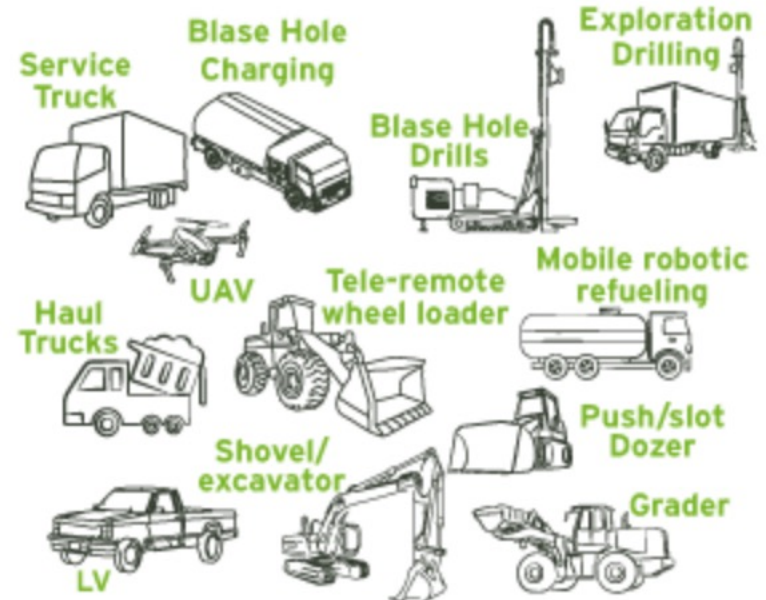
## Launch of autonomous mining programs

- ▲ Safety
- ▼ Productivity
- ▲ Cost
- ▲ Environmental/Carbon footprint
- ▼ Workforce Transition



## Mixed-mode autonomous operation

- ▲ Safety
- ↗ Productivity
- ↘ Cost
- ▲ Environmental/Carbon footprint
- ↗ Workforce Transition



## Zero-Entry Mining

- ▲▲▲ Safety
- ▲▲ Productivity
- ▼ Cost
- ▼▼ Environmental/Carbon footprint
- ▲ Workforce Transition

2005

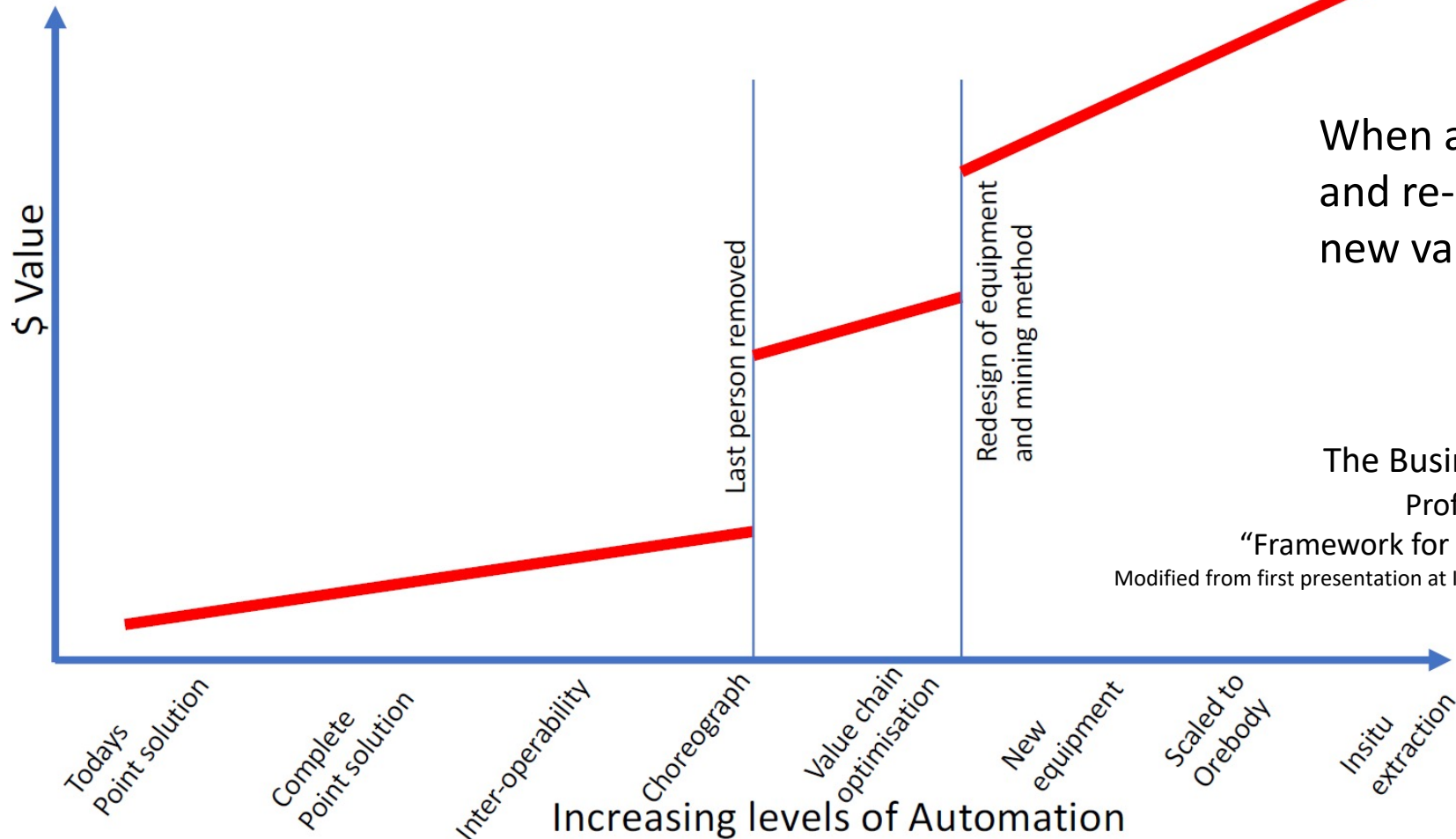
2020-today

Future



# The value of zero entry mining

## Value of Zero Entry Mining



When automation enables both zero entry and re-imagined mining methods, significant new value is unlocked.

The Business Case for Zero Entry Mining

Prof Peter Knights & Gavin Yeates

"Framework for the Path to Zero Entry Mines", Jul 13 2021

Modified from first presentation at IEEE-ICIT Automation in Mining Conference, Melbourne, 13-15 Feb 2019

# Challenges for zero entry mining

Three broad areas of challenge:

- (i) Operations
  - (i) Interoperability
  - (ii) Autonomy/RC gaps
  - (iii) Mission planning
  
- (i) Integrity
  - (i) Cyber-security
  - (ii) Risk Control (Configuration management)
  - (iii) Reliability and fail-safe design
  
- (i) Support
  - (i) Campaign Maintenance and Equipment recovery
  - (ii) Skills requirements



<http://news.dronesforhire.com.au/post/144500118867/for-mining-drones-keep-projects-on-track>

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# Operations

- 1. Interoperability.** How should equipment best co-operate? This explores issues related to sharing procedures, applications, infrastructure and data between equipment from different OEMs
- 2. Automation/RC gaps.** How do we manage equipment inspection, refuelling, cable movement and geological and geotechnical surveying practices in a zero-entry mine?
- 3. Mission planning:** How do we best coordinate mission planning in a multi-agent environment?

	Procedures	Applications	Infrastructure	Data
5. Enterprise				
4. Domain		X		
3. Functional	X		X	
2. Connected				X
1. Isolated				

Inspiration: Defence Inter-operability standards

The Business Case for Zero Entry Mining

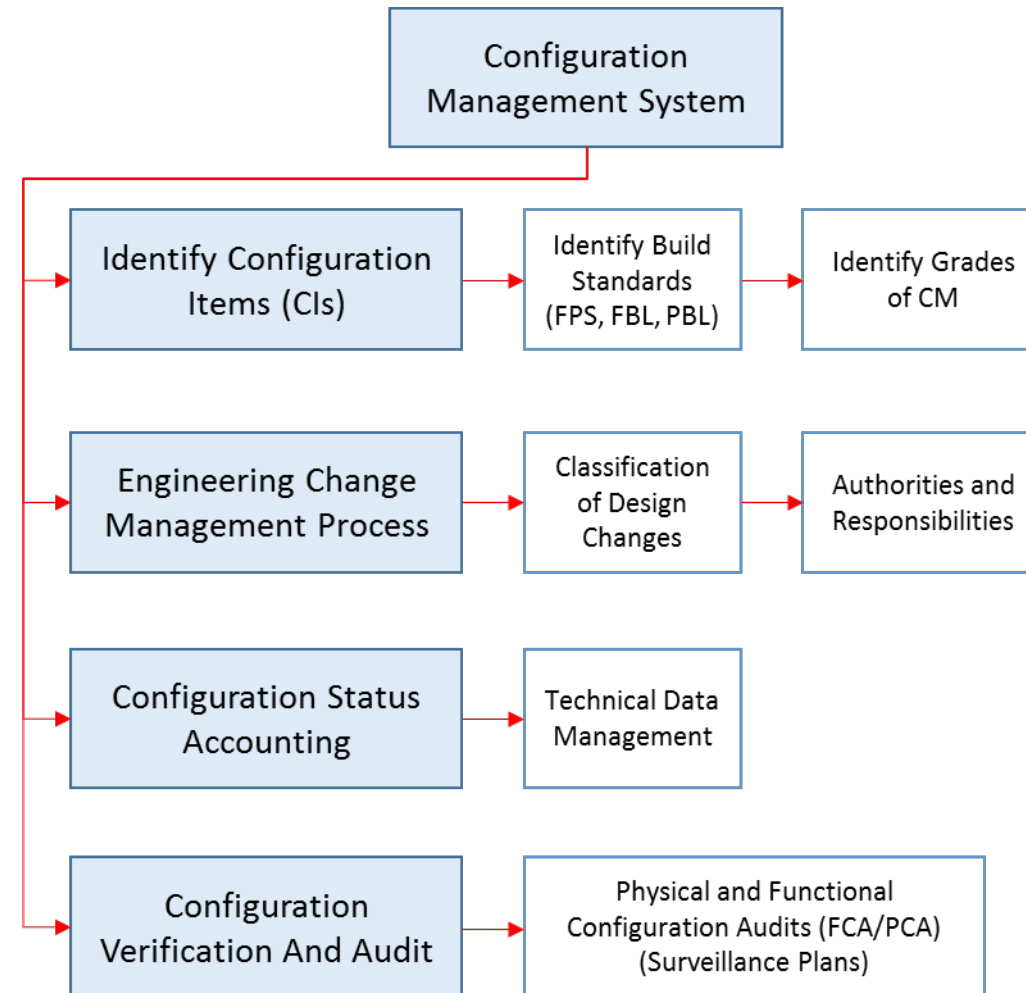
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# Integrity

1. **Cyber security.** How can we prevent malicious damage due to cyber attacks and hacking?
2. **Risk management.** How can we best control changes to equipment configuration, application or environment so as to minimise risk?
2. **Reliability and Fail-safe design.** What are the possible new failure modes? Make extensive use of Use Case Modelling in mission design. Apply function safety systems and System-Theoretic Process Analysis thinking (Levinson & Thomas, 2018)



Inspiration: Defence Configuration Management Process

1. Campaign Maintenance. Maintaining equipment to complete extended periods of remote service. This involves:
  1. Knowing what jobs to perform during maintenance downtime
  2. Enhanced condition and performance monitoring
  3. Precision maintenance (doing work properly)
  4. Operation within limits
  5. Testing and surveillance of critical functions
  
2. Equipment recovery  
How do we retrieve broken down equipment from zero-entry mining zones? Needs enhances systems and robotics thinking.
  
3. Skills requirements
  1. What are the new job roles involved with zero-entry mining?
  2. How do we best prepare people for these new roles?

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# Conclusion

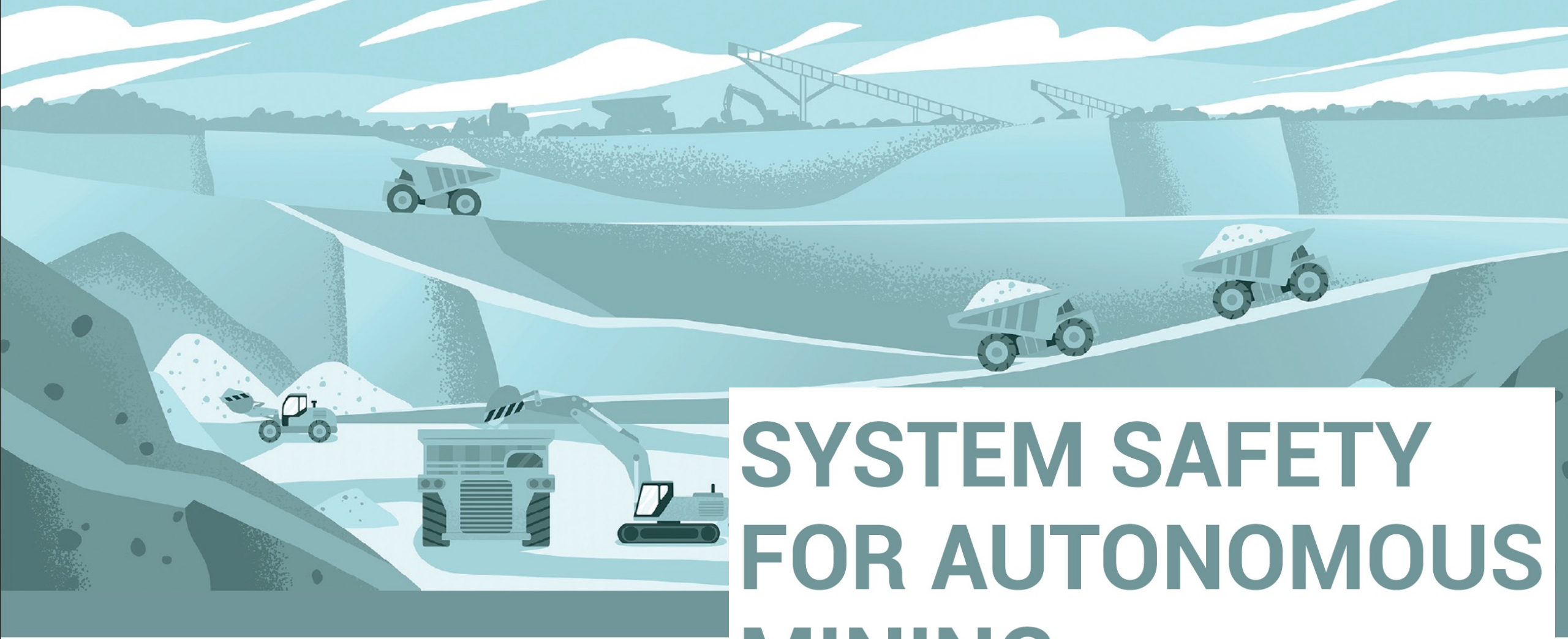
- Zero entry mining has the potential to unlock significant value in the form of enhanced safety, productivity, operating costs, capital intensity and enhancement of reportable reserves.
- However, some significant hurdles need to be overcome in order to introduce zero-entry mining.
- These challenges include: **interoperability; systems integrity** and **support** involving maintenance and recovery strategies as well as skilling requirements.

The Business Case for Zero Entry Mining

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# SYSTEM SAFETY FOR AUTONOMOUS MINING

GLOBAL MINING GUIDELINES GROUP

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A White Paper to Increase Industry Knowledge  
and Enable Industry Collaboration on Applying  
a System Safety Approach to Autonomous Systems





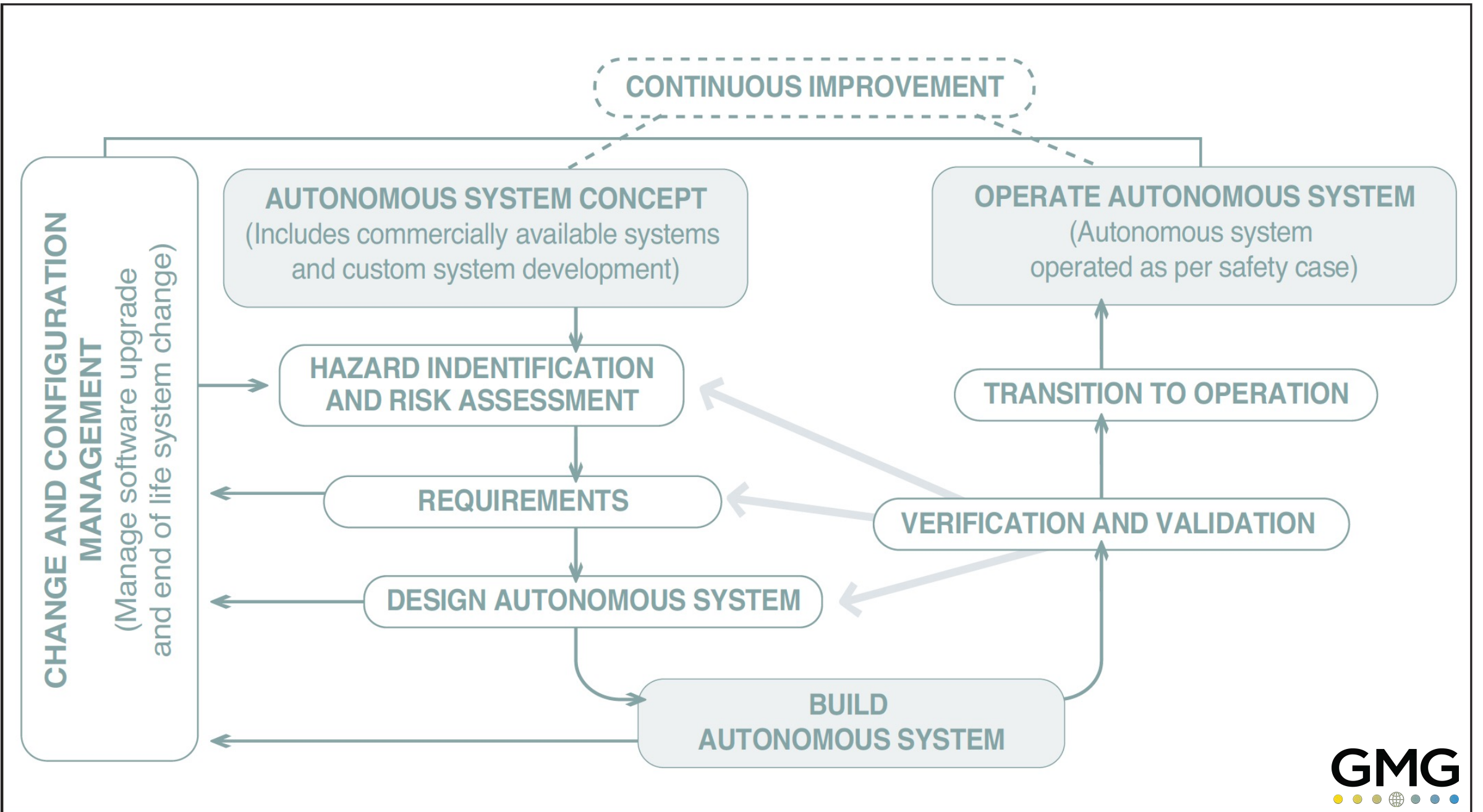
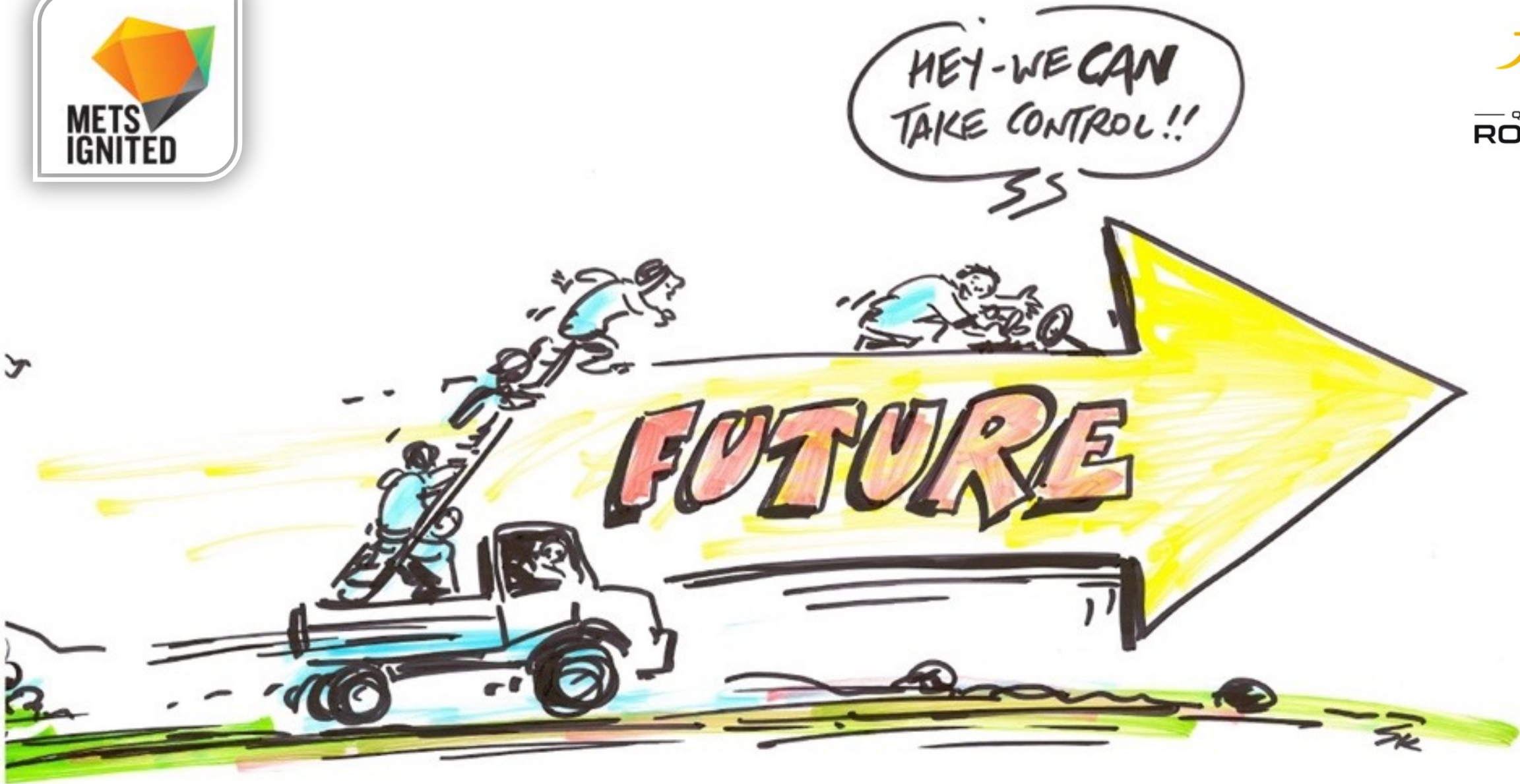


Figure 2. Example of System Safety Lifecycle for Applying Autonomous Systems in Mining



EXPLORATION + MINING + SPACE + AGRIBUSINESS + MANUFACTURING + BIONICS + AI + ROBOTS = SUSTAINABLE FUTURE



— QUEENSLAND —  
**ROBOTICS**

BUILDING A SUSTAINABLE ROBOTICS INDUSTRY

[www.qldrobo.org](http://www.qldrobo.org)

*“The march of digitalisation, robotics, automation, 3D printing and a plethora of other technological innovation will affect most jobs in some way. But it’s **people**, not technology that will decide the **future of work**. The right decisions will put technology at the service of people with full employment and just transition measures for workers.”*

*- Sharan Burrow, Vice-Chair, The B Team*

**Any questions?**

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**GMG**



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in our future*

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