

# Mining in the Future: Autonomous Robotics for Safer Mines



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# Mining in the Future

- Safer mines with reduced hazard to which personnel are exposed
- Improved production and efficiency
- Gain access to new resources
- Many industry leaders are investing in automation in both underground and opencast mining
  - Rio Tinto/ ACFR
  - Anglo American 2030 mine
  - Sandvik
  - Atlas Copco
  - Komatsu
  - CMU

# Field Robotics



- Robotic systems for “real-world” environments
- Operating in environments:
  - Dynamic, unknown and unstructured
  - People may be present
- In contrast to controlled environments (e.g. Factories/Assembly Lines), these environments are much more challenging
- MIAS focuses on field robotics

# Advantages of Autonomous Robots

- There are several advantages to using autonomous robots
  - Operate in extreme/inaccessible environments
  - Do not suffer from fatigue and the associated errors
  - Not bored by repetitive tasks
  - Require less support infrastructure
  - Advanced sensors

# Degree of Autonomy

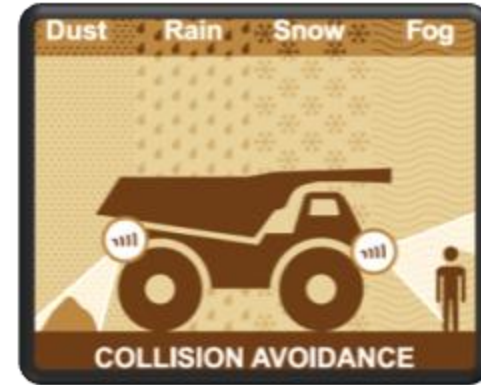
- Teleoperation



- Semi-autonomous



- Autonomous



# Mobile Intelligent Autonomous Systems Group

- The Mobile Intelligent Autonomous Systems (MIAS) was formed as an Emerging Research Area (ERA) in 2007.
  - CSIR did not have existing capability
  - Was deemed to be an important future capability
- First 5 years focussed on capability building – now moving into commercial ventures
- Focus is on intelligence and sensors for field robotics applications

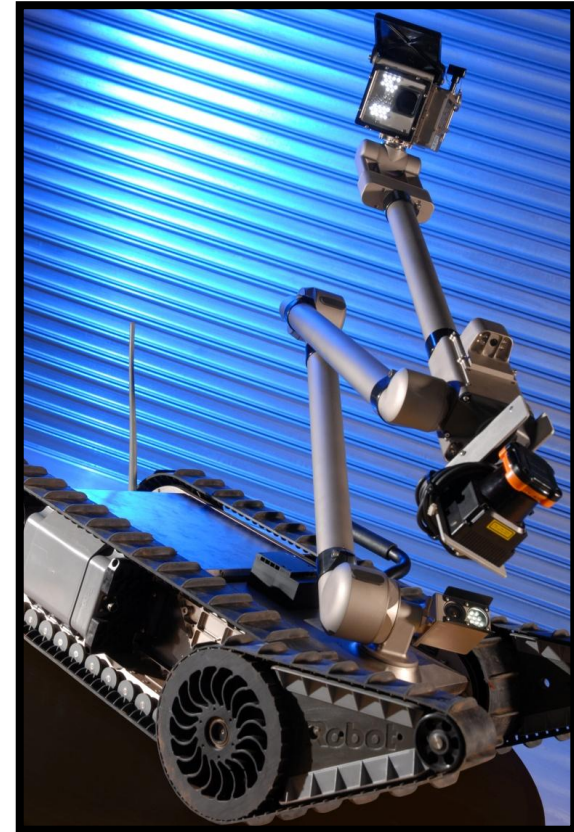
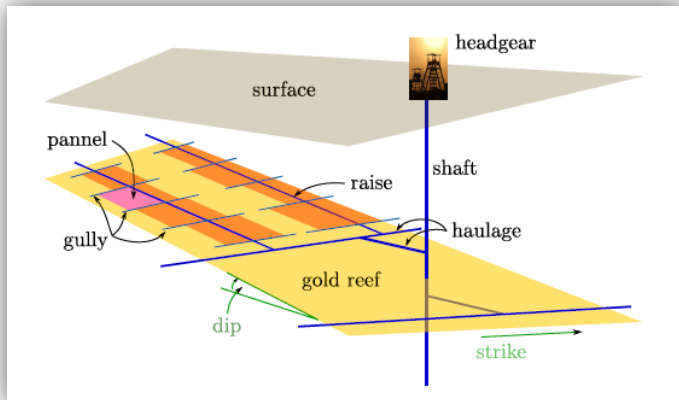
# Autonomous Rover

- A GPS-guided autonomous platform
- Autonomously navigate along known paths with collision avoidance
- Applications of this technology include
  - Security patrols
  - Transportation of cargo
  - Mining



# Mine Safety Platform

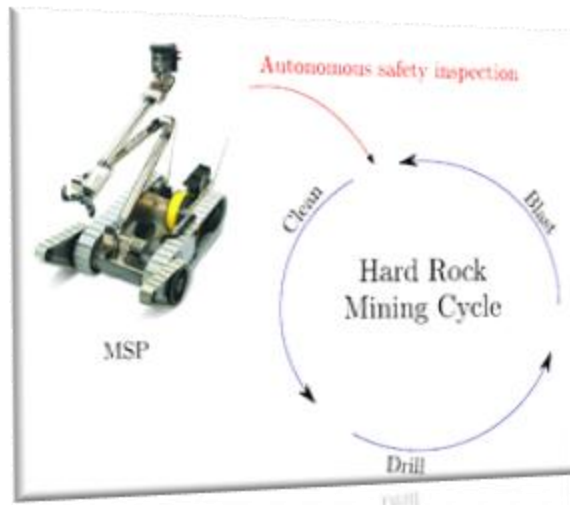
- Joint project with CSIR Centre for Mining Innovation and Material Science and Manufacturing
- Focuses on performing pre-entry safety inspections in deep mines





# Problem Statement

- South Africa's hard rock mining is one of the most dangerous types of mining
- Many fatalities happen post-blast and before stabilizing the roof



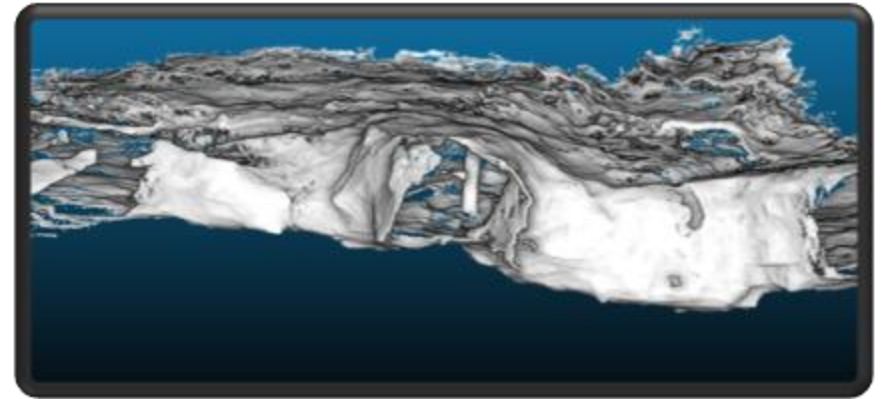
# Challenges

- Unknown and unstructured environment
- GPS deprived
- No landmarks and few distinguishing features
- Hostile environment, i.e. dark, humid, high temperatures
- Challenging to traverse



# Operation Phases

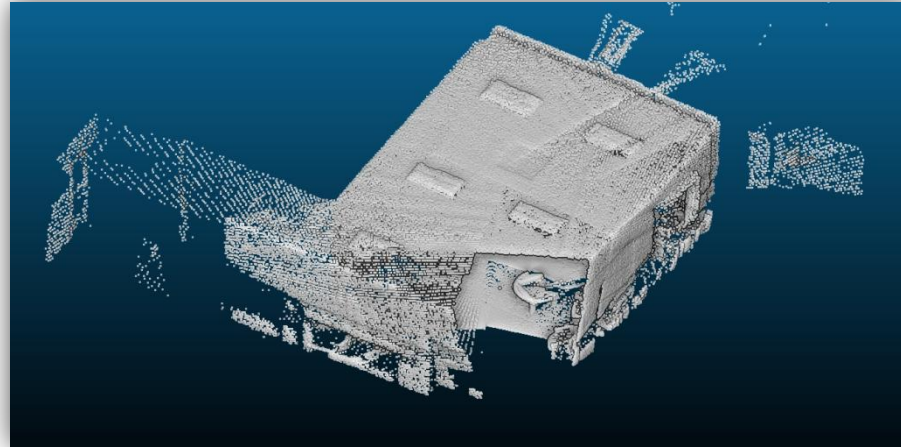
- Simultaneous exploration and mapping
  - Local scans
  - Exploration frontier planning
  - Path planning
  - Platform motion control
  - Global map generation
- Sampling user-defined points on the hanging wall
- Generate a hazard map of the entire hanging wall



# System Modules

- Exploration

- Localization



- Manipulation



# Current System

The screenshot displays the ROS RViz interface for a mobile robot system. The window title is "packbot\_ui2.vcg\* - RViz" and the system clock shows "Mon Oct 1, 4:14 PM". The interface includes a menu bar (File, Panels, Help) and a toolbar with options like "Move Camera", "Interact", "Select", "2D Nav Goal", and "2D Pose Estimate".

The "Operator" panel is visible, showing the following settings:

- PHASE: Exploration
- OPERATION MODE: Manual
- Execution: Running
- Joystick mode: DRIVE
- A prominent red "E-STOP" button is located at the bottom of the Execution section.

The main display area is split into two parts:

- Image:** A top-left camera view showing a mobile robot in a large, brightly lit indoor space.
- Image2:** A bottom-left camera view showing a different angle of the same robot.
- 3D View:** A large central 3D visualization showing a point cloud of the environment. A 2D floor plan is overlaid on the ground plane, with different colored regions (red, green, blue, yellow) representing various areas or obstacles. A 3D model of the robot is positioned on the floor plan.

At the bottom of the interface, a "Time" panel displays the following metrics:

- Wall Time: 1349100861.56
- Wall Elapsed: 572.81
- ROS Time: 1349100861.56
- ROS Elapsed: 572.81
- Current workspace: "Workspace 1"

# Conclusions

- Field robotics can help increase the safety in mining operations
- Tele-operated, semi-autonomous and autonomous robots can be utilized to reduce the hazard to which personnel are exposed
- Robots can be beneficial in operation in extreme/inaccessible environments, i.e. no fatigue, less error, repetitive tasks, less support infrastructure, advanced sensors
- Autonomous Rover Project outcome can be adopted for automating haul trucks in opencast mines
- Mine Safety Platform is a joint project with CMI and MSM targeting the task of post-blast inspection in deep hard rock mines

# Thank you

