MINERALS COUNCIL
SOUTH AFRICA

FOGAP NEWSLETTER
EXOSKELETONS

November 2023 edition

As part of its **Fall of Ground Action Plan** launched in July 2021, the Minerals Council South Africa and its members set out to investigate the potential of **exoskeletons** in reducing falls of ground risks during barring, through improved safety and effectiveness of the task.

Research undertaken between September and October 2023 led to the shortlisting of 8 high-potential commercially available exoskeletons for use in underground mining.

These 8 exoskeletons shortlisted stood out due to the following characteristics:

- Light weight and promising user-friendliness features
- Target support of the muscles typically put under strain in the act of barring.
- Can offset the weight range of standard pinch bars at varying lengths.
- Have no electronic components and seem to meet safety standards for underground mining.
- Have costs that can be feasibly covered by mining operations.
- Suppliers are open to further R&D improvements for specific use in mining.
- Have durable materials and are easy to maintain onsite.

The Minerals Council will follow four steps to validate and -- if successful -- implement this promising technology in underground mining:

1) Obtain shortlisted models for testing in South Africa

2) Test and trial in a mock-up environment with key ergonomics, biokinetics, and user-experience assessments

3) Coordinate testing and piloting in underground testing environment (Mandela Mining Precinct Test Mine)

4) Transition from Research, Development and Innovation to dissemination of leading practices. Promote within industry.

Safer and more efficient barring: exoskeletons review

The mining industry is committed to reaching its **Zero Harm** ambitions.

Despite recent encouraging improvements, such as the safety performance in 2022 of the industry with the lowest number of annual fatalities, and a 73% reduction in fall of ground fatalities compared to 2021, falls of ground are still a significant area of concern.

More recently, a tragic increase to 14 fatalities due to falls of ground has been experienced in 2023 up to mid-October.

The Fall of Ground Action Plan launched in July 2021 by the Minerals Council and its members, identified the need for a new, safer approach for removal of loose rock under its Research & Development pillar.

This technology or solution should remove or distance the worker from the direct hazard area of potential rock falls.

Initial research in 2022 and early 2023 indicated the promising potential of exoskeletons to improve quality, safety and efficiency of barring.

In 2022, the Loose Rock Removal innovations technology scouting identified exoskeletons (wearable technology) as one of four types of technologies with high potential to improve barring.

RETC now wants to identify and test potential of exoskeletons for improved and safer barring.

The findings of the research between September and October 2023 aimed to:

- Define requirements for exoskeletons to be used in barring in SA underground mining.
- Identify existing exoskeletons available meeting these criteria.
- Evaluate and select top potential exoskeletons for further testing and trialing; and
- Recommend next steps.

What is an exoskeleton?

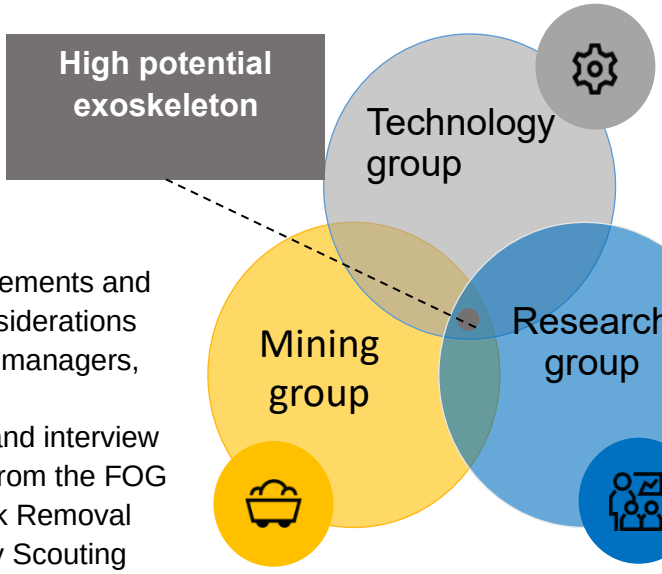
Originally designed for rehabilitation and medical support, exoskeletons are wearable robotic suits engineered to augment human strength, endurance, and mobility.

By providing ergonomic support and redistributing loads, exoskeletons alleviate physical strains, thereby minimising the risk of Muscular Skeletal Diseases. Industries such as construction, manufacturing, and logistics are benefiting immensely from these advancements.

With a clear emphasis on worker well-being, exoskeletons are transforming the workplace, ensuring both efficiency and enhanced safety.

So far, the use of exoskeletons has not been explored for use in strenuous tasks in SA underground mining.

Key stakeholder groups



Potential solution providers
Existing exoskeleton manufacturers

User requirements and design considerations
Engineers, managers, miners
Research and interview outcomes from the FOG Loose Rock Removal Technology Scouting report 2022

Implementing partners
Innovation hubs
Research institutions
Centers of excellence

Types of exoskeletons





Type	Arm Exoskeleton	Tool-Holding Exoskeleton	Back Exoskeleton	Leg Exoskeleton	Full-Body Exoskeleton
Purpose	Reduce strain on arms in repetitive tasks (drilling and hammering)	Help carry power/heavy tools over long distances.	Support and reduce stress on spines and back muscles.	Support leg muscles and reduce physical strain of walking / moving on uneven surfaces.	Cover the entire body, improve mobility and support during strenuous physical tasks.
Suitable tasks	Overhead tasks	Tool-carrying	Heavy lifting, carrying, overhead tasks, bending, carrying equipment	Walking, climbing, standing for long periods	Heavy lifting, carrying, overhead tasks, pushing, pulling, climbing, carrying
Price range (ZAR)	22,500 - 65,000	45,000 - 100,000	30,000 - 80,000	45,000 - 100,000	150,000 - 500,000
Main uses	Construction Manufacturing Automotive Filming	Construction Manufacturing Automotive Aerospace Military Filming (gimbals)	Logistics Construction Manufacturing Automotive	Sports Logistics Military Medical (assistive and rehabilitative)	Military Medical (Rehabilitation)

Exoskeletons that meet the functional criteria

Arm supporting exoskeletons

Designed to assist and support workers in tasks that require them to **work with their arms raised above their shoulders for extended periods**.

Come in various types, each designed to support specific parts of the arm:

- **Upper arm support: for overhead tasks and lifting heavy objects, mainly focusing on the upper arm and shoulder. May not address forearm and wrist support needs.**
- **Forearm support: for precision tasks requiring repetitive forearm movements, offering support to the forearm and wrist. Not suitable for tasks requiring upper arm support.**
- **Full-arm support: Versatile and comprehensive, providing support to both the upper arm and forearm. Suitable for many tasks but may be bulkier and more complex.**

Practical considerations: Ensure support offered offsets the weight of the heaviest pinch bar enough to counter the effects of fatigue from holding arms up for extended periods, from the weight of the pinch bar itself as well as the energy expended when prying rocks loose.

Tool-holding exoskeletons

Designed to assist users in **holding, manipulating, and using heavy tools or equipment**.

Different types supporting specific parts of the body:

- **Leg-connected: for tasks requiring significant leg support and distribution of lower body loads. Mobility can be limited, and upper body support may be insufficient for some tasks.**
- **Waist-anchored: Provides upper body support while leaving the legs free. Suitable for many tasks; may not provide as much lower body support as leg-connected devices.**
- **Back-supported: for tasks involving overall body support and loads on the back. Ideal for long-duration activities but may not offer specific leg support.**

Practical considerations: Account for time and effort in mounting different lengths of pinch bars for different stoping widths as well enough degrees of freedom of the frame to carry out the sounding part of barring.