

The background image shows a large, industrial ABB robot arm with yellow and black cables, positioned in a dimly lit tunnel. The robot arm is extended towards a rough, grey rock wall. The wall is covered with numerous small, dark, circular marks, likely from previous drilling or blasting operations. The lighting is focused on the robot arm and the wall, creating a high-contrast scene. The overall atmosphere is industrial and technological.

NIOSH OCTOBER 2024, JAN NYQVIST

ABB Robot Charger for tunnel explosive charging

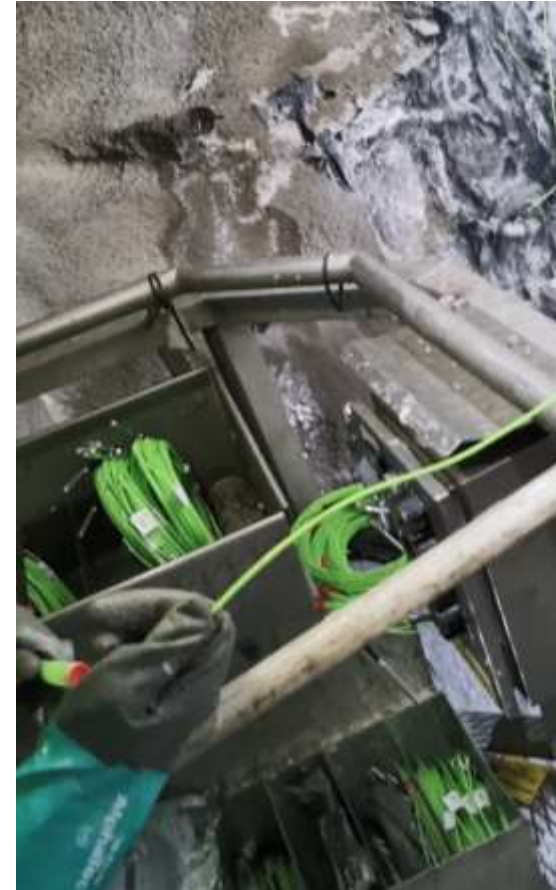
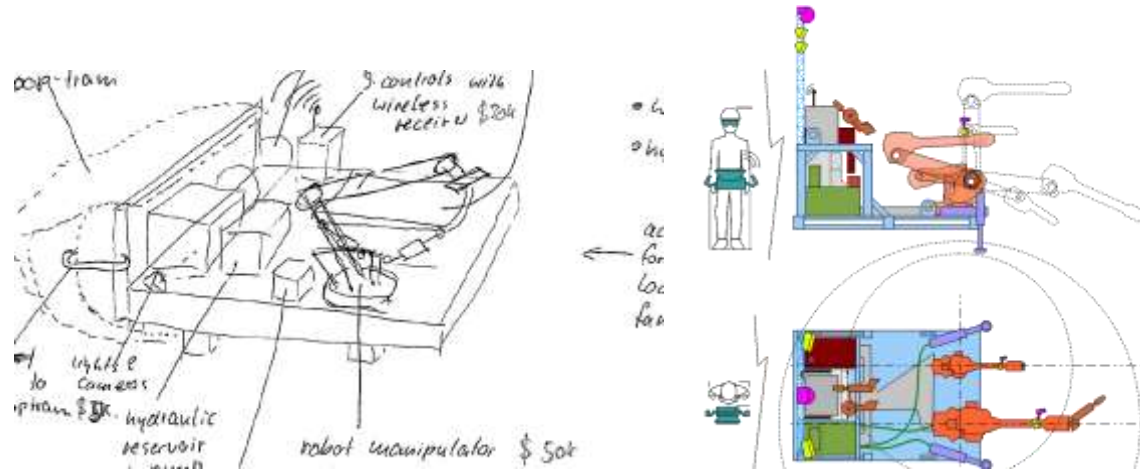
Mining robot technology for protecting people

Background and purpose

Safety first

Charging is one of the more dangerous operations in underground mining. Today, the operator needs to stand close to the drilled and unreinforced rock face to manually load the holes with explosives from a work platform.

The development of the Robot Charger started as a R&D initiative, to explore possibilities of **increasing safety through automation**. The goal was to be able to offer people a safer and more healthy working environment



Our Business Areas

Electrification

Motion

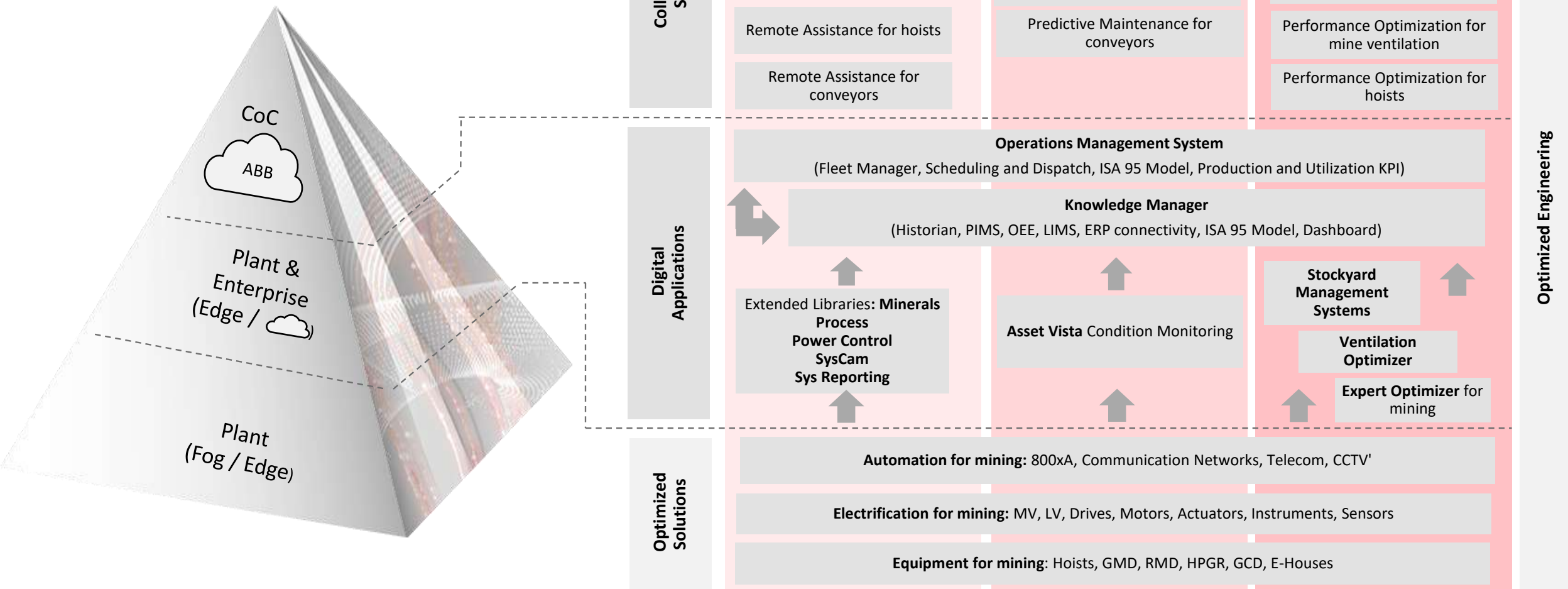
Process Automation

Robotics & Discrete Automation



ABB Ability™ MineOptimize

Automation and Digital Landscape



An ambitious goal

Full safety and automation

By leveraging our unique combined expertise in robotics, automation and mining domain knowledge, we can aim high. That's why we're developing a robotic solution that can load explosives into pre-drilled holes on its own, without a human having to do any operations at the face.

We are boldly investing in renewing underground charging operations and improving the working environment for people.

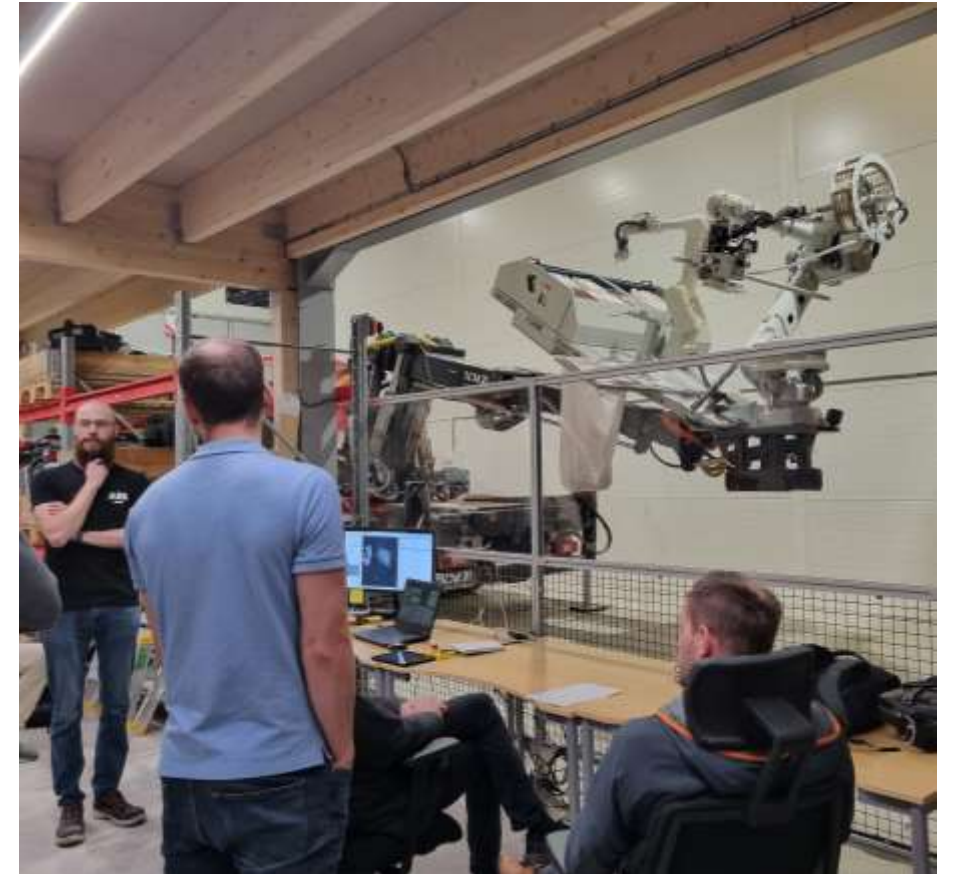
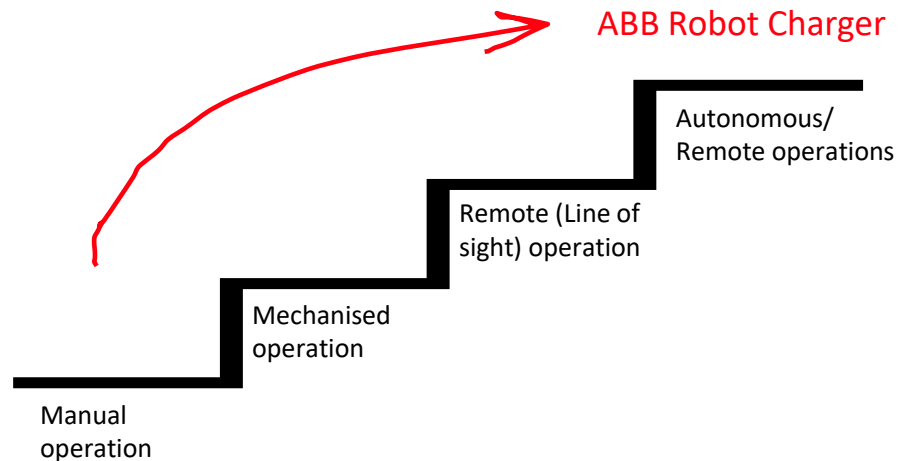


ABB Industrial Robot

A standard product

- Developed, manufactured and supplied by ABB since 1974
- Installed base 400 000+ units
- 30 models in 70 variations
- Payload up to 1000 kg
- Available in IP69 protection class
- Robust with near or 100% operational uptime
- Automotive largest segment expanding in to many other segments



CIMC Fenggang
Automatic shipping container
manufacturing base.



Vision system

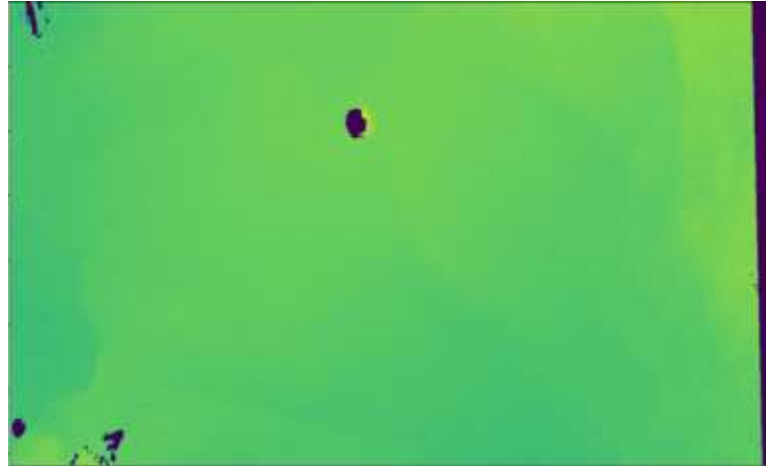
Automatic adaption to new surroundings

The camera



Intel RealSense L515 Lidar-based depth camera for data collection

The image



The depth data is stacked to the color images as a fourth channel, increases the amount of information

The training



The neural network training is done by annotating the overlaid color and depth images

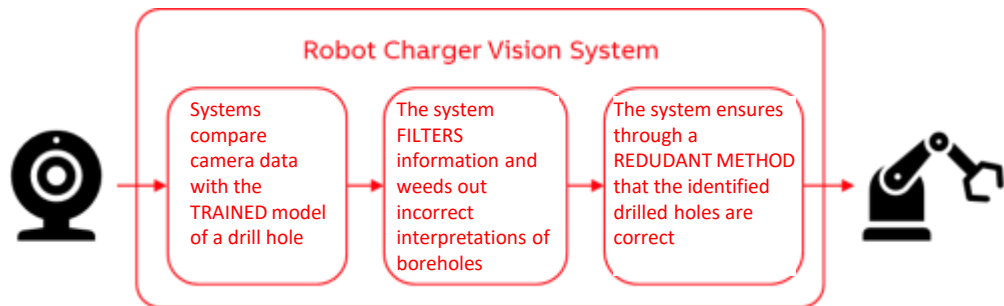
The network model produce robot coordinates in cm precision

ABB Robot Charger – system status

Four dynamic system acting as one

Robot charger is now mounted on a hydraulic crane on a wheeled carrier. It is fully mobile and has full range across the entire face. The robot collaborate with a smaller robot, on the same platform, which supplies the large robot with assembled detonators and primers. On the robot there is a camera mounted with two different sensors to scan the face. All system - camera, large robot, small robot and crane – are synchronised and collaborate to perform the charging process efficiently and autonomously.

The patented vision system, for image analysis of camera data, have been developed further to ensure robust identification of boreholes and navigate at the face.



The system compare camera data with the trained model of drill holes

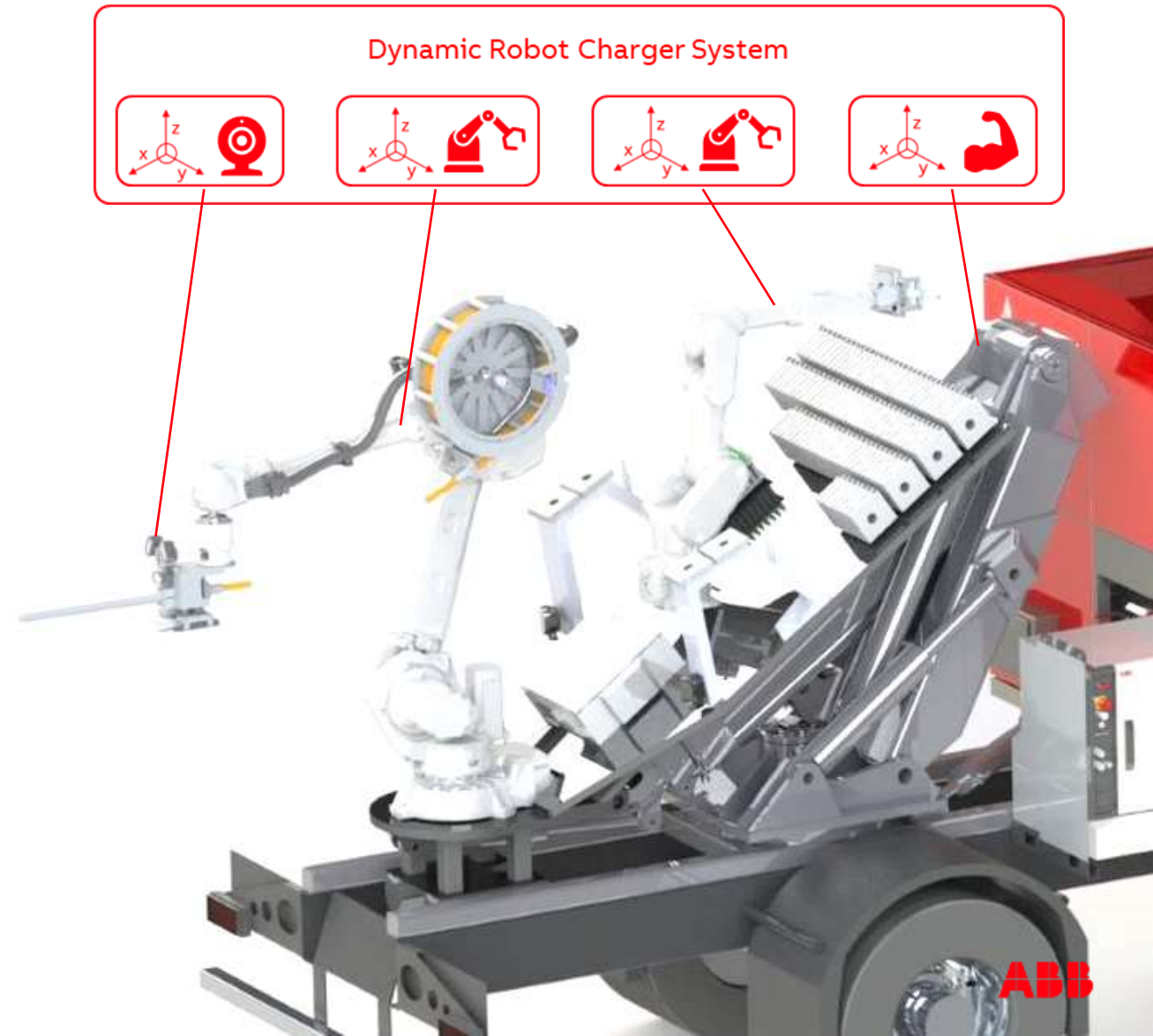


ABB Robot charger

Mechanics

Enabling the transition from a manual process to automated.

- Hose feeding
- Handling of conventional explosives (including cords)
- Magazine for detonators and primers
- Design of entire robot platform
- Mounting an industrial manipulator on a crane.

The mechanics are designed to be supplied, manufactured and installed locally



ABB Robot charger - carrier

Retrofit of existing carrier



Retrofit of existing charging truck

Complete charging truck used in the tests

Open standards allowing integration to any carrier and explosive supplier, both retrofit or new carriers

Project set-up

Collaborative development.

Combined collaborative competences

Joint project with ABB, Boliden, LKAB, Forcit and Kimit

Uppgrade a charging truck from LKAB Kimit with crane control, emulsion equipment from Forcit and the Robot Charger platform.

Charging operator input through fields tests in mines

ABB

BOLIDEN

LKAB

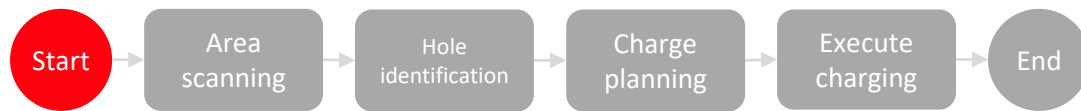
LKAB Kimit

**FORCIT
EXPLOSIVES**



Working flow

Plan 2023



The operator prepare the robot platform with detonators and primers.

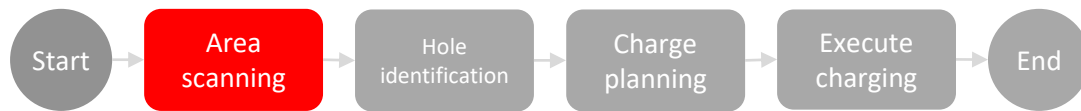
The carrier is driven to the face and established, the supporting legs are activated. When the robot system is started, the laser gates on the carrier are activated, ensuring that the robot system stops if someone enter the area

Picture from fields test in Garpenberg 2023



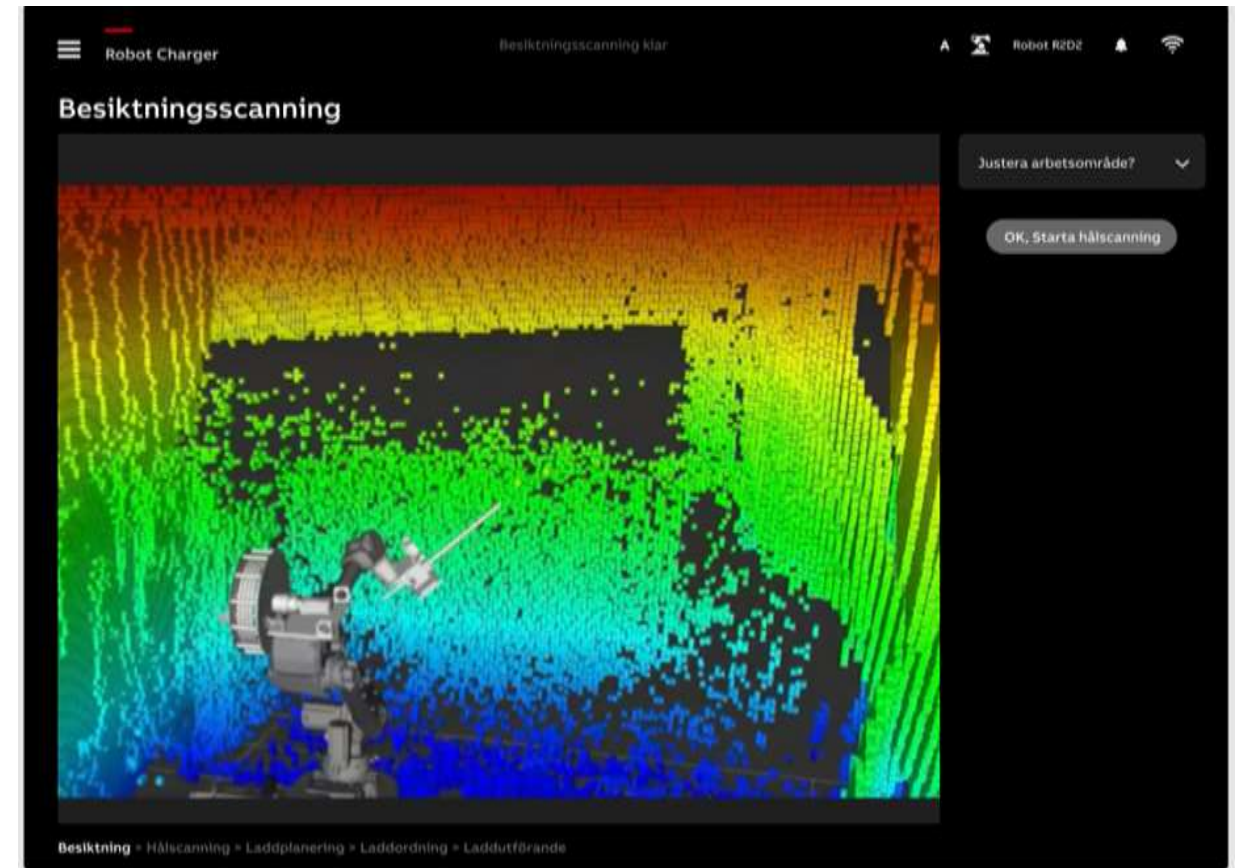
Working flow

Plan 2023



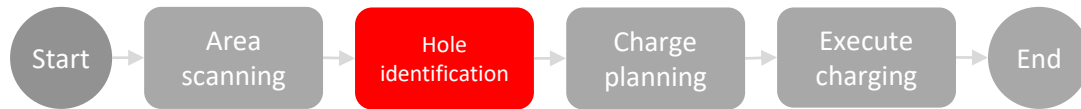
The robot starts by scanning the entire work area from a fixed position, to read the size and if there are any protruding objects or other things that the robot should avoid. A first rough hole scan is also taking place now. In parallel, the small robot scanners the magazines on the platform to identify available detonators.

Picture from HMI prototype 2023



Working flow

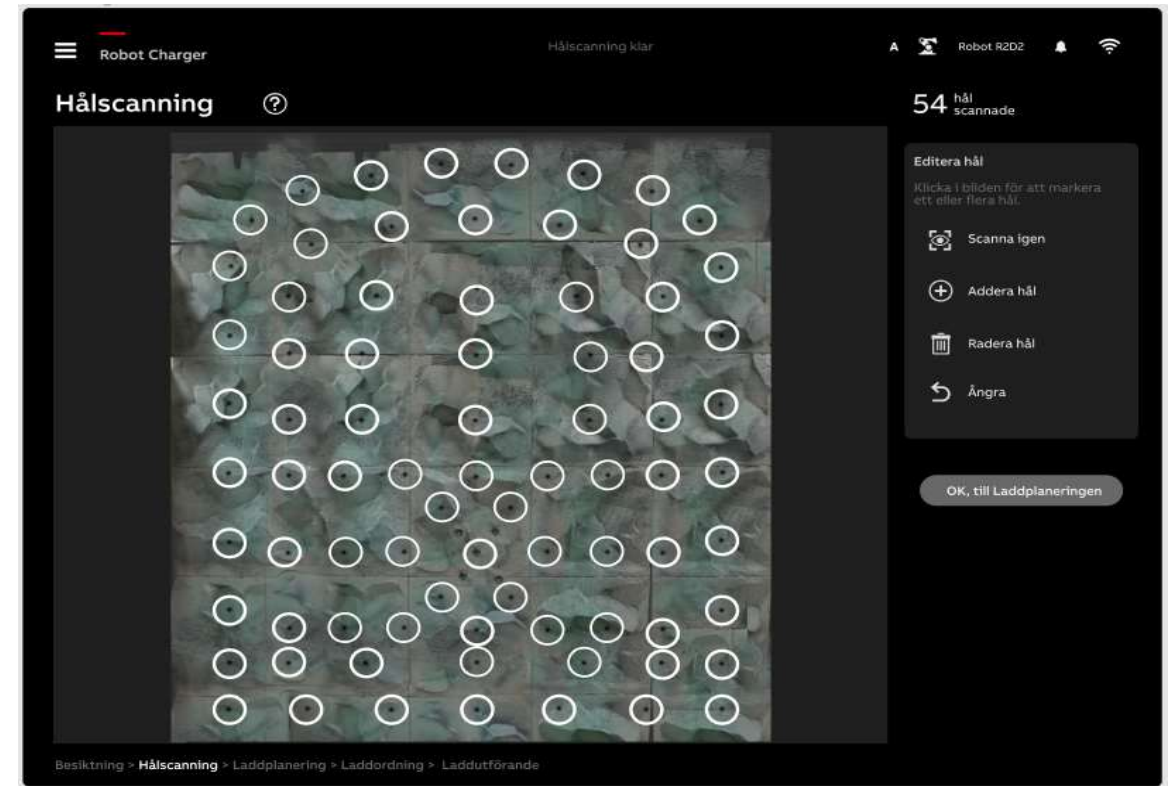
Plan 2023



The robot sweeps over the face to make a more accurate scan so the vision system can identify the holes. In parallel, the robot system calculates positions and motion patterns so that each hole can be accessed to be loaded.

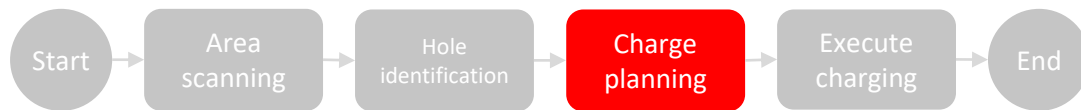
The identified holes are visualized in the HMI on the tablet for the operator to approve the scanning.

Picture from the HMI prototype 2023



Working flow

Plan 2023



The operator makes the charging planning in the HMI on the tablet, sets out the detonator and recipe per hole, based on the standard plan and the conditions of the current face.

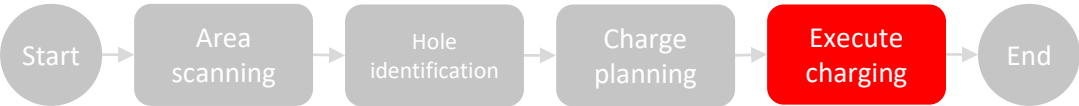
In the long term, the robot could make a proposal for planning, based on a standard charging plan, which the operator could adjust and approve.



Picture from HMI evaluation with operators in the Renström mine 2023

Working flow

Plan 2023



The robot calculates a motion plan for charging and executes it. The operator can follow the progress in real time on the tablet and monitor the available hole depth and kg of explosives loaded per hole.

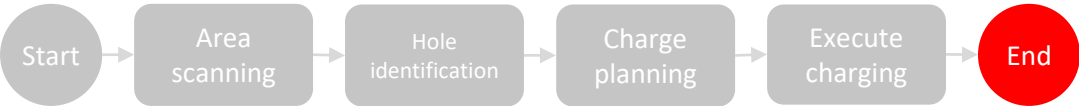
In the event of an obstacle (e.g. a short available hole depth), the operator is noted and may make a decision on action, e.g. leave that hole and continue or replan.

Picture from HMI prototype 2023



Working flow

Plan 2023



The charging is ended, and the robot returns to the transport position on the carrier, which is disestablished and driven to the next face.

A detailed report of the execution is available in the tablet and for export.

HÅL X,Y	TÅNDARE	RECEPT	STATUS	LADDORON	HÅLJDUP, M	MATRIX, KG
352, 799	60	R5	Laddat	1	4,8	8,0
352, 53	55	R4	Laddat	2	5,1	7,4
249, 36	50	R4	Laddat	3	5,3	9,5
46, 968	-	-	Laddning pågår	4	-	-
15, 987	-	-	Planerat	-	-	-
259, 876	-	-	Planerat	-	-	-
09x...						

Picture from HMI prototype 2023



ABB