LKAB Mining Project

STA Scooptram + Grizzly Grid.

Karl-Otto Saarman
MFA Advanced Product Design
Umeå Institute of Design
Umeå University

LKAB Mining Project, 1365 m.

Class of Advanced Product Design 1 and Program Director, Thomas Degn together with the project supervisors from Atlas Copco. The study trip was guided by four representatives from LKAB. Group picture taken at the Visitor Centre, 540 m.

Introduction

1. Background

1.1 General background
The term project of Advanced Product Design is held in collaboration with LKAB, the world largest underground iron ore mine and Atlas Copco, world leading provider for industrial productivity.

The project started with a study trip to LKAB and the iron ore mine in the city of Kiruna in northern Sweden.The visit was held both at the headquarters of LKAB for introduction and questinoaire and also inside of the mine. The visit was held at different levels of the mine to observe offices, workhsops, unloading of transportational trains and a visit of the production. The team was at the deepest of 1365 meters below ground level.

1.2 Impressions
Working in a mine includes an extreme environment. The surroundings are dark, humid and warm. However safety is priority and the processes, machines and equipment maintain world class quality.

Introduction

User centered workshop
The visit was summarized with a workshop in group sessions to compile the gathered information and impressions of the study trip. The workshop was divided into several phases.

Identifying process and user characteristics.
Working in teams, the collective data was gathered to visualize and present the different processes and equipment used in the mine. The conducted interviews where also presented and put as a base for the personas used in the workshop.

VSP Diagrams
A Visual Social Persona diagram is a visualization of the persona the designer is working with. The process was implemented to show the daily life of the persona, not only as a worker in the mine but also as a private person.

This approach led to further problem identification and discussions

Brainstorming and concept generation
The gathered information was used during team brainstorming which was held in several phases and concluded in the creation of product concepts.

LHD Background

Definition
A LHD (Load Haul Dump) also known as a scooptram, is a specialized loading machine used for the underground mining industry. The center articulated vehicle is used for removal of the mines ore and its waste. The vehicle may operate using diesel engines or electric motors.

Process
The LHD is used mainly for three types of tasks.

Loading - used to scoop a large amount of extracted ore, such as iron ore, with its front load bucket.
Hauling - Transporting the ore to prefered pitstop. Either a truck or shaft.
Dumping - Dump it into a truck or the bottom of the mine to undergo primary crushing before being hoisted to the surface out of the mine.

Equipment
The LHD is equipped with an EOD bucket (Eject-O-Dump) which is placed in front of the tires in order to access harder to reach areas. The bucket may also be equipped with an automatic tramming system to facilitate the dumping process. A buckets volume can differ with payloads of 1.5 to over 20 tonnes.

The tires can be treaded or smooth and may be fitted with chains.

Brief history of the LHD.
The earliest form of ore carts used in the 1800s were hauled by mules or horses or pushed by men. The carts were constructed in different manners and the process of transportation and dumping was managed in many different ways. The cart would be loaded with manual labour. Construction of the carts were made so components easily could be maintained or replaced.

During the industrialization new inventions led to a mechanized cart which could manage loading of the ore itself, reducing manual labour.

The first scoop tram was delivered by Wagner Minings Scoop Co. in 1958 and the first LHD vehicle stood finished in 1963. In 1989 the company was acquired by Atlas Copco AB.

Today many LHDs are remote controlled or automatized. Remote controlling and surveillance is either managed from an office within a safe zone or by a remote control standing outside of the vehicle. Automatization does not require any driver but surveillance of the vehicle is still necessary.

Problem Description

Overview
LKAB works continuously with increasing efficiency. The iron ore is only considered ore when it is profitable and maintaining extraction in cost efficient ways is always on the agenda.

The process of dumping the iron ore into the mine shafts
can be time consuming and wearing on machines. As the LHD dumps the ore into the shaft, some rock pieces (boulders) are to big to fit. A picker is then used to crush the boulder into smaller pieces thus making it fall down the shaft. The picking is a remote controlled task and can take minutes to manage. During this period the LHD remains static in the waiting of dumping the iron ore. This procedure is costing the company up to 10% of its capacity in loading the shafts.

Risks
Working in a mine includes an extreme environment.

The surroundings are dark and unsecured walls and ceilings remains a risk for the workers. The mine also suffers from fires due to overheated vehicles.These fire incidents are occurring at a rate of one time per year.

Main problem area
As efficiency is key the main problem area with the LHD is the waiting time for dumping ore in the shaft. This cost LKAB 10% of their loading capacity.

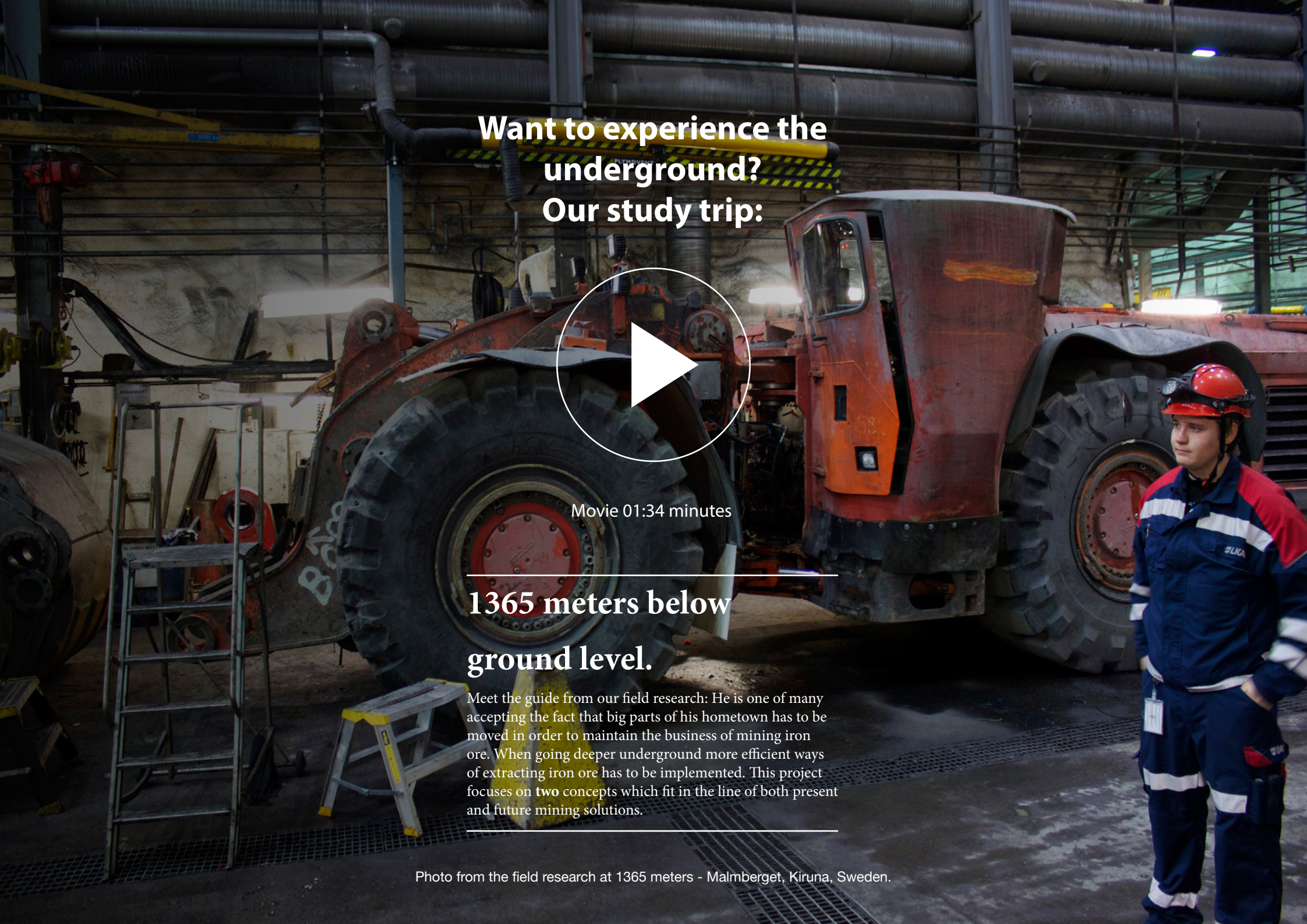
Secondary problems
Today many LHDs include remote controlled or even automatized systems. The dangers of working down in the mine has lead to trying to get the workers out if the mine while the vehicles remain. The issues regarding these systems is how to design them for the user/ supervisor to feel responsible and connected to the vehicle no matter the distance between them. Underground mines are also facing the problem of reducing ventilation which is mainly used for the diesel fuelled vehicles in the mine. The stress of ventilation costs is universal for most underground mining businesses as it can reach 30% of the total running costs in a mine. Costs also increases as the mine has to increase in size or in depth.

Atlas Copco LKAB

Atlas Copco
Scooptram STA + GRIZZLY Grid

The **STA** is a new type of scooptram (LHD) used for underground mining. The fully automated and battery driven LHD breaks new ground in safety and efficiency when it comes to the process of loading, hauling and dumping the content of the mine.

The new "Grizzly" grid provides a better solution for the process of dividing the iron ore from boulders, thus facilitating the breaking of boulders.



Want to experience the underground? Our study trip:

Movie 01:34 minutes

1365 meters below ground level.

Meet the guide from our field research: He is one of many accepting the fact that big parts of his hometown has to be moved in order to maintain the business of mining iron ore. When going deeper underground more efficient ways of extracting iron ore has to be implemented. This project focuses on **two** concepts which fit in the line of both present and future mining solutions.

Photo from the field research at 1365 meters - Malmberget, Kiruna, Sweden.

PROCESS ANALYSIS

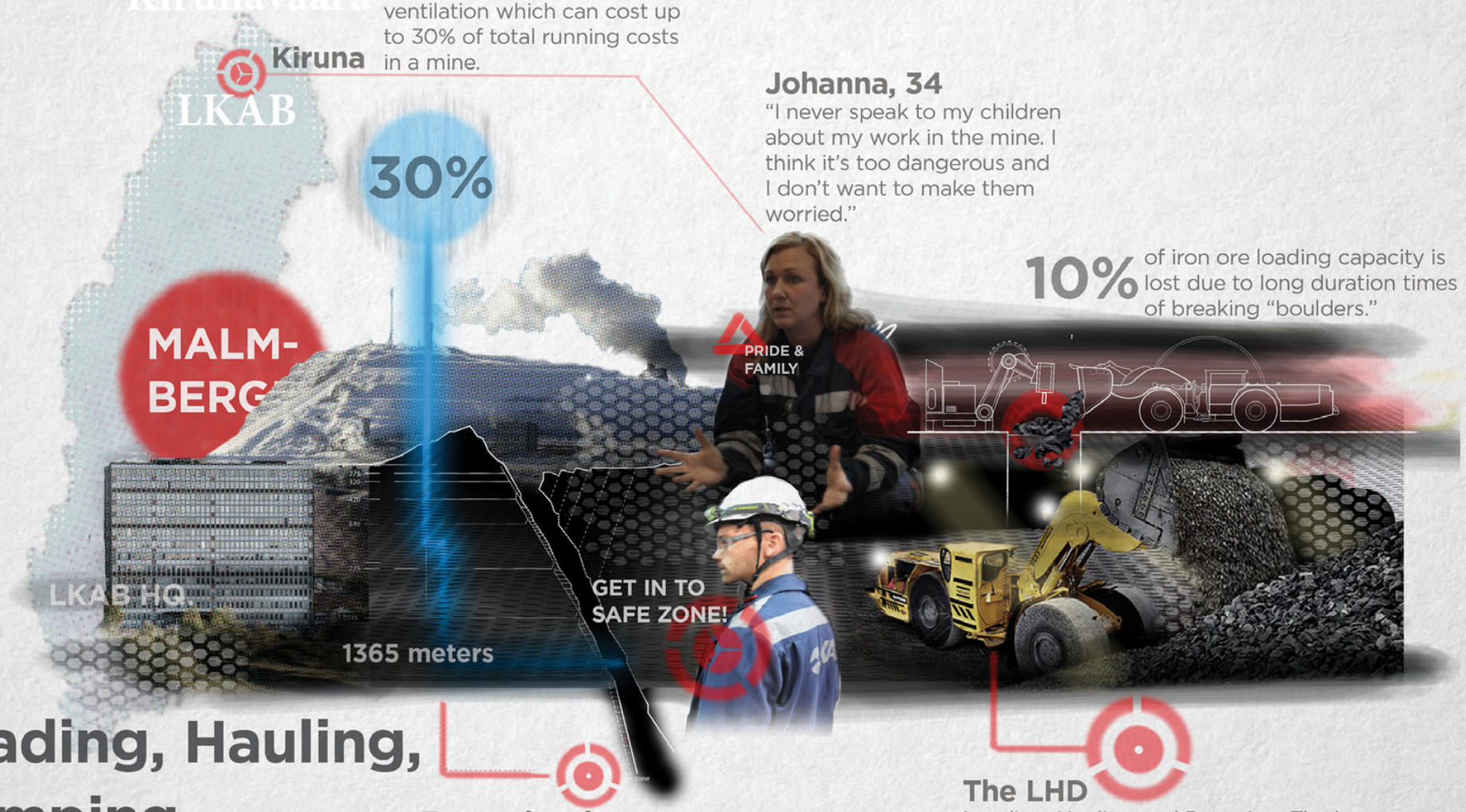
Ventilation

Combustion engines and toxic fumes is the strongest reason to the need of ventilation which can cost up to 30% of total running costs in a mine.

Johanna, 34

"I never speak to my children about my work in the mine. I think it's too dangerous and I don't want to make them worried."

10% of iron ore loading capacity is lost due to long duration times of breaking "boulders."



Loading, Hauling, Dumping.

The Process.

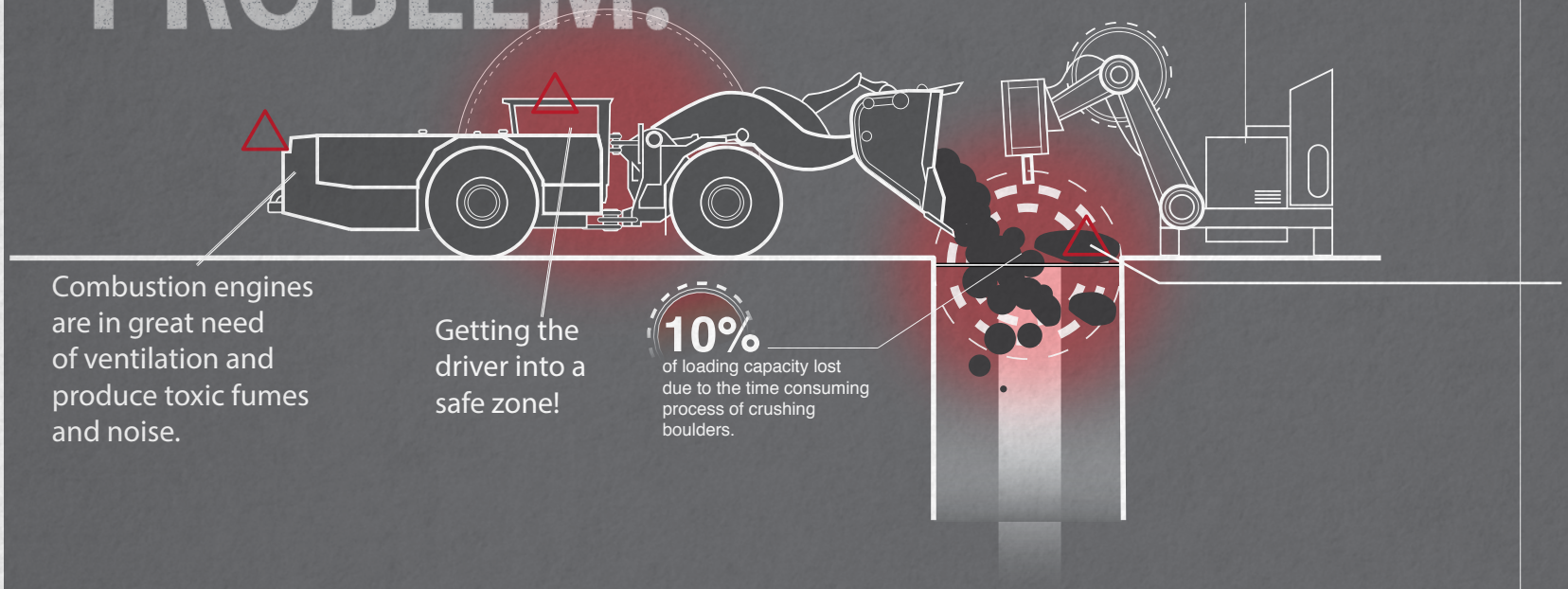
Future levels

- Higher risks.
- Increased running costs.

The LHD

Loading, Hauling and Dumping. The heavy machines are working closest to the non-secured parts of the mine increasing the risks for their drivers.

PROBLEM:



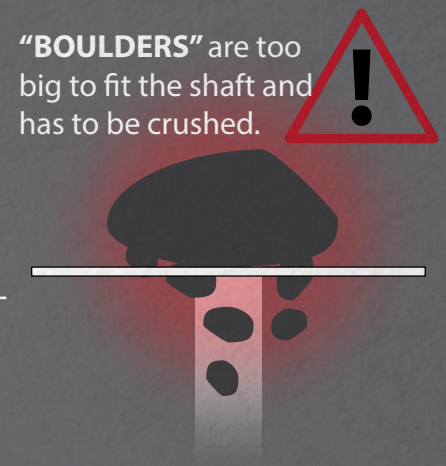
Pedestal Boom. The crusher of Boulders.

Combustion engines are in great need of ventilation and produce toxic fumes and noise.

Getting the driver into a safe zone!

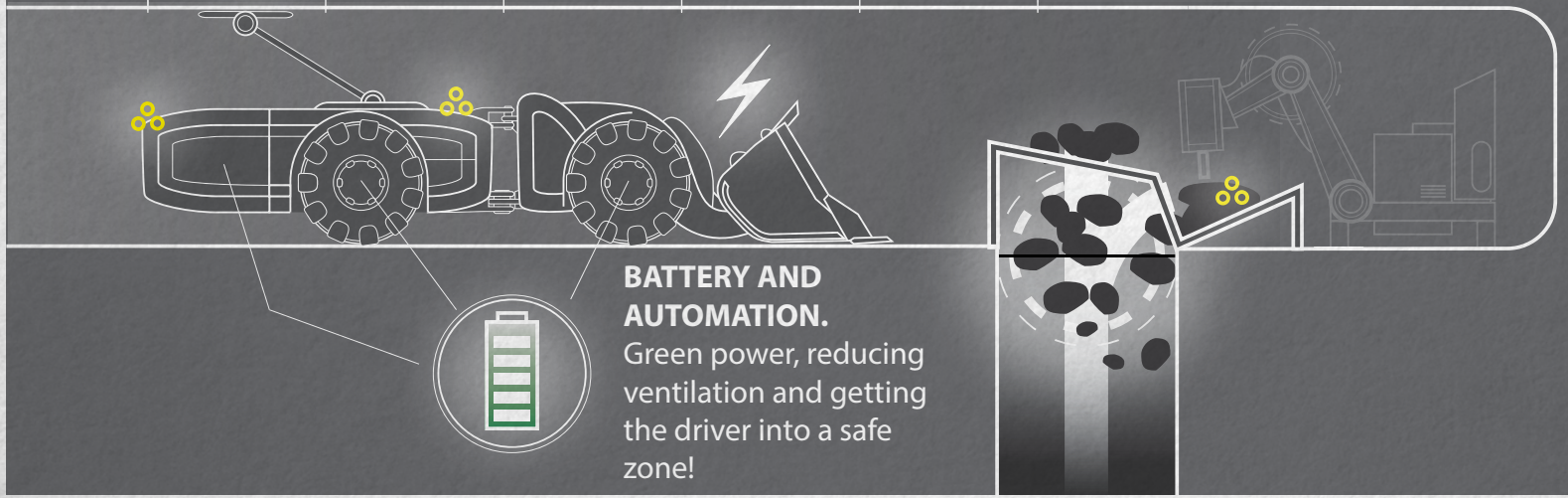
10% of loading capacity lost due to the time consuming process of crushing boulders.

"BOULDERS" are too big to fit the shaft and has to be crushed.

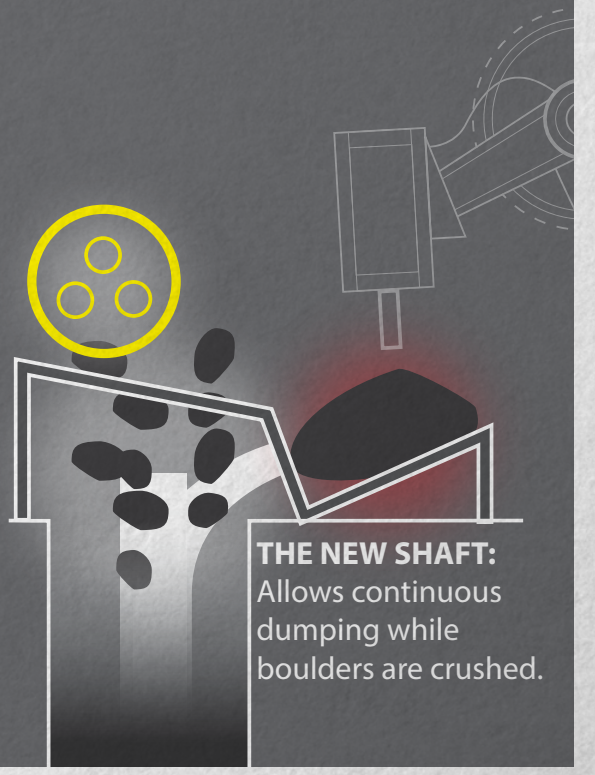


RECHARGING:
A pantograph helps recharging the battery.

TWO CONCEPT SOLUTION:

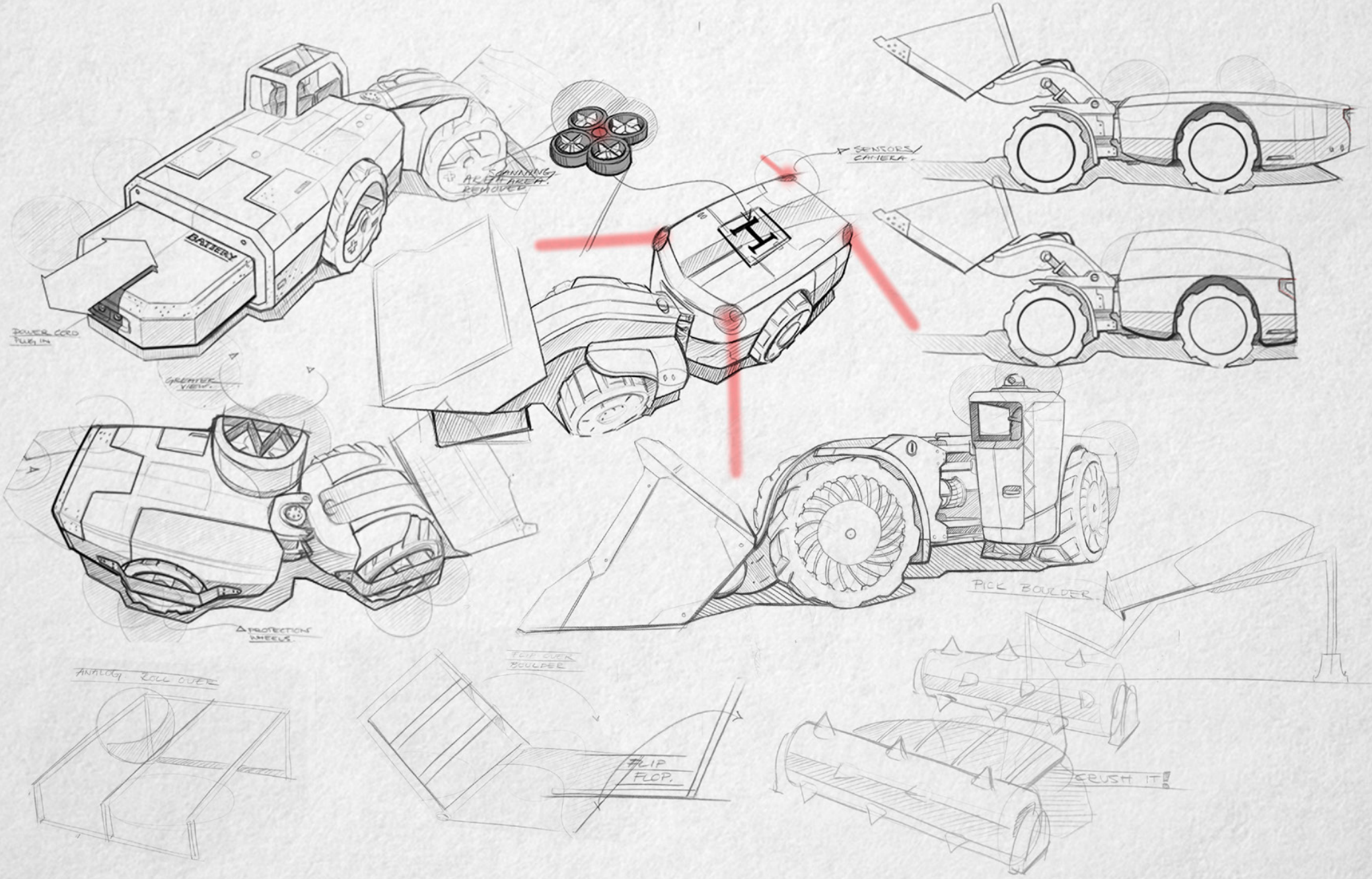


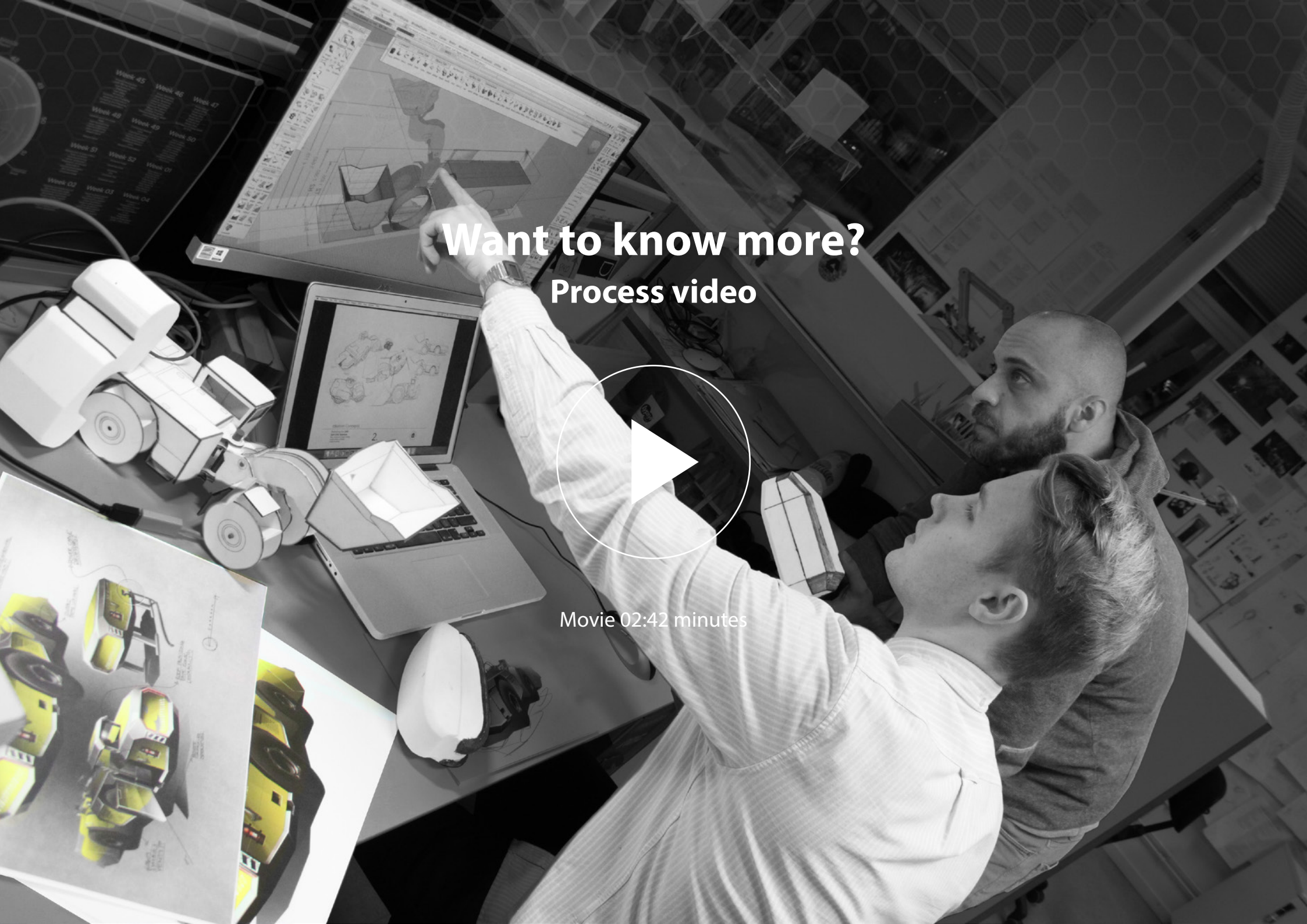
BATTERY AND AUTOMATION.
Green power, reducing ventilation and getting the driver into a safe zone!



THE NEW SHAFT:
Allows continuous dumping while boulders are crushed.

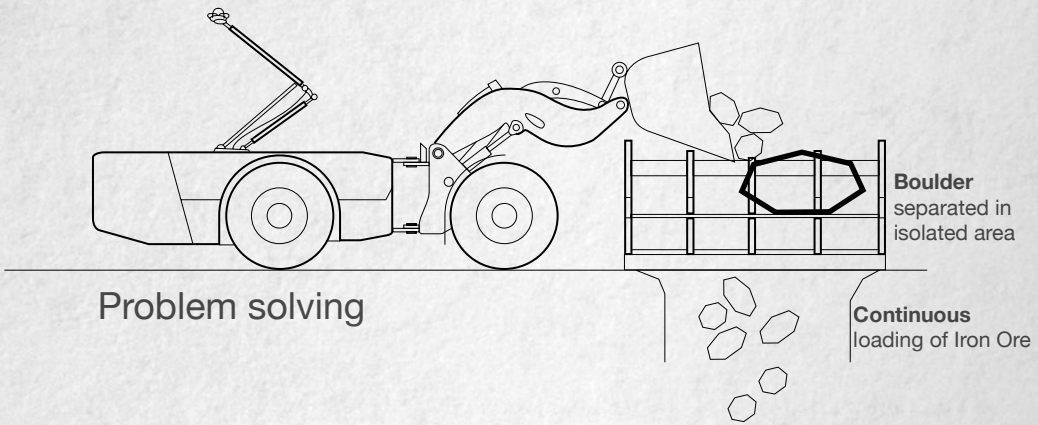
Initial concept sketches
Focus on two issues




Want to know more?
Process video
Movie 02:42 minutes

I will be your eyes.

Despite the STA being an autonomous vehicle it needs to be monitored from the control central. What the STA sees, so does the person monitoring it. By providing protected houses for lights, cameras and laserscanners the monitoring is protected and may constantly be directed to the control center. The laserscanner provides a live update of the 3D-mesh of the mine and gives feedback of the STA's position.



Problem solving

Pantograph:

The pantograph is automatically raised to reach electrical wires providing the battery with new energy.

Battery:

Ryden Dual Carbon Battery provides greater prestanda and enables a 20 times faster recharging time of the battery.

The eyes:

Cameras, lights and laserscanners provides visuals for monitoring.

Laser scanner:

Cameras and laserscanner providing vision and updated 3D-mesh of the mine

Bucket:

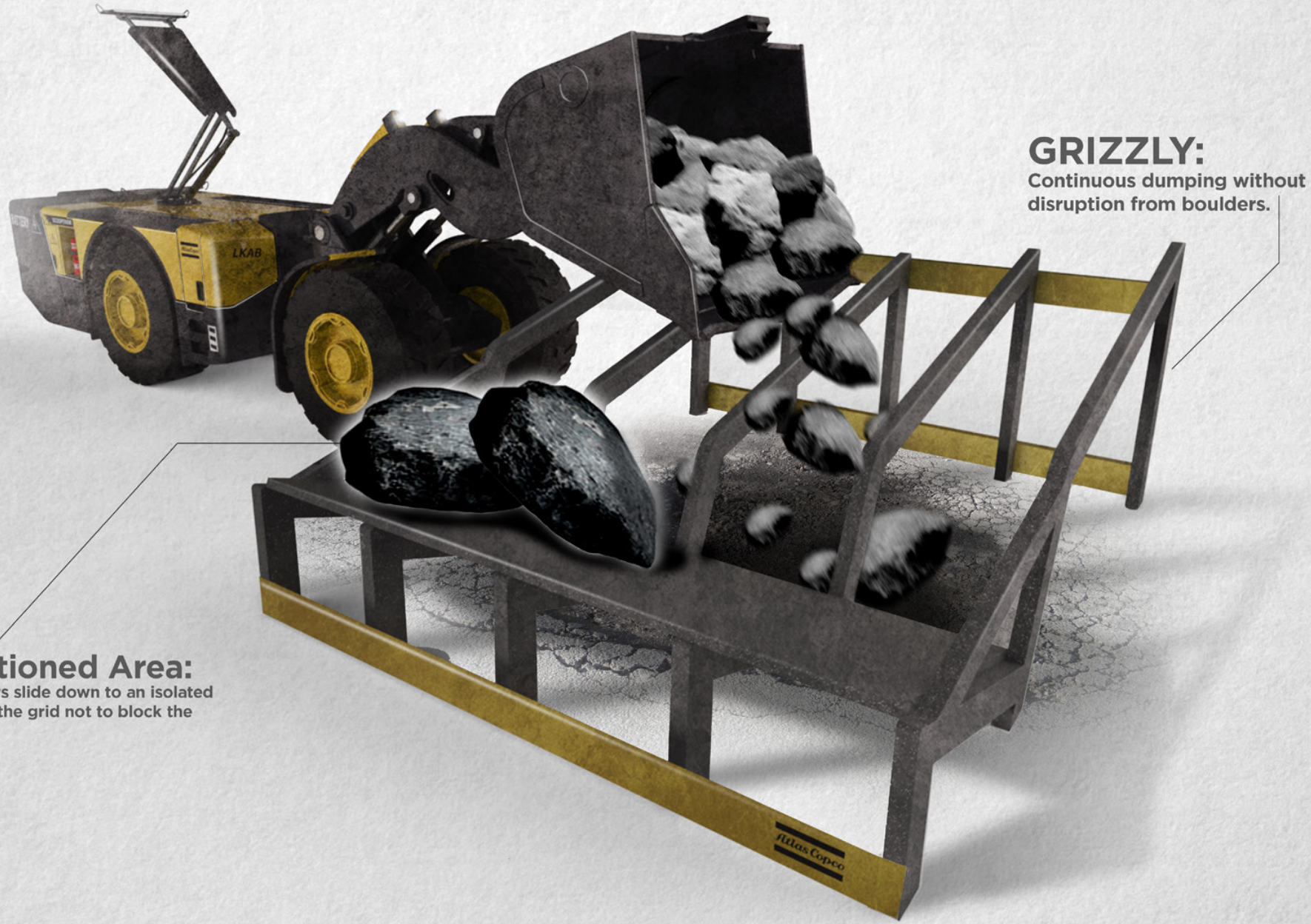
6 cubic meters with the capacity of 14 tons fully loaded

Maintenance:

Ladder for reaching top region of pantograph and maintenance area.

Power Connection:

Cable connection for battery.



GRIZZLY:

Continuous dumping without disruption from boulders.

Sectioned Area:

Boulders slide down to an isolated part of the grid not to block the shaft.

Final Presentation & Model