"I dearly loved my coal mining job. It was the type of job that you could have and be proud of. **If I had it to do over again, I would have worn my respirator more than I had"**

RSX´15

Worlds first respiratory mask that is designed for safety helmets

***Report** by Andreas Enebrand*

A project collaboration between:

Umeå Institute of Design
MFA Advanced Product Design

+ LKAB + Atlas Copco

Contents


green cargo
Rc4
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USER CENTERED DESIGN

In this project will learn how to use User Centered Design (UCD) in a design project. UCD applies methods from psychology, sociology and ethnography to understand the user and to get a deeper understanding what people really want and need in order to develop better products for tomorrow.

We will discover new design opportunities in the end, which no one has considered or realized before by studying their everyday life activities, aspirations, dreams, desires and also their fears and struggles.

LKAB around the world

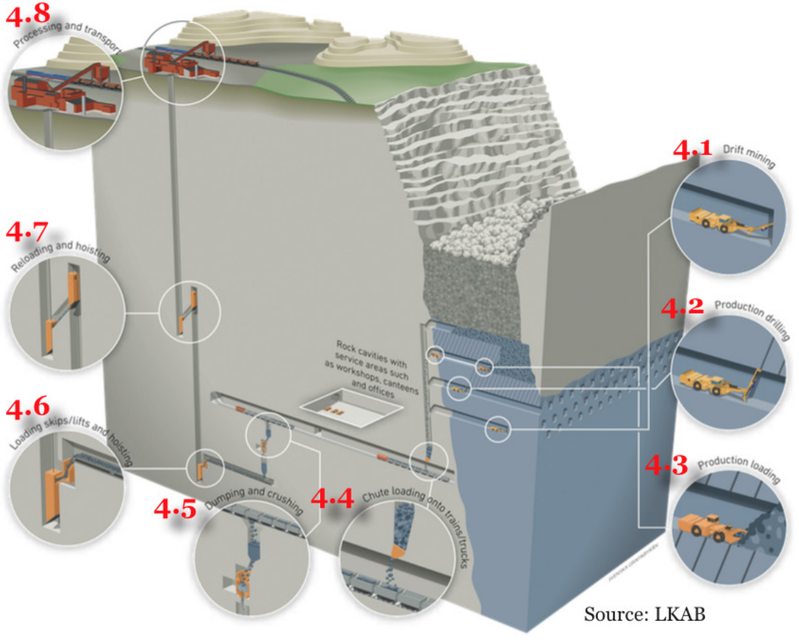
ABOUT LKAB

LKAB has existed since 1890 and began mining around 1900. Open pit mining was the mining method until 1962. Sub-level caving started in the late 1950's and has been the mining method since then. A large amount of the world's iron ore reserves lies near the surface in the earth's crust and can therefore be mined relatively easily in enormous open-pit mines. LKAB's main ore deposits are mined in underground mines several hundred meters down in the ground. Mining ore at great depths is a logistical problem. LKAB is therefore trying to mine the ore as efficiently and to the largest scale possible in an open-pit mine.

The headquarters of LKAB is situated in Kiruna in front of the mine in the Kiirunavaara mountain. The mine in Kiruna, which is located 600 km from Umeå, is the world's largest underground iron ore mine. The daily production adds up to 76,000 tons of iron ore, which is mined and brought up to the surface. Approximately, this corresponds to a 12-storey building in terms of volume. The current main level is located at 1045 meters, whereas the new haulage level is located at 1365 meters (both measured from the top of the Kiirunavaara mountain). The decision for the new main level, which has been partly operational since March 2013, was taken in October 2008 and the estimated cost was 12,400 million SEK.

LKAB Kiruna currently produces around 28.1 million tons crude ore per year (2013). By 2015 the goal is to reach a production of 37 million tons per year. The total sales in 2013 were estimated to 23,656 MSEK and the profit of that year was 6,032 MSEK.

Source: Brief from Thomas Degn



Source: LKAB

Field Ethnography

We started the mining project with a 3-days field trip to Kiruna, together with two industrial designers from Atlas Copco, to visit LKAB's largest mine in Sweden. It is 1365 meters deep. We began the Kiruna visit with a morning meeting at the LKAB head office above ground where they shared some useful facts and insights about their mine and the mining industry in general.

Because of the strict visitor rules in the mine we needed to follow a guide for the whole day. A small minibus transported us through the mine area in order for us to see the different parts of the process.

The second day in Kiruna was focused on interviews and a presentation from Atlas Copco about what to think of when you are designing for the mining industry. Our priority was to document what were going on, where the users were working, and what they were doing. It was also important to understand why every step is necessary and where time is made or lost.

FIELD TRIP ANALYSIS

When we arrived back home to Umeå we started to analyze our field trip in groups, both the visit in the mine and the interview. The goal was to see that everyone in the class got the same knowledge about the mining process and to start discover areas that could be improved.
Our group also analyzed the annual reports from both LKAB and Atlas Copco to get some of their insights/predictions about the future in the mining industry.

VSP DIAGRAM

The class was divided into new groups to each develop a VSP diagram. A VSP diagram is a map over a day in our fictitious user life. The diagram is based/modeled on the interviews we did in Kiruna.

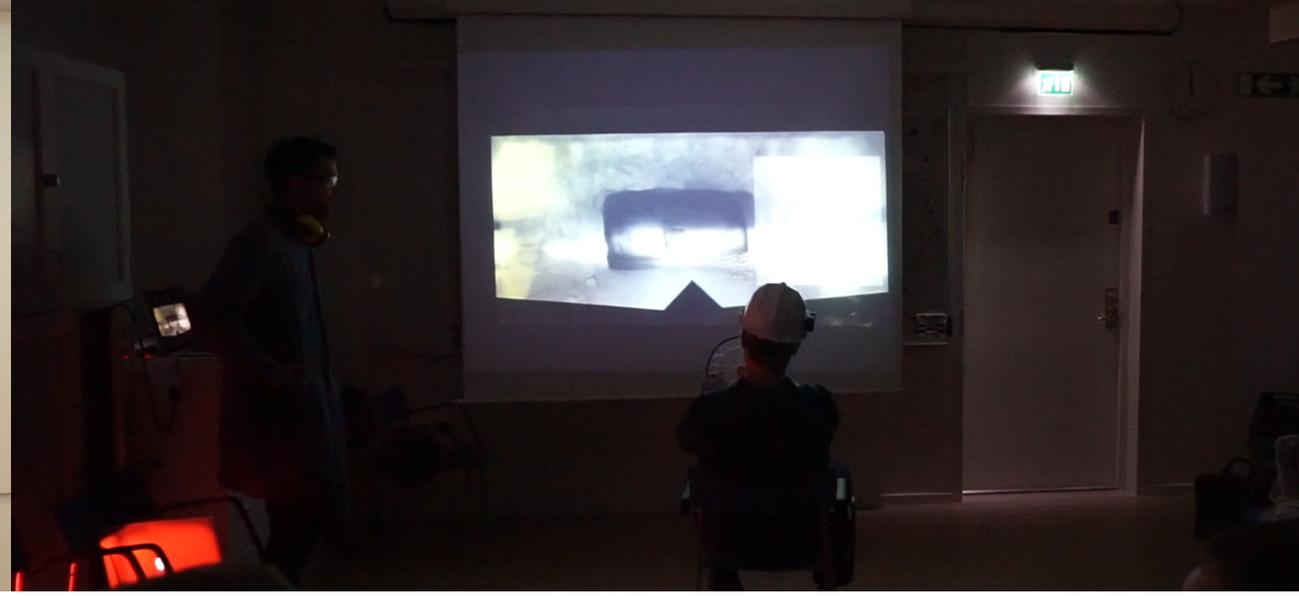
The goal with the VSP diagram is to discover new problems and solutions from the viewpoint of a potential user.

Our Persona, Björn

- 42 years, married, 3 kids
- Family man
- Works as a safety inspector - cares about the health of others
- Worst part of his job - wake up in the morning
- A bit old school, likes to work in his garage with his car

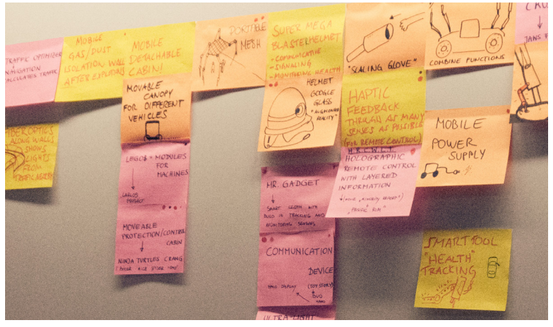
USERS PROBLEMS AND SOLUTIONS WORKSHOP

After the VSP diagram we continued the workshop by identifying and writing down problems from the initial research on post it notes. We continued to work with a double team method as we continued to work on other groups post it notes in order to generate more new ideas. We continuously culled the weakest ideas by always choosing the best 2 post it notes from the other groups and 1 post it from our own group. The result was some well-analyzed solutions and problem areas that could be a good start for us in this project.



USERS QUICK CONCEPT EXERCISE

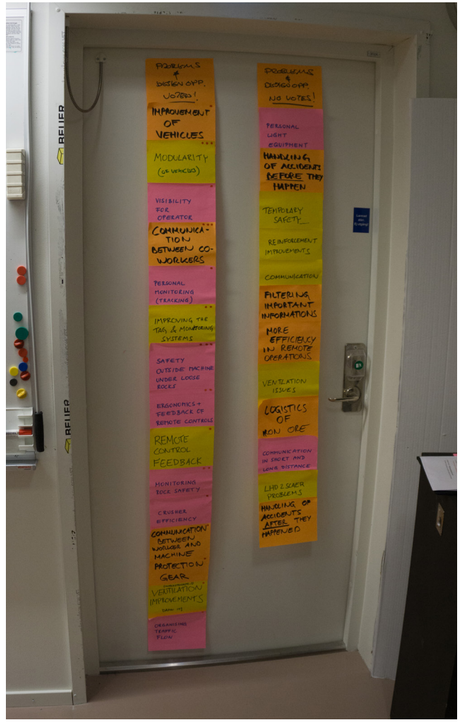
From the final post it notes we where asked to pick a potential solution and then developed it to the next day. Our class came up with ideas like smart ventilation, protection unit, communication between co-workers, protection mask, laser scanner to analyze the rock surface.



ROLE-PLAY EXERCISE

After the concept presentation we should pick one concept per group quickly to show in a role play the day after. The goal with this exercise was to immediately identify some of the issues that the user would face with the chosen solution. The role play is also an effective way to develop new ideas as you need to act around it.

Design opportunities



Problems / design opportunities (votes by the class)

- Improvement of vehicles
- Modularity of vehicles
- Visibility for operator
- Communication between coworkers
- Personal monitoring (tracking)
- Improvement of the tag
- Safety outside the machines
- Ergonomics and feedback of the remote control
- Monitoring rock safety
- Crusher efficiency
- Communication between worker and machine
- Ventilation improvements
- Organizing traffic flow

Problems / design opportunities (No votes from the class)

- Personal light equipment
- Handling of accidents before they happen
- Temporary safety
- Reinforcement improvements
- Communication
- Filtering important information
- More efficiency in remote operations
- Ventilation issues
- Logistic of iron ore
- Communication in short and long distances
- Lhd 2 scaler problems
- Handling of accidents after they happened

The yellow marked text is areas that I personal find interesting to continue to work with.

Areas of interest

Personal safety

- **Helmet**
- Protects the user against falling rocks
- Carries the light unit
- Modular with protection glasses
- Headphones module
- Workers leaves helmet in the vehicles

- **Clothes**
- Non flame able
- No high visibility color, difficult to see each other when its dark.

- **Tag**
- LKAB know that the user is in the mine but only on which level.
- Easy to forget?

- **Protection Mask**
- If something happens i.e. Dust or fire, protection masks are located in the vehicles or the safety room - Far away

- **Light**
- Light on the helmet lets the user know how the floor surface is, reduces the changes of stumbling.
- Lets coworkers and other machines know that the user is in the area.
- Light only on the front of the helmet.
- Easy to glare each other with the lights

- **Radon meter**
- Collects data over a year to check the workers health in the mine
- Only LKAB knows the results
- Don't know in which area of the mine that is dangerous.

Communication

- **Cell Phone**
- Smartphone
- Call or text coworkers
- Warn coworkers i.e. Fire.

- **Tag**
- LKAB know that the user is in the mine but only on which level.

- **Light**
- Lets coworkers and other machines know that the user is in the area.

- **Radon meter**
- Collects data over a year to check the workers health in the mine
- Only LKAB knows the results
- Don't know in which area of the mine that is dangerous.

- **Traffic jams / accidents**
- Communication could avoid jams and accidents in the tunnels

- **SEMIC (Microphones in the mountain)**
- Communicate if something strange is happening inside the mountain to avoid accidents.

Visibility

- **Coworkers and vehicles can see you**
- Avoid accidents

- **Better working light**
- Light up a wider area
- Only use the head lamp gives a concentrated light - lights up a small area

- **See if machines gets overheated**
- Using a heat camera

- **See cracks in the mountain**
- Avoid accidents

- **In case of an emergency**
- Find the right way to the safety room

Personal monitoring

- **Health**
- By smartphone i.e. Apple watch
- Radon meter, only LKAB knows the results
- Workers don't know about their current environment - toxic materials or not.
- Take care of each other - see coworkers health status

Modularity

- **User can configure the product itself**
- More personal
- Fits the needs

- **Wider usage area**
- Configured to fit other professions

- **Same product can do more**

Conclusion

After the research and the workshop week I have come to the conclusion that I want to continue to work with personal safety and monitoring in this project. I will focus my work on a protection product that can be mounted on the workers helmet to protect the user from unhealthy materials in the air. The unit will probably monitor and notify the user about the current environment.

”Jet fighter feeling”

Goals

- Fits on a standard safety helmet
- Protect the user from dust/toxic gases
- Easy installation
- Easy to use - should be a quick task to get it on/off.
- Easy to change parts i.e. batteries.
- Should work with other accessories for the helmet, i.e. protection glasses & headphones.
- Light unit - minimize the stress on the neck/head

Wishes

- Modular - Can be configured for different professions/Users
- Sensor for dust - alarm the User or make the user aware that there are things in the air that are not good for your health.
- Facilitate verbal communication - without taking off the mask.
- Working light
- Light 360 degrees to tell everyone that you are in the area.
- Design that works for everyone
- Record the working environment - health status monitoring
- Facilitate in an emergency, maybe show the right way
- Make it possible to make it more personal - i.e. text and color.
- Jet fighter feeling - feel proud over the mask.
- Could be used without helmet

Protection masks

Used in mines around the world today

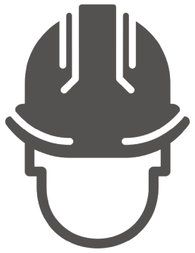
Protection masks

Examples from other areas

”I dearly loved my coal mining job. It was the type of job that you could have and be proud of.

If I had it to do over again, I would have worn my respirator more than I had”

From p.36



Dust & Gases in Mines

Methane gas explosions are one of the most common causes of underground coal mine disasters. Methane is an odourless, colourless and highly combustible gas that leaks out during mining of coal seams and, if left undetected and uncontrolled, can explode violently with a small spark. Therefore, it is of paramount importance to control the methane through adequate ventilation when it is present in small amount in the air.

For detecting methane gas level, the coal mining equipments are recommended to be fitted with methane monitors in order to enable the machines as well as the electricity to be automatically shut off once the methane level reaches 1.5%. Recently developed sensor-based methane detectors utilising radio frequency identification (RFID) technology can be deployed in any part of a deep underground coal mine transmitting methane concentration readings wirelessly to the surface. US-based Tunnel Radio, for instance, has developed a wireless detection system for monitoring methane gas and carbon dioxide (CO2). It comprises of an easy-to-install gas sensing module suitable for battery-powered application. The device can send precise gas-level readings to the surface computer system on a continuous basis even in the harshest environments

Dust build-up in the underground mining area is another major cause of coal mine explosions. The inhalation of silica and coal dust also poses serious health hazards for the miners. The use of air ventilators and water sprays, and the regular cleaning of coal dust lying on the surface are some of the basic techniques to prevent coal dust explosions. An array of dust-buster agents including binders, foams and antioxidants are also being developed to mitigate the chances of coal dust related disasters. GE's newly launched CoalPlus technology, for example, can reduce coal dust by up to 90% in different coal mining operations.
The coal dust explosibility meter (CDEM), a portable and handheld instrument for instant monitoring of the ratio between coal dust and rock dust levels in the underground mine, is currently available in the market. The device originally developed by USA's National Institute for Occupational Safety and Health (NIOSH) is being commercialised by Sensidyne. Personal dust monitors (PDM) have also been developed to give miners a tool to track exposure to respirable coal dust in real-time.

http://www.mining-technology.com/features/featuremining-safely-innovative-technologies-to-prevent-mining-accidents-4207131/.

Dust Related Illness

Lung damage caused by rock and mineral dust is a major health problem. Whether you are mining underground or above ground, you may develop lung damage if:

Dust covers your clothes, body, and equipment as you work. You cough a lot and have trouble breathing. A man using a jackhammer wears a mask and gloves. A man working nearby does not and is coughing.

Once dust has damaged the lungs, there is no way to reverse the damage. Dust is a threat both to mineworkers and to communities near mines.

The most dangerous kinds of dust are coal dust, which causes black lung disease, and silica dust, which causes silicosis. Dust that contains asbestos (which causes asbestosis) or heavy metals is also dangerous.

Dust from mining can make it difficult to breathe. Large amounts of dust can make the lungs fill with fluid and swell up. Signs of lung damage from dust include:

- shortness of breath, coughing, wheezing
- coughing up green or yellow sputum (mucus that comes up from the lungs)
- sore throat
- bluish skin at ears or lips
- fever
- chest pain
- loss of appetite
- tiredness

Black lung disease, silicosis, and asbestosis, are serious conditions with no cure. It is best to prevent exposure to harmful dust. Because these diseases worsen very quickly, by the time you have signs all you can do is keep the disease from getting worse. If you have any of the signs above, or have been exposed to these kinds of dust, see a health worker right away.

Because smoking greatly increases the risk of lung damage from dust, it is particularly important that miners do not smoke tobacco.

Black lung disease and silicosis
Black lung is caused when coal dust blocks the lungs, causing severe and permanent breathing problems. Underground coal miners, and children and women who work separating rocks from coal, are most affected by black lung.

Silicosis is caused by exposure to silica dust. Silica is a common mineral released from sand and rocks during mining, exposing many miners to harm.

http://en.hesperian.org/hhg/A_Community_Guide_to_Environmental_Health:Illnesses_from_Dust

Asthma
Another obstructive lung disease, linked to exposure to irritants or allergens at work. A reversible shortness of breath, between 15-20% of all cases are work related.

Cancers
Tumours, particulary of the lung and nose, are related to substances commonly encountered at work including asbestos, silica, chrome VI, nickel, cadmium and wood dust. These account for thousands of work-related deaths each year.

Chronic Obstructive Pulmonary Disease
COPD, also called Chronic Obstructive Airways Disease (COAD), a blanket term for obstructive lung conditions like bronchitis and emphysema. Reduces airflow out of the lungs.

HSE estimates 15-20% could be work related.

Heart disease
Dust-affected lungs put extra strain on the heart, which can lead to right-sided heart failure. Some occupational exposures like hard metal dust can cause potential fatal conditions like cardiomyopathy. Very fine dust particles cause inflammation of the heart and a higher risk of heart attacks.

Other problems
Exposure levels half the level allowable for most workplace dusts overwhelm the body´s first line of defence, the mucociliary clearance that filters out dust in the upper respitory tract. This can leace the worker more vulnerable to infections and more susceptible to occupational lung disease. Lots of other dust-related conditions occur, some specific to particular exposures: Beryllium is linked to sarcoidosis, chrome dust to chrome ulcers.

”Very fine dust particles cause inflammation of the heart and a higher risk of heart attacks”

Fibrosing alveolitis
Also known as pulmonary fibrosis, can be caused by some occupational dust exposures, for example work with cobalt or hard metals in cutting tools. Related conditions for example ”flock workers lung” and ”popcorn lung” have been discovered recently.

Pneumoconiosis
A group of ”restrictive” lung diseases like silicosis, talcosis and asbestosis, where dust exposure causes debilitating lung scarring.

Extrinsic allergic alveolitis (EAA)
An allergic condition which affects workers exposed to biological dusts, causing conditions including farmers lung and pigeon fanciers lung.

Black Lung: *Why Respirators Are Not A Solution*

Howard Berkes
July 09, 2012

This story is part of an investigation into how federal regulators and the mining industry are failing to protect coal miners from the excessive toxic coal mine dust that causes black lung.

Respirators and other breathing devices may seem useful for protecting coal miners from the dust that causes black lung. But federal law does not permit using respirators as a way of complying with dust exposure limits.

"[Mine operators] must control the dust first and then they can offer respirators to the miners if they choose to wear them," says pulmonologist Edward Petsonk, a consultant for the National Institute for Occupational Safety and Health.

Some miners find respirators a burden, including David Neil, who spent most of the 1980s mining coal underground in West Virginia.
"It [would] get so dusty [and clogged] that you couldn't wear it," he recalls. "It was suffocating."

Neil has complicated coal workers' pneumoconiosis, as does Randall Wriston, whose last mining job underground was in 2008. He says he's one of the few miners who wore a respirator.

"I'm finding out now that the respirators that they supplied us with were no good," Wriston says. "You'd be cutting rock [and] ... the heat ... would actually burn through my respirator."

Hundreds of coal miners have sued respirator manufacturers, alleging the devices were defective and did not protect them from coal dust and silica.

**"Now add to that the fact that these miners spend eight to 10 to 12 hours ...
operating dangerous equipment [and] needing to be able to talk and communicate in a split second," says Petsonk. "You understand that a respirator is just not a meaningful response."**

Airstream helmets were once considered a solution to exposure for miners in the dustiest jobs. The helmets pump clean air down across a worker's face, which is behind a plastic shield.

The helmets "may offer some improvement but they are bulky. They are noisy," says Petsonk. Some miners also complain that the helmets impair vision.

"Controlling the dust at the source is always a more efficient approach," he adds.

Bob Glenn, a black lung consultant for the National Mining Association (NMA), believes helmets could be useful as a short-term fix "but then you need to correct the situation. That is, you need to ventilate the mines until you get the exposures low."

Former miner Mark McCowan said he tried to use the Airstream helmets after he was diagnosed with black lung. He wanted to continue working and to limit his exposure to mine dust.
The mine had helmets but "these things were junk. They had dust all over them," he recalls. He was told he could scrape a working one together from the old and unused helmets found in the mine.

McCowan says he took home pieces of the helmets and put one together "but the battery was so old it wouldn't hold up."

Could Personal Dust Monitors Help?

The National Mining Association (NMA), the United Mine Workers of America (UMWA) and mine safety advocates focus instead on personal dust monitors (PDMs), which do not provide protection from coal dust, but monitor exposure in real time.

The trade group and the union want federal rules that require every miner to wear them all the time, so they can monitor their own exposure.

"If the PDMs are used across the board like they're supposed to be there's no doubt that we would see less disease," says Dennis O'Dell, the UMWA's safety director.

The Mine Safety and Health Administration's proposed rules include the use of personal dust monitors for certain work positions underground, but not all the time, for every miner.

"A work position does not contract black lung disease, a worker does," says Bruce Watzman, the regulatory affairs director at NMA, the industry trade group.

The industry and the union differ when it comes to using the data from the dust monitors. The union wants sampling to result in citations when dust monitors measure overexposure. The industry says the devices are not yet accurate enough to be used for compliance.

The proposed rules for controlling coal dust do not include use of respirators or helmets.

http://www.npr.org/2012/07/09/156375910/black-lung-why-respirators-are-not-a-solution

Why is Black Lung Back?

Larry Mongold, 57, a retired underground coal miner for 19 years, said he received thorough safety and health training at the mine he worked at in Keyser, West Virginia.

"We had training on wearing respirators and self-oxygen masks. We were well trained, and it was required by law each year to get refreshed on everything. We wore masks and respirators from time to time. Sometimes, they got in your way or interfered with your work or breathing, and I didn't wear them," Mongold said.

It was years after Mongold left the mine and was working elsewhere that he began to notice something was wrong. "I was having trouble doing day-to-day things like walking up and down hills on account of not getting enough oxygen. I did a lot of coughing. I still do a lot of coughing," he said.

He began to see WVU pulmonary specialists and had lung function tests to determine what was going on. The tests confirmed that Mongold had black lung disease – an irreversible, debilitating and potentially fatal condition caused by inhaling coal dust. "It wasn't really a surprise on account of knowing I was a coal miner.

I dearly loved my coal mining job. It was the type of job that you could have and be proud of. If I had it to do over again, I would have worn my respirator more than I had," he said.

Multiple possible explanations abound for the spike in black lung disease, including flaws in existing dust regulations, dust control practices, and dust exposure enforcement of coal mining companies, Petsonk said. Other theories include miners working longer shifts underground because fewer miners are employed today and they're exposed to more dust, silica, and other toxins.

"With these cases of advanced black lung we are seeing, 100 percent of the people who get the disease have too much exposure in a very dusty environment. No one has ever gotten this type of massive lung scarring from smoking, and black lung disease has never been reported outside of very dusty jobs," Petsonk said.

In an effort to end black lung disease among the nation's coal miners, the U.S. Mine Safety and Health Administration submitted a draft of tougher rules this fall to the White House Office of Management and Budget for review. "The system still needs to be aware of black lung…It's the coal dust that you can't see that gets you," Mongold said.

http://wvuhealth.hsc.wvu.edu/issues/fall-2013/why-is-black-lung-back/

"Coal mine operators must be able to locate and communicate with mine workers at all times - particularly in the event of fires, roof falls or other life-threatening situations"

COMMUNICATION EQUIPMENT

CSIRO, the Commonwealth Scientific and Industrial Research Organisation, Australia's national science agency, recently visited more than eight underground coal mines to discuss the types of issues confronting surface Control Room operators. A number of common issues were identified including:

- The large variety of diverse and proprietary communication systems that were in use at each site
- Large numbers of system-generated false and misleading alarms
- Time delays in locating and contacting individuals
- A cumbersome manual statutory reporting system
- Extreme workloads in emergency situations

Today's communication systems used in underground coal mines generally employ a hard-wired system or a special cable called a "Leaky Feeder". Fiber optic cables are also used in some applications. Through-the-earth (TTE) and wireless radio systems are less common. Here are some types of equipment and their suppliers:

Presently Available Through-The-Earth (TTE) Communication Systems: A TTE system likely will have the best chance of providing contact with miners since it offers the best resistance to damage from roof falls, fires and explosions. There are several companies who offer TTE systems. Most are limited to communication from surface-to-underground. Only one system provides communications both surface-to-underground and underground-to-surface, but it is not a portable system.

Flexalert - Mine Radio Systems - Canada: FLEXALERT replaces the need for stench gas, by facilitating rapid and reliable emergency evacuation, paging and restricted area warnings: employing the latest low frequency telemagnetic technology, the signal can penetrate miles of soil and rock, without any cable.

PED - Mine Site Technologies - Australia: PED is a through-the-earth communication system installed in over 120 mines. PED's ability to transmit directly through hundreds of meters of rock strata enables it to provide true mine wide signal coverage. As such PED is used in many mines as the primary emergency warning system, as well as a general day-to-day communication system. PED's emergency warning capability is well documented by MSHA, having been credited by MSHA and mine officials as being instrumental in saving five lives at Willow Creek Coal Mine in 1998.

Other Coal Mine Communication Systems

- Leaky Feeder
- Ethernet
- WiFi
- LAMPS - CSIRO - MineCom - Australia - LAMPS - Intrinsically Safety approved, personnel & vehicle tagging system powered from an internal lithium battery with a two year life, Tag Readers are linked by fibre optic backbone
- Wireless-Mesh-Networks

http://technology.infomine.com/reviews/coalminesafety/welcome.asp?view=full

What is a respirator?

A respirator is a device designed to protect the wearer from inhaling harmful dusts, fumes, vapors, or gases. Respirators come in a wide range of types and sizes used by the military, private industry, and the public. Respirators range from cheaper, single-use, disposable masks to reusable models with replaceable cartridges.

There are two main categories: the air-purifying respirator, which forces contaminated air through a filtering element, and the air-supplied respirator, in which an alternate supply of fresh air is delivered. Within each category, different techniques are employed to reduce or eliminate noxious airborne contents.

Respirators – *and how they've changed over time*

Hunter coal miners have workplace safety drilled into them every day – although this aspect of the industry has improved considerably over the years.

Safety in the mining industry isn't just a modern concern though – it was, to a certain extent, part of life even as far back as the first century AD, when the Romans used animal bladders to create face masks to protect miners from dust and lead fumes. More recently – compared to Roman times – Alexander Von Humboldt introduced a primitive respirator when he was working as a mining engineer in Prussia in 1799.

This consisted of a bag placed completely over the head and fastened at the throat, featuring eye slots for sight. The first air purifying respirator was invented by Lewis P. Haslett in 1848, filtering dust from the air using valves and a filter made of moistened wool, which was later changed to cotton fibres. The benefits of charcoal were discovered by Scottish chemist John Stenhouse, who used it to capture and hold large volumes of gas. He created the first respirator to remove toxic gases from the air and pioneered its use in filters. This mask advanced in 1871 when cotton wool, saturated with lime, glycerin and charcoal, was added as a filter and dubbed the 'fireman's respirator', filtering smoke and gas from the air. During World War I, improvements were made and the development of a resin-impregnated dust filter created inexpensive and efficient filters that had effective dust-loading characteristics and low breathing resistance.

The down side was they were extremely large, consisting of a rubberized fabric face mask connected by a fabric covered rubber hose to a small box made of tin plate.

Today, modern respirators come in many different styles and sizes to accommodate all types of face shapes.

The General Manager of Mines Rescue and Regulation & Compliance for Coal Services, Paul Healey, said protection against pneumoconiosis (black lung) relies on elimination and control of dust at its source and personal protection in the worker's breathing zone.

"Respirators as personal protective equipment are one of the key elements in making sure that black lung does not return to the NSW coal industry," he said.

http://coalfacemagazine.com.au/ohs-equipment-has-advanced-a-wee-bit/

Repository protection masks on the market: Everyday usage

Dust/Bacteria

Full face

Air-helmet

Firefighter face mask

Half face

PAPR System

Repository protection masks on the market: Only for emergency

Emergency hood

Self-contained breathing apparatus (SCBA)
(Common in the mine industry)

Self-Contained Breathing Apparatus (SCBA)

Wikipedia defines a self-contained breathing apparatus, or SCBA as "a device worn by rescue workers, firefighters, and others to provide breathable air in a hostile environment." It is also sometimes referred to, as a Compressed Air Breaching Apparatus (CABA) or simply Breathing Apparatus (BA). There are two kinds of SCBA: open circuit and closed circuit.

http://technology.infomine.com/reviews/coalminesafety/welcome.asp?view=full

- **Closed-circuit SCBAs** - The closed-circuit type filters, supplements, and recirculates exhaled gas. It is used when a longer-duration supply of breathing gas is needed, such as in mine rescue and in long tunnels, and going through passages too narrow for a big open-circuit air cylinder.

- **Open-circuit** - Open-circuit industrial breathing sets are filled with filtered, compressed air, the same air we breathe normally. The compressed air passes through a regulator, is inhaled by the user, then exhaled out of the system, quickly depleting the supply of air. Most modern SCBAs are open-circuit.

The Process (screenshots from youtube)
https://www.youtube.com/watch?v=pJcClQE2DtE

Escape hood / Fire hood

Escape hood is for self rescue in the event of a fire or a chemical emission accident.

The hood is equipped with multiple filter that provides a short-time protection against carbon monoxide and other toxic gases and particles that may be emitted in a fire or in a chemical emission accident.

The hoods are often vacuum-packed in aluminium bags and have a due date.

The process

http://www.honeywellsafety.com/SKU/Respiratory_Protection/Respiratory_-_PAPR_-_SAR_-_Filters_-_Escape/31282.aspx?site=/uk#

http://www.srsafety.se/produkter/flykthuvor/flykthuva-sr-76-2-chem

Filters

Since filters capture particles, caution must be exercised to always check that these filters are not clogged as it makes it harder for air to pass through and increase the likelihood of contaminated air entering the mask. Cartridges can also become "full" or saturated. It will stop working and "breakthrough" will occur – this term means that the gases or vapours will leak through the cartridge. Both cartridges and filters must be replaced on a regular basis by using the manufacturer's recommendations (usually determined by using warning properties or end-of-service indicators)

There are 9 classes of particulate filters, depending on the particulate material. They are also classified based on levels of oil resistance and filter efficiency. Oil can break down certain types of filters which means it is important to know the materials you are working with at all times and always select the right cartridge for your respirator.

The main categories are:

- N series (Not resistant to oil) - May be used in any atmosphere where there is no oil particulate.
- R series (Resistant to oil) - May be used in any atmosphere where there is no oil particulate, or up to one shift where there is oil particulate present. "One shift" means eight hours of continuous or intermittent use.
- P series (Oil-Proof) - May be used in any atmosphere, including those with oil particulates, for more than one shift. If the filter is used in atmospheres with oil particulates, contact the manufacturer to find out the service life of the filter.

What are the different types of cartridges and filters?

Filters are made of material that is designed to trap particles as you breathe. Cartridges contain a material that absorbs gases and vapours. It is very important to make sure you are using the right filter or cartridge for the chemicals or substances present in the workplace.

How do you select the right respirator?

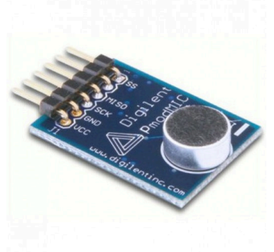
Choosing a respirator is a complicated matter. Experienced safety professionals or occupational hygienists, who are familiar with the actual workplace environment, are the staff who should select the proper respirator. They can choose a suitable respirator only after they have evaluated all relevant factors. This includes considering the limitations of each class of respirator.

Communication Solutions

There is not so many communication solutions for protection masks on the market. The resonance inside the mask might be the answer to why there are so few on the market or they don't think that communication is a problem for the users.

One interesting technology that could be used in protection masks for communication is a bone conductive microphone that uses the vibration from head bone and translate it into sound. The military, police for example is using this technology to be able to talk to each other in loud environments.

My reflections with today´s small microphones and smart audio software´s I think it should be possible to place a microphone inside a mask and record the voice with good quality.



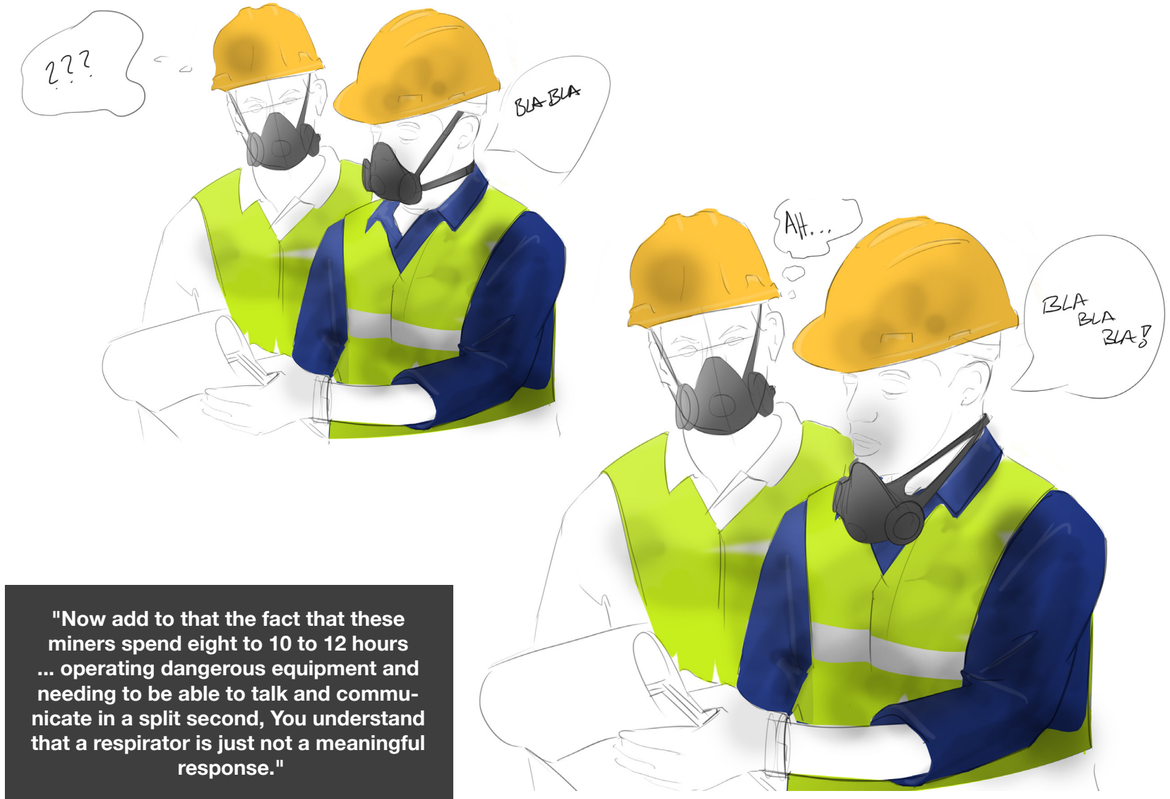
DIY (Do-it-yourself) microphone kit

Small microphone for military gas masks

http://www.srsafety.se/produkter/tillbehor-masker/rostforstarkare-sr-324

http://www.buhelstore.com/media/catalog/product/b/u/buhel_d06_how_to_use_s.jpg

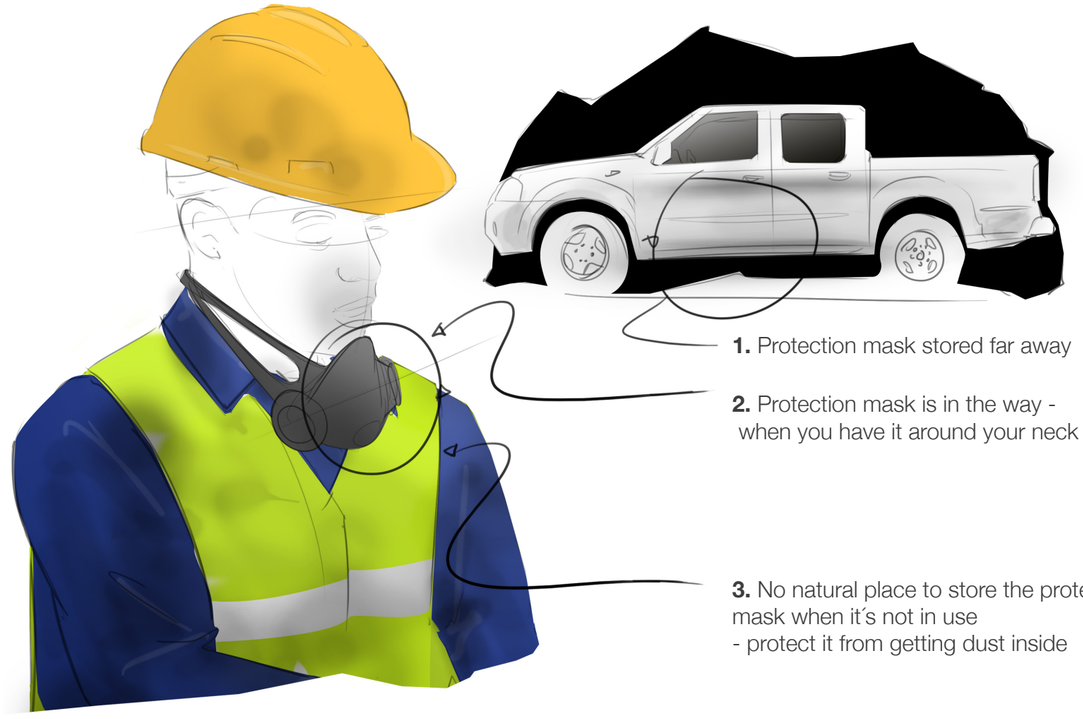
Problem Identification: Communication



"Now add to that the fact that these miners spend eight to 10 to 12 hours ... operating dangerous equipment and needing to be able to talk and communicate in a split second, You understand that a respirator is just not a meaningful response."

From p.34

Problem Identification: Storage



1. Protection mask stored far away

2. Protection mask is in the way - when you have it around your neck

3. No natural place to store the protection mask when it´s not in use
- protect it from getting dust inside

Picked

Safety Helmet

- Always with you
- Often personal
- Different accessories exists

- Users often drop the helmets
- Exposed for dirt
- Unbalanced helmet can cause neck pain

Storage

How and where do you store the mask so it is always near you?

I compared the closest equipment the user uses to see where the best place is to store the mask.

Safety Jacket

- Often with you - Safety requirements
- Personal
- Close to the mouth and nose from the neck/hood (possibilities for a protection mask to be stored)

- Users often have more than one
- Users often don´t wear jackets in hot areas

Safety Pants

- Always with you
- Personal

- Users often have more than one pair
- Long distance to users face
- Pockets are quite small

Neck Mask

- Close to mouth and nose
- Personal

- Easy to forget
- Can be too warm

Helmet Accessories

Face & neck protection

Protective headphones

Core77 winner: Halo light that increases the visibility for workers in dark areas

Headlight

Helmet standard connection

Majority of the safety helmets on the market today use this type of connection for accessories.

During my research I couldn't find any protection mask system for safety helmets.

Storage system

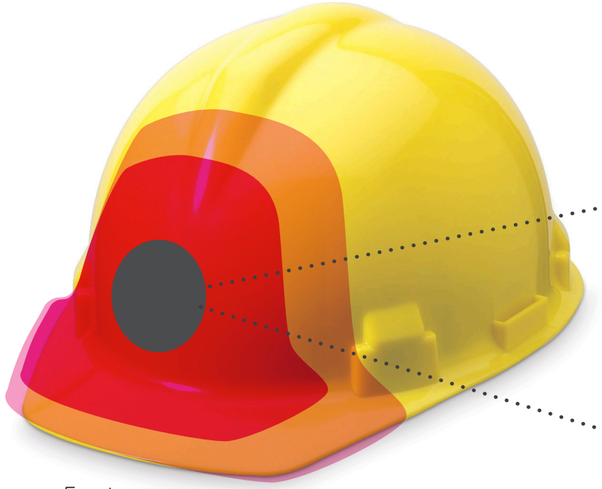
Rear mirrors..

sweat protection

Emergency identification system

Face protection

Protective glasses



Easy to access area

Combining Products

The best place to store the mask on the helmet is on the front part, this is the most accessible area for the user when the helmets is on the head.

Safety helmets are often equipped with an light unit in the same area so if we add a protection mask this will create a interference between the mask and the light.

As a professional user you don´t want too many products on the helmet or have things that interfere with each other that makes both product useless. So the conclusion from this is to make the protection mask and the light into the same product.

Market Opportunity

I realized that there are other professions that also could be interesting to look into.

I mapped out other professions and wrote down their possible needs they might have on the mask/helmet.

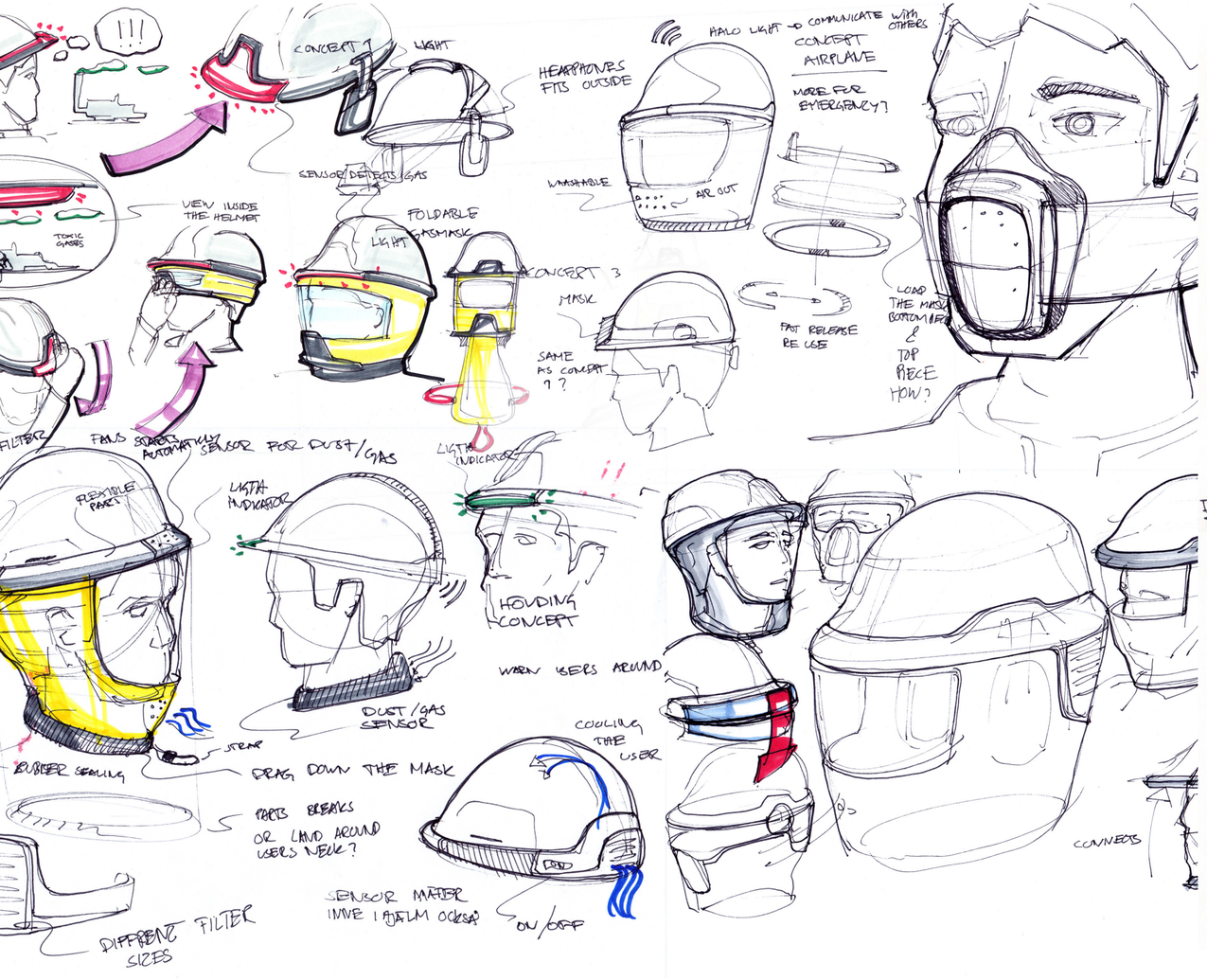
Mine Worker
- Lots of light
- Dust
- Gas/fumes
- Communication
- Emergency i.e. Fire
- Tracking user
- Fall detector/alarm

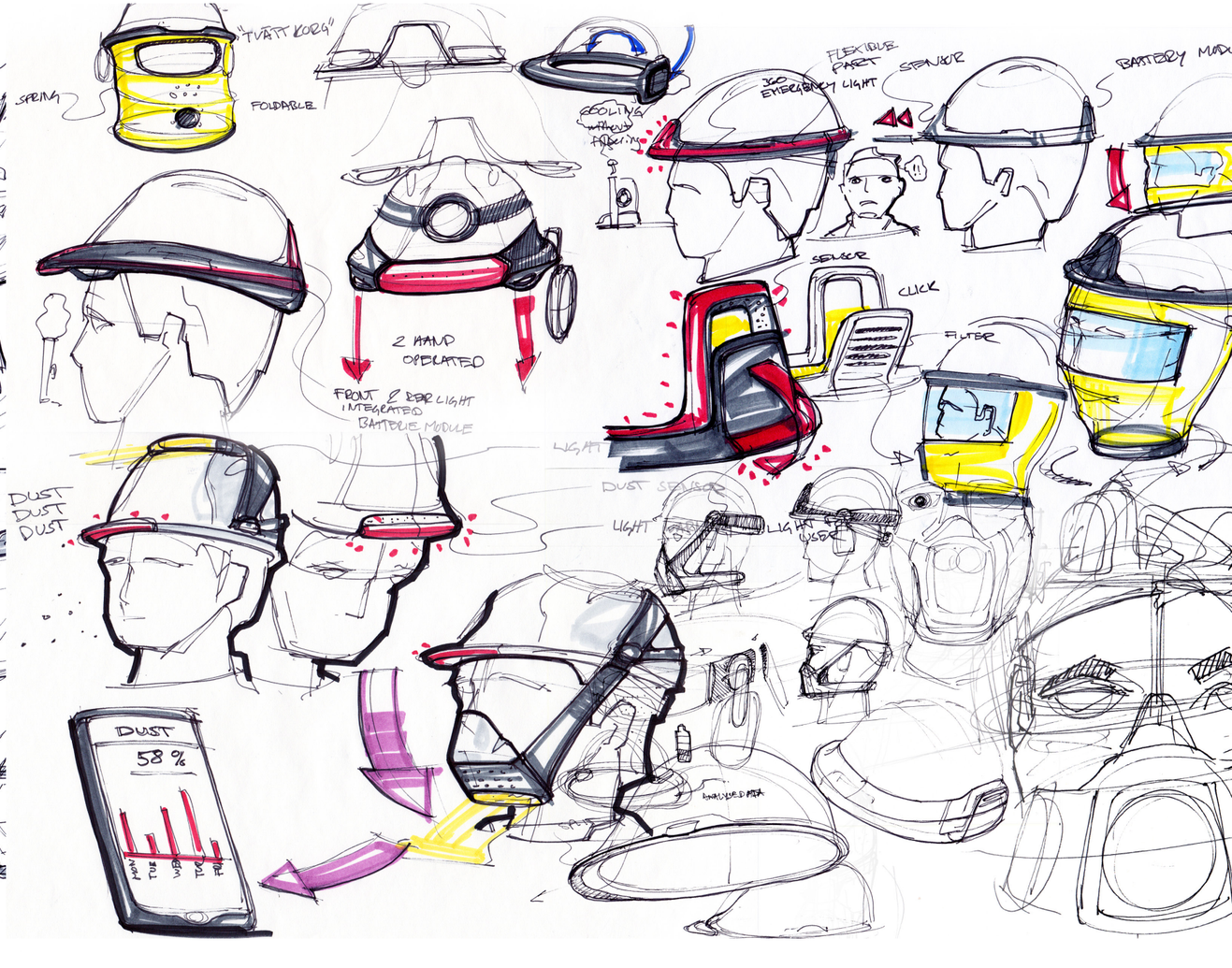
Petrochemical worker
- Gas
- Dust
- Light
- Communication
- Emergency i.e. Fire
- Detect leaks
- Heat camera/sensor
- Fall detector

Construction Worker
- Dust
- Communication
- Light
- Fall detector/alarm

Electrician
- Light
- Dust
- Fall detector/alarm
- Communication

Ideation


CONCEPT 1
LIGHT
SENSOR DETECTS GAS
VIEW INSIDE THE HELMET
TOXIC GASES
FOLDABLE GASMASK
LIGHT
FILTER
FANS STARTS AUTOMATICALLY
SENSOR FOR DUST/GAS
LIGHT INDICATOR
FLEXIBLE PART
LIGHT INDICATOR
DUST/GAS SENSOR
STRAP
RUBBER SEALING
DRAG DOWN THE MASK
PARTS BREAKS OR HAND AROUND USERS NECK?
DIFFERENT FILTER SIZES
SENSOR MAPPER
ON/OFF
COOLING THE USER
HOLDING CONCEPT
WORN USERS AROUND
CONNECTS
HEADPHONES FITS OUTSIDE
WASHABLE
AIR OUT
HALO LIGHT → TO COMMUNICATE WITH OTHERS
CONCEPT AIRPLANE
MORE FOR EMERGENCY?
FAST RELEASE RE USE
CONCEPT 3
MASK
SAME AS CONCEPT 1?
LOAD THE MASS BOTTOM PIECE & TOP PIECE HOW?


"TVÄTT KORG"
SPRING
FOLDABLE
2 HAND OPERATED
FRONT & REAR LIGHT INTEGRATED BATTERY MODULE
COOLING WITHOUT AIRFLOW
360 EMERGENCY LIGHT
FLEXIBLE PART
SENSOR
BATTERY MODULE
SENSOR
CLICK
FILTER
DUST
DUST
DUST
LIGHT
DUST SENSOR
LIGHT
LIGHT
USER
DUST
58 %
MON
TUE
WED
THU
FRI
ANALYSED DATA

Lots of ideation doodles together with simple cardboard models helped me in my process

Here I tested where a possible warning light could be placed so it is visible to the user (green area)

I started my ideation phase with fast sketches and simple cardboard models that I could rapidly evaluate.
I used real protection masks against dust to get a good fit on my face.

I realized after a while that the front light needs to be designed in a way so it can give light forward when it is on the helmet or the face.

With the cardboard models I could test where to place the mask on the helmet for an easy access

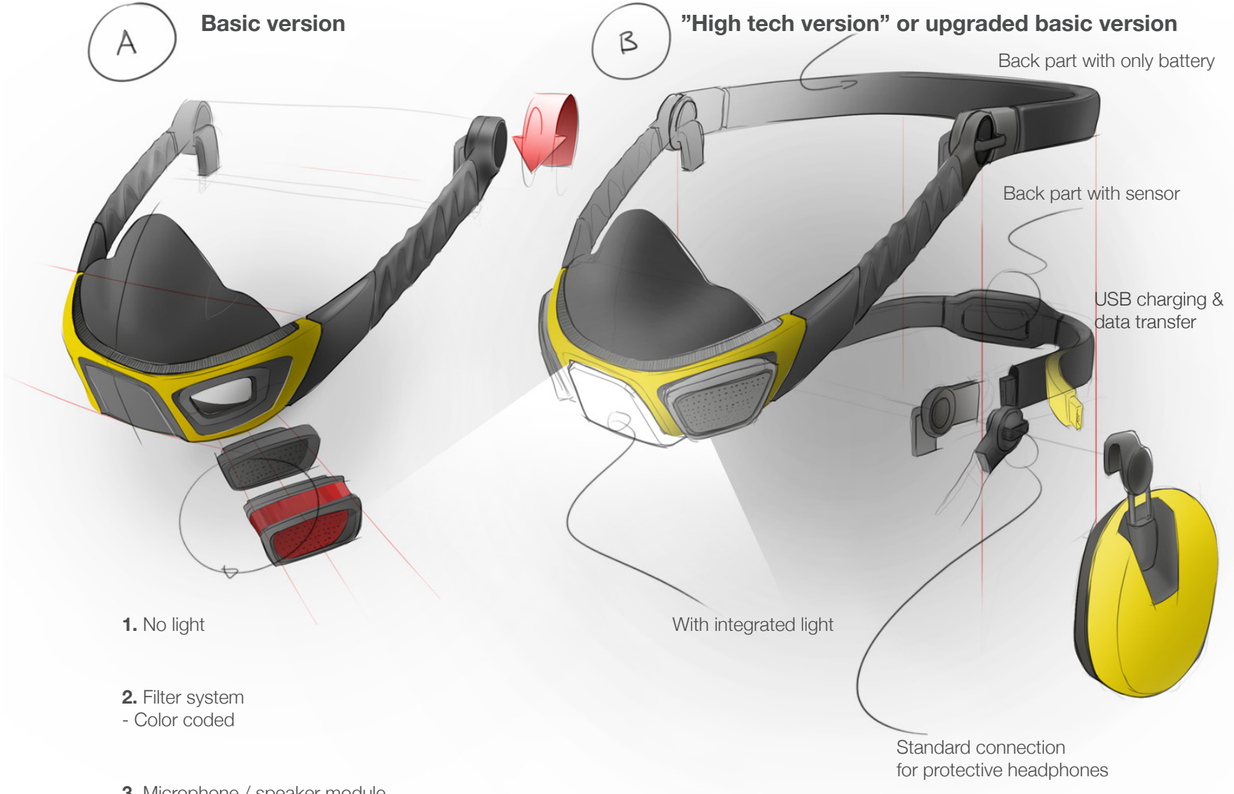
Ideation Presentation

Concept 1

1. User receives warning about the working environment

2. Pull down the mask - Upper part of the mask pops up

3. Adjust the strap on the back if it´s necessary



1. No light

2. Filter system
- Color coded

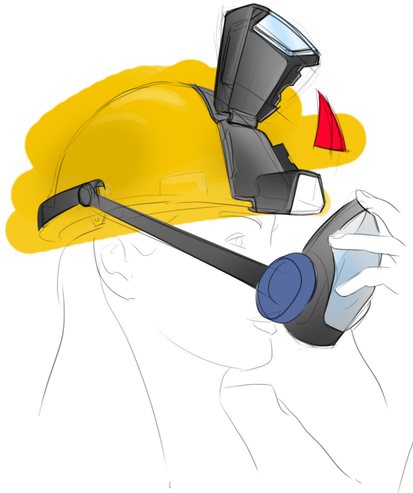
3. Microphone / speaker module
- Send voice audio to coworkers headphones or through the speaker

Concept 1

1. Optional extra light on the sides
- Eye level
- Accessory

2. Rear light for better visibility to others

Concept 2



1. Mask is protected from dust inside the ”safe house”

2. Mask unfolds when the user pulls it down

3. Lights through the mask

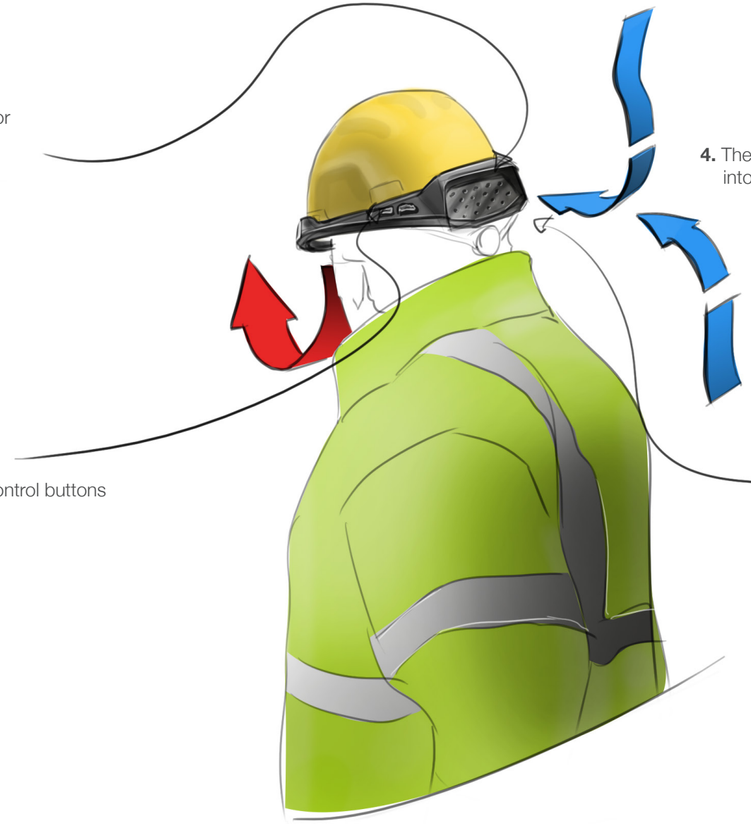
1. User receives warning

2. Pulls down the mask

3. The fan on the back starts to pump fresh air into the mask

1. Filter/sensor

2. Ventilation control buttons



3. Fan/battery unit

4. The fan/filter system can also blow air into the helmet for cooling in warm working environments

Concept 1

Picked Concept

⊕
- Fits on all helmets
- Modular
- Microphone & speaker module
- Light module
- Dust/gas sensor
- Warning LED´s in the front

⊖
- Needs extra light - eye level?
- Too heavy with all the features?
- Adjustable direction of the light?

Concept 2

⊕
- Mask is always protected
- Transparent mask

⊖
- No sensor?
- Light quality through the mask
- Filters unprotected outside the ”safe house”

Concept 3

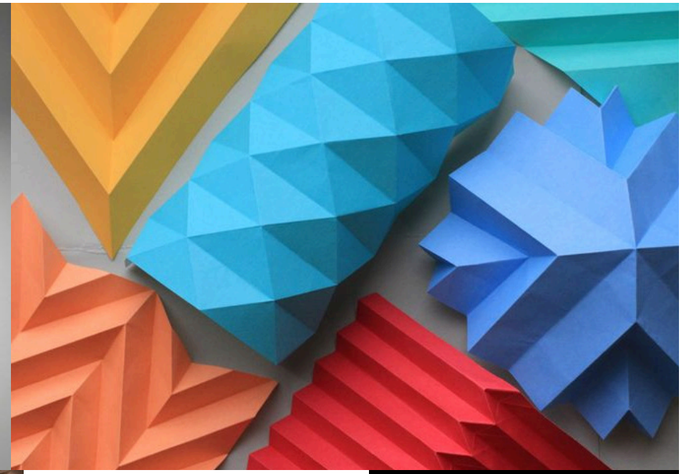
⊕
- Quick access
- Cooling in warm environments
- Light unit always on the helmet
- Filters on the back of the helmet
- Dust/gas sensor
- Warning LED´s in the front

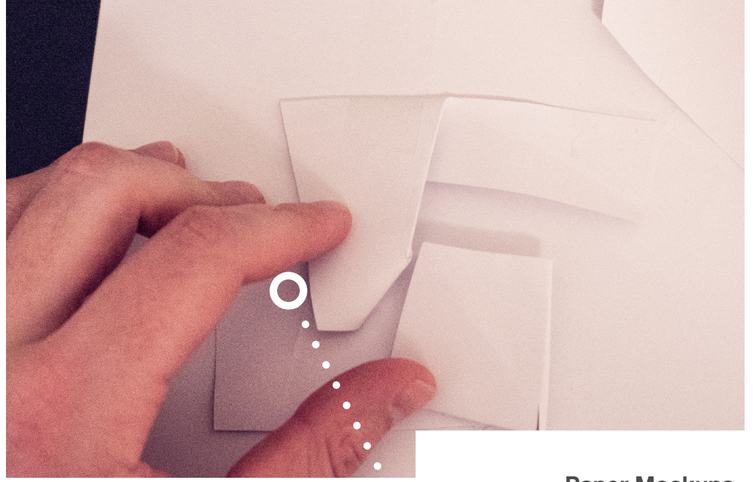
⊖
- Only for emergency?
- Fits all helmets?
- To hot inside?
- Reusable?
- Communication

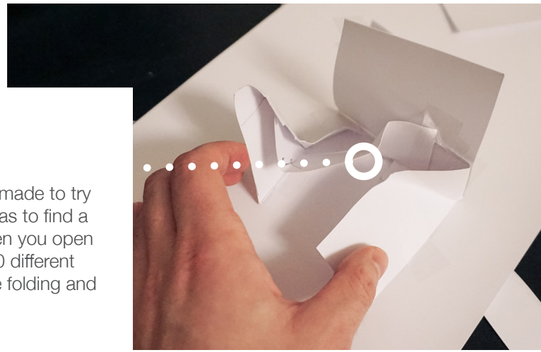
Conclusion

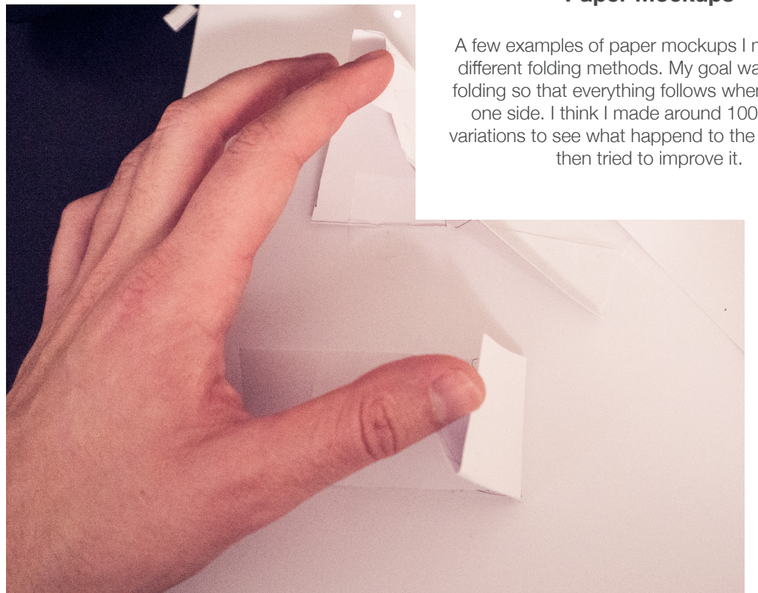
I choose to continue to work with concept 1 even if concept 3 was my ”darling” at the time. The reason why I choose to kill my darling was that I saw a better potential on the market if I focused on making the protection mask to be an everyday product and not only emergency/rescue kit.

Moodboard: Origami & Foldings



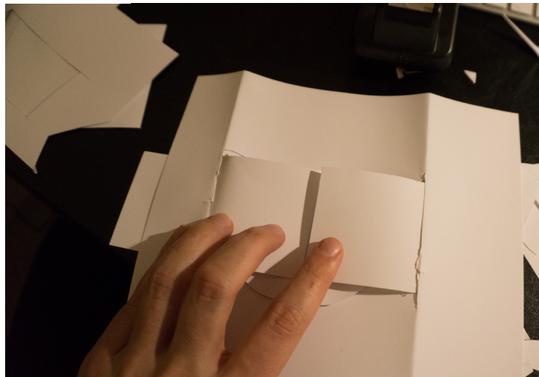






Paper Mockups

A few examples of paper mockups I made to try different folding methods. My goal was to find a folding so that everything follows when you open one side. I think I made around 100 different variations to see what happend to the folding and then tried to improve it.



Sketchworkshop with Daniel Sellberg from Atlas Copco

LED-X is a small Swedish company that manufactures professional head lamps for orienteering and enduro riders

ww.ledx.se

To get some input on the light I had a telephone meeting with one of LEDX engineers. I showed my process and told him what I wanted to achieve with my light.

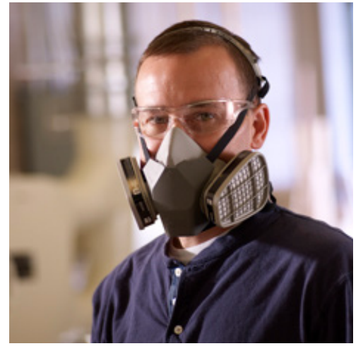
Short summary what I got from the interview:

- 2 Led´s will probably be enough
- The lens is the most important part - this controls the focus and spread of the light
- One idea can be to use the breath as a natural cooling system - led light needs some kind of cooling to last longer.
- 2 Battery cells (315mh,135g) 18WH will be enough for a 8h working day (calculated on 2 Led´s)
- Led+Lens+Circuit Board = 7- 8.5mm depth all together
- XLamp XP-G 1W 5600K (Daylight) - cheap & good quality led

To get some feedback on my project and some useful information I contacted 3M.
I got a meeting with Johan Rapp (Product Manager) and his college Marie Kransdal (Regulatory & Technical Engineer).

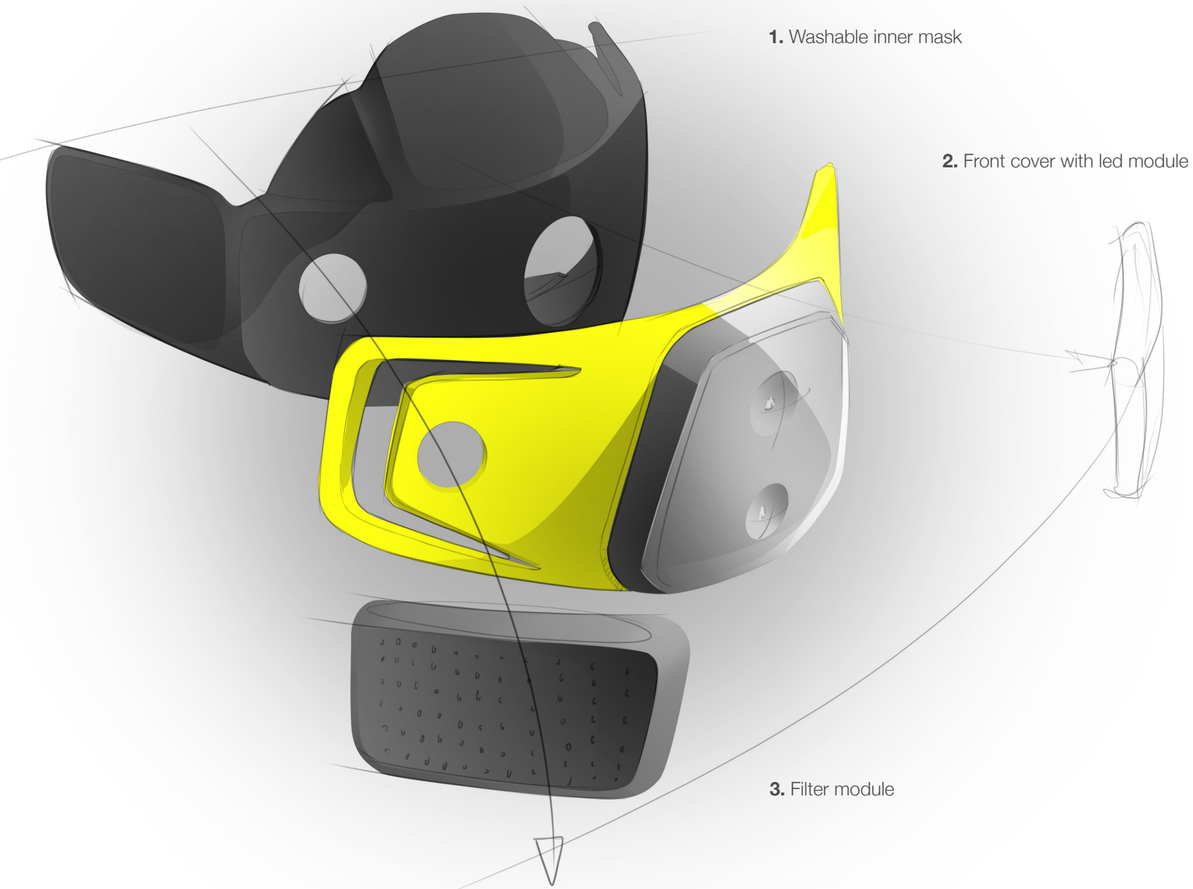
Short summary what I got from the interview:

- Good problems and an interesting project
- Need probably be a neck strap too to get an equal pressure onto the face and to make the mask more stable.
- The reason to have two filters instead of one is that you can make the mask smaller and more balanced on the users face.
- User offer feels when the filters getting old/filled up
- Lot of regelations when it comes to the filters and the mask
- Should be possible to place a light and communication unit inside/onto the mask
- The protective headphone connections can cause a problem, not enough pressure to the ears. Maybe need to be special headphones that only works with this mask.



3M is an big American innovation company that works with a wide range of products. I.e. Healthcare, Transportation, Industry, Office, Electronics, Safety.

Updated Concept



1. Washable inner mask

2. Front cover with led module

3. Filter module

Chosen Concept: Folded

Chosen Concept: Unfolded

Chosen Concept: Walk Trough

1. Neck strap on the backside of the helmet

2. Unlock the neck strap

3. Drag the mask forward and the neck strap backwards

4. Drag down mask and the neck strap

5. Unlock the sides

6. Open the sides

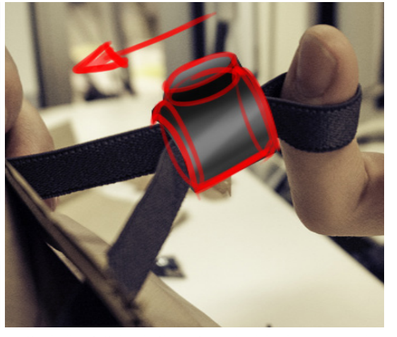
7. When the sides open the rest will be unfolded automatically

7.1. First the cheek support

7.2 And then the upper part that covers the nose

8. Unfolded mask

9. Place the mask over your face



10. Adjust & lock the strap behind your neck

Design & Model Building

Moodboard

Trustworthy

Contrast matt vs glossy

Soft meets sharp

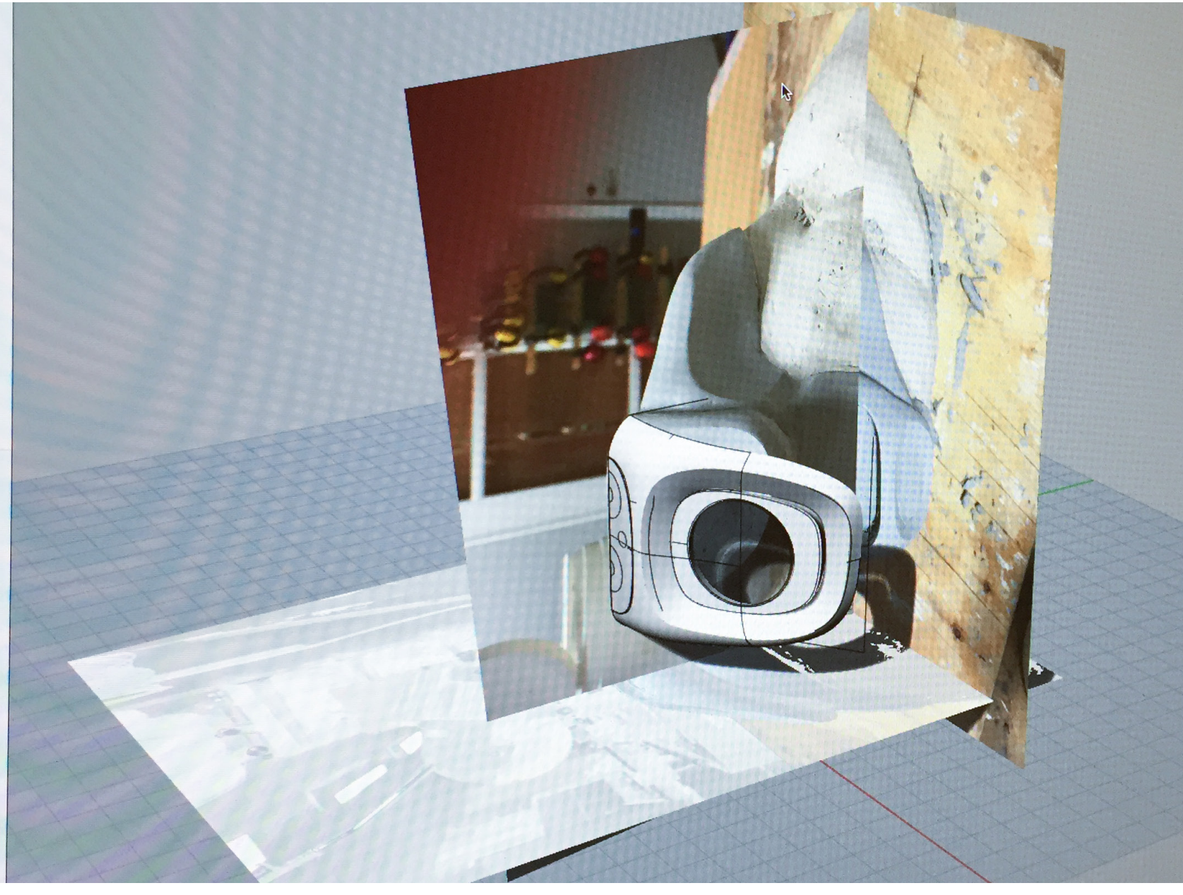
Interesting details

Functional details

”clean” feeling

Simple

Modular shapes

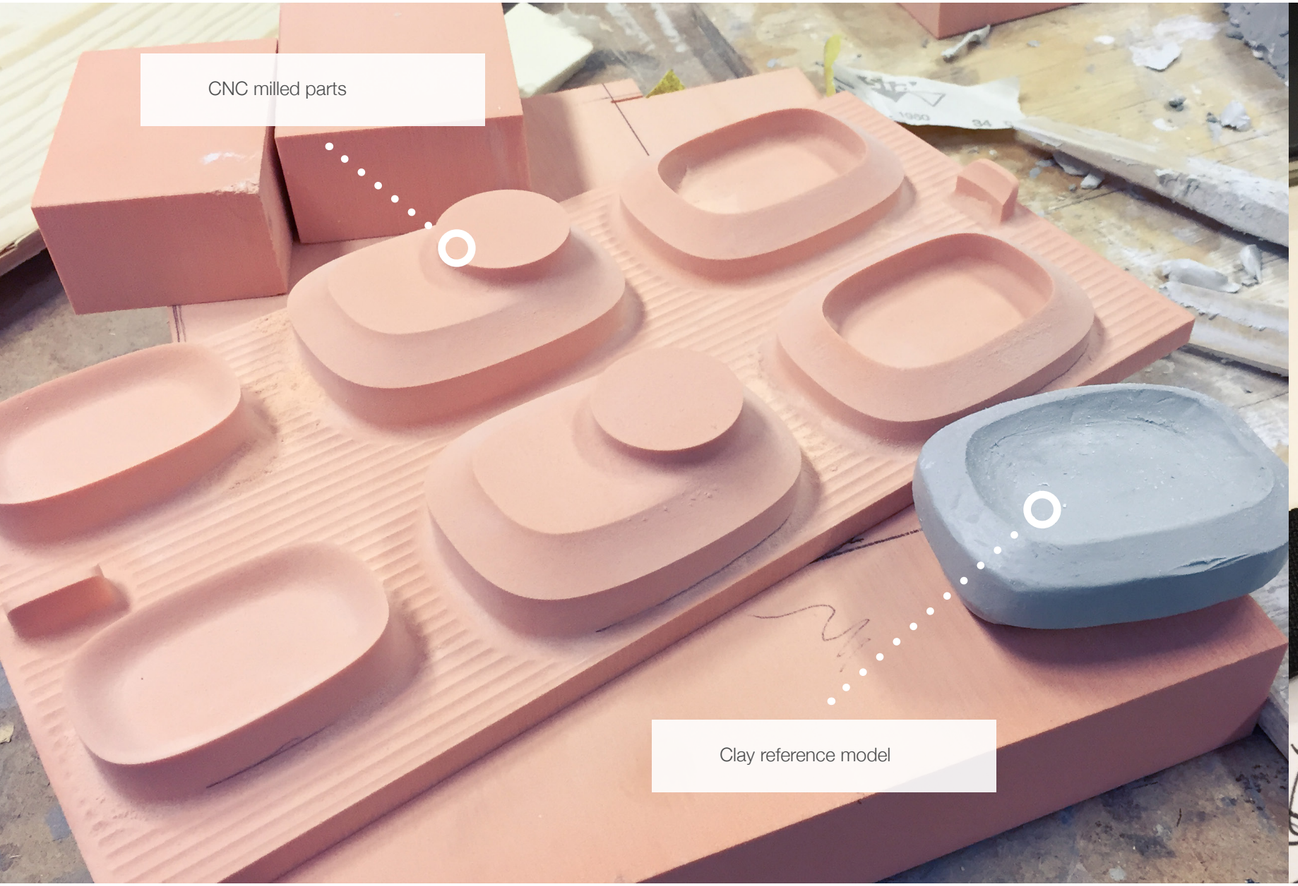


I worked parallel between clay modeling and CAID to explore the shapes and proportions on the different parts. This gave me a fast workflow to a decided design and a finished model.

I used simple photos taken with my phone as underlay, when I changed something on the clay model I could easily continue in the CAID software to do the same change. Another benefit with this workflow was that I could measure on the clay model during the CAID.


Making a negative mold out of silicon


Using gypsum to build a support to the mold so it keeps its shape


CNC milled parts
Clay reference model

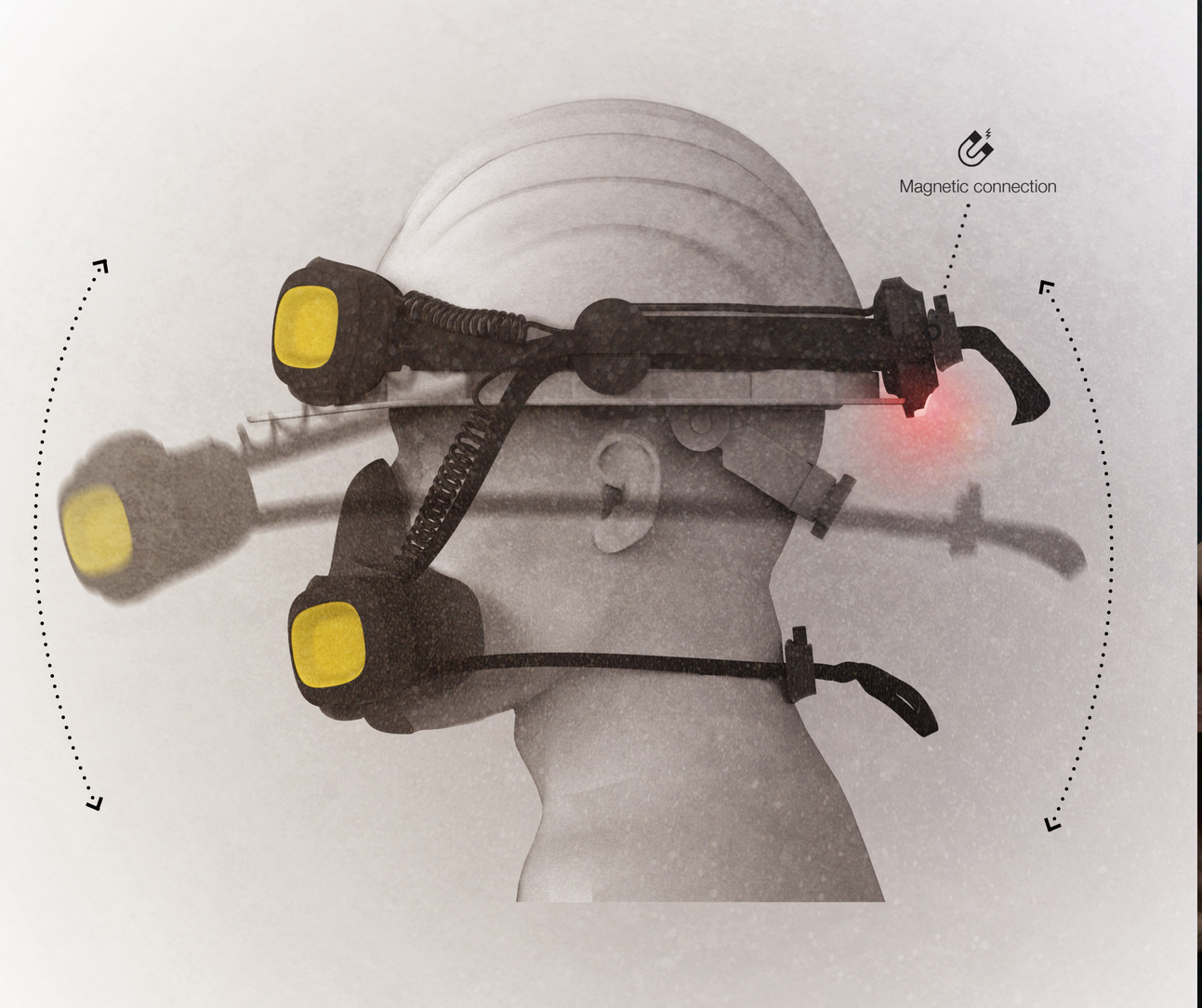

Testing the 3D printed parts
60
80m


HAGMANS
STÅLPLAST


MPLY

Presenting RSX´15


Connection for i.e. headphones
Changeable filters
Changeable front module
Power/Data cable
BATTERY
- With build in smartness
Neck Strap
Rear Light
Helmet Connection


Magnetic connection

Natural Cooling System
- The led lights is using the outgoing air as cooling

Exchangeable Front Module

- The user can self change, depending on what their current need is

Led Lights - This module has two integrated LED lights with two different lenses which achieve a balanced light when the mask is on the helmet as well as when it is on the face.

The user can change the led lights himself and also switch to other lenses i.e. If you need to replace a broken LED or if you want a more focused light or more wide depending on the light situation.

Light sensor - Modern head lamps are using a light sensor to control the light. The sensor is measuring the surrounding light and the light that is reflecting back, It then self adjust the power so it is perfect for the current environment.

Speaker/Microphone - This module has an integrated speaker and microphone. Depending on your setup you can choose between sending the audio trough the speaker or if its a noisy environment to your headphones.

The microphone activates first when you have the mask on your face.

The idea is that the front module will have a “standard” connection so more than one company can develop new modules to the RSX15. The goal is to make the RSX15 better over time and to attract new users and professions.

I came up with a few possible third party modules just to show what can be made in the future for RSX15.

Basic Transparent Module This one has a transparent window to facilitate lip-reading when you are talking to someone

Gas Probe/Sensor Module With this module you can discover possible gas leaks before they hits you.

Full light module This module is for more extreme conditions where you need as much light as possible.

Filter Module - That you can analyze

1

Analyze Filter This module has its own exchangeable filter that you can send for analyzation after a certain period.

⊕

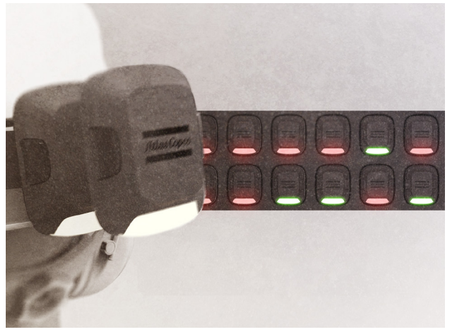
2

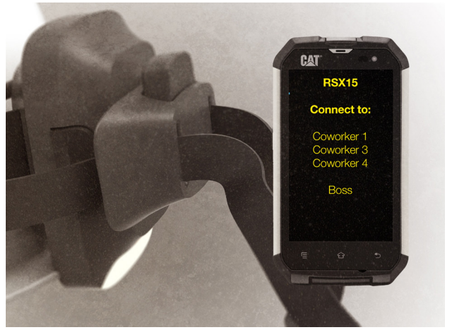
Results With the results you can easily see what you have been exposed for during a specific period. With the results you can keep track of your working environment and this can be useful for i.e. health/work insurances.

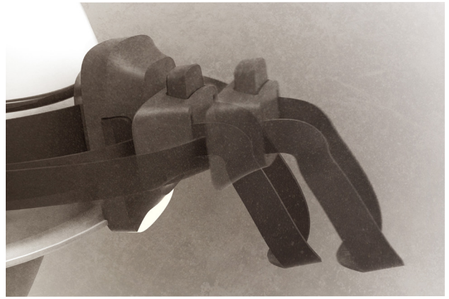
Intelligent Rear Light RSX´15 has a build in light sensor that can feel when the user is entering a dark area then the rear light turns on automatically.

Battery With Smartness

RSX´15 has no on/off button. Everything is controlled by the build in proximity sensor that feels when the user is using the helmet or not. The proximity sensor also works as a fall-detector and can send an alarm if the user has not moved for a while.



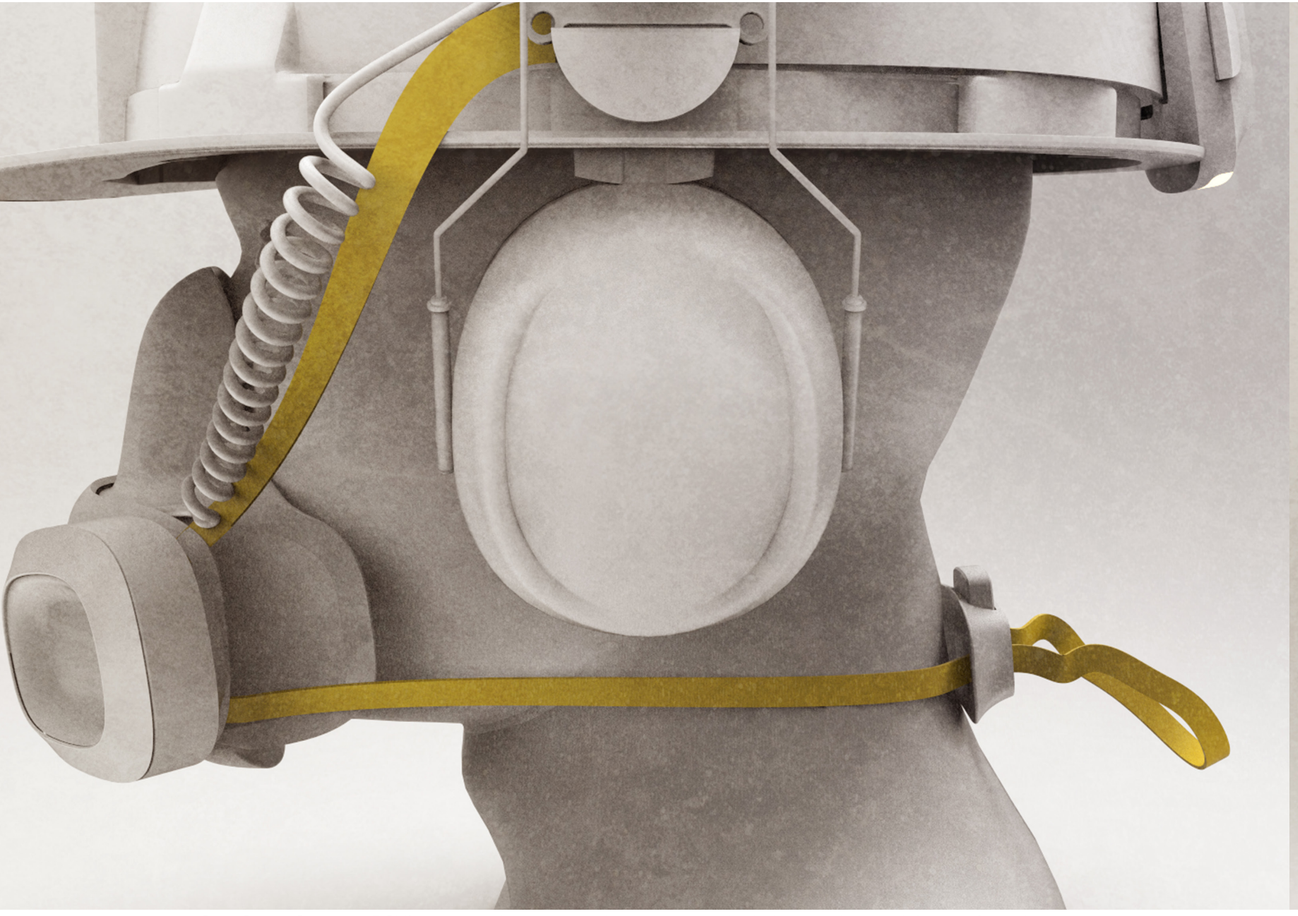




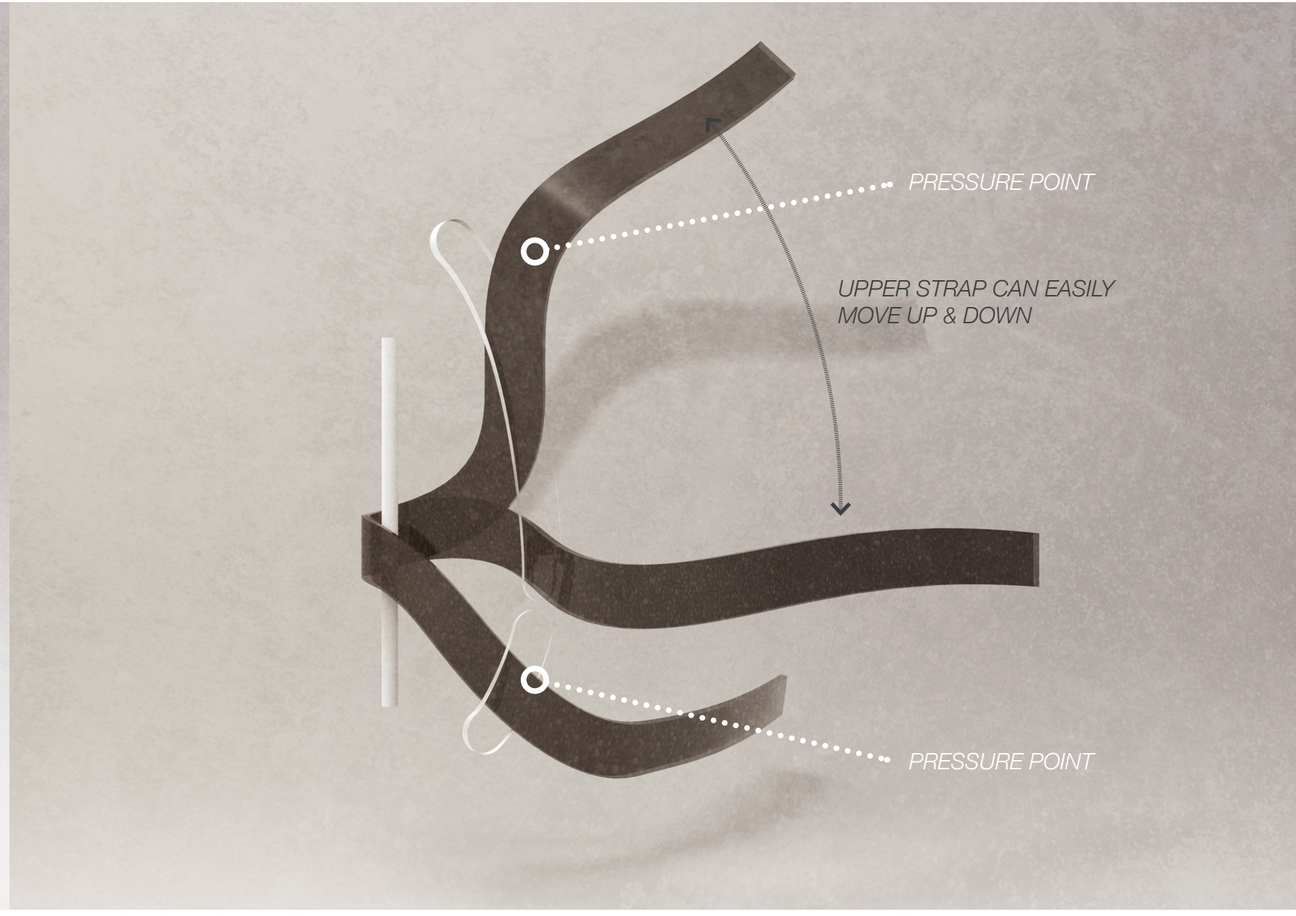
Charging - RSX´15 have rechargeable battery modules that also use the rear light as a charging indicator.

NFC Connection - You can connect and setup your RSX´15 by using NFC / bluetooth. In the app you can i.e. select which colleagues that are in your current working area and where to send the audio, either through the module speaker or to the protective headphones.

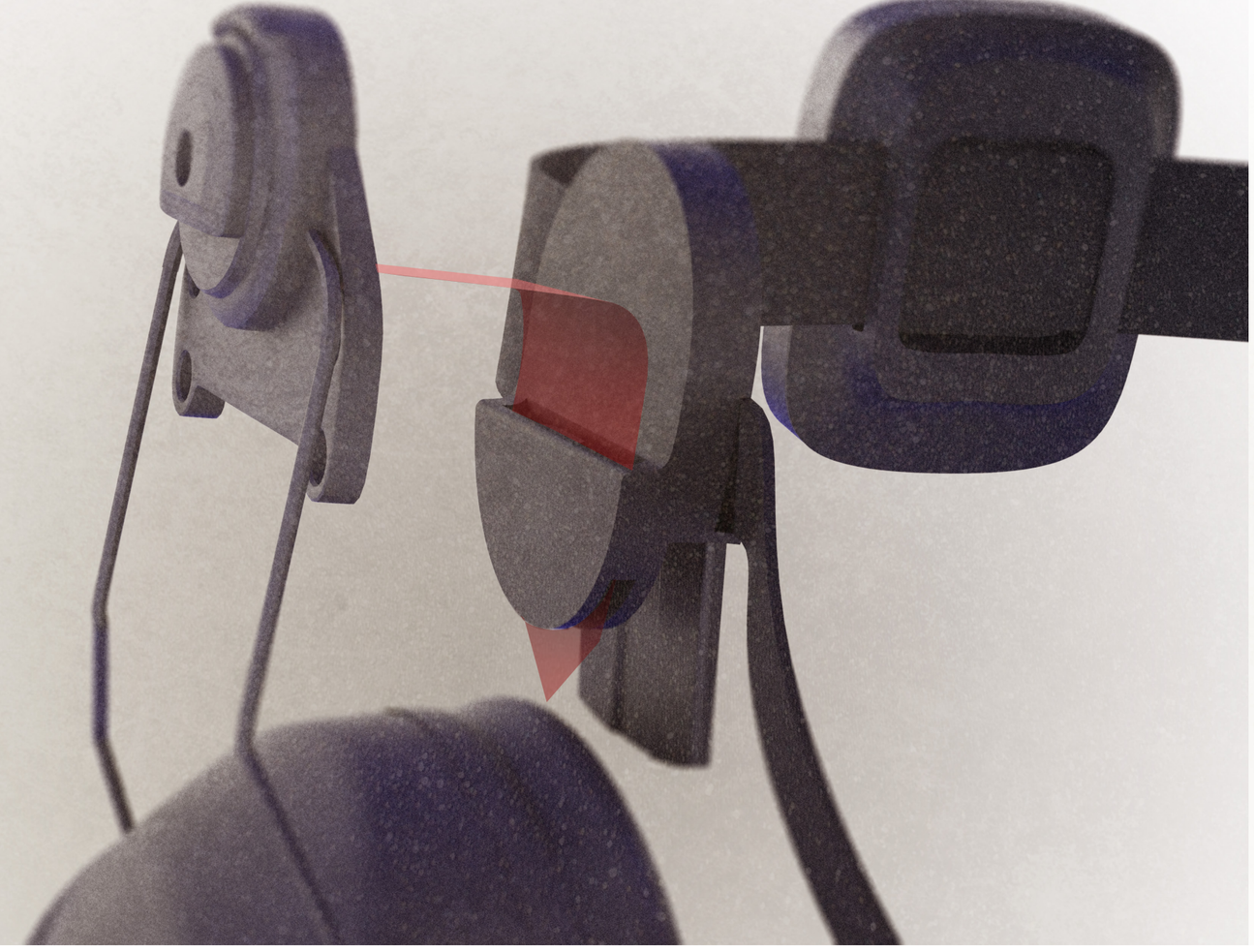
Activate Front Module - To activate the front module (speaker/microphone) you simply remove the neck-strap from the battery. In this way the battery unit knows that you are going to use the mask.



One Strap System RSX´15 uses only one strap that goes from the helmet and around the user´s neck.



One Strap System The upper strap can easily move up and down and the lower strap is fixed. The strap can move freely around the pin.



Headphones Connection You can easily mount your existing headphones on the RSX´15

CMF Examples To make the RSX´15 more personal or to brand it to a specific company, you can change the colors on the different parts. On the picture you can see some examples with the keywords: Discrete / Sport / High Visibility

Photomontages


Strecke 2

Final Presentation & Reflections


PLEASE
DO NOT TOUCH
THE MODELS

Final presentation for LKAB and Atlas Copco

After 10 weeks of research, ideation and decision, it was time for the final presentation. To support our model we printed posters to show our concepts in a context.

After all presentations we got feedback and comments from LKAB and Atlas Copco.

***Alex Liebert**, Design Director Atlas Copco*
***Francisco Lindoro,** Industrial Designer Atlas Copco*
***Patricia Boeg-Jensen,** Researcher Engineer LKAB*

Goals

- Fits on a standard safety helmet
- Protect the user from dust/toxic gases
- Easy installation
- Easy to use - should be a quick task to get it on/off.
- Easy to change parts i.e. batteries.
- Should work with other accessories for the helmet, i.e. protection glasses & headphones.
- Light unit - minimize the stress on the neck/head

Wishes

- Modular - can be configurated for different professions/users
- Sensor for dust - alarm the User or make the user aware that there are things in the air that are not good for your health.
- Facilitate verbal communication - without taking off the mask.
- Working light
- Light 360 degrees to tell everyone that you are in the area.
- Design that works for everyone
- *Record the working environment - health status monitoring*
- *Facilitate in an emergency, maybe show the right way*
- Make it possible to make it more personal - i.e. text and color.
- Jet fighter feeling - feel proud over the mask.
- *Could be used without helmet*

- *Can be solved in a new front module*
- *With some small changes I think you can make it work*

Reflections

When I look back at this 10 week long project I can summarize that it was very intense where quick decisions and progresses was the key to success.

After our trip to Kiruna I had no idea what I wanted to do in this project, it was first after our workshop week where we - as a group brainstormed possible design ares. Then I started to get a clear picture.

I had a lot of struggles in this project, during our ideation phase I killed one of my darlings (Concept nr3- the escape hood) which took a lot of time and focus from me. I also spent a lot of time (maybe to much) to solve the folding of the mask. One thing that can be a problem for me is that I want to make sure that everything works and if something is not working I want to solve it. With the folding of the mask I knew that I had found a good technique that seemed to work but I was not 100% sure. After my talk to 3M I realized that there are so many rules and regelations that controls the design of the mask so it was more or less impossible for me in this short project to make a 100% working mask.

One thing that I wish I started earlier with was the design and CAID, after the Christmas break I had no final design and no CAID and we all where supposed to start in the workshop when we arrived back in Umeå..
I can admit that I had a couple of days where I could not do anything. For me it became like a bad circle where I started to early with CAID without a chosen design direction, my rescue turned out to be the clay. I have never worked with clay in the design process before so it was a big risk but it was a positive experience that I will probably continue with in the future. I am really happy with the results in this project and I think with this product you can really improve people´s health and working environment.

With the changeable front piece you have the possibility to adjust it to your personal needs, which I think is fantastic. This creates also a great opportunity for other companies to develop their own front module to make the product even better over time.

It is also fun to look back at my goals and wishes that i wrote in the beginning of this project and I can see that I managed to solve the most of it.

References

About LKAB
www.lkab.com
Thomas Degn - Brief for the mining project

Pictures
Engin Güzel
Felix Hora
Thomas Degn
LKAB
Google

Research
P.30 Dust & Gases in Mines:
http://www.mining-technology.com/features/featuremining-safely-innovative-technologies-to- prevent-mining-accidents-4207131/

P.31-33 Dust Related Illness:
http://en.hesperian.org/hhg/A_Community_Guide_to_ Environmental_Health:Illnesses_from_Dust
http://www.hazards.org/images/h116dustned800px.jpg

P.34 Black Lung:
http://www.npr.org/2012/07/09/156375910/black-lung-why-respirators-are-not-a-solution

P.36 Why Is Black Lung Back
http://wvuhealth.hsc.wvu.edu/issues/fall-2013/why-is-black-lung-back/

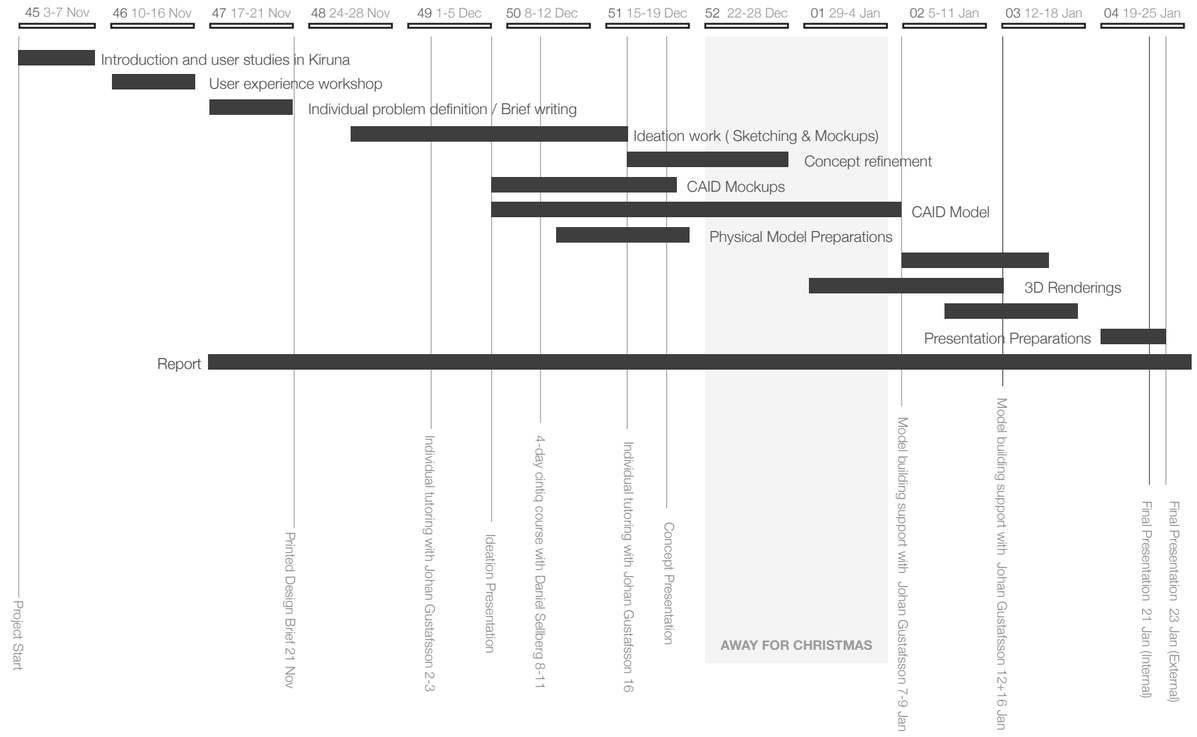
P.37 Communication Equipment
http://technology.infomine.com/reviews/coalminesafety/welcome.asp?view=full

P.38 What is a Respirator
http://en.wikipedia.org/wiki/Respirator

P.39 Respirator History
http://en.wikipedia.org/wiki/Respirator

P.42 SCBA
http://technology.infomine.com/reviews/coalminesafety/welcome. asp?view=full

Timetable

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RSX´15 is the worlds first foldable respiratory mask that is designed for industrial safety helmets.
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