Can a self-contained self-rescue unit be more comfortable to wear over long periods of time, not damage other equipment and be donned easily?
ABSTRACT

Can a self-contained self-rescue unit be comfortable to wear over long periods of time, not damage other equipment and be donned easily?

A self-contained self-rescue unit is a device that is used in the mining industry in case of fires or release of toxic gases that depletes or contaminates breathable oxygen in the surrounding atmosphere. These units are the first line of defense by providing oxygen in a closed breathing cycle, allowing personnel to get themselves to safety.

The goal of this project was to design a unit that is more comfortable to carry during the daily operations in and outside the mines. A unit that is easier to don and less likely to damage the users and/or surrounding mining equipment. It is developed in close collaboration with Atlas Copco, as the main sponsor, as well as Dräger and personnel working at Zink Gruvan Mining.

The result is a unit with an operational time of twenty minutes and a reduced size and weight. It's position can be adjusted to be worn around the waist or the chest, depending on the tasks the user performs, as well as simplifying the donning procedure.

THANK YOU

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INTRODUCTION
BACKGROUND OF THE SCSR UNIT

SELF-CONTAINED SELF-RESCUE
A self-contained self-rescue unit, or Air Pack, is a portable oxygen source for providing breathable air in emergency situations. Such as if the oxygen level in the surrounding atmosphere would unexpectedly drop or become contaminated with toxic gases. A SCSR is a closed-circuit breathing device intended for one person and usually provides one hour of breathable air. The oxygen is provided with a chemical oxygen generator or a compressed oxygen cylinder and a carbon monoxide absorber. They are most commonly used by personnel in the mining industry, especially in coal mines. Also in other fields where personnel are working in an environment that could be sealed off and oxygen levels can drop due to fires, explosions or cave-ins, such as tunneling. The purpose of an SCSR is to provide breathable air in emergency situations, long enough to facilitate escape from mines after a fire or explosion. Usually the goal is to reach a safe bunker and wait for rescue.

BACKGROUND
The history of the self-contained breathing apparatus dates back to 1853 of a portable machine for a prize competition of the Belgian Academy of Science. In 1903 the Dräger apparatus appeared in Germany. 1907 some mining companies in the USA started providing a rescue apparatus to the workers in their mines. The apparatus was designed to provide good air for at least 2 hours, “no matter how bad the surrounding air may be”. I was hoping to say that a lot has happened since then, but that does not appear to be the case. The size of the SCSRs have certainly decreased since those days, making them more portable, but in large they still work in the same manner.
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Can a self-contained self-rescue unit be more comfortable to wear over long periods of time, not damage other equipment and be donned easily?
PURPOSE
The purpose of the visit to the Zink mine in Askersund was to get a feel for the work situation, the environment and context in which the SCSR units are used. I got in contact with Fredrik Jönsson, who is the service manager for Atlas Copco’s service department within the mine. Their job is to service all of the Atlas Copco products that are used in the mine. This means that they are familiar with the different vehicles and products used within the mine, as well as the people working there.

APPROACH
I joined Fredrik down the mine during one morning to see what the environment is like and meet the miners to ask them questions. He explained that the mine is 1200 meters deep and that we would be going all the way down.

I found out that they actually do not use the SCSR units anymore in the mine, but instead they use filter hoods. The difference is that it does not produce any oxygen and is therefore not as complex as an SCSR unit.

Despite the fact that SCSR units no longer were in use in the mine, I still felt that this visit would give me a lot of good information. Many of the miners had several years of experience with carrying around the SCSR units that were previously used.

Before it was time to head down to the mine I had to be prepared. First I got to see an instruction video of what garments I should be wearing. A blue overall, a yellow vest with reflectors and rubber boots. I was also required to wear an escape hood in a shoulder strap and a helmet.

The general rule concerning the escape hoods are that they must always be within 10 meters of reach. This leads to that they must always be carried around on your person, since there is no other way to ensure that the device is no further away than 10 meters.

Just as we were ready to head down the fire alarm went off. I quickly learned that this was a fire drill, which also mean that we had to wait for the fire drill to be over before we could continue. Fredrik told me that they have fire drills like these four times a year.

This gave us a bit more time to talk before we continued our tour. I took the opportunity to let Fredrik try out the vest with weights that I had made. My idea with this mock-up was to see if there could be some way to distribute the weight of an SCSR unit differently. I needed to find out what the alternatives could be.

It did not take very long for Fredrik to realize that carrying any kind of weights above the waistline causes some problems. The first thing he noticed was that it shifts your balance, which is not optimal when working in a mine. It would also cause fatigue in the shoulders since the work they do often means holding your arms over your head, moving around in tight spaces and climbing on, and under, big vehicles.

Finally the fire drill was over and we were able to head down the mine. I was expecting the mine environment to be dirtier, messier, more crowded and perhaps a bit old fashioned. I was met with a long tunnel five meters wide with concrete covering the sides and the ceiling. It was not very different from driving down a regular car tunnel, except there were no asphalt and no lighting. There was however road signs and traffic lights. I noticed that many workers were wearing t-shirts when working instead of a big jacket on the lower levels.
We eventually reached the bottom level and I got to visit one mine worker who were operating an Atlas Copco Boomer. A boomer is a vehicle that drills holes in the rock face to fit explosives. This is to break of mineral ore and increase the length of the tunnel.

The cabin of a Boomer is usually quite large. We could easily fit three people in it, the operator, Fredrik and me. The operator of the vehicle explained that they were required to wear three things at all time. The battery for the lamp on top of the helmet, a com-radio and the escape hood. All of this attached to specific belt, provided by the mine, that is attached around the waist of the person.

The operator would usually detach the bag containing the escape hood and place it on a shelf in the cabin of the boomer. There is enough space in the boomer to be able to do this, also enough space to have two extra escape hoods.

What I learned from talking to the operator was that the biggest problem with both the SCSR unit and also the escape hood, is the high level of discomfort. They are always in the way. When walking around, when sitting down in a car it gets stuck between the thigh and the car door. He did like that the escape hood was in a bag that is softer and not as heavy as the SCSR units were. Yet they still are uncomfortable and gets in the way. He also told me of an incident from the time when they all were wearing the SCSR units. One of his coworkers had tripped and fell during work. He landed with his whole body weight on the SCSR unit and got injured.

After meeting the Boomer operator I got to see an Atlas Copco Scooptram ST18. The cabin of this machine was very different. The cabin was very small, and there were lots of instruments all around. I had to keep my escape hood case in my lap, I could not find another place for it. Personally I would be worried that the bag would fall down on the floor and get stuck between my feet and the controls pedals. To have something that big attached to your hip in this kind of environment could easily become problematic.

**CONCLUSION**

I had expected there to be more issues and opinions regarding the SCSR units. I was thinking of issues regarding safety, training on how to use the units, aches from wearing them, damages to other equipment and so on. But the major factor was simply discomfort. It was what I kept hearing over and over again, that it is simply uncomfortable to wear. Fredrik told me that if personnel could chose wether to wear them or not, they would most likely leave them in their cars or in the break room. The feeling of safety was not the prevalent issue, nor did they seem worried about not being sure how to use them or not.

It does make sense that discomfort is the biggest issue for the miners. The fact of the matter is that most miners will go though a whole career without ever having to use an SCSR unit. But they will be wearing it for every hour during every day in the mine. I find it odd that something that needs to be worn by people so much is not that well adapted for that purpose. Also the fact that it is so critical for the miners survival in an emergency, yet it is so complicated to done, that they need to be constantly reminded how to do it.
ATLAS COPCO VISIT
WORKSHOP AT ATLAS COPCO INDUSTRIAL DESIGN COMPETENCE CENTER

PURPOSE
The Purpose of having a workshop at Atlas Copco was to generate some early ideas. I wanted to keep it simple and open with no limitations. My goal was just to get as many ideas as possible on alternative ways that this product could be worn, used, function and look like.

APPROACH
Besides myself, there were three people participating in the workshop: Francisco Lindoro, Apurba Pawar and Ali Dehghanpour. I started with a very short presentation of what the product looks like and how it is used today. I described the problem areas that I found both before and after my visit to the zinc mine. After that I just let them brainstorm freely on alternative functions, looks and placements of SCSR units.

CONCLUSION
The workshop went very well and I got exactly what I wanted from it. We came up with a bunch of ideas and possible new solutions, which is exactly what I needed for the upcoming visit to Dräger design office. We also chose to revisit the vest with weights and discussed the idea of separating the unit into different parts when it’s inactive. These very light parts could perhaps be worn above the waist line and be close to the face. Perhaps a breathing tube or mask could be positioned closer to the mouth for instance. I also got a few tips on new technologies that could be used within a device like this one. All in all, it was a very successful workshop.
VISIT TO DRÄGER
THE DRÄGER RANGE, TECHNICAL INFORMATION AND LÜBECK

PURPOSE
I was invited to visit the Dräger headquarters in Lübeck by Lennart Wenzel [Product Design Manager]. The purpose was to give me as much information as possible about Dräger's range of SCSR units. They are today one of the biggest manufacturers of SCSR units worldwide and of course has extensive knowledge of the technical aspects of these units, mining regulations and a close contact with the industry and the end users of these products.

APPROACH
When I arrived at Dräger's headquarters in Lübeck I was introduced to Lennart Wenzel, Kirstin von Waaden [Segment Manager for Escape Devices in Mining] and Malte Gröning [Project Manager for current SCSR's]. I got to spend the whole day with them, talking about the SCSR units, how they work, what the customers need, what the users say about them and possible future improvements.

My approach to this informative day was to get as much information as I possibly can from the people that knows the most about SCSR units and everything concerning them. After a brief tour by Lennart where I got to see other product ranges that also concern mining safety, Kirstin held a presentation of all the SCSR units. Also Dräger's entire portfolio concerning mining self-rescue devices.

She told me that SCSR units are used in both coal mining and hard rock mining for minerals. But the there is a big difference in case of emergencies. In an ore mine there are rescue chambers throughout the whole mines, which means that miners can get to these chambers using only the SCSR unit that they are wearing. However in coal mines there are no rescue chambers like these, the only option available is to simply go all the way out as fast as possible. Coal mining is the most extreme environment and a fire there is incredibly hard to extinguish.

This is solved by donning the SCSR unit and then start to head out of the mine, but one unit will most likely not last long enough to get all the way out. Therefore there are cachês with additional SCSR units stationed every 500 meters throughout the mine. The miners would then don the unit they are wearing, keep going until they reach a caché, don new one and keep going like this until they reach the exit. Another method that Dräger also provides are stations with full face masks and oxygen tubes that the miners put on when reaching a caché. They can then refill these oxygen tanks at every caché, in just a few seconds, until they reach the exit. They are still dependent on the SCSR units to reach the first caché, since the oxygen tubes are far too big and heavy to carry around on a regular basis.

Malte told me a lot about the technical aspects concerning the SCSR units. One interesting fact was the difference between high-stack and low-stack potassium superoxide cartridges. Apparently the low-stack ones that Dräger uses are more effective at providing oxygen and scrubbing of carbon dioxide, as well as having a longer operational time than their competitors. The main difference between high-stack and low-stack cartridges are that the high ones are thinner and longer, like a can of soda, where as a low-stack one is broader and shorter, looking more like a puck. Most of their competitors rely on high-stack cartridges, which is one reason why Dräger's units always performs better in tests.
We also discussed if there was a possibility to introduce new components to an SCSR unit. Such as small oxygen tubes, some electrical components that can alarm the user if the seals has been broken and so on. Malte then informed me that these units has to last for at least 8-10 years. During this time the inside of the unit can never be exposed to the outside atmosphere, there has to be a perfect seal at all times, or the unit will be destroyed. This also means that there can be nothing on the inside that needs to be maintained, that can easily break och run out of batteries. This is a purely mechanical product for a reason, it has to be able to last for nearly a decade without ever being opened. The reason why only chemicals are used for the starter and the production of oxygen for the closed breathing cycle is quite simple really – they always work.

“The benefit of using chemicals – they work”

CONCLUSION

I found my visit to Dräger to be incredibly rewarding. I learned a lot of important information about the SCSR units, the regulations concerning them and the people that use them. Besides all of this I also got to practice the donning procedure on training units that Kirstin had brought to the workshop. Something that surprised me was that despite the fact that I had watched several instruction videos prior to my visit, I still struggled quite a bit with the donning the units. I doubted how well I would fare if I found my self in a situation where a unit would be the difference between life and death.

After this visit and with the information that I got, I made the decision to focus on a unit that solves the most immediate problem in a mining disaster. Which is the very first unit that the user is wearing and will be donning directly to get to a caché to retrieve a new unit on the way out of the mine.

At the end of this very interesting day we compiled a list of things that I should consider as I keep designing my new and improved SCSR unit.

CUSTOMER REQUIREMENTS/WISHES

1. Water tight and robust
2. Compact, more ergonomic, fool proof
3. Intuitive use – donning sequence, color coding, pictograms
4. Duration 15-30 minutes
5. Cleaning: Homogenous surface. No gaps/pockets to collect dirt.
6. Indicator: Shows humidity on the inside
8. In most of the cases it has to be worn the whole day 8-12 hours
Components of a Dräger OXY 6000 training unit
CURRENT PRODUCT
AN OVERVIEW OF DIFFERENT BRANDS AND LOOKS OF CURRENT UNITS

Although the Self-Contained Self-Rescue units come in a wide range of brands and looks, the main function is basically one and the same.

What differs between different models are of course the way they look but also the way that you don the self rescuer. So if you know how to don a Dräger OXY 6000, it will not guarantee that you know how to don a CSE SR 100.

Even if there are some differences in the basic layout of the SCSRs, the active component all work in the same way. There is a breathing hose, a nose clip, goggles, KO₂ cartridge, breathing bag and so on.

Since Dräger is one of my collaborators during this project, I will use the Dräger OXY 6000 as an example to show how a SCSR unit works on the following spread.

Dräger Oxyboks K 25
Duration: 25 min
Weight unopened: 2,1 kg
Weight during use: 1,2 kg

Dräger OXY K 50S
Duration: 50 min
Weight unopened: 3 kg
Weight during use: 2,4 kg

Dräger OXY 6000
Duration: 60 min
Weight unopened: 3,4 kg
Weight during use: 2,3 kg

CSE SRLD
Duration: 210 min
Weight unopened: 2,7 kg
Weight during use: 2,2 kg

CSE SR 100
Duration: 60 min
Weight unopened: 2,6 kg
Weight during use: 2,2 kg

DZGA Ci-30 KS
Duration: 30 min
Weight unopened: 2,5 kg
Weight during use: N/A

OCENCO M-20
Duration: 15-32 min
Weight unopened: 1,4 kg
Weight during use: N/A
HOW DOES IT WORK?
THE DRÄGER OXY 6000

INFORMATION BASED ON AN INTERVIEW WITH MALTE GRÖNING, DRÄGER SCSR PROJECT MANAGER.

The Dräger OXY 6000 is made to last for 60 minutes during use. This is if you would be breathing 35 liters of air/minute. An average human being would find it incredibly difficult to breathe more than that. This means that the estimated 60 minutes of usage is not a maximum operational time but a minimum operational time. The unit could easily be used for as long as 90 minutes, and if you would be sitting down and breath calmly the unit could be operational for as long as 4 hours.

The component that makes it possible to produce oxygen in this self-contained breathing system is the KO₂ cartridge. KO₂ stands for potassium superoxide. It is an inorganic compound that decomposes in moist air. This decomposition produces oxygen, which means that every time you exhale in the breathing apparatus you generate more oxygen because the moisture in your breath decomposes the potassium superoxide. This process will continue as long as there is any KO₂ left to decompose. For this to be effective the breathing cycle has to be completely sealed, therefore it is called a self-contained system.

To make sure that the KO₂ does not start to decompose until it is needed, the cartridge has to be properly sealed from the outside atmosphere. To check this you need to make sure that all of the seals on the housing of the unit are unbroken. There is also an indicator window that changes color if the potassium superoxide has started to decompose prematurely.

The average lifespan for an SCSR unit is between 8-10 years, although some has been reported to still function after 15 years. If a unit would get damaged they get sent back to Dräger for repairs or to be replaced with a new one. Out of all the units that Dräger produces about 80% of them are never seen again. Less than 20% gets sent back for repairs or to be replaced because of damages and as little as less than 3% are ever used in an actual emergency situation. With this information it could also be interesting to know that one SCSR unit comes with an average price tag of 1000 euros.

“LESS THAN 3% ARE USED IN AN EMERGENCY”

The SCSR units are used in all kinds of mines, not just coal mines. They are also used in tunneling, tunnel rescue, oil refineries and military vessels and ships. Basically, they can be found anywhere where it is impossible or difficult to leave the danger zone.
FUNCTIONAL PART
AND ITS COMPONENTS

NOSE CLIP
HEAT EXCHANGER
BREATHING HOSE
STARTER
BREATHING BAG
KO2 CARTRIDGE
BUTTON LOOP
GOGGLES
NECK STRAP
MOUTHPIECE
CHEST STRAP
THE CASING
THE DRÄGER OXY 6000

- Opener with Seal
- Safety Eye
- Tightening Strap
- Top Cover
- Bumper
- Shoulder Strap
THE BREATHING CYCLE
THE DRÄGER OXY 6000

When donned the starter ignites and fills the breathing bag with the first cycle of oxygen.

When the user exhales into the mouthpiece, the air goes through the cartridge which collects the CO2 and releases oxygen as the air continues in to the bag.

When the air is inhaled again much of the CO2 has been absorbed and the air is enriched with oxygen. This cycle of absorbing CO2 and releasing oxygen in to the sealed breathing cycle then continues as long as there is enough KO2 left to react with the moisture in the exhaled air.
FLOWCHART
USE OF A DRÄGER OXY 6000 IN AN EMERGENCY

1. Kneel on the ground
2. Place SCSR on the ground in front of you
3. Remove helmet
4. Place helmet on the ground so that the light shines on the SCSR unit
5. Hold the SCSR unit in both hands

**Warning:** (With other common brands of SCSR units, actions performed in the wrong order here can render the entire unit useless)

6. Hold device tightly by the yellow neck strap
7. Put the yellow strap over the head. Device facing forward
8. Pull the mouth piece to your face
9. Bag fills with oxygen
10. Place mouthpiece in the mouth

**If bag does not inflate**

11. Put goggles on
12. Put helmet back on
13. Pull out chest strap
14. Wrap chest strap around the body
15. Attach chest strap on opposite end
Breathe heavily three times in to bag to fill it with air

Pull opener until the tightening straps fall off
Open the top cover
Discard top cover
Use yellow strap to pull the SCSR out of the housing
Remove and discard housing

Make sure hose is not twisted
Place mouth piece between teeth and lips
Place nose clip on the nose
Use yellow neck band to adjust the units position
Remove goggles

Pull chest strap tight
Breath normally

Get to safety

Get to safety
THE FIGHT OR FLIGHT RESPONSE
HOW DO WE ACTUALLY REACT IN CASE OF AN EMERGENCY?

AN INTERVIEW WITH PSYCHOLOGIST NILS MALMSTRÖM

When faced with an emergency the body and mind naturally goes in to a state called the fight or flight response. The outcome of this reaction depends greatly on how prepared you are.

Since this is a product whose main function is to facilitate self-rescue during life threatening situations. I wanted to find out how people normally react during a state of emergency. If I want to change the way you don an SCSR unit, then I also need to know how people normally would react, so that my design does not come in to conflict with this response.

FIGHT OR FLIGHT RESPONSE

This is a physiological reaction that occurs in response to a perceived harmful event, attack, or threat to survival. In short what happens is that the brain interprets the signals of a perceived threat and sets of a chain reaction. The pituitary gland releases a hormone called ACTH. The adrenal gland is activated almost simultaneously and releases the neurotransmitter epinephrine. The release of these chemical messengers results in the production of the hormone cortisol and noradrenaline.

The effects this has on the body is an increase in heart rate and blood pressure. The blood gathers in the torso, breathing becomes more shallow and rapid. This decreases fine motor skills and hands starts to shake. Pupils dilate, tunnel visions occurs, the mouth feels dry and hearing also decreases. What does this mean in the context of an escape from a mine?

PREPARATION IS KEY

The result of this response usually leads to the person effected becoming very focused on what they are presently doing. The most typical reaction is not total panic and irrational behavior. But this all depends on if you have and idea of what to do and can see a way out of the threatening situation. Mine workers do get training on ho to use the SCSR units and how to act in an emergency, so it is very likely that they will be more focused and not become paralyzed. For a visitor in the mine, that perhaps has not been as thoroughly prepared, the reaction could become more dangerous. If the task at hand seems to overwhelming to be able to escape, the person would be more likely to become paralyzed and essentially give up or panic.

However if you still manage to remain focused, the unit you are about to use can not be too complex, since your fine motor skills are decreased. Also, as some brands of SCSRs can be rendered useless if you mix up the steps in the donning process. Simply the knowledge of the possibility of failure can further increase the stress level and make it even more difficult to remain focused and not panic.
THREAT

NORADRENALINE

CORTISOL

INCREASED PULSE
TREMORS
DILATED PUPILS
SHALLOW BREATHING
LOSS OF HEARING
TUNNEL VISION
ANALYSIS
PROBLEMS AND FOCAL POINTS

Can a self-contained self-rescue unit be more comfortable to wear over long periods of time, not damage other equipment and be donned easily?
MARKET OPPORTUNITY

HOW DO I HOPE TO SET MY DESIGN APART FROM TODAY’S PRODUCTS?

The market is teeming with different versions of the SCSR units. Although they vary in technical details, donning procedures, cartridge layouts, and brands, they are very alike.

Something I learned from my visit to Dräger was that these units are firstly designed and developed with mining regulations and the mining companies in mind. The needs of the actual users come second, in some cases they are hardly considered at all.

Although, I learned that if you design a better product that might not be entirely within the frames of mining regulations, it is likely that said regulations will adapt to allow a new solution to come out on the market.

For this reason I have decided to look very little into the regulations and focus on designing a solution with the users first in mind. My approach to this challenge is to design a product that is less complicated and more ergonomic, to fill a gap in today’s market.
PROBLEMS
DEFINING THE PROBLEM AREAS

My conclusion of the main problem areas that I want to use to evaluate my concepts and keep the process moving forward. After my research phase where I got to meet the miners who use the products, the people that design, develop and manufacture them, I have sorted out the problem areas that I wish to focus on.

As I mentioned earlier, today’s SCSR units are more often designed with regulations first in mind and the needs of the users second. Therefore the problem areas that I have chosen to focus on are based on the insights from my research out of the needs of the actual users, i.e. the miners.

**COGNITION**
Understanding how to use the unit in an emergency

**COMFORT**
The level of comfortability when wearing the unit

**INJURIES**
The risk of injuring oneself with the unit

**DAMAGES**
The risk of damaging other equipment with the unit

**FLEXIBILITY**
The level of flexibility of the unit depending on work task and environment

**DURABILITY**
The units ability to handle the harsh environment of mining operations
FOCAL POINTS
THE WHAT WHERE AND WHYS

WHAT
An SCSR unit that is comfortable to wear and offers a supply of oxygen in a self-contained breathing cycle, regardless of how bad the surrounding air may be.

WHO
The main user group are coal miners which are in need of a supply of oxygen in case of a life threatening emergency, for the purpose of self-rescue.

WHEN
When? At all times during the users shift, including in case of an emergency.

WHERE
The mine is a challenging and potentially dangerous workplace that places high demands on durability and usability.

WHY
Since the unit is worn at all times and could mean the difference between life and death in an emergency. I wish to make it more adapted to the needs of the user.

HOW
The exciting solution that is yet to be discovered.
WHAT
PRODUCT

MAIN FUNCTION
- Supply oxygen

SUPPORT FUNCTIONS
- Ability to be worn
- Hold components
- Offer closed breathing cycle
- Absorb CO2

DESIRABLE FUNCTIONS
- Improve comfortability
- Enable wearability
- Posses durability
- Improve flexibility
- Improve adaptability
- Optimize intuitiveness
- Maximize safety
- Improve usability (reduce donning time, improve donning procedure)
GENDER
5% female and 95% male

OCCUPATION
Coal miner on 7-7 shifts. (Working 12 hour shifts for 7 days straight, then gets 7 days off)

WORK TASKS
Maintenance of machines, operating boomers, scooptrams and mine trucks, setting explosives.
WHEN
SCENARIO OF A COAL MINE EMERGENCY

On these two pages I present two different methods of escape in a coal mine, where the only option is to leave the mine entirely.

General practice in a coal mine emergency is to reach the exit of the mine. There are two ways to achieve this and Dräger produces products for both scenarios.

The first method is to leave the mine via SCSR escape. This means that the user donnes their SCSR unit, heads towards the exit and changes their unit for new ones at chacés along the way out of the mine. The second method is to donne the SCSR unit that you are wearing, then continue to a station where you donne a SCBA unit instead, that can be refilled along the way to the exit.
1. An explosion occurs in the mine
2. Fire rages in one of the tunnels
3. Miners are not yet aware
4. Gas detector alert the miners
5. Miners donne their SCSR units
6. Walks to a SCBA station
7. Donnes the SCBA units
8. Discards the SCSR units
9. They notice oxygen level is low
10. Recharges at air station
11. Continues until they reach exit
WHERE

CONTEXT

The mine is a challenging and potentially dangerous workplace that places high demands on durability and usability. The environment where this type of product will spend its lifespan is a challenging one. The workloads for miners are heavy, there is plenty of dust and dirt and risk of the unit being scratched and scraped against hard surfaces is something that is not only likely but something that can be counted on. Units that have been sent back from the mines to Dräger are full of scratches and dirt.

Something to keep in mind here is that the current units are always placed on the hip attached to the miners’ belt. This is a position that often puts it in harms way.
WHY

PRODUCT

Since the unit is worn at all times and could mean the difference between life and death in an emergency, I wish to make it more adapted to the needs of the user.

For being a product that needs to be carried on your person for such incredibly long times, it is not really adapted for such extensive use. The work environment in the mine is hard as it is, and I find it strange that such a vital piece of equipment has not been made easier for the users to wear. It could indeed even make their work day more uncomfortable.

Also looking at the way that this product is used, I find that it is unnecessarily complicated to don. It’s an excellent opportunity to create a better solution.

HOW

THE SOLUTION
Can a self-contained self-rescue unit be more comfortable to wear over long periods of time, not damage other equipment and be donned easily?
I gathered a few students for a workshop where we would brainstorm on different concept ideas. I did not want to direct them to much, and just let them think freely around the problem areas that I had found through my research.
CONCEPTS
#1 BACK

This concept is based on an SCSR unit that is worn as a harness on the upper and back side of the torso. On the back are two breathing bags with a cartridge in the middle. On the straps over the shoulders are a breathing hose and protection goggles on the other side.
CONCEPTS

#2 BELT

The belt concept is a unit where all the components are kept in a belt. This belt can freely be adjusted to fit around the waist or across the torso, depending on what tasks are performed. If the user is working in a small cabin of vehicle for instance, the belt can be fitted around the torso so it is not in the way.
CONCEPTS
#3 SEPARATION/COMBINATION

This concept revolves around an idea of keeping different parts of the units separated into different pieces to allow a better weight distribution. When the unit is to be used, the different parts are combined into one unit. There is a breathing hood that is hidden in the helmet, and KO2 cartridge and breathing bag on each side of the belt.
EVALUATION

CHOOSIN CONCEPT

Can a self-contained self-rescue unit be more comfortable to wear over long periods of time, not damage other equipment and be donned easily?
EVALUATION WITH DRÄGER
BACK, BELT AND COMBINATION/SEPARATION

An opportunity to evaluate my concepts with the people that design and develop current SCSR units

During my visit to Dräger in Lübeck I had an opportunity to evaluate three of my concepts with Lennart, Malte and Kirstin. I soon found out that my understanding of all the technical components were quite limited, and my perception of the size of the unit perhaps a bit optimistic. Despite this they found that my concepts were heading in an interesting direction and this is what the evaluation together with them brought.
**STRENGTHS**

- Looks interesting.
- Ergonomic

**WEAKNESS**

- Breathing bag is not visible on the back. Presents a safety risk.
- Not possible to protect the breathing bag, since it sits on the back

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**CHosen Concept**

**STRENGTHS**

- Good that its position can be changed at will.
- If placed on the chest it removes the problem of it being in the way in a tight vehicle cabin

**WEAKNESS**

- Hose is too long, can lead to CO2 poisoning

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**STRENGTHS**


**WEAKNESS**

- If you lose one part, like the hat, the unit is unusable.
- Too difficult to clean and maintain
- The miners do not like breathing hoods. It gets too hot.
LIMITATIONS
CALCULATIONS AND LIMITATIONS OF FINAL DESIGN

Before I continue with the project I decided to establish a few limitations and calculations regarding future technology, operational times of the unit and the amount of potassium superoxide.

REMOVING THE BATTERY
There are better options than regular light-bulb lamps with large batteries. You can already find high quality LED lamps for mining helmets on the market. These lamps require much smaller batteries that can be built in to the lamp fixtures, or the helmet. Although the mining industry is a conservative one, I will assume that within ten to fifteen years people are no longer walking around with large batteries around their waists. This gives me the opportunity to remove one of the three items that miners are required to wear on their belts during their shifts. This leaves only the com-radio and the SCSR unit as required items to be worn.
OPERATIONAL TIME OF 20 MINUTES
Considering that SCSR cachés are stationed every 500 meters throughout the mine, in accordance with current regulations. A unit that has an operational time of 50 or only 30 minutes is quite excessive. Therefore I have decided to design a unit that is operational for only 20 minutes, which is ample time to get to a cahcé with new units. This would afford a decrease in size of the KO2 cartridge and allowing for a lighter and smaller SCSR unit. It also makes sense that the unit that you wear on a daily basis is as small as possible to increase comfort.

SIZE OF THE KO2 CARTRIDGE
From Malte Gröning, project manager at Dräger, I received the information that the KO2 cartridge of a unit that lasts 60 min contains 900 gram of KO2. A unit that lasts for 30 min contains 500 grams of KO2. From these numbers I calculated an approximate volume of KO2 for a unit that lasts 20 minutes.

900 / 60 = 15 gram/min
15 x 20 = 300 gram/20 min

≈ 350 gram of KO2 for 20 min unit.
CONCEPTUALIZE
MOCK-UPS, MOODBOARDS AND FORM

Can a self-contained self-rescue unit be more comfortable to wear over long periods of time, not damage other equipment and be donned easily?
UNIT MOCK-UP
COMPONENTS OF THE UNIT

Before continuing with the form I made a mock-up with the different components to get an understanding of the size of the unit. By adding weights to the cartridge mock-up I could also get a feel of how heavy the unit would be.
BELT MOCK-UP
TRYING DIFFERENT CONFIGURATIONS OF THE BELT

Since I chose to continue a concept with a unit that can be worn around both the waist and the chest, I needed to work on a belt that will allow a comfortable fit in both positions. I made a mock-up of the belt and the components of the unit to figure out which configuration would be most comfortable and able to carry the unit securely.
COLOUR AND MOODBOARDS
KEY WORDS & MOOD BOARDS

The following pages details the choices in colour, keywords and the moodboards I have made to define the expression of my final design.

Since I am designing my unit to fit in with the Atlas Copco common core design language, the choices in colour are an easy one. They are in tune with the Atlas Copco grey and yellow colour scheme, so that it is easily recognizable as an Atlas Copco product. You can see some examples on this page.

On the following pages there are the moodboards that I have put together to instil a sense of the expressions that I am looking for. Reliable in being able to handle the rigors of the environment it will be present in. Comfortable since it will be worn so often I want to express that it allows for that. Straightforward in that there are no unnecessary features that confuses the user, but instead is self explanatory.
RELIABLE
DURABLE TRUSTWORTHY
STRAIGHTFORWARD
INTUITIVE CLEAN
FORM EVALUATION
PU FOAM MOCK-UPS
KEY SKETCHES
PEN AND PAPER, ILLUSTRATOR AND PHOTOSHOP
PROTOTYPING
CREATING A PHYSICAL MODEL
RESULT
PRESENTING THE FINAL DESIGN

Can a self-contained self-rescue unit be more comfortable to wear over long periods of time, not damage other equipment and be donned easily?
SCSR 20
THE ATLAS COPCO DRÄGER SCSR 20

The next generation of self-contained self-rescue units, designed with the user in mind.
THE CONCEPT
THE SCSR UNIT FOR EVERYDAY USE

The result is a unit with an operational time of twenty minutes and a reduced size and weight. Its position can be adjusted to be worn around the waist or the chest, depending on the tasks the user performs, as well as simplifying the donning procedure.

The reason for this being that the unit that you wear on a daily basis is no larger than it needs to be to increase every day comfort. Yet still allowing plenty of time to get to a cache with larger units and continue the evacuation in an emergency situation.

To increase comfort the position of the unit can be changed at will depending on the environment the user is currently working in. The user is free to decide when to wear the unit around the hip or the chest while working. But in case of an emergency the unit should be placed around the chest so that it is close enough to the mouth. Since the user has probably changed the position of the unit a lot if times previously, this action is familiar and does not involve any unfamiliar straps or belts. This leads to a smaller, more comfortable, more adaptable and easier unit to use.
COMPONENTS
EXPLODED VIEW
DETAILS
THE INSIDE OF THE UNIT
FUNCTIONALITY
WEARING AND DONNING THE UNIT

WEARING THE UNIT AROUND THE WAIST

WEARING THE UNIT ACROSS THE CHEST
FUNCTIONALITY
WEARING AND DONNING THE UNIT

OPEN THE UNIT BY PULLING THE OpENER AND DISCARDING THE UPPER HOUSING

EXTEND THE BREATHING HOSE BY PULLING IT OUT OF THE HOUSING. THIS IGNITES THE STARTER THAT INFLATES THE BAG WITH THE FIRST CYCLE OF BREATHABLE OXYGEN
REMOVE THE NOSE CLIP THAT ACTS AS A PLUG FOR THE MOUTHPIECE AND PLACE IT ON THE NOSE. THEN POSITION THE MOUTH PIECE IN THE MOUTH.

AFTER PUTTING ON THE PROTECTIVE GOGGLES THE USER IS READY TO PROCEED WITH THE EVACUATION.
TODAY AND TOMORROW
A COMPARISON OF TODAYS UINT & THE CONCEPT OF TOMORROW

[Image of two workers in a mine]
EXHIBITION
MY EXHIBITION DURING UID DESIGN TALKS 2015
SCSR 20

IMPROVING SELF-RESUE EQUIPMENT

Our new combined self-rescue unit is measuring-in to your long period of time, with designed self-rescue equipment and the abilities needed.

A self-contained unit where a user can operate a switch, with the unit holding enough gas for their needs. The gas can be stored in the self-contained unit and the unit can be recharged. They can easily and quickly access the self-contained unit and the unit can be recharged.

Atlas Copco
IMPROVING SELF-RESCUE EQUIPMENT
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