



THUNDER

Adaptive avalanche airbag system

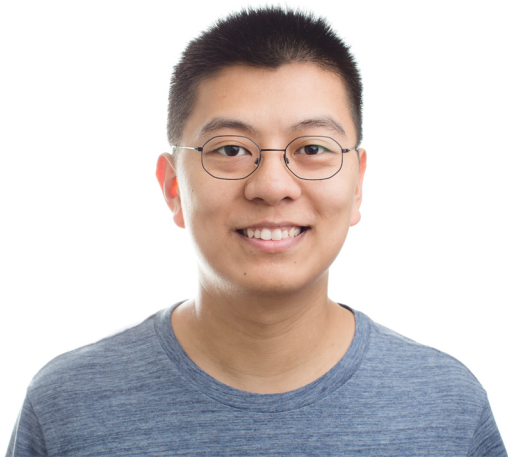
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Kan Chen | Diploma project report
Industrial design | 2017 spring semester

THUNDER

Adaptive avalanche airbag system

The Oslo School of Architecture and design
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Background

This product design diploma is about developing an avalanche airbag system in avalanche circumstance. Unlike most of the avalanche airbag products that especially design for skiing enthusiast, this product is mainly designed for most of the skiers who think they are in the danger of the avalanche. By solving the main problems of the avalanche airbag products on the market, Thunder concentrate more on the human behavior and therefore create an avalanche airbag system that has the potential plays an important role in the whole skiing process.



Summary

■ **Context and motivation**

Norway is a country where people born with skis on the feet. Here, people's passion for skiing is tremendous. During the winter holidays, whether you are young or old, many people put on layers of warm clothes, getting out with hats and mittens and embracing the cold for a day or a weekend of cross-country skiing. Skiing in Norway is an undisputed national sport.

However, every activity comes with risks. Skiing is one of the most dangerous sports, in general, skiing injury rates vary from between 5 to 8 injuries per 1000 skiing days. However, what concerns people the most in skiing is called avalanche. Comes with great impact, avalanche is a great representative of natural power.

Avalanche is deadly, but it also leaves a great potential for us to do something about it. Therefore I began to look into the possible solutions, hoping to design a product that can really contribute to this circumstance.

■ **Problem and challenge**

There are several challenges for me.

First of all is the design challenge. An innovative design would increase the complexity of the project. In this case, I designed an avalanche airbag product that is not like any of the product before. Therefore more time was putted on research phase analysing and arranging the existing information. I managed to solve every demand I listed, but the model at this stage requires a further development to refine the details in the future.

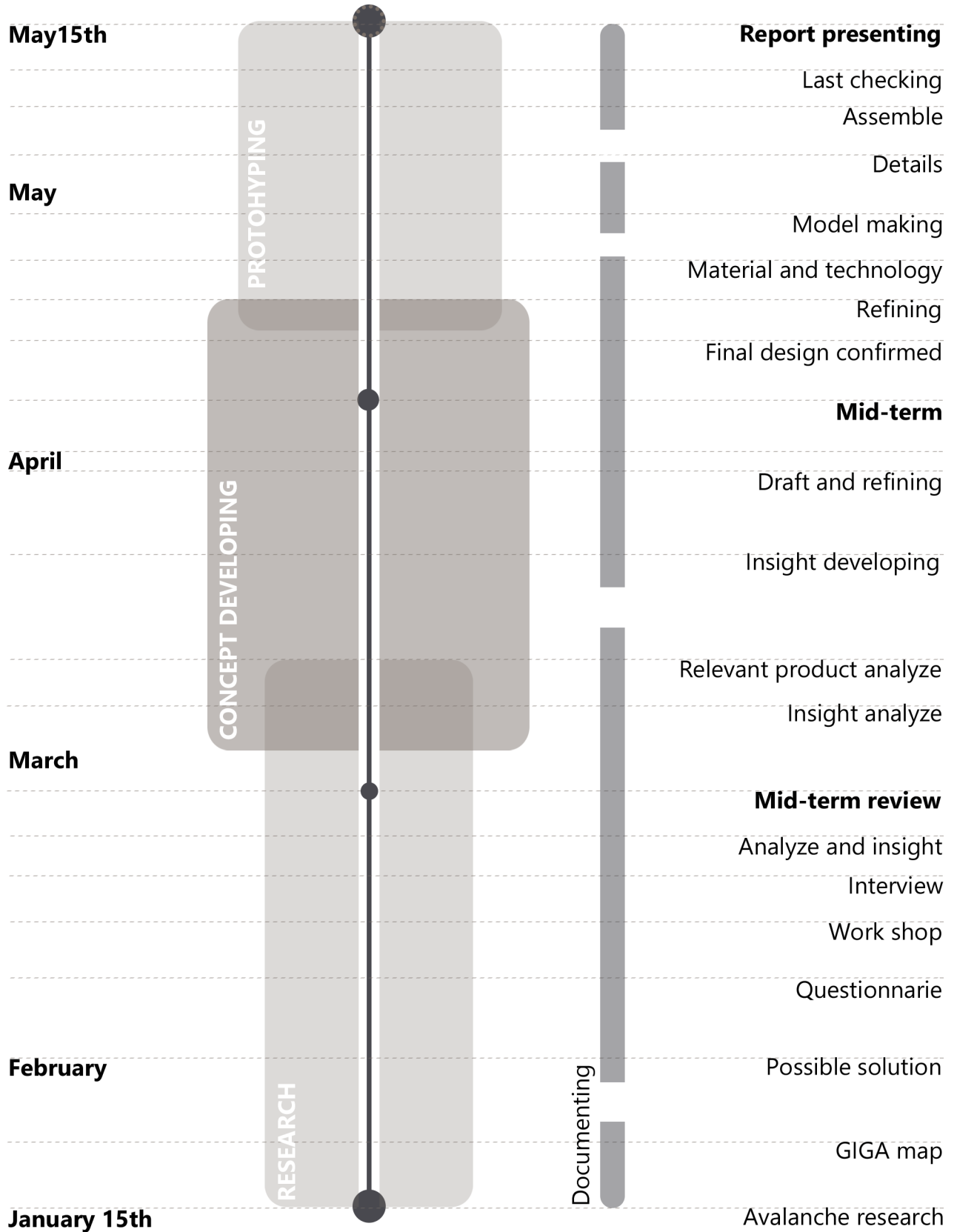
Secondly, as a foreign student, communication problem is an obstacle for me. Design a product for local means you can find the most of the resource here, however, it also means that some information and chances are harder or even impossible to get because of the language barrier.

■ **Design outcome**

This diploma is delivered as one report, an introduction booklet as well as one prototype describing the different aspect of the project.

The report presents a detailed description of the design process and outcome. The booklet and model could together provide an overall and more intuitive impression of the design.

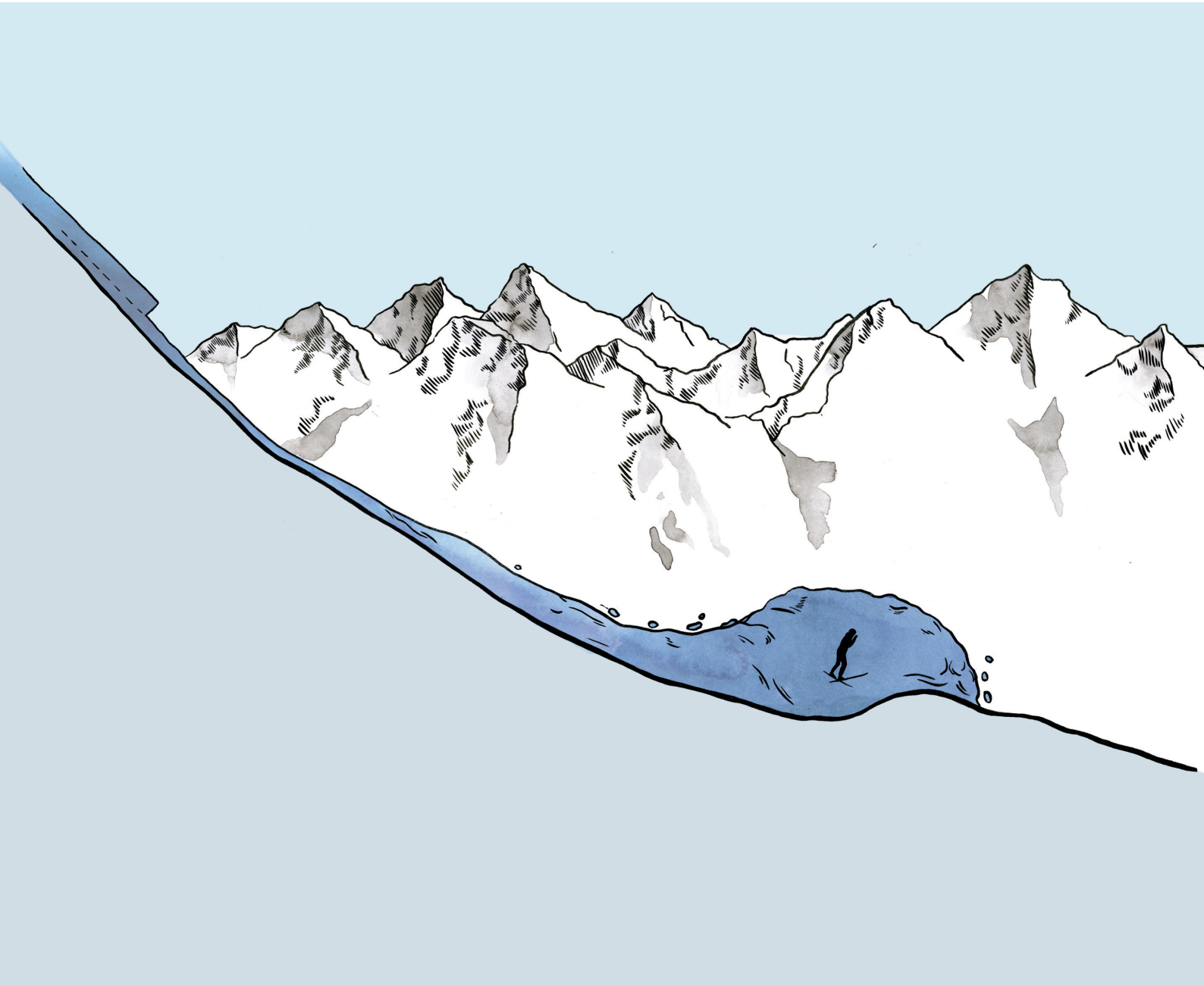
Time table



Introduction

**The entire
mountainside was
suddenly a big
movement and ground
strikes stone and
other irregularities. It
was like a small white
volcanic eruptions.
Last option is to stay in
balance. I told myself
don't look back.**

———— Thomas T. Kleiven



Avalanche scene

Avalanche

Year after years, avalanches claim victims around the world. Like every accident, avalanche is preceded by a chain of events or a series of errors. Generally speaking, an avalanche is a rapid flow of snow down a hill that may also contain ice, soil, rocks or other debris.

There are four main types of avalanches. They are loose snow avalanches, slab avalanches, cornice collapses and ice avalanches. Avalanche can be triggered by a variety of factors, including terrain, weather, temperature, slope steepness and snowpack conditions etc. Apart from the type of avalanche mainly triggered by natural causes, because most of the avalanche accident involving human elements, I am more concentrate in human-triggered slab releases, therefore the focus is slab avalanches.





Slab avalanche

Slab avalanches occur when one or more layers of cohesive snow release as a unit. When the slab released, usually was triggered by human activities, the bond between the bed surface and the slab were broken. As the snow slab moves downhill, it begins breaking up into smaller and smaller blocks or clods.

Slab thickness can range from less than 5cm to 10 m or more. When slab avalanche happens, the first thought of people might be skiing away from it as soon as possible. However, wet slabs can move at speeds of roughly 10-30 meters/second while fast-moving dry slides can have speeds ranging from about 20-70 meters/second. Which makes moving away from the avalanche area very difficult.



Rescuing Thomas |

The danger of avalanche

There are a few typical causes of death from an avalanche. The first one is trauma. Like what we talked before, avalanche tend to move in a high speed. Therefore anyone who caught in the avalanche's would be thrown with great force across the avalanche's path. There will most likely be branches, rocks and the snow itself hitting at you. In the worth case scenario, you might even drop off a large cliff.



90%
CHANCE OF SURVIVAL



50%
CHANCE OF SURVIVAL



15%
CHANCE OF SURVIVAL

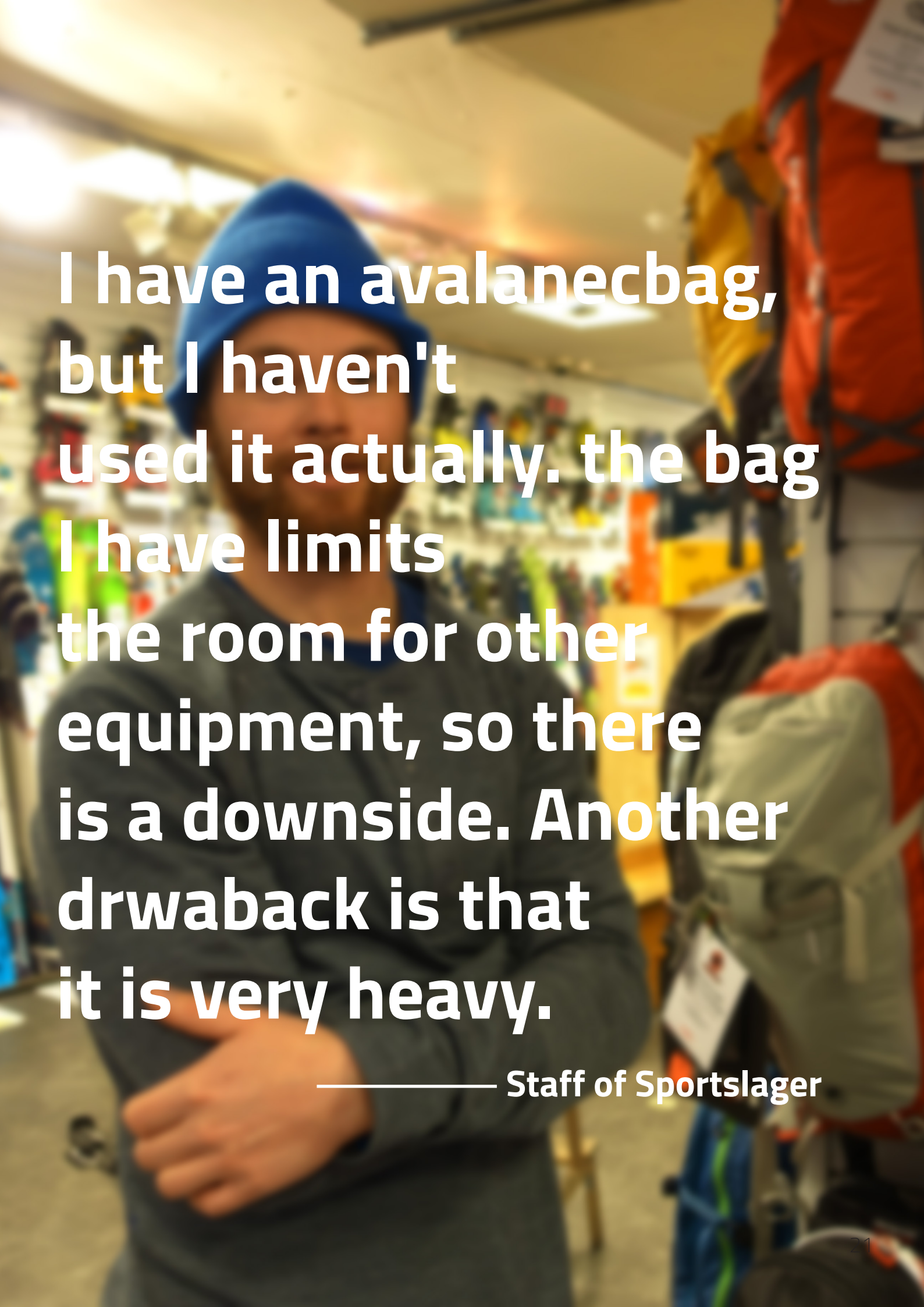
If you survive the first impact intact, another reason would be suffocation. There is limited air beneath the snow. When you try to breath in the snow, your CO2 level will rise gradually in enclosed space and you will find yourself harder and harder to breath. In general, If you are buried in snow for 15 minutes, you still have the 90% chance of survival, however, when you are buried in the snow for 25 minutes, your chance of survival will dramatically drop to 50 percent.

When you are buried in snow, your body temperature as well as your breath will start melting the snow around you. You will suffer the hypothermia problem. If you are in the snow for an hour, your chance of survival will drop to 15% for even less.

Without a doubt that the avalanche is the worst thing a skier would like to meet.

Exploration



A man wearing a blue beanie and a grey jacket stands in a store filled with outdoor gear. He is looking towards the camera. The background is filled with shelves of various items, including jackets and bags. The lighting is warm and indoor.

**I have an avalanche bag,
but I haven't
used it actually. The bag
I have limits
the room for other
equipment, so there
is a downside. Another
drawback is that
it is very heavy.**

————— **Staff of Sportslager**



Standard avalanche hazard equipment

Avalanche safety equipment

■ **Standard avalanche safety equipment**

If you survive the first snow impact, you might probably be buried under the snow. In this case, like any other emergency circumstance, there is some standard safety equipment that might save your life.

They are **avalanche beacon, shovel and probe.**

In a companion rescue scenario, first, you can use an avalanche beacon to pin-point the strongest signal at the surface of the snow. Then, you deploy your avalanche probe and start probing in a spiral pattern. At last, when you find the specific position of the victim, you can use a shovel to dig him out.



BCA avalanche aribag |

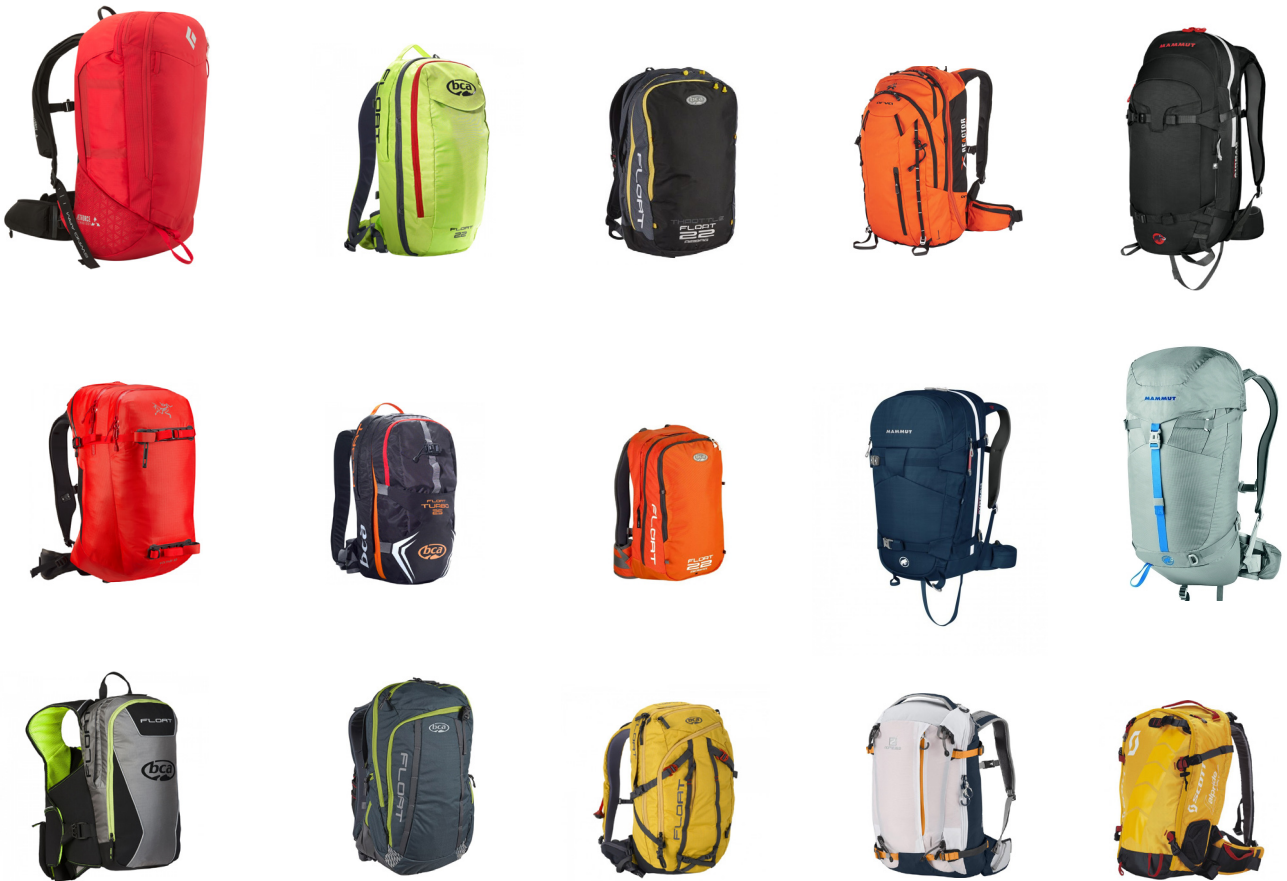
■ **Avalanche airbag**

We can save an avalanche victim with the right equipment, but on the perspective of a victim, buried by snow and doing nothing doesn't sound like the perfect plan, but there is infact a product can save us from being buried. We all know that large and light objects always move to the top. This phenomenon also works in the avalanche. For a normal object, larger volume can help you naturally float on the surface of the snow during the avalanche. And this is the main principle of the avalanche airbag, also know as ABS backpack.





Avalanche airbag backpack in action simulation



Most commonly seen avalanche airbag products

■ **Avalanche airbag**

Although there are different kinds of avalanche airbag backpack. An ABS backpack always contains two parts, airbag part and the storage part. As long as you pull the trigger, the airbag will be filled with gas in a few seconds. According to Brugger's 2007 studies of the dataset, the percentage of people caught who died in an avalanche decreased from 19% to 3% for those who successfully deployed an avalanche airbag. Which significantly increase the victim's chance of survival, an ABS backpack is sure an effective safety equipment.

Safety equipment survey

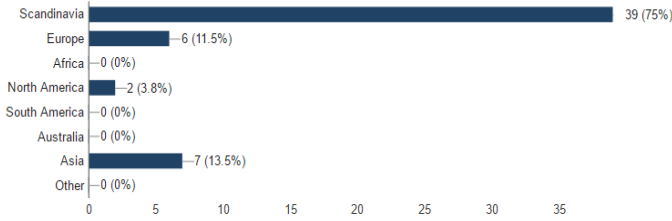
54 responses

SUMMARY

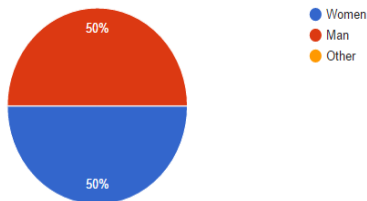
INDIVIDUAL

Accepting responses

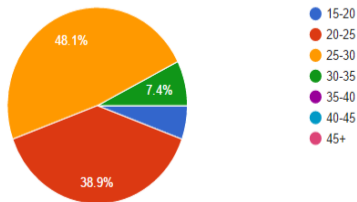
Where are you from? (52 responses)



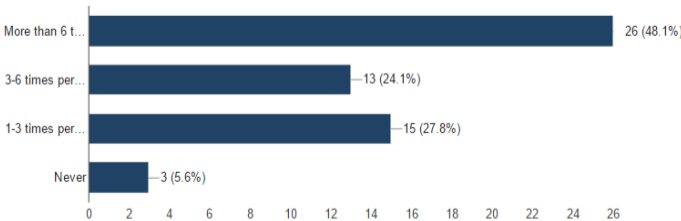
What is your gender? (54 responses)



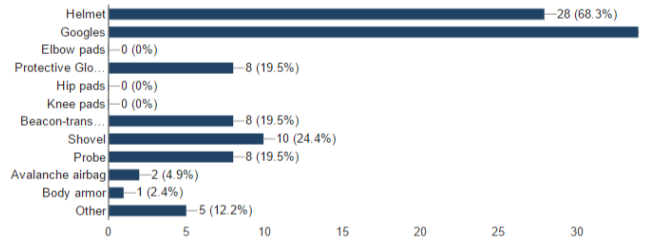
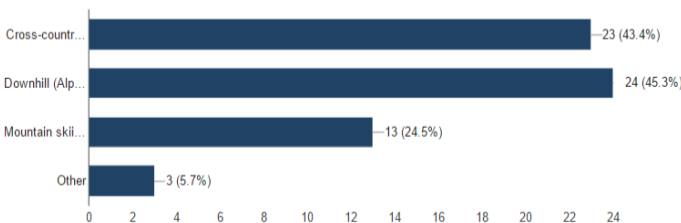
What is your age? (54 responses)



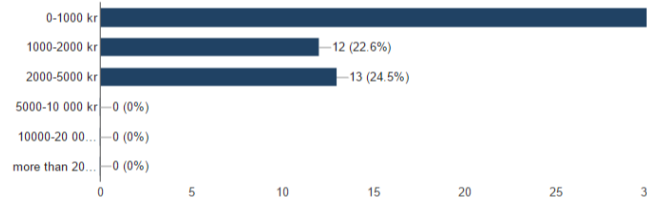
How often do you ski? (54 responses)



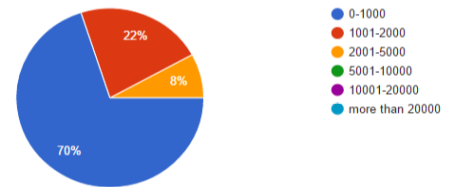
What is your favorite form of skiing? (53 responses)



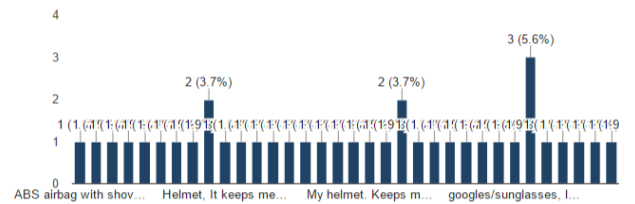
How much would/do you invest for ski equipment each year? (53 responses)



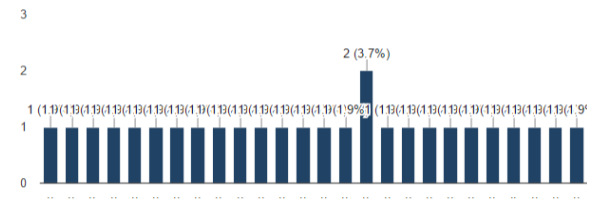
How much would you invest for the ski safety equipment per year? (50 responses)



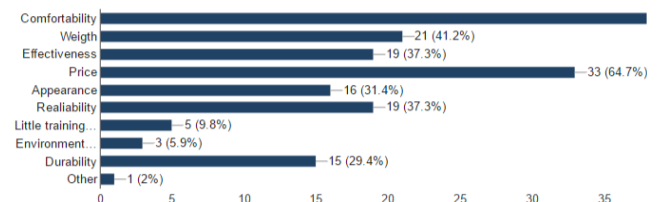
What is your favorite safety equipment and why? (38 responses)



What is your less frequently used safety equipment and why? (27 responses)



What matters you the most when you are choosing safety equipment (51 responses)



Human factor

■ Users

Although the existing ABS backpack is an effective safety equipment, but it is clearly not designed for most of the potential users. There are more and more people of different ages and not so experienced skier choosing to participate in long range crosscountry or mountain ski these days. Safety equipment questionnaire I have done shows that 33% of the people do concerns about the avalanche problem, but nearly no one is using an ABS backpack.

I also interviewed some mountain skier in Norway, who is most likely to meet an avalanche. Most of them claimed that they are not using this avalanche airbag at all. Combine with the result of the questionnaire. These are the main problems they consider ABS backpack has.

1: Uncomfortable to use.

An ABS backpack usually weigh more than 3 kilograms, also, many of them also require to tie up with harness across the body. Which means that you have to bear more pressure on shoulders and feeling more restrained everytime you carry it.

2: Price.

Price of ABS backpack ranges from 4000nok to 14000nok. For safety equipments that expensive, even for the consumer who have enough money, they probably tend to invest the same money for other ski equipment instead an ABS backpack

3: Limit room.

Avalanche Airbag component usually occupies more than 10 liters of space, which cannot carry as much as a normal backpack could accomodate.

4: Few chances of using them.

Avalanche doesn't happen everyday, infact, even the most enthusiastic skier might not be able to meet a truely deadly avalanche for years. Even if you purchase and carry an ABS backpack for the first month, you will soon find yourself lacking enthusiasm carries them anymore. And this happens all the time for most of the ABS backpack users.

Table 1. Suggested Framework of Emergencies, Time Sensitivity, and Geo-Specificity

| Emergency Type | Emergency | Time Sensitivity |
|-----------------------|---------------------|-------------------------|
| Weather | Impending blizzard | Low |
| | Severe thunderstorm | Medium |
| | Tornado | High |
| Crime | Theft | Low |
| | Missing person | Medium |
| | Active shooter | High |
| Hazard | Chemical spill | Medium |
| | Travel conditions | Medium |
| | House fire | High |

Note. In this table, a sample of emergency types are provided and categorized by time sensitivity (the degree to which something about the warning once received) and geo-specificity (the degree to which recipients may be affected by the location).

| Geo-Specificity |
|-----------------|
| Large |
| Medium |
| Medium |
| Small |
| Medium |
| Small |
| Medium |
| Large |
| Small |

recipients can/should do
the emergency based on their

Context

As a typical emergency circumstance. There is a question I have to ask myself. "What happens in an avalanche?"

I realized that in the whole process, there are in fact three different users using one product in three different contexts. **They are the first person who is calm and relax, choosing the equipment in a safe area; the second person who has habituated to the product through the skiing experience; the third person who is in great panic because of the avalanche is approaching.**

We tend to design a product for a rational people who is on the first stage. Nevertheless, we seldom consider the other two types of situation. People's mental and behavior state changes along with the context. For instance, it wouldn't take long for a person to start thinking not to carry the safety equipment without meeting any emergency. Or if the avalanche does happen, people who caught in panic are prone to error and tend to follow instincts, which make him more difficult to operate the equipment correctly.

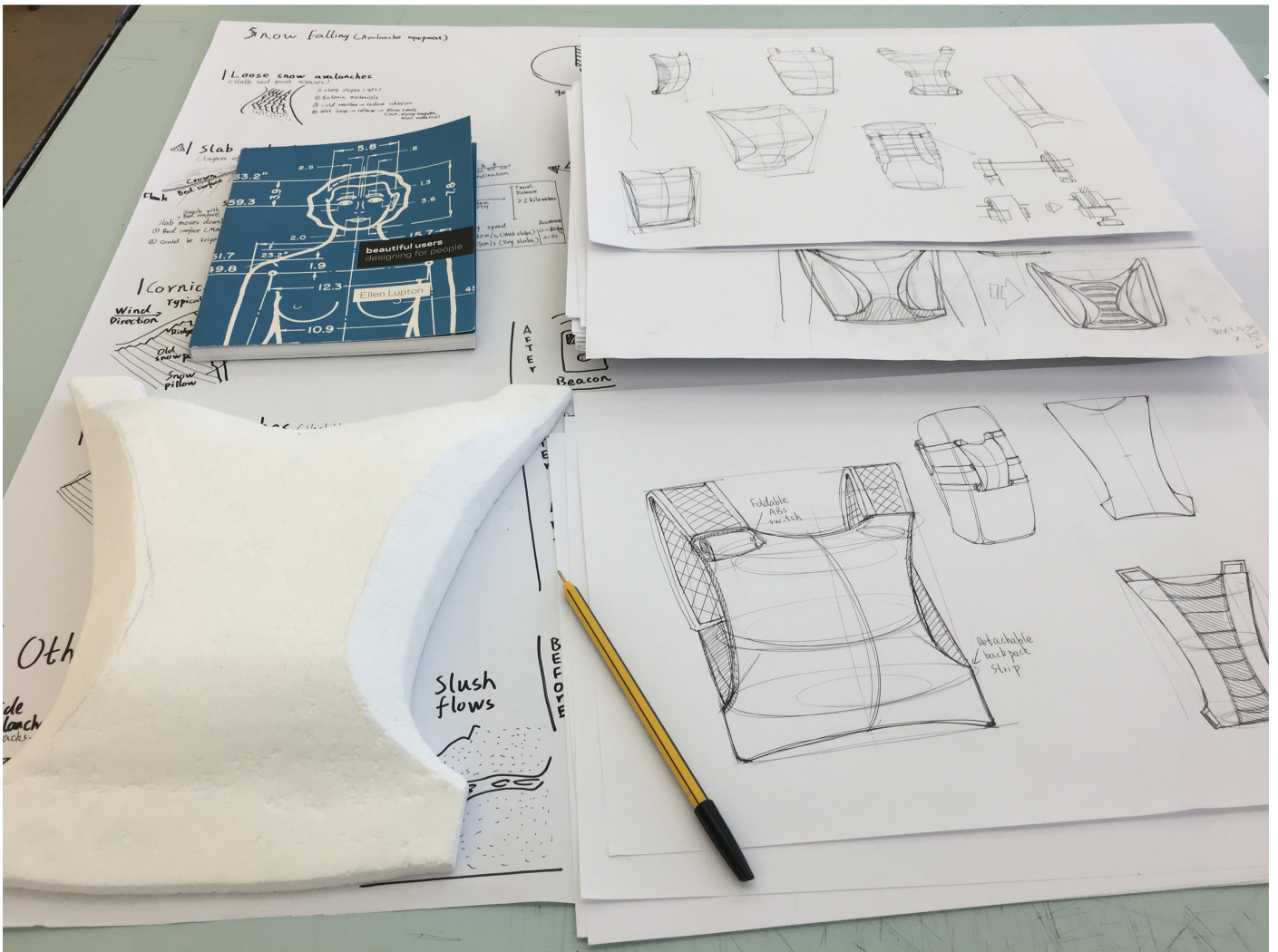
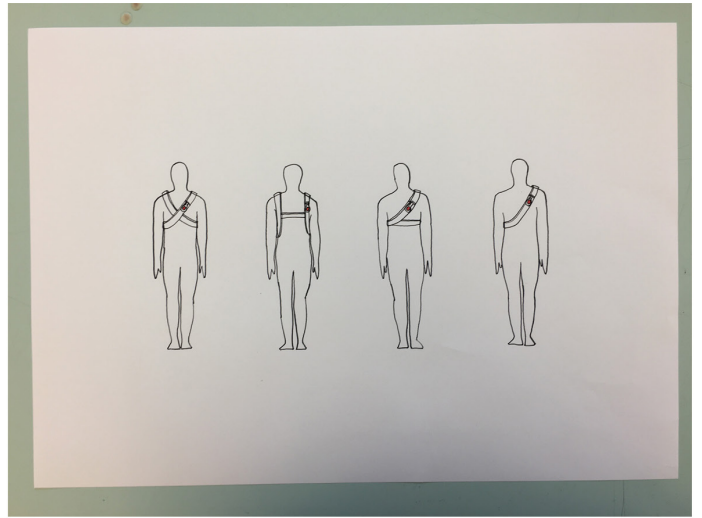
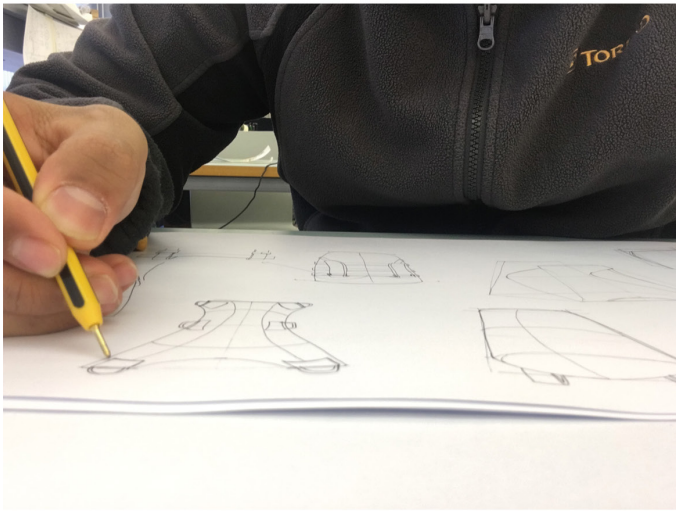
Demands and mockups

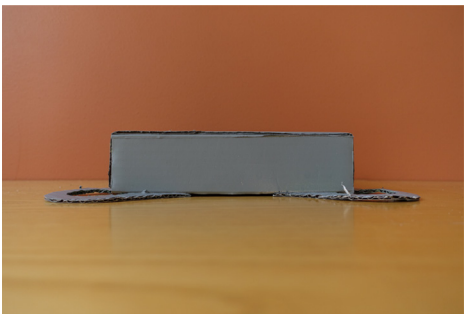
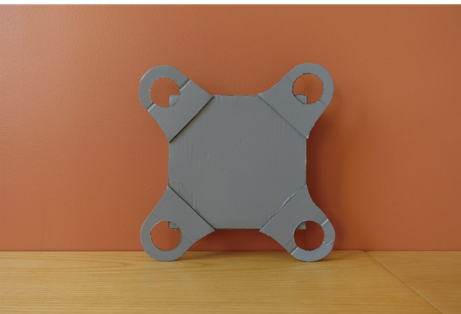
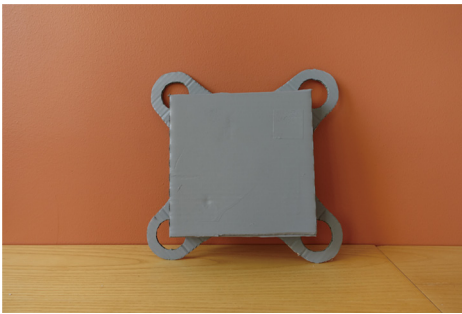
■ **Avalanche airbag system**

A comprehensive problem requires a systematic solution. I want to design an effective avalanche airbag system that not only fits the needs of general outdoor skier, but also proves its value in its different life cycle.

For a more general outdoor siker who have less money and experience, they tend to choose the safety equipment that is more affordable and comfortable to use, also, most of them tend to start a trip with full load of different objects, like food, water, clothes, sleep bag ect. Therefore the size and weight matter to them.

Based on the information, that I have gathered, I started to do some sketches and mockups to better illustrate possible ideas.





First mockup
Size: 30cm x 30cm x 5 cm

■ **First mockup**

In the first mockup, I have extracted the most basic component of an avalanche airbag in order to have a more intuitionistic feeling about how compact could an avalanche airbag device could be. I tried to carry this mockup in a different way, and soon I realized one of the ABS backpack's main problem.

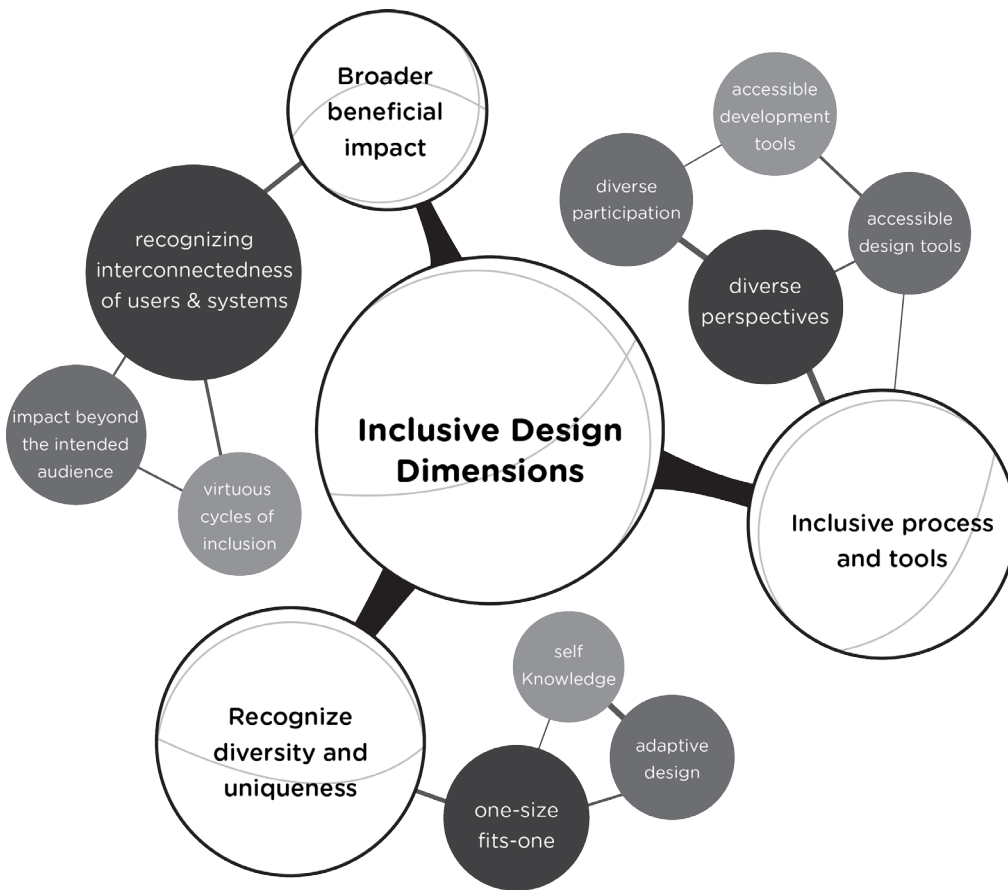
Not all the outdoor ski activities have the risk of avalanche. For the majority of the skier, although it is true that we should carry different equipment to fit different context, but most of us would not specifically buy an extra ABS backpack. They would rather use the backpack they already have all the time in different outdoor activities. Also, the relatively limited room of an ABS backpack also limits how much stuff people could carry and therefore set more boundaries in outdoor activities.

No matter where I put the airbag component, the fact that it would occupy a lot of space would never change, so the only way to solve this problem is to change the basic structure of an ABS backpack.

Second mockup



Second mockup
Size: 35cm x 20cm x 5 cm



<http://idrc.ocadu.ca/about-the-idrc/49-resources/online-resources/articles-and-papers/443-whatisinclusivedesign>

■ Second mockup

The second mockup follows the principle of inclusive design. Inclusive design means the design should consider the full range of human diversity like ages, abilities or other forms of human difference.

It is clear that what people want is only its protection aspect but not any of its drawbacks. In order to solve the problem of an ABS backpack has a more fundamental way. I cancelled the "backpack" part and leave the "airbag" part only.

In this mockup, the airbag part is considered as an individual object that can attach to any other backpack. As a result, people don't need to worry about the space problem anymore. They are allowed to carry the same amount of items as they normally carry. Moreover, as an attachment, you can flexibly choose to install it or not according to the context. At last, the price could be reduced because you don't need to pay for the backpack part anymore.



Backpack volume: 55liters
Connection between the backpack and the airbag part



Mockups and backpack demonstration

■ **Adaptive design**

If we want one specific product to adapt most of the outdoor backpack, we have to see if there is anything in common with the majority of the outdoor backpack so that we can take advantage of it.

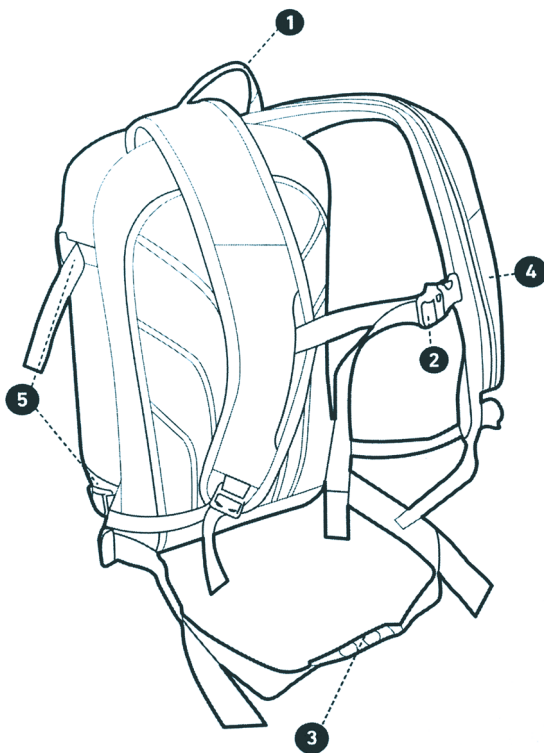
I managed to design the form of the airbag part more ergonomic to better attach to the backpack, what's more, in order to enable the attachment strong enough, I attached it to the main body of the backpack. In this stage, this airbag part has the ability to adaptive the majority of the outdoor backpack. Therefore I call it an adaptive avalanche airbag.

If we look into more details of this design, it also shares some drawbacks. First of all, even I have managed to extract the airbag component to be as compact as possible, it still occupies too much space. Secondly, the strap which surrounded the backpack also interferences with the normal use of the backpack. At the end, the way how it connects to the backpack doesn't feel stable enough.



FRONT ANATOMY

1. Top handle
2. Front pocket
3. Safety compartment
4. Diagonal ski carry
5. A-frame ski carry
6. Snowboard carry
7. Ski pole and ice axe attachment
8. Helmet holder



BACK ANATOMY

1. Handle
2. Sternum strap
3. Hoop sleeve
4. Compression straps

33 liters ski backpack anatomy

■ **Characteristic of Backpack**

Although different backpack have different forms and design, but most of them shares some similar characteristics. Take this ski backpack as an example, you can definitely find many aspects in common with the backpack we already have. For instance, they all have a tubbish body and shoulder straps, a compression strap and sternum strap also can be seen in most of the outdoor backpacks. These are some reliable locations that we can use.

However, a fully functional airbag unit would at least occupy 10 liters of space, which is nearly one third of the space of a 33 liters backpack on the left. Apart from the a tubbish body, the other joints clearly don't have enough space to attach this component in a convenient way.

The main characteristic of the second design is adaptation, so I call it an adaptive airbag design, but I still need to push this design to get a more convincing result.

Technology

A blurred background image showing a car accident scene. A white car is visible, and a person in a red jacket is crouching near it. The scene is outdoors, possibly on a road or parking lot.

A mature technology is a technology that has been in use for long enough that most of its initial faults and inherent problems have been removed or reduced by further development.

Wikipedia

Inflation technique

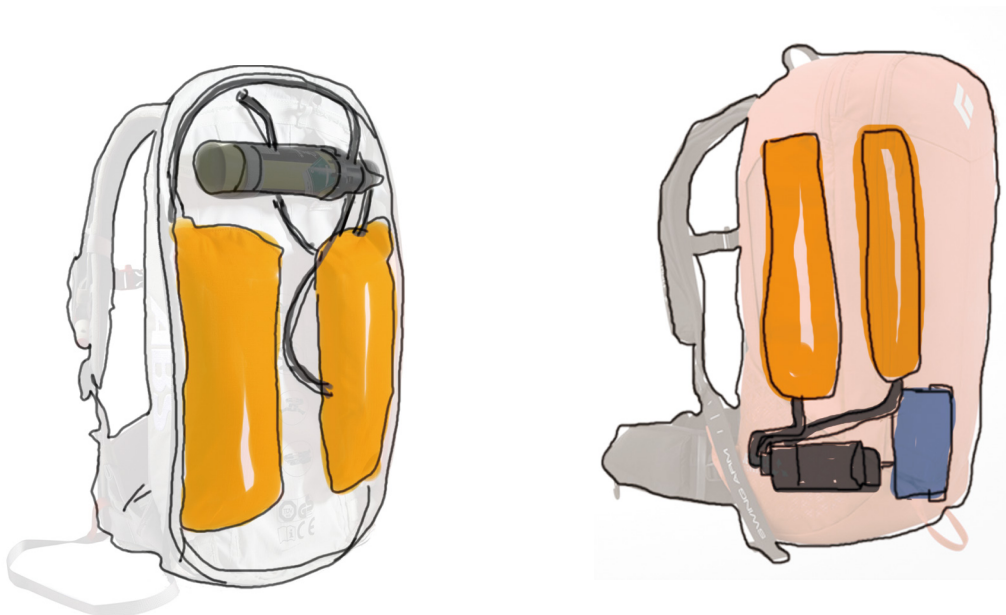
■ General Avalanche airbag component

There are two kinds of methods to inflate an airbag in the existing ABS backpack. Most of them are using compressed air stores in the cylinder. This inflating method is fast and reliable, but it is relatively heavier and you need to buy a new cylinder everytime when you use it or when the pressure goes low. There is also a new method called battery-powered electronic blower inflating. In general, it is a powerful fan pumping the air into the airbag. It is lighter compared to the first one, you can also use it multiple times in a single charge, but the component occupies more space and it is not as reliable as the compressed air solution.

In any cases, I believe they are both not the best solution. In order to have a truly adaptive design, I have to search for some better methods of inflation.



Avalanche airbag main component



Compressed air type and battery-powered electronic blower type



Inflatable float airbag

Inflation mechanism: Compressed air
Inflation time: 0.5-2 seconds
Airbag volume: 2-5 liters
Inflation part space occupation ratio: 20%



Bike airbag helmet

Inflation mechanism: Compressed air/ blowing
Inflation time: 0.3-0.5 seconds
Airbag volume: 5-10 liters
Inflation part space occupation ratio: 25%



Avalanche airbag

Inflation mechanism: Compressed air/ blower
Inflation time: 5-9 seconds
Airbag volume: 70-150 liters
Inflation part space occupation ratio: 35%



Airbag bed

Inflation mechanism: Electronic blower
Inflation time: 30-60 seconds
Airbag volume: 500-1000 liters
Inflation part space occupation ratio: External

■ Inflation solutions

This is the airbag product comparison list that we can see in our daily life. From this list, we can classify them into two types. The first type is more about physics, using the stored or transferring the air from the outside environment to inflate the airbag. The second type is more about chemical reaction, inside the gas generator, the reaction transforms solid chemicals into gas.

In a relatively small product, where you don't need too much air, compressed air solution can be considered as reliable and efficient. However, as the volume of the airbag increases, the size of the inflation part increases dramatically because it requires much bigger cylinder and pipe. The cylinder and the pipe can't enlarge forever, therefore the inflation speed gets slower as well.



Plane Life vest

Inflation mechanism: Compressed air/ blowing

Inflation time: 3-8 seconds

Airbag volume: 10-20 liters

Inflation part space occupation ratio: 10%



Swimming ring

Inflation mechanism: Manually/ blower

Inflation time: 10-60 seconds

Airbag volume: 20-40 liters

Inflation part space occupation ratio: External



Car airbag

Inflation mechanism: sodium azide reaction

Inflation time: 0.3-0.5 seconds

Airbag volume: 75-200liters

Inflation part space occupation ratio: 15%



Plane evacuation stair

Inflation mechanism: sodium azide reaction

Inflation time: 3-4 seconds

Airbag volume: 3000-4000liters

Inflation part space occupation ratio: 10%

Airbag product comparison

The compressed air solution can be considered compact and effective in a small volume of the airbag product. However, in an airbag that is larger than 100 liters like avalanche airbag, it can barely consider as a good solution.

In similar volume of airbag product, There is a mature inflation technique were widely used all around the world, which is lighting fast, compact and reliable. This airbag design is built on a chemical reaction and we usually call it the car airbag.

Car airbag

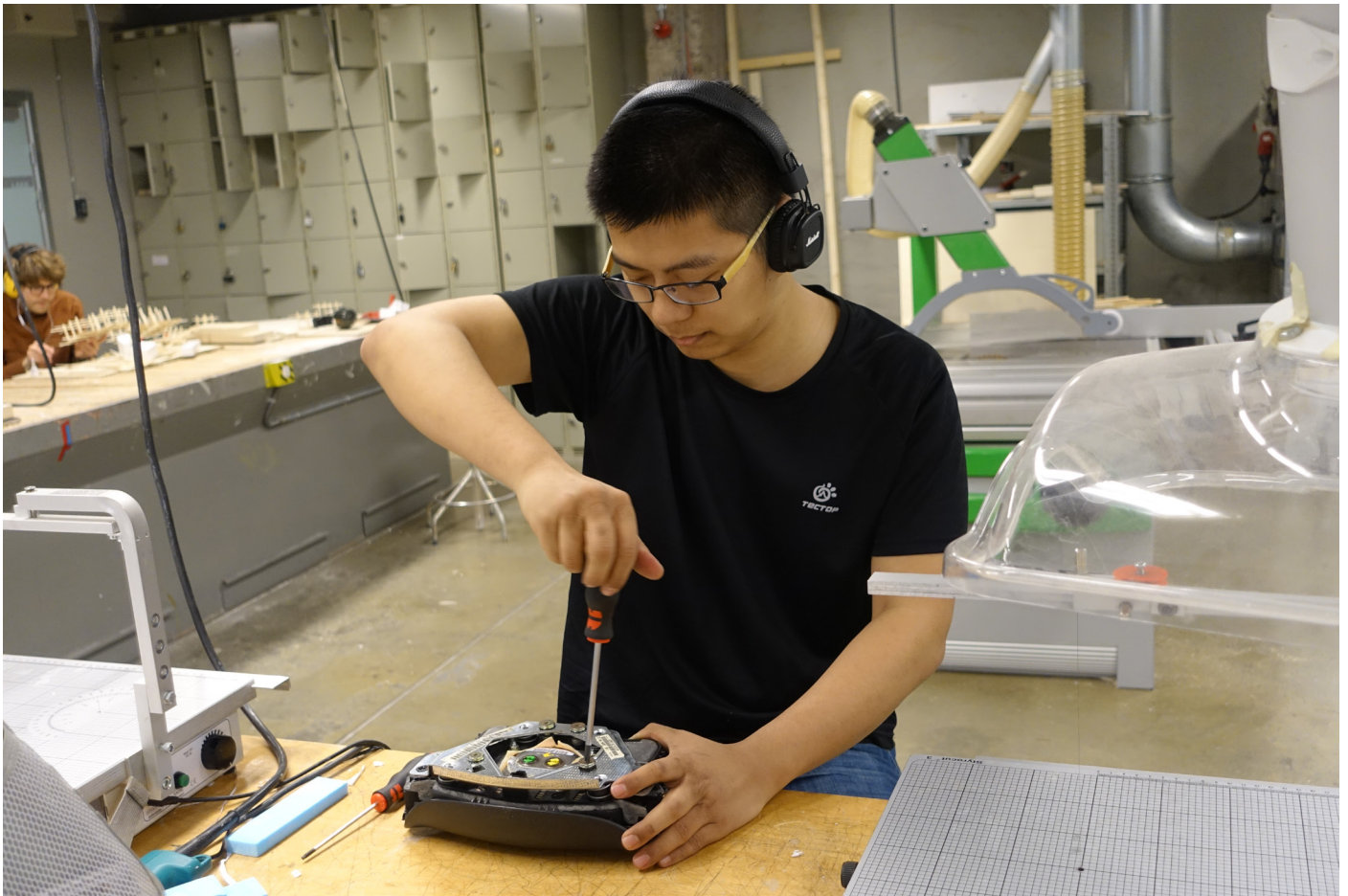
■ Car airbag

Car airbag is one of the most important parts of your vehicle's safety components. Proper airbag deployment can ensure that you and your passengers survive a crash that you may have otherwise experienced serious injury or death as a result of. There are airbags at the front of the dashboard of most of the cars. These bags are compressed and kept in a small area. When there is an accident, the airbags fill up with air quickly and reduce injury and prevent death.





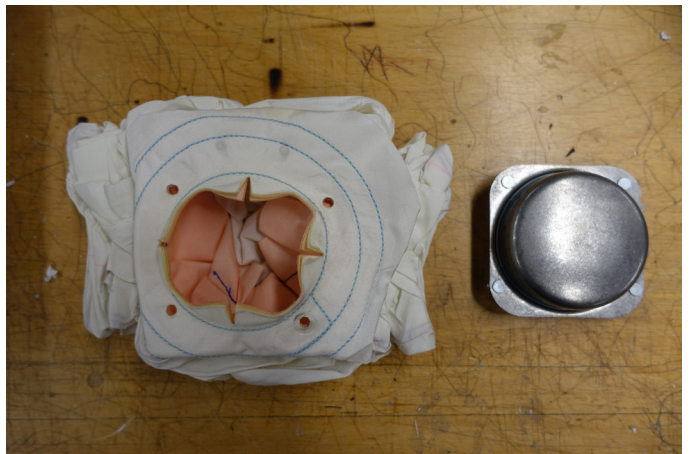
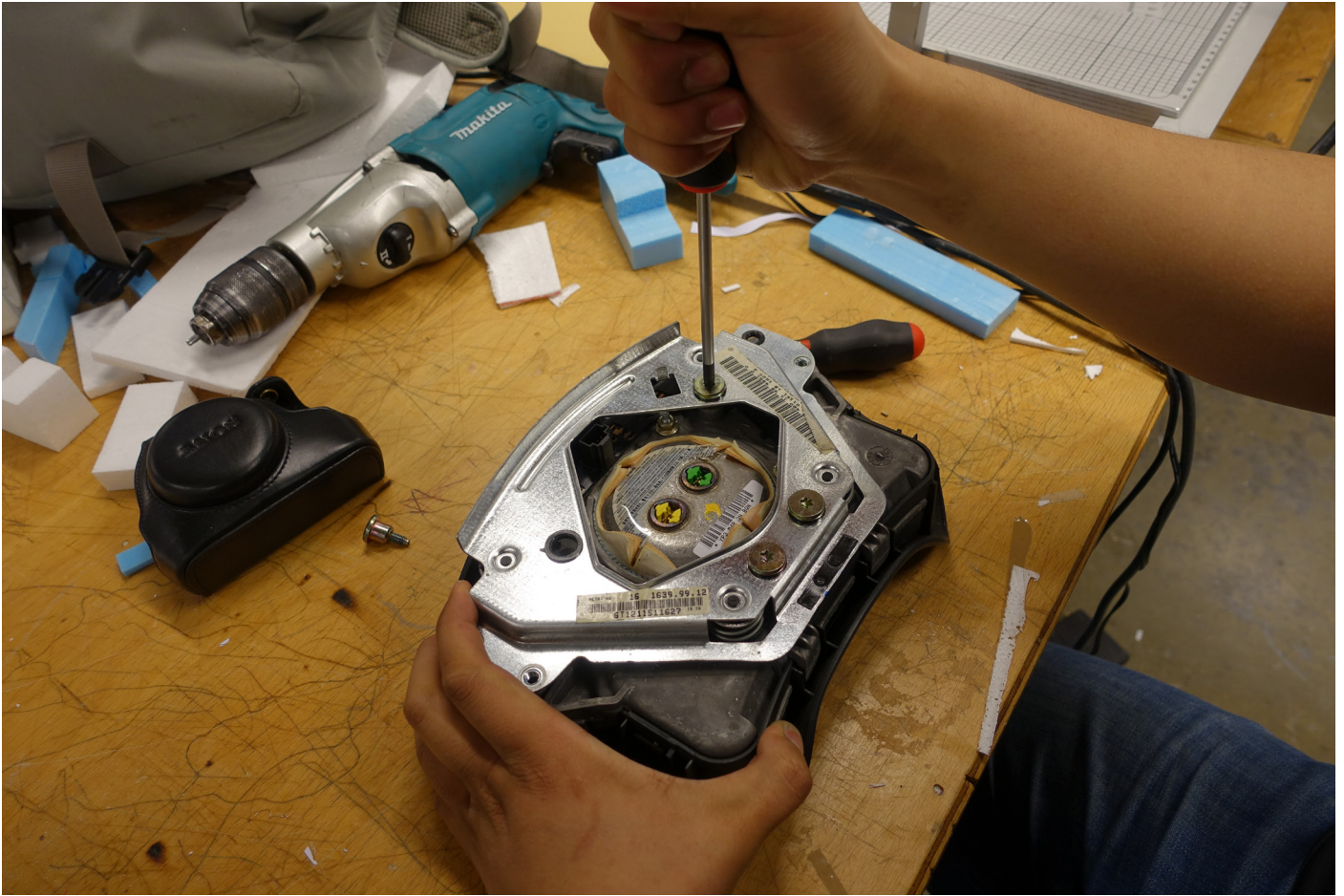
Car airbag in action



■ **Car airbag dismental**

Car airbag shares many similarities with the avalanche airbag. In order to better understand the car airbag system, I went to the car demolition site and bought back one airbag component.

I then dismantled the car airbag component and leave only the basic part that I need.





■ **Gas generator**

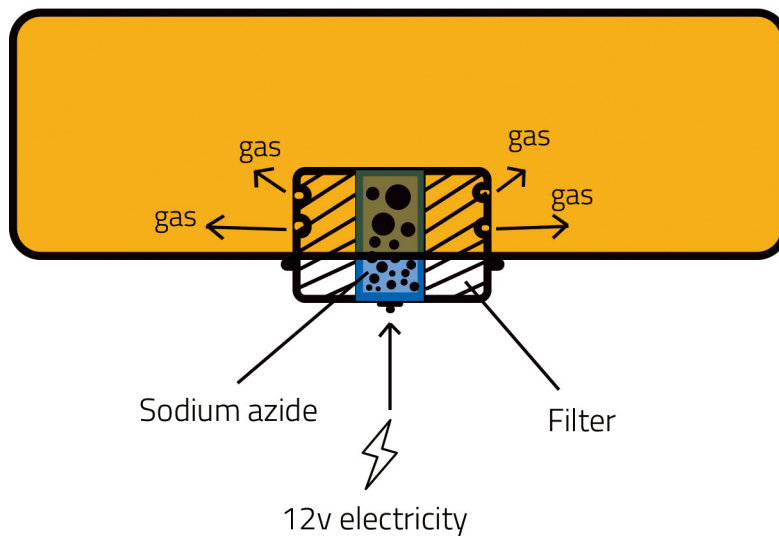
What makes a car airbag different is its gas generator. Unlike cylinder that compresses air, the gas generator of the car airbag is using a chemical reaction. The principle of this reaction is expected to be very simple. Inside the metal shell, you can find a small amount of chemicals called NaN_3 , also known as sodium azide. It keeps stable in a normal environment, however, if you connect them with electricity more than 12v, you can disintegrate them and generate a lot of nitrogen. **With only 150 grams sodium azide, you can generate 100 liters of gas in less than 0.03 seconds.**

Even with the metal shell it has, the gas generator is still super compact. The size of it is only 8cm x 8cm x 4.5cm and the weight is only around 450 grams.

With the gas generator, I can finally do away with the cylinder and pipes of traditional avalanche airbag. Not only the size and weight could be lowered, but also its performance in any way could improve dramatically. Apart from the design part, using existing mature technology could definitely reduce its price and guarantee a stable operation.

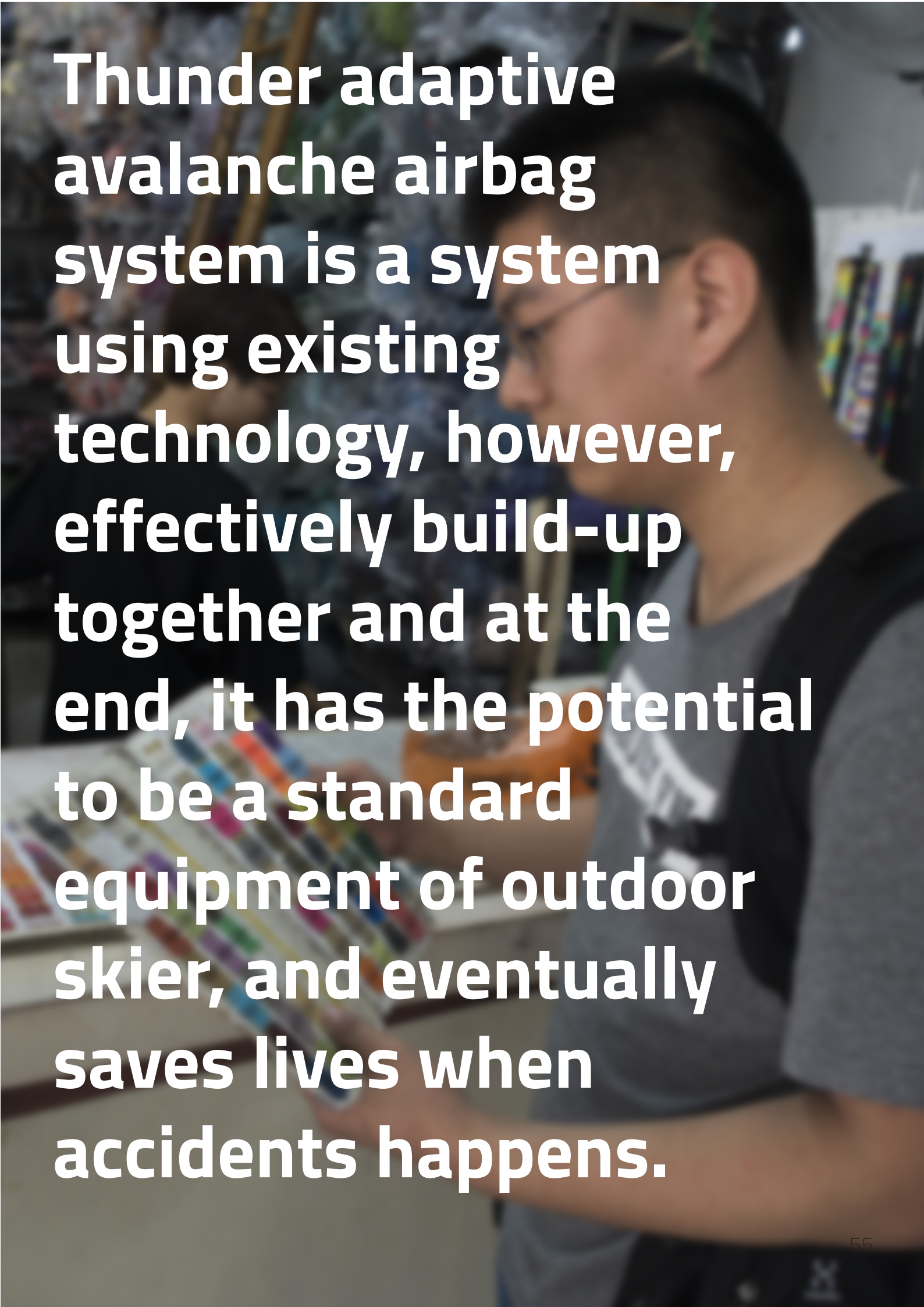


130 grams --> 67 liters of nitrogen gas



Gas generator structure
Size: 8cm x 8cm x 4.5cm

Product design

A person wearing glasses and a grey t-shirt is working on a project in a workshop. They are holding a small orange object and a tool. The background is filled with various tools and materials, suggesting a technical or engineering environment.

Thunder adaptive avalanche airbag system is a system using existing technology, however, effectively build-up together and at the end, it has the potential to be a standard equipment of outdoor skier, and eventually saves lives when accidents happens.

Thunder

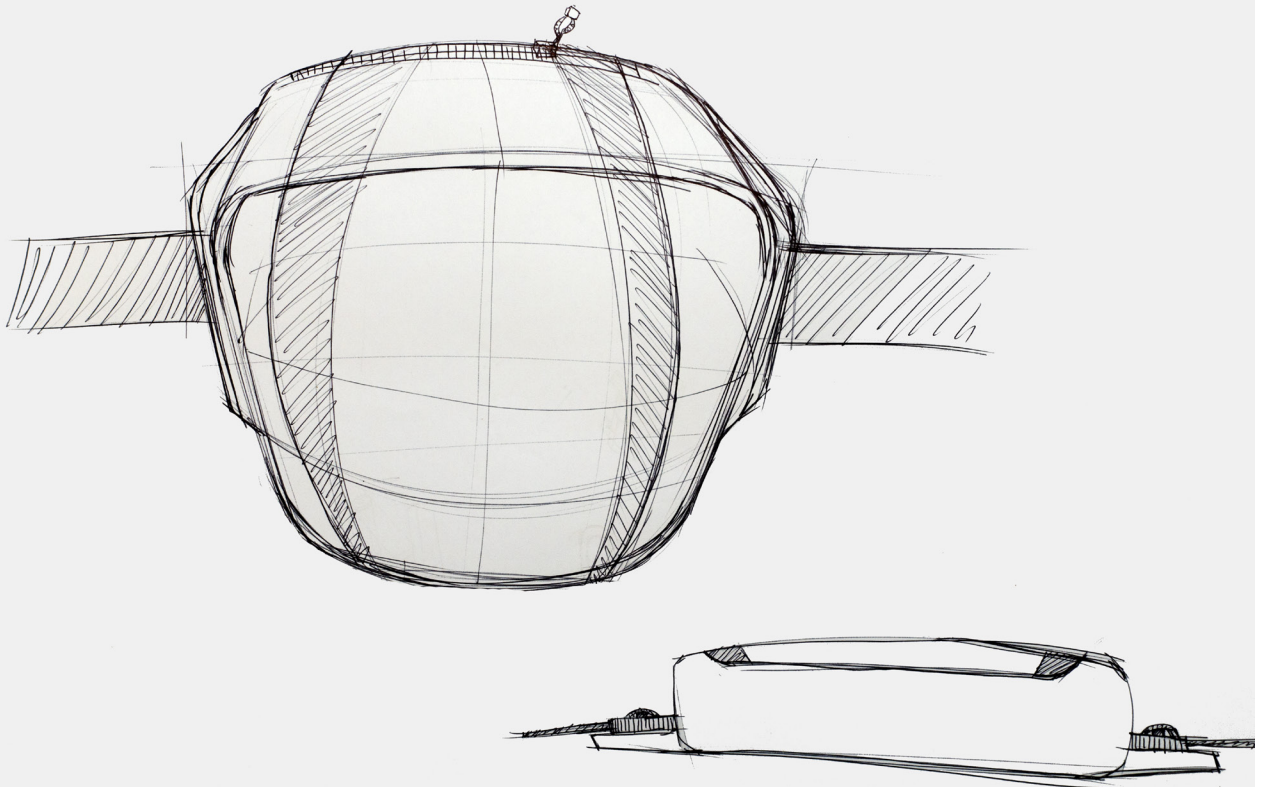
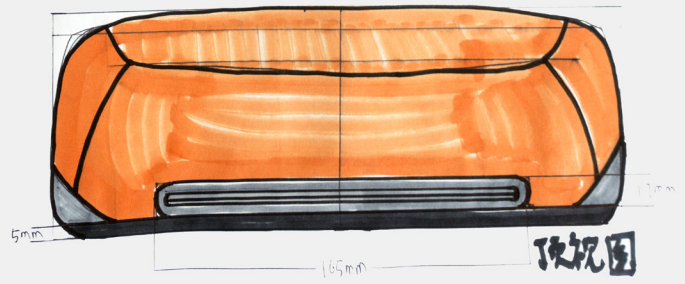
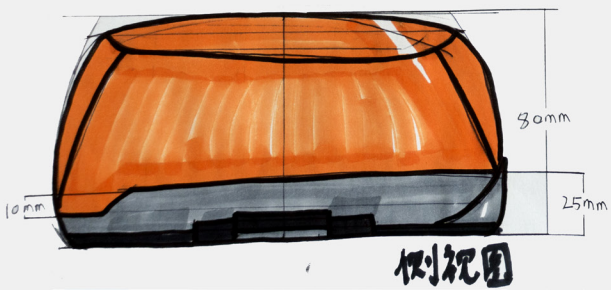
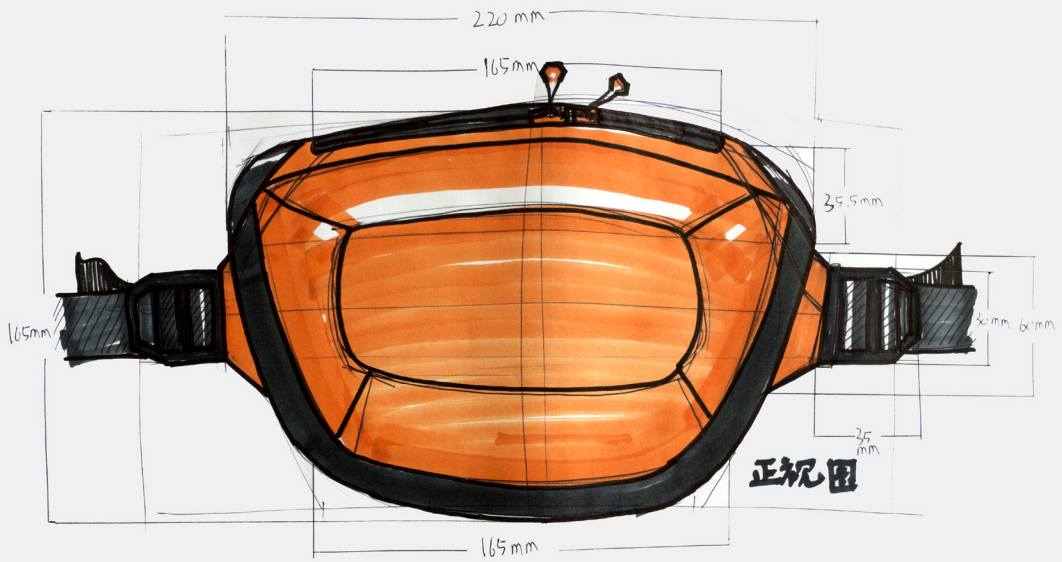
Adaptive avalanche

airbag system

■ Thunder

Thunder is an adaptive avalanche airbag system. The name "Thunder" comes from its lightning fast reaction, both the operation process and inflation time.

Thunder effectively build-up the existing technology together and at the end, it has the potential to be standard equipment for outdoor skier, and eventually saves lives when accidents happen.



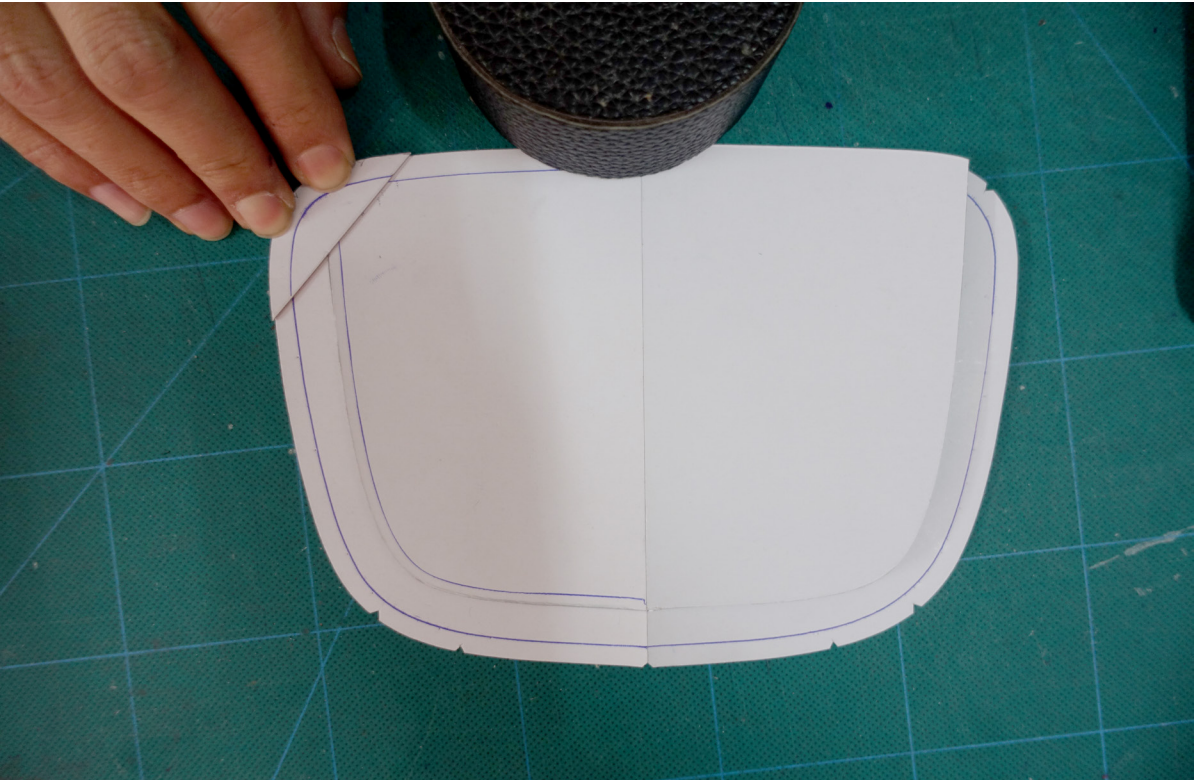
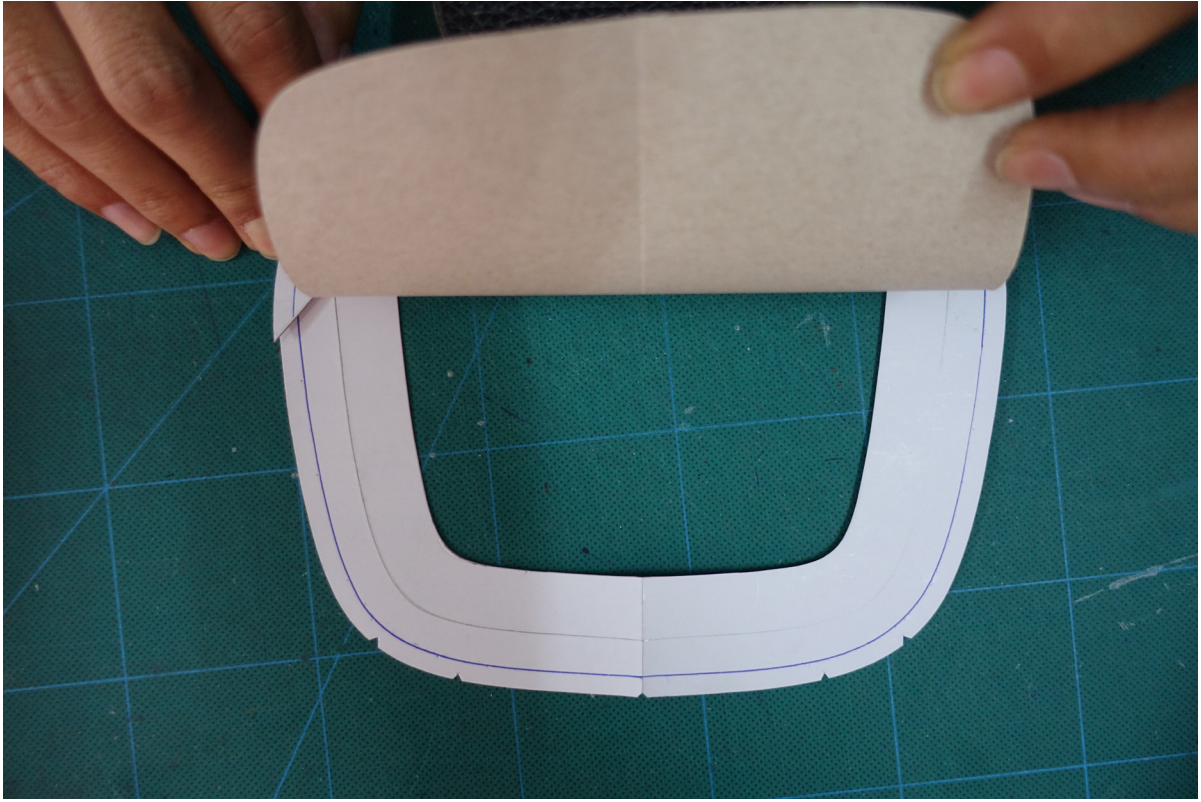
Developing the Thunder

■ **Design choice**

I considered Thunder as an accessory of the backpack, so in order to maintain a simple structure, there are mainly three parts in this design.

The first part is the cloth sack that contains the gas generator, cables and the folded airbag. The second part is the front cap, when the airbag being inflated, the cap will be pushed by the airbag and opens. The third part is an attachment part with the combination of webbing buckle and velcro strap.

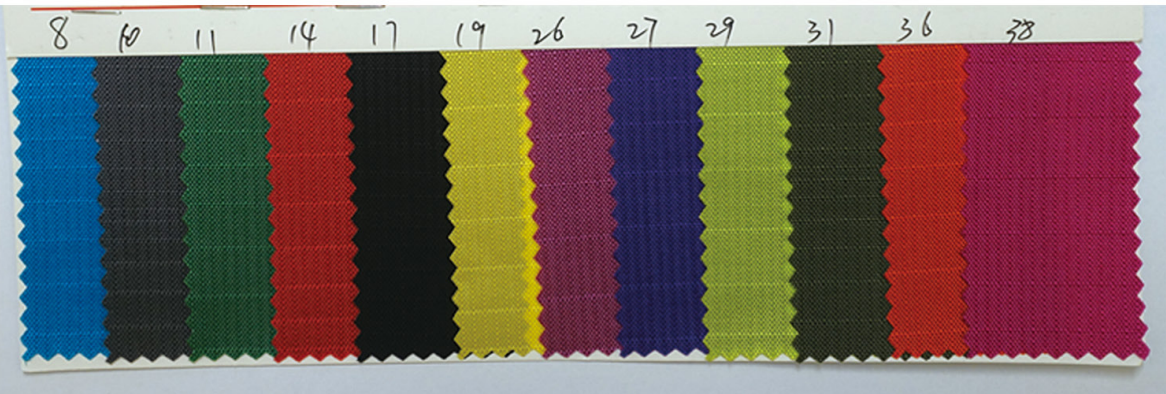






■ **Paper model**

After determined the basic structure. I then drew and cutting every pieces of the structure and see how they fit together.





■ **Material**

To maintain the quality and low price production, I chose the nylon fabric as its main material. Nylon fabric has the advantages of strong and water proof. It is the most common material in outdoor product.

In the first attempt, I used the combination between orange and dark blue. These two colours have a very high contrast, I believe it can increase the visibility in snow environment.



First model
Size: 220cm x 165cm x 8cm

■ Conclusion

This model is the main part of the adaptive avalanche airbag system design. It shows how the adaptive design successfully works on a typical backpack.

It can be considered as a prototype now, but it still has many aspects can be improved. First, by using the gas generator, even with every component inside the structure, it still left more space than I expect. Which means it still has the potential to be more compact. Second, the orange color seems draws too much unnecessary attention since it is a product for a more typical skier. There are some minor design details need to improve as well. Based on the work I have done, it brings us to the final design.



Final design

■ **Thunder-Adaptive avalanche airbag system**

Thunder is an avalanche airbag product different from any other one. It is a system that takes part in all phases of outdoor skiing.

On phase one, taking advantage of its compact size, Thunder is able to connect to any existing backpack with compression straps without occupying any space in the backpack. On the second phase, by using the existing sensor of your phone, after connecting your phone with the airbag system, Thunder can timely tell you the avalanche risk level through the trigger that attaches to the shoulder strap, which helps you stay alert and therefore act more cautiously. On phase three, when an avalanche does happen, unlike the normal avalanche airbag which uses compressed air to inflate the airbag, THUNDER uses the car airbag system, a chemical reaction-based gas generation solution, which not only greatly reduces the weight and size of the system, but also guarantees a stable and burst inflation process.

THUNDER

Adaptive avalanche airbag system

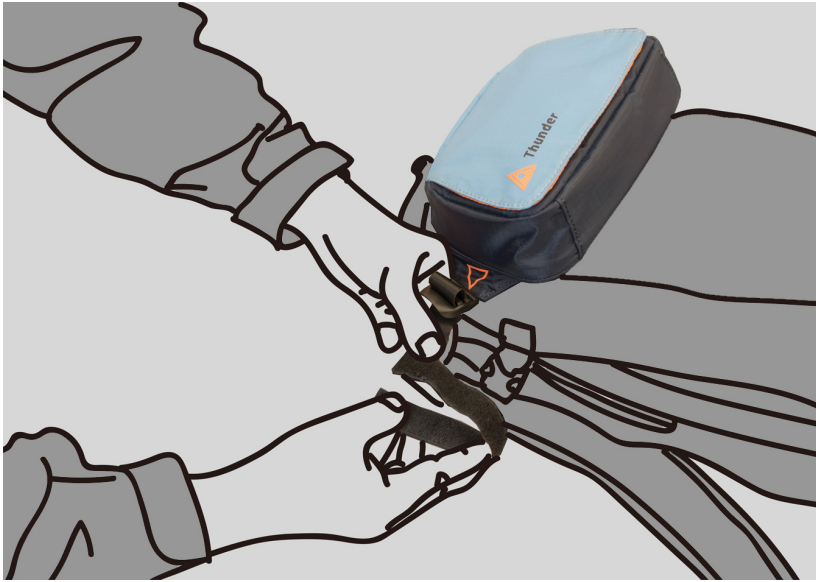


■ **Attachment**

In order to be adaptive, we need a reliable and simple attachment system. I used the combination between Velcro and webbing buckle. You can simply tie the velcro with the compression strap. Then you tighten the webbing buckles and therefore form a simple and strong joint.









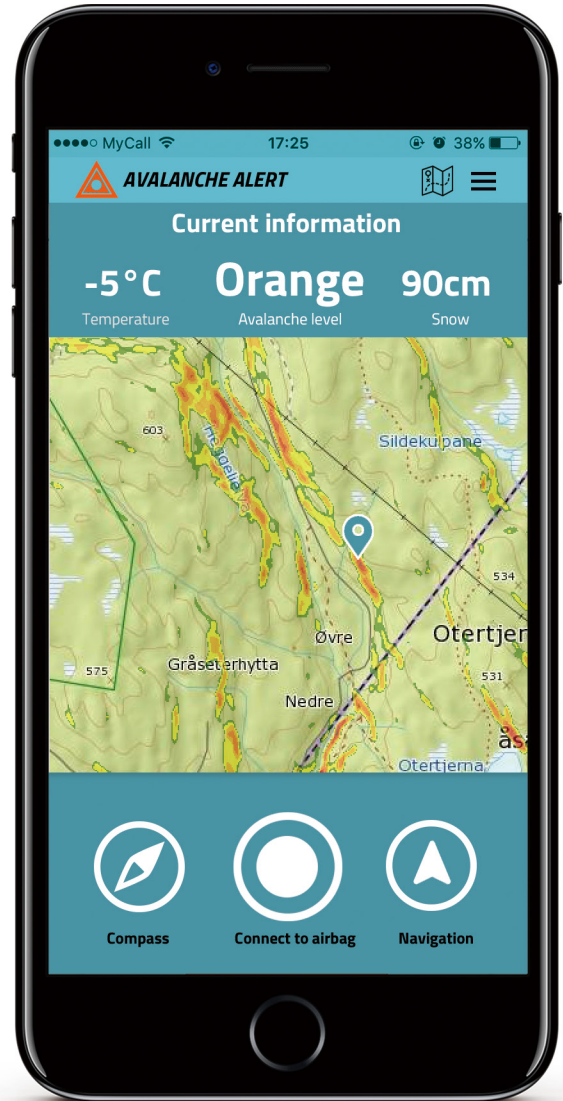
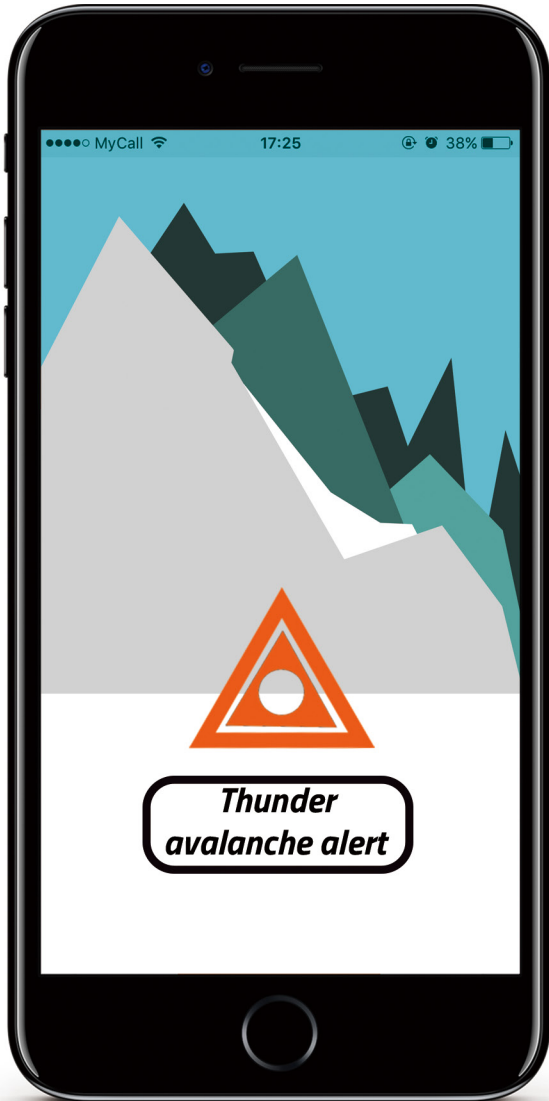
■ Alerting system

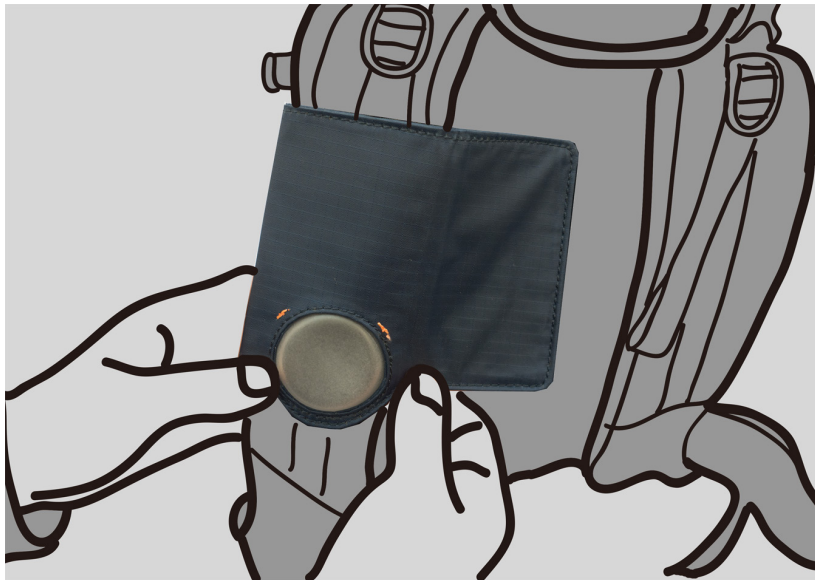
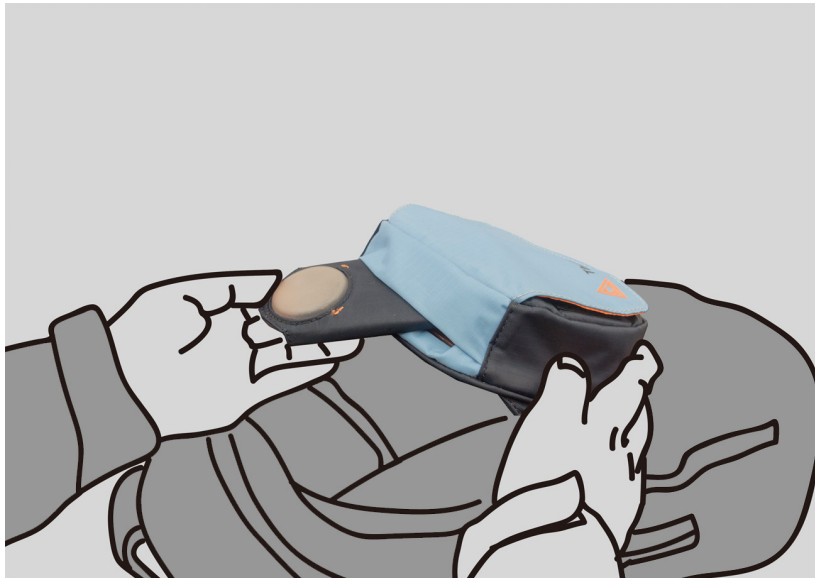
We all know the best safety equipment is your brain. Keeping your mind sharp could forecast most of the accident. But our brain is lazy, without constant stimulation, we will lose the tension and tend to be more comfortable instead of thinking about safety. This is the reason why we have always talked about safety to keep warming people.

This happens in avalanche hazard often. There are a lot of skiers owns avalanche equipment, but still die in an avalanche. Because they find the equipment useless most of the time and simply left them home. How can we avoid this kind of problem, I believe the avalanche alerting system will be a perfect solution.

Our cellphone is the super computer in our pocket. We carry it everyday and it can do much more than calling and surfing internet. In fact, sensors in the phone know your exact location, weather condition, geographic information, speed etc. In general, it can be a very reliable source about whether your current situation is in the avalanche threat.

The phone is the foundation of the alerting system. When we attach the avalanche switch with the should and switch it on, we can then match the airbag system in the avalanche app. When it successfully matches, it can constantly tell you your current avalanche level and therefor greatly reduce your chance of caught in an avalanche.







■ Airbag

No matter how hard we want to prevent the accident, sometime it might come to you. Maybe we have thought about it for many times, but when the moment comes, you will still in great intensity and might catch in panic.

For avalanche, a conventional airbag will take more than 6 minutes to inflate, but an avalanche could rush into you with less than 8 seconds. There really left no time for you to think.

Thunder however, are gas generator that reacts lightning fast. A complete inflation time only lasts for 0.03 second. What is more, in order to reduce the reaction time, instead of using a handle, you simply hit the button hard enough. The button will generate a 12V electricity and then start the whole inflation process.











■ **Details**

I have tried my best to make the model, but limited by my craft technique and equipments. I have to simplify the design to be allowing me to sew them together. However, it is also a prototype that answers all the question I asked before. I am looking forward to seeing the next version of it.

Discussion

■ Reflection

Testing how far I can go during the diploma might not be the safest choice, but I still consider diploma part of the learning process. The result in this diploma still left lots to refine in the future, It was a pity that I don't have more time polishing the design details, but I believe every obstacle that I had met in the whole process would be a great value to me in the future.

About next step. Polishing the details will be the first priority, for instance, from a review of the former respondents, he still has some doubt with the attachment. Later, I think it would be interesting to follow a certain design language of some brand. It will provide a more immersing experience and also increases its chance of mass production.

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