SMART ENVIRONMENTS PROJECT
DOCUMENTATION REPORT

TEAM ONE DOWN
21-01-2021

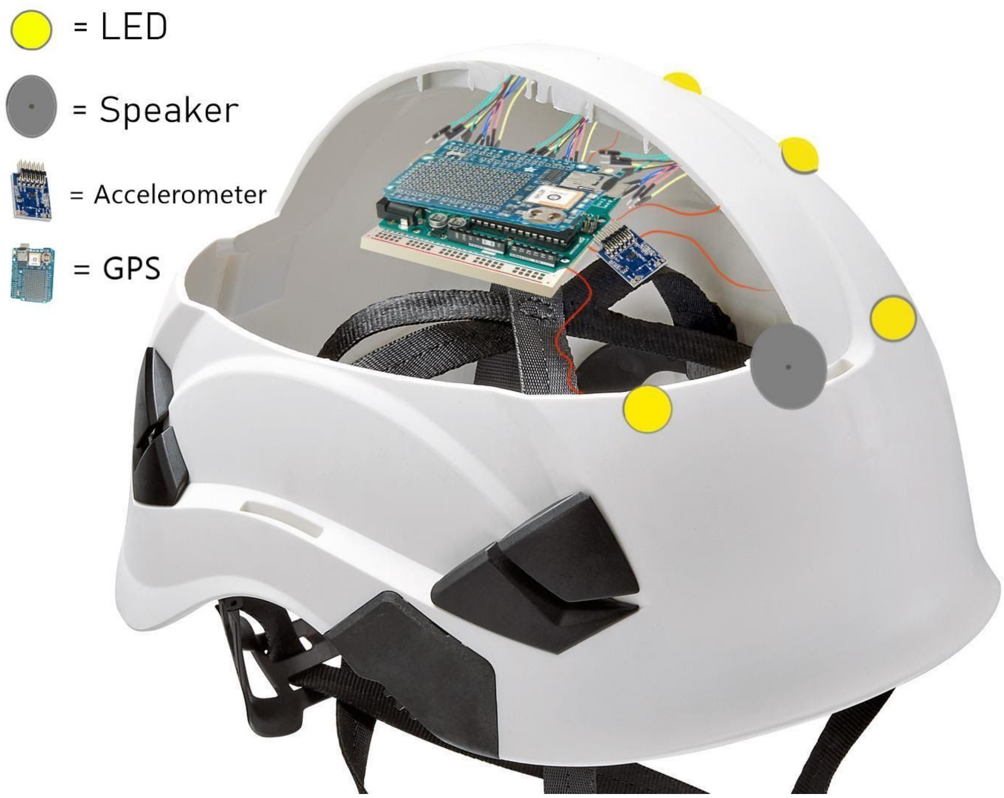

Figure 1 (VERTEX VERSION CANADA, z.d.)

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Chapter 0: Introduction

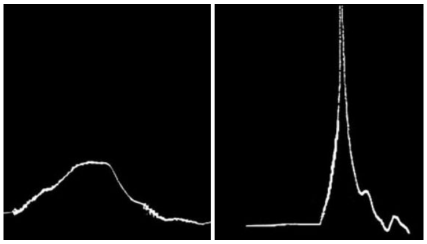
This year's topic for module two of Creative Technology is disasters, in which a smart environment related product should be designed. In this report, the thinking process and progress will be documented by use of eight different chapters. The product that has been developed during the project is a Smart Safety Helmet. This helmet is to be used by people who practice potentially dangerous sports alone in remote areas.

There are many extreme sports that can be practiced nowadays, such as mountain biking, mountain climbing, hiking and motocross. The helmet would actually be used in these situations because people practicing these sports are already wearing a helmet anyway. The developed Smart Safety Helmet is not yet designed for extreme sports under extreme weather conditions, like skiing, snowboarding, surfing and skydiving. Adjusting the design to different weather conditions, is something that was out of the scope of this project. Therefore the focus of the helmet will be on mountain biking.

The inspiration for this project was found after reading an article about a mountain biker gone missing. A mountain biker in Sierra Hill had injured himself after falling down a steep slope ssteade@bayareanewsgroup.com. (2020, 3 november).After many hours the local police and fire department started a search operation. After 12 hours the mountain biker was finally found. The search team could not get to him since it was getting dark, they had to leave him until sunrise. The next morning the mountain biker was rescued. This however, was too late for the mountain biker, he passed away from his injuries.

Multiple studies have also proven that wearing a helmet while biking is effective. Some examples of these studies are "A Case-Control Study of the Effectiveness of Bicycle Safety Helmets" by (Thompson et al., 1989, p. 1365) and the study "Helmets for preventing head and facial injuries in bicyclists" by (Bazarian, 2003, p. 738). Out of these two papers the one written by Bazarian is the most recent. This research paper focuses on bicyclists of all ages in the United States, Europe and Australia. The paper states that every year about 900 bike riders in the United States die from injuries that can occur when someone crashes. It also states that more than 500 000 people in the United States had to be treated in emergency departments. The objective of this study was to find out if bicycle helmets reduce the amount of injuries that occur at the head, brain and the face. This paper concluded that helmets provide a 63% to 88% reduction in risk of injuries at the head and severe brain injuries.
These two research papers about the efficiency of helmets are both a bit outdated, luckily there are also two more recent reports that also talk about the efficiency of helmets. These two papers are "Effectiveness of Bicycle Safety Helmets in Preventing Facial Injuries in Road Accidents" by (Stier et al., 2016, p. 351) and "Factors affecting severity of bicycle-related injuries: the role of helmets in preventing head injuries" by (Abu-Zidan et al., 2007, p. 367). The research of (Stier et al., 2016, p. 351) the objective was to determine how much a helmet protects a biker during accidents. This study focuses mostly on Germany and the bike crashes between 1999 and 2011 which were approximately 5.350 crashes. This study concluded that bicycle helmets do not reduce injuries of mid face features. Since helmets barely protect this part of the face. It was found that helmets do not reduce but increase injuries of mandibular fractures. With this is meant the fracture of the jaw. In this research it was concluded that helmets do not always reduce injuries, this was concluded because the data they used for their research did not always include data about whether the rider was wearing a helmet or not.

However the organization the Bicycle Helmet Safety Institute proves in their report “What Happens When I Hit?” (Bicycle Helmet Safety Institute, z.d.) that wearing helmets is indeed useful. They describe how a helmet can reduce damage. Because when wearing a helmet during a crash the head comes to a stop in about 6 milliseconds without the helmet this lowers to less then one milliseconds. The blow from a fall will be much faster and thus harsher.



6ms　　　　< 1ms

Duration before the head reaches the ground. When reaching the first half of the spike the danger of permanent brain damage begins.

All of this inspired the team to create a product that is able to alarm rescue teams/workers automatically. Meaning that even when the user of the helmet is unable to alarm someone, the helmet will do it for the user. This way victims can be more easily found by rescue teams and emergency services.

In 2017 and 2018 during the Enduro World Series (EWS) Seasons one of the largest medical studies of the health and injuries among mountain bike riders was held. For this medical study 2029 riders participated in 10 races.The study concluded that the majority of injuries occurred when riders hit the ground. The most common injuries were around the shoulder, other common injuries occurred around the head, hand and the lower leg. About 9% of the injuries happen around the head area. One of the most dangerous injuries that can occur is a concussion. In the situation of a major crash, the driver might be unconscious for some time due to the impact and a concussion. It is also possible that the crash inflicted life endangering injuries. At this moment, it is crucial to get help to the injured athlete as quick as possible to increase the chances of a successful rescue. This can be very challenging for a rescue team because it might not get notified immediately or even at all. As long as the rider is not found by someone else or regains consciousness, emergency services can not be alarmed and lead to the place of the crash. A smart, GPS enabled, helmet could greatly reduce the time between a crash and the arrival of a rescue team.

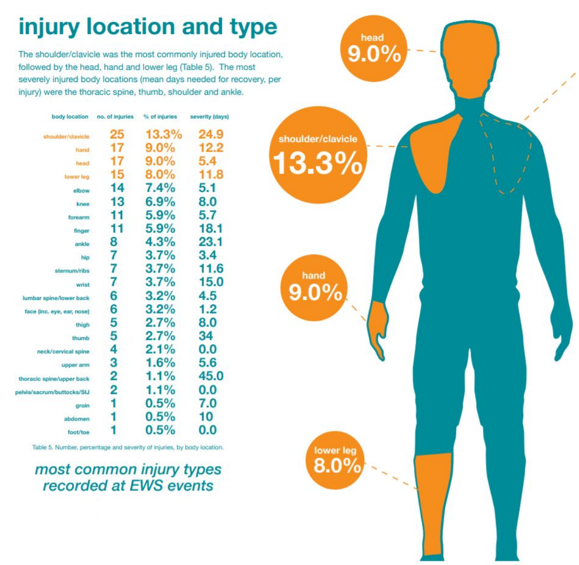


Figure 2: Statistics on injuries

The aim for this helmet is to make these athletes feel safer when they are wearing this helmet. This helmet automatically transmits an emergency signal as soon as it recognizes a crash. This emergency signal contains the severity of crash, expressed in the amount of g-force experienced by the user together with a location provided by the GPS tracker included in the Helmet. Additionally, the helmet will be equipped with several other features to make it noticeable, also at night. e.g. flickering lights and buzzers. In depth working of the helmet shall be explained in a later stage. Enduro World Series. (2019).

Chapter 1: Literature Review

Below are 20 articles about disasters that we reviewed and summarised. For many articles there immediately were ideas on how to integrate a smart environment related device to the disaster mentioned in the article. These articles contributed to the ideation phase of this project.

1. **Wildfires**
   Summary:
   Extreme wildfire events have a significant socioeconomic impact and are becoming more and more common as the world climate changes rapidly. However there is no common way to tackle or even classify these events. The goal of the paper is to create a better understanding about fires of large magnitude and social impact to provide for the possibility of a better transdisciplinary approach to this issue, bringing different perspectives together. Main goals are (among others):
   Enhanced detection, prevention and mitigation. Tackling social need in the aftermath of such an event (temporary/permanent relocation, loss of social support/ sense of community, loss of symbols/heritage destroying location attachment/identity).
   Tedim, F. (2018, February 25)
   Possible solutions:
   More accurate prediction of wildfires

2. **Blizzards**
   Summary:
   A blizzard is a severe storm. These can be quite disruptive and deadly. In 2013 parts of Long Island had about 30 inches of snow. Going outside on foot or with a car is not recommended during these conditions. In this publication they give tips for situations in which people have to go out or use their car.
   Brooks-Waterburn Corp. (z.d.).
   Possible solutions:
   Heated road (detect icy conditions or snow on top of it)
   Transportation system with help of an app.
   App that notifies if and where people are stuck/snowed in (GPS tracking of location)
   Smart roads (connection to google maps)

3. **Volcanic eruptions**
   Summary:
   This publication is about volcanic eruptions, about how their effects can cool down an area for a certain time period. And about how geoengineering might be able to mimic these effects in order to slow down global warming
   Kurzgesagt – In a Nutshell. (2020, 27 october).
   Possible solutions:
   Smoke severity detection

4. **Risk of hurricanes**
   Summary:
   The risk of hurricanes hitting a populated area can usually be detected long before it actually hits. Despite this, many people will remain behind in the affected area, either because of a personal decision or because the infrastructure was already severely damaged and they had no route to get out safely. Those people have to be accounted and cared for in time. Essential needs (shelter, food, water, medical help) can be brought into the area and placed at strategic points to be accessible to everyone remaining behind.

Idea: Being able to quickly react to different infrastructure failures would be helpful for both sides.
Horner, M. W., & Widener, M. J. (2011a, June 3).
Possible solutions:
Autonomous IoT infrastructure for information
Smart roads

5. **Internet of Things**
Summary:
Different kinds of natural disasters can lead to power outages and lack of internet connection in affected areas. However, the internet is crucial for quick communication and coordination of relief and mitigation measures in such an event, both for the local population and the helping organizations. The popularity of the Internet of Things (IoT) could play a crucial role in helping to aid this problem. IoT-devices are often enabled to connect between one another within a limited range and are often battery powered. This means that they could enable micro-message-delivery in case of emergency to transmit simple messages that indicate the status of an affected area.
Petersen, H. (2014, October 27).
Possible solutions*:*
Emergency communication without power/internet

6. **Collapsing buildings**
Summary:
Collapsing buildings is a big cause of mortality and morbidity around the world. In 2013, a big building in Bangladesh collapsed and it is considered to be the deadliest garment-factory in Bangladesh ever. Bangladesh had limited resources and therefore, crowdfunding was crucial. There were also a lot of volunteers, but they were not skilled enough to know how to rescue people.
Biswas, A. (2015, 14 april).
Possible solutions:
Safe house/safe spot
Emergency communication
GPS helmet

7. **Volunteers**
Summary:
Volunteers are very important after a disaster. Because of good technology, disasters can be predicted and so, people can prepare for the disaster and make evacuation and rescue plans.
Ignou The People's University.
Possible solutions:
Safe house/safe spot
Emergency communication
Instructive app (warning, directing to safe place, instructions for volunteers)

8. **Emergency response 101**
Summary:
The first step is providing medical aid and starting search and rescue work. There will be a lot of people with injuries, so the medical systems will be overwhelmed. Arrangements for shelter, food, water, medicines must be developed immediately.

The Fundamentals of Emergency Response. (2020, 13 februari).

9. **Tsunami**
   Summary:
   This paper is about tsunami and how to build shelter and behave in the post-tsunami period. In addition, to how previous experience can help.
   Kennedy, J., Ashmore, J., Babister, E. and Kelman, I. (2008, March).

10. **Tsunami**
    Summary:
    This topic shows the possible expenses and how to provide a significant defence for this flooding hazard. Additionally, it shows how science and technology in combination can be used in the creation of tsunami warning systems.
    Bernard, E. and Titov V. (2015, October 28).
    Possible solutions:
    Decrease expenses

11. **Tsunami**
    Summary:
    Contains total information about tsunami, its appearance and how to predict tsunami behavior.
    Eric L. Geist, Vasily V. Titov and Costas E. Synolakis. (JANUARY 2006).

12. **Going Missing**
    Summary:
    A 14-year-old girl went missing this summer after watching the sunset in the North Sea on Ameland. The KNRM (rescue services) went looking for the girl with five boats and a helicopter. The KNRM kept on searching but started to suspect that the girl had been taken by the strong/dangerous currents and the temperature of the water. Throughout the whole day the KNRM warned people for the strong currents, there were three posts with lifesavers, the whole day they had been busy with rescuing people because of the strong currents
    NOS. (2020, July 12).
    Possible solutions:
    GPS tracker

13. **Skiing**
    Summary:
    Eleven people were injured after a ski lift in Gudauri went out of control. The ski lift started to move in reverse at a very high speed. At the bottom of the lift this caused the lift chars to crash into each other. The cause of the malfunction is suspected to be voltage fluctuation or brake issues. The people inside the lift needed to jump out of the lift once they reached the bottom. Otherwise they would be crashed into the other lift chairs. The lift was produced by the Doppelmayr Garaventa Group, they investigated the case after the incident.
    GeorgianJournal. (2018, March 17).
    Possible solutions:
    Smart skiing seats

Smart skiing helmets

14. Snowstorm

Summary:

This year around the end of October a snowstorm knocked out power for thousands of households. It also caused hundreds of accidents. The National Weather service recorded that 7.9 inches of snow fell. It is said to be the biggest amount of snow that has fallen since October 1916. The snow caused the roads to be icy. There were over a thousand road related accidents. Furthermore, there were 33,500 customers that had no access to power. For the upcoming days/weeks, travel is suspected to be very difficult due to the wind that reaches a speed of 35 mph. More severe snowstorms are predicted to impact Minnesota in the upcoming winter.

Fox News. (2020, October 21).

15. Hacking data

Summary:

University of Maastricht (UM) paid 197.000 euros to Russian hacker-group in order to obtain 'decryptor' and ability to recover captured data. 19.000 students and 4500 employees suffered from technological problems for at least two weeks (december 2019). Students of the university were requested to change passwords and the university implemented a higher security system. Other universities were warned of this attack immediately, thus UM. University of Utrecht was able to successfully defend its systems from a similar attack. In an official report following this attack, it was concluded UM had made too little effort to protect its systems after the first sign of the attack was already detected in october of 2019. The same report states UM did however act adequately concluding this crisis. By means of a symposium providing insight, the UM enabled other organisations to learn from this accident.

Inspectie van het Onderwijs (12-06-2020).

16. Eggs

Summary:

Dutch poultry farms (dutch: pluimveebedrijf) are closed after use of fipronil. This toxice was used in an anti louse agent distributed by a company named Chickfriend. Consequently, eggs of multiple farms were contaminated with fipronil. In the end, 180 farms were temporarily closed due to this contamination, supermarkets were to retrieve these eggs from its shelves and lists of egg-codes were published so one could check if eggs that were already sold and at home were possibly contaminated as well. Eventually, this contamination reached Belgium, Germany and France and farms were to be closed there as well. Damages among farms round up to 150 million. First notice (anonymous tip) of the use of fipronil was made in November 2016. Egg sales in supermarkets turned back to normal in the midst of August 2017.

NOS (17-08-2017).

17. Smog

Summary:

Easter China Smog, during 2013, one of the worst appearances of smog, decreased visibility, caused disruption in traffic and transportation among many other daily activities. Large areas of China reached levels of over 251 microgram/m^3 labelled as hazardous (worse than very unhealthy) for multiple days. Highways, Airports and schools were closed, outdoor activities were reduced as much as possible. Citizens were advised to make use of protective face masks and air purifiers. Negotiations in China's

government were started to change primary energy sources from coal to natural gas and renewable sources. Green energy companies were encouraged by means of financial incentives. Tougher control over emissions were placed, and a fund started to help companies meet new environmental standards.
Wikipedia ed. (23-10-2020).
Possible solutions:
Make face masks better
Filter in ventilation/ vent air purifier
App for showing most toxic area

18. Rescuing Norms
Summary:
The social norm during disaster is ”woman and children first”. You may think that this gives women an advantage in and during maritime disasters. But research shows the opposite, men and the crew have a higher chance of surviving.
Elinder, M., & Erixson, O. (2012).
Possible solutions:
Special trainings

19. Caterpillar
Summary:
Caterpillar plague in 2019. The caterpillars let go of their hairs and when these hairs come into contact with human skin it becomes very itchy and irritated. Getting rid of these caterpillars turned out to be harder than expected due to the size of the problem. Thousands of mentions around the country were made yet only the ones with the highest priority could be handled and helped to get rid of this plague. A variety of outdoor activities were closed due to this problem.
Huijben, M. (27-06-2019).
Possible solutions:
App to report nests of

20. Pandemic mental health
Summary:
Pandemics have a significant socioeconomic impact, especially on groups that are at higher risk, in this paper elderly people. Anxiety, depression, and social distancing leads to loss of social connectedness among people who cannot use modern means of communication. This also leads to a higher chance of spread of misinformation, which can lead to more panic or mass hysteria. On the flip side, people who have access and heavily use modern communication can experience information overload, a phenomenon leading to the same results as previously mentioned.
Banerjee. (2020, May 4).
Possible solutions:
Communication apps, easy to use for elderly
Digital pet/ thing that needs to be taken care of.
For traumatized children: A “friend” you can talk to, e.g a teddy bear with built-in phone to hotline and powerbank.

Chapter 2: Identification of General Problems and Challenges

Below is a list of problems and challenges that were identified from the articles summarised in chapter 1. Some of these challenges are recurrent and applicable to multiple disasters. This list helped us identify what would be an interesting and meaningful challenge to design a solution for.

- Victims/traumas/social impact of disasters, also deaths and damage to nature
    - People need assistance to deal with the destroyed environment around them.
- Damage to infrastructure
    - When infrastructure is damaged, this can have a great effect on people. This is something that is recurring with multiple disasters.
- Inability to connect/contact others during a disaster
    - Without proper communication in place, it can be very hard to locate victims and locate people in need of help.
- Problem recognition for natural disasters
    - Governments and organisations, sometimes ignore the early signs of disasters, this causes them to be unprepared for possible disasters. Sometimes they are also unable to recognise the early signs of disasters. This, on its term, could also lead to lacking preparation for disasters.
- Only handle problems once they get out of hand
    - As stated before, if organisations and governments are unprepared for disasters, they are unable to tackle the situations once the disaster does occur. They focus too little on what to do after or if a disaster happens.
- The volunteers are not skilled enough to rescue people (lacking of skills)
    - Trying to help out of courage is not always helpful or successful when done by an untrained person.
- (too much) pressure on the medical staff
    - Understaffing and no space for regeneration times leads to failure to carry out a job correctly.
- Logistics in case of an emergency
    - If division of items such as food and water is not handled well, this could lead to problems or even quarrels among victims.
- People are forced to go out of the house during natural disasters, which brings their life in danger. (No help present) (underestimating problem, not enough available)
    - When people have to stay in areas of long lasting disasters like blizzards the danger of going outside can often not be avoided.
- Lacking protocols
    - Where does the help need to go first?
    - Who makes the important choices?
    - Who is in charge?

Chapter 3: Identification of Relevant Problems

After defining the recurring problems and challenges. Five relevant and meaningful problems were selected. For every problem, a possible solution has already been thought of.

1. **Dangerous/inaccessible roads**
   During natural disasters, for example, a snow storm. Many roads and infrastructures become inaccessible due to the weather conditions. This causes many people to be locked up inside their homes, or to be bound to a property. This is a situation that governments wish to resolve quickly, since many people are dependent on going to work and getting their groceries at stores. A solution to dangerous and inaccessible roads are smart roads. These smart roads will be able to either notify that a road is blocked, by snow or rocks from an avalanche. It could also help fixing the problem. For example, a road that melts the snow or a notification that tells you that the road is blocked.
   → Smart road

2. **Dangerous situations on ski lifts**
   Multiple ski lifts accidents occur every now and then which is problematic. People hanging out of ski lifts whilst the lift continues to move or even people falling out of the lift completely. In order to prevent this from happening a solution should be found where this does not happen anymore or the response to such a thing is much faster. One solution that was thought of are Smart ski seats. Seats that recognize if the person is still in its seat properly and consequently act on that.
   → Smart ski seats

3. **Outage of internet/power leading to communication breakdowns.**
   During large scale disasters, the power grid of big areas can be affected. Without power little to no communication is possible and coordination of evacuation/mitigation is almost impossible for regular people or helpers without radio equipment. Autonomous communication devices, such as battery powered IoT devices, could be the solution, as well as shelters that make use of this communication.
   → Smart Emergency communication and smart shelter (smart safe spots)

4. **Locating of victims**
   During disasters like avalanches, snow storms and earthquakes or maybe even during extreme dangerous sports, people might go missing and it can be very hard to locate (possible) victims. This is because mobile connection can be down, the power can be out or any other reasons why communication can not be accessed. Besides, people can be lost during chaotic situations easily. The first hours after such a disaster are critical for locating and helping victims. That is why a specific location tracking smart device could be of great impact.
   → location tracking using GPS during disasters

5. **Smog**
   Polluted air is becoming more and more of a problem in cities, hence private, home filtration systems might be helpful to avoid breathing polluted air.
   → Smart ventilation in smart houses (smart air purifier) (volcanoes/ smog)

Chapter 4: Problem Selection and Motivation

Looking at the past two chapters, one recurring problem is locating victims in cases where communication can not be accessed. At first this problem relates to many different situations as is also mentioned in the previous chapter. People can go missing in case of an avalanche or an earthquake and as a result they are stuck somewhere without inability to move and access help. Another example of a similar situation can occur during practicing potentially dangerous sports. A really specific situation is a hard crash of e.g. someone that is mountain biking. A hard crash can leave the mountain biker unconscious and with severe injuries. Due to unconsciousness or physical inability (think of bruised or broken body parts) emergency communication can not be accessed.

At this point in the selection process of a relevant problem it was chosen to step away from avalanches and earthquakes and focus on the last mention of inaccessible communication, after a crash or an accident during sports. Avalanches and earthquakes require a whole other approach in which also extreme conditions need to be considered, which was thought to be a bit too ambitious.

Summarizing the selected problem, there are some key features that a solution to this problem should cover. Firstly, emergency communication can not be obstructed, meaning that even when one is physically limited to contact emergency services, there should be some way of communication. Secondly, the solution should contain a quick and easy way for e.g. rescue workers to locate the victim.

Chapter 5: Potential Solutions

After selecting the problem of locating victims, five possible solutions were ideated. Many of the solutions can or could be implicated in different ways. One idea that arose was combining multiple of these solutions into one solution.

1. **Smart helmet - detects acceleration (g-force)**
   - People normally wear a helmet when they go mountain biking or climbing or anything like that. This helmet will have some additional features that can save someone's life. For example, it could detect hard falls by passing a minimum acceleration value. The helmet would then be activated and send the location to rescuers.

2. **Attachable audio signal beacon**
   - A small device that sends a loud audio signal when a person stops moving. It can help friends and rescue squads to find a victim quicker.

3. **Radio transceiver**
   - Sends a short range signal to a handheld receiver carried by rescue squads. The victim can be detected easily.

4. **Sending GPS signals to nearby transmitters via short range radio waves**
   - GPS signals are globally available but sending data via satellites to emergency services is too costly for individuals. Sending the coordinates to a nearby shelter/transmitter via radio waves can make this more accessible for everyone, as communication via cellular connection is not always available.

5. **Audio system that guides the victim through survival steps**
   - The audio system can be activated manually or automatically when a person stops moving. It will help the person take necessary steps for survival when under pressure. It can be implemented in various wearables.

Chapter 6: Solution Selection

The Smart Safety Helmet is the solution to the chosen problem, because it is the most feasible idea for implementation. There are many possible variations of using this helmet. It can be used in a variety of situations, such as extreme outdoor sports. The capabilities of this device may also positively contribute to the easy distribution of this device. Some of the other solutions were more limited to one specific type of life-saving function during an emergency. The helmet idea can be expanded as much as is desired.

After the decision was made to develop the Smart Safety Helmet, there were even more decisions to make regarding the features of the helmet. Skills and time had to be taken into account. Mostly due to a lack of time, the helmet has less features than what the initial plan was. More important- and less important features were distinguished from each other and the conclusion was, that the main focus would be to get the accelerometer, LEDs, speaker and the GPS shield to work and most importantly, to get it to work together.

We have realised that implying all the separate ideas for the smart helmet might be too ambitious, therefore we are scaling down the amount of functions of the helmet. We want our helmet to be able to connect to the internet. But because of the short time span we have for this project we have decided to make the connection to the internet part of the advanced plan. Of course if we would work on further prototyping with the goal to make this helmet wireless.

Basic Plan:
The basic plan consists of putting the elements that we found to be the most important on the helmet. Also the elements that we found the most doable. These elements are the LED lights, the buzzer for the sound, the GPS and the accelerometer. The LED lights and buzzer will be activated once the user is in danger. These elements can together form a perfect fit onto the selected problem. The accelerometer will be used for crash detection and as a trigger for emergency communication and the GPS, buzzer, and lights allow for easy ways to locate the victim.

Advanced Plan:
In the advanced plan the helmet can be connected to the internet. So that data can be sent from the user to the rescue teams and/or relatives. The GPS data will be sent with the help of processing with a client and server. When the helmet The server will show a screen with the last location of the Smart Safety Helmet User, which will simultaneously be visible on the client which is used by rescue workers or emergency workers.

To the right is a division of the tasks with who is responsible for what. This division was made to increase efficiency and make progress without meeting up personally.

Tasks:	**Who:**
Programming / wiring	Max, Atosh, Joris and Nikita
Documentation/ Research	Everyone
Buying supplies	Roos
Designing	Roos / Nikita / Anaisa
Presentations / Final demo	Anaisa
Feedback / result analysis	Joris

Table 1: Task division

Chapter 7: Methodology

To equip the Smart Safety Helmet with the right sensors and data there needs to be an understanding of what happens when people crash and how this can be recognized. Additionally, an understanding of how GPS signals behave in nature is required. To start this chapter of, a list of all the equipment that is needed in order to make this project work is given. After that, why this is used and how this is used in this project is explained.

Necessary equipment

The Smart Safety Helmet needs to have a tracker (GPS shield), accelerometer, ledstrip, resistors, wires, breadboard, and a buzzer. The GPS tracker is necessary in order to know where the person is. The buzzer and the ledstrip are included to make it easier to find the missing person. The accelerometer will detect high values of acceleration (g-force) and will consequently trigger the emergency communication. In this project that is, writing serial data with the location provided by the GPS tracker and the severity of a possible crash (amount of g). This data is received in processing which consequently shows a screen to a rescue worker that there might have been a crash. At the same time, the buzzer and the ledstrip are activated which could possibly notify any people who are near that can either hear or see that something is going on.

Another important piece of equipment that has not been talked about yet is the implementation of a killswitch (and also an on-switch). In cases where the accelerometer registers a crash but the helmet's user is actually just fine one could press the killswitch, so no emergency signal is being transmitted. It could also be used the other way around, to trigger emergency communication even though there is not a crash being registered. In that case however, a phone would also suffice.

For the prototype, all the components are put in a construction helmet, because these helmets contain a lot of space, which comes in handy for prototyping. If this product were to be further developed, the construction helmet would be replaced by a helmet in the field of the concerning sport.

GPS signals in nature

GPS relies on 24 satellites and is theoretically accessible anywhere without vertical obstructions. There are, however, a lot of factors that influence the accuracy of a result. Under ideal conditions, GPS signals are very precise (Hiking Gps Zone, z.d.). In this project, locating the missing person is done using GPS signals.

Detecting crash

In order for the helmet to detect if someone is in danger or has crashed, an accelerometer can be used. This device measures acceleration in 3 different directions (x,y,z). Using the output data from this device it can be determined that there might have been a crash or an accident. For example, if you hit your head on a tree, you make a sudden stop, which is measured as a very large deceleration. To implement this into the project, one could read these values into arduino and if these values exceed a limit value, it's notified as a possible crash.

If a person crashes into an object with 30 miles per hour, the person would experience 30g of force Rasansky Law Firm. (2020, 1 februari).There is not a lot of research about the G-force impact on bicyclists in a cycle accident, so the minimum G-force value in this project is estimated, as the research behind this, is out of the scope of this project. An explanatory limit value chosen for this project value is 3g, which will show that the system works.

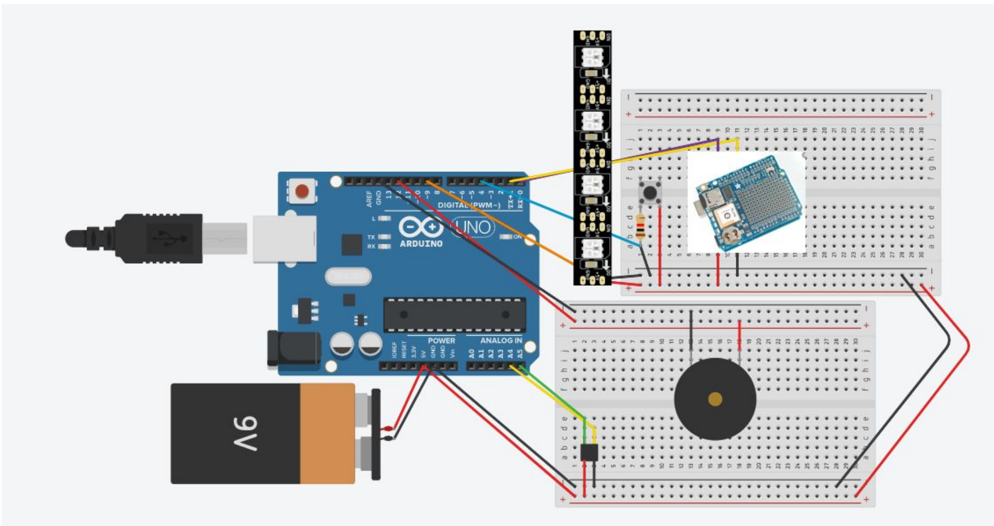


Figure 3: The setup of all the components including: tracker (GPS shield), accelerometer, ledstrip, resistors, wires, breadboard, external battery, killswitch and a buzzer.

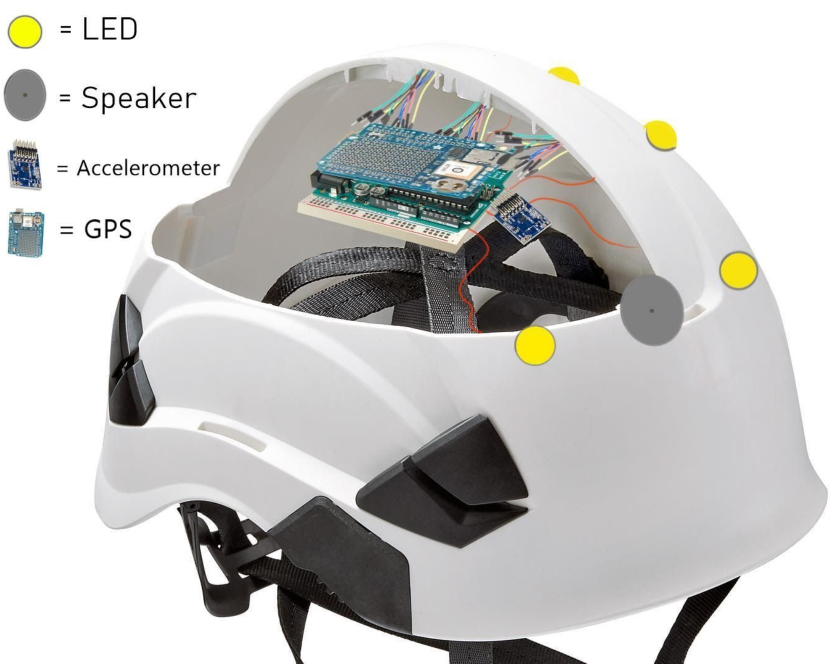


Figure 4: Placement of all the big components in the helmet.

Chapter 8: Results

Because of limited time, the approach that is chosen for this project lies between basic and ambitious. The main focus is on getting the accelerometer, the LEDs, buzzer and the GPS shield to work

^^^we have to wait until we know if we managed to complete advanced^^^

Testing the accelerometer

For the use of the Smart Safety Helmet an MPU6050 accelerometer is used for sensing. This accelerometer measures acceleration in g (=9.81m/s^2). However, for convenience it was decided to work with acceleration values in m/s^2. Consequently, the data outputted by the accelerometer has been multiplied with the earlier mentioned 9.81m/s^2.

The accelerometer measures the acceleration on three perpendicular axes, the x, y and z axis. In order to get the acceleration in the direction it is actually being accelerated (the largest acceleration), the Pythagorean theorem is used twice.

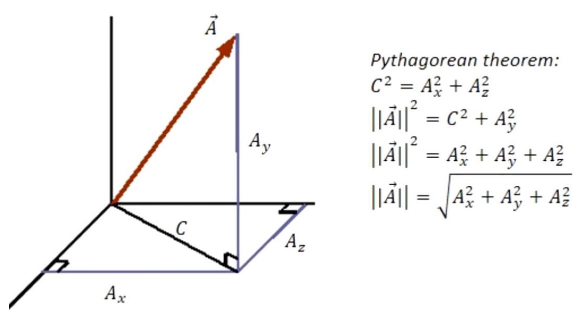


Figure 5: Using pythagorean theorem to determine from different axes the direction of acceleration.

As a result, there is now one acceleration being outputted for which a limit can be set. Using the research from crashes it follows that expecting a crash just from an accelerometer is hard. As a result, to show our prototype does indeed work, low values for acceleration are used as a trigger. To make the helmet and the crash detection useful, some actual extensive research has to be done on when a crash happens and what this means for acceleration. However, it was decided that an extensive research on this might be outside the scope of this project. Below is a figure of the helmet experiencing a crash. This was tested multiple times. This was executed by moving and stopping the helmet very rapidly in different directions. If the acceleration exceeded the earlier mentioned limit value of 3g, the alarming functions on the helmet started working.

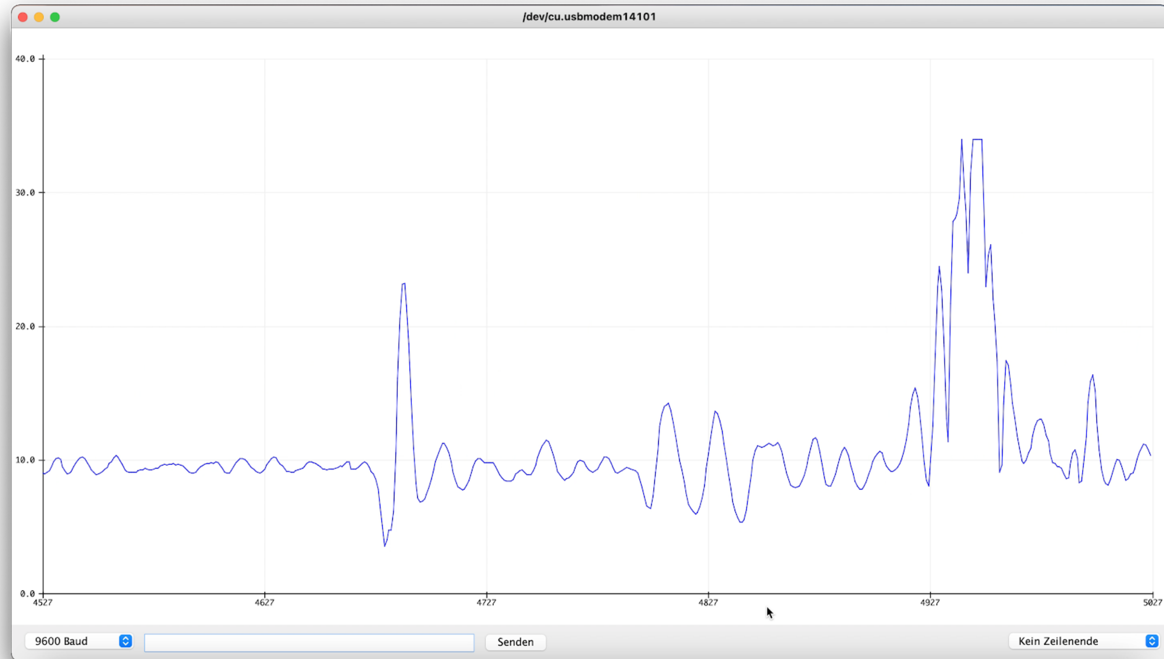


Figure 6: The activity of the accelerometer simulated to imitate a rough ride followed by a crash (acceleration >3.5G).

Testing the accelerometer further, resulted in the following two graphs. Figure 7 shows a soft hit on the table with the helmet. Figure 8 shows a hard hit on the table with the helmet.

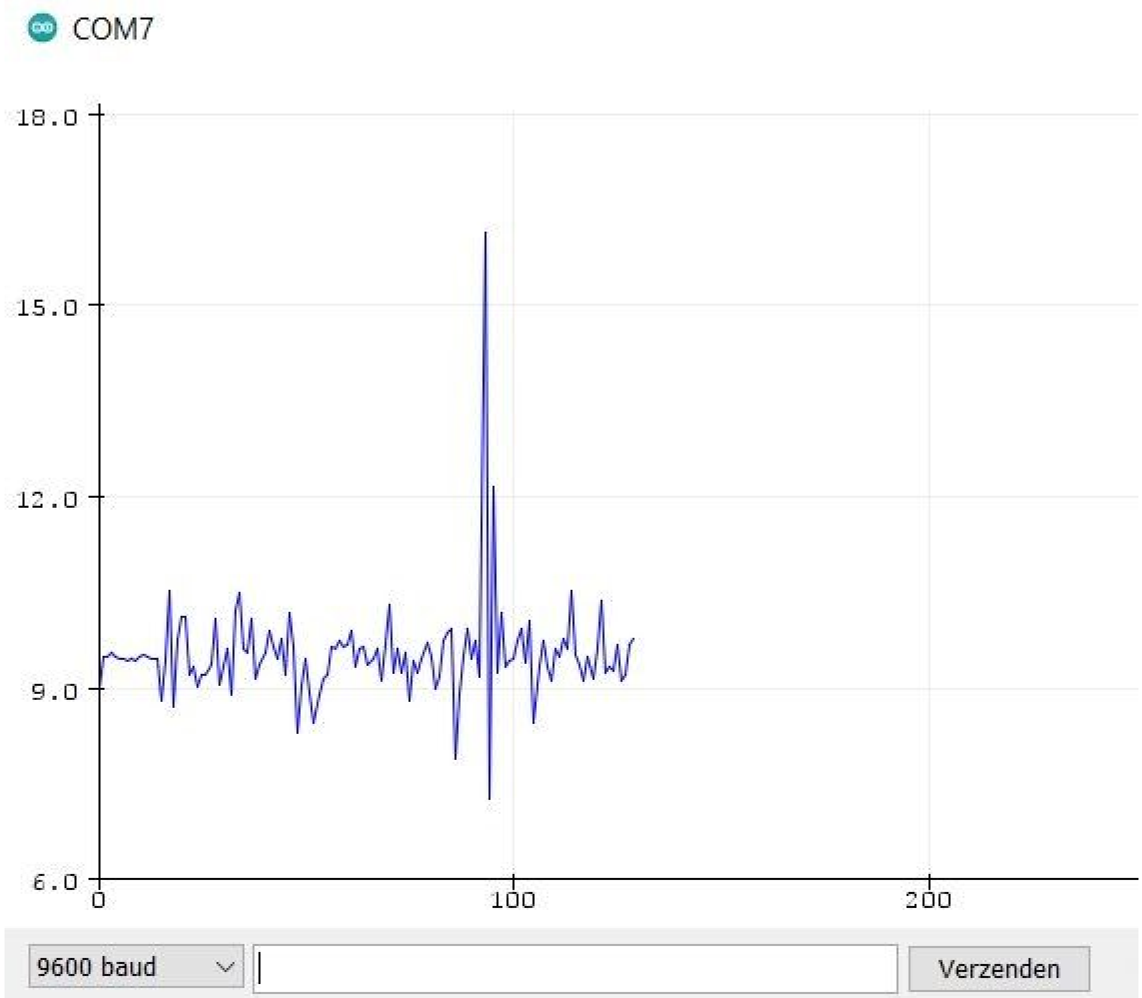


Figure 7: The activity of the accelerometer simulated to imitate a rough ride followed by a crash (acceleration almost 2G).

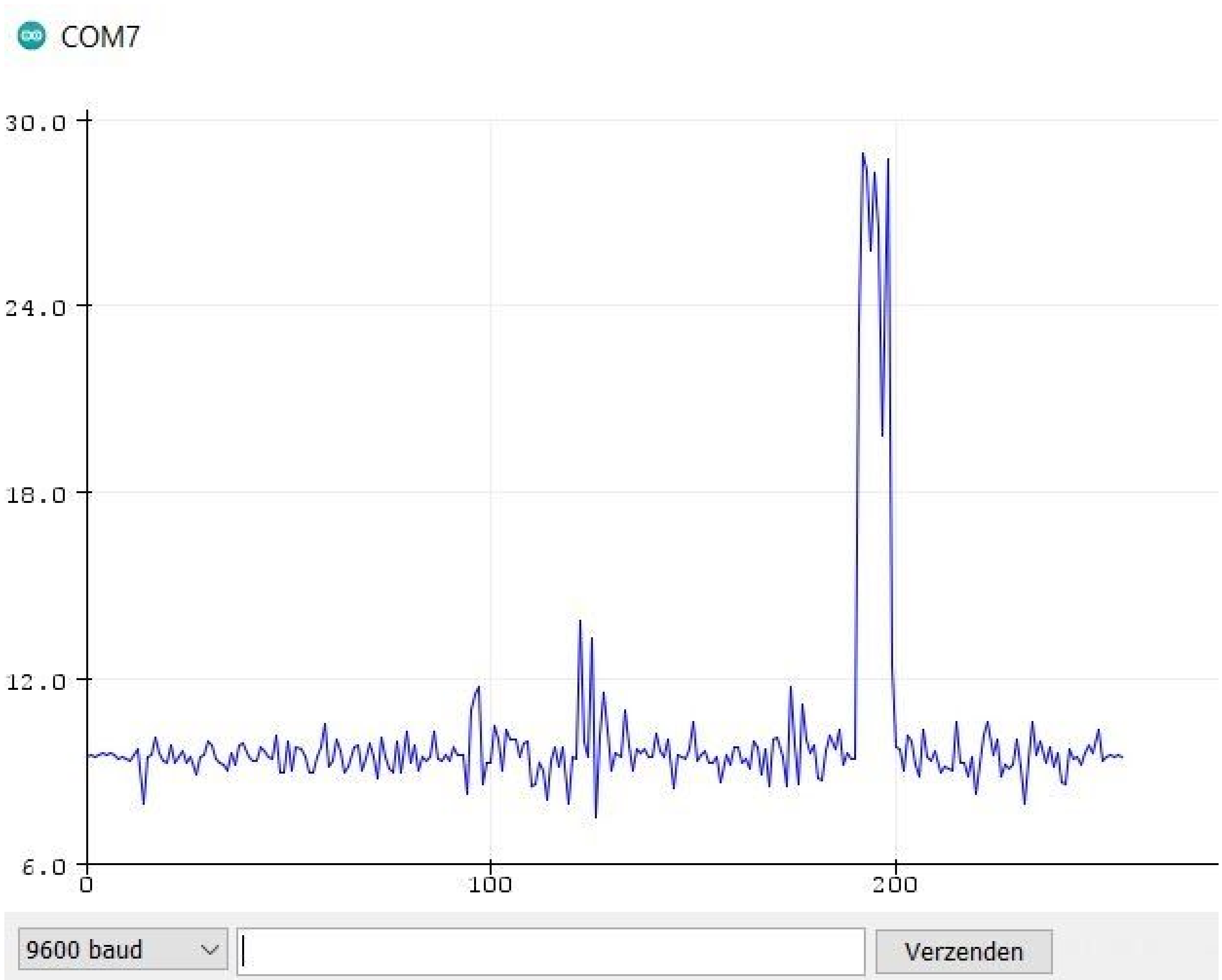


Figure 8: The activity of the accelerometer simulated to imitate a rough ride followed by a crash (acceleration almost 2G).

Additionally, a graph showing the acceleration when when hitting the accelerometer with different force, mimicking different impacts.

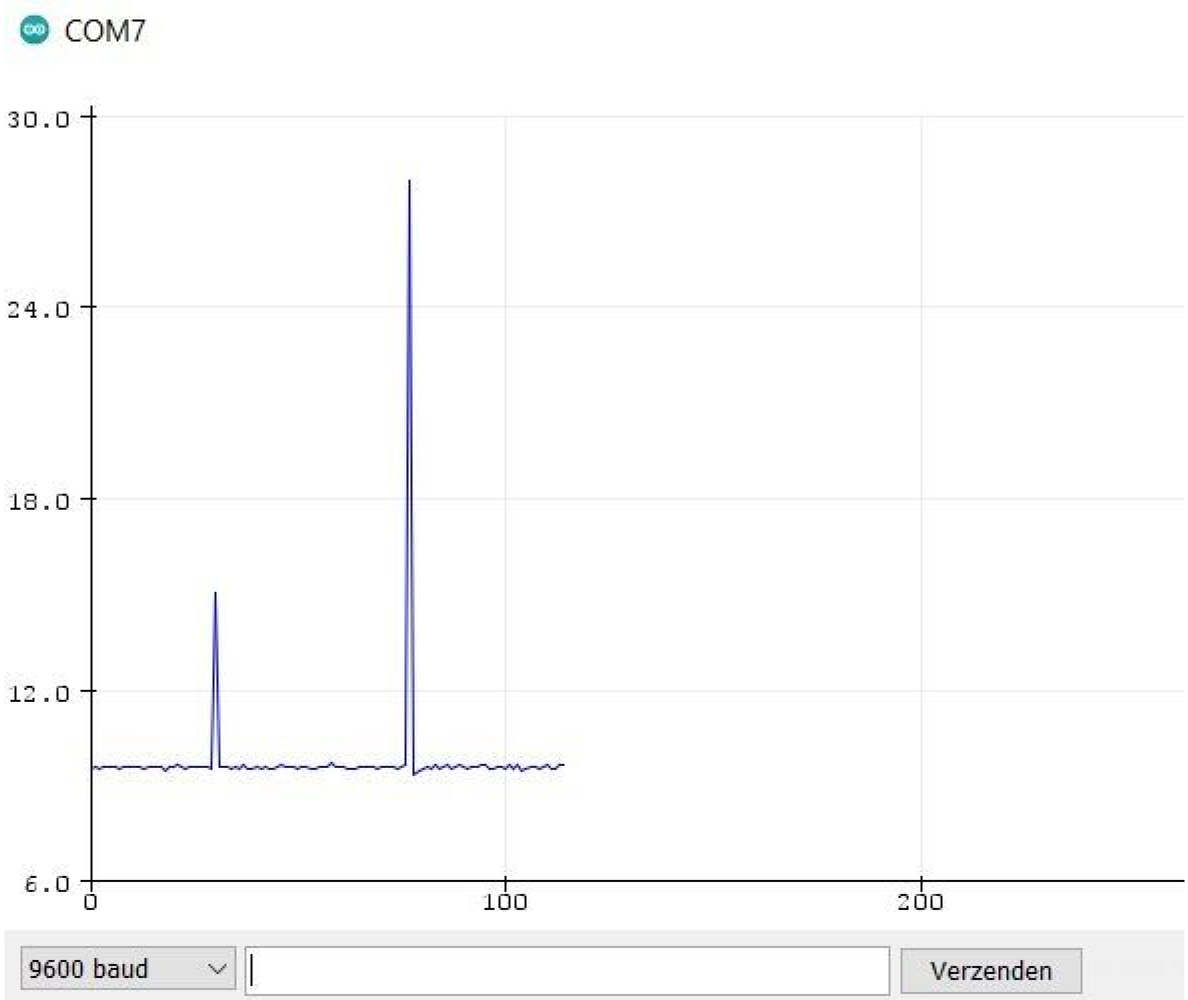


Figure 9: Plot of acceleration after a soft and after a hard impact.

Findings/conclusions

Looking back on this project, a functional prototype of the Smart Safety Helmet has been designed and created. As a group, some of the findings encountered in this project are that locating victims is still a big challenge in many disasters. A solution that was designed for this problem is the Smart Safety Helmet. This design was made after looking into many different disasters and coming up with a variety of ideas to simplify and speed up the process of locating victims. The end design has a combination of features that have been mentioned throughout this report. Our findings as a group are that an easy and relatively simple helmet could be deployed among mountain bikers to improve the locating of victims. This helmet could also be deployed among other dangerous sports. This design could save lives in a relatively easy manner. Many people that practice dangerous sports already wear helmets. Upgrading these helmets to the designed Smart Safety Helmet could have an enormous impact on helping rescue services locating victims.

Discussion:

Potential deployment/use, feasibility, scalability
The Smart Safety Helmet could be potentially introduced on a large scale. However, the prototype would need some improvements. The Smart Safety Helmet could be used in several dangerous sports and situations. For it to be used in all these different situations It would need different limitations of g values. If this project was to be developed further, a switch or something alike could be introduced to switch between different values and thus sports. If the Smart Safety Helmet is to be used as a motor helmet, the limit for the acceleration (g-force) might already be exceeded whenever one is accelerating on the highway, which is of course not a crash and thus no emergency signal needs to be sent. Therefore, the g value should be higher for a motor sport.

Just for prototyping and convenience, the helmet is connected via a USB cable to a laptop. For this helmet to actually be used that is of course not possible. Therefore, a few changes need to be made. A possible implementation would be an Arduino GSM Shield. This shield can be equipped with a SIM-card and consequently make a connection to the mobile network. Data transmission would as a result of this go by means of this mobile internet connection instead of over a USB cable. This way it is possible to get rid of Processing and serial data communication and actually develop an application expanding this emergency services. An external battery is also needed, if the arduino isn't connected to the computer.

Another important part of this project and most definitely of this discussion is recognizing an emergency. In this project only a crash has been considered as a reason to initiate emergency communication. However, what is really important here is that the underlying problem was inability to access communication and that just a crash does not mean someone is unable to e.g. make a phone call. If someone is actually unconscious, then this automatic sending of an emergency signal is useful. Therefore, more attention could be given to actually understand when someone is unconscious. One possible addition could for example be to also look at the blood pressure and heart rate and this combined with the data output from the accelerometer to determine if someone is actually unconscious and thus send an emergency signal.

We use GPS to track the location of the victim. A downside of GPS is that the environmental circumstances need to be good in order for the location to be reliable. The GPS will therefore, not always word accurately. This is of course a problem, as the helmet should be working perfect, also in, for example, bad weather circumstances. However, GPS is the best option, as internet connection isn't always and everywhere accessible either.

Because the GPS sometimes will not be perfectly reliable, it would be nice to have the buzzer react to rescue workers, when they are nearby. In the current design, the helmet starts buzzing, as soon as the helmet is activated. This could make the victim go crazy and it would, thus be better for the helmet to only make sound, once the rescue workers are nearby. This is something that could be improved, if the helmet would be further developed.

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