CERN IdeaSquare Progress Report Team 3

Design process and milestones for H-Cube applications

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Table of Contents

1. Introduction

Team 3, SM!RK consists of five individuals, students at the universities in Delft, Rotterdam and Amsterdam, that have participated in the course UD1056 (CERN HPD Summer Course). The five members of the team are Subramanian Ramasubramanian, Mark Schuttelaars, Iulia-Maria Aldea, Raven Timmer, and Kirsten van der Ham. Team 3 was tasked with analyzing the possible applications of H-Cube, a terahertz scanner developed at CERN.

This report aims to document the actions and decisions taken, noting the milestones in the design thinking process. To this end, the report provides insight into the analysis of the technology, the ideation activities, the solution found and its market and impact analysis.

2. Team Composition

2.1. Individual Introductions

Subramanian Ramasubramanian

I am an Indian-origin Norwegian BSc Aerospace Engineering student at TU Delft currently entering my third year of studies. My background is mainly focused on the aerospace sector, but I share a sense of curiosity for other fields of science and engineering as well - This autumn semester, I will be doing a robotics minor at ETH Zurich. Being part of a highly technical degree like aerospace, I felt the need to explore how technological advancement can be used for the betterment of society. In this context, I believe that the CERN IdeaSquare Summer School, as part of my interfaculty courses for my honors bachelor's degree, presents an excellent opportunity to gain insights into the innovation process. My fascination for the CERN institute also plays a central role in my excitement to participate in a project like this. I am eager to bring a strong sense of team spirit and energy to contribute to the success of my team!

Aldea Iulia-Maria

I am a Romanian student following the Computer Science and Engineering Bachelor at TU Delft. I am entering my third year, where besides deepening my knowledge in Computer Science, I will follow the Biomedical Engineering Minor, where I will further explore how technology can improve healthcare.

In addition to my studies, I love to read and immerse myself in different worlds through books. I also have a passion for creative writing. I enjoy crafting stories and exploring new ideas through words. It's a fantastic way to express myself and think outside the box, which I believe is crucial in both literature and technology.

The CERN IdeaSquare Summer School was a way for me to explore a different aspect of technology, namely its societal impact. By making a product pitch and a prototype, a technology can further be developed into a startup and shipped to market to prove its usefulness. Through this summer school, I learned to keep an open mind and to find general-use applications for cutting-edge technologies. I enjoyed talking and brainstorming with people from different backgrounds. This course provided an open challenge to innovate, and I was thrilled to answer it as part of an amazing team.

Kirsten van der Ham

Hello, I am Kirsten van der Ham, I am a master student at Strategic Entrepreneurship of Erasmus University Rotterdam, and I did my bachelor in Industrial Design Engineering at

TU Delft. In my personal life, I like to dance, make art and read. Besides my studies, I have spent time during a board year of the VerenigingsRaad Delft, working on relations between student associations, TU Delft, Gemeente Delft and the National LkvV level. Currently, I help out at a sustainable fashion store named the Swapshop as a model and substitute worker and I started as a professional mixed media artist. I chose this program because it was the perfect blend of my previous studies, and I thought it would be a great opportunity to learn and make new connections.

Raven Timmer

Hello, my name is Raven Timmer. I am a second year Computer Science student from the University of Amsterdam, before which I also completed a year of Political Science. The contrast between these two fields reflects my broad interests, particularly in understanding how things work, and why it might be (un-)successful. This semester I will be going on an exchange to the University of Toronto, where, to broaden my academic skills, I will only be following courses that have no overlap with my current study.

Besides my studies I work as a teaching assistant for which I teach classes in multiple first year courses and am a tutor for a group of about 15 first-year students. In my free time, I play tennis, work on some projects, and am a member of the acquisition committee withing my study association VIA.

For me, the CERN summer course was exciting because I would be able to work on a problem together with some of the smartest students from a wide range of studies. This in combination with learning how to go from a technology to something that can be applied in the real world, sparked great enthusiasm in me. Looking back at this I am happy that this enthusiasm was not misplaced, and I believe that this team was able to put out a great final product.

Mark Schuttelaars

My name is Mark Schuttelaars, a Dutch second year nanobiology student at the TU Delft. For the past two years I have been focused on understanding and predicting the core cellular mechanisms that are so important to life. While I greatly enjoy my studies, I am actively trying to explore other areas of research. For example, this semester I am going on exchange to the National University of Singapore to explore various subjects and the different cultures of South-East Asia.

Outside of academia I enjoy playing the piano and sports. Since I started studying in Delft, I have joined the volleyball association D.S.V.V. Punch. Joining the association not only allowed me to practice and play volleyball all over the country, but also facilitated

connecting with people from different faculties within the university and even students from outside of TU Delft.

These are also the reasons why I was excited for and enjoyed the CERN HPD summer course a lot. During the summer school I was exposed to a new field of study: entrepreneurship. I was keen to learn how novel technologies, which in my bachelor I am thought to develop, can be used to have an enormous, everyday impact on the lives of many people. Additionally, I enjoyed the challenge of trying to explain and make low-tech prototypes to explain difficult concepts to people. However, the most rewarding aspect of the course was working together with an interdisciplinary team with people from three different universities. I felt that our different academic backgrounds complemented each other well, resulting in a final product that I am proud of.

2.2. Code of conduct

In order to have a smooth collaboration within the team, a set of common rules was established at the beginning of the UD1056 course. As such, the following code of conduct aims to encourage open communication and facilitate a work environment where fun and responsibilities intertwine.

- When a person talks, everybody listens.
- All opinions are taken into consideration.
- Everyone is responsible for ensuring that the deliverables are finished on time.
- Ask for help if needed.

3. Innovation Process, Choices, and Milestones

This section introduces the innovation process and its steps, highlighting the important choices that were made. Additionally, it will note the milestones that have contributed to the final design.

3.1. Overview of the process

Having been assigned the technology H-Cube, the team's aim was to come up with an innovative and useful application for it. To this end, the course was split into three phases: the initial meetings in Delft, the design sprint in Delft and Amsterdam, and the Summer School in Geneva. The Design Thinking Framework was applied during the process. As such, the first step was understanding the technology followed by finding opportunity fields.

During the initial meetings in Delft, first contact with the person responsible for the technology was made. This meeting served to clarify details about the technology, as well as figure the state of development, feasibility concerns, and the original creator's future plans. By doing so, we have gained information both about the specifics of the technology as well as the current state of the market. During this time an important milestone was reached as well: the technologies "We know how to…", an efficient way of describing a technology in layman's terms. The core idea behind H-Cube is the ability to see light not visible to the human eye. To be more precise it is able to see light within the THz spectrum.

With proper knowledge of the technology, we moved on to the next step and explored domains where our technology might prove useful. The individual analysis of the domains, as well as the establishment of more concrete zones of impact were done during the Three-Day Design Sprint.

The final stage of the ideation process took place in Geneva at CERN IdeaSquare, where an in-depth analysis of eight applications was made. Experts were contacted and the value and impact of three chosen applications were established. Value propositions for each application were made, and at the end of this process, one technology was chosen to be prototyped.

3.2. Technology Unbundling

The first step of the process was understanding the technology. To do this, the team has contacted the developer of H-Cube as well as other experts in the domain of Terahertz sensing. After understanding the technology, we also met with companies who work in industries that currently use terahertz technology. This was to gain insight into the unique characteristics of terahertz technology and understand the market gap that it addresses.

On the technology card, the h-cube is explained as hyperspectral imaging in the terahertz (THz) region of the electromagnetic spectrum using a micromechanical bolometer array for terahertz imaging.

This way of explaining this technology is very challenging to deconstruct and understand. Instead, a more understandable expression can be formulated using simpler words which allows for a more accessible idea of the technology. H-cube technology can turn a certain type of light into images by use of heat/movement into electrical signals. In other words, the technology at its core is a scanner or camera that works in the THz spectrum.

By talking to experts, we gained more insight on some specific aspects of terahertz technology. The reason why terahertz frequencies have not been used commonly as of now, is that it has been historically really hard to emit and detect. H-cube is cheaper by 1 or 2 order of magnitude with the current technology in practical use. Moreover, terahertz has required special conditions for detection and emission, like cryogenic temperatures that is required for certain methods. H-cube represents the first terahertz sensing technology able to operate regardless of temperature. Furthermore, h-cube also provides the possibility to implement the scanner on a portable device. This means that it is lighter and less power-intensive than existing technology.

It is also important to identify the characteristics of terahertz that set it apart from other parts of the electromagnetic spectrum. Terahertz is non-ionizing as opposed to X-rays for example. It can also detect polar molecules, which gives terahertz a lot of interesting applications. For example, water is a polar molecule which means that terahertz can detect water. While it can detect polar molecules, it is also absorbed by these molecules, which means that it cannot penetrate a thick layer of these molecules. Terahertz can also not pass through thicker layers of metals. We also found out that a lot of materials have unique fingerprints in this frequency range, which allows us to accurately identify them.

In the end, some of the experts we talked to also suggested some examples of applications that utilize these qualities. For example, as terahertz allows us to see through materials, it is used in airport scanners. It is also used in the maritime industry to inspect paint layers and as a form of non-destructive testing for quality control. Non-ionizing medical imaging, for example in dentistry and also scanning for vulnerable groups such as pregnant women and infants.

This shows how we unbundled the h-cube technology to give the foundation for the rest of the project. This step can be summarized by reformulating the we-know-how-to in a technology level, application level, and industry level.

On a technological level, we know how to observe a specific non-destructive low-energy radiation range. An example of an application-level formulation would be we know how

to observe through layers of materials, which exploits one of the advantages of h-cube terahertz technology. On an industry level, we can give the example from the maritime industry, where we know how to see through the ship hull and non-destructively inspect the paint thickness. In this manner, we formulated numerous we know how to on the application and industry levels to identify the applications that would utilize the advantages of h-cube in the best possible manner.

3.3. Domain Exploration

Once we properly understood and considered the strengths and weaknesses of our technology, we were ready to search for domains where we could make an impact. Our first task was to identify a hundred different domains where we thought the h-cube could be a significant innovation. What was so interesting about this exercise was that the selection of the first 50 domains was relatively straightforward, while the last 25 domains required creativity and imagination to come up with. After identifying 100 domains, we grouped the domains together and highlighted the industries that we thought would be the most impactful and interesting for further exploration (Figure 1).

Figure 1: 100 different domains where the h-cube could have an impact

Out of these 100 domains we chose 10 domains that we thought were the most promising. This was the first time we tried to quantify the impact of our ideas. We found this quite a sobering task as it showed that the ideas that we found most promising were often already being researched or there were better alternatives to a terahertz scanner. Still, this exercise gave valuable insight into how we should alter our ideation process to

find original applications for the h-cube. In Figure 2 our subdomains can be seen. What is interesting is that none of these domains we chose initially were in the final top five applications for our technology.

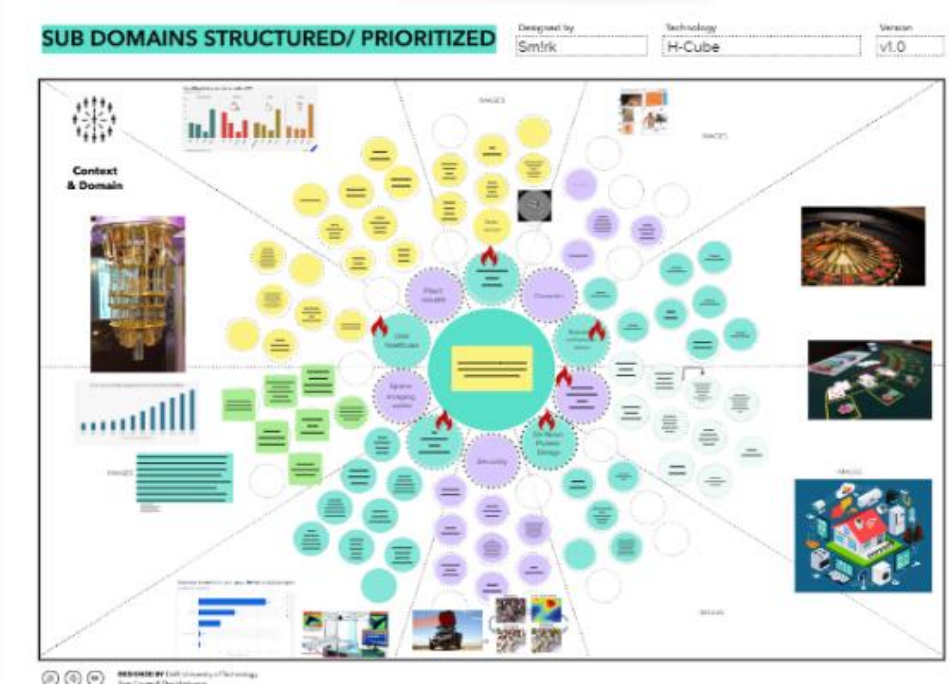

Figure 2: The 10 most promising applications researched

After more research, we discovered that we had mostly come up with more or less standard applications that were already being developed. We found this quite surprising as we had listed 100 applications. To get more creative ideas each member of the team chose a science fiction book or movie and investigated where the h-cube could be utilized in these stories. In Figure 3 an example of ideas gotten from these science fiction stories is shown. We thought it was intriguing that an idea from such an unorthodox thought experiment was almost our final application. In retrospect, we realized these exercises lead to truly innovative ideas.

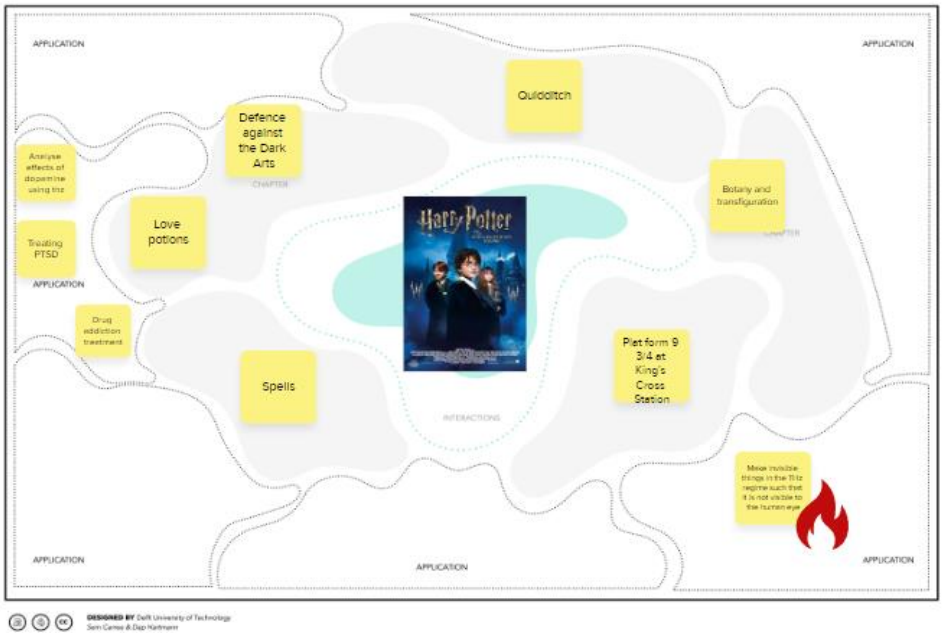

Figure 3: Applications where H-Cube could have an impact in Harry Potter

During the design sprint we were also challenged with approaching the project from a completely different angle. We were introduced to the sustainable development goals (SDGs). The SGDs are a set of 17 goals set by the UN that they aim to complete before 2030. These goals include things such as zero hunger and gender equality. We investigated how our technology could contribute to the different SGDs. This was a second way of finding application, not the usual looking for problems that fit our solution, but investigating how our solutions fit in a very broad project. During the search for how we can contribute to the SDGs we got a better understanding of exactly where we could make a difference and made a start to quantifying the impact we could make. In Figure 4 our impact on the infrastructure SDG is shown. This part of the mural gave us the inspiration to develop one of our most impactful applications: inspection of the quality of wood.

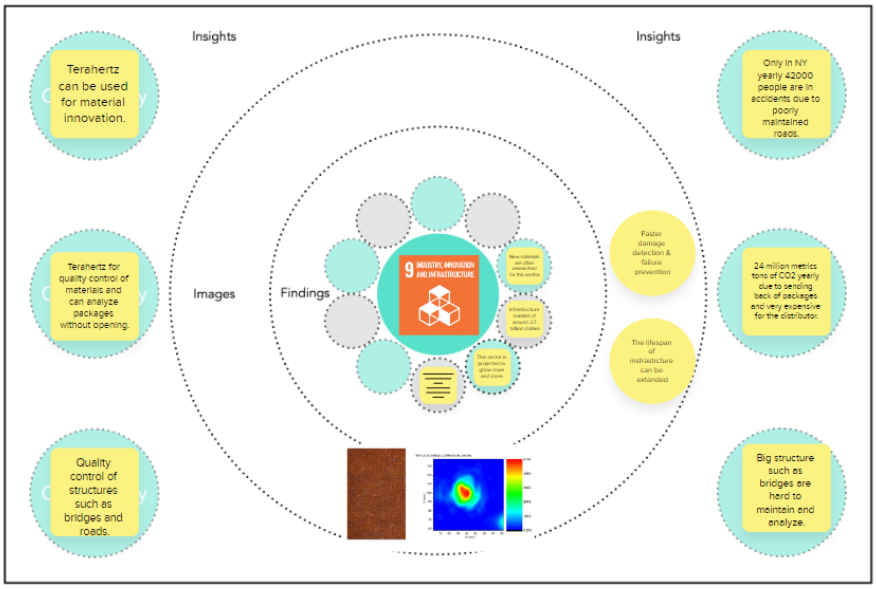

Figure 4: Places where H-Cube can make an impact in industry innovation and infrastructure SDG

After doing a deep dive into our applications we chose to zoom out again and look at the urgency and importance of our 100 applications. The importance of this exercise is clear: it indicates whether we were developing the right ideas and whether we missed any important applications. In Figure 5, the ranking of our applications is shown. On the x-axis, the importance of the application is shown, while on the y-axis the urgency. It is interesting to note that the ideas show a tendency to have a positive linear correlation. This is due to the fact that even though importance and urgency are two distinct concepts, they often appear together. We also noticed that most of the applications that are both important and urgent that we came up with in the original 100 applications were already being researched or had great alternative technologies.

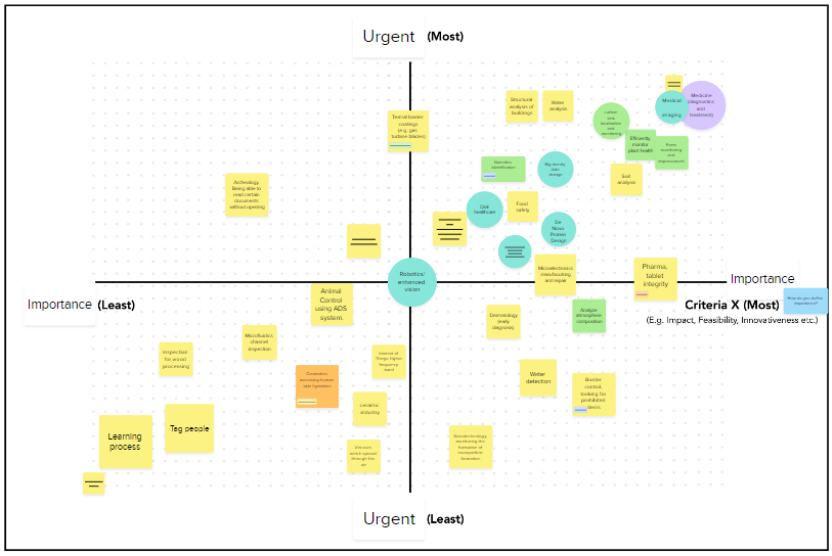

Figure 5: Applications ranked on urgency and importance

3.4. Domain Selection

Once a lot of domains were found where the h-cube could be applied, we had to converge and isolate the most promising and innovative ideas. This isolation of the most interesting applications can be characterized best eliminating applications rather than the choosing of certain applications. The process was also iterative: first 5 applications were left and later on we eliminated ideas until we had only one left.

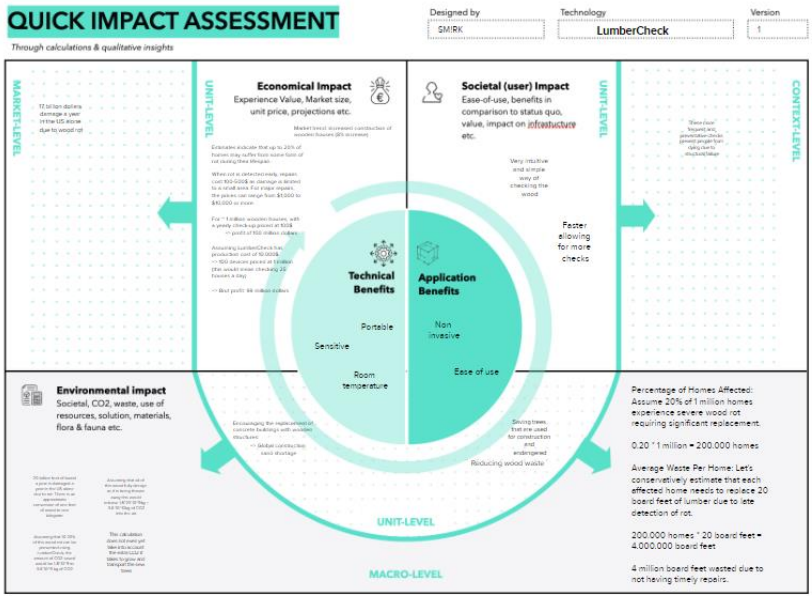

Figure 6: An impact calculation for LumberCheck

The team used various exercises to help in the classification of applications.. Some of these exercises were provided by our lecturers, Sem and Dap, however we also came up with some of our own ways to rank our ideas. Examples of the exercises provided were the back of the envelope impact calculations, which Pablo had provided us with a lecture on. An example of such calculations is shown in Figure 6. These exercises, together with talking to professionals, guided us to our final 3 applications.

4. Clearly defined problem

4.1. H-Cube applied in the lumber industry

In the search for a solution to combat the high amount of carbon released into the atmosphere during concrete production, more wood in our buildings has been mentioned more than once. By using wood instead of concrete there is not only the benefit of the extremely low carbon footprint, but also the fact that naturally grown wood absorbs carbon out of the atmosphere, which would thus be stored in any building that might be made from it.

One of the major pains in this industry is the fact that the detection of mold and other defects withing wooden structures is too hard or expensive to detect. Using current methods, wooden structures often need to be torn open to insert electrodes that can measure moisture that is normally associated with mold. Depending on the location of the check, this could mean boring a hole into a beam or removing parts of a wall or roof which would need to be rebuilt after. Because these operations can often become too expensive or cumbersome to perform, only 20% of wooden buildings inside of the United States are regularly checked. This results in many preventable cases of mold, growing to larger problems which take more to remove, or in extreme cases cause the closure of the property.

4.2. H-Cube applied for mine detection

There are 110 million unexploded mines in the ground worldwide. Each year around 100 thousand are removed, while 2 million more are planted. These mines lead to significant damages: 15,000–20,000 people (about the seating capacity of Madison Square Garden) every year are maimed or killed. Out of these 80% are civilians, the most affected being children. In addition to their obvious danger of exploding, buried unexploded ordinance can also cause environmental contamination, as the chemicals used may enter soil and water and thus prevent agrarian uses.

The way in which mines are removed has not seen significant changes since the second world war. This means that mines are most often removed using metal detectors and shovels. Because mines are often located in regions where labor rules are not strictly enforced, the usage of kids in the clearing of the mines is widespread.

4.3. H-Cube applied in the prostheses industry

Each year over 1 million people (about the population of Birmingham) have limbs amputated. Out of these people about 70% suffer from phantom limb pain. To combat this, patients often undergo long and complicated therapies which take a long time and cost a lot of money, while also limiting a patient in their working life.

5. Impact and Market Exploration

In order to choose an appropriate application for the selected domains of interest, we have investigated both the market as well as the societal impact our technology would have. The market investigation consisted of numerous discussions with both specialists in the fields as well as businesses or associations known for their interest in specific domains.

The aforementioned impact and market research was conducted for three applications of the technology:

- LumberCheck: a handheld device for timely inspection of wooden structures
    - Inspections accounted for mold, humidity and damage due to termites.
- MineSafe: a drone operated high accuracy mine localization device
    - The MineSafe sensor was able to identify both plastic and metal mines buried shallowly in the ground
- TeraFeel: a medical device meant for gland stimulation using THz radiation in order to relieve phantom pains caused by limb loss.
    - Application was extended into stimulating gland secretion of hormones in order to combat their deficiency.

Each of the above applications targeted a specific market and was meant to relieve different pains. Due to differences in customer base size, as well as target customer group and their financial abilities, the applications presented different advantages and disadvantages.

5.1. LumberCheck – inspection of wooden structures

Increasing interest in using wood as a universal construction material (Almusaed & Almssad, 2022), has made an already profitable industry even more profitable. LumberCheck aims to solve one known "pain" of this industry: namely the timely and non-destructive detection of defects in wooden planks.

Current mold detections work by investigating the suspected plank of wood by sticking electrodes in the plank and measuring moisture content in the plank by measuring the electrical resistance of the plank. This process is highly invasive - the wall covering the plank has to be removed to facilitate testing and the plank itself also suffers damage from the process. This is why only 20% of wooden houses that should be checked for mold in the United States are actually checked for mold. Aside from that, most checks are only conducted once wood looks moldy from the exterior, meaning that both the structural soundness of the house is threatened, and health concerns are raised due to exposure to mold. Mold removal prices increase exponentially as well.

A small mold infestation can cost as little as $500–$1,000 to remove, but professional mediation for large problems can cost up to $30,000. As such, with early detection using LumberCheck, we expect a decrease in homeowners' costs by a factor of 30.

Taking the above into account, as well as the increase of wood in construction, we reason that the implementation of proper mold and decay early detection, will not only decrease homeowner costs, but early damages detection would lay the foundations to a society where wood replaces cement.

If only 2.5-5% of concrete buildings will be replaced by wood yearly and taking into consideration that 3.24 billion tons of CO_2 emissions from concrete in 2019, this means that the amount of CO_2 saved would be 0.081-0.162 tons of CO_2. To put matters into perspective around 5% of worldwide emissions are due to concrete, thus building with wood under the assumption above would save around 0.125-0.25% of worldwide emissions.

5.2. MineSafe – mine localization device

While the Anti-Personnel Mine Ban was signed in 1997, mines still continue to be a problem, long after conflict in that specific region has ended. Mines lead to significant damages: 15,000–20,000 people every year are maimed or killed. Out of these 80% are civilians with children, the most affected age group.

In addition to their obvious danger of exploding, buried unexploded ordinance can also cause environmental contamination, as the chemicals used may enter soil and water and thus prevent agrarian uses. A world map presenting the mine-contaminated areas can be seen in Figure 7.

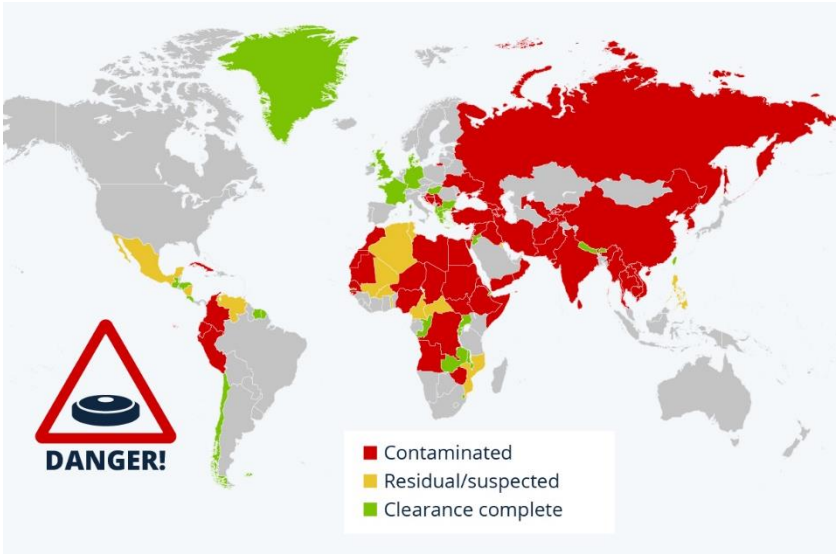

Figure 7: Global landmine contamination status in 2022

It is estimated that there are 110 million land mines in the ground in 2024. An equal amount is in stockpiles waiting to be planted or destroyed. Until recently, about 100 000 mines were being removed, and about two million more were planted each year. This means, that using current mine detection and removal methods, it is expected that it would take 1100 years to remove all of them. Following this, we investigated how the use of our technology MineSafe would help these efforts.

Figure 8: Comparison between the time taken to find mines by human teams and with trained rats

Plastic mines buried shallowly are notoriously hard to detect, and unfortunately just as deadly as the day they were first placed. Figure 8 presents the time it takes to identify all mines within a football field, using current methods of detection, namely human crews, and trained rats. Even taking the significantly lower amount of time it takes to find all mines trained rats take compared to human crews, MineSafe reduces that time significantly, as can be seen in Figure 9.

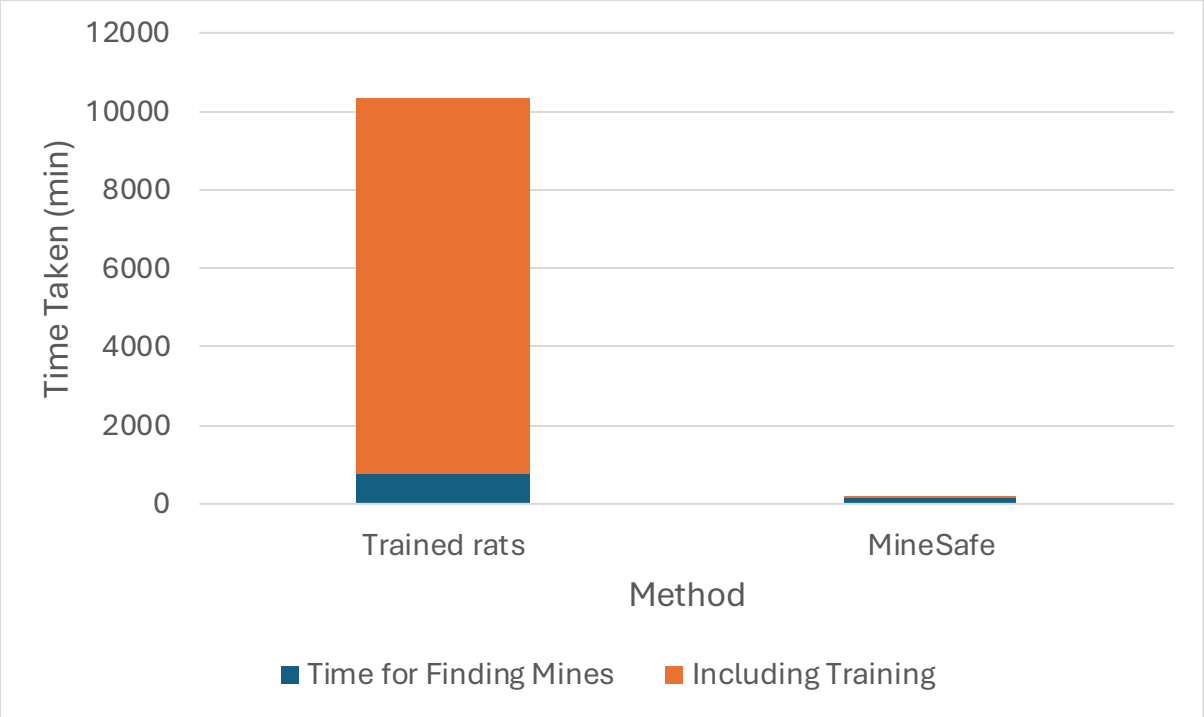

Figure 9: Comparison between the time taken to find mines with trained rats and with MineSafe technology

To summarize, MineSafe removes the risk lives are exposed to during the mine detection process and reduces the time spent by a factor of 500.

5.3. TeraFeel – phantom pain relief

As THz radiation is non-ionizing, unlike X-Ray, it has various uses in the medical field. One such use, is related to prosthetics. With THz radiation it is possible to stimulate glands and improve blood flow, which could be a great help when relieving phantom pains, for example.

We have studied the impact of such a technology and found that worldwide, there are 500 million people missing limbs to some degree. Even if our technology could only help 1% of these people, it would still help 5 million people.

On the other hand, TeraFeel is far more versatile than just being used as phantom pain relief. Due to its unique properties, TeraFeel would be able to stimulate glands to produce hormones. According to the World Health Organization, 1 in 4,000 to 1 in 10,000 children suffer from Growth Hormone deficiency. This would represent 220,000 children globally, a low estimate. Helping even only 10% would help ease the life of at least 20000 families.

6. Solution – motivation behind the chosen technology

Having defined three new applications for the h-cube, a choice had to be made for the final application. To decide we used the impact calculations, that were made in the previous paragraph, to 'score' our ideas. To summarize the impact that the applications would have: LumberCheck could potentially reduce the global CO2 output by 0.125-0.25%, while MineSafe could reduce the amount of time it takes to clear mines worldwide 500-fold and TeraFeel could improve the lives of numerous people and families all over the world.

However, to properly score our application we also had to investigate and score how the ideas impacted other areas of life and the SDGs. To quantify this, a matrix was made, with on the rows the applications and on the columns the metrics that we deemed important. Examples of these metrics are sustainability, marketability and impact.

Based on this matrix and the discussion with experts we chose MineSafe as our final application. The choice was made with a process of elimination. The first application that we eliminated was TeraFeel. While this application had the potential to have a huge positive impact on the lives of numerous people, we felt that this idea was too futuristic. The chances of this technology actually working as we imagined and there being no better technologies in the coming 30 odd years were very slim. Subsequently we eliminated LumberCheck. The reason for this was that while LumberCheck had great potential there were a lot of different technologies in use that were good enough. So, it was estimated that the actual impact of LumberCheck would be smaller than calculated because establishing the technology in the market would be very difficult.

This left us with MineSafe, which could save numerous civilian lives, open up huge swaths of land for agriculture and save the lives of deminers. Furthermore, terahertz technologies are especially well suited for this task as this frequency can penetrate ground and reflect off metal and plastics at certain wavelengths. What made the choice even more obvious was that there were very few technologies that have the same qualities and thus could compete with our MineSafe technology.

7. Individual Reflections

Subramanian Ramasubramanian

Initially, when I applied to this course, I was most excited about working in Geneva with top experts and scientists. However, after the first lecture, I realized that the program was aimed at utilizing state-of-the-art technologies for societal applications rather than scientific breakthroughs. This departure from a "scientific" framework to a more entrepreneurial one initially dampened my enthusiasm. Nevertheless, over the course of the program, I found new meaning and motivation in the value and applicability of the course. The program delved into several key topics, providing an overview of the entire design development process, ideation, assessing impact, and prototyping, among others. The creative environment at CERN IdeaSquare, combined with engaging interactions with academic and industrial experts, offered a mentally stimulating atmosphere.

The opportunity to work within CERN's facilities and interact with their staff was an enriching experience, where I honed invaluable skills like teamwork, public speaking, and strategic planning. These skills are crucial for my personal and professional growth, bridging the gap between being a good engineer and becoming an impactful entrepreneur capable of making a difference. The program's structure, while challenging, was incredibly rewarding and helped me see the broader impact of technology beyond pure science.

I must also say that I had an amazing time in Geneva, thanks to my teammates and fellow participants. We had numerous opportunities to interact, which allowed us to forge lasting friendships. Despite some areas for improvement, such as providing a clearer overall timeline of the program, the experience was immensely beneficial. The creative exchanges among committed students and the shared struggle to meet deadlines fostered a strong sense of camaraderie and pride in our efforts. I am grateful to have been part of this inspiring journey and believe it has significantly contributed to my growth as a professional.

Iulia-Maria Aldea

The CERN IdeaSquare Summer School was, as its name suggests, a place of innovation. I was initially surprised when we were asked to put aside our technical minds and instead look at cutting-edge technologies with curiosity and an entrepreneurial spirit. We were encouraged to look at the possibilities and I particularly enjoyed the exercises where we were asked to push the boundaries of what we thought was possible and explore uses for our technology inspired by science fiction movies.

As we searched for societal applications of cutting-edge technologies, we gained valuable insights into design thinking, impact calculations and the steps required to take an idea from proof of concept to business. It was exciting to brainstorm with people from different backgrounds and to build a prototype of our idea at the end of the process. Working within IdeaSquare and interacting with top scientists at CERN was a great experience and perhaps a bit of a challenge to our current way of thinking. I have enjoyed validating ideas with experts and gained or strengthened valuable skills in the process. Working on the six peas has given me valuable skills in public speaking, teamwork and time management, but perhaps what I find most useful is the ability to be concise and get to the heart of a technology, product or idea.

Of course, the CERN IdeaSquare Summer School experience would not be complete without all the people involved. The programme, while sometimes fast-paced, encouraged teamwork and collaboration. Communication was key, both when brainstorming and when working on the prototype. But the Geneva Summer School is more than these activities. We had time to bond and form friendships while exploring CERN or having fun by the lake.

Mark Schuttelaars

Long before I started university, I knew that I wanted to pursue a career in the hard sciences. I did not take any courses related to business or entrepreneurship, leaving me with a certain curiosity and, admittedly, skepticism towards this world. I had certain expectations going into the course as to what entrepreneurship entailed, but I quickly discovered that my picture of innovation was completely different from what is done in the industry. I had to switch off my technical mind and learn to think about what is possible, not only right now but also in the future.

One of the most challenging assignments of the course for me was the exploring of 100 different domains where our technology could be applied. This exercise forced me to use my fantasy, to search for problems that the h-cube could solve. This was especially challenging as during my studies I have always been thought to look for solutions to problems that come up. This exercise completely reversed my usual way of problem solving as we had a solution and had to find problems.

To validate the domains and applications we came up with it was vital to discuss our application with people that work in these domains. These discussions gave us critical insight as to whether we were on the right track with our applications or whether we had to go back to the drawing board. Initially, I was a bit apprehensive about cold-calling companies and speaking with experts without having a deep understanding of their fields. However, once I started calling, I noticed that I enjoyed talking with these people. I felt that the experts also enjoyed talking with us and sharing their experiences and input

on our applications. This aspect of the course was unique and insightful, as I would have never cold-called companies and people without taking this course.

The last few days of the course we had the opportunity to construct prototypes. I found this to be the most exciting aspect of the course. This part of the course challenged us in a variety of ways. Firstly, we had to come up with a prototype that we could make in one day, but which also gave the user or viewer insight into our application. Then we had to construct the prototype, which demanded both creativity and technical skill. Lastly, we had to present our prototypes in such a way that people could understand it at a first glance and could appreciate the importance of our application. Prototyping forced me to not only develop new skills, but also use the knowledge I have gained during my studies for a tangible product.

I enjoyed my time in Geneva, not only because of all the new skills I learned, but also because of my amazing team. I think that we had a great balance between having fun and being able to work hard and communicate. Furthermore, meeting all the other students, people from CERN and lecturers was what made the course truly memorable.

Kirsten van der Ham

Overall, I really enjoyed the experience. I learned communication skills, how valuable different minds are, more about government funded incubators and not to stress too much.

The five lectures before the design sprints were really enjoyable, with content relevant for creative, technical, and entrepreneurial people. I found it helpful to refresh my mind and learn new skills, such as making impact calculations to support arguments, rather than just discussing concepts without prior knowledge. I also appreciated learning about working with technical people and how our mindsets differ. This prompted me to be more assertive in communicating my preferences for how the group interacted. While I found it challenging to be the only one with a design background during the design exercises, I was overall very happy with my teammates and their response. The design sprint days were quite exhausting, but I thrived on the creative energy. I also greatly appreciated the input from the various experts, as well as the remote support from Ole, Pablo, and Catharina. Visiting the University of Amsterdam and Nikhef was a nice change of pace and environment.

The experience in Genève was really intensive in a way that I didn't expect it to be. Visiting CERN was really cool. However, I think the separation of work time and relaxation could have been better, but that may also be due to my own and my team's desire for optimal results. When waking up at 7 and coming home at 7, there is little room for relaxation, especially if you also want to explore the city. While it was intense, I think it is valuable to push oneself to get the most out of the experience. However, personally, I had a tight

deadline for my master's thesis two weeks after Geneva, and that was a bit too much, especially since I also got sick during the program. Overall, I'm really glad I did it, mainly because I formed great connections with the people there.

Raven Timmer

Coming into the CERN IdeaSquare Summer School, I was excited but also unsure of what to expect. My background is mostly in computer science and technical problem-solving, so I prepared for a program focused on scientific research. However, I quickly realized that this course was about much more than just technical innovation. It was about using a given technology to create societal impact. Initially, this change in focus was a bit unsettling, as I had to change my thinking from a purely technical perspective to one that focused entrepreneurship and the broader impact of a technology.

One of the most eye-opening exercises of the program was pushing myself to imagine what a technology could be, and to not get hung up about what a technology can do now. It became clear that, when talking to professionals within our field, this was something most people struggled with. It became easy for people to get stuck on things they knew could work, and not search for new, maybe even better, implementations.

Working together with a diverse group of students was a highlight to the program for me. It was fascinating to see how people from various backgrounds approached problems differently, bringing different perspectives that I would not have considered myself. This diversity became especially clear during our prototyping phase, where the mix of our different skills led to something I believe we can be proud of. Because of the tight deadlines, I was forced to make use of effective communication, and I believe that this led to great teamwork withing the group. In technical fields the importance of teamwork can often be overlooked, and I believe that this experience will be of immense value in my future career.

Despite the challenges, I left the program feeling inspired and motivated. I am grateful for the friendships I formed and the knowledge I gained, both of which I know will have a lasting impact on my personal and professional life. The CERN IdeaSquare Summer School was an amazing experience, and I am proud to have been part of such a great community.

A. Discussions with experts

Name	Position	Institute/Comp	Date	How valuable?	Talked to by	Notes
Leda	Unknown	Unknown	6/20/2024	★☆☆☆☆	Siddarth and Mark	
Patrizia	Researcher for the h-cube	University of Salerno	10/6/2024	★★★★☆	Siddarth, Kirsten, Iulia and Mark	We got a lot of general information and base knowledge from the talk
Claudia	Marketing specialist	Asteria business development	6/14/2024	★★★★☆	Whole team	We had a talk about what exactly was being done and what the problems are
Bickel	Student	Utrecht University	6/27/2024	★★☆☆☆	Mark	We discussed the technology and thought about some possible applications
Henk	Professor mathematics	TU Delft	1/7/2024	★★★☆☆	Mark	We discussed the technology and thought about some possible applications
Andrea	Professor electrical engineering	TU Delft	11/7/2024	★★★★★	Mark, Siddarth, Iulia, Raven	We discussed the limitations of terahertz, current research, what is feasible and discussed possible applications.
Mathias	Wood quality tester	Swedish woods	7/17/2024	★★★★★	Mark	We discussed whether terahertz scanning would be useful in the lumber industry and according to Mathias this was definitely the case and it was a big upgrade as to what is done now
Yuri	Student	TU Delft	7/20/2024	★☆☆☆☆	Iulia, Raven	Initial discussion - feedback on the mode of presentation. Response: enthusiastic about possible "healthier X-Ray"
Yannick	Ambulance background	Gerontspsychiatrie	7/21/2024	★★★★☆	Kirsten	Initial discussion possibility ambulance drug testing on scene. Very large pain
Ole Werner	Psychologist behavioural change	CERN IdeaSquare	7/21/2024	★★★★★	Whole group	Discussed how to go from 6 to 3 concepts, doing calculations to make decisions
Ralph	lieutenant-colonel	Army staff	7/21/2024	★★★★☆	Raven	We discussed military usage of the THz system, and pivoted to peace usages. Primarily mine finding.

Jeroen	Grape farmer	Vineyard Hesselink	7/21/2024	★★★★★	Kirsten	Discussing the possibility of grape quality checks with technology, result not useful no pains in taste test
Gijs	Student	TU Delft	6/15/2024	★☆☆☆☆	Kirsten	Discussing applications initial 100 applications
Pablo	ATTRACT coordinator	CERN IdeaSquare	7/21/2024	★★★★☆	Kirsten	Asked about experts in spectroscopy, got send 3 papers regarding the subject
Sem	Summerschool instructor	TU Delft		★★★★★	Whole group	Feedback on design journey
Dap	Summerschool instructor	TU Delft		★★★★★	Whole group	Feedback on we know how to statement
Dr. Rameshbabu	Quality Control Expert	DNV GL Maritime	6/7/2024	☆☆☆☆☆	Siddarth	Discussed existing applications in maritime and materials industry
Emiel	Software engineer	unknown	6/15/2024	★☆☆☆☆	Kirsten	Discussed potential applications
Silvester	Student	UvA	6/15/2024	★☆☆☆☆	Kirsten	Discussed potential applications
Pim	Chemist	Uva	7/22/2024	★★★★☆	Whole group	Talk about molecular applications and decided to look into Future applicability of spectroscopy
Jan	Summerschool coordinator	Nikhef	7/23/2024	★★★★★	Whole group	Talked about statements for 3 concepts and got feedback
Tamara	Prosthetics specialist	Gyromotics	7/23/2024	★★★★☆	Kirsten	There is a trend in decrease of funds for support of prosthetics from insurance companies
Katarina	CERN IdeaSquare Organizer	CERN IdeaSquare	7/21/2024	☆☆☆☆☆	Whole group	Discussed the methodology that we can use for the paper
Lauri	CIJ editor	CERN IdeaSquare		☆☆☆☆☆	Whole group	Discussed about how we can structure the paper and refine the research question
Johan	Branch manager	DERIX	4/7/2024	★★★★★	Mark	Discussed how the moisture of wood affects construction and what are the problems in the field.

Dr. Bruno Lopes Dos Santos	Professor in Aircraft Maintenance	TU Delft	6/7/2024	★★★☆☆	Siddarth	Discussed the need for fuel inspection using THz
Alfonso Medina Marrero	Student in Aerospace Engineering	TU Delft	6/21/2024	☆☆☆☆☆	Siddarth	Explained our technology and discussed potential application
Alex	Unknown	Unknown	6/15/2024	★☆☆☆☆	Iulia	Explained our technology and discussed potential applications: raised questions on marketability
Nico	Student	TU Delft	6/20/2024	★☆☆☆☆	Iulia	Explained our technology and discussed potential applications: Marine microorganisms research
Random	Insurance specialist	OHRA insurance company	7/23/2024	★★★☆☆	Kirsten	New contact for insurance trends
Random	Summer intern	CERN	7/23/2024	★★☆☆☆	Raven, Mark	Pitched the technology
Random	Summer intern	CERN	7/23/2024	★★☆☆☆	Raven, Mark	Pitched the technology
Random	Specialist	CERN	7/23/2024	★★☆☆☆	Raven, Mark	Pitched the technology
Random	Specialist	CERN	7/23/2024	★★☆☆☆	Raven, Mark	Pitched the technology
Oscar	Specialist	CERN	7/23/2024	★★★★☆	Iulia	Pitched the technology: discussion about LumberCheck; suggested awareness raising activities rather than feasibility concerns.
Ronald	Architect machines	ASML	7/23/2024	★★★☆☆	Kirsten	Input on technology concept choice
Bernice	Chief information officer	Vivent	7/23/2024	★★★☆☆	Kirsten	Input on technology concept choice
Celine	Student	Turkish high school	7/23/2024	★★★★☆	Siddarth	Pitched the technology and input technology concept choice
Random	Student	Turkish high school	7/23/2024	★★★☆☆	Siddarth	
Random	Student	Turkish high school	7/23/2024	★★★☆☆	Siddarth	

Random	Student	Turkish high school	7/23/2024	★★★☆☆	Siddarth	
Chandrakaanth Ramamurthy	Senior Business Consultant	Equinor	7/23/2024	★★☆☆☆	Siddarth	Input on technology concept choice
Poorna	Human Resources	Accenture	7/24/2024	★★★☆☆	Siddarth	Discussed landmine technology with terahertz and what he thought about our idea. We also discussed how to enrich our application.
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