Progress Report CERN Ideasquare Summer Course

Karel Aarts | Nicoleta Dobrica | Jesse van der Kooi | Anna Lewicki | Valter Somlai

Geneva, Switzerland

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Contents

1 Team and its members

The CERN Ideasquare summer school is based on multidisciplinary teamwork, where students with different educational backgrounds come together and innovate. The teams were created based on individual's personality types to form a harmonious environment for creativity and collaboration.

Figure 1: ThinkCube working together.

Our team is composed of five students: Anna Lewicki, Karel Aarts, Jesse van der Kooi, Nicoleta Dobrica, and Valter Somlai, pictured left to right in Figure 1. We chose our team name to be ThinkCube: a play on Ideasquare, with the logo seen in Figure 2.

Figure 2: ThinkCube logo.

As a team we chose to prioritize communication, creativity, trust, and adaptability. We found it important that everyone could freely share their ideas and be listened to by

other team members, trust one another with their assigned responsibilities, and respectfully give and accept criticism.

1.1 Background of team members

1.1.1 *Valter Somlai*

Valter is a third-year Aerospace Engineering student at the Aerospace Engineering faculty of Delft University of Technology. His liking towards rockets and a challenging experience led him to apply to this bachelor. Later in his studies, he developed a great passion towards the study of aerodynamics and decided to research this domain for his bachelor thesis. Besides his studies, Valter also enjoys participating in a variety of sports; such as badminton, hiking, cycling or padel; during his free time in Delft or when he is home in Spain. Joining this programme enabled him to learn about topics outside of his area of expertise and discover the world of business/innovation.

1.1.2 *Anna Lewicki*

Anna is a first-year master's student in Physics and Astronomy on the GRAPPA track at the University of Amsterdam and Vrije Universiteit. Their research focuses on early universe cosmology, gravitational waves, and dark matter. Their background in philosophy has beautifully complimented their scientific pursuits, encouraging them to think beyond the boundaries of their current research in astrophysics. They're deeply committed to making physics and astronomy more inclusive through extensive community outreach efforts. Beyond academia, Anna is a social justice activist, avid reader, nature lover, and enjoys creating art. Their interdisciplinary mindset has made the application of existing scientific technology to societal challenges particularly appealing to them.

1.1.3 *Karel Aarts*

Karel is a Erasmus University Rotterdam alumnus, having joined the CERN Ideasquare summer school right after graduating from the master Strategic Entrepreneurship. With a background in Industrial Design (BSc.) from the Eindhoven University of Technology, he is interested in combining Design Thinking methods, Strategic Thinking and entrepreneurial theory within the summer school. Besides his educational endeavours, Karel loves photography, being active and socializing with friends.

1.1.4 *Jesse van der Kooi*

Jesse is a third-year bachelor's student at the Applied Physics faculty at the TU Delft. He has always had a very large curiosity and always wants to know more about the inner workings of things. This quality led him to pursue physics and is a great motivator in his bachelor. He is very invested in his studies and is not planning to stop learning any time

soon. Next to his studies, Jesse is an active member of his Study association, taking part in various committees and attending most events. He is also a competitive volleyball player at the local student association. In the end, it was curiosity that drove Jesse to take part in this summer school at maybe the “center of curiosity”, CERN.

1.1.5 *Nicoleta Dobrica*

Nicoleta is a third-year Bachelor student at the Computer Science and Engineering faculty of TU Delft. She has shown an interest in programming from middle school, which she chose to put into practice through her study choice. During her high school years, she obtained awards at several international linguistics competitions, developing skills of logical reasoning and pattern analysis. These ended up perfectly suited to her choice of Honors research project, in the field of cryptography. In her free time, Nicoleta enjoys reading and watching movies. She has decided to join the summer school programme in the hopes of growing a network of acquaintances from different backgrounds and further expanding her entrepreneurial knowledge for the future.

2 Innovation process, choices, and milestones

The heart of the project was the innovation and ideation processes. Each team navigated through countless tasks based on creative power and were steered towards their completion with the help of lectures and imaginative exercises. Our entire journey started as diverging from a technology into multiple application domains, to then converge towards a singular, explicit application.

2.1 Technology unbundling and domain exploration

One of the first milestones in the program was selecting and familiarizing ourselves with our chosen technology. After the second lecture at TU Delft, when teams were formed, instructors provided descriptions of five technologies from the ATTRACT program. ThinkCube selected SNIFFIRDRONE, a drone-based odor monitoring system using advanced infrared chemical sensors for industrial plants.

Only basic information was provided through the technology card: its function, working principle, unique features, potential impact domains, and some imagery. However, the focus was on what the technology could achieve rather than its technical design. To deepen our understanding, we conducted additional research using online sources and consulted CERN IdeaSquare members. Each team had a contact person for accurate information; for us, it was Agustín Gutiérrez-Gálvez, associate professor at the University of Barcelona and researcher for this technology. After the lectures and the Design Sprint at TU Delft, we scheduled an online meeting with him to clarify the technology’s capabilities. We prepared a list of questions in advance, and during the meeting, he provided answers, shared additional materials like scientific papers, and resolved some uncertainties. Key insights included:

- The infrared sensor needs to be within 1m of the source.
- Similar applications have been explored, but always using the technology on a drone.
- The technology's main advantage is predicting smell intensity from a human perspective via Neural Networks.
- The current sensor sensitivity is around 5 ppm.

On the first day of the TU Delft Design Sprint, the SNIFFIRDRONE technology was "unbundled." The group summarized all the information and brainstormed to enhance understanding, supported by filling in the online canvas shown in Figure 3.

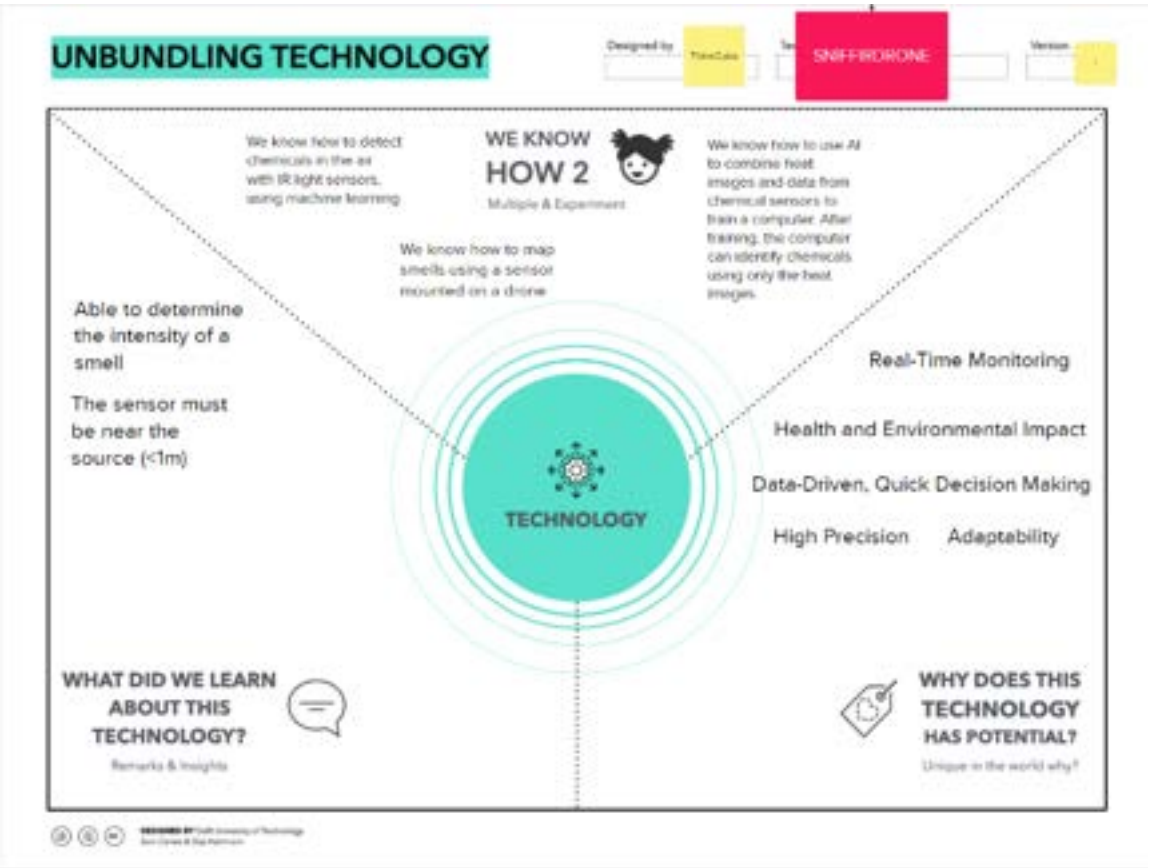

Figure 3: Mural canvas of unbundling technology includes interesting characteristics captured from the tech card and meeting with contact person.

Moreover, the unique features of the SNIFFIRDRONE technology were identified, including its ability to process data in real-time, its high precision, and its capability to predict the intensity of smells as perceived by humans. In the end, the group attempted to finish the sentence "We know how to...". After a couple of iterations, the final statement at the end of the Design Sprint was:

"We know how to see chemicals from a distance in real-time"

Due to our late meeting with our technology contact, our group was not able to completely grasp the technology. This is why the previous sentence contains “from a distance”, since at that point the group had thought that the infrared sensor had a longer range. A more correct sentence, after our meeting with our technology contact, would be:

"We know how to detect and predict the intensity of smells in real-time"

After understanding our technology and defining the first “we know how to”, the team had to come up with 100 possible domains of applicability, as well as possible sub-domains within these (see Figure 4). These domains were chosen based on where infrared detection of substances could be applied. Many of these would have used detection at a long distance, which turned out not to be viable, and some did not use a drone-based system. Some of these domain ideas came from talking to university personnel, family, friends, or connections. The overarching topics were climate and nature protection, tourism, water body monitoring, food and agriculture, beauty, petroleum industry, drug fighting, medicine, waste treatment, human protection, forensics, city planning, education, sports and miscellaneous.

Figure 4: 100 Domains and subdomains for the SNIFFIRDRONE technology

After identifying these domains, the teams were given six rounds of 5-minute sessions, with each member exploring one domain, resulting in 30 domain exploration sessions (see Figure 5).

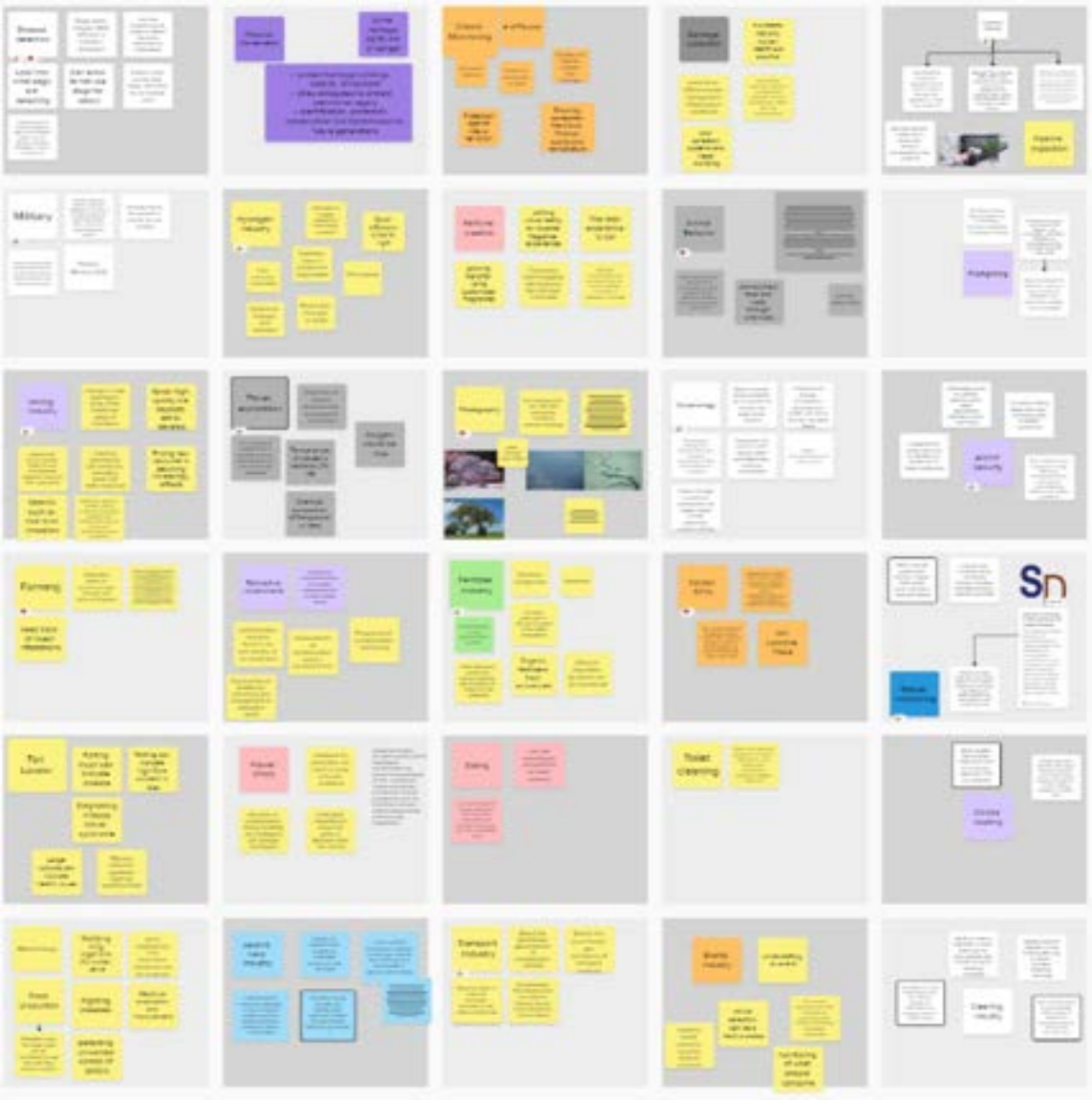

Figure 5: domain exploration result

During this domain exploration, the team looked at possible issues within those industries where our technology could assist in substance detection. Some examples are shown below:

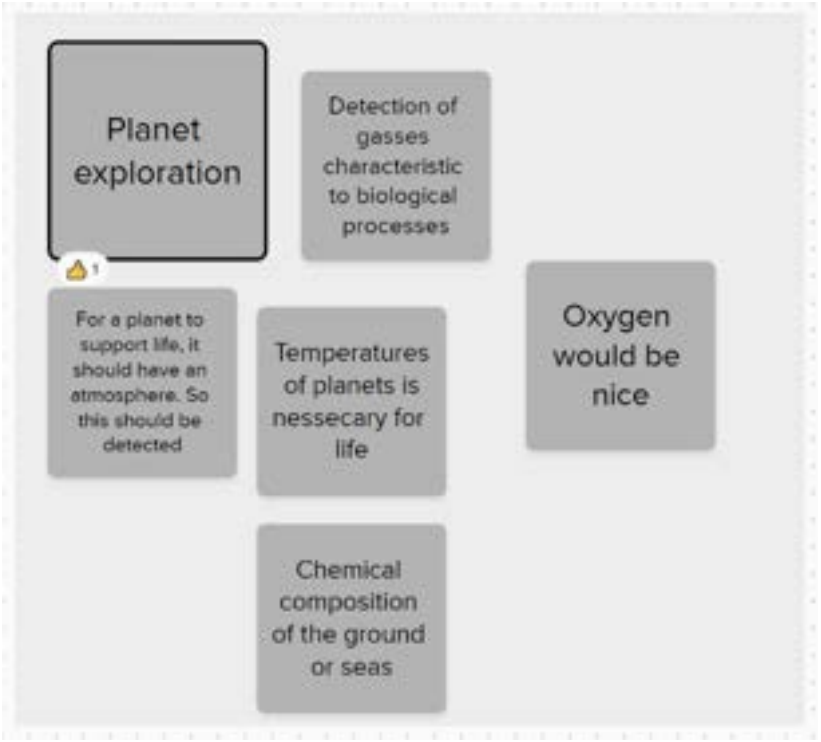

Figure 6: planet exploration domain exploration

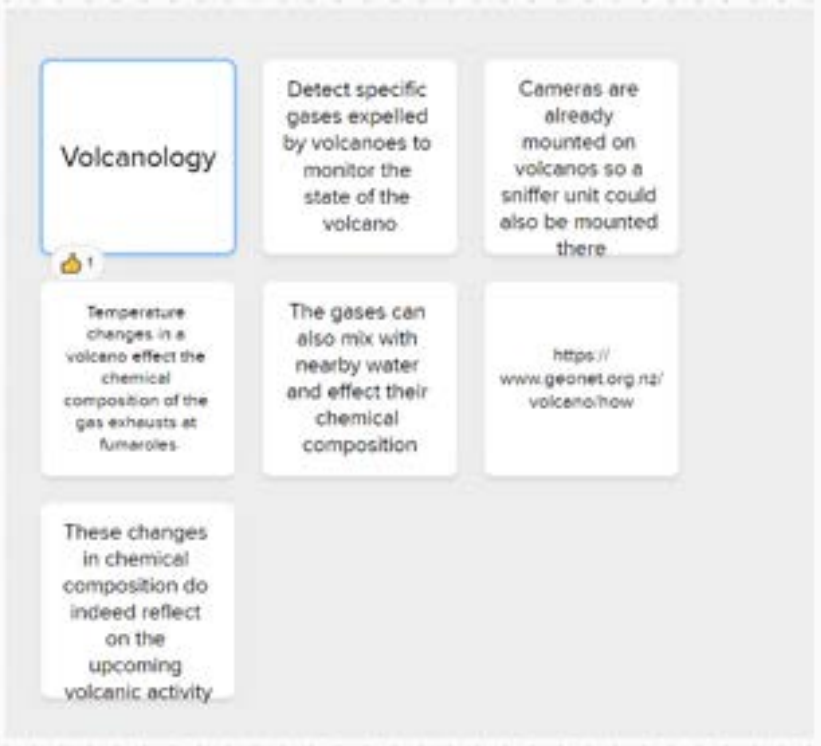

Figure 7: volcanology domain exploration

In a subsequent investigation session, the 10 most interesting subdomains were chosen by the team: military, mining, hydrogen industry, carbon sinks, animal behavior, fermentation industry, firefighting, life-guarding, glacier monitoring, and drug identification. Each of these domains were then explored with the help of the below canvas (Figure 8).

Figure 8: further domain exploration result

From these 10, the team selected 5 for further consideration. First, the hydrogen industry was highlighted due to its growing importance in the hydrogen economy and the significant safety and financial impacts of containment and leakage issues. Second, the mining industry showed potential for monitoring emissions during processing, gas levels in subterranean mines, or detecting mineral/gas deposits by identifying faint signatures. Third, with a focus on saving lives, the team looked at a military application for detecting dangerous substances after a chemical attack or on the battlefield. In relation to the climate, the firefighting industry was also noted for early fire detection and mapping chemical gas spread from fires. Finally, monitoring glaciers in polar regions was chosen; as they melt and crack, they release detectable gases that indicate their health and stability.

Additionally, for further inspiration, teams were encouraged to connect media content—like movies, video games, or novels—to their technologies. Examples included "Wall-E" and "Iron Man," which inspired ideas for soil or plant monitoring through

chemical signatures, atmospheric monitoring, autonomous system integration for drones, and nuclear plant monitoring.

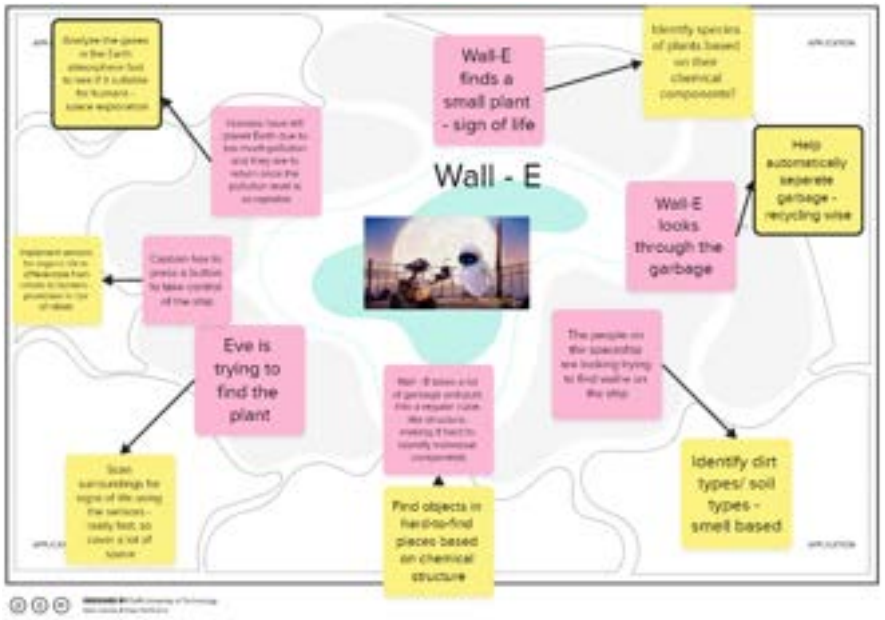

Figure 9: Wall-e inspired applications

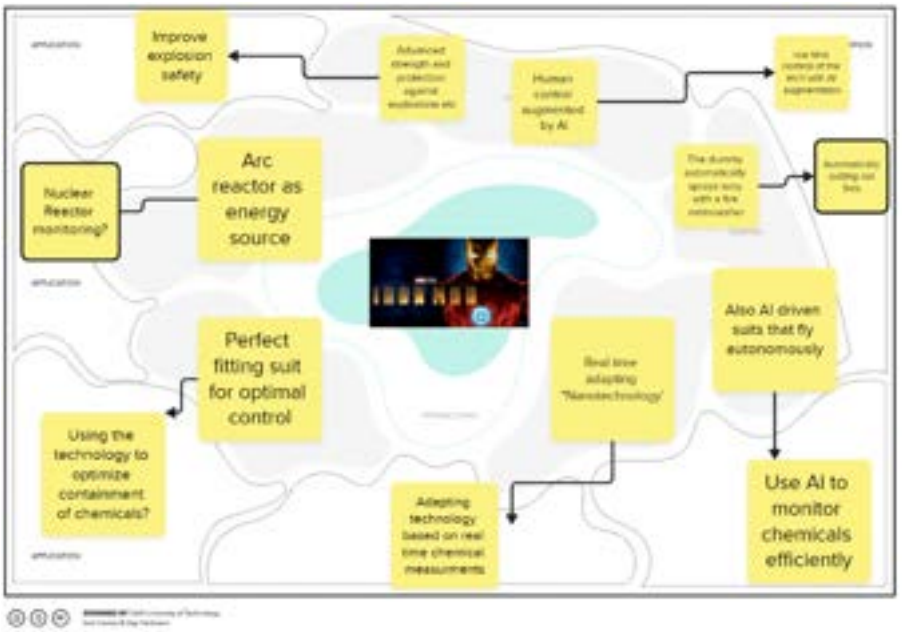

Figure 10: Iron Man inspired applications

On the second to last day of the Design Sprint, lectures about impact calculations and sustainability were given and the groups were tasked with analyzing how their technologies support the Sustainable Development Goals (SDGs) of the United Nations. Our group's technology was found to impact at least 9 out of the 17 SDGs and these were investigated using the board in Figure 11.

One example is the "Clean water and sanitation" sustainable development goal related to clean and safe water being an available resource to all people on Earth. In the water sanitation industry our technology could aid in the detection of harmful chemicals in bodies of water such as ports or waste water management facilities.

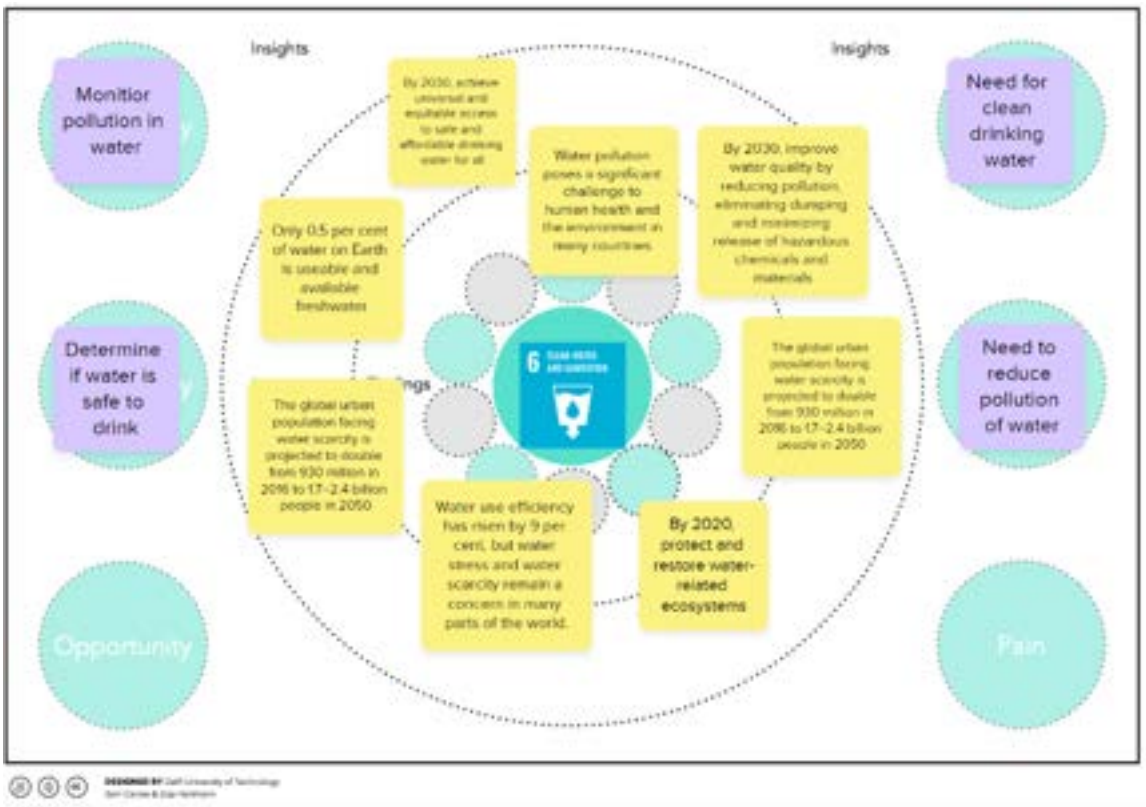

Figure 11: Clean water and sanitation SDG exploration result

After exploring domains and identifying opportunities, the group needed to narrow down a list of key opportunity fields and their applications on the final day of the Design Sprint. This involved considering factors like key players, users, impact, pain points, and market size, which will be discussed in the following subsection.

2.2 Converging towards an application

To narrow down the list of possible domains and applications, the team defined criteria for ranking their ideas using a C-Box canvas (Figure 12). The canvas had two axes: urgency (vertical) and importance (horizontal). By evaluating each application's urgency and importance, the team could place them on the canvas, providing insight into their potential impact. The impact can be measured in many ways, but it's often related in financial terms. This way we could estimate an application's monetary impact as a way to measure its feasibility—for example, the value of saved crops in field monitoring or the cost of undetected hydrogen leaks.

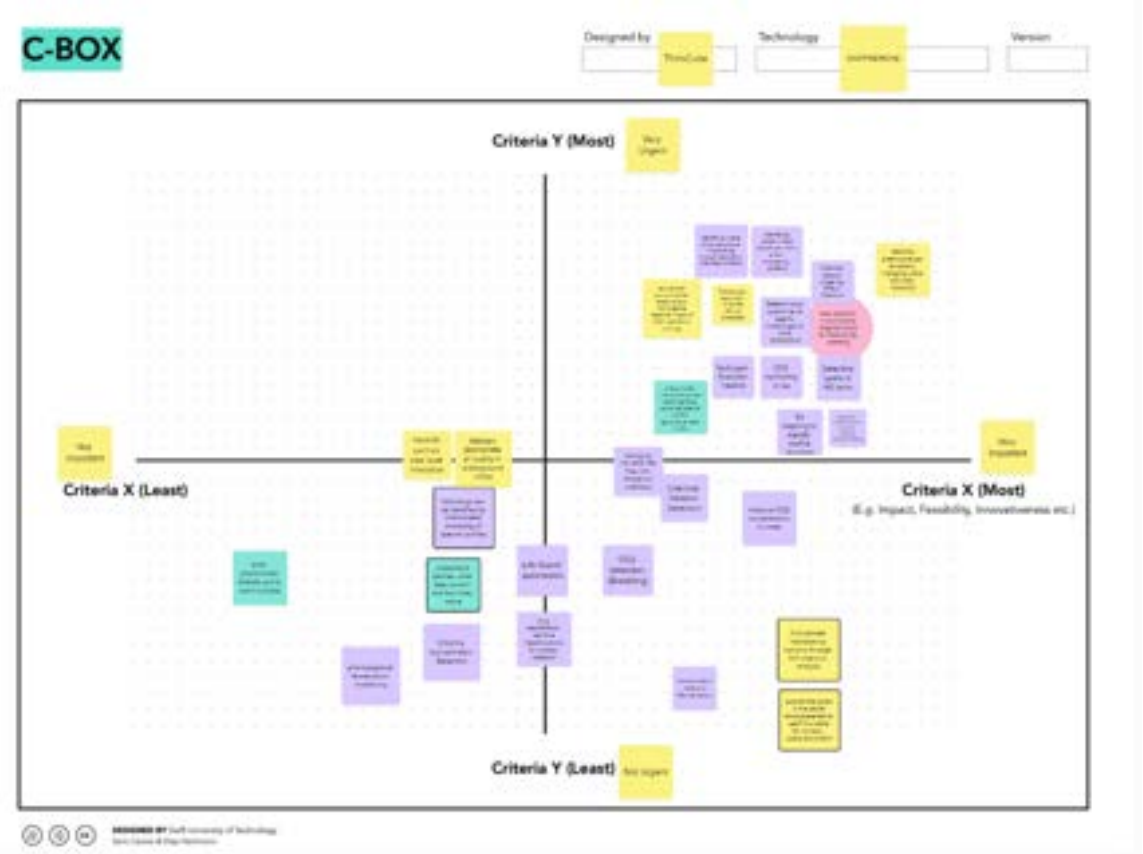

Figure 12: The C-Box displaying the importance and urgency of the applications

Having finished the C-Box, the team was tasked with producing "Cardboard Prototypes" of a few of the applications found. The goal behind this was to visualize and internalize the technology even better and get a feel for which applications fit well with it.

A couple of these prototypes are shown below:

Figure 13: Cardboard Prototype visualizing the principle of using the SNIFFIRDRONE technology in rescue missions

Figure 14: Cardboard Prototype visualizing the potential application of detecting leaks in hydrogen storage and transport

After cardboard prototyping, the team focused on converging on promising applications, or “Opportunity Fields.” We reviewed all applications and selected 10 to develop further based on the C-Box impact estimates. These were then categorized into three types: "Hair on Fire" (urgent problems), "Hard Fact" (accepted problems), and "Future Vision" (future challenges and solutions). Below is shown the canvas belonging to the future vision category:

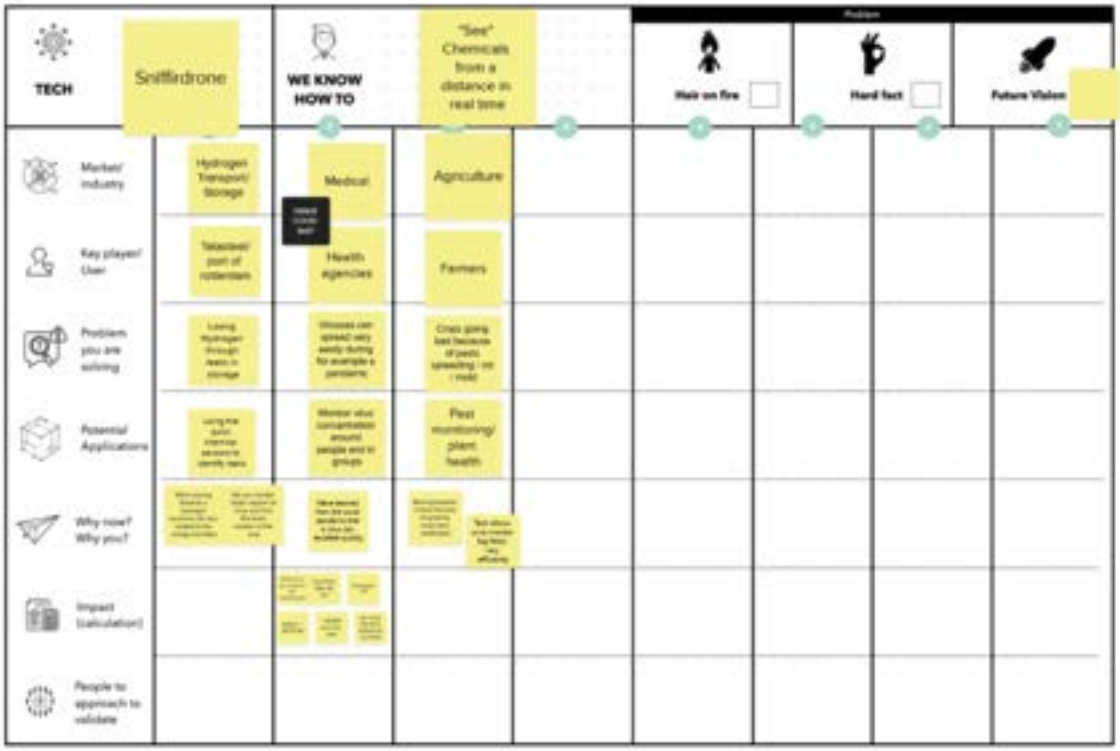

Figure 15: Tech Application Fit with future vision includes hydrogen storage, medical and agricultural industries.

Working out the opportunity fields gave us a better insight into which applications might actually attract customers, and who the key players in the industries would be. Knowing this, further research was done on the 10 applications to further develop the concepts.

We selected 3 concepts from the original 10 based on Technology-Application Fit, application impact, and previous findings. The chosen concepts were:

1. **Nose M.D.** - Inspired by sniffing dogs and as a wordplay on the TV-series “House M.D.”, this concept uses smell and chemical detection technology to diagnose illnesses like airborne viruses and certain cancers. This technology could significantly reduce diagnostic times in the medical field.
2. **MoldBuster** - This concept detects mold that is not visible yet. Unlike current widely used humidity sensors that only offer indirect detection, MoldBuster can pinpoint mold's exact location and type, enabling early detection and reducing mold-related costs.
3. **Nose Cancellation** - This application relies on the identification of smells and their perception. Akin to noise cancellation in audio technology, Nose Cancellation neutralizes unpleasant smells by identifying their chemical composition and counteracting them with a targeted combination of chemicals that act as neutralizing agents.

To choose a final concept, we consulted with experts, including CERN employees, and compared the concepts to the original SNIFFIRDRONE technology. Our goal was to maximize the use of existing components while assessing how each concept deviated from the original. After thorough discussions, we selected MoldBuster due to its strong fit with the original technology's mobile and concise design, making it a more competitive option.

3 Defined problem

The problem of mold has been present in the lives of people for centuries. Mold tends to appear in places with high humidity, surrounded by a lot of moisture. Once it has started to grow on a surface, mold is able to cover it within hours. Due to its high speed of spreading, one in every six European homes is infested with mold, as well as around 47% of American buildings. Exposure to mold particles in the air is a cause of respiratory afflictions in humans, having been shown to lead to cases of asthma.

Early detection of mold in human-inhabited places is a key factor in reducing the price of its removal and posing minimal health risks to people. However, mold can quite often hide in dark places or behind walls. If they cannot see it, people are not capable of determining its exact location by smell alone, so large removal operations end up happening that could have otherwise been avoided. Moreover, there are no precise mold detectors on the market. Companies specialized in this field use moisture sensors to predict where mold growth could happen. Lab samples are a more reliable solution, but the time it takes to analyse what has been collected can end up delaying the actual removal of mold. And in the end, the entire process is cumbersome for the people living in the infested homes.

4 Solution to the problem - user story

In order to accurately detect mold we need to be able to perform two tasks: detect mold particles, and map the exact location of the mold concentration within a 3D environment. Our MOLDBUSTER technology allows us to detect mold particles with a high accuracy using our NDIR sensor. By passing air through a tube and analyzing the infrared (IR) light absorbed by the air, we can accurately detect a wide range of mold particles. Using a LIDAR sensor and a camera, we can create a detailed 3D map of an indoor space (see figure 16). This 3D mapping technology is already available in mobile consumer devices such as iPhones and iPads. By combining both the data from the chemical sensor (NDIR) and the 3D mapping technology (LIDAR & camera) we can create a detailed 3D map of a building where mold hotspots are highlighted directly in 3D space.

Figure 16: 3D map of a house using a LIDAR scanner and a camera in sync. Source: Polycam

This 3D map of mold hotspots enables users to make better-informed decisions on tackling mold infestations. Potential users include mold removal agencies, construction companies renovating big buildings, and realtors. Currently, mold removal agencies operate reactively, addressing mold only after it's identified. This technology would enable early detection, even before mold becomes visible, shifting the business model from reactive removal to proactive prevention.

Construction companies renovating big buildings often halt entire renovation projects when mold is detected, as they may not know the mold type. Different molds require specific safety measures and certain construction activities may need to be restrained in specific areas. This technology enables real-time identification of the mold type, allowing companies to secure affected areas and continue work elsewhere in the building while mold removal occurs.

Realtors must accurately price homes, and hidden mold can lead to significant future costs for new homeowners. By detecting mold themselves, realtors can prevent health issues and save on mold inspection fees. In the US, mold inspections are mandatory before selling a house, but elsewhere, such checks would only make sense if governments required them. Without these regulations, homeowners might face decreased property values or be forced to cover the cost of mold removal themselves.

We hope that in the future the price of this technology will be low enough so that this can become a household item for homeowners, or where it makes financial sense for them to rent this technology once a year to preventively check for mold. This could also

be a service provided by insurance companies as the early detection of mold has the potential to significantly save in repairs and renovations.

The user journey for a homeowner would be as follows:

1. **Yearly mold check moment**
   The time has arrived again where homeowner Martijn will have to check his house again for mold as has been doing for the past years. His insurance company has sent him a mold detector which he has received by mail.
2. **Setting up the mold detector**
   As this is not the first time Martijn uses the mold detector, he takes the mold detector out of the packaging and skips through the menu explaining how to do a mold check.
3. **Entire house walk around**
   Martijn has already moved his furniture from the walls so that he has enough space to walk around. He starts off with his living room and is able to see on the on-device screen what parts of his living room have been mapped. He continues this process until his entire living room is scanned and moves on to the other rooms in his house looking for mold.
4. **Finding early mold**
   For the first time since scanning his house for mold, Martijn sees a transparent red spot appearing on the screen, right next to the bathroom door. The mold detector has detected signs of early mold! Following the instructions appearing on the screen, he scans the specific area in greater detail by moving closer to the wall with the nozzle of the device.
5. **Sending the results**
   With permission from Martijn, the device sends a secure report to the insurance company with only the necessary data points.
6. **Removing the mold**
   Because Martijn was very early with detecting the mold, he has received a set of instructions from his insurance company to tackle the mold. This includes ventilating the area where the mold is present, setting up a moisture removal device and checking back in two months.

By utilizing MoldBuster, homeowners are able to prevent mold outbreaks from becoming potentially hazardous and save money on renovations at the same time. Other stakeholders such as realtors, construction companies, and mold removal agencies are able to put this technology to use until it has become cheap enough to become a household item. At the end of the day, MoldBuster will allow for better living and working conditions, prevent diseases, and reduce costs.

5 Impact of MoldBuster

MoldBuster was chosen as our final product, as it represented a feasible and realistic solution to a problem that targets billions of people. Early and accurate detection of mold can have a significant impact. Mold removal companies are able to save money on

the products they use, realtors can give more accurate information on the status of a house, preventing legal issues in the future, and the renovating process also becomes shorter, as the time needed to identify and remove the mold is shorter.

A rough estimate of the price of MoldBuster places its value at around 2650 US Dollars, taking into account the current price of the sensor manufacturing and approximate market estimates for LIDAR products and touch screens. A mold detection company could invest in a few of these products, to aid them in their job. MoldBuster could become even more impactful in the future, if its cost were to decrease (from mass production or material price reduction). It would then be plausible for regular people to buy it and scan their own homes for mold at their leisure.

Our team has analyzed the market-level impact of such a product, using data from the USA. In this country, there are approximately 5.2 million residential buildings. With about 47% of buildings being mold-infested, this would mean about 2.4 million homes present a health risk to their inhabitants. A rough estimate of the money needed to treat a mold-infested house is around 2400 dollars. As early and accurate detection of mold means less removal product being used over a shorter period of time, a sum in the order of billions of dollars could be saved, at national level. The impact can also be considered from the realtor point of view. Depending on the place and amount of mold, the price of a house can drop by 10-30% if it is infested. Considering the average price of a home in the US to be 400000 dollars, real estate companies and regular people would end up making between 200 to 600 billion dollars more from the total house sales.

As has been mentioned above, exposure to mold particles can lead to health problems in people, including the development of asthma and respiratory problems. Medical treatments end up costing large sums of money depending on the gravity of the condition. Therefore, by limiting the time people are exposed to mold-infested air, costs in the health field would also decrease. It has been estimated that around 3.5 billion dollars from treating mold-related health problems can be saved in the US alone. To put the number into perspective, it represents twice as much as the amount of money required to build the Large Hadron Collider at CERN.

According to a real estate agent the team has talked to, people would eagerly be willing to pay for such a product. Enabling accurate pricings of houses, prevention of health problems and efficient mold removal, MoldBuster has the potential to become a highly sought after product, with a significant economic and medical impact in the future, as can be seen in figure 17.

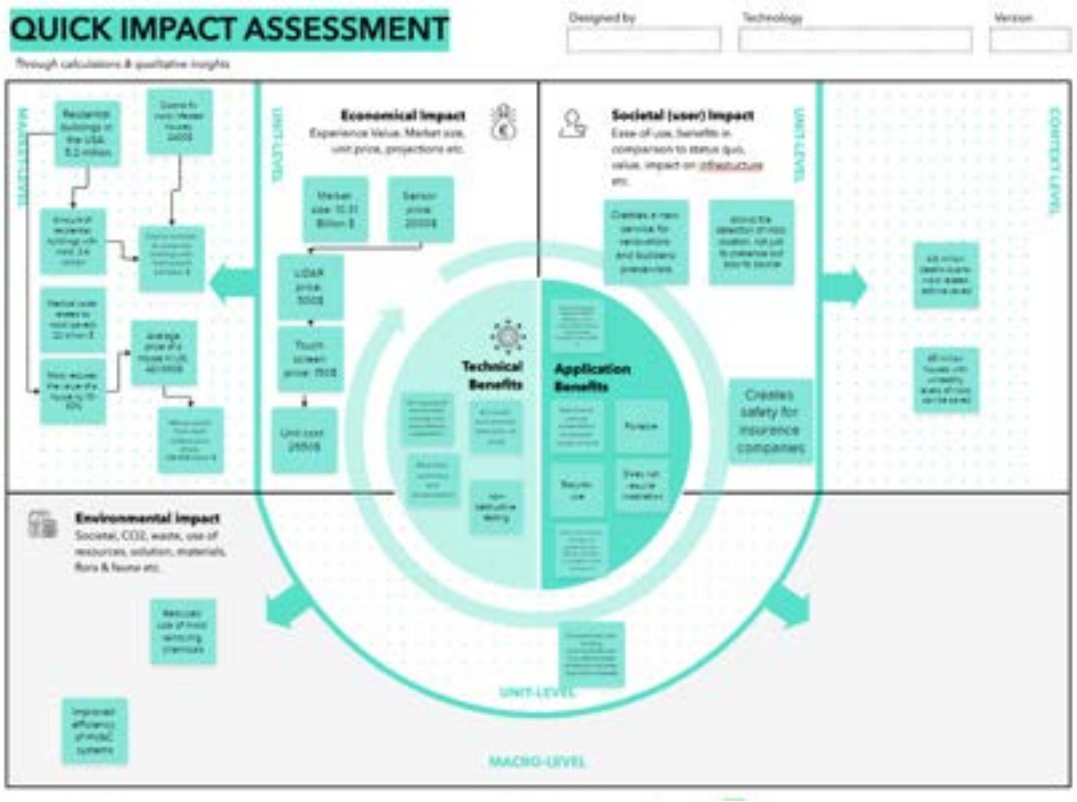

Figure 17: Quick impact calculations made by the team

6 Individual reflections

6.1 Anna

It was incredibly fun to be so wildly imaginative and innovate with a multidisciplinary team during the CERN Ideasquare summer school. This program helped me realize that what I like in physics research is actually the innovation part; pushing the limits of what we think we can do. This realization has opened up new possibilities for what I can do in the future. It gives me more confidence that I can be satisfied outside of academia and shows me how I can make a societal impact as an astrophysicist.

In addition to giving us the freedom to be creative, this program created a space for productive team work. I think the primary reason why our team won the best presentation and concept is because we built a supportive team dynamic. We had clear communication, we got along, and we played into our strengths. The natural leaders arose but we always made sure that all of our ideas were heard. Having an internal midweek check in was also beneficial to our group dynamics because it allowed for concerns to be brought up and strengths to be emphasized. Although our group was able to create a constructive space for ideation that wasn't necessarily the case for the entire cohort. From the start our team chose to prioritize clear communication and constructive criticism because that is what we found important but that may not have been the case with other groups. It would have been nice to have a short reminder with

concrete examples of what the pillars of good teamwork are at the beginning of the school so that each team had resources they could use if they chose to.

6.2 Valter

The summer school was a widely different experience than my usual academic activities. Nonetheless, it provided me with a new perspective towards design and innovation which is why I joined this course. It was a highly positive experience to be able to visit a new environment with new people and produce a great product in such a short time. The combination of more science-rooted and business-rooted people throughout the programme allowed me to realize the benefit of including members with a widely different background in discussions. I had previously not seen the value of including non-engineers in certain discussions, but from now on I will certainly make an effort for this.

The cooperation with my teammates was smooth and effective, we were able to quickly resolve our issues and not take them personally. The reflection sessions between us also helped to reduce any conflicts. Ultimately, all these positive elements contributed to us being able to produce the winning product as well. Finally, the techniques taught during the camp will be a useful tool in my future career to be able to brainstorm certain ideas. Many of these tools and quick ideation sessions made it possible for us to quickly develop the concepts for our product.

6.3 Nicoleta

The summer school has proved to be an extremely unique and exciting experience. It offered me the opportunity to collaborate with teammates from different fields to come up with an application of a complex technology. I was also able to reflect on the importance of making scientific discoveries relevant to the general public, a principle which I intend to bear in mind for the future.

Learning about the innovation and ideation process has been a fruitful experience, especially in the context of the creative environment provided at the IdeaSquare workplace. The resources provided by the course staff, as well as the activities we had to do, were also extremely useful. My team was also able to collaborate efficiently. We prioritized open communication and our winning concept was the result of good team cooperation.

It would have probably been useful if we would have had a bit more time to work on our prototypes. The last day and a half of the summer school were quite hectic, as we had to divide our efforts between the prototypes, poster, pitch, and paper input. Although my team managed to organize our tasks successfully, I am aware other teams' work had to suffer from this. As the prototypes were the ones most people had the least experience with, I feel like starting on them earlier might have been better in the

overall process (which would also involve choosing the final idea quicker so the teams have more time to perfect their data).

6.4 Jesse

When starting the course and summer school, I was not entirely sure what to expect yet. Nevertheless, it was an incredible experience from which I have learned a lot of very valuable things. One of the main things I learned is thinking more like an entrepreneur. I have always thought very much into the details of everything, but this course has taught me to zoom out, and think about the bigger picture. I had never really worked in a setting so creative and free, together with people of varying backgrounds, but I really liked working with my team members and we got along very well.

From the start, we decided that the core of our teamwork would lie in communication, and being able to say what you think. I think we did this very well. Even though some team members are more talkative, we still made sure that everyone was heard, and that a consensus was met after every discussion. This great communication made the teamwork very comfortable and created a very healthy work environment.

Overall, the summer school was a great learning experience. It will certainly be helpful later in my career, when the inevitable teamwork with multidisciplinarians will come into play. The structured creativity provided by Sem and Dap has greatly altered my way of seeing creativity and thinking outside of the box. I will surely be able to use these new skills in the future.

6.5 Karel

I found the summer school to be a valuable experience. The environment fostered mutual learning, allowing everyone to benefit from each other's insights. Initially, many of us shared the assumption that collaboration between engineers and business students would not work. However, by the end of the program, we were pleasantly surprised to see that it actually could.

I personally found development of mutual trust and respect among my team members throughout our time in Geneva to be an interesting phenomenon. We got to know each other better on a personal and professional level as the week progressed, which had a positive impact on the way we worked together. I feel I have improved my ability to tackle communication barriers between myself and peers, by empathizing with my team members and understanding everyone’s personal language. To me, this drastically improved our ability to get stuff done as a team.

On a critical note, I felt a distance between our internal group process and the overall process of the summer school. After a few days, I had completely lost track of the direction we were going. Whilst the canvases initially provided a lot of guidance, they began to feel as dreaded tasks we had to complete as the week progressed. By creating

a clear overview of the entire process (where are we going, how are we going to do this, and why are we doing this?) I think the clarity and understanding for the participants will be greatly improved. Finally, I felt the Mural was a good fit for group work during the preparations, but not during the summer school as everyone has to switch between a digital and a physical environment, which created a divide between what was up on the walls of our container and what we put on our mural.

Overall, I feel like the summer school has been a valuable experience for all participants in terms of new insights on teamwork, personal connections and I was personally inspired by all the people involved within this process. I loved the creative atmosphere that was present during the entire trajectory and the interaction we had with different groups, which sparked a lot of new ideas.