Progress report CERN Ideasquare, Group 4 2024

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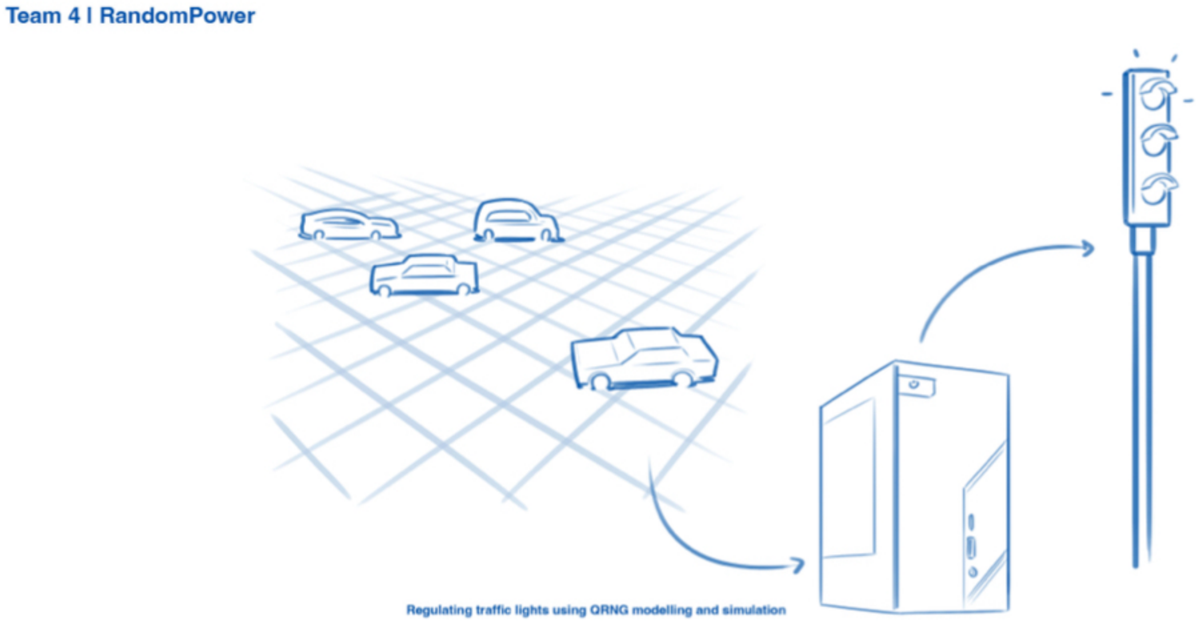

Figure 1: Final application; artwork by Malik Ivan Tas

1 Introduction

This progress report is written in the context of the CERN Ideasquare program of 2024. As an interfaculty group of 5 students from the University of Amsterdam and the Delft University of Technology, team 4 worked on developing an application for Random Power, one of the five ATTRACT technologies. With their different backgrounds, every team member brought distinctive qualities that allowed for a unique application to be devised. This progress report presents the final application and methods used in the innovation process.

Random Power is a technology in development at the University of Insubria Como, Italy and AGH University of Science of Technology Krakow, Poland. It is a random bit generator that spun off silicon Detectors for Sub-atomic particles used in experiments at CERN, the European institute for particle physics. The spin off is a random number generator with a working principle based on the quantum properties of semiconductors. The thing that is important to stress is that the bit generation is randomized by a quantum process, hence the randomness is true. Random Power aims to provide a secure, cost-effective, robust, and small device. Random power can be used for encryption in security of the Internet of Things, automotive and mobile devices. Improvements in the graphics industry are also possible thanks to the Quantum random number generator, as well as diverse simulation applications.

Contents

2 Team members

Firine Bugenhagen

I just finished my second year of a Bachelor's in Aerospace Engineering at TU Delft. My main motivation for applying to the CERN summer school was the opportunity to work in an interdisciplinary team. The environment of the summer school provids a space to explore new and creative approaches to developing ideas and thinking outside the box. I find it appealing to apply these concepts to take a technology and transfer it into an application that makes an impact. I am convinced that the interdisciplinary aspect is crucial in doing so. It does not only lead to versatile and creative problem-solving ideas but also facilitates learning for everyone on the team.

Sameh Mikhail

I am a third-year Physics and Astronomy student at the University of Amsterdam. The program is very theoretical — which I find fascinating of course — but I also wanted to gain experience outside my field. When this summer school crossed my path, I saw it as an opportunity to step out of my comfort zone and learn something that will be valuable later in life. I have developed and improved many skills, such as working in an interdisciplinary team, engaging with state-of-the-art technologies, and thinking like an entrepreneur, just to name a few. I can confidently say that I am grateful for the opportunity to learn new things, make new friends and connections, and explore a new city.

Michael Rubin

I am a Belgian student, who recently graduated BSc Mechanical Engineering student at TU Delft. Early on in my academic carreer at the TU Delft, I heard about the CERN IdeaSquare Summer School and it motivated me to join the BSc Honours program Programme. Learning another approach to innovation and acquiring new methods to implement in the design process without being too constrained will help me become a better engineer. And being able to do this all in an amazing academic environment like the CERN research center is an amazing opportunity I am really looking forward to.

Kyrian Rahimatulla

I recently finished the second year of the electrical engineering bachelor programme at TU Delft. I like programming and sketching, and I am interested in robotics and automation. In the future I would like to contribute to the automation of complex manual labor. Since the beginning of my second year, I have been participating in the TU Delft Honours programme. Specifically I have chosen the Next Generation Robotics specialization. Within that specialization, I, in cooperation with three other students, am developing a prototype for a home assistance robot that can search for and retrieve objects. The CERN Ideasquare programme fulfills the interdisciplinary part of my honours programme. In hindsight, though, the Ideasquare programme has been the best thing that has come out of my honours programme up until this point.

Floor van Steijn

I am an incoming third-year BSc Information Science student at the University of Amsterdam. I was very interested in attending the CERN IdeaSquare Summer School because the content was very appealing to me. During my studies, I discovered a strong interest in the interaction between humans and computers (HCI) and understanding the needs of users and society. Within the HCI field Design Thinking is very important and also innovation plays a big role. The summer school also covered these topics, making it very useful for me as I was able to broaden my knowledge. Since I would like to continue in the HCI field, this summer school was very valuable for me because I had the opportunity to put theory into practice for the first time. Another thing that I really liked was the interdisciplinary teamwork. Working together with students from different study backgrounds was very engaging because everyone has a different approach, so you can learn a lot from each other.

3 Innovation process: 0-100-1

There are many scientists developing technology with great potential, but many ideas never make it to the market. Importantly, the product must be attractive for investors and applicable in the real world. How to bring technology from the lab to the market, bridging scientific research and industry, is not covered in our university studies. Working on research projects with ATTRACT has brought more insight on the subject, as this program covers the transition of projects to the market as a topic. Applying design and entrepreneurship methods in the innovation process has taught us about the acceptance and needs of the market, staying on the edge of an innovation and how to increase your chances of finding seed funding for developing prototypes. The methods that were used will be described in this chapter. This chapter documents the ideation process that has taken us from zero ideas for applications, to one hundred, to one final application that we pitched at CERN.

3.1 Teambonding and goalsetting

The group started by coming up with a group name, what better way of doing this than using a random word generator, a logo and a slogan. These can be seen in the image above. Following this, core values and general goals of the project were devised. Clarifying this is a great motivational tool and a way to ensure every member has a say in this project.

3.2 Evening lectures: 0-100

During the weeks of the evening lectures, our primary goal was to understand the technology to a sufficient degree, and then to find as many applications for it as possible (but at least a hundred) in as many different societal domains as possible. To that end, we had an online meeting with two of the people who are developing the technology, Professor Wojciech Kucewicz, co-founder of Random Power and professor of Microelectronics at AGH University of Krakow, and Kamil Witek, who programs the Q-RNG PCB. In this meeting we not only discussed how the technology works, but also how it compares to traditional RNG's, and in what fields it can be applied. Based on the insights we gained from this meeting, we filled in our technology unbundling canvas, which can be seen in figure 2.

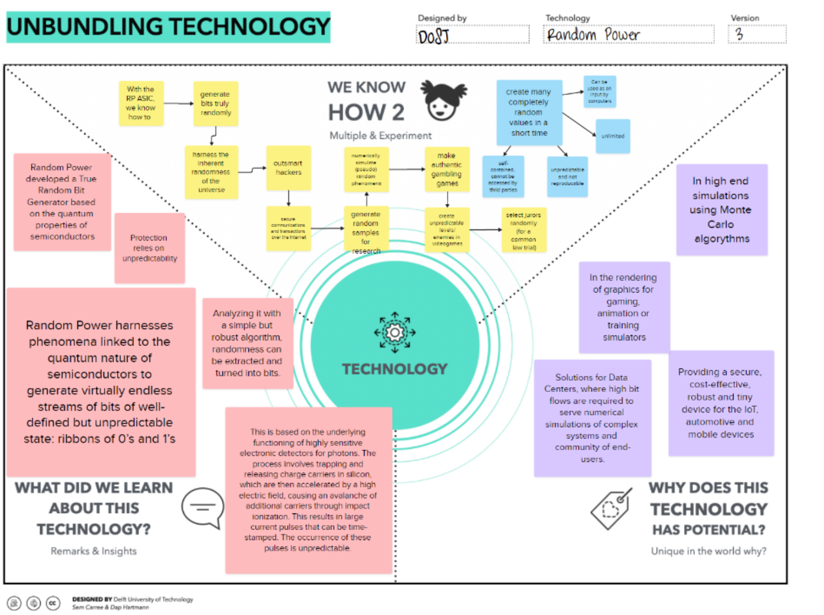

Figure 2: Undbundling technology canvas

Which ultimately led to a clear "we know how to" statement:
We know how to rapidly generate truly random computer readable numbers on a small chip with low power consumption

Then we got the opportunity to have a professional graphic designer, Malik Ivan Tas, pair this "we know how to" statement with some informative and enticing artwork, so that we might use that later in our final pitch. In order to make accurate and comprehensive art work, Malik obviously needed to have an understanding of our technology and its potential applications. To this end we made a technology explanation video of about two minutes in which we explained the basics of our technology and its potential applications. The video can be viewed with the following link: `https://youtu.be/NoL054PJRqY`

Based on this video, Malik made the design seen in figure 3.

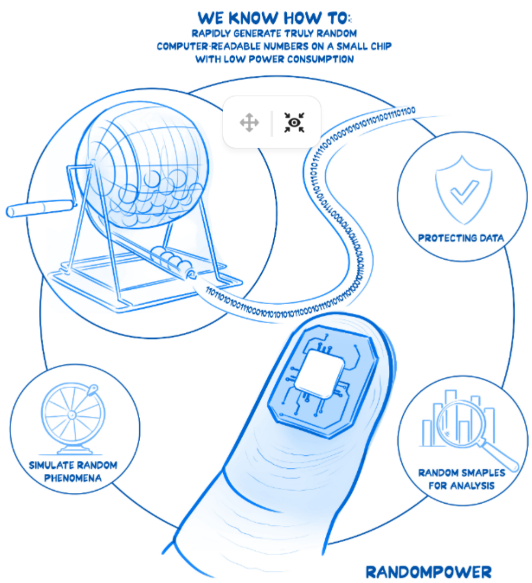

Figure 3: Technology visualization; artwork by Malik Ivan Tas

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With these things at our disposal, we had everything we needed to start talking to people in order to gain inspiration to fill in our 100 application slots. The suggested amount of people to talk to before the start of the design sprint was 10, but we aimed for 25. We set out to talk to people from many different backgrounds, so that we could get feedback from people who were familiar with the technology and its potential, as well as from people who were not, because sometimes outsiders provide unique insight. Our technology explanation video proved useful in some of these conversations, since it efficiently communicated everything the person should know in an accessible way, so that we could talk about new ideas right away.

Finally, in order to find 100 applications, we came up with some loose categories, which we based on our conversations and on Google searches about applications for our technology. Within these categories we tried to find as many applications as possible. These categories are, among some minor others:

- Security
- Simulation
- Gambling and gaming
- AI
- Scientific research
- Art

The complete inventory of applications can be seen in figure 4.

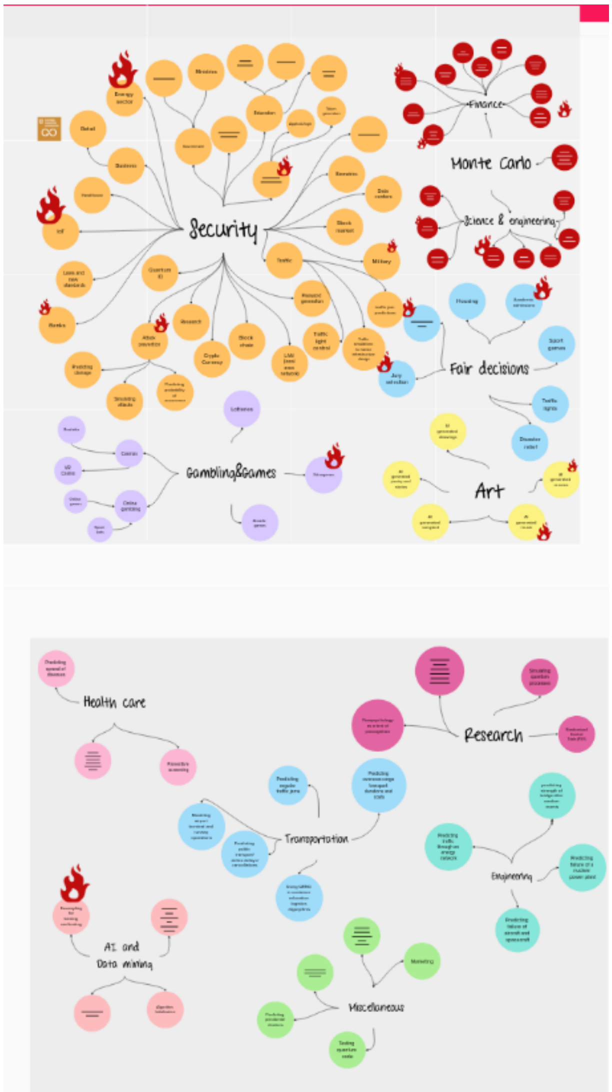

Figure 4: 100 applications

Tasks and team responsibilities were also devised and the 6 deliverables, namely the 6 p's: people, paper, prototype, poster, pitch and progress report were clarified. After the preliminary lectures we felt armed and ready to tackle the project and start the three day design sprint.

3.3 Three day design sprint: 100-15

While the early ideation stage broadened our view and understanding of the concept of innovation and the Random Power technology, during the three day design sprint, we focused on depth, and slowly started laying the groundwork for the filtering process that would get us to the one final application.

We spent the first two days at TU Delft and the third day at UvA. During these three days, we continued our ideation process. Besides that, we had some lectures from and conversations with some professors and Ideasquare employees. The chronological order in which we did everything is a bit lost to history, but some insights from these lectures and conversations were later used in the following ideation stages, so we'll talk about the lectures and conversations first. The first lecture was from Pablo, in which he talked about the value of being able to quantitatively estimate the impact of your technology, and also about how to go about that. Though it wasn't mentioned in the lecture itself, the method essentially comes down to the Fermi estimation method [3]. The second lecture was from Lori. That lecture was about how to get your paper published in the CERN Ideasquare Journal of Experimental Innovation (CIJ). The third lecture was given by Dap, in which he explained the Urgency-Importance matrix, a tool that can help you assess what type of problem you are dealing with. We also talked about our technology with the Industrial Design teacher Marc Tassoul. He suggested that we should zero in on applications where our technology has a competitive advantage over the alternatives. We talked to Ole about our technology, but also about our research paper for the CIJ. He helped us modify the phrasing of our research question so that we could more easily design an experiment for it. Lastly we got a lecture from Catarina, in which she talked about the Sustainable Development Goals (SDG's) and about a framework with which to categorize applications based on the type of change they bring to a society (Hair on Fire; Hard Fact; Future Vision).

We used these insights in the process of narrowing down our initial 100 applications to 15 high value applications. The first step we took was to pick some of the societal domains within which we had found applications for our technology, and explored them a little further than we had previously done, not specifically to find more applications, but just to familiarize ourselves with the domains a bit more. Then we explored the SDG's and tried to find ways in which our technology could help achieve some of those goals. After that, we plotted a bunch of our applications on the Urgency-Importance matrix, and found out that some applications were definitely more immediately relevant than others.

Then, some of these applications were chosen to prototype. This taught us to find a way to visualize a concept in a simple and concrete manner. A couple of these prototypes and applications are explained below.

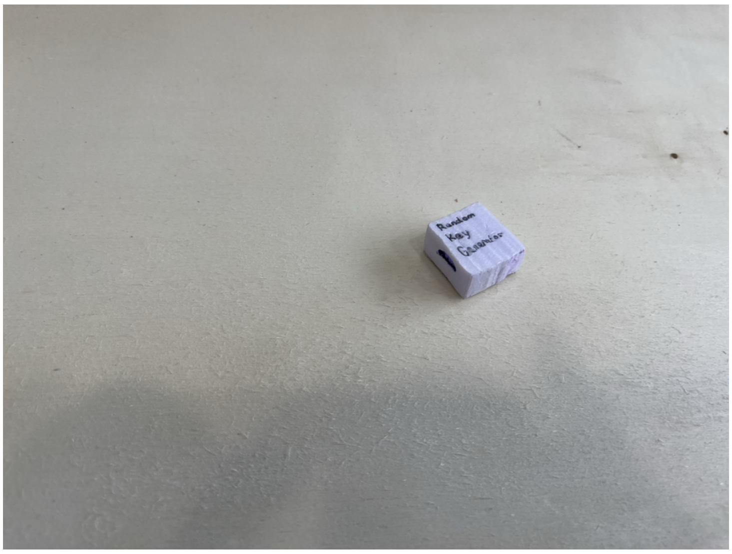

Figure 5: plug in prototype

To visualize the compactness of the product, a small plug-in that can be used for security token generation using the QRNG chip is prototyped. This shows how versatile of a product it can be, and that safe log ins and high end data protection are possible using the QRNG. This prototype is shown in figure 5.

Figure 6: QRNG for data obfuscation in military AI training

Military aircraft have to be flown with incredible precision. Using AI models to enhance a pilot's ability to control an aircraft could result in revolutionary performance. These AI models would have to be trained for real life scenarios. Using the QRNG's randomness in the AI's training results in more realistic and diverse training scenarios. Another point where the QRNG can be used is in data obfuscation: in order to train a military pilot AI, you need a lot of military flight data. Should this data fall into the wrong hands, that could pose an intelligence security risk. Data obfuscation is the process of injecting the data with random noise in such a way that the statistical properties are preserved, while the original data is not retrievable. The QRNG could supply the necessary randomness. This prototype is shown in figure 6.

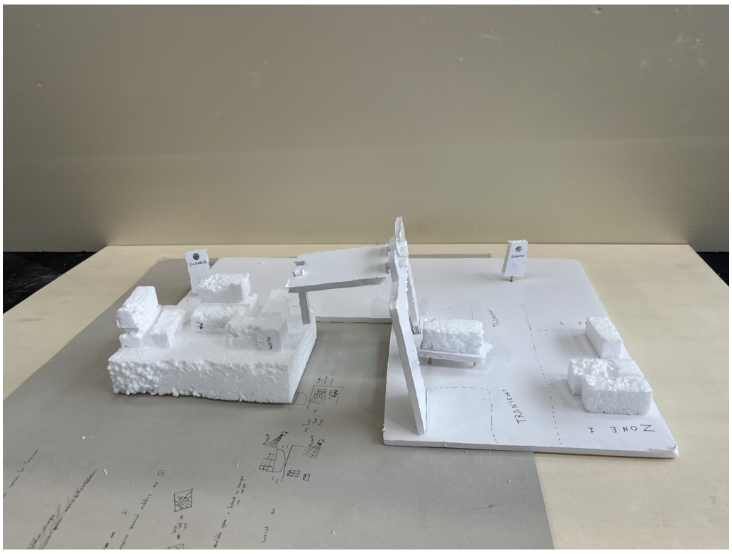

Figure 7: QRNG in an algorithm for automated container terminal modelling at a dock

Ships can carry thousands of containers, each with different product inside and different manufacturers. This results in a whole lot of differently sized and weighed containers, that have to go to many different places. A docked container ship is losing money by the second, and wants to get unloaded and reloaded as fast as possible. Finding the most efficient way to do so is an important problem of today's industry, and that is what QRNG would be able to solve. Using QRNG to generate a multitude of scenarios in a Monte Carlo simulation, the most efficient way to regulate dock logistics will be in a probabilistic manner (Doing this in a deterministic manner would be more accurate but requires too much data and time to process, that is where the QRNG comes in). The prototype includes a dock, with a docked container ship. The dock is divided in different areas, arranged by time before pickup, weight, size, etc. Scanners on the dock scan the boat's load and generate the best way to unload and arrange the containers on the dock. This information is passed down to automated robot vehicles (each carrying a container) that perform the given task. This prototype is shown in figure 7.

This process lead us to better understand which applications were more valuable than others, based on impact, importance, urgency, scale, commercial viability, and potential to aid in achieving SDG's. So we categorized our 15 favorite applications with the help of the framework taught us by Catarina, of which the hair-on-fire entry can be seen in figure 8.

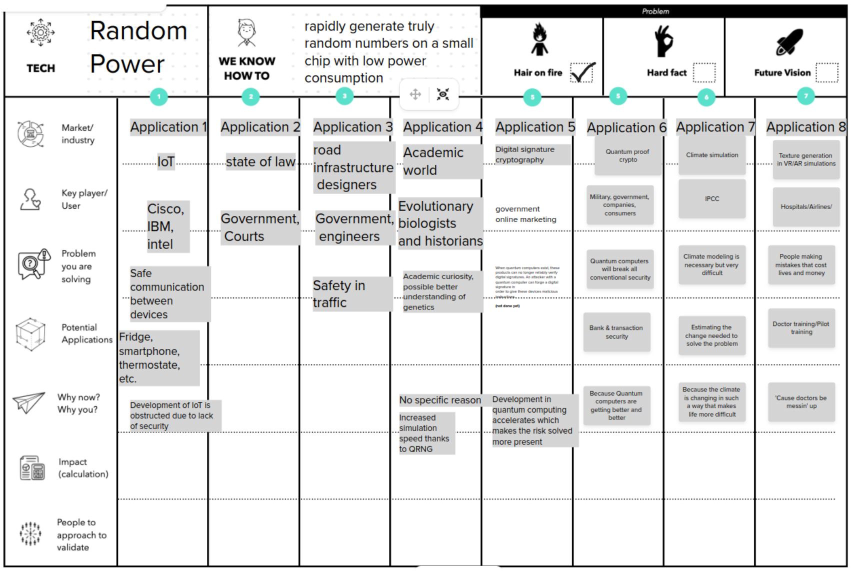

Figure 8: Hair on fire problems

3.4 Design week in Geneva: 15-5-3-1

As the title of the section suggests, the main goal during the CERN design week was to gradually narrow down our application proposals from 15 to 1. We would then evaluate the potential impact of this final application, make a rudimentary prototype of it, and pitch our final results in the cafeteria of CERN. As was the case during the 3 day design sprint, we documented our slimming down process in the Mural.

On the fist day of the week, we continued where we left off on the last day of the design sprint, with 15 applications to choose from. One thing has developed in the mean time though. In the days between the sprint and the week, we managed to talk to some more people about our technology. With our inventory of applications already slimmed down to 15, the conversations were more focused on evaluating the merits of ideas that we already came up with, rather than on finding new ones. We used this input to select our favorite 5 from the 15 that we had. Another benefit of this practice was that we could immediately elaborate on these 5 ideas in the Mural, of which an example can be seen in figure 9.

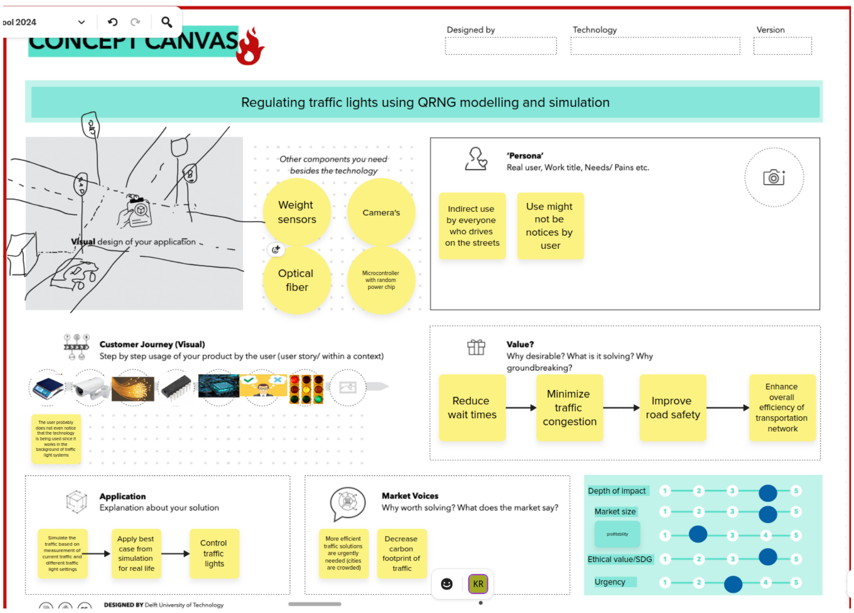

Figure 9: One example of the final 5

At this point, all of our remaining applications looked very promising, and the process of filtering down to 1 was getting more difficult. That is why we got another lecture from Dap Hartmann on how to quantitatively predict the impact of our applications, so that we could use that skill to select among applications that at first glance seemed equally promising.

With these new tools at our disposal, we narrowed down our options to the final three, which can be seen in figure 10. These applications were selected for different reasons. We selected the graphics application because we expected it to have the highest commercial potential of the three, as gaming is the biggest entertainment industry in terms of revenue by a large margin, and realistic graphics are highly sought after. We selected the universal key application because of its scale potential. Of the three applications, this one has the potential to directly benefit the lives of the most amount people in the most diverse aspects of life. Finally, we chose the predictive traffic simulation application because of the promise that it would aid in the achievement of some important SDG's. More about that later.

Figure 10: Final 3; artwork by Malik Ivan Tas

Now that we had only 3 applications left, it was time to start thinking about the pitch. How were we going to present our final application? How were we going to convince the panel of judges and other people at CERN that our application was worth the investment? These questions were addressed in one of the final lectures, from which we also learned of the concept of the user story. A user story is a short narration of the experience of a person or persons while they are using the technology, and how it impacts their life. It is a very persuasive presentation technique, as it gives you the opportunity to very concretely highlight how the benefit of the application actually manifests itself.

We also got the chance to explain our final 3 applications to members of the other teams, and to listen to their explanations. This gave us the chance to gather feedback for our final selection, and to practice our pitch a little bit. Shortly after this, we made our final decision. We chose Predictive Traffic Control, because our back-of-the-envelope analysis showed that, of the final 3, that application yielded the highest potential benefit to society. This was also partially based on our values. We expected the graphics application and to some extent the universal key application to be more profitable for the IP owner, but for this program, profit was a lower priority to us than aiding in the achievement of the SDG's, specifically the Good Health and Well-being goal and the Climate Action goal.

What was left was to finalize the pitch, make the poster, and develop a prototype. The pitch and the slides were made and presented by Michael. The poster was made by Floor. Firine, Sameh, and Kyrian made the prototype. The prototype, which can be seen in figure 11, is an intersection with traffic lights. It runs two programs to demonstrate the difference in traffic efficiency resulting from, on the one hand, a purely non-responsive system, and on the other, a system that not only responds to input from cars, but that also uses logic to think some steps into the future. Our prototype did not include any type of random number generator, as the level of computational complexity that would warrant the use of one was far beyond the scope of the prototype. For the record, the code of the adaptive system ended up not working as intended. This was due to errors in the code that could only be attributed to a skill issue.

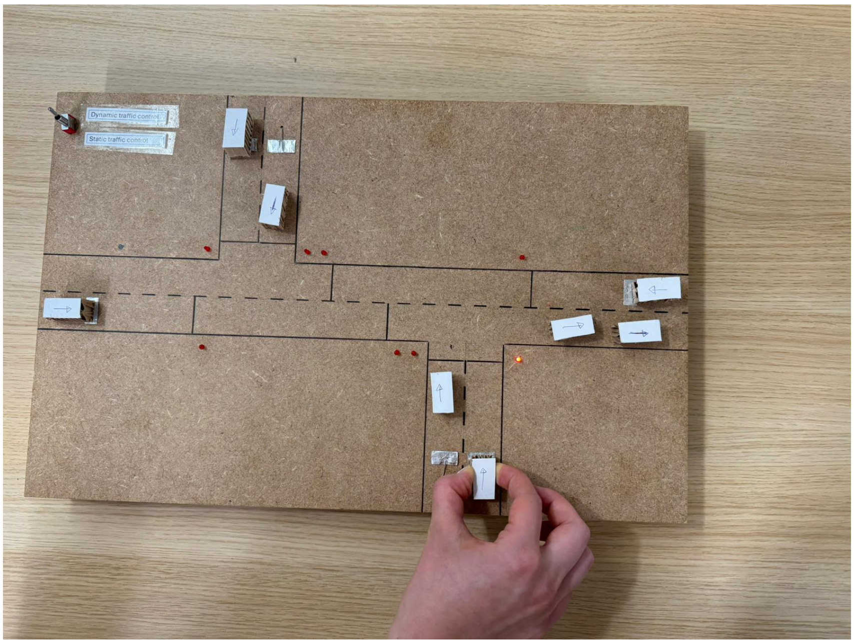

Figure 11: Prototype

Shortly after this, it was time to present our idea to the panel of judges. It went well, though the panel came up with some very valid critiques. As will be elaborated on in the next chapter, we proposed that the Q-RNG could aid in predictive traffic regulation by facilitating the randomness in a Monte Carlo traffic simulation. But it turns out that, due to the properties of Monte Carlo simulations, they are not a good choice at all for traffic simulation. Fortunately, the type of simulation that is suited for traffic also benefits from random numbers, so no real harm was done. Besides that, the judges were skeptical about the return on investment, which is reasonable, because the commercial viability of this application is very low. Lastly, the judges also wondered why we were expecting municipalities to invest in automobile infrastructure rather than public transportation. While there are definitely reasons why one might want to do that, we have to admit that we had not thought of that trade-off at all before the cross examination.

All in all, were happy with our final application, the pitch, the poster, and the prototype, and therefore consider our ideation process to be a success.

4 Our Final Application: Predictive Traffic Control

4.1 The problem: intra-city traffic congestions

The problem we are trying to solve with the Random Power Q-RNG technology is intra-city traffic congestions. Research has shown that, in large metropolitan areas, such congestions can add 50% to the congestion-free travel time on average [2]. This means that, if you experience such congestions, you will effectively be standing still for a third of your travel time. Even more so, the nature of congestions is that you will actually be standing still, rather than just driving more slowly. This is because intra-city congestions tend to cause stop-and-go traffic. This has two main consequences. The first one is due to the fact that most internal combustion engines, especially those in cheaper cars, keep idling while the car is standing still. This means that you are wasting energy and polluting the air while you aren't even progressing in your journey. As will become clear later, this inefficiency has quite a large impact on the environment. The second consequence of this phenomenon is psychological. Research has shown that commuting to work is detrimental to mental health [5]. It stands to reason that taking 1,5 times as long as necessary to get to get to work and back only makes this problem worse. Another thing to consider is that employees who arrive late to work cause Western economies billions annually, as will be elaborated on later. It is reasonable to expect that congestions play a part in this phenomenon, especially since congestions are difficult to predict. The 50% added travel time is only an average, so it is not necessarily an accurate predictor of your upcoming travel time on any given morning.

4.2 The solution: predictive traffic control

The solution to this problem that we propose is a predictive traffic regulation system. Research has shown that cascades of intersections of which the traffic lights are regulated intelligently can reduce the travel time by 17% compared to cascades of intersections that have a non-adaptive time-based traffic light regulation system [1]. This is not enough to eliminate all the intra-city traffic inefficiencies (a travel time reduction of 33% is needed for that), but it is a significant leap. But what role does the Quantum random number generator play in this application?

Advanced simulations frequently benefit from partially randomized inputs. These inputs simulate the outcomes of phenomena that are too complex for the available computing power to deterministically analyze, or of phenomena of which there is simply not enough information available to exactly predict how they are going to play out. The predictive traffic regulation system will receive information about the amount of cars on the road and their immediate heading from cameras that are placed at intersections, with software that can detect vehicles. It uses this information to predict the traffic flow some time into the future. This is where the Q-RNG comes in, because immediate heading doesn't tell you exactly where the car is going to be much later. For that, the system has to make educated guesses with randomized inputs. The system can then use these predictions to change the timing of the traffic lights in an attempt to prevent the congestion from ever building up.

Imagine that you are commuting to work in a dense metropolis, but you can drive at a reasonable pace the entire time, never getting stuck in a congestion that seems to have come out of nowhere, and never having to wait for unspeakable lengths of time for traffic lights to turn green. Imagine that your travel times are consistent, and you arrive at work in time every single day. Imagine consistently arriving home half an hour earlier than you used to, so that you can spend more time with your family... or in front of the tv. Take your pick. This is the promise of a predictive traffic regulation system.

Or imagine that you are the mayor of a dying city. People are leaving left and right, and the reason they give is: "These congestions and commuting times are literally driving me crazy! No really, check out this research paper that proves it." Then one day, a rag tag team of innovators aggressively kicks in the door to your office and pitches their predictive traffic control system. You decide to implement it, and the very next year your city is ranked number one in the world in terms of living quality, and people start flooding back in. This could be you, so don't wait!

4.3 The numbers: 0, 1, 2, 3... you know the rest

The first quantifiable effect of predictive traffic control is the effect on global CO_2 emissions. Global CO_2 emissions are 35 billion metric tonnes annually [7]. 21% of those emissions come from transportation [6]. 75% of transportation emissions come from road traffic [6]. This brings the road traffic contribution to CO_2 emissions to 5,5 billion metric tonnes annually. Figures on how much emission is caused by intra-city traffic are hard to find, so let's make a rough guess and say it's half of total road traffic. This brings the count to 2,76 billion tonnes annually. Assuming that that 17% reduction in travel time means the same reduction in idle time, we conclude that a predictive traffic control system could eliminate 0,47 metric tonnes of CO_2 emissions annually.

Secondly, research shows that employee tardiness costs the US economy 3 billion dollars annually [4]. This figure has to be weighed against the prediction that implementing a predictive traffic control system in the largest 75 metropolitan areas in the US is expected to cost 58,24 billion dollars in today's money [9]. This means that, if your only concern is money lost due to tardiness, your investment will pay for itself in 19 years, assuming that this system eliminates all tardiness.

Lastly, mental healthcare costs the US 280 billion dollars annually [8]. How much of that goes away after the commuting problem is solved is hard to determine, but it is definitely worth considering the benefit of this solution in this area.

5 Individual reflections

5.1 Firine Bugenhagen

I applied for the CERN summer school because I liked the idea of working in an interdisciplinary team on a project in a summer school setting without any other distractions or obligations. Although I knew that the summer school was about finding impactful applications of ATTRACT technologies for society, I did not know exactly what the process would look like.

With an engineering background, I am used to having a problem that is usually clearly defined and finding a solution to solve it. During this course, the process of developing ideas differed greatly: instead of finding the solution for a problem, we were looking for a problem for a solution, the ATTRACT technologies. Furthermore, the problems were not clearly defined, and the entire solution-finding approach was more creative and broader. This was my first experience with the ideation process, and it was at that moment that I became most aware of the team's interdisciplinarity. We had different default methods of approaching problems. During projects in my regular bachelor's program, I am around students who think in a similar way, but in an interdisciplinary team, I started reflecting on and breaking my default methods since they were questioned.

One example is handling a new idea that emerged from brainstorming. I am used to following one idea and testing its feasibility. If it does not work, a new idea is created and tested. During the summer school, we came up with many different ideas without going into depth quite at the beginning and tested their feasibility at the same time to converge on the best ones in the end.

Another example highlighting the value of interdisciplinary teamwork was in acquiring new skills. For instance, I was heavily involved in building a prototype, something that hadn't been part of my studies until then. This was only possible because our team included students with experience in prototyping who could guide and support me.

The summer school was my first contact with the field of entrepreneurship. Taking the market into account to develop impactful and feasible ideas and learning how to grow a product was a new aspect for me that should be considered when developing new ideas. Especially the visit to FONGIT was very insightful for me. My main takeaway was that building a startup is less dependent on luck than I thought and that there are think tanks and existing structures to help small teams with a new idea grow.

Beyond the project itself, I found the IdeaSquare setting inspiring, and it changed my view of offices. During my internship, for instance, I was working in a conventional, standard office, and I was impressed by the design and layout of IdeaSquare. I loved the setup with the diverse range of spaces, from group collaboration areas to quieter spots for concentrated individual work. I think that such a thoughtfully designed working environment facilitates productive and effective progress.

An important part of the summer school was also getting in contact with people. I am thankful for all the people we talked to at IdeaSquare, the cafeteria at CERN, and in the industry while working on our projects.

I am grateful for the incredible opportunity to participate in the summer school at CERN IdeaSquare. It has certainly broadened my view in many ways.

5.2 Sameh Mikhail

When I started this course, I did not know what to expect. Sure, CERN is a place where physics is explored, and summer school is for people who do not go on vacation, but beyond that, I was in the dark. I was pleasantly surprised in the first lecture when I learned what the course was about since I had no prior knowledge of entrepreneurship. We received lectures on a wide range of topics, from the art of approximation to how to write a scientific paper. During the first part (five lectures at TU Delft), I mostly observed, learned from the lectures, and connected with people involved in ATTRACT technology. This was something I was not usually comfortable with, but I pushed myself to reach out to people I didn't know, and it worked out really well.

In the second part of the course (a three-day design sprint), we focused on three main things: brainstorming about the technology, creating prototypes, and becoming more familiar with our team. Since the days were from 9:00 to 17:00 (instead of the evening sessions from 18:30-20:30 like during the first part), the days felt longer—because they were, of course—but we also got more done. It was mentally challenging to think deeply, make connections with people, and gather enough inspiration to come up with industries and applications. We had the chance to take one of our ideas and create a cardboard (low-fidelity user) prototype with our own hands, which was interesting, to say the least. The last time I worked on something practical was years ago, so some things did not go according to plan, and I didn't have enough time to finish it the way I wanted. We were also given a lot of responsibility, from organizing our lunches during these days to buying our own tickets to Switzerland. During the breaks, we talked about various topics, and it was fascinating to see the different perspectives (since we were an interdisciplinary team) and nice to see how sociable everyone was.

During the third part of the course (a 1.5-week stay in Geneva), we did a lot of things. First, we had a drink on the first day because the teachers said it was going to be such a busy week that we wouldn't have extra time. Little did I know how right they were. On the second day, we got in contact with Geneva and CERN Ideasquare, and it was beautiful, to say the least. The days were basically scheduled like this: from 10:00-17:00, we worked on the technology and applications, and after that, we were free to do as we wished. I remember that the minimum number of steps I took each day was around 15,000. At Ideasquare, we had our own cubicle to tinker with the tech and a large space for the lectures. Three highlights were meeting Robert Cailliau, the co-founder of the internet, visiting FONGIT and learning about the practical road from idea to market, and the final presentations, where all groups could shine in front of CERN in the cafeteria.

I would like to thank the teachers for the knowledge and patience they showed in helping us, CERN Ideasquare for the summer school and the program, and my teammates and the group for making the course a wonderful experience. It was the perfect combination of learning new things and having a good time.

5.3 Michael Rubin

I participated in the CERN-HPD Ideasquare summer-school to further challenge myself and complement the knowledge I acquired in my mechanical engineering Bachelor's degree. Its focus on entrepreneurship and the design thinking process was exactly what I was looking for to prepare for my further education and career.

There are many scientists developing technology with great potential, but many ideas never make it to the market. To be successful, a product must be attractive for investors and applicable in the real world. How to bring technology from the lab to the market, bridging scientific research and industry, is not covered in my major. I obtained a better understanding of this process by joining CERN Ideasquare. We learned about the acceptance and needs of the market, parallel design to stay on the edge of an innovation, feasibility and impact assessment and ways to find seed funding for developing prototypes. Theory and examples were presented in the preparatory lectures throughout the program, and simultaneously working on our research project from ATTRACT brought more insight on the subject.

The most significant impact this program had on me was the inspiration I drew from the people I met and the places I visited. The visit to the innovation incubator FONGIT for example, showed me the methods and tools available to grow from a small start-up with an exciting idea to a legitimate company. By traveling to CERN I was also inspired by the local research methods and their connection to the start-up culture in Geneva.

Connecting with the group of interdisciplinary students from the summer-school was one of the most rewarding parts of the program. Sparring with each other led to new insights and due to our different backgrounds it taught me about approaching problems from different angles.

I believe creativity and a wide range of knowledge make a good engineer. Collaborating with students and researchers from different fields is the best way to develop these skills. To further boost creativity and pave the way to new possibilities the design thinking process must be implemented. Defining the engineering problem and testing out solutions iteratively leads to an out-of-the-box, optimized design. Learning more about the design thinking process and getting a chance to put it in action on the RandomPower technology has inspired me for the remainder of my prospective career in engineering.

5.4 Kyrian Rahimatulla

I entered into this program with some but limited understanding of what I should expect. I am an electrical engineering student who is used to solving problems at a technical level, where the tools and constraints are very clear, and the problem essentially takes the form of a puzzle that can be solved analytically. So when I first found out that the technical details of the ATTRACT technologies were not the focus of this program, rather the ways in which those technologies could meaningfully impact society, and how one could go about finding a worthy application, I knew that I had an interesting personal challenge before me. I turned out to be right. The initial process of going from 0 to 100 applications required creativity and exploration far more than it did analysis, and I don't usually get to practice those skills in my bachelor. I specifically noticed that the way I used Google was drastically different from the way I typically use it during my studies. Whereas I am usually searching for an answer to a very specific question and therefore want to make my search queries as limiting as possible, during the Ideasquare ideation process, I was specifically looking for things that I hadn't thought of yet (because if I had, it would already be listed as an application in the Mural), which meant that I had to keep my queries broad and vague, and scour through a lot of articles in the hopes of finding something new.

One specific problem that we ran into that I want to highlight was the fact that our technology, the Q-RNG, does exactly the same thing as already existing technologies. It just uses a different process to do the thing. This meant that a lot of the really meaningful and impactful applications that we came up with were already in place in society, because they were already possible with existing technology. The way we dealt with this was to look at the ways in which our technology had a performance advantage over the existing alternatives. This strategy worked relatively well, although we did have limited quantitative information on both the Q-RNG and existing RNG's, which meant that we had to mostly guess at the advantages, something with which I initially struggled quite a bit, but later came around to doing quite well, with significant help from my teammates, that is.

Of course we also did a bunch of activities that weren't directly tied to the ideation process and therefore not extensively covered in the first six chapters of the report, such as visiting Nikhef at UvA, and the old Synchrocyclotron and the Anti-matter Factory at CERN. Though most of the presentation that we got at the Anti-matter Factory went way over my head, I learned a lot at Nikhef and at the old Synchrocyclotron. At Nikhef I was intrigued to learn how interconnected the various research and development institutions around the world are, with some critical components of the LHC being made by Nikhef in the Netherlands. During the presentation at the Synchrocyclotron I was impressed to learn of the time scales on which the planners and developers at CERN are operating, thinking about research that can be done 30 or even 60 years from now when the equipment that is decades in the making is finally ready.

I also very much enjoyed our visit to FONGIT. The presentation that was given there was of very high quality and very insightful. In hindsight, after completing the Ideasquare project, I realize that that presentation was really the best summary of the philosophy and learning objectives of this course. I particularly liked the 3 (or 4) P's pitch framework and will definitely continue using that in the future.

All in all, this program has had the highest new-insights-per-period-of-time count of anything that I have ever done, and I will forever look back on this program as one of the greatest learning opportunities that I have ever had.

5.5 Floor van Steijn

I am very grateful for the opportunity to participate in this summer school. It was a truly enriching experience, where I not only learned many new things but also had the chance to meet people from a variety of disciplines. One of the highlights was gaining insight into CERN and learning more about the organization.

A key takeaway for me was the experience of working intensively as part of a team. This was the first time I had participated in a project that involved such close collaboration over a week. I found it particularly valuable to engage in the full design process as a group, where everyone could complement each other's strengths.

It was also new to me to generate and explore a wide range of ideas before making a final decision. In the past, I was used to choosing a direction early on and developing it from the start. Looking back, I do wish we had more time to refine our final idea. I believe that with an extra day, we could have significantly improved our concept.

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A Appendix

A.1 List of people we talked to

Michael:
Ariel Rubin: commercial engineer & CEO of Rubin en zonen The idea to check if we can do anything with token verification for bank logins? Talking about banks as big potential clients because security is lacking there.
xxx: Army security dude, don't know his name because it was pretty informal Talking about cybersecurity and its importance for military data.
Chloe Plat: Animator, director & screenwriter Rendering faster is important :) (a lot of programs used: skyline render (super slow), VRAY render, ...)
For animation the market is kind of saturated already. Real time would also be nice to see your work fully while working.
Video game rendering more important because it's real time (unreal render), starting to be used in animation too.
Depending on the image: render from 5min to 1h, speed is variable due to Global illumination (shadows and light for 3D feeling), renderfarms used to minimize time (divided over a lot of computers, less time but just as much computing power)
Maybe also applicable for special effects and simulations (clothes, rain, hair, waves, ...), super physical and complicated + real time needed
Dann: US army cybersecurity dude Still meeting with him
Robert Cailliau: www guy, mainly talked about climate change as the real problem we should focus on. But I didn't find a relevant application using QRNG except for extensive simulating of solutions.
Dirk Van Zuijlen: bachelor student, talked about entrepreneurship and how to assess market need/value
Theo Devoldere: mechanical engineering bachelor student, compared design methods of our Bachelor's to what we learn in the Ideasquare program
Ideasquare chick, talked about the traffic application and how it would change infrastructure of cities in the future
T. Speelman, master graduate computer science & works for the government now Talked about the UniKey idea because his thesis was about something similar Dylan Blend, Control systems engineer doing his thesis at CERN Talked about the 3 applications and he thinks the traffic one is the most promising. Also talked about feasibility and he thinks it's hard to simulate accurately, but possible. He did remark that it has to be really fast to work well because it is a lot of data. (we knew this but we don't know
Kyrian: Riaz Rahimatulla (Business consultant Stedin) Energy network information flows are split up into two isolated parts: Administrative and Operational (the latter is net data and instructions). Between these only encrypted data is allowed to flow. The encryption is done via SSL. At the moment data only flows from Operational to Administrative, but Stedin is working on also getting a data flow from Administrative to Operational going. The problem: this flow is extra sensitive, as it contains net instructions. For that reason they first want a better encryption scheme. This could be aided by a Q-RNG. Rik Wolsheimer (Embedded software engineering consultant from Capgemini for ASML) In order to test code that is supposed to run on a quantum computer without a properly functioning quantum computer, you need to be able to simulate a quantum computer on a normal one. This means in part that quantum randomness needs to be simulated. A Q-RNG can simulate randomness. Stefhen Heck (EE bachelor student) Random numbers are good for data protection, authentication, and simulation. A lot of random seeds are penetrable. Maarten Wijdekop (Quantum gateway foundation) Christian Shaffner (Quantum gateway foundation)
Firine: Gabriel Sa (Aircraft Design Master with computer science expertise) Could be used for simulations of aircraft design softwares Encryption No super new insights Lucie Hortmann (Researcher) Also mentioned simulations for studies within the study of psychology to create random subgroups (not sure if the random number generator is necessary for that) Mentioned gaming for making storyline more random -¿ need to create random visuals in a fast way -¿ quantum random number generators are fast Daniil Serdyuk (Computer Scientist) Creating data for AI training The data stuff is very expensive Monte Carlo Emnify (only email for now, gonna call them) Wega Freese Just Encryption applications Harald Hortmann (engineering, still need to talk)
Floor: prof.dr. P.W.H. Pinkse - Are in the process of certifying quantum random number generators. Now this is not yet certifiable - Traffic light at 2 equivalent paths - White noise - Fair sampling in quantum research - Grading study voters fairly - Online gambling - Security - Quantum chemistry - Many scientific applications - UT -¿ quantum with light (photon) Delft -¿ quantum with semiconductors (companies like IBM already have this too) - Monte carlo integrals

Edwin (electrical engineering) Any company that has access on machines can secure more easily because it randomises keys without humans having to do it themselves. At OM, they use software that now allows the employee to generate their own key. Putty gen (for generating key), terminal application to get access on large machines, you want to encrypt that connection to get access. You only need it first time to get access after that you always have access and therefore don't need it. Therefore, the market will not be very big. So better find a place where new keys are needed very often.
Internet providers issue certificates to make secure connections to websites. For secure connection between you and the website. HTTPS. Companies that send a lot of files Secure phone connections
Nout (MSc Game and Media Technology)
Said that within his studies, he does not use random numbers when developing games.
Gobert (PhD candidate at Nanobiophysics)
He thinks the application might only be used within simulation but within molecular/ biomedical research it is not really used. Within his own research studies, he does not use random numbers.
Gerard Would use QRNG in lotteries and roulette. He also mentioned the interesting option of using it for fair quizzes where the questions are chosen completely randomly from an extensive database so it is fair.
Chiara (Artificial intelligence) Liked all the ideas but find it hard to judge which one is the best.
Sameh: Dr. Philippe Corboz: teacher and researcher from the University of Amsterdam Dr. Witek: See next dude Prof. Kucewicz: Add notes later -¿ see recording of first meeting Think about the future, don't limit yourself by thinking in today's possibilities. Don't think too much about transitioning to your solution, make some assumptions that make it easier (and then worry about the rest later).
Example we talked about: self driving car communicating with all the cars in their vicinity and react accordingly with a simple algorithm (like fireflies). Create a complex environment and order without the need for a centralized decision maker (better in terms of time, data processing, efficiency, coolness)
Oliver Alexander from Ideasquare Concerns: Is it worth for companies to invest to the perfect encryption? Is it worth to add an extra part to the block chain of the process? -¿ can create problems Is it worth it on the hackable vs recoverable balance? -¿ human error ¿ encryption error
Pablo from ideasquare
CERN lunch (23 may) Guillaume Makes physics explanation videos for CERN channel on YouTube. He said that security is maybe a boring choice because it's not original. Patrick Is a content developer for labs at CERN. He likes the idea of the videogames. Qassem H.A Awayes (Physic summer school) Enrico (Physic summer school) Andrea (Physical Particles at CERN) Numerical simulations for particle physics because of random seed setting Mary (Physic summer school) Filip Trajkovski (Computer Scientist) Monte Carlo Simulations Milia Rajcic (Electrical engineering)