PROJECT REPORT FOR THE CBI. ATTRACT PROGRAM

by team h-cube

See through the ordinary

Academic Year 2023-2024
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INTRODUCTION

CBI.ATTRACT is a challenge-based and open innovation program made possible thanks to the organized effort of numerous partners: the universities of Bologna, Modena and Reggio-Emilia, Almacube, ATTRACT, Ideasquare and h-cube, our tech partner for this project.

For the sake of this program, five multidisciplinary teams have been formed in order to explore exciting possibilities for innovative technologies funded under the ATTRACT program. In the course of about four months, the teams have had the chance to familiarize themselves with their assigned technology, explore possible fields of application and develop a prototype. The primary objective of this program was to search for solutions that addressed a variety of both local and global problems that stem from societal, human and natural issues in alignment with the United Nations framework of Sustainable Development Goals.

For the sake of this program, teachers, coaches and students employed a number of methodologies spanning from tech-driven innovation processes to human-centered approaches to design thinking. This approach is meant to give the students the right tools to become competent entrepreneurs and future innovators in their respective fields of competence.

CBI.ATTRACT is part of the broader ATTRACT program, a research initiative funded by the European Commission.

ATTRACT

THE TEAM

This project is the result of the work of six young and fierce master students driven by the desire to leave a positive and lasting impact on the world. Our different academic backgrounds and interests allow us to be a well-rounded team capable of tackling difficult challenges.

The following are the six members of the h-cube team:

Alice Turrini is a computer science engineer with a master's in AI. She's proud of her engineering background, but she's careful about falling into the usual stereotypes. She's an organized, extroverted professional that feels passionate about networking and brainstorming together in a team, as she believes learning from each other is better than learning from books.

Majoring in: Artificial Intelligence at the University of Bologna
Can be contacted at: alice.turrini@studio.unibo.it

Andrea Daniel D'Ambrosi is trying his best to improve the often conflictual relationship between hard sciences and the humanities. In his free time he writes about contemporary and performative art, poetry and movies.

Majoring in: Semiotics at the University of Bologna
Can be contacted at: andrea.dambrosi.work@gmail.com

Parian Hatami comes from Iran with a diverse background in mathematics, entrepreneurship & design thinking. She believes that having a diverse background leads to more opportunities than focusing on a specific area.

Majoring in: Applied Mathematics at the University of Bologna
Can be contacted at: parian.hatami@studio.unibo.it

Simone Mascaro specializes in 3D modeling, electromechanical and programming with his bachelor's in mechatronics engineering. He is currently launching a startup business in smart clothes and is very passionate about problem-solving and technology. When he's not working, he loves playing his saxophone.

Majoring in: Digital Automation Engineering at the University of Modena and Reggio Emilia
Can be contacted at: simonemascaro@peceasy.it

Tommaso Malaguti has always been passionate about technology and innovation, with a particular focus on sustainability. He's often thinking about the future and potential entrepreneurial opportunities. In his free time he likes to write music and play basketball.

Majoring in: Green Economy and Sustainability at the University of Ferrara
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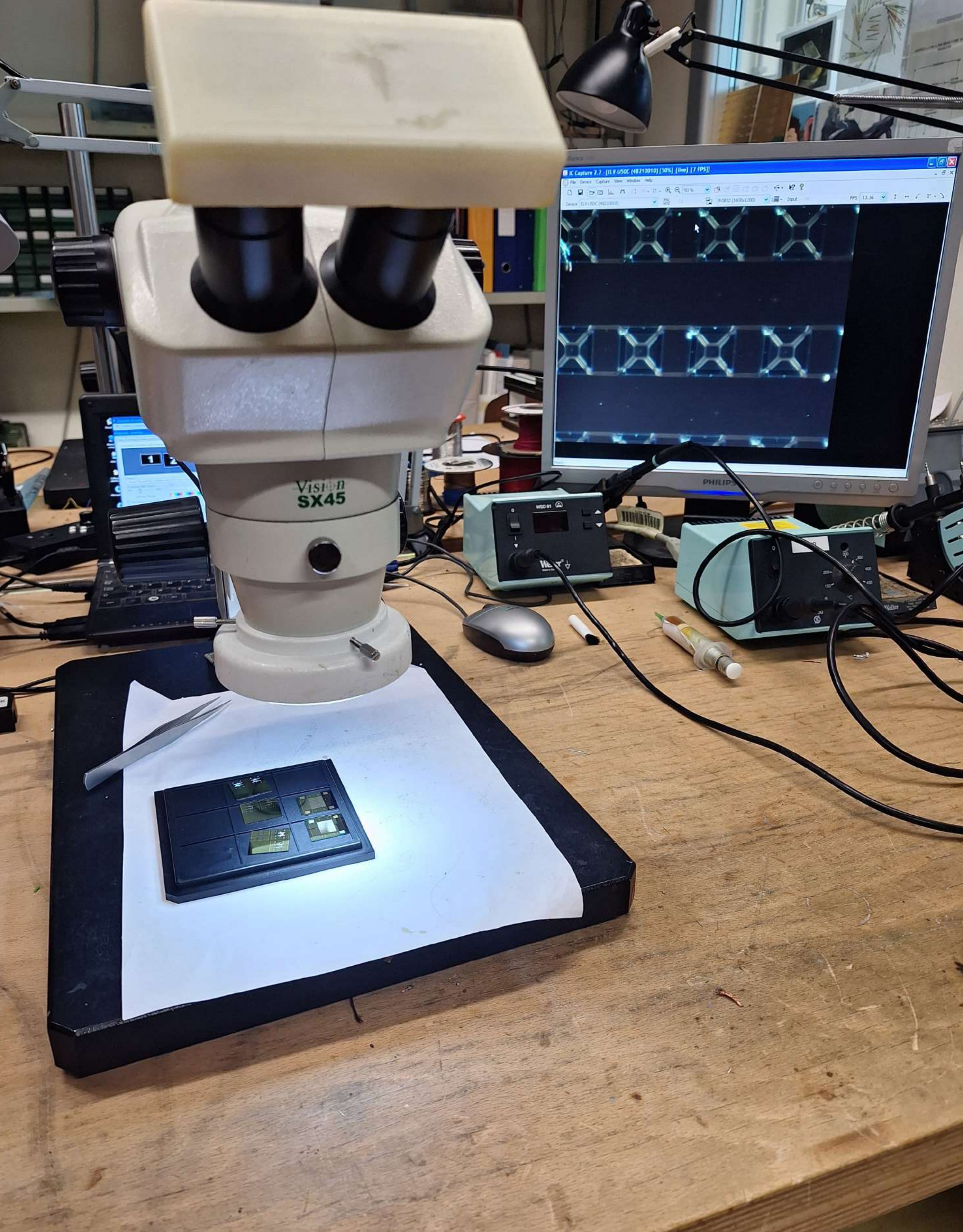
Beatrice Viola Stucchi creates exceptional designs and 3D models, excels in various design and editing software and is actively committed to non-profit voluntary work for refugees, showcasing her dedication and versatility. Her passion for artistic activities lead our team forward to reach success.

Majoring in: Service Design at the University of Bologna
Can be contacted at: beatrice.stucchi@studio.unibo.it

We would also like to thank **Elena Colombo** and **Lucia Monti** for their roles as facilitators and innovation coaches, and **Patrizia Lamberti** for her dedicated support and role as an important point of reference for the team.

From left to right
Tommaso Malaguti, Simone Mascaro, Andrea Daniel D'Ambrosi
Parian Hatami, Alice Turrini, Beatrice Viola Stucchi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H-CUBE: THE TECHNOLOGY

H-cube is a small camera sensor capable of creating hyperspectral images in the sub-Terahertz and Terahertz light spectrum. This is achieved thanks to arrays of micromechanical bolometers, very small trampolines that can vibrate if excited that have been arranged on a silicon chip.

Terahertz radiation is a special kind of electromagnetic radiation. It's one of the most common kinds of electromagnetic radiation, as it is emitted by every molecule that exists, and it's known to be able to penetrate almost every material (with the exception of metals and water). Most importantly, it's non-ionizing, which means that it's safe for living beings.

As every molecule vibrates, the vibration produces Terahertz rays. This means that, for example, we could detect them in the same way we would with a fingerprint, enabling us to assess the material properties of an object just by measuring which THz rays it's emitting. This is called passive acquisition. From this assumption, Terahertz could also be produced by a light source to be detected by a camera, exactly like a photo flash but for Terahertz. This is called active acquisition.

Using active acquisition, we could shine light onto an object/surface in order to look for specific material properties we would like to detect. An example of this process could be shining the light to detect a fracture in an internal structure that would've been impossible to detect otherwise. But unfortunately, Terahertz radiation has been very difficult to detect. There are already technologies that mainly work using CMOS sensors, but they are limited and cost a lot.

That is why h-cube's impact is truly remarkable, in particular when it comes to the camera sensor's capability of detecting THz light using a fraction of the power of current CMOS applications' detection methods.

When it comes to production, the process to create the h-cube sensor is compatible with conventional methodologies used by the chip manufacturing industry. Finally, the output: h-cube is capable of creating hyperspectral images of a very large part of the Terahertz spectrum (0.1 to almost 10 THz).

When we combine all these characteristics, we get h-cube: a portable, low-power and capable sensor, which could revolutionize the way we look at the Terahertz spectrum.

3.1 Tech Partners

We would like to thank our tech partners for allowing us to work on h-cube:

- **Asteria Business Development**
- **Consorzio Nazionale per le Ricerche (CNR)**
- **Elettra Sincrotrone Trieste**
- **Fondazione Bruno Kessler**
- **Research Center for Non-Destructive Testing**
- **TeraVil**
- **University of Eastern Finland**
- **University of Salerno**

Countries involved:
Austria, Finland, Italy, Lithuania, United Kingdom

METHODOLOGY AND SUMMARY OF PHASES

As we mentioned previously, the CBI.ATTRACT program used some key concepts from the fields of tech-driven innovation processes and human-centered design thinking.
The 4-month long program was structured in three different phases: Discovery, Design and Development.

4.1 Discovery

Two different kinds of discovery were the main focus of this initial phase: the discovery of our assigned technology, of which we knew nothing about, and the discovery of our dynamics as a team of people who did not know each other and had both different academic backgrounds and ways of working as a group.

In this initial phase, we gained a comprehensive understanding of h-cube, our assigned technology, and all the essential concepts of physics that were necessary to understand how everything worked.

As the first milestone we decided to bring forward five fields of application: art and restoration, telecommunications, food manufacturing, healthcare and legal screening.

4.2 Design

In this phase, we narrowed down the applications of our assigned technology by conducting a multiple factor decision making including ease of entering market, profitability, feasibility, readiness of the technology and so on.
After this milestone we were left with two fields of application, healthcare and art, and a difficult choice to make in regards to our final choice.

4.3 Development

The development phase was the moment in which we had to decide which of the final applications we designed we would want to bring forward. We had a tremendously hard time opting between the fields of healthcare or art and restoration. In the end, we opted for the art and restoration field, where we created a device for the layer analysis of paintings.

In this phase our knowledge and dedication were transformed into a tangible prototype which we could test and showcase in the real world. Our solution was then developed around the final application. Our final prototype had two main components: a software and a device.

Regarding the development of the device, we worked in Almalabor's makerspace to create a physical model and test it for the final milestone.

FIRST PHASE: DISCOVERY

In this initial section of the report we will present our main activities and discoveries of the first phase of the program.

5.1. Group dynamics and team conduct

Our first ever meeting was quite an essential one. To start, we took some time to get to know each other as people before starting to work together. We also set up a few rules to make sure everyone was on the same page regarding shared workload of tasks and personal expectations regarding the program.

To do so, we briefly talked about our academic backgrounds and personal interests, the reasons why we decided to apply for the program, our strengths, weaknesses and past experiences in regards to group projects. This allowed us to set realistic expectations regarding our future months of collaborative work and to better know our respective fields of expertise; it's important to note that this activity wasn't done with the idea to delegate each given task to the "most competent" member of the team, but as a way to know in which areas we could rely more on the input of specific members of the team. After this meeting, it was time to get to work on the technology.

5.2. Understanding the technology

In order to be able to work on the project, everyone in the team had to have at least an adequate understanding of the various components and physical properties of our assigned technology.

After thoroughly reading the tech card provided to us by our team of researchers, we tried to identify a number of key concepts and words that we thought would be important to understand.

Some of the words we selected were micromechanical, bolometer, array, terahertz, imaging, and non-ionizing. After everyone in the team had a satisfying understanding of these words, we had a chance to figure out the way our assigned technology worked.

5.3. Divergence and idea generation

At this point we had two main tasks: think divergently, as a team, in order to brainstorm potential fields of applications for our innovative technology and start looking for people of interest to interview and consult, especially with our first international mobility fast approaching.
Let's proceed in order. Before brainstorming, we mapped out a list of h-cube's main characteristics, functions and possible applications. Here we can see a picture of one of our earliest brainstorming sessions, in which we mapped out everything we just mentioned. We started by making a simple summary drawn on a piece

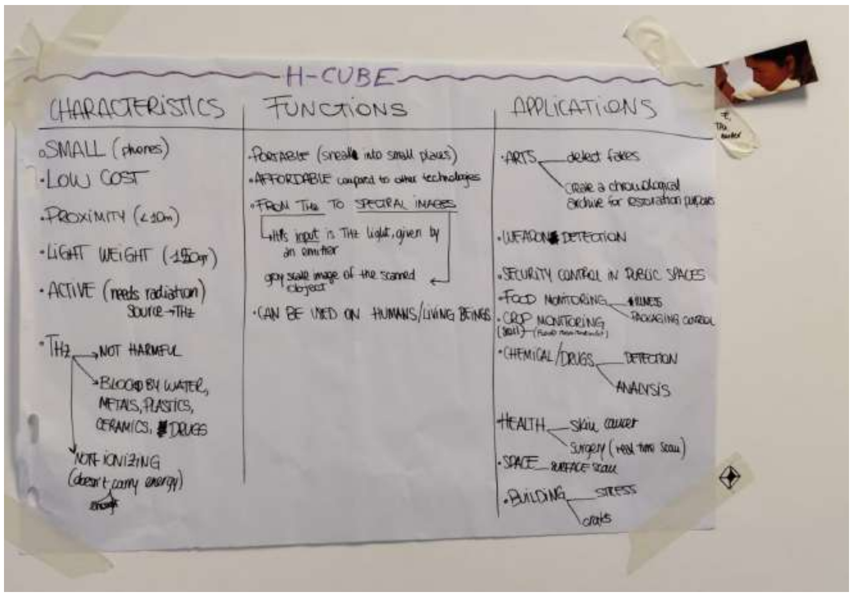


Fig. X – A physical summary of h-cube's characteristics, functions and applications. Regarding the Dune sticker placed on top of our summary, we would like to remind everyone that no member of team h-cube endorses the actions of Paul Atreides.

Afterwards, we moved on to the digital word to create a more complete map which included more considerations, alongside some thoughts on possible fields of applications that we could explore thanks to h-cube:

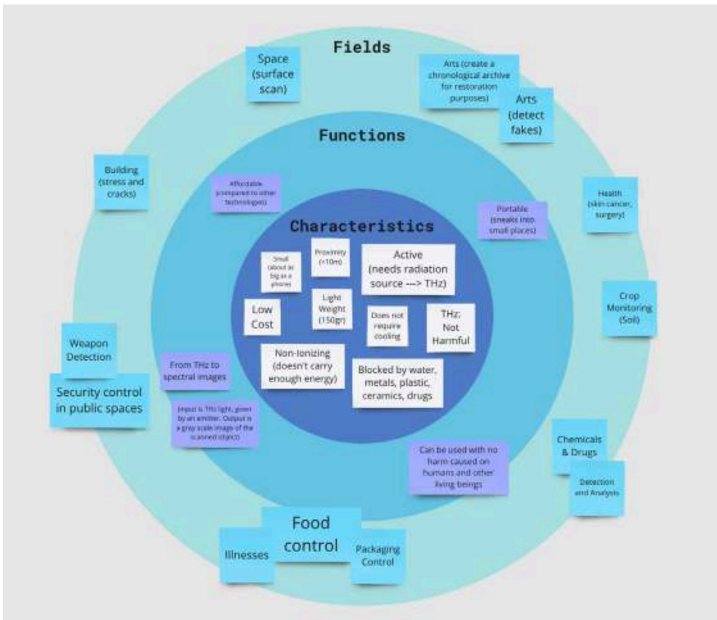


Fig. X – A digital map of h-cube's characteristics, functions and applications.

5.4. Strengths, weaknesses and limitations

While it's important to remember that the h-cube technology is still in development, we have discovered the main strengths and weaknesses of the current iteration of h-cube to be:

STRENGHT	WEAKNESSES
Portability: h-cube is quite small (15cmx10cmx10cm)	Must be in close proximity: <1cm
Light-weight (<5kg)	Requires high stability
Not harmful to living beings: non-ionizing, non-disruptive	Current iteration is active (but researchers are developing a passive application that already works in the lab)
Output image is coloured: returns hyperspectral images	The technology is active, which requires an expensive source
Long lasting lifetime	Readout of the images is quite slow (around 10s)
Low energy consumption	Readout of the images is quite slow (around 10s)
No cooling system needed	Unable to see through metals (metals block terahertz light)
Current technology is very sensitive, but still active	Optical lenses are quite difficult to manufacture
Low cost: ~2000€	

5.5. Initial Interviews

A key activity of this first phase of discovery was interviewing experts. We had the chance to talk to a number of experts pertaining to different fields in order to do some preliminary research on our selected fields of application.

We had the chance to have a chat with two members of ADVACAM, a company working in partnership with CERN. These were Martin Tyburec, head of marketing and communications, and Jan Jakůbek, co-founder and CSO of ADVACAM. With them we discussed the potential of h-cube, especially in the field of food monitoring.

We had a brief call with Hamed Shaker, a physicist who collaborated for over eighteen years with CERN. We followed Dr. Shaker's advice and did further research on the properties of h-cube's sensor. His guidance helped us narrow down our scope in regards to some fields.

Among some of the experts we contacted during this phase, we were also lucky enough to have some connections with some people who helped us in this phase of discovery, such as Sara Baccini, a friend of Viola, who as a technician in the restoration of cultural heritage gave us some valuable insights on common restoration practices. Or Michele Mascaro, our team member Simone's dad, who is an expert in the field of food monitoring and gave us guidance regarding possible applications of h-cube in the food industry.

5.6. Visit at CERN'S IdeaSquare

As part of our project, we had the opportunity to visit CERN, the European Organization for Nuclear Research. We mainly stayed at Ideasquare, where we attended lessons, participated in activities and shared joyful moments together.

While we were at IdeaSquare, we had the opportunity to do some activities for teambuilding, we became more familiar with the different SGDs and had the chance to work on our projects while being surrounded by different experts that helped us with our work. Fun fact to mention, but we also had the chance to meet Robert Cailiau, the co-founder of the world wide web. It was an inspiring moment, and it was exciting to learn about the history of such an important invention directly from him. We even had the chance to share a fondue dinner with him!

We were also lucky enough to have an interview with Giovanni Anelli, head of the Knowledge Transfer programme at CERN. His insights on the way CERN operates in some aspects, alongside his advice on how to tackle some problems were essential to the smooth continuation of our work. He also got us into contact with Francesco Taccetti, Coordinator of INFN-CHNet (Istituto Nazionale di Fisica Nucleare, Cultural Heritage Network), who works at Opificio delle Pietre Dure in Florence.

Upon returning home, we quickly followed up on Dr. Anelli's advice and interviewed Dr. Taccetti, who was very enthusiastic about our project and put us into contact with some experts who were working with Terahertz in the art restoration field, which is exactly what we were looking for.

5.7. Fields of application

After an initial phase of brainstorming and divergence, we settled on five different fields of application. To better understand them, we have employed the use of an *Evidence-Problem-Opportunity frame*, which helped us to better understand the various characteristics of each field. The five fields that were taken into consideration were the following: *food monitoring, art and restoration, telecommunications, legal screening and healthcare.*
Here's a few considerations on the problems and opportunities of each of the five different fields:

Food Monitoring: we found evidence of THz application in the development of sensors that can help detect if food such as dry fruits, chestnuts and dry nuts are either healthy inside or spoiled without the need to destroy or damage the fruit in any way. This has proven to be an interesting field, as food manufacturing is a sector with quite a lot of interest from investors and with a possible high impact when it comes to quality control and loss resource prevention.

Art and Restoration: regarding this field, we found some papers that proved the potential use of THz in different sectors of the arts, such as in preventive conservation and layer analysis for fake detection. In particular, the possibility of transporting the h-cube device instead of moving the precious artworks was found to be of particular interest to our team, researchers and art experts we interviewed.

Telecommunications: the most ambitious of our proposals, our idea was to use the h-cube sensor to enable further developments of new telecommunication technologies in the 300 to 500 GHz region.

Legal Screening: one of the initial fields explored by our researchers, legal screening is a field in which h-cube could be used to create tools capable of quickly detecting things such as weapons and other illegal items, enhancing the security in a wide variety of different places and occasions.

Healthcare: we have found a possible application in the realm of skin tissue analysis with a particular focus on skin cancer detection. The flexibility and portability of h-cube would allow us to bring a new kind of device that could help doctors in having an easier time diagnosing melanoma as quickly as possible, greatly reducing the mortality rate.

5.8. Milestone I

To close this first phase off, we prepared a presentation containing our findings and considerations regarding the five fields of applications.

After our showcase, we had a call with all our tech partners to hear their considerations regarding the feasibility of each of the five applications and their own personal preferences. Following our discussion with them on our ideas and after listening to their feedback, we had to cut out two of the five fields of application.

After careful consideration, the two fields of application we decided to cut were legal screening and telecommunications. We cut legal screening for a multitude of reasons, ranging from the limitations of the Attract program on the usage of the funded technologies for applications that could be used in military settings, to strong political and ethical reservations shared between a number of different team members regarding the possibility of working on such applications. Telecommunications was scrapped both because it was deemed too ambitious and far-fetched by the researchers, and also because our team wanted to design something that could potentially be implemented and released in the near future.

SECOND PHASE: DESIGN

6.1 Pretorypes

A pretotype is a draft version of a prototype, made of cheap and easy to find materials (like cardboard, paper, twine, etc.) or digitally crafted to demonstrate only the main functionalities that would be added to the final prototype.

The pretotype should neglect aesthetic value as much as possible. This is because, when showcased to experts, its appearance could potentially influence the feedback experts would feel comfortable giving us. A prototype that has been very carefully crafted could put the experts in a position where they would feel bad about giving negative (but fundamental for us) feedback on our idea.

The pretotypes we made for this phase were both physical and digital. In particular, we designed a physical pretotype for our art application and two digital pretoypes for the food and medical fields.

6.2. Pretotype interviews

After our pretotypes were made, we did an additional round of interviews to receive some feedback on them and see if there was any critical problem we might have missed.

We interviewed Dr. Raffaella Fontana, Dr. Valentina Di Sarno and Dr. Alessandra Rocco , three physicists from CNR- National Institute of Optics (INO). They were kind enough to chat with us for about an hour, and were very surprised to hear about h-cube's incredible characteristics. Their enthusiasm for our pretotype was an important reason for our decision regarding which field of application we decided to develop a solution for.

Regarding the healthcare field, we interviewed two people, Martina Bedeschi, a pharmacist, and Marco Morante, a dermatologist. They were also quite enthusiastic about our program, and provided us with precious insight on the way things work in the healthcare field. They helped us visualize how a hospital operates and the way doctors and patients interact with each other.

6.3. Personas and user journey

Personas are fictional characters created based on some kind of research (in our case, through the information we gathered both online and from some interviews we conducted with field experts) in order to try and understand the way our end users would use our proposed solution. We then decided to make two personas: one for the healthcare field, that was meant to embody a potential patient that noticed a suspicious mole on her skin, and one for the art field, who is a museum curator in the process of dealing with the restoration process of a valuable artwork.

Along with these two user personas, we also made two potential user journeys for them. This allowed us to notice some potential pain points for both kinds of users, and enabled us to address these problems and find effective solutions. The creation of these two personas and user journeys also helped us create a convincing presentation for the second milestone

6.4. Visit at the research partner's site in Trieste

In Trieste we visited our partners at the Elettra Sincrotrone laboratories to see the real h-cube technology in action. After months of teamwork on the project, countless interviews and pretotypes, it was awesome to see the technology working in real life.

With our tech partners, we discussed some of the most promising fields and better understood the current capabilities of h-cube, all while keeping in mind the possible further developments of the tech. Thanks to these discussions with the laboratory's experts, we understood that we had to cut the food monitoring field in favor of the more promising art and medical fields.

To conclude the visit we had a long team dynamics session and a fantastic dinner as a group, together with prof. Vignoli and our tech partners.

6.5 Milestone II

Having reached the end of the design phase, it was time for our team to get ready for the second milestone. At this point, we had two fields of application remaining, respectively healthcare and art, as food manufacturing was scrapped following some feasibility concerns that we'd found about during our visit to Trieste. Once again, we started with a brief presentation of h-cube, which this time was followed up by a more in-depth exploration of our pretotype's potential impact on the world.

To showcase this, we created different personas for our two fields of application which we paired with their two potential user journeys. Giulia, our persona that notices an unusual mole on her skin and has to go through a grueling gauntlet of hospital calls, bookings and appointments to get her skin checked. We imagine that she would have been happy to save a considerable amount of time and energy by using our proposed device, powered by h-cube. On the other hand, our second persona Marina would really appreciate the peace of mind that would come with not having to move precious artworks around.

After our presentation, we talked again with our research partners to bring them up to speed on our latest findings and ideas. We knew we had to choose a final field of application to work on, but this time we found it very difficult to agree as a team on which one it should have been. But this was a necessary step before moving to the final phase, so after consulting with our coaches, using tools such as decision charts and following plenty of long and lively internal discussions, we settled on the art field on a majority vote. Other decision factors of relevance were our interviews with the previous art experts, the high feasibility of this field's application, and finally our desire to contribute to something that's characteristic of Italy, our country: wonderful artworks. With our final field of application chosen, it was time to get ready for the final phase of this program. **Let's continue.**

THIRD PHASE: PROTOTYPE

7.1 Protorype

A prototype is an early sample, model, or release of a product or service built to test a concept or process. It's often a visual demonstration or model that mimics the final service and its functionalities. Prototypes are created to see how users interact with them and to see if they have positive experiences. They come in various forms ranging from basic, low-fidelity models to high-fidelity digital versions with interactive elements. In this way it's possible to test concepts, identify problems, and refine the product before it goes into full production.

On the other hand, a Proof of Concept (PoC) is used to test and/or verify the validity of the principal product idea. It's typically used to assess the feasibility of the idea before substantial resources are committed to its development. A PoC is often represented in the form of documentation or as a presentation, wireframes, or some combination of all three.

While a PoC is used to determine whether an idea is viable and technically feasible, a prototype is used to visualize the product, test its design, and improve it based on user feedback. Both are crucial steps in the product development process but they serve different purposes and are used at different stages.

In our case, as we didn't physically receive the technology from the tech partner, we decided to prototype our service around the Proof of Concept design. Therefore, to complete the PoC of our service, we needed to develop a hardware and a software part. Our physical prototype has been built to showcase the main features we have identified in the discovery and design phases of the program. In particular:

- Its scanning capabilities in the XY plane, to scan a painting fixed to the wall in a stable and controlled way to be able to later reconstruct the final image.
- Its easy portability, meaning the prototype is easy to transport by a single person and easy to build on the scanning site.
- Its usage safety, as the prototype can be used by the technician without having to wear special equipment.

To accomplish the goal of respecting the main features, we have decided to build a moving cart that, thanks to a linear actuator, mimics the way already existing "automatic wall printer motorized carts" function.

In order to complete the prototype, it was essential to create a digital counterpart that simulates how the software would behave in respect to the user interaction and what images would be displayed in it for the user to analyze. The digital prototype programming was carried out in Figma.

In order to make sure our proposed prototype made sense, we had two interviews with Dr. Antonino Cosentino, the current director of CHSOS, who is also a physicist specialized in imaging and analytical techniques for art examination. He very kindly listened to us and was excited about our project. Dr. Cosentino shared with us some interesting facts about the state of the art research regarding Terahertz analysis in the field of art and restoration, shared with us some thoughts on the typical process he undergoes every time a client purchases one of his company's services, and finally gave us some feedback on our idea for the prototype. This interview was extremely helpful to us, as it gave us confidence on the fact that there actually was a market for our solution, and that we were heading in the right direction.

7.2. Business model canvas

In order to properly assess the business part of our project, we decided to construct a business model canvas, a tool which is a key part in understanding the real potential of a possible business, its feasibility, and how we intend to create and distribute value for us and our potential stakeholders.

The business model canvas is a visual representation of the various elements of the business model and it is made up of nine different parts. We'll go through them extensively:

- **Value proposition:** it explains why a customer should buy our service, and what they gain in terms of added value. The basic service that we provide is the detection of fakes and the layer analysis of paintings, especially for particular preparatory drawings. What our customer gain for purchasing our product is:
  1. **Reduced cost:** compared to competing companies, our new technology and our revenue model allows us to significantly lower our prices for customers;
  2. **Flexible pricing model:** related to the revenue mechanism. It allows us to offer a service instead of a single product, so that we may tailor the price of our service to the needs of every customer without forcing them to purchase the whole product;
  3. **No transportation risk:** due to the intrinsic characteristics of our technology, we can travel directly to the customer and perform the analysis in a relatively short time. This can relieve them from the high risks, expensive costs and time consuming bureaucratic procedures that come with the process of transporting art pieces to distant laboratories;
  4. **A precise imaging that's non-disruptive:** h-cube's technology is non-ionizing, which means that both the analysts and the artworks will be safe while under analysis;

5. **Avoid the closure of museum or other relevant buildings:** since our solution is safe for people and artworks, there is no need to close museums and buildings to potential visitors, enabling the continuation of the service even while the analysis is currently undergoing;
6. **Saving up on insurance money:** insurance costs can be considerably lowered, as there is no need for transportation;

- **Customer segment:** it explains for which customer we are creating value. Our customers are:
  1. **Private collectors**
  2. **Auction houses:** especially for fake detection;
  3. **Museums:** especially the larger and most important museums;
  4. **Restoration labs**
  5. **Studios**

- **Distribution channels:** this section explains through which channels our customers want to be reached. Since our business model is based on a service, we mainly think that we can reach our customers through in person appointments (delivering service), virtual or phone consulting and with a cloud service delivery system;

- **Customer relationship:** explains which types of relationships our customer segments expect us to establish and maintain. Since we offer a tailored service for each of our customers, we expect to establish a dedicated personal relationship;

- **Revenue steam:** explains the revenue model and how we intend to deliver value. We operate in a B2B2C environment, since we expect our customers to be both businesses and consumers. Our main revenue model consists in selling the layer analysis service to our customers. We also want to offer expertly tailored consulting services related to artwork authentication, restoration, conservation, and evaluation based on the results of our analysis. Lastly, we intend to offer training programs, workshops and seminars on painting analysis techniques, conservation methods, and other similar activities;

- **Key resources:** this section explains what are the key resources that we need in order to deliver our value proposition. The relevant resources that we need are:
  1. **Human capital:** technicians, software engineers and at least one art expert to help us with evaluations;
  2. **H-cube sensor:** the main technology in our solution that enables us to deliver our expected value;
  3. **Proprietary software:** a software capable of visualizing the analysis in depth;
  4. **Hardware parts:** mainly for our technology's movement;
  5. **Emitter:** an emitter for terahertz and other frequencies;
  6. **Insurance**
  7. **Cloud memory**

- **Key activities:** explains which are the key activities that we need in order to deliver our value proposition. The activities in question are:
  1. **Data collection:** mainly in regards to the layer analysis;
  2. **Software maintenance**
  3. **Imaging collection**
  4. **Hardware maintenance**

- **Key partners:** it explains what are the key partners that we need in order to deliver our value proposition. The partners we consider are relevant are:
  1. **Server providers**
  2. **Hardware suppliers**
  3. **Art restoration lab**
  4. **H-cube's research lab:** the provider of our main technology;
  5. **Art insurance companies**

- **Cost structure:** explains which are the most important costs inherent to our business model. We can divide costs into two different parts:
  1. **Fixed costs:** these are the expenses that remain the same no matter how much a company produces, and are: office rent, utilities, and cloud server rent;
  2. **Variable costs:** these are the expenses that change based on how much a company produces and sells, and are: salaries, maintenance, travel, hardware supplies, marketing and communication;

7.3. Ethics canvas

Before moving on with our final prototype, we decided to consider the ethical implications of our work. We reflected on the possible implications of our prototype in regards to the individuals and groups affected, and the possible cases in which our prototype could either be used in problematic ways or fail.

Working in the art sector has luckily granted us the ability to dodge a lot of the possibly difficult ethical questions we would have had to answer if we only considered our sensor, h-cube. As it stands, we don't think the existence of our service could cause any meaningful damage to anyone. It would also not disrupt any existing jobs, as it would become just another device in the toolbox of art restorers and analysts. We can confidently say that the only ethical impact our service could reasonably have is making the life of art forgers and scam auction houses harder. Convincing our team that this would be a negative development would be a hard sell.

7.4. Proof of concept: building the physical prototype

Building the physical prototype of the device that will include the h-cube technology was a very important part of our job, as it was necessary to showcase the real-world application of the technology in our selected field.

To construct the physical part of our final prototype, we used the laboratory located in the makerspace. In particular, we used the soldering station, the 3d printer, a wood laser cutter, some electronic parts and testing equipment to build the electrical circuits that power the moving cart and the cart itself.

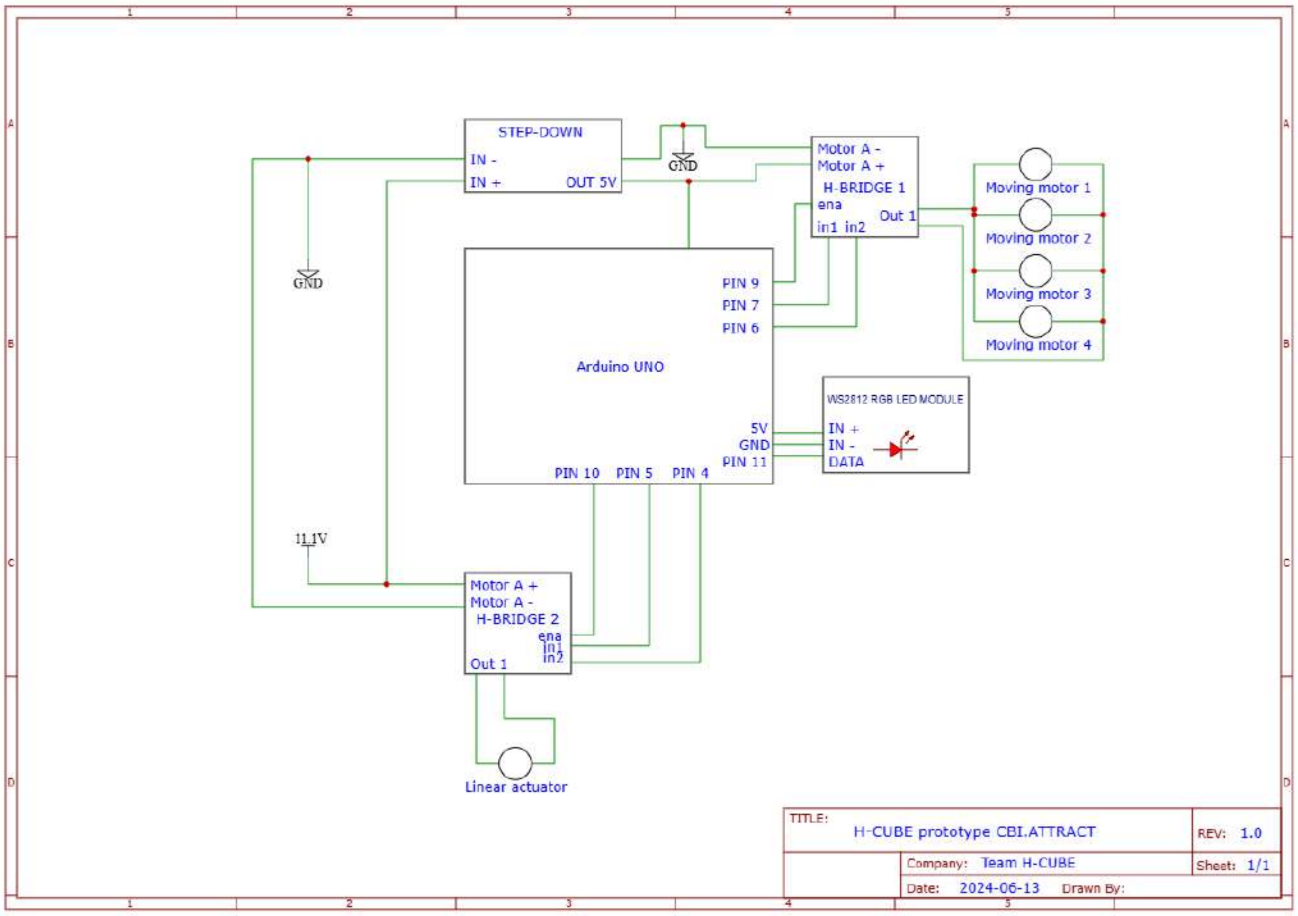
The physical prototype is based on a moving cart with four motorized wheels. The cart has a removable linear actuator that can be mounted and fixed in a 3d printed (designed by the team) and can be fastened in the middle of the cart.

On top of the linear actuator, a lifesize simulated version of the h-cube camera is placed. The camera is a wood cutted box featuring the h-cube word engraved on the side and a RGB LED ring that simulates the Terahertz light source, which can be turned on/off by the electronic board to simulate the acquisition of images and different kinds of Terahertz light.

The configuration was inspired from motorized automatic wall printers. If the cart is placed parallel to an artpiece, it can move on the x axis thanks to its motorized wheels and on the y axis using the linear actuator, making it a wall scanner capable of capturing small and stable images. These images will then be reconstructed by an external software in order to generate one high resolution big image.

Our prototype's moving cart has been programmed on the Arduino IDE and electrically designed around the Arduino UNO R4 minima development board.

For an easy carrying experience, the prototype can be disassembled by removing 2 screws, one located at the camera and the other at the base of the linear actuator. The quick process of assembling and disassembling the prototype doesn't take more than 2 minutes and doesn't require special tools or equipment to be carried. Not only that, but it also doesn't endanger the technician or anyone that might happen to be nearby.



7.5. Team poster and tech poster

In anticipation of our final milestone we had to prepare two posters: a poster showcasing our service, HCB (powered by h-cube!) and a poster showcasing us as a team.

In order to do this, we began by agreeing on a style that would be coherent with the aim of our service, our values and personal preference, and finally the main objective of our communication. We decided to settle for a simple and elegant approach. To do this, we took inspiration from the principles of the International Typographic Style and the Swiss School.

We also picked a font (Montserrat) that was clean, sans serif and free for commercial use, and a main color to complement our shades of black and white. We settled on a bright, energetic and lively shade of yellow.

e8c534 **000000** **f3bf35**

Ho usato il giallo senape a sx, ma vorrei stampare anche con questo giallo più ricco

H-CUBE

Montserrat bold 128p

See through the ordinary

Montserrat semibold italics 48p

Our service enables museums and private

Montserrat regular 32p

Ritratto di

Montserrat regular 24p

H-CUBE

See through the ordinary

CBI Attract 2024

Anonimo, Ritratto di:
GIOVANNI PIETRO MOLINELLI,
Palazzo Poggi

Our service enables museums and private collectors to analyze the hidden layers of paintings through a THz detecting camera, revealing hidden details revealing hidden details such as preparatory drawings

7.6. Assembling the teaser video

Finally, we were also tasked with making a teaser video showcasing our final prototype. This was a complex task, so we divided it into smaller, more feasible tasks and tackled them one at a time.

We began by drafting a script for the video, which started at about 260 words and got progressively cut down in size, reaching less than half of the starting word count. To start things off, we designed a clever narrative hook to get viewers interested in watching the entire video. The idea was to introduce a twist in the narrative as soon as possible in the hopes of convincing viewers to stick through the entire tech/service presentation. We based our narrative hook on a recent paper[1] written on THz Time-Domain Imaging in which researchers found a preparatory drawing of a woman wearing a large summer hat under a forest landscape.

As another goal for the video, we really wanted to showcase the key strength points of h-cube. To do so, we made a simple storyboard containing some of the key frames we wanted to include in the video, frames in which keywords written in large text would appear on screen followed by a brief vocal explanation on how they were related to our tech.

We also got in contact with Bologna's prestigious scientific museum of Palazzo Poggi, which kindly allowed us to film inside a few of their rooms and even showed interest in our proposed technology! After getting their approval and filing a couple of modules, we proceeded to film the footage we needed for the video with the help of Francesco Marinelli, a freelance video maker based in Bologna which we had hired with our team budget. We also took this opportunity to shoot some pictures for our final deliverables and our two posters. Afterwards Andrea, one of the members of the h-cube team, recorded the voiceover for the video and sent it to Francesco, which edited everything together and created the final teaser video

1 Fukunaga, K., Ueno, Y., Watanabe, C. et al. Nondestructive Observation of Multilayered Paintings on a Single Canvas by THz Time-Domain Imaging and X-ray Fluorescence Elemental Mapping. J Infrared Milli Terahz Waves 45, 124–140 (2024). https://doi.org/10.1007/s10762-023-00963-w

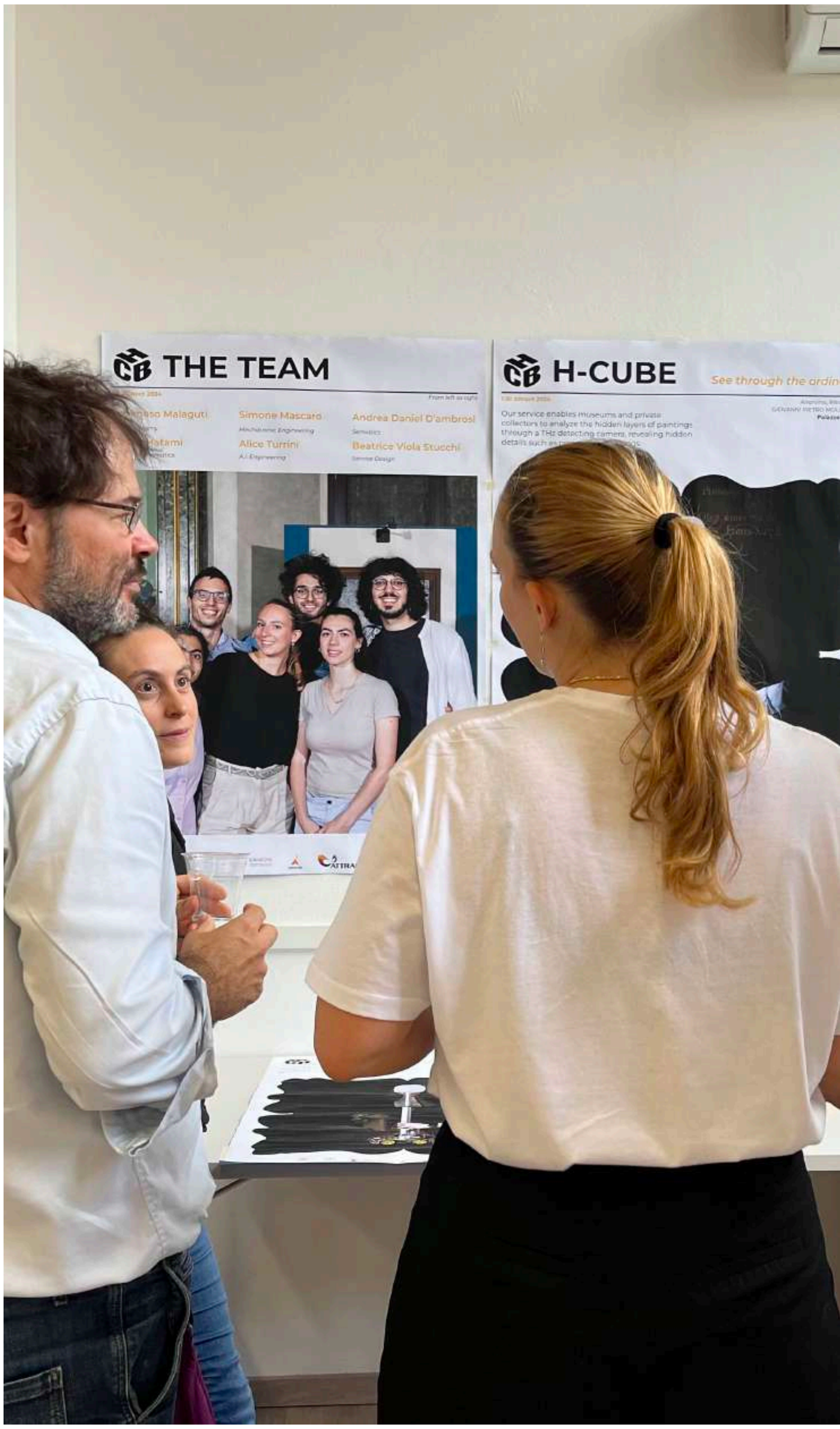
7.7. Milestone III

To wrap things up, we'll briefly discuss our last presentation for the third milestone. Since we knew that this time we'd be presenting at an event open to the public, our objective was to create a presentation that was both informative but also full of interesting moments for the public, in order to keep their focus up over the course of our allocated twelve minute time slot.

In order to do this, we had to grab the public's attention right away: we opened with a narrative hook, showcasing an untitled oil painting that depicted a forest landscape, and then asked the public what they thought they were looking at. Most people answered with a series of words ranging from trees, to a forest, to small horses (which are depicted in the picture), to a combination of all these words. So we proceeded to show that there was something hidden under the painting: a preparatory drawing of a woman wearing a necklace and a large summer hat, hidden under the layers of paint and only noticeable thanks to a Terahertz analysis.

After this initial hook, we then proceeded to talk in depth about HCB, the service we imagined using h-cube. We then proceeded with an explanation of our strength points, a brief user journey detailing the way our clients would be able to interact with us and future services.

We concluded our final presentation with a lighthearted joke about hidden layers in famous paintings that caught our audience by surprise, and with a closing soundtrack of applause, our CBI. ATTRACT journey was over.



CONCLUSION

CBI.ATTRACT has been an innovative, inspiring and challenging program.

We are proud to have been part of this program, and we are thankful to everyone that helped us complete our project in some way or the other: from the wonderful coaches, who guided us for the past four months and acted as inspiring mentors during some challenging times, to all the experts and tech partners we interviewed during the course of our project, who generously offered us their time and expertise, and finally to all of our colleagues, who we shared some wonderful moments with, becoming good friends in the process.

During CBI.ATTRACT we learned how to work as a team on difficult tasks that required the knowledge and expertise of multiple people. We had the chance to earn the trust of our colleagues and learn when some tasks should be delegated to someone else you know you can rely upon. We learned to work on projects that reside outside of our comfort zone, all while interfacing and collaborating with people from different academic and social backgrounds.

We are very proud and satisfied with the work we created during these four months, and we hope our ideas will be of use to the researcher's team or to future people involved in art restoration, be it private owners or museum curators. This has been a transformative experience and we are very grateful to have had the chance to participate in this program.

Alice Turrini
Andrea Daniel D’Ambrosi
Parian Hatami
Simone Mascaro
Tommaso Malaguti
Beatrice Viola Stucchi