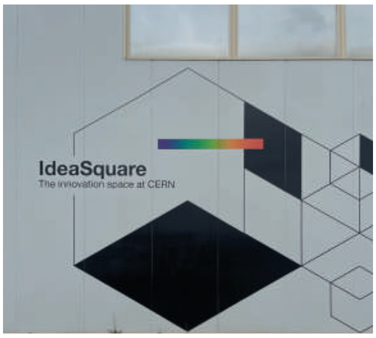
This report presents the process of development and the proof of concept of an innovative service solution obtained during the CBI Attract programme. The project is called Panákeia and represents a systemic solution between different actors which assist in detecting Xylella in its early stages directly on the field.

This report aims to present all the steps followed during the challenge-based innovation process in order to arrive at the final solution. Moreover, this document recognises the presence of pending opportunities for further exploration.

Index of



contents

Introduction

CBI ATTRACT represents one division of the second phase of the ATTRACT EU project, an innovative endeavour that unites Europe's fundamental research and industrial communities to spearhead the advancement of cutting-edge detection and imaging technologies. It addresses societal challenges in the spirit of open innovation to create concepts that contribute to the United Nations Sustainable Development Goals. (ATTRACT, n.d.)

During the first phase, the project successfully identified and provided financial support to 170 groundbreaking technological concepts within the realm of detection and imaging technologies across Europe. ATTRACT introduced the ATTRACT Academy in the second phase. The network comprises ten university projects that aim to generate ideas for social innovation, drawing inspiration from the technologies developed in the research, development, and innovation projects of the first phase. Within this network, CBI ATTRACT emerged as a collaboration between the University of Bologna, the University of Modena e Reggio Emilia, the University of Ferrara, and Almacube.

The programme methodology is a hybrid model based on the human-centred approach of Design Thinking and Tech-Driven Innovation processes. Its objective is to identify and evaluate technology opportunities with societal impact on a global and local level. During the programme, specific technologies are assigned to multidisciplinary teams with the objective of innovating new potential fields of application that extend beyond their current scope of use. (ATTRACT, n.d.)

The programme is structured into three distinct phases: discover is about exploring and gaining a comprehensive understanding of the technology, design phase emphasises on understanding the needs and experiences of users or customers, and development is dedicated to transforming conceptual solutions into tangible outcomes.

Six thinking hats

This section will present the six thinking hats that generated the ideas presented in this report. "Six Thinking Hats" and the associated idea "parallel thinking" provide a means for groups to plan thinking processes in a detailed and cohesive way, and in doing so to think together more effectively. (de Bono, 1999)

The fundamental premise of the method is that the human brain employs a multitude of distinct thought processes, which can be deliberately challenged and subsequently utilised in a structured manner. This allows for the development of strategies for thinking about specific issues. De Bono identifies six distinct directions in which the brain can be challenged. In each of these six directions, the brain will identify and bring into conscious thought certain aspects of the issues being considered.

the Red Hat

Anna Aldini

Mechanical engineering. She is the feeling and emotion of the group even though she hardly expresses them, but this is why she is perfect for the role, the red is recommended to be used for a very short period to get a visceral gut reaction, we usualy propose a voting.

Alessio Conti

Artificial Intelligence. He sees the big picture. At the beginning of every meeting, he is the referent for the "recap point" leaving us forward to discuss how the meeting will be conducted and to develop the goals and objectives.

the Blue Hat

the Yellow Hat

Chiara Detomaso

Service Design. She is the positive one, not knowing exactly what the problem is about but strongly believing it can be solved. The yellow is used to have a "Plus, Minus, Interesting" view of the fact being discussed.

the Green Hat

Giuli Guazzo

Environmental Economics. She is the proposal of new ideas because a question from the green hat is always a PO, a provocation is an idea which moves thinking forward to a new place from where new ideas or solutions may be found.

Manikanta Gutha

Advanced automotive engineering. Mani is the one in charge of developing criticisms of the solution set, he has a natural gift which resulted to be very useful to aim high but act concretely.

the Black Hat

the White Hat

Yasas Sajana

Physics. The project began with him on the first day when we had an extended white hat action, during which facts were assembled about our technology. Yasas metaphorically represents a “pause button” when pressed information comes out.

the Sentinel

Alessandro Cacace

Philosophy. The sentinel is the figure that assists the aforementioned six thinking hats in addressing problems from a variety of angles and focusing on deficiencies in the way that they approach problem-solving.

Tech and Partners

After a quick introduction to the team and the program, it is time to discuss the technology, the pillar of this project. POSiCS (POsition-sensitive Silicon-photomultiplier Compact and Scalable) is a radiation imaging camera equipped with a solid-state position-sensitive light detector capable of detecting beta and gamma rays, proposed for radio-guided non-invasive surgery for tumour removal. (Kurfess, J. D., Johnson, W. N., Kroeger, R. A., Phlips, B. F., & Wulf, E. A., 2010). It seeks to be more capable of finding the right target and minimising the impact of the surgery on people. (ATTRACT, 2023)

Posics is a cost-competitive, handleable, wireless, compact, and lightweight camera with features such as promptness, sub-millimeter spatial high-resolution imaging, and quick image-capturing. Due to its versatile nature, the device is not confined to being used in the surgical field alone but can be adopted into multiple other fields to showcase the true potentiality of the camera.

(image) POSICS-2 - Position-sensitive SiPM Compact and Scalable beta-Camera (Phase 2)’

Who is POSICS-2?

The laying stone of the technology started with the thought of the on-site accessibility of Radiographic imaging techniques in the mind of the nuclear physicist named Domenico Della Volpe who is currently aligned with CERN and the Université de Genève working with the group of people focusing on the experimental Astro/particle physics. Domenico was able to transform his idea into a working prototype with funding from the ATTRACT project, in collaboration with the Fondazione Bruno Kessler, Trento (Italy), and the research group of the Hôpitaux Universitaires de Genève. After the successful development of the working prototype, the POSICS camera is currently being tested on rodents for a final assessment of camera performance under the guidance of the Hôpitaux Universitaires de Genève, which has a worldwide recognized expertise in the field of Radiographic imaging. This is the first step towards the adoption of POSICS cameras into Radio-Guided Surgeries. In conclusion, with the collaborative efforts from the partners, the development of the POSICS camera marks a significant advancement in the field of radiographic imaging, promising a great scope for precision and accessibility in medical imaging by revolutionising Radio-guided surgeries.

to obtain **sight** or **knowledge** of for the first time

definition retrieved from Merriam-Webster

Discover


POSICS-2 — understanding the technology
Collision at CERN — A place where people have the licence to dream.
Methodologies — A pomodoro and some double-diamonds
Keep Listening — voices from expert corridors
Milestone
y Phase
PANÁKEIA | DISCOVERY PHASE

POSICS-2 — understanding the technology

The science behind the project

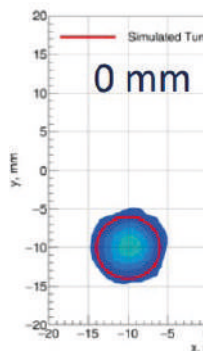
As mentioned above, The POSICS-2 camera introduces a groundbreaking approach in intraoperative practices for Radio-Guided Surgery (RGS), moving away from the current probe-based methodology. Demonstrated during ATTRACT Phase 1, the POSICS-2 features a custom position-sensitive sensor capable of achieving sub-millimetre spatial resolution with fewer than eight readout channels for a 3.0 cm x 3.0 cm surface area. This scalability allows the number of channels to increase linearly with the array's linear size rather than quadratically as is typical.

Numerical simulations indicate that the POSICS-2 camera can efficiently detect very small tumours (3 mm in radius) within seconds, even deep within the tissue. The camera's larger field of view reduces localisation time and allows for adjustable exposure times to balance statistical noise with real-time feedback. While it cannot provide full 3D insights, the ability to reconstruct tomographic images from different views significantly enhances diagnostic accuracy, especially for deep-seated or overlapping lesions.

The POSICS-2 camera's resourceful design allows it to operate with both beta and low-energy gamma emitters, named radiotracers, making it suitable for a wide range of applications beyond RGS.

Radiotracers are radioactive substances used in medical imaging to diagnose and treat various conditions. They emit radiation (Gamma and beta rays) that can be detected by a sensor panel, such as the POSICS-2, allowing doctors to visualise parts of organs and tissues that may be affected. In the context of cancer, radiotracers help to locate tumours and assess the spread of cancerous cells. Their ability to provide real-time, detailed images makes them invaluable in diagnostic and therapeutic procedures, thus enhancing the efficacy of the POSICS-2 camera.

It can be used in both outpatient treatments and intraoperative surgeries. The project aims to develop a full-scale prototype ready for real-life applications, targeting a Technology Readiness Level (TRL) of 6. As a benchmark, the device will be tested on SLN biopsies and mammary cancer, representing a broader class of applications involving low-energy gamma radiotracers. Although the project's timeline and budget constraints preclude extensive clinical trials, pre-clinical trials will validate the system on real biological tissue, ensuring a practical demonstration of the concept and achieving the project's goal of TRL 6. (Acerbi et al.,2019)



Strengths and uniqueness

The POSICS-2 camera outstands due to its innovative design and adaptable capabilities, offering several key strengths and unique features:

Minimally Invasive and Highly Accurate: POSICS-2 supports the ongoing trend toward minimally invasive surgical interventions, improving patient outcomes and quality of life. Its ability to detect very small tumours quickly and accurately, even deep within tissue, underscores its potential to enhance diagnostic precision and surgical effectiveness.

Compact and Lightweight Design: The camera's wireless, handheld, and compact form factor makes it highly manoeuvrable and easy to integrate into various surgical settings. This design reduces the physical burden on healthcare providers and enhances operational flexibility.

Sub-Millimetre Spatial Resolution: The custom position-sensitive sensor achieves sub-millimetre spatial resolution with fewer than eight readout channels, offering high-resolution imaging essential for precise tumour localisation.

Scalability and Efficiency: The scalable design of the POSICS-2 camera allows for larger imaging areas without a proportional increase in complexity. This scalability ensures that the device can be adapted for a range of medical applications, maintaining efficiency and effectiveness.

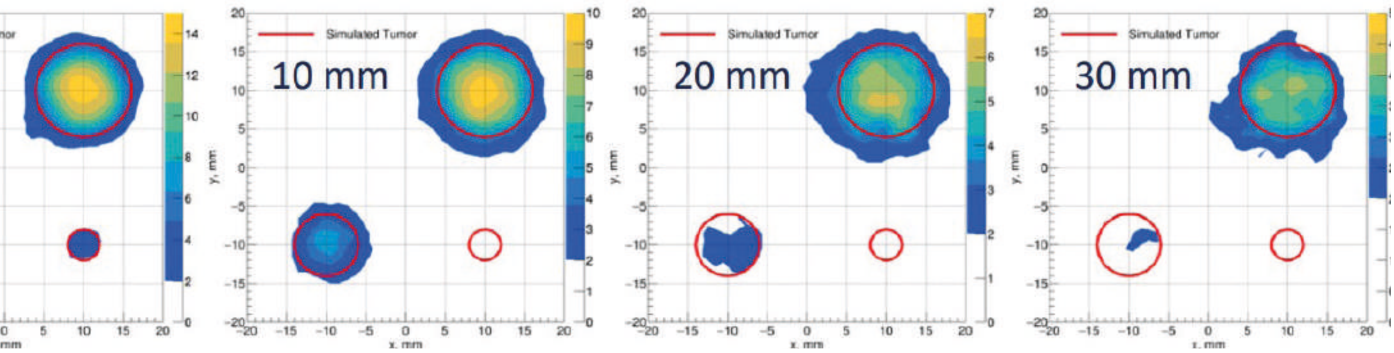
Dual Modality: POSICS-2's capability to work with both beta and low-energy gamma emitters broadens its application spectrum. This dual modality allows the device to be used in various clinical scenarios, from outpatient treatments to intraoperative surgeries.

Real-Time Feedback and Adjustable Exposure: The camera provides real-time imaging feedback, with adjustable exposure times that enable users to balance noise levels with the need for timely information. This feature is crucial for making immediate, informed surgical decisions.

Potential for Diverse Applications: Beyond its primary use in RGS, POSICS-2's design allows it to be employed in numerous other fields, including pre-operative and intra-operative phases.

Pre-Clinical Validation: The commitment to pre-clinical trials on real biological tissue ensures that the POSICS-2 camera will undergo rigorous testing and validation. This process is critical for demonstrating the device's practical efficacy and reliability in real-world medical settings.

(image) Reconstructed image of the same tumours for an acquisition time of 20 seconds but situated at different depth into the body.



Collision at CERN — A place where people have the licence to dream.

As it has been stated previously, the goal of the CBI programme is to find an innovative use for the assigned technology that will have a positive impact on society. The main goal for the week was to understand impacts, make informed decisions, identify opportunities and anticipate challenges. To do so, Ideasquare allowed us to meet renowned experts, ground-breaking researchers, professors and even students to discuss with and interview. This helped us explore the unexpressed potential our technology might have. Moreover, the experience included theoretical lectures and practical group activities which provided useful insight to further expand divergent thinking.

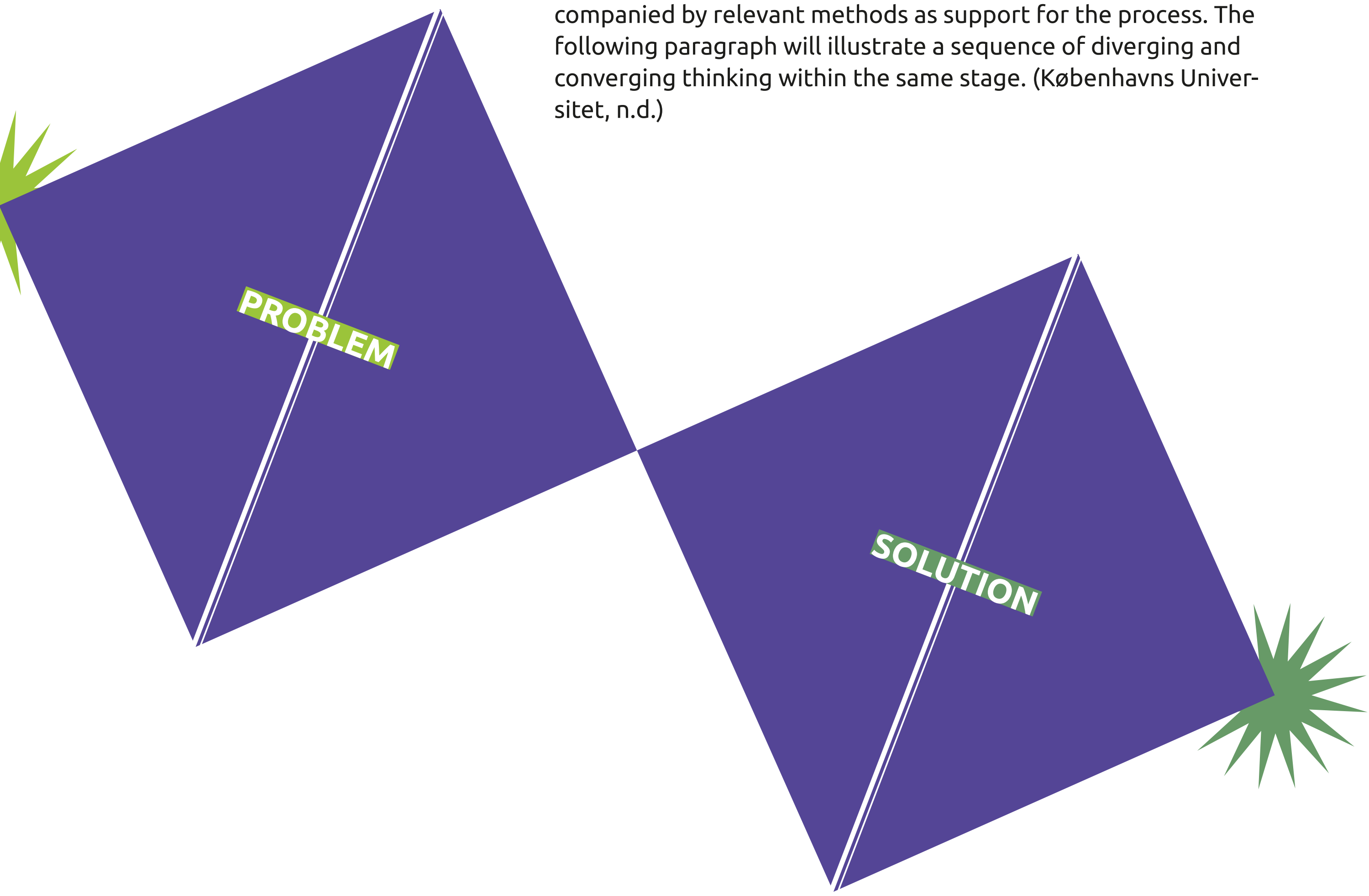
(image) the team at the science gateaway at CERN

Methodologies — A pomodoro and some double diamonds

The double-diamond design proces

The double-diamond is a visual model that facilitates comprehension of the design process. The model's near-universal appeal stems from its uncomplicated concentration on both the problem and the solution. In fact, the Double Diamond illustrates two distinct activities in design: problem-finding and problem-solving. Both approaches make use of the duality of divergent and convergent thinking. (The Fountain Institute, 2023)

The divergent thinking is characterised by a free-flowing, non-linear approach, which facilitates the acquisition of multiple perspectives and angles on the project. In contrast, the convergent thinking is focused and linear, enabling the project to be narrowed down to a manageable and deliverable scope. It is possible that the process may necessitate the divergence and convergence of ideas on more than one occasion within the same stage. This sub-alternative represents the project's stream of thinking. Each stage (Discover, Define, Develop and Deliver) could be accompanied by relevant methods as support for the process. The following paragraph will illustrate a sequence of diverging and converging thinking within the same stage. (Københavns Universitet, n.d.)



Pomodoro timing

At this point in the process, we were unable to enter the Define stage due to a lack of information. Our previous work had focused on critical thinking, and we had not yet gathered the necessary data. In any case, a convergent phase was required to evaluate the ideas proposed in terms of their relevance to the application fields and their potential to address specific problems within those fields. In order to achieve this, the SDGs were employed as a tool for voting. The integration of the SDGs into the project framework was undertaken to identify the key advantages of the selected opportunities from the perspective of these large-scale, globally recognised goals. (United Nations, n.d.)
The Pomodoro technique was employed to ensure that biases did not influence the voting process. (Cirillo, 2018)

The voting process was divided into the following tasks:

20 minutes to read, implement and ask questions about each application for each field

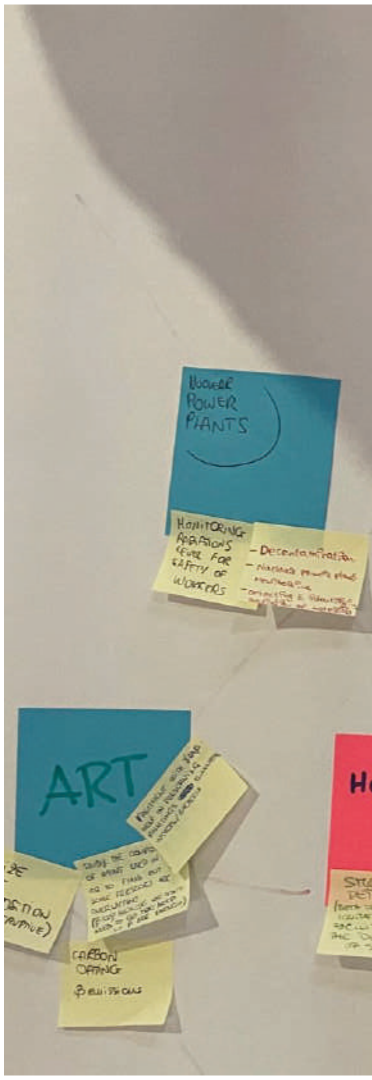
10 minutes break

15 minutes to combine various SDGs to the applications

5 minutes break

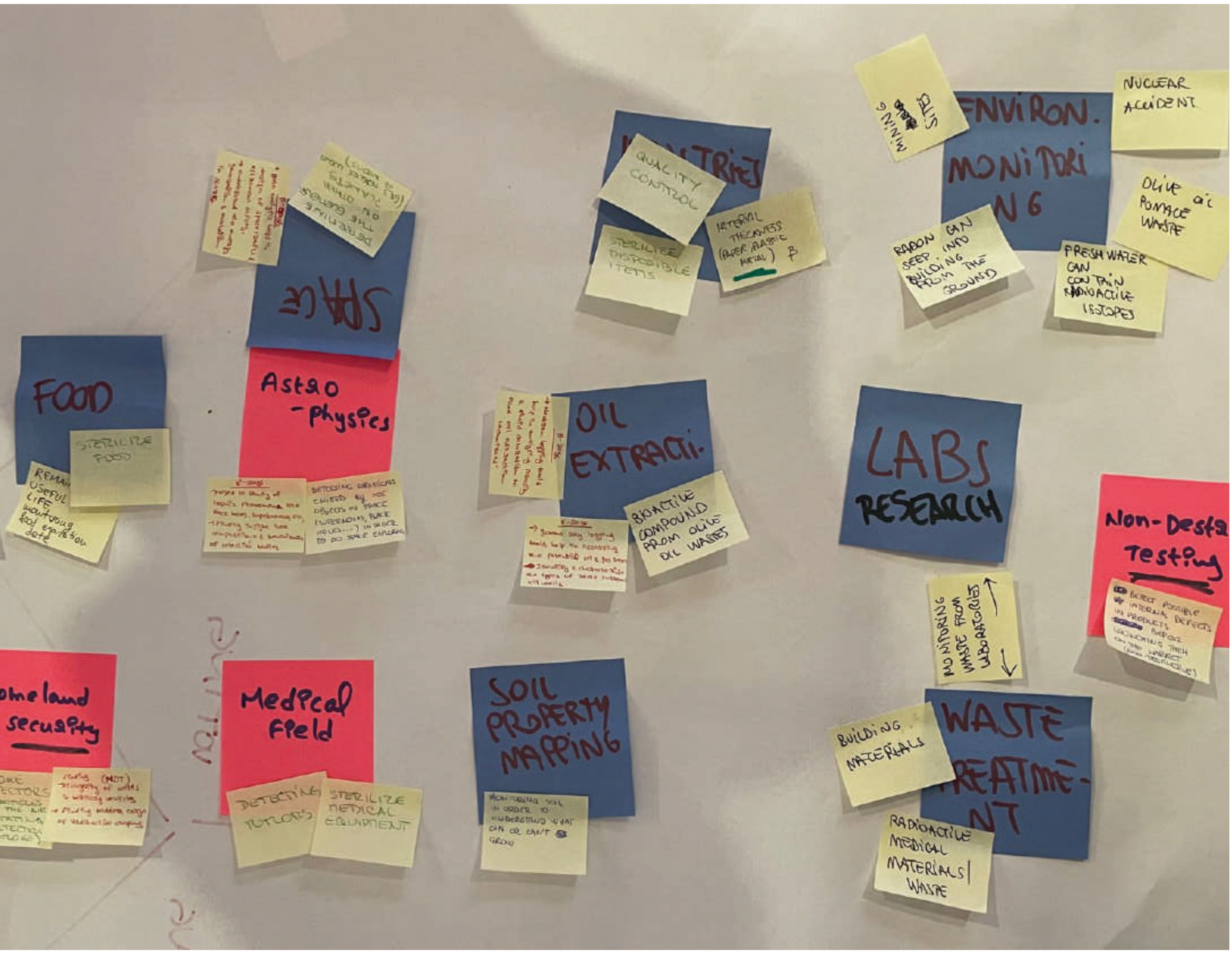
10 minutes voting based on the most combined SDG

With this method the content was reorganised into a divergent map, which is made of circles. The technology is located in the centre of the map, with the inner circle representing the functions, which represent literally what the Posics does. The middle circle represents the applications, which are the fields in which Posics would have an impact. The outer circle represents the needs that our technology would solve. Attached to every need is a list of the various Sustainable Development Goals in which the single need would have an impact.



(United Nation, n.d.) The SDGs, or Sustainable Development Goals, are a set of 17 global goals established by the United Nations in 2015 as part of the 2030 Agenda for Sustainable Development. The SDGs are aimed at tackling poverty, hunger, environmental sustainability, and other pressing issues.

(Cirillo, 2018) The Pomodoro Technique is a time management method developed by Francesco Cirillo in the late 1980s. The technique employs a kitchen timer to divide work into discrete intervals, typically 25 minutes in duration, interspersed with brief intermissions. Each interval is designated as a pomodoro.



Divergent map

(image) Pomodoro Planner: analysing SDG impact

The Discover stage initiates a solution space and investigates a broad range of ideas and opportunities. We employed the MindMap tool to gather input and thoughts about the technology and to present those ideas on paper, primarily in the form of post-it notes. This approach allowed us to visually represent relationships between ideas. We focused on our technology's functions to explore the most promising fields of application and surrounded each one with several examples of concrete applications. Finally, we added a dot voting system to assess the SDGs in relation to each example. A post-it-shaped mind map was created, which resembled a galaxy of possible applications linked by the satellite impacts between the examples.

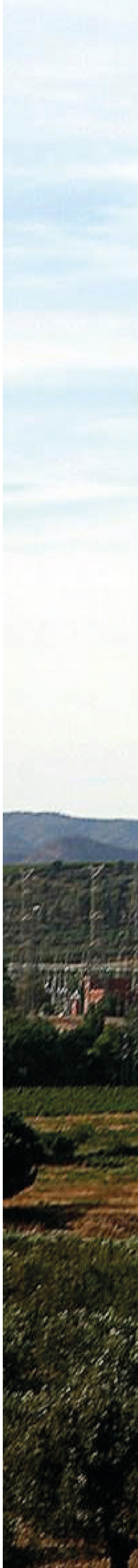
Fields of application

Throughout the process, we aimed to strike a balance between realism and creativity, ensuring that our ideas remained grounded while retaining an element of imagination and possibility. We selected four main opportunities:

Environmental monitoring and waste treatment

Environmental monitoring of radiations refers to the observation, measurement, and analysis of radiation levels in the environment. This includes tracking both natural and man-made sources of radiation to ensure they remain within safe limits, to assess potential health risks, and to take appropriate actions if unsafe levels are detected.
The device could bring much value in this scene given its imaging capabilities. Follows the main areas in which we considered useful having a portable gamma imaging device:
- Analysis of radiation impact of nuclear disasters on local fauna and flora.
- Sampling of soil, groundwater, and seawater to detect contamination levels as well as specific areas in which the concentration is higher.
- Checking for radon presence in construction fields and in houses in exposed areas.
- Regular monitoring of workers and tools within areas of high risk of exposure (healthcare, industries, mines).

The last area regarding radiation level monitoring is particularly necessary in the scenario of waste treatment. The task involves addressing the levels of radioactivity present in waste products and materials. This is crucial in ensuring that radioactive waste is handled, stored, and disposed safely to prevent environmental contamination and protect human health. The process includes regular surveillance, assessment of radiation levels, and adherence to regulatory guidelines.
An imaging device addressing the configuration of radioactive materials in disposal warehouses makes the process more precise and safer. Accurate handling of radioactive materials can help in optimising space and store the materials only for the necessary time.
The use of cameras then can be helpful to assess structural integrity of containers for sign of corrosion, damages or leaks.



Food and Agriculture

Radiation in the context of food and agriculture involves the use of ionising radiation to improve food safety, enhance agricultural productivity, and monitor environmental conditions.
The primary techniques include:
- Irradiation for food preservation of spices and herbs to eliminate bacteria, moulds, and insects. This process helps in maintaining the quality and safety of these products without affecting their flavour or nutritional value.
- Radiotracers for studying agricultural processes, especially to understand the dynamics of agricultural systems, such as nutrient uptake, water movement in plants and presence of specific pathogens.

The former technique can highly benefit from a high precision camera imaging for spotting if the food is properly irradiated. The latter benefits from the use of a portable camera to perform live monitoring directly in the field.

Art research

Radiation in the context of art research involves using the ionising radiation to explore the painting and the sculptures that are intertwined within our history.The ionisation radiation has the capability to deeply penetrate into the painting exposing the layers behind the painting that are not visible to the human eye. The same methodology can be used when exploring sculptures to avoid damages that the sculptures are subjected to during the necessary transportation to testing facilities .
The Prime benefits of the using radiation for the art research include:
- Avoid damaging the art during the testing
- A great possibility to explore the internal composition of the art.

Ground-breaking research

Radiation, both ionising and non-ionizing, plays a crucial role in advancing scientific research and developing new technologies. These applications span various fields, including medicine, materials science, space exploration, and environmental monitoring. The unique properties of radiation allow scientists and engineers to probe the fundamental nature of materials, develop innovative treatments for diseases, homeland security and explore space and planets.


log in.
SUD
L2

Domenico della Volpe tech partner and **Aramis Raiola** POSICS team member

Voices

Interviews with partner Domenico Della Volpe and the POSICS2 research team from University of Geneve initially had the objective to understand the key values of the device. It proved extremely important to understand the reasons behind their design choices so as to understand which aspects and characteristics make it a unique device.

Of particular interest was the interview with Aramis Raiola, one of the team members. We had the opportunity to discuss with him our initial ideas regarding the different areas of application that we thought were promising. *(see above)* This discussion with him was valuable in validating some of our ideas in relation to the device's capabilities at this stage and taking into account future developments.
The most discussed characteristic was its modularity, which allows the sensor to adapt to different sizes. Another factor considered was the field of view. For application fields other than medicine, where the device is used a few centimetres away from the subject, it is necessary to rethink the depth and width of view accordingly. Some proposed improvements involve the use of collimators, or employing a pinhole camera technique, depending on the specific requirements for each alternative scenario.

While discussing the most promising new applications, we were particularly intrigued by the suggestion of exploiting the capabilities of the sensor to display in real time the flow of radiotracers after injection. This was something that had always been considered in the background of our minds while conducting research.

CERN experts and researches

Voices

During our visit to CERN, we had the opportunity to discuss with various researchers who employ similar technologies to POSICS.

This allowed us to gain a deeper understanding of the current research priorities in the field of gamma and beta radiations. We interviewed different people that gave us interesting information about their research work.

Magdalena Kowalska explained to us technicalities about laser spectroscopy and Beta-NMR applications to biology. Giving us insights about possible interesting applications in non destructive testing and educational purposes given the compactness of the device.

With Ana Rita Pinho we explored more the field of material analysis and biological imaging; trying to understand the fit of the device in the industry given its characteristics, especially timing and high spatial resolutions.

We then had the chance to speak with Alessandro Raimondo working at CERN's Knowledge Transfer Group for medical applications. He suggested we exploit the portability of the device. For instance, having a device that could be used directly into the field and greenhouse to detect if plants have been attacked by pests or have some diseases. One example is the case of Xylella, an invasive pathogen that attacks the water vessels of plants like olives and grapes, causing debilitation of the plant leading it to death.

For the initial milestone presentation, we conducted a detailed investigation into the various fields identified at CERN. Our findings revealed that these fields could be classified into two primary scenarios.

Therefore we designed a two-layered presentation, highlighting the presence of a naturally radioactive source versus the use of an external source of radiation. We presented the ones that for our understanding had more impact on society combining the insights we had from the interviews and the desk research. The proposed fields of application are as follows:

I Milestone

we discussed with the technical partner to gather feedback on his interests and the feasibility concerns of the different ideas. Among the five proposed, the three most interesting ones were identified for further research:
The top three choices were the following:
01. Health status in plantations
02. Non Destructive Testing for art
03. Food Monitoring

Layer 1 — presence of naturally radioactive source

Layer 2 — human-made source of radiation

Food Monitoring

Up to 60 countries in the world have adopted food irradiation techniques and many more will follow in the future for different types of foods. [The united states food and drugs administration]

The proposal is to measure the correct exposure of the irradiated food ensuring a uniform treatment in real time, enhancing the reliability of the process.

Radiation levels monitoring

Radon is the cause of up to 14% of lung cancers. This gas is colourless, odourless and radioactive. It originates from the natural decay of uranium in soil, rock, and water. Long-term exposure to high levels of radon can lead to lung cancer and the risk for people is higher in areas with significant uranium deposits in the soil.

Our proposal is to exploit the portability and high sensitivity features of the device to perform environmental monitoring detecting radon presence in the soil. Assessing environmental safety for residential, commercial, and agricultural lands.

Radioactive waste monitoring

Iinvolves the systematic surveillance and management of radioactive materials produced from nuclear reactors, medical treatments, research facilities, and other sources. This process ensures that radioactive waste is safely handled, stored, and disposed of, minimising risks to human health and the environment.

Our proposal wants to help in this process giving the possibility to have real-time imaging of the radioactivity concentrations within objects and disposal boxes. There is no need to wait anymore for the estimated decay date of each disposal container. This process will optimise storage capabilities and resources of the facilities, while minimising exposure risks for workers.

Health status in plantations

In south Italy more than one-third of the olive plants have been infected by Xylella in the past years. Xylella is a pathogen attacking the plant from the inside, targeting the vascular network's tissues, making the infection imperceptible from the outside.

Our proposal is to create a device that can be used directly into the field making the analysis possible. This will help farmers recognize if a tree is sick on time, reducing the financial losses.

Non Destructive Testing for Art

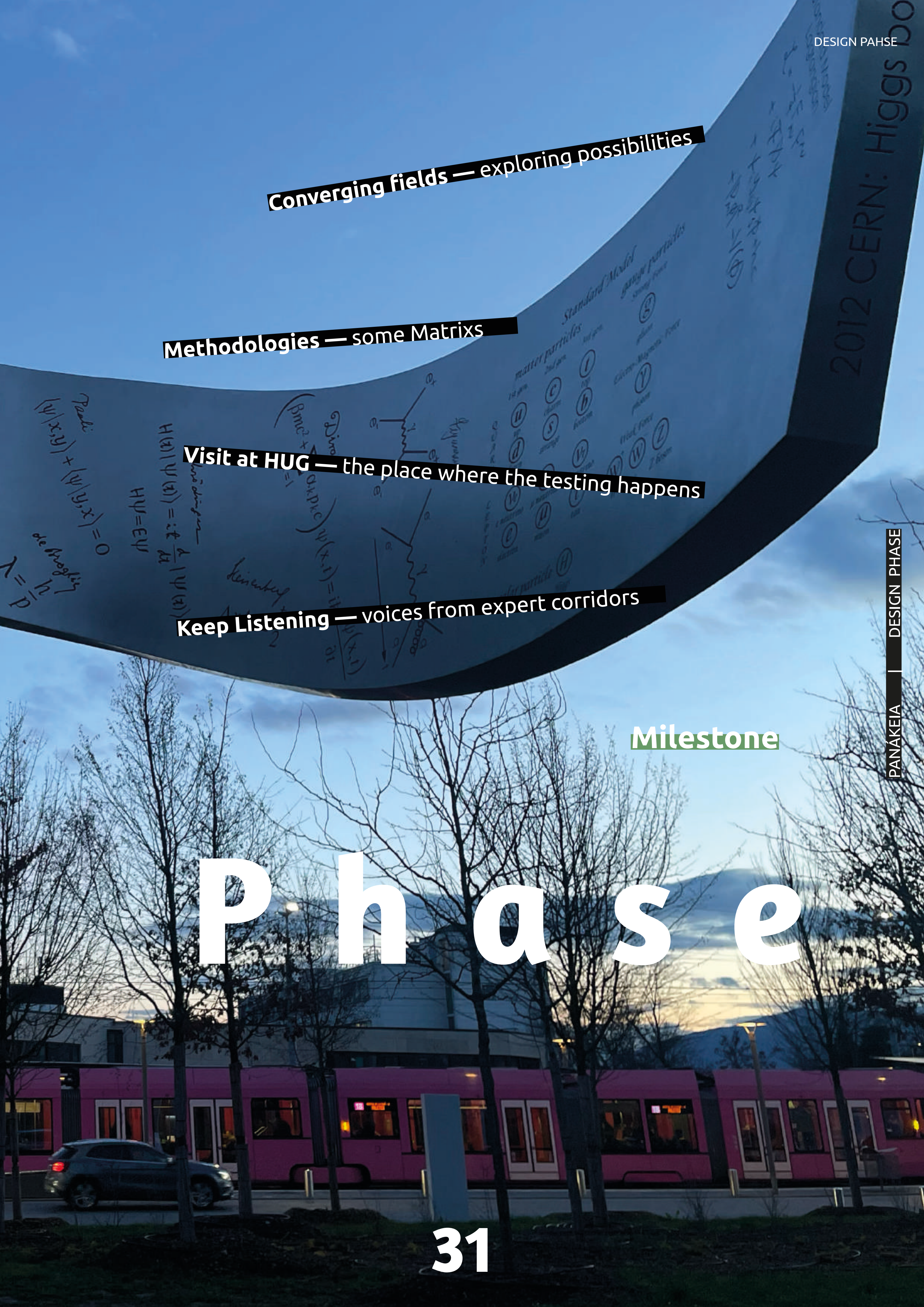
The art industry is a huge market, not only for investors but also for forgers.

Our proposal is to exploit this technology to certify authenticity of artefacts while preserving the integrity of the art pieces. On the other hand the highly penetrating capabilities of gamma radiation can be used to scan the internal structure of sculptures to check their integrity or any defects that can cause major damage to the sculpture itself.

to **create**, execute, or construct according to plan

definition retrieved from Merriam-Webster

Design



Converging fields — exploring possibilities

Methodologies — some Matrixs

Visit at HUG — the place where the testing happens

Keep Listening — voices from expert corridors

Milestone

Phase

Converging fields — exploring possibilities

"What if" as a state of mind

The initial steps in the design phase of the project aimed to substantiate our comments on the adoption of technology in the three discussed fields of application: agriculture, food, and art. Our next steps involved contacting experts in these fields and scheduling interviews. Concurrently, we expanded our knowledge by reading various research journals and articles. During this exploration, we identified three main factors to consider: feasibility, the presence of competitive technologies, and the urgency of the need for this technology in each field. The following paragraphs will discuss our findings related to each specified field as we prioritised them:

(image) the team wearing their new personality minds

Firstly, we will discuss the agricultural field of application. Agriculture is the backbone of every nation's economy, as it meets the nutritional demands of the population through its yields. Any threat to this vital sector can lead to a food crisis and famine. Therefore, we prioritised the agricultural field for evaluating the adaptability of our technology.

During our exploration, we found that disease-causing pathogens are a major cause of the destruction of long-term plantations like almonds, olives, and grapes before they reach maturity. This results in significant economic losses for farmers and impacts national food supplies.

We focused on the possibility of using our technology to detect pathogen attacks on plantations in their early stages before any symptoms are visible. This involves feeding plants with radioactive material through nutrient intake mechanisms like fertigation. Our approach is inspired by tumour detection methods but is more complex due to the need to detect pathogens, which are microorganisms with complete structures, unlike tumours. Interviews with various professionals helped us understand plant architecture and the critical points for detecting pathogens using this revolutionary technology. This novel approach has never been experimented with in agriculture, giving us the freedom to explore its full potential.

Secondly, the most interesting and critic favourite field of application is the art field.

One of the most intriguing aspects of this field is its potential to uncover the secrets lying behind the vast collection of paintings and the sculptures that were the lying stones of our history.

According, our research we found that currently X-ray spectroscopy is used as a non-invasive technique for the detailed internal analysis of the paintings and the sculptures. However, further investigation revealed that the use of X-rays in denser sculptures may pose a risk to the surrounding environment due to the potential for exceeding the recommended dosage levels. So, in this field the POSICS has huge potential to be applied as a Non Destructive Testing technique, a means to understand the external and internal structures of the sculptures with the reduced dosages helping everyone in maintaining the harmful radiation doses in limits.

Finally, we explored the adoption of our technology in the food industry, specifically focusing on the eradication of food wastage.

A currently available methodology that aligns well with our technology is food irradiation, where food is sterilised with radiation. By exposing food sources to high-intensity beta/gamma radiation for short durations, foodborne illness-causing bacteria or insects are eradicated, and the shelf life of food sources is extended.

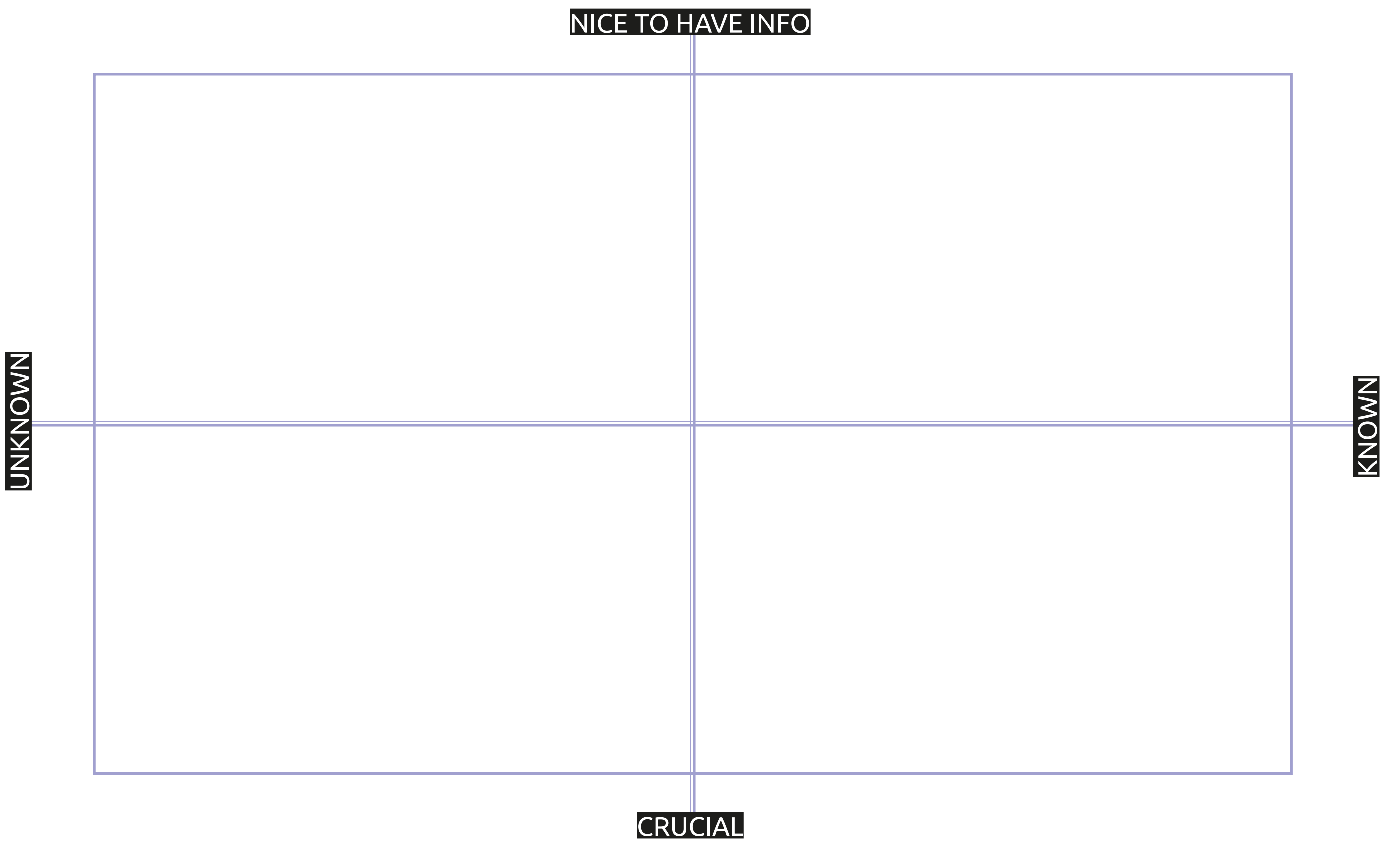
Through several interviews and reviewing various articles, we understood that our technology could be adapted to monitor the effectiveness of food irradiation before the food leaves the facility. The live monitoring capabilities of our device offer a significant advantage over competitor technologies like dosimeters, which fail to provide real-time information on the efficacy of the irradiation process. These findings strengthened our argument for the use of our technology in the food irradiation field, demonstrating its potential to enhance the monitoring and effectiveness of food sterilisation processes.

Methodologies — some Matrixs

The way into finding the right question

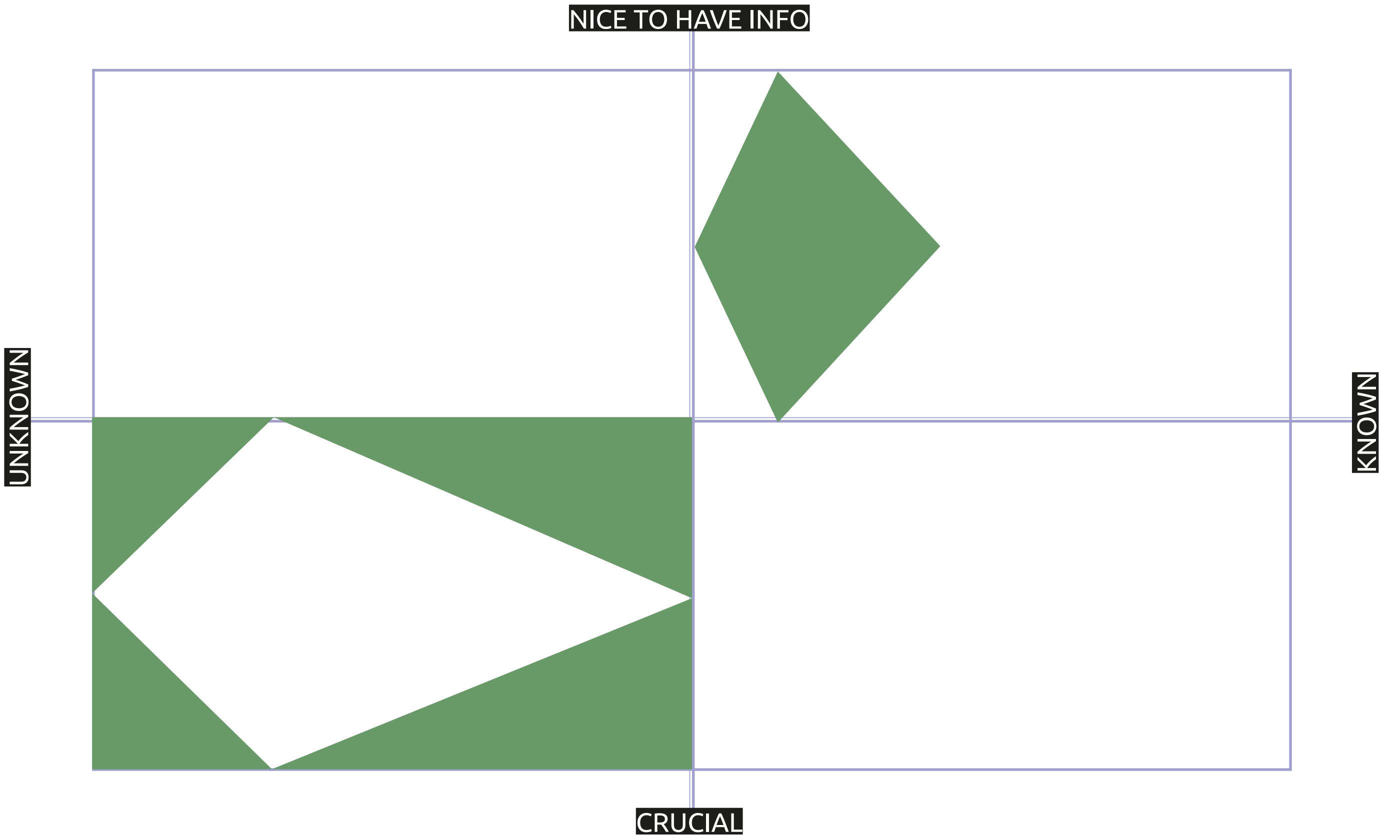
Prior to scheduling the interviews mentioned above, we were introduced to a valuable tool: *the priority matrix*. This matrix helps to prioritise tasks, topics, or projects based on chosen variables such as impact, importance, and effort.
The primary goal of utilising it was to refine our interview questions. By categorising the existing knowledge and identifying knowledge gaps, it was possible to ensure that the questions would be meaningful and relevant. This process was of crucial importance for the effective identification and development of the most viable concept for each field of application.

Thanks to the matrix constructions we had a clearer idea of both our doubts and the topics we had more knowledge about.



As shown in the picture above, the x-axis represents the distinction between known and unknown factors, while the y-axis indicates the significance of questions in terms of concept development. By building the matrix like this, the most important questions to be included in the interviews are located in the second quadrant (high importance and unknown), followed by the ones in the first quadrant (crucial and, at least partially, known).

o1. Health status in plantations



In relation to the agriculture field the main difficulties the team had to deal with were due to the lack of information about Xylella Fastidiosa. (Bucci, 2018) This bacterium is relatively new to scientific research, and as a result, there is limited literature available. Corbellini, G. (2010). Some of the most crucial uncertainties included understanding how Xylella is transmitted to trees, how it moves within the plant's vascular system, and whether it seeks out specific molecules to sustain itself inside the host plant. (Anderson, J. L., Green, R. D., & Parker, M. S. 2023).

Gutha Venkata Ramesh, plant pathologist with a Ph.D. in Plant Pathology from Punjab Agricultural University, India

Voices

The team consulted him to gather insights on plant diseases, particularly their mechanisms of spread, and the water and fertiliser transport systems in trees. This information was crucial for understanding the absorption rate of radiotracers and selecting the appropriate isotope based on decay time. The primary objectives of the meeting was to gain a detailed understanding of plant diseases and how they spread, to learn about the water and fertiliser transport systems in trees, and to assess the feasibility of developing a device to detect Xylella in olive trees or other pathogen in different species.

Then he explained the main difference between bacteria and pathogens: pathogens are microorganisms, including bacteria and viruses, that can cause diseases. Bacteria mostly remain non-harmful, but sometimes can evolve to become harmful, causing diseases in plants, such as Xylella in olive trees. Pathogens have different modes of infection: some pathogens start affecting the plant from the roots, others begin at the leaf level, and some pathogens can be transmitted by vectors like insects, which infect the plant at their feeding site, which is the case for Xylella.

Regarding water and fertiliser absorption, the Dr. detailed that water intake time varies between plants and is influenced by the plant's health: a dehydrated tree absorbs water and fertilisers more quickly than a healthy one. In large trees, water can travel from the roots to the leaves in 6-12 hours, but this time shortens up to 2 hours in smaller plants.

Towards the end of the discussion, the team inquired about the potential utility of a device capable of detecting Xylella in olive trees. Dr. Gutha Venkata Ramesh endorsed the idea, noting that current plant analysis methods are invasive and time-consuming. Typically, these methods require cutting small branches or other parts of the tree and sending samples to labs for analysis, a process that can take several days. A non-invasive, efficient detection device would significantly improve the speed and ease of diagnosing plant diseases. His expertise affirmed the potential benefits of developing a rapid, non-invasive detection device for plant diseases such as Xylella.

Following our discussion, we clarified various doubts regarding common plant diseases and the fundamentals of plant physiology. Conclusively, he suggested future research topics. Our next steps should involve investigating the movement of Xylella bacteria within plants to select an appropriate molecule as a radiotracer. Another critical aspect should be determining whether the injection of radioactive material could harm the plant.

During our research, we found that injecting radioactive material into plants is feasible. Matthew R. et al. explored various isotopes to inject into plants to gain insights into nutrient flow within plant vessels. (Kiser, Reid, Crowell, Phillips, & Howell, 2008) The suggested isotopes included carbon-11, nitrogen-13, oxygen-15, and fluorine-18. The choice among these isotopes depends on their decay time, the type of plant to be injected, and the injection method used (through hydroponic irrigation or environmental absorption)

Lorenzo Marini, agronomist from Stuard Company, Padova

Voices

During this interview we focused specifically on the behaviour of Xylella to determine whether it would have been feasible to detect bacterial clusters.

During the initial part of the interview, we explained the project's objective and our concept of developing a service or product capable of detecting Xylella inside olive trees to halt the eradication policy implemented in many European countries. He expressed great interest in the idea, noting that the same concept could potentially be used in the future to identify different types of diseases and to perform hormonal analyses on plantations, which are currently in high demand in the agricultural field.

He explained that Xylella is a pathogen transmitted by an insect, affecting not only olive trees but also almond and citrus trees, vineyards, and other smaller species. The pathogen infects the plant, causing a reduction in water and nutrient flow due to blockages within the xylem vessels. He also outlined that Xylella can coexist with the plant in a latent state for several years before becoming harmful, transitioning from a symbiont to a pathogen.

He later detailed some aspects of the radiotracer's injection. While the transportation method of Xylella bacteria within the plant remains unknown, he suggested focusing on identifying molecules or nutrients that the pathogen targets. This approach could provide insights into which molecules might serve as vectors for radiotracers *(as previously discussed in this report, the idea is to use a vector, similar to how glucose is used in PET scanning, to detect bacterial clusters)*.
Regarding the absorption process, he also recommended investigating foliar fertilisers, which exploit the high absorption capabilities of the plant's green parts (leaves) This process can be enhanced by using amino acids that facilitate plant absorption.
Given the limited research on Xylella, the expert advised us to focus on herbaceous plants in general. These plants can serve as models due to their similar behaviour and characteristics to a variety of species.

Following our discussion with Lorenzo Marini, it became evident that we needed to consult an expert on Xylella disease to gain a deeper understanding of the xylem network in trees and how it is affected by Xylella. While we had learned that the disease causes blockages in the vessels, we looked out for further insights into its additional effects. This necessity led us to reach out to the next interview.

Enzo Verrastro, agronomist, currently a scientific administrator at CIHEAM, Bari.

Voices

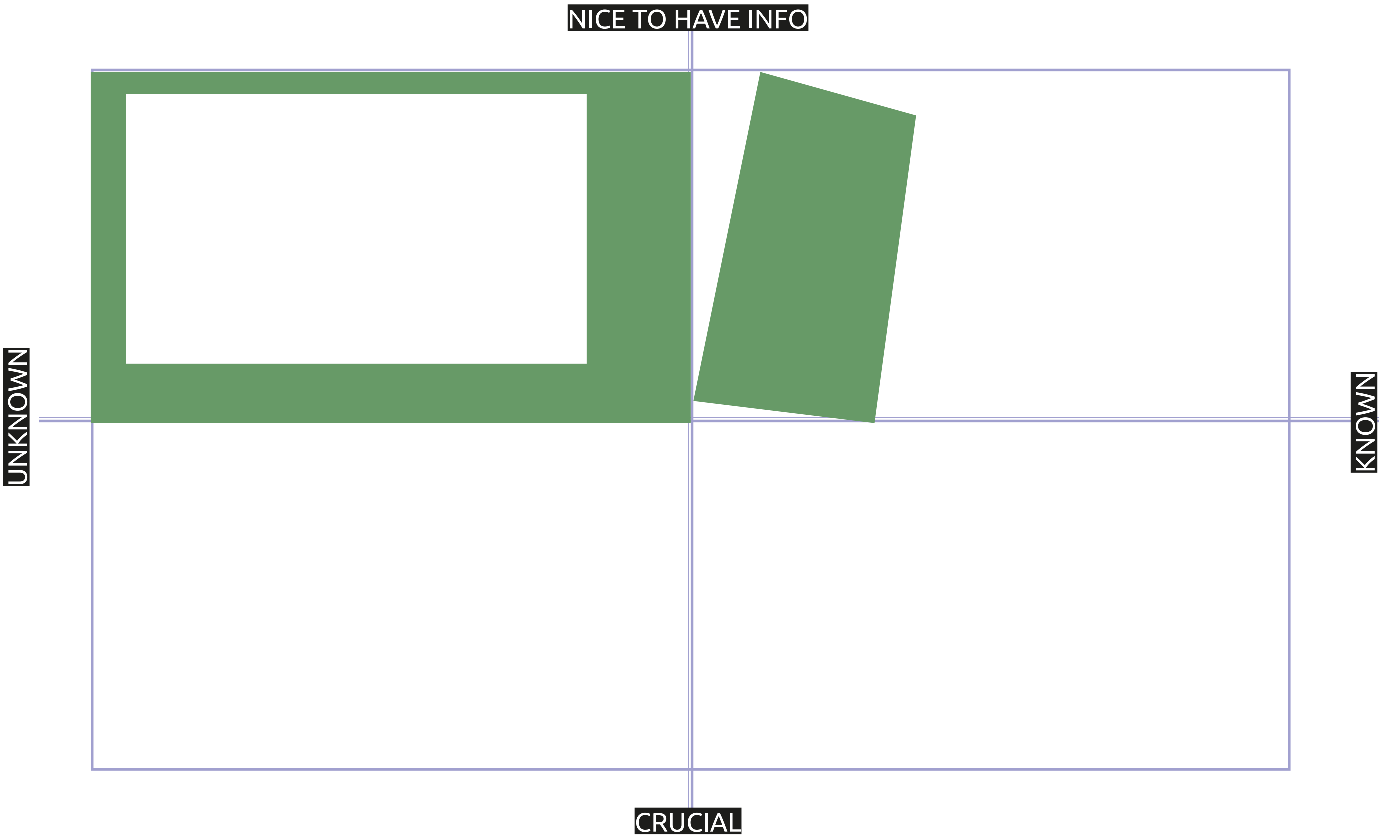
The initial meeting with Dr. Enzo Verrastro and his colleague, Danile Cornara, was primarily focused on explaining the CBI. Attract program and its objectives. In the subsequent meeting, which also included our technical partner Domenico Della Volpe, we concentrated on gathering the so far missing information about Xylella disease.

Recognizing the potential of our idea and the capabilities of POSICS device, they expressed interest in the project. They repeated that, due to Xylella being a newly discovered pathogen, there is a significant lack of literature to support our research. Consequently, they recommended starting with tests on herbaceous plants, as previously suggested by Lorenzo Marini.

Their proposal involved generating our own data by injecting the pathogen into plants within laboratory greenhouses and analysing the plant reactions using a transcriptomic approach. This analysis is crucial for identifying whether the bacteria produce specific molecules within the plant, and if so, determining the nature of these molecules to design or select a suitable radiotracer capable of binding to them. Ensuring that the injected solution is fully absorbed and metabolised by the plant is a key aspect of this process.

02. Cultural heritage maintenance

Regarding the art field, the team had previously selected sculptures as the type of art craft to focus on. The key questions in this field were to determine which materials could be safely exposed to radiation without causing any damage, to understand the potential risks and types of damage that could occur, and to identify the specific needs and concerns of art restorers.



Following our initial milestone, our technical partner highlighted that scanning frameworks using gamma rays could potentially damage the paint. As a result, our focus shifted exclusively on analysing only sculptures. One significant challenge for restorers is ensuring the safe transportation of the statues they work on. Existing scanning methods, which employ radiation, were known to us. (International Atomic Energy Agency, 2020) The most critical gamma emitters for non-destructive material testing include both natural and artificial sources such as radium, iridium-192, selenium-75, cobalt-60, and cesium-137. (Vogt, n.d.)

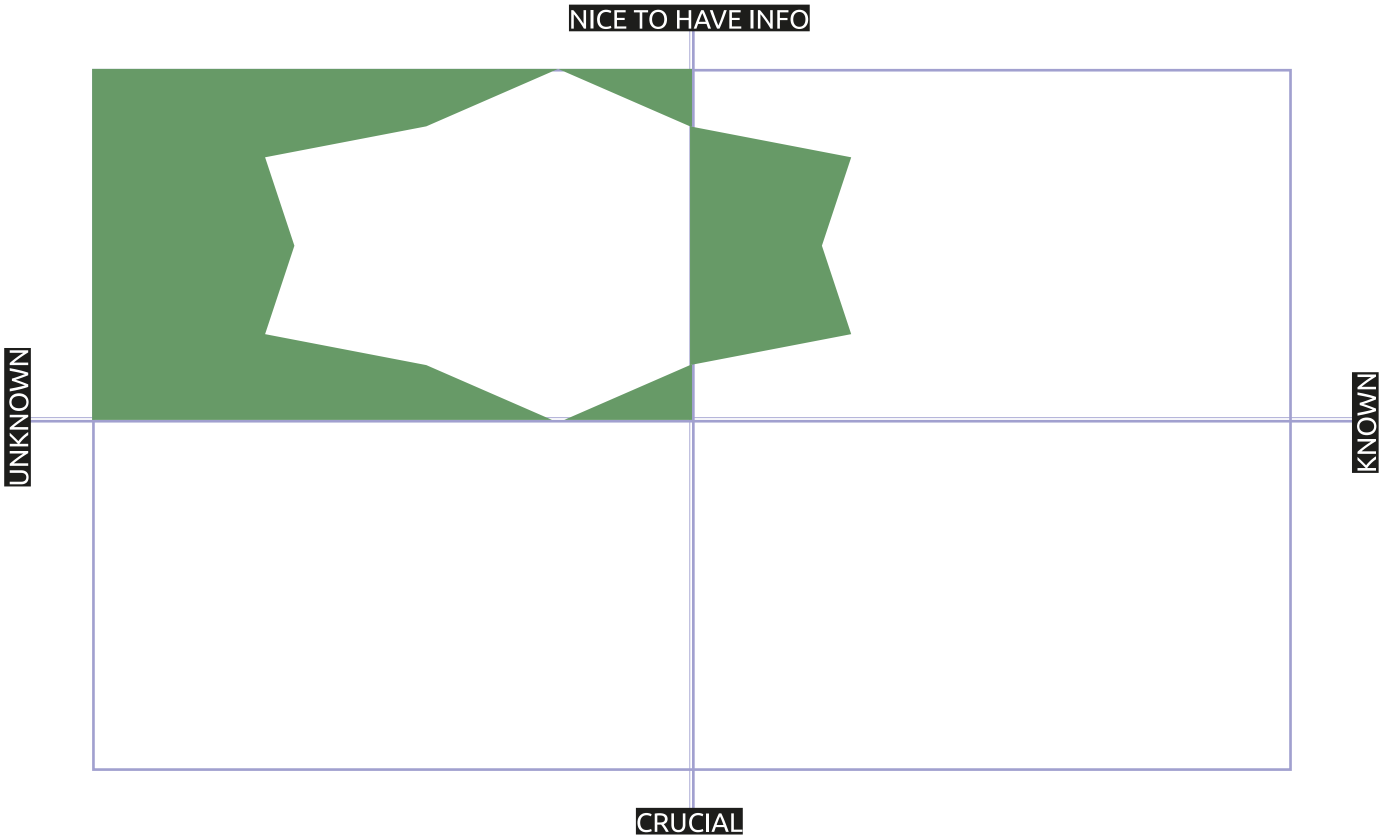
Two notable applications of nuclear technology in this field are the Menkaura statue case and the examination of eight swords discovered in Japan.

The Menkaura statue, recovered in 1907 in fragmented pieces, initially revealed parts of the torso and throne base, followed by the statue's head. Post-restoration, the statue was exhibited on the second floor of the museum until 2010, when museum staff decided to move it on the second floor. At that time, there was a lack of data concerning the statue's internal conditions and previous restorations, raising concerns about the impact of transportation on the artefact. This required the use of tests capable of providing the missing information. The choice fell on gamma radiography, which uncovered that the large, heavy stone fragments were not securely joined. Missing parts had been filled with a mixture of plaster, metal tubes, and other materials, with the throne base constructed from solid brickwork on a cement foundation. Previous restorations had not anticipated future relocations, resulting in a patchwork of ancient and modern materials. The gamma radiography analysis allowed restorers to identify the statue's fragile points before moving it, thereby preventing damage. (Museum of Fine Arts, Boston, n.d.)

In the case of the swords, gamma radiography was used in 2001 to identify an iron core in the hilt of a sword from Iran, housed at the Okayama Orient Museum. This iron core was believed to have functional or ritual significance. Researchers hypothesised that the original iron blade had been replaced with a bronze blade, leaving a small iron tang in the hilt. Gamma radiography enabled precise profiling of the iron tang, offering more accurate results compared to X-ray analysis. The comparison demonstrated that gamma rays provided more detailed insights, particularly regarding the tang's thickness, due to their greater penetration depth. (Baechler et al., 2017)
Still, the most known application of isotopes in the art field is indeed the carbon dating procedure in order to find out the age of materials, wood, cotton or paper objects, several kinds of art crafts and also bones and fossils. Since all organic organisms absorb carbon, in the moment they die the isotope carbon-14 starts decaying at a known rate. Using the so-called Accelerator Mass Spectrometry (AMS) technique, scientists are able to measure the amount of time passed since the expiry date: knowing the decaying rate and approximately knowing how much carbon a specific organic object has inside they can understand its age. The technique thus helps determine the age of heritage objects up to 50 000 years old.

These analyses, conducted in laboratories, underscored the necessity of a portable device capable of delivering more precise imaging for field use. This research made us define the concept of our idea: our objective was to provide restorers with a portable device that uses gamma radiation to generate a detailed internal image of a sculpture, identifying internal support structures and potential failure points.

03. Food monitoring



With regard to the monitoring of food, the main focus of the research was on the regulation of food irradiations. So far, the team has understood that this is a quite common procedure in some countries, but it depends on the specific states' norms in terms of food safety. (International Atomic Energy Agency., 2015).The objective was to provide the opportunity to live monitor the entire irradiation process in order to ascertain whether the quantity of radiation being employed is appropriate. The main information we needed by now was understanding in which situations the procedure is utilised and what levels radiation can reach.

In the preliminary research conducted before the first milestone, we identified foodborne diseases as a significant issue in many countries, including the United States, where approximately 48 million people are affected each year. A potential solution to mitigate this problem is food irradiation, a technique that can reduce the presence of pathogens such as Escherichia coli and Salmonella in food. This method not only extends the shelf life of food without altering its nutritional value or taste but also ensures safety standards are maintained. (Munir, M. T., & Federighi, M., 2020).

Food irradiation is a process where food is exposed to ionising electromagnetic radiation, such as gamma rays or X-rays, to inactivate microorganisms that could cause foodborne illnesses. (Singh & Singh, 2020) Unlike pasteurisation, which uses heat to kill germs, food irradiation is a "cold" method that does not require a heat source. Food undergoes the irradiation after it has been packed: during irradiation, the packaged food enters a chamber where it is exposed to a specific amount of radiation sufficient to kill bacteria and other pathogens. Currently, over 60 countries have adopted food irradiation. However, in some regions, the procedure is not trusted sufficiently, and regulatory barriers complicate its implementation. This lack of trust and regulatory jeopardise the widespread use of this effective technology. (Martins et al., 2017)

Our research proposes the use of the POSICS system to monitor the uniformity of radiation exposure during the food irradiation process. POSICS offers promptness and the ability to provide real-time imaging, enabling immediate feedback on the process. This capability allows scientists to adjust the radiation dosage dynamically, ensuring precision and effectiveness. By using POSICS, the need for multiple tests to monitor the outcome post-process is eliminated, thereby reducing waste and avoiding underexposures. This advancement could significantly enhance the efficiency and reliability of food irradiation, promoting greater adoption and trust in the technology.

Visit at HUG — The place where the testing happens

The visit to the Hopitaux universitaires de Genève is a part of visit to the partner site during the starting period of designing phase after the 1st milestone, this visit acted as a ideation chamber to help us clearly understand the scenes behind the robes i.e. We were able to clearly understand the working principles and the working methodology of the PET (Positron Emission Tomography) scanning and the MRI (Magnetic Resonance Imaging) and the difference between both breakthrough technologies used in the field of medicine.

The other most important learning of this visit is about the procurement of the radiotracers to be used for the PET scanning and the kind of modifications to be adopted before injecting the radiotracer into the human body in order for the easy acceptance of the radiotracer by the cancer cells. After the explanation about the competitors technologies of the POSICS we were finally able to get our hands on the POSICS device and get to know more about the capabilities of the device by accessing through the testing data of the device. The next steps of the visit are followed by a group discussion with the partners on further discussion into all the fields of applications that were discussed during the 1st milestone with the further understanding on the feasibility of the application with the help of the experience of the partners.

(images) Fueling ideas after a productive day at Hopitaux universitaires de Genève

During the second milestone of our project, we had the opportunity to present three potential application fields. To make our concepts more relatable and engaging for the audience, we used personas—fictional characters that represent our potential end users.

II Milestone

Health status in plantations

For this field, we imagined Olivia, a young and dedicated farmer from Apulia. Olivia is passionate about her work but is currently facing the significant challenge of dealing with Xylella, a disease that threatens her olive trees and, by extension, her family's agricultural legacy.

Cultural heritage maintenance

In the art sector, we introduced Vincent, an art curator responsible for the care and transportation of valuable artworks. Vincent is currently struggling with the logistics of moving a famous sculpture, "Le Tre Grazie," to a laboratory where tests need to be conducted.

Food monitoring

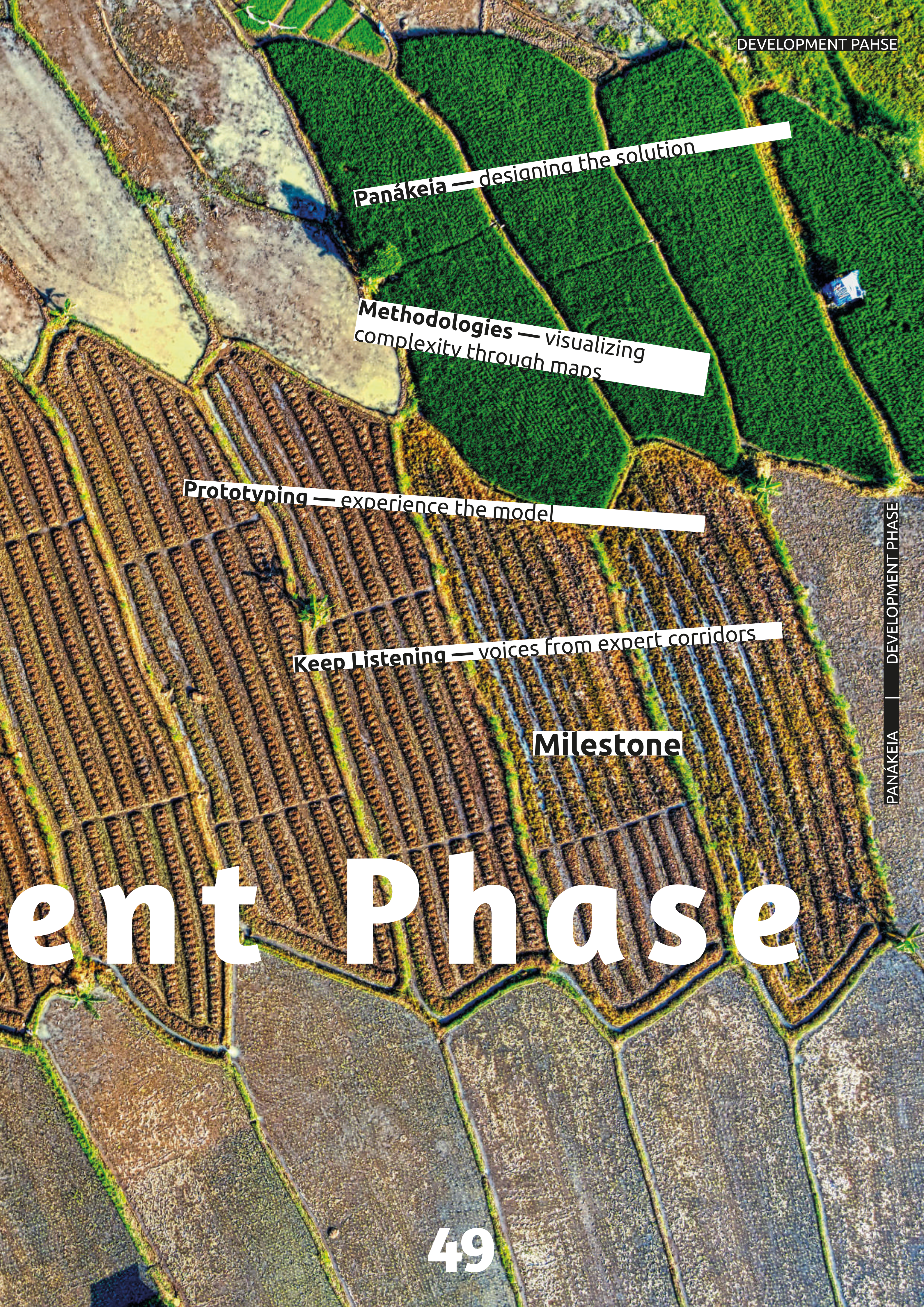
For our third application, we presented Donald, a devoted father who is deeply concerned about his daughter's health. His daughter has been affected by a foodborne illness, named Escherichia Coli, and Donald is seeking solutions to prevent such incidents in the future. This is the moment he learns about Food Irradiation.

In the end, we chose to focus on the agricultural concept. We all agreed that, despite being a long-term project, it has the greatest potential to be disruptive and innovative in the market. While the other two concepts were feasible and could be implemented in a shorter timeframe, we felt that the agricultural application offered something truly new and impactful. Furthermore, the positive feedback from experts during our interviews reinforced our decision to prioritise this field.

to **create** or **produce** especially by deliberate **effort over time**

definition retrieved from Merriam-Webster

Developm



Panákeia — designing the solution

Methodologies — visualizing complexity through maps

Prototyping — experience the model

Keep Listening — voices from expert corridors

Milestone

ent Phase

Panákeia — Designing the solution

Embrace the future of agriculture

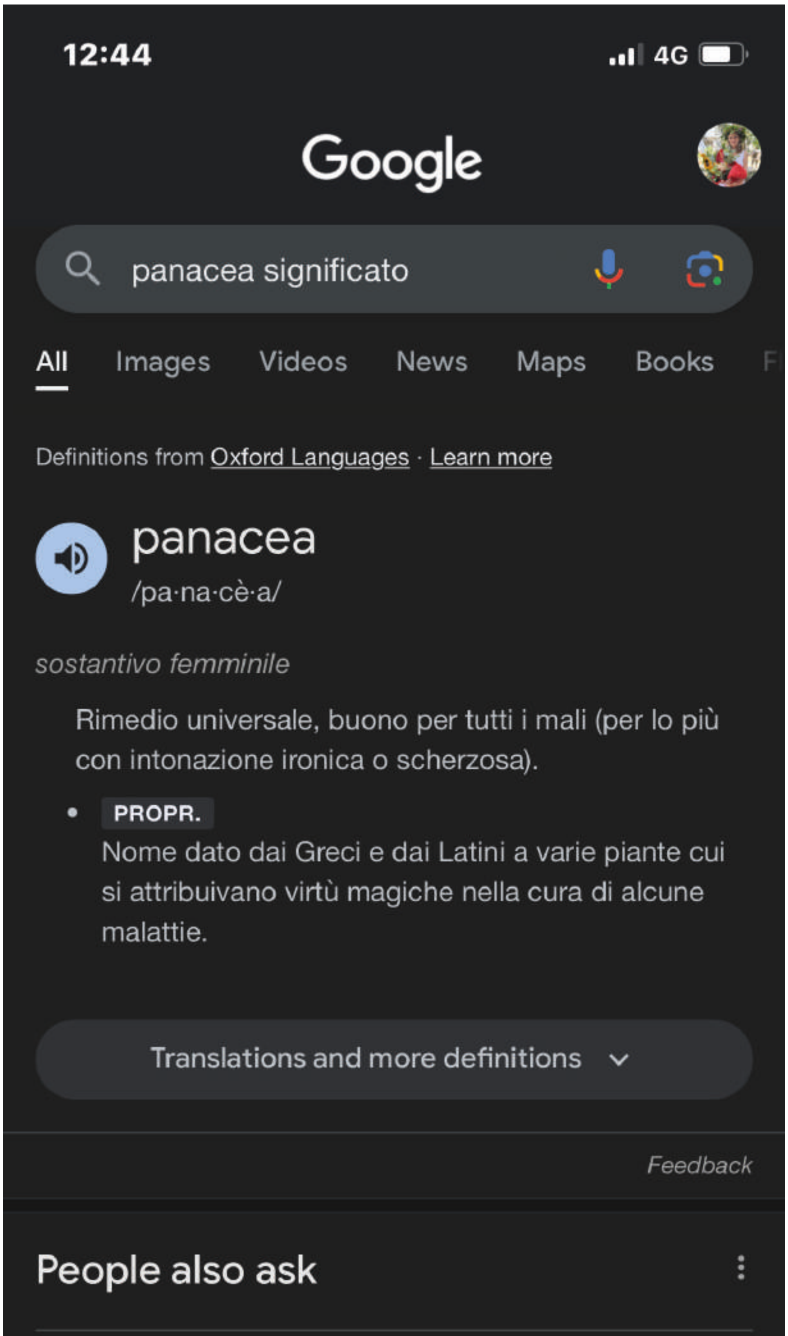
During the developmental phase, our team brainstormed the final solution, pooling the expertise of each team member and collaborating with agriculture professionals. Through interviews and card-sorting exercises, we gathered insights from the field, refining our final strategy. This collaborative effort culminated in the creation of Panákeia — an innovative service that enables agricultural consortia to efficiently monitor plantation health thereby preventing the spread of diseases

At Panákeia, we revolutionise agriculture with the predictive analytics and cutting-edge radiographic technologies to prevent the outspread of crop diseases therefore reducing losses and enhancing productivity. The novel method encourages a cultural shift in plant monitoring methodologies, fostering a new era of agricultural intelligence and efficiency.

In order to provide further assistance to users who interact with the device independently, a digital and paper-based assistant was created, named after the project. Panákeia eases the process for the user, ensuring that they are not left feeling abandoned during the different steps.

Panákeia is the goddess of cures in the form of medicines, salves, and other curative agents. It is therefore necessary to determine the nature of her curative powers in the context of agriculture. The potential to prevent (by knowing ahead of time) the spread of disease in the territories in which she operates. Her guidance will facilitate a cultural metamorphosis within agricultural consortia, leading to the generation of new knowledge (regarding diseases) and the review of plantation monitoring techniques. (with radiography methodology)

[pictogram] The pictogram illustrates three key elements: the detail of a plant, which is subject to monitoring, the flow of energy it produces, which allows the pathogen to be seen within it and the circle representing the earth where everything happens. The intertwined of these elements is a metaphor for the see-not-see experience of the radiography methodology.



(images) Panakeia: the name takes roots

PANÁKEIA

Embrace the future of agricolture

To better outline our solution it became necessary to conduct additional interviews, particularly with representatives from the organisations and institutions we identified as potential partners.

Hossein Arabi, physicist from HUG, Geneva

Voices

The first expert we reached out to was Hossein Arabi from Geneva Hospital, a collaborator of our technology partner, Domenico della Volpe, whom we met in Geneva.

As a physician working in the medical field, Hossein Arabi was well-suited to provide insights into the logistics of transporting radioactive materials. Our primary concern was understanding the protocols for the transportation and disposal of radiotracers. He explained that hospitals typically rely on affiliated pharmaceutical companies to deliver radioactive molecules as needed. Mr. Arabi also informed us that the small quantities of radiation we are working with are manageable, thanks to specialised small boxes that shield the operator during transportation. Additionally, he confirmed that the isotopes we are using have a short decay time. This allows for the syringes to be safely placed back in the shielding boxes after use and returned to the pharmaceutical company for proper disposal.
Since we identified the agronomist as the specialist in charge of the test, we aimed to understand whether an agronomist would be willing to perform the procedure following appropriate training.

hospitals typically rely on affiliated pharmaceutical companies to deliver radioactive molecules as needed

Lorenzo Marini, agronomist from Stuard Company, Padova

Voices

He confirmed that the proper professional figure who could handle the test is the agronomist or else an agrotechnical; they are both used to spending a lot of time on the field. There are three levels of study: the junior agronomist who completed the bachelor's degree; the middle agronomist, who completed the master's degree, and the researcher, who also completed the PhD.

Apart from the choice of the professional figure, he told us that a possible problem we could face is the scepticism of people working in agriculture. To overcome this difficulty, he suggested to organise demonstration days to show the test we plan to use to make the experts and possible customers understand the opportunity this idea represents.

the proper professional figure who could handle the test is the agronomist or else an agrotechnical

Marta Cantina, expertise in organic computational photochemist, France

Voices

We also had the chance to talk to a chemist, Marta Cantina, for what concerns the tracer to be utilised. Given her experience in the field of computational chemistry she was able to give us some insights about what kind of molecule we should use both as a radiotracer and as a carrier.

She confirmed that the biological half life of the isotope is both a limit to the effectiveness of the test and a safety net for the operator: we will be dealing with short half-life molecules and this means that we need to be fast while taking the test but at the same time the residual radiations are not a problem.

Her primary recommendation was to use an already established radiotracer, allowing the focus to be on the carrier molecule. This carrier could be glucose cages, peptides, proteins, or nutrients inherent to the plant. To achieve this, we need to understand the behavior of the bacteria within the tree's xylem, which necessitates comprehensive research on Xylella — a topic currently not in-depth studied in biological literature. Therefore, Marta recommended that we seek answers to these questions while conducting tests with various carriers and subsequently compare the results.

the biological half life of the isotope is both a limit to the effectiveness of the test and a safety net for the operator:

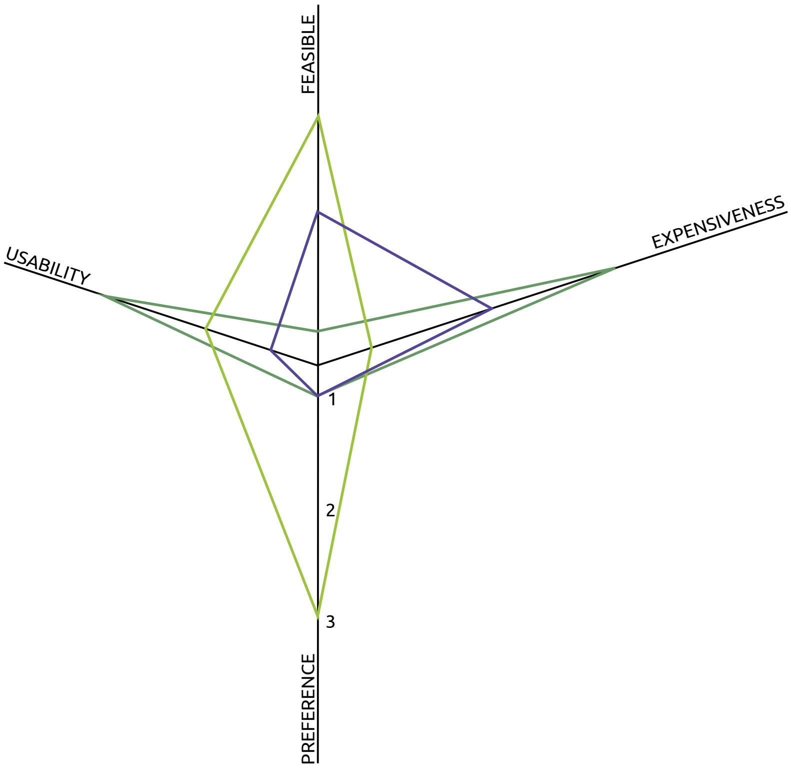
Prototyping — experience the model

The card sorting method

By now we still had one doubt regarding the most appropriate method to pursue the test on the field. In order to solve it we utilised *card sorting* with some of the experts we talked to: a research method in which participants have to organise several labelled cards into groups according to specific criteria.

The questions we addressed were the following:

If I present to you these three items, what would you choose? Why?
If I ask you to list them from the most usability to the less usability one?
If I ask you to list them from the most feasible to the less feasible one? (Where as feasible we mean easy to realise and effective to achieve the task)
If I ask you to list them from the most expensive to the less expensive one?



For what concerns the ranking in terms of usability the most frequent answer we got was: robot, tripod or hand made, drone. As for the more or less feasible the ranking was: handmade, drone and robot scanning.

The drone was categorised as the less utilisable and feasible because it is not stable enough to return a reliable image. On the other hand the robot can be remotely moved at the chosen speed and at distance from the plant and the same can be said about the handmade analysis.

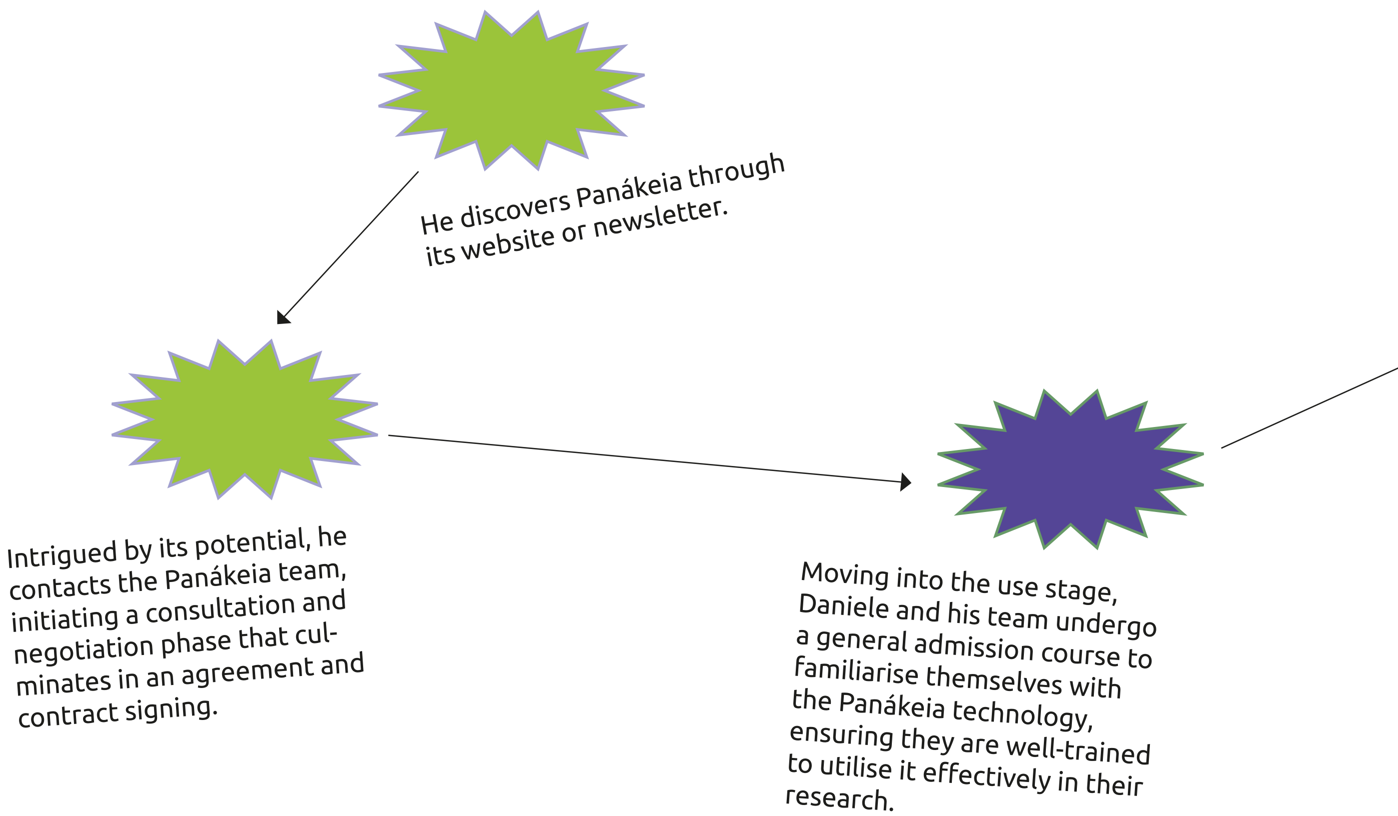
Regarding the last question we all agreed on the fact that the scanning made by hand is the cheapest while the robot is the most expensive.

This method was extremely useful for dispelling our doubts before defining the journey of our possible customers.

Methodologies — Visualizing complexity trough maps

Early stage opertional blueprint

The blueprint illustrates the journey of Daniele, the manager of a greenhouse involved in research programmes regarding diseases in plantations.



Then, Daniele's lab orders a short-term, discounted lease of the device, which allows them to integrate this advanced technology into their operations with minimal financial risk.

They also start placing regular orders for the necessary radiotracers, establishing a reliable supply chain essential for their ongoing experiments.

They also start placing regular orders for the necessary radiotracers, establishing a reliable supply chain essential for their ongoing experiments. The team begins generating valuable data on plant health.

This data is then shared with the Panákeia team, creating a continuous feedback loop that benefits both parties. The lab gains access to cutting-edge technology at a reduced cost, while Panákeia receives real-world performance data that is crucial for further refinement and development of their product.

As the end of the lease period approaches, Daniele faces the decision of whether to return the device or request an updated version, reflecting on the latest advancements and improvements made possible by the feedback and data provided by Panákeia labs network.

Panákeia lab uses the collected data to refine and enhance their device. This continuous improvement process is driven by the insights gained from its practical application in various research settings. Panákeia also focuses on expanding their network of collaborators through conventions and publications. This strategy not only broadens their research base but also fosters a wider community of users who contribute to and benefit from the technology.

Future expansion blueprint

This second blueprint illustrates the journey of Olivia, which would take place after the research initial phase will be consolidated. She is an agronomist working in Apulia.

Olivia is interested in using advanced technology for field inspections to detect diseases, such as Xylella. She discovers Panákeia methodology through the website or during the local open-days organised by the team.

She contacts the Panákeia team via email to learn more about it. They engage in detailed consultations and negotiations to tailor the service to Olivia's specific needs. This phase culminates in the signing of a formal agreement and contract, laying the foundation for their partnership.

Olivia then participates in a kick off day conducted at the Panákeia lab. This occasion is crucial for her to understand both the value of the technology and the how-to-use methodology.

Furthermore, the Panákeia team provides comprehensive training, ensuring Olivia is well-prepared to utilise the technology in her fieldwork, adhering to all safety protocols.

Panákeia coordinates the logistics for delivering the Panákeia device to Olivia under a leasing agreement, ensuring a seamless transition from training to practical use.

Equipped with the Panákeia device, Olivia begins to apply the technology in her work.

On the one hand, she receives a call from a client, possibly a private individual, a company or consortium, seeking her expertise for a field inspection.

On the other hand, she identifies farmers needing disease inspection services, creating new business bonds and expanding her network

She conducts preliminary in-field inspections and places regular orders for the necessary radiotracers. Each time she receives the radiotracers, she uses them in her inspections, providing valuable data back to the Panákeia team. Partners ensure timely delivery of radiotracers to Olivia as for other agronomists, and also manage the regular collection and disposal of decayed radiotracers.

Throughout the year, Olivia continuously evaluates the impact of the Panákeia device on her research outcomes. This includes monitoring the accuracy and efficiency of disease detection.

At the end of the leasing period, Olivia decides whether to return the device or request an updated version of it. Panákeia lab, in turn, leverages the data and feedback. This continuous improvement process is driven by real-world application insights.

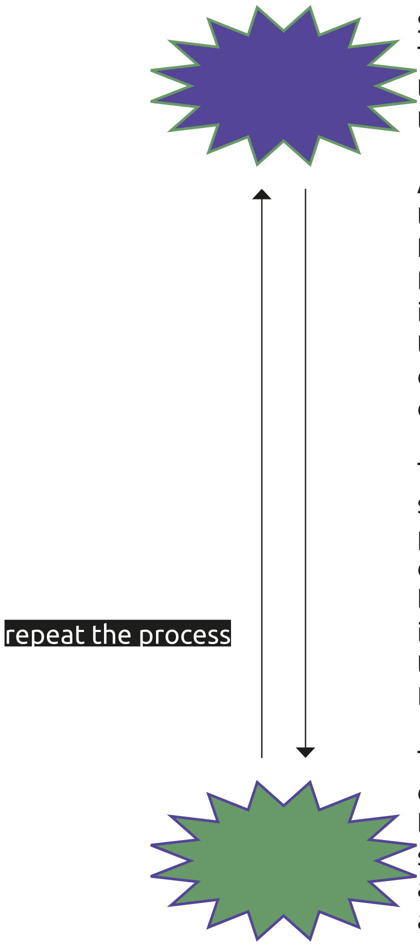
Panákeia lab uses the collected data to conduct further research and development, constantly improving the device and expanding its applications. For instance, it could be applied to a technique in personalised medicine and nuclear medicine where one radioactive drug is used to identify (diagnose) and a second radioactive drug is used to treat cancerous tumours (theranostics). (Li et al., 2022)

Panákeia also focuses on building a broader network of partners and universities through conventions and publications, fostering a collaborative environment that benefits all stakeholders involved. By fostering strong business relationships and maintaining a focus on sustainability and environmental commitment, both parties achieve their goals, creating a sustainable and impactful partnership that advances the field of agricultural research.

Trust the process

The main character is going to be a highly specialized agronomist who will be part of our research Team.

Initially a Preliminary inspection, made by Anna directly on the field is performed. This is needed to understand the amount of plants that will be inspected and to address their specific characteristics. Once he has clarified the situation, Panakeia will take care of the process. The right amount of radiotracers will be ordered to the nearest affiliated pharmaceutical company that will deliver the material directly on the field ready to be used by our technicians.

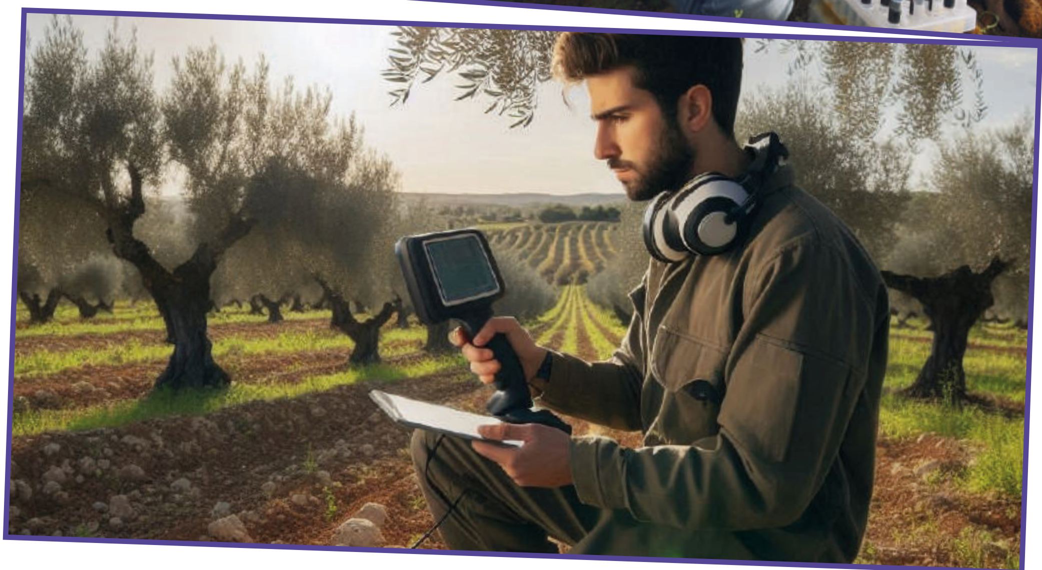


So let's start! here we go:
The agronomist injects the radiotracer inside the plant through the bark.

After the injection it is time to use the detector.
Its reduced size it can adapt to different scenarios: from handmade inspection, if the number of trees to inspect is limited, to a tripod or a drone that can easily scan an entire field with no effort.

The device captures the contrasts shown by the cluster of bacteria present in the tree, generating detailed internal images to highlight areas affected by pests. This images will help the farmer see the problem they've been facing BLINDLY during the past years!

Throughout the testing process, our sophisticated software collects vital data, which is securely stored in the cloud for further analysis. Consequently, farmers and agronomists receive real-time data, allowing for immediate action.

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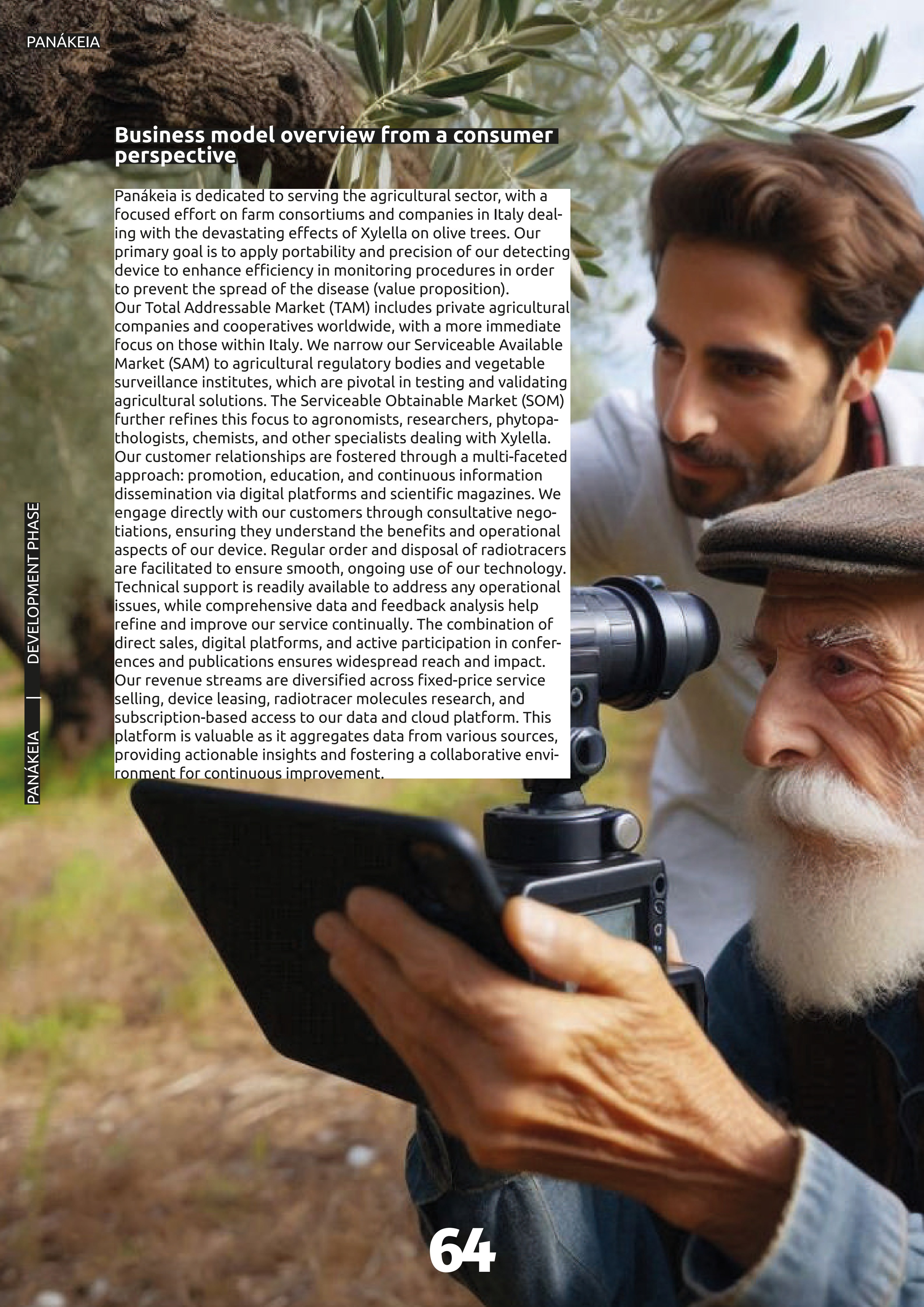
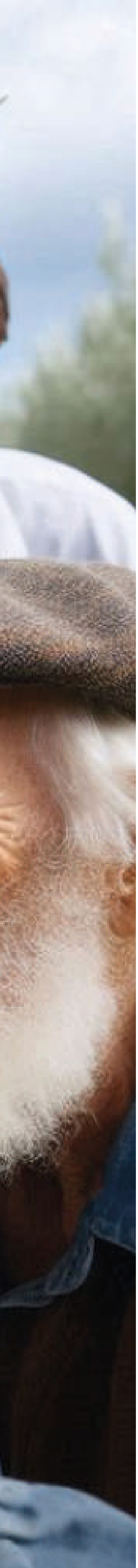


Business model overview from a consumer perspective

Panákeia is dedicated to serving the agricultural sector, with a focused effort on farm consortiums and companies in Italy dealing with the devastating effects of Xylella on olive trees. Our primary goal is to apply portability and precision of our detecting device to enhance efficiency in monitoring procedures in order to prevent the spread of the disease (value proposition).
Our Total Addressable Market (TAM) includes private agricultural companies and cooperatives worldwide, with a more immediate focus on those within Italy. We narrow our Serviceable Available Market (SAM) to agricultural regulatory bodies and vegetable surveillance institutes, which are pivotal in testing and validating agricultural solutions. The Serviceable Obtainable Market (SOM) further refines this focus to agronomists, researchers, phytopathologists, chemists, and other specialists dealing with Xylella.
Our customer relationships are fostered through a multi-faceted approach: promotion, education, and continuous information dissemination via digital platforms and scientific magazines. We engage directly with our customers through consultative negotiations, ensuring they understand the benefits and operational aspects of our device. Regular order and disposal of radiotracers are facilitated to ensure smooth, ongoing use of our technology. Technical support is readily available to address any operational issues, while comprehensive data and feedback analysis help refine and improve our service continually. The combination of direct sales, digital platforms, and active participation in conferences and publications ensures widespread reach and impact.
Our revenue streams are diversified across fixed-price service selling, device leasing, radiotracer molecules research, and subscription-based access to our data and cloud platform. This platform is valuable as it aggregates data from various sources, providing actionable insights and fostering a collaborative environment for continuous improvement.



Enrico Fravilli, agronomist and professor, Apulia

Voices

The agronomist Enrico Fravili told us that nowadays farmers from Apulia started pursuing a "do it yourself" method: they eradicate the tree showing symptoms on their own, hoping this would prevent the future spread of the disease.

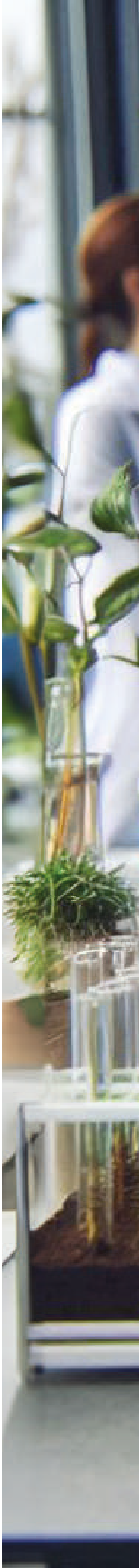
our goal: make them trust science!

Daniela Barreca, co-founder of Facciamo Filiera, consultancy agency, Apulia

Voices

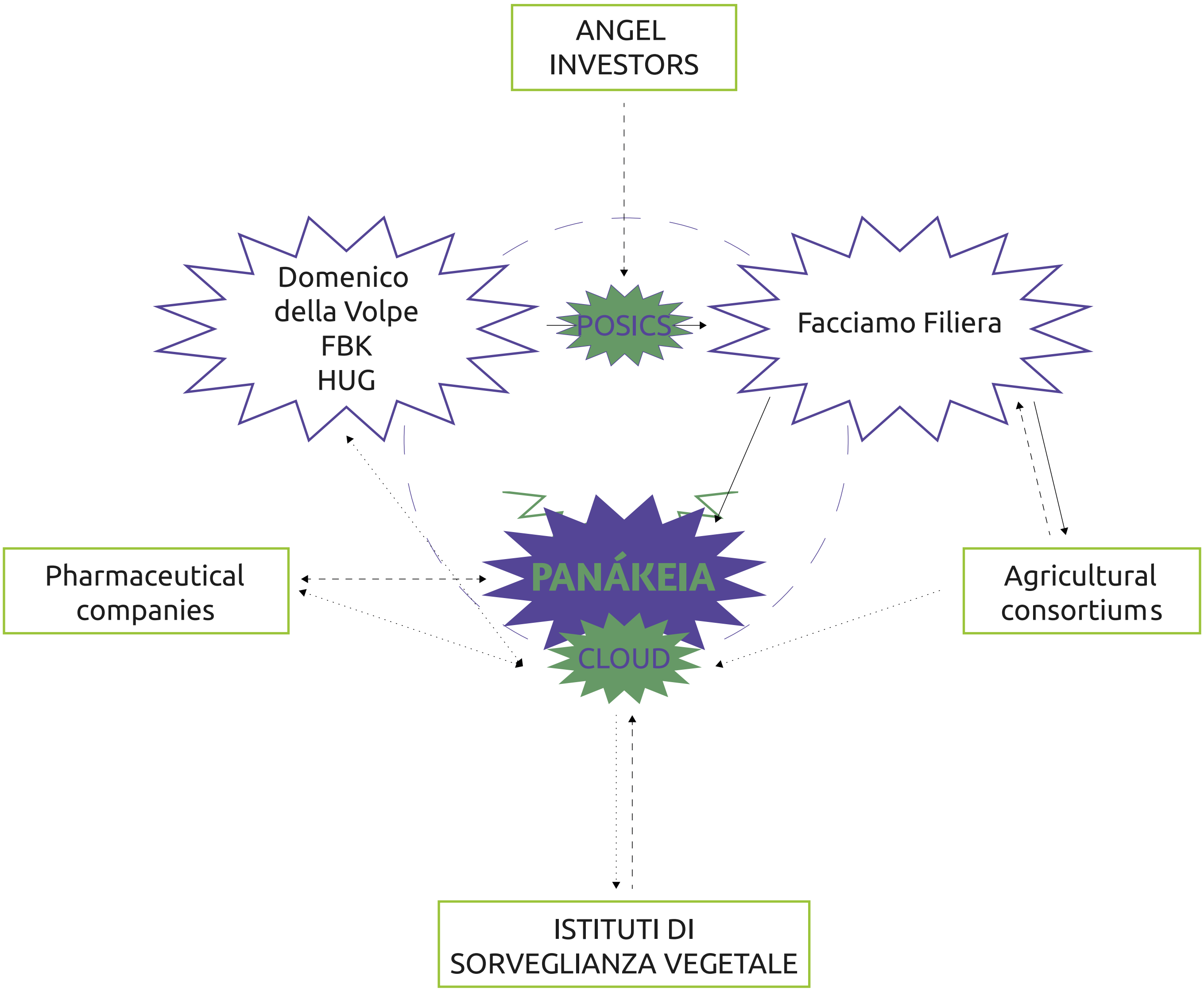
She explained to us that the appointed institute that has to confirm the presence of Xylella in the plantation is ARIF (Agenzia Regionale attività Irrigue e Forestali). As soon as the farmers identify symptoms, they should contact the institute.

our goal: work with local autor-ities and provide an information campaign for local farmers



Business model overview from the supplier perspective

Panákeia relies on a network of key partners including vegetable surveillance institutes, agricultural consortia, university departments, and research institutions like the CNR. Our collaboration with radiotracer producers, typically pharmaceutical companies, ensures a steady supply of the necessary materials. We also partner with original equipment manufacturers for the development of our device and potential integration with drones or robotic arms, with institutions like FBK playing a crucial role. Support from regional consultancy agencies and external collaborators further strengthens our operational capabilities.
Our key activities revolve around intensive research and development, robust data analysis, and effective service delivery, maintaining strong customer relations. Our key resources include a platform domain and hosting services, secure cloud data management, and the physical assets essential for operation, including radiotracers, the detection device, and our facilities. Intellectual property and human capital are central to our success, driving continuous improvement.
Panákeia's cost structure balances innovation and sustainability, encompassing customer support, manufacturing, platform, and cloud service fees, alongside R&D and data management costs. Our business model is founded on strong partnerships, leading-edge technology, and a commitment to combating plant diseases in agriculture. Through continuous feedback loops and collaborative innovation, and with our advanced data cloud, Panákeia aims to pioneer sustainable agricultural solutions.


ANGEL INVESTORS
Domenico della Volpe FBK HUG
POSICS
Facciamo Filiera
Pharmaceutical companies
PANÁKEIA
CLOUD
Agricultural consortiums
ISTITUTI DI SORVEGLIANZA VEGETALE


COLLAB
ECONOMIC
DATA
TOUCHPOINTS
PARTNERS

System map

Combining the information gathered from the interviews we ultimately made some changes from the initial blueprint which resulted in the following and definitive system map.
The map below illustrates the ecosystem of actors that enables the service to function. Panákeia is a start-up that offers a service that combines research, development and innovation with agricultural consortia and companies. Ultimately, farmers will benefit from this service because the consortia in which they participate will monitor the health status of their plantations.

The network

How? Through a co-participating network of actors, who share the data obtained from monitoring the plantations of the participating agricultural consortia in the Panákloud.

The network comprises two distinct categories of actors:

so-called ghost actors, who act backstage, and active actors, who interact directly with the end user. The phantom actors are the consortium of partners that developed the POSICS sensor, used by Panákeia for field sensing, and all investors and funding institutions from which Panákeia receives R&D funding. In the front stage, the actors interface directly with the user through two parallel and intersecting streams: the product and the service. The service is provided in collaboration with Facciamo Filiera, a consultancy agency in the Apulia region that facilitates connections between agricultural consortia and the innovative methodology proposed by Panákeia for monitoring the health of the member consortia's plantations. The consortia, in turn, share all the data from their plantations in the Panákloud. Furthermore, the product is provided by Facciamo Filiera, which makes the POSICS detecting device available to the member consortia. However, the agricultural consortium is responsible for autonomously interfacing with the pharmaceutical companies that produce the radiotracers necessary for POSICS to function. This is done for the purchase of the latter each time the consortium wishes to carry out monitoring.

Prototyping — experience the model

The science behind the project

Since we are working with radioactive material it would have been impossible for us to have a real and working prototype. Therefore, we decided to build an experience prototype to make people understand the main phases of the test and overcome the false perception most people have when thinking about radioactive material.
We aimed to create a simplified representation of the Xylem network of the tree with blocks inside to simulate bacteria clusters. We used a plant as a support structure for a transparent plastic tube, to simulate the vessels, and we used a few resin balls placed inside it to represent the clusters. To represent the detector, we used a UV light therefore the resin was mixed with ink to make the clusters glow when exposed to UV light. To make the prototype more real we made water flow inside the tube thanks to a small water pump.

(image) Visualizing Science: prototype of the final exhibition

(image) Visualizing Science:
prototy of the final exhibition

Conclusion

The end of the development phase is marked by the presentation of the third milestone, with the presence of the audience from the varied disciplines. We took off the presentation with an introduction about the current day scenarios and the momentous requirements in the field of agriculture. To address the pervasive issue of the Xylella in the agriculture field, the lying stone of the strategic idea was the fruitful result of the development phase of Panákeia by extensive research, and innovative problem-solving with the help of agricultural professionals through interviews and card-sorting exercises

The next stage of the presentation discusses the creation of Panákeia that represents a groundbreaking shift in agricultural disease detection, combining predictive analytics with cutting-edge radiographic technologies to enhance productivity by reducing crop losses by fostering a new era of agricultural intelligence and efficiency. The service is meticulously designed to ensure user-friendliness and support throughout the monitoring process.

We further addressed the concerns of the individuals regarding the safety of the use of the radioactive materials by interviewing experts like Hossein Arabi and Lorenzo Marini whose recommendations to overcome scepticism highlight the importance of hands-on experience in gaining trust and acceptance in the agricultural community.

The main motto of Panákeia focuses on serving the agricultural sector, with a spotlight on the olive plantations that are affected by the pathogen named Xylella. Our commitment to sustainability and continuous improvement is evident in our structured cost management and robust support network.

In the near ending of the presentation we were glad to present an experienced prototype of our device and the steps followed by the agronomist from the injection till the analysis of the gathered data in the Panákloud.

This explanation was focused on effective communication of the main phases of our test, addressing misconceptions about radioactivity.

This hands-on representation underscores our innovative approach and dedication to transparency and education.

Conclusively, we show a little spoiler of the test our partner Domenico della Volpe had in the lab at Hôpitaux universitaires de Genève (continue the reading to find out more!)....

IIIMilestone

Laboratory test — one has to see in order to believe

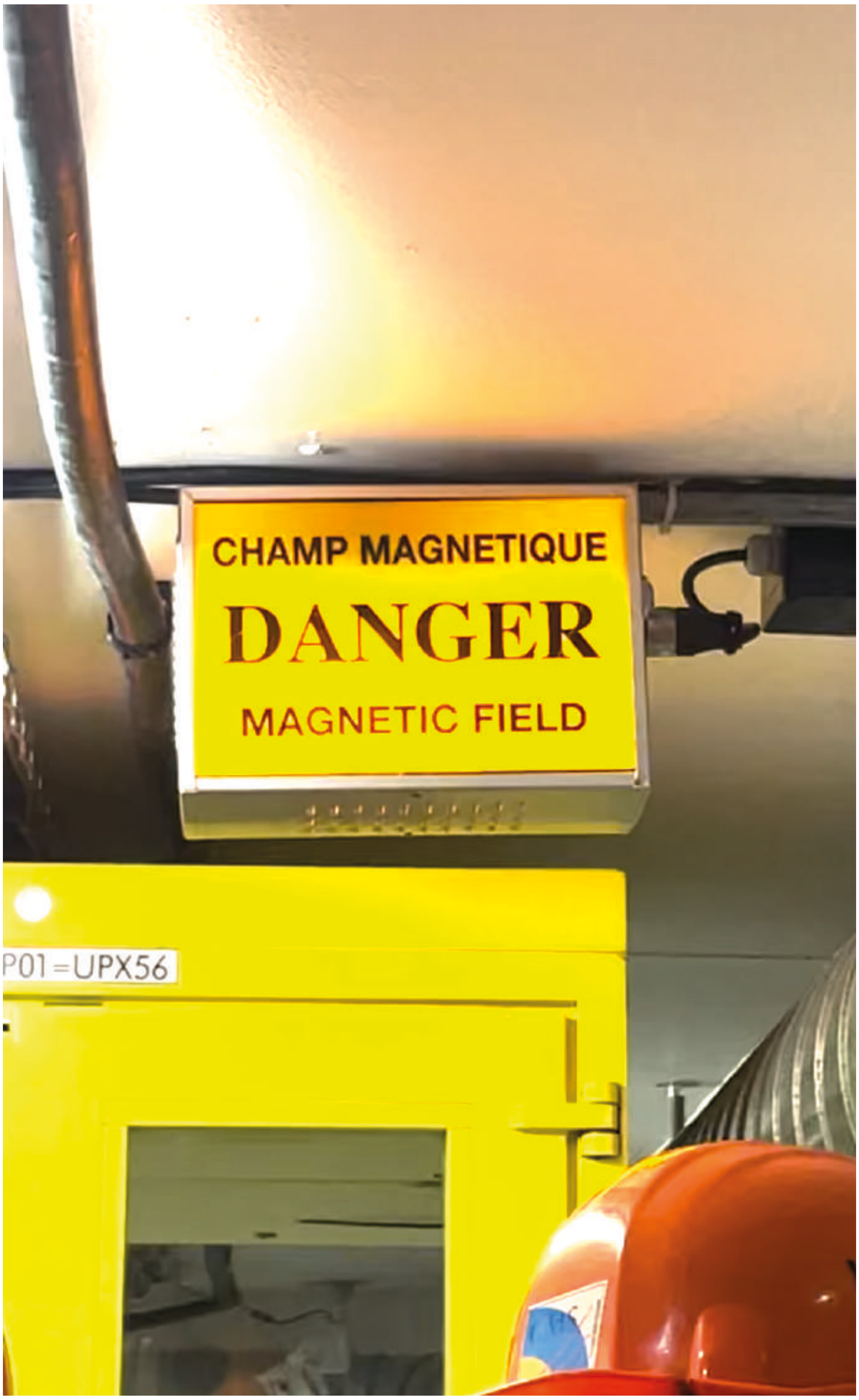
A true proof of concept

The week before the last Milestone our partner decided to take the first test to check the feasibility of our idea.

A few branches were immersed in a radioactive material solution containing FDG, the radiotracer commonly used in PET scanning.The plant absorbed the solution through osmosis, and, after about one hour, was scanned using a high-resolution PET machine.

POSICS hasn’t the exact same resolution but the returned image you can find below was similar to the one that would have been returned by POSICS.

Being this the first test they used the PET machine in order to be fast and quickly understand the response of the plant. POSICS would have required a different tracer (Tecnezio 99m).



Are you ready to see what else can come out of this? Well…Stay tuned!

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Images

All the images presented in this report have been either taken by members of the team during the mobilities or selected from public repositories.

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