



Newsletter

Issue 2 - April 2024

Introducing the world of mechanical impedance and multi-physics technologies



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Welcome

Welcome to the second issue of the MELCHIOR Newsletter. In this edition, you can read a summary of the second part of the Pencast interview with our project coordinator, Professor José Luis Pérez Díaz, and we report on the project's recent mid-term review, an essential milestone to ensure the project's progress.

There is an interesting overview of the various technologies being developed in the project and a

more in-depth interview with MICAM, the project partner making the blast-proof container, which will have an essential role in the pilot technology demonstrations and tests. We are also delighted to include three partner profiles of the Hellenic Police, CEA (the French Atomic and Alternative Energy Commission) and the University of Galati in Romania.

We hope you enjoy finding out a bit more about the current progress and successes in MELCHIOR.

Positive Mid-Term Review reinforces project's work



MELCHIOR partners attending the mid-term review and technology demonstrations.

The MELCHIOR Mid-Term Review and technical demonstration were successfully held on 28th February this year in Madrid, and we are pleased to report that it was a positive review on the progress achieved in the first period.

The project's leadership team presented summaries of the key achievements in each of the active areas of the project. The project officer and reviewers gave the team very helpful feedback after the presentations

with some important recommendations for the next period.

Significant progress has in fact been achieved since the project began in September 2022 with all the groundwork now complete, regarding the definition and quantification of the targetted items, as well as the types of body and clothes. Building on these fundamentals, the preliminary designs of the acoustically tuned blast proof cabin were also

developed, as indeed were the different sensors and cameras that will be located inside of the cabin. The positioning of the various sensors was also agreed, but with the essential built-in flexibility for them to be moved if necessary during further development stages.

Emphasising that the project is looking to detect rather than identify abnormalities in sound patterns, detailed research into acoustic capabilities, comparing

initial simulations with more direct testing, was carried out. One of the priorities for the continuing research will be a focus on moving persons, which was specifically requested by the end user partners.

Much has been achieved in period I, but there is a significant amount to do in the second half of MELCHIOR, including all of the planning and organisation of the five technology demonstrations (see page 6).

Technology Demonstration, Madrid, 28 February 2024



MELCHIOR detection technology in use during the Madrid demonstration.

All the participants were then taken to an off-site location in a nearby industrial area where they were shown some of the detectors being developed as well as the assembled MELCHIOR blast-proof cabinet for the first time.

After a short description of the way in which the technology had been built, a demonstration and explanation of the technology in operation was given, after which all participants were invited to walk through the system to experience how it functioned

for themselves.

At the end of the demonstrations, a fruitful discussion took place and there was a general positive impression on the progress made so far, while acknowledging that much still needs to be done by the end of the project. To this end, and as planned, the consortium will keep up the good work to bring out the best possible results.

In the spotlight: the second part of our interview with MELCHIOR Coordinator Professor José Luis Pérez Díaz

Dr. José Luis Pérez Díaz is a Professor in Mechanical Engineering at the University of Alcalá, Spain, and Coordinator of MELCHIOR. On behalf of the customs innovation boosting network PEN-CP (www.pen-cp.net), Tom Mueller recently interviewed him for the podcast known as “Pencast”. Below is a summary of the second part of this interview. The full Pencast interview is available both on Spotify and YouTube (links shared below).

His background in acoustics made him search for ways of safeguarding physical privacy at borders. Therefore, he started thinking of ways of using acoustic properties to perform searches without physical contact. The idea for the MELCHIOR project started through the MESMERISE project. The idea came up in MESMERISE because the team in the University of Alcalá had been working with infrasound, echolocation, and other uses of sound.

Asked about the main benefits for custom officers using MELCHIOR, the project coordinator explained that in an extreme case, a customs officer doing security checks would obviously avoid touching somebody that may be wearing an explosive belt. But even in a more day-to-day scenario, a customs officer might want to avoid any awkward physical contact when searching a person, which has the potential to be ‘distressing’ for both parties. Always at the core of the work in MELCHIOR and the technologies being developed are the interconnected issues of the privacy and dignity of the person being scanned.

Benefits for customs officers

Perhaps the biggest benefit for customs officers will be MELCHIOR’s development of a new tool that will not disrupt the flow of people. In fact, it will increase that flow with a relatively high rate of reliability. If it normally takes one minute to physically search a person and you can do this in half that time without touching the person by using our technology, you are making everything smoother, less intrusive, simpler and more efficient, with the added level of respect for



Coordinator Professor José Luis Pérez Díaz.

the physical privacy and dignity of the person being searched.

Other potential end users for the MELCHIOR technology include prisons, sports stadia and arenas. In those situations where you have crowded sites like football stadia, or arenas or concert halls, you need to prevent people from carrying guns or explosives.

“This will be a very convenient way to manage these situations – because you’re not using any harmful technologies, you can make it quite fast and prevent serious risks,” expanded Prof. Pérez Díaz.

Discussing some of the benefits that he has encountered when working with a consortium of different partners, Prof. Pérez Díaz enthused about the free communication between members of academia, industry and government. That’s part of what a broad-based consortium brings – a group of different perspectives and different backgrounds, so that you can capture those different viewpoints.

Risks and benefits of AI

Returning to the discussion of the technology being used in MELCHIOR, the conversation moved on to the question of training and the importance of preparing customs officers to use the technology.

“It’s not just the technology, it’s also the people who use it,” emphasised Professor Pérez Díaz.

The system needs to be independent of the user – independent of the customs officers. Currently, being able to use a technology depends on the level of training, on the sensitivity and the skills of the officer. But so is the ‘condition’ of the officer, because someone who has been working for the whole day is perhaps not quite as ‘alert’, as when they started work that morning. People become tired, their senses are not as sharp. Artificial Intelligence can help us to

“It’s not just technology, it’s also the people who use it.”

solve this, because the machine does not get tired. AI is a tool that we can use to help the user, the human. The final decision though must be a human decision, a decision not uncritically attached to the outcomes of the AI system.

For sure we have to be aware of and vigilant about any potential misuse of Artificial Intelligence. As far as AI is concerned, like all science, it must comply with ethics. Dr. José Luis Pérez Díaz concluded that “if you forget humanities, you will become non-human. That is a real problem.”

At the end of the interview, Dr. Tom Mueller came to the following conclusion: It’s deeply reassuring to hear a research scientist at the cutting edge of customs innovation, and other innovation, speaking about the humanities and the importance of ethics. We all need to keep in mind that if you forget humanities, you will become non-human.



MELCHIOR scanning technology being demonstrated.

You can listen to the full PEN-CP Podcast interview with the Coordinator of MELCHIOR Professor José Luis Pérez Díaz here:

Podcast 2023 (Episode 11) – José Luis Pérez Díaz - Part 1



Podcast 2023 (Episode 11) – José Luis Pérez Díaz - Part 2



Delivering significant advancements in airport, prison and stadia security

The technologies being developed in MELCHIOR are designed to deliver exactly what Professor Díaz was discussing in his interview on the previous pages, namely a better and safer way for people to be scanned for weapons, drugs or other illicit goods secreted on or inside their bodies. Safer for the customs officer or operator, whilst also offering less intrusiveness, and therefore greater privacy for the person being scanned.

To achieve this major security innovation, the project's consortium has brought together leading technology SMEs and research organisations to deliver a substantially novel technology, based on infrasound Mechanical Impedance Interrogation, which can be optionally complemented with other harmless and non-contact technologies.

These new and improved technologies will be deployed in a series of five demonstrations (see below for further details) within the prototypes of a blast-proof container, which has detection capabilities that have been extended to limbs and body cavities, as well as having improved sensitivity levels.

Infrasound computer aided modelling with improved Artificial Intelligence, together with improved new infrasound generators and sensors will enable enhancements in both their reliability and sensitivity. Combining these with other non-contact technologies like low-cost mm waves and THz point echo sensors with no image formation will be explored within the parameters of the project. The introduction of specific bio-aerosols and chemical vapour detection novel technologies will also be tested in the prototypes.

This combination of technologies being developed in

the MELCHIOR project has the potential to deliver significant advancements in security and operator safety at airports, large stadia and in prisons right across Europe and beyond.



MELCHIOR blast-proof cabinet and detection technology.

Technology Demonstrations and Tests

An essential aspect of the project will be the five technology Tests that will take place in the final six months, between March and August 2025. These Tests will provide truly tangible opportunities for our customs and border control partners to use and assess the MELCHIOR technologies.

The technologies that have been developed and the final version of the prototype blast-proof cabins will be demonstrated in operational environments of our partner customs and border authorities in

European external air, land and sea borders crossing points in Spain, Greece and Romania. Because the multiple benefits and enhanced security offered by the technical solutions extend into other operational environments, for example arenas and prisons, demonstrations will also be held in these locations in Spain and Finland.

The dates and further details of the Tests will be announced in the following issues of the Newsletter.

Introduction to the MELCHIOR Consortium

The MELCHIOR Consortium consists of 15 partner organisations from 9 European countries. In each issue of the Newsletter we will introduce three of our partners – Issue 2 covers the end user Hellenic Police, technology partners MICAM and CEA and research partner the University of Galati.



The Hellenic Police is the national police service having assumed its present structure in 1984 when the Gendarmerie and the Urban Police Forces were merged.

The Law Enforcement Agency has the responsibility not only to prevent and to confront and halt any criminal activities, but also to protect the State and the democratic form of government within the framework of the constitutional order. This extends to the implementation of public and state security policy. Further responsibilities include the policing and protection of Greece's borders, preventing and deterring the illegal entry and exit of people and implementing the laws relating to their stay and labour in the country.

The Hellenic Police comprises both central and regional Services with its headquarters being the supreme authority over these Services. In its continuous mission to serve and protect citizens, the Hellenic Police has responded to current demands and challenges by improving training, adopting a modern crime prevention policy, better utilising science and technology and by exploiting international law enforcement cooperation.

Member of the Hellenic Police's team in MELCHIOR is Captain Emmanouil Palaigeorgiou, who has served in the force since 1996. In 2008, he transferred internally to join the scientific police personnel. His duties relate to Crime Scene Investigation with an emphasis on DNA samples, so collecting samples from a crime scene and any terrorist activity, preparing skeletal remains samples for DNA extraction. He is also a trainer at the main response unit for CBRNe threats.

Captain Palaigeorgiou graduated from the Police Academy and the University of West Attica as a Medical Laboratory Technician. He has a Master of Science from the Medical School of Athens NKUA

in "Environment and Health, Capacity building for decision making" and a diploma in "CBRNe Threats for humans and the environment". He has published four papers and has furthered his knowledge with specific courses in CSI and Forensic Anthropology.

The Hellenic Police's primary role and contribution to the MELCHIOR project is not only to organise one of the five technology demonstrations in the second half of the project, but also to assess the prototype machine and other technologies during the tests to ensure that they meet not only the expectations set out in the Grant Agreement, but also operational police requirements and needs. Although Captain Palaigeorgiou does not expect that the outcomes of the project will directly impact his personal work, he does believe they will be of great help to other police departments, such as border control.

Asked about recent progress in MELCHIOR that he has witnessed first-hand, he explained that at a recent meeting in Valdemoro, Spain, a prototype machine was built and presented. Also that the research has been extended to find the appropriate frequency that will provide the maximum effect.

"My major challenge will be trying to provide the necessary requests from the Hellenic Police side, so that the scientific team can make the necessary modifications to the device that is being constructed. The biggest reward for us will be that the device is able, as far as possible, to detect prohibited objects and substances," explained Captain Palaigeorgiou.

The Hellenic Police has been involved in more than 40 European Projects, including (in the area of Evros) completed projects NESTOR, FOLDOUT and CAMELOT, and ongoing projects BORDER UAS, FLEXI-Cross and CONNECTOR.

Delivering enhanced protection from bomb blasts



MICAM Limited is one of the MELCHIOR consortium partners. We spoke with Dr. Neil Straker to learn more about him and his company.

Dr. Neil Straker is the Research and Development manager at MICAM and has 22 years of experience there. Established in 1966, MICAM started operations producing industrial laminates, copper-clad materials and woven glass products. In 1994 MICAM commenced the production of printed circuit boards and in 1995 the product range was extended to include laminated tubes.

20 years ago, MICAM shifted away from commodity manufacture into more specialist areas and research and development, many of which require some exacting tolerances from the materials. During this time, they were involved with a major UK airport authority to design panels intended to absorb bomb blasts.

Dr. Straker explained that the materials had to perform in a very particular way and not exacerbate the situation by shattering and causing injury. As deployment was for public environments, very exacting standards have to be met to maintain the integrity of the materials. There is a UK policy document called Aviation Security in Airport Development (ASIAD) to incorporate design elements into airports that will impart resistance to bomb blasts. MICAM designs and manufactures materials that meet these policy standards in full compliance with the health and safety regulations.

It is this knowledge and expertise that have been incorporated into one of the use cases for this project. In MELCHIOR, MICAM has designed a specialist walk-through cabinet that houses the detection technologies used. As part of the rigorous testing process, the cabinet will need to be exposed to the type of threat that it is designed to protect against to demonstrate its capability for this purpose.

“They are going to detonate an explosive charge inside”. Replied Dr. Straker when asked. “There is a lot of interest in seeing that take place”. He added. He then went on to reveal that the intention will be to try and do a second blast test from outside of the cabinet too.

When asked where he might see the biggest rewards and major challenges concerning MICAMs’ involvement in MELCHIOR, Dr. Straker felt that in terms of the challenge, MICAM was quite fortunate because they had already done the development work to have a mission-ready material, and their focus was on delivering a product that met the requirements of the end-user and, with the test in mind, performed well. He felt that the reward was from the collaboration with other partners, as each of them was contributing to arrive at a common goal.

One of the fascinating aspects is that to the casual onlooker, the cabinet can almost be dismissed as an open-looking corridor, but the true technology is below the surface in the way the materials are laminated and bonded together so that they will flex and absorb an explosive detonation.

Our conversation revealed that the work in blast mitigation materials is just one facet of a much wider portfolio. It was interesting to learn from Dr. Straker that their specialism in components has been used in wind turbines, fuel cells, Formula 1 racing, aerospace applications, and even in iPhones.

The final question to Dr. Straker was whether MICAM Limited had been in any previous Horizon projects, and if so which. Dr. Straker noted that although they had been involved in some national projects previously, this was the first successful consortium they had been part of in an EU project. He felt that the fact that the skills base is drawn from across the European Union makes for a very unique collaboration and he appreciates the experience.



CEA (Commissariat à l'énergie atomique et aux énergies alternatives) is the French Atomic and Alternative Energy Commission, a research and technology organisation (RTO) and member of EARTO – the European Association of Research and Technology Organisations. Active in four main areas: low-carbon energies, defence and security, information technologies and health technologies, CEA manages 10 research centres and six regional technology directorates throughout France, employing more than 16,000 people.

The Electronics and Information Technology Laboratory (LETI) in Grenoble specialises in micro and nanotechnologies and their applications, from wireless devices and systems to biology, health and photonics. The CEA Tech Institute was created in 2012 to carry out the technology transfer of KETs to SMEs in the French regions and its Multi Spectral Photonics platform will be used in MELCHIOR utilising LETI components.

Maher Hamdi is a Research Engineer in the multi-spectral imaging platform and on top of his PhD in physics, he has 15 years' experience in THz imaging and spectroscopy systems. He joined CEA in 2015 to share his expertise in THz, both in terms of systems and data processing. He contributed to the commercialisation of the first French THz bolometric camera as part of a joint laboratory with an industrial partner, as well as to the optimisation of THz imaging quality by working on the elimination of optical interference when using monochromatic sources.

Maher explained that CEA is contributing to MELCHIOR as an expert in THz imaging, providing a module for validating the presence of illicit objects hidden under clothing. Two approaches were possible: firstly, passive THz imaging, already available industrially but with low resolution, or secondly more resolute active imaging, but which is hampered by the low power of the sources. As the aim was not to image the body, the choice fell on active imaging at 300GHz. The technical problem to be resolved in the project is the reconstruction of THz information backscattered by the body or objects when dealing with non-planar

objects. THz imagery will provide a complementary source of information to analyses using infrasound and millimetre waves. The combination of these sources and AI analysis should improve the predictability of the presence of illicit objects.

CEA has several expectations for the results of the project, which are firstly to validate a THz reflectance detection concept by optimising the lighting and detection line; secondly to validate the system's ability to produce relevant information for the detection of illicit objects; and finally to improve the algorithms for reconstructing objects using reflectance imaging on non-planar surfaces, in order to solve the detection challenges.

Maher is very positive about the progress that has been made, describing it as "remarkable" with key milestones having been achieved in the development of both the hardware and software. He added: "It's important to bear in mind the delays in equipment delivery and the ongoing integration work. We've successfully designed a prototype system and are presently conducting tests to ensure its accurate detection of hidden objects, laying the groundwork for future implementation at the security checkpoints at border crossing points, in airports and in prisons."

Perhaps the main challenges CEA has faced in MELCHIOR has undoubtedly been understanding the information gathered by reflectance imaging, which is necessarily fragmentary and of low intensity, so that they can build the algorithms for aggregating this information, which is capable of providing robust and reliable information for the predictive analysis of illicit objects.

CEA is involved in many Horizon Europe projects, as it is one of the main RTOs in Europe, but this is the first project for the multi-spectral imaging platform, which is more dedicated to developing French and international industrial competitiveness through bilateral projects. Other projects that CEA has participated in include MIRPHAB, PhotonHub Europe, ACTPHAST and EUROSKY.



“Dunarea de Jos” University of Galati (UGAL) represents a pole of academic excellence for the South-East Region of Romania, but with both national and international reach. In its more than 70 years, it has expanded and modernised, gathering around it an academic community focussed on obtaining performance in teaching and research, and becoming a European-level university.

The Modelling & Simulation Laboratory (MSLab) is a top research infrastructure in the University, developing novel computational methods, including acoustical measurement systems and image reconstruction/analysis. By digitally simulating technical acoustics in virtual environments, reductions in development costs and time can be achieved without sacrificing the high standards of quality required of physical prototypes. MSLab has extensive experience in identifying and measuring acoustic parameters, sound propagation in layered media, and inverse scattering problems for the identification of scatterers.

Prof. Dr. Ing. Luminita Moraru, a physicist and engineer, is currently a Full Professor in the Department of Physics, Chemistry and Environment. In addition to her teaching responsibilities, she has an important role in the University’s research into physical principles of sound propagation and the behaviour of technical systems placed in acoustical fields and numerical simulations. Dr. Moraru is an Editorial Board member of several national and international journals and is an evaluator expert for national and international projects. She is also a member of various boards of External Examiners, adjudicating on international Ph.D. theses.

The fundamental problem of modelling sound propagation is to find a solution to an integral equation expressing the wave field at some points in space, in terms of the wave field at other points (or equivalently on surrounding surfaces). The difficult computational challenge is to model the scattering of sound waves in operational environments, so as to detect concealed objects on a person’s body.

To establish a mechanical-acoustical model in the near field, three target boundary conditions are considered: firstly fixed-rigid (or hard, the boundary condition requires that the normal velocity is zero at the boundary interface); secondly pressure-release (or soft, the boundary condition requires zero acoustic pressure at the boundary interface); or thirdly penetrable scatterers (or transmission condition, i.e., to ensure the continuity of the velocity field and the continuity of the pressure or the normal stress across the interface between two domains).

UGAL has developed a 2D acoustic model based on multiple inverse signal scattering using circular tangent elastic cylinders filled with biological tissue, i.e., non-fat or fat and muscle tissue. The influence of various low-frequency values on the backscattering field is being explored in the far (Radar Cross Section RCS) and near field (Sound Pressure Level SPL) approaches. MSLab is also focussed on evaluating the various design configurations (two, three and four layer systems) and testing the model on a variety of fabrics. The goal is to keep the frequency range as close as possible to the infrasound range and to offer the opportunity to avoid physical interaction with individuals being inspected.

The challenges for us in MELCHIOR are that all of these approaches are limited in one or more ways – frequency range, class of surfaces, types of boundary conditions, eccentricity of shape and/or computational implementation, and numerical efficiency.

“Considering the important challenges addressed by the MELCHIOR project and the experience gained through being part of a multi and interdisciplinary international research team, we want to establish an interdisciplinary centre of excellence with ambitious and beyond state-of-the-art objectives in the areas of passengers and goods security, prevention of illicit trade, piracy and other criminal acts,” enthused Professor Moraru.

MELCHIOR Project Partners



[UAH](#) is a public Spanish university with a commitment to increase social, employment-oriented and internationalisation of its students



[CEA](#) is a French research and technology organisation, with a lab specialised in micro and nanotechnologies and their applications



[TUM](#) is a German School of Engineering and Design which carries out world-class research and teaching at the interface of engineering and design



[SJT](#) is a Spanish SME focused on mechatronics and advanced research on science and engineering, especially for space and security



[Microflown Technologies](#) is the Dutch world's first and only manufacturer of a MEMS based sensor enabling measurements of acoustic particle velocity sensors



[UGAL](#) is a Romanian pole of academic excellence specialised in educating professionals in numerous fields with national and international reach



[MICAM](#) is an Irish company which manufactures speciality high pressure laminates (HPL) and prepregs and designs and manufactures specialised systems



[INTA](#) is the Spanish Institute of Aerospace Technique and is a Public Research Establishment attached to the Spanish Ministry of Defence



[KEMEA](#) is a Greek scientific, consulting and research organisation which conducts theoretical and applied research and studies on security topics and policies



[MININ](#) is the Department of the Spanish Government responsible for national and public security and maintaining order



[HPOL](#) is the Law Enforcement Agency in Greece with the mission to ensure peace and order, and to prevent and interdict any type of crime



[FIMOJ](#) is responsible for internal security and migration and manages law drafting, strategic planning and steering within its branch of government



[RBP](#) is part of the Ministry of Internal Affairs and deals with the varied problems connected to the use of illegal means of transiting the Romanian border



[UNIOVI](#) is a public institution of higher education and research, offering a full range of undergraduate degrees in many knowledge areas



[CBRA](#) is a Swiss research association specialising in supply chain security research and customs innovation services



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