



#90
MARCH 2020

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A molecular camera allows real-time imaging of cancer resection margins

A better understanding of stress responses in coral bleaching

Higgs pairs could yield new physics beyond the Standard Model

SPECIAL FEATURE
SATELLITES:
A MINI REVOLUTION
UNFOLDS ABOVE US

Editorial

How satellites are getting smaller and more sophisticated, how aerosols are impacting the climate and celebrating one project's success in a prestigious mobility award

welcome to this month's Research*eu magazine

When eagerly looking up at the sky as an awestruck child on a clear night, perhaps you saw a streak across the blackness that you thought was a shooting star. Or maybe you saw an extremely bright orb hanging in the sky that you eagerly took to be Venus or another celestial body that encapsulated the mysteries and wonders of the universe. Actually, chances are you were looking up at a very metal, very human satellite and it never seemed to capture the imagination in quite the same way.

If any of the above gave you a flashback to a disappointed childhood memory, then we hope our special feature this month might help to alleviate some of that disappointment and persuade you to give satellites a second chance. Because the global – and European – satellite industry is simply booming and is arguably one of the most innovative sectors in terms of technological development and economic expansion.

Rather than the big, clunky satellites of old, new satellites are small, including some that are sufficiently tiny to even fit into the palm of your hand. Smaller satellites have many things going for them – they are cheaper to manufacture, can be mass-produced and travel around the Earth together in 'swarms.' We may not be

able to see them with the naked eye anymore but they're becoming absolutely a vital component in our modern, technologically advanced society. And Europe is seizing all of the scientific and commercial opportunities of the satellite revolution as our seven showcased EU-funded projects clearly highlight.

Back down safely on Earth, this month's **Life After** catches up with a very promising former Marie Skłodowska-Curie fellow who has been at the forefront of research that could help us better understand the unfolding climate crisis, specifically looking at the impact of aerosols. We also celebrate the **NeMo** project that recently scooped up a prestigious mobility award in the city where the car is king – Los Angeles. Flick over to **Project of the Month** to find out more.

Finally, **EU Agenda** highlights upcoming events and our nine regular sections fill you in on everything going on recently in the dizzying world of EU-funded research.

Until next month, if you have queries, questions, suggestions (but hopefully never a complaint), please feel free to drop us a line at editorial@cordis.europa.eu

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A molecular camera allows real-time imaging of cancer resection margins

Surgery constitutes one of the primary treatments for cancer, yet we lack the tools to accurately identify and remove cancerous tissue. A breakthrough imaging modality promises to change the status quo by providing real-time intra-operative analytic capability.

Currently, over 3 million people are diagnosed with cancer each year across Europe. Healthcare costs exceed EUR 125 billion, posing a significant economic challenge. Despite medical advances, the primary mode of treatment for most cancer types is surgery.

IMAGING THAT ENLIGHTENS SURGEONS

The EU-funded CerISMA (Cerenkov Imaging for Surgical Margin Assessment) project tested the clinical efficacy of an innovative technology that assists with the surgical resection of cancer in a single operation. The LightPath™ imaging system developed by Lightpoint Medical Ltd in the UK can detect the uptake of positron-emission tomography (PET) imaging agents commonly used in pre-operative scans. As project coordinator Joanne O'Shea explains, "LightPath™ enables surgeons to differentiate cancer from normal tissue and define cancer margins during surgery."

The LightPath™ molecular imaging camera can detect Cerenkov light, a phenomenon first described in the 1930s. Cerenkov light appears when a charged particle travels through matter such as water or tissue faster than light. However, it wasn't until 2009 that scientists discovered that PET imaging agents – used nowadays for cancer diagnosis – produced the same visible light.

IMAGING AGENTS DEFINE SURGERY MARGINS

Prior to surgery, the patient is administered the imaging agent, which selectively accumulates in cancerous cells.

LightPath™ rapidly images the tumour specimen immediately after excision. As imaging agents travel only a few millimetres in biological tissue, the LightPath™ system depicts positive signals from cancerous cells only within a few millimetres of the tissue's surface, providing clear resection margins.

In particular in breast cancer, complete removal of the tumour is critical, but histological examination of the resected tissue can take up to 2 weeks. Positive margins are detected in nearly a quarter of the patients who are advised to undergo re-operation and/or receive further adjuvant therapies. To assess the efficacy of LightPath™, the CerISMA project undertook a clinical study.

LIGHTING THE PATH TO THE FUTURE

The LightPath™ imaging system has been tested in a pilot breast cancer trial at Guy's & St Thomas' Hospital in London and in a larger-scale study with over 60 patients at three hospitals across Poland. Results demonstrated that it can be safely and effectively used for surgical margin assessment in breast surgery. In general, LightPath™ provided good quality images while staff radiation exposure was low and within acceptable limits.

Overall, CerISMA produced invaluable results that will be instrumental to the further development of LightPath™ technology. During the project, the company secured 'early adopter' sales of the imaging system in Germany, the Netherlands and the United Kingdom. Ongoing result evaluation in conjunction with emerging data from current pilot clinical trials in prostate cancer and head and



“The LightPath™ imaging system will offer a dramatic reduction in costly re-operations and adjuvant therapies across a wide range of major cancer types.”

neck cancer surgery will further help shape the device commercialisation strategy.

In view of the future, O'Shea remains confident: “The LightPath™ imaging system will offer a dramatic reduction in costly re-operations and adjuvant therapies across a wide range of major cancer types.” The device will not only comprise an innovative solution for health-care providers, but also substantially reduce cancer care costs.

CERISMA

- Coordinated by Lightpoint Medical Ltd in the United Kingdom.
- Funded under H2020-LEIT-ADVMAT and H2020-HEALTH.
- cordis.europa.eu/project/id/698263
- Project website: cerisma.com

An ecosystem for integrated care of multimorbid patients

Chronic disease management costs the EU healthcare system EUR 700 billion annually. ProACT is a European initiative that aims to advance home-based patient chronic disease and multimorbidity self-management via a digital integrated care system.

Approximately 50 million people in Europe live with multimorbidity (the presence of two or more chronic health conditions). Most models of care focus on a single disease approach to treatment, which is not always suitable for multimorbid patients, given the complexity of managing multiple disease symptoms, medications and health professional appointments. This can be confusing and potentially unsafe for patients, if not handled appropriately.

PROACT: A DIGITAL SOLUTION TO SELF-MANAGING CHRONIC DISEASES AND MULTIMORBIDITY

To empower patients and their caregivers to play an active role in self-management and care, the EU-funded project ProACT (Integrated Technology Ecosystem for ProACTIVE Patient Centred Care) developed a digital integrated care system capable of supporting multiple-disease management. "Our goal was to advance integrated care by providing patients, their caregivers and health and social care services with a single digital platform to manage multiple chronic conditions. ProACT provides a suite of digital applications and technologies to effectively support multiple-disease management and people-centred care. The project also aims to offer the best delivery of care through 24/7 real-time feedback to individuals," explains project coordinator John Dinsmore.

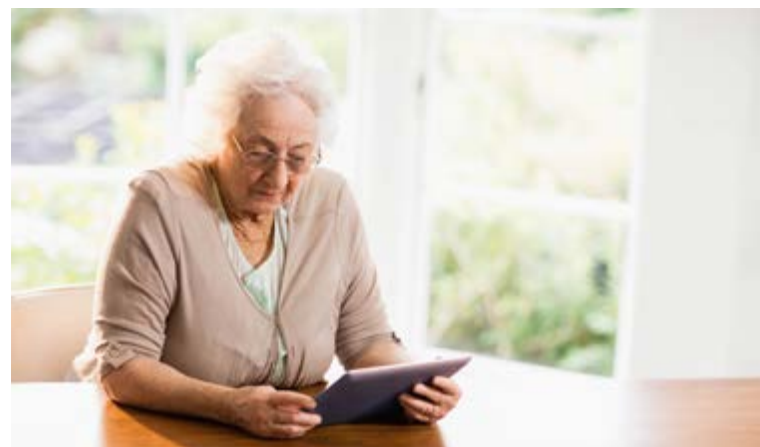
The platform allows multimorbid patients to monitor both health symptoms (e.g. blood glucose and blood pressure) as well as well-being (e.g. mobility and sleep) on a single-user mobile application. ProACT collects and analyses this data through a mobile app and a tailored toolkit of wearable and medical devices, specific to each individual user's disease profile. The data becomes available to patients and their relevant care network of supporting actors via a suite of CareApps, offering both personalised

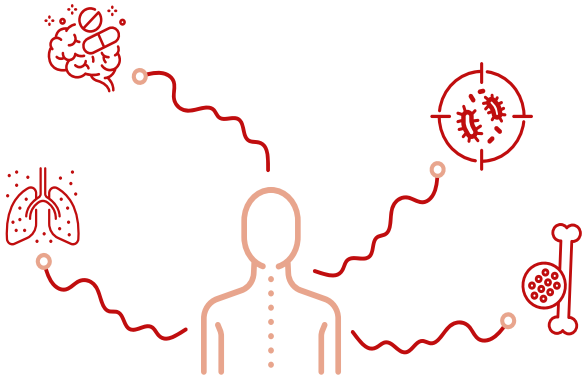
feedback as well as education and training specific to the needs of the user (e.g. education on heart failure or diabetes and training on using the application and devices).

The ProACT system has been designed to target diabetes, heart disease, chronic heart failure and chronic obstructive pulmonary disease, with the potential to be further developed to address other chronic diseases. Over 160 key stakeholders, including general practitioners, pharmacists, caregivers and hospital consultants across the participating countries, were also involved in the platform co-design and development process. Data from 8 504 adults via The Irish Longitudinal Study on Ageing (TILDA) was employed to train the AI system on the key ProACT diseases.

ACCEPTANCE AND FUTURE PROSPECTS

ProACT has been tested with 144 individuals in a proof-of-concept trial across three EU Member States (Belgium, Ireland and Italy) with promising outcomes. The intervention design was successful with participants





Approximately **50 million people** in Europe live with **multimorbidity**

effectively changing their behaviour towards using a digital self-management solution.

In addition, patients demonstrated improved health self-awareness, better diet and increased physical activity, and learned how to better manage their symptoms. Equally, caregivers and healthcare professionals positively endorsed the flexible ProACT approach for monitoring patients via the tailored CareApps. “Undoubtedly, developing a single digital system that can support multiple-disease management while advancing integrated care for patients and their care network was the most significant achievement of the project. To our

knowledge ProACT is the first system to successfully deliver this goal,” emphasises Dinsmore.

The project’s behavioural science-based co-design and patient-centric approach has significantly advanced EU understanding of digital care for people living with multiple chronic diseases, an area previously underexplored within EU health systems. At the same time, the project has provided clear guidelines to optimise the transferability potential of such digital platforms for their successful integration into European healthcare systems.

ProACT received a commendation from the Irish Healthcare Awards 2018 and was a finalist in the 2019 European Data Science Awards. A number of grants have been secured to advance the ProACT platform and associated research, with further trials due to commence in February 2020. A spin-off company scheduled to launch in 2020 will exploit the collective outputs of the ProACT project in parallel with any ongoing research activity.

PROACT

- Coordinated by Trinity College Dublin in Ireland.
- Funded under H2020-HEALTH.
- cordis.europa.eu/project/id/689996
- Project website: proact2020.eu
- bit.ly/39mhE9d

HEALTH

Cardiovascular disease biomarkers in blood detected at nano levels

An ever-increasing demand for point-of-care testing devices has given rise to the PHOCNOSIS analysis technology for early diagnosis of cardiovascular diseases.

Cardiovascular disease (CVD) is the leading cause of death in the EU, accounting for 1.9 million deaths each year (40% of all deaths) with an estimated associated cost of almost EUR 196 billion each year. However, CVD can be successfully treated when detected early and managed according to best practices.

DOUBLE ‘NANO-ATTACK’ ON TARGETED BIOMARKERS

“Our EU-funded PHOCNOSIS (Advanced nanophotonic point-of-care analysis device for fast and early diagnosis of cardiovascular diseases) project has devised a

nanotechnology-based analysis device for the minimally invasive diagnosis of CVD,” outlines project coordinator Jaime García-Rupérez. The approach relies on the combination of nanophotonics and micro-/nanofluidics. The sensing elements in the system consist of nanophotonic structures with a very reduced size able to provide high sensitivity. As García-Rupérez explains: “This means that the analysis chips can contain thousands of sensing elements in an extremely reduced area.”

To further increase the sensitivity to detect the required concentrations of the target biomarkers, the nanophotonic sensors were combined with an electrically controlled nanofluidic system based on depletion zone isotachophoresis, or dz-ITP. This technique can significantly increase the concentration of the target analytes at a certain location.

INTEGRATION OF THE TWO NANOSYSTEMS FOR THE FUTURE

Although the operations of the nanofluidic and nanophotonic systems have been demonstrated independently, it has not been possible in the project period to integrate the two. “When working on their integration, we observed that the electrical signals used to control the nanofluidic concentrator produced a significant increase in the optical losses for the nanophotonic sensors,” explains García-Rupérez. The researchers tried unsuccessfully to change the electrical signals to keep the concentrator working while maintaining acceptable optical losses. However, sufficient testing was not possible in the time available. Ironically, the researchers’ opinion is that this undesirable effect may have applications in other scenarios such as optical signal control and processing.

Once the PHOCNOSIS researchers can solve these problems, they expect to be able to deploy a device that could



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analyse two to three drops of a patient’s blood in just 10-15 minutes to diagnose early signs of CVD. Another relevant option the PHOCNOSIS team devised was to use fluorescent labels with the concentrator. Very good results were obtained using this approach.

Work along these lines will continue and the target development will be a low-cost, compact and easy-to-use system. “The sample to be analysed simply has to be placed in an analysis cartridge and introduced in the automated reader platform,” adds García-Rupérez.

Summing up the situation, it is worth noting that there is a platform prototype already in place, which might also be used for other applications where the detection of not-so-low concentrations or not-so-small analytes is required in other assays, such as for bacteria detection in food or environmental industries. This could be achieved by calibration of the assay targeted by the sensing chips.

The use of fluorescent labels with the nanofluidic concentration system may have more direct application in the medical diagnostic field. “Overall, the progress in the different research fields involved in the PHOCNOSIS project has been remarkable and has allowed us to learn a lot for future work with point-of-care testing devices,” concludes García-Rupérez.

PHOCNOSIS

- Coordinated by the Polytechnic University of Valencia in Spain.
- Funded under H2020-HEALTH.
- cordis.europa.eu/project/id/634013
- Project website: web.archive.org/web/20180412122207/https://phocnosis.eu



Exploring the media's influence on how European citizens think and feel about immigration

Immigration has become a hot topic across Europe in recent years, but how citizens think and feel about it can be influenced by how the media 'frames' immigrants themselves. The IMMIGRANTS project set out to unravel the underlying mechanisms.

Despite wide acceptance that the mass media influences attitudes to immigration, there is little empirical evidence. Macrosocial studies that have documented the effect of mass media on acceptance of immigration correlate news about immigrants (how often and in which tone?) with data on people's attitudes. Yet their results struggle to evidence direct causation.

This research carried out by the IMMIGRANTS (The Effects of Media News about Immigrants on Majority's Attitudes and Behaviors towards Immigrants) project, undertaken

with the support of the Marie Skłodowska-Curie programme, pursued a more individual-centred approach by exposing people to particular immigration news and then recording their reactions – in terms of their attitudes and emotions.

Sylvie Graf and Sabine Sczesny, professors at the University of Bern, found that language used to describe immigrants (e.g. nouns vs adjectives), the tone of the news (positive vs negative), who was talking about immigration issues (migrants vs experts), and the presence of

IMMIGRATION



accompanying images influence attitudes toward immigrants and immigration.

REVEALING THE UNDERLYING MECHANISMS

One method the IMMIGRANTS team used was to create fictitious newspaper reports inspired by real news. For example, they prepared various versions of an article about either positive or negative behaviour of Italian immigrants in Switzerland – one including descriptions of nationality with only nouns ('immigrated Italians') and another with only adjectives ('Italian immigrants'). Participants were randomly divided into four groups, one for each report.

After reading the fictitious article, participants were asked how they felt about Italian immigrants, and about their attitudes toward immigrants and immigration. The team compared the results from the four groups, surmising that any differences would be the result of the experimental manipulation. The evidence suggested that mass media news about immigrants can alter attitudes toward the immigrant group at stake after only singular exposure.

Regarding labels, when ethnicity or nationality of immigrants was described with nouns, people felt more negative about the given immigrant group than when it was described by adjectives, independent of whether they read about immigrants' positive or negative behaviours.

"We cannot avoid labelling when describing other people's group membership. We search for information about where others come from or belong in order to make sense of our social environment. But we should choose our words carefully as our descriptions may polarise attitudes of our audiences," says Graf, a Marie Skłodowska-Curie Fellow.

Preliminary evidence on the effect of images in news reports (increasingly prevalent with online news) on immigration suggests that reports with an image depicting an immigrant evoked greater empathy than reports without

“Better understanding of the factors that fight or enhance intolerance can inform tailored interventions to improve relations between groups in society.”

and subsequently led to more positive attitudes to immigrants and immigration. However, according to Graf: "The specific role of pictures accompanying news reports on immigration needs further investigation."

TOWARDS INCLUSIVE AND HARMONIOUS SOCIETIES

In order to create inclusive and harmonious societies, the goal defined within the European Platform against Poverty and Social Exclusion, residents of European countries must come to terms with people from different ethnic, cultural and religious backgrounds. "Better understanding of the factors that fight or enhance intolerance can inform tailored interventions to improve relations between groups in society," states Graf.

While the team have shared their results in workshops for professional communicators about immigrants and immigration (journalists and NGO employees), they are now seeking to reach a larger audience. They also plan to extend their research into the impact of images, as well as into behavioural intentions towards people from different groups.

IMMIGRANTS

- Coordinated by the University of Bern in Switzerland.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/703495
- Project website: immigrants-pro

Copies of past glories cause controversy in the present

Recreating a nation's past heritage after treasures are traumatically lost can be desirable. But reproductions need to follow high standards to avoid being abused by governments, found the REPLICIAS project.

Technological advancements and better knowledge about history make it increasingly possible to recreate the buildings and treasures of the past for the present day. But care needs to be taken over how we shape the way people now and into the future view the past.

REPLICIAS (Architectural replicas in the scramble for the past: Politics of identity in Istanbul, Athens, Skopje) Research fellow Kalliopi Amygdalou, with support from the Marie Skłodowska-Curie programme, researched examples of historical reproductions in Athens, Greece, in Skopje, the Republic of North Macedonia and in Istanbul, Turkey. She looked at how the reconstruction of buildings like the National Theatre and the Officers Hall in Skopje fitted together with other revivalist architectural work that was carried out by the previous government, to redefine the whole city's urban identity.

Amygdalou also analysed the reconstruction of selected Ottoman buildings in Istanbul, such as the medrese of Hagia Sophia. On a smaller scale, the researcher looked

at copies of museum artefacts like the Alexander Sarcophagus in Istanbul and its copy in Skopje and the Parthenon Marbles in London and their copies in Athens.

"Reconstruction creates new matter and new evidence based on little information and is therefore very open to manipulation or distortion," Amygdalou found. "It is easy to advertise to a general public compared to archaeological or preservation work. It is therefore more usable in the hands of populist politicians, many of which are in power today."

IDENTITY POLITICS

Amygdalou had studied the relationship between architecture and nation-building in south-east Europe, but it was when she was living in Turkey in 2013 during the Gezi Park protests that she began noticing how copies became part of identity debates. In the protests, which spread throughout Turkey, at least eight people died and 8000 were injured, according to a Turkish doctors' association quoted in The Guardian. The trigger was the reconstruction of the Ottoman barracks on Taksim Square in Istanbul, remembers Amygdalou: "This was the first example that made me think about what reconstruction meant for both its supporters and its opponents. Meanwhile my home country Greece was in an intense dispute with North Macedonia over the ownership of ancient Macedonian heritage."

Supervised at the Hellenic Foundation for European and Foreign Policy by Thanos Veremis, Professor Emeritus of Political History at the University of Athens, Amygdalou conducted fieldwork, interviewed architects and heritage workers and examined archives. She set out to explore the politicisation of copies in a region in which empires such as the Macedonian, Roman, Byzantine and Ottoman



“Reconstruction creates new matter and new evidence based on little information and is therefore very open to manipulation or distortion.”

were eventually replaced by nation-states. These also have been involved in turbulent times.

Amygdalou's findings on Skopje were part of an exhibition that she co-curated in Athens, titled 'The Future as a Project, Doxiadis in Skopje', and that featured in a documentary.

Heritage can never be neutral; politics will always be involved, concluded the REPLICIAS project, but it should be discussed and debated in a transparent way, with the

involvement of educated experts. The researcher points to the Venice Charter's guidelines on meaningful, acceptable reconstructions and cites the Frauenkirche in Dresden, Germany, and Mostar Bridge in Bosnia as good examples.

"The standards are as strict as for an archaeological excavation and the process can take many years. It is not meant to be completed in time for visual consumption on political posters," Amygdalou concludes.

REPLICIAS

- Coordinated by the Hellenic Foundation for European and Foreign Policy in Greece.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/748634
- Project website: replcias.eu

SOCIETY

Technology that kisses clunky audio guides goodbye

Few use the audio guides offered at museums and some venues struggle to offer them because of the cost of making and maintaining them. With EU support, the Nubart7 project has developed a way of offering take-away guides that work on our mobile phones.

When museums offer audio guides to enrich our experience of visiting a museum, few of us pay the extra for them, and even when they are offered for free not even 35 % of us accept them, says Spanish company Digital Tangible. That could change quickly, though, thanks to cards with take-away guides for our mobile phones that the company marketed and developed during EU project Nubart7 (From museums to everywhere: Nubart's highly innovative audio guides are looking for new verticals).

Digital Tangible first launched its Nubart technology for museums in 2016 and has been able to test it in new sectors during the project. "When you are on a very tight budget, as we are in a boot-strapped company, it's hard to free up resources of time and money, and to take a breath. But you need to get out of your daily routine to see what you can do from a different perspective,"



says Rosa Sala, the founder and chief executive of the Barcelona-based firm.

The company carried out pilots to see if the technology would work beyond the museum business. It discovered it was also ideal for trade shows and has already signed up a new customer in Brussels and is in talks with another in Düsseldorf. “Many non-museum venues had never considered the possibility of audio guiding their business before,” explains Sala. “But when they tried out our cards they were amazed at how simple, quick and easy the access to the content is.”

The Nubart cards are designed to be both tangible and digital. An end customer buys or receives the card for free at a tradeshow or museum; it contains a personal key code to access the digital guide. The card can be kept as a souvenir, containing a logo, and the guide still works after the visit, though is personal and non-transferable.

The technology operates on a user’s smartphone and therefore doesn’t require any bulky handheld device, like those traditionally used in museums. Sala argues Nubart’s content management system is easier and cheaper to update than museum apps which are downloaded from the AppStore or Google Play. They are more efficient than a responsive webpage with audio tracks on a museum’s webpage. “None of the traditional options allows the museum to recover the investment in content production and development,” adds Sala.

“*The result of the project is a more motivated team, new horizons to pursue and a highly innovative product.*”

As with all development, not all the Nubart7 project trials were successful. However, all the pilots improved the product. To tailor it to trade shows, the developers allowed visitors to choose the part of the venue they were really interested in – a feature Digital Tangible now offers to museum clients. All clients are pleased the system returns anonymous data to improve future customer satisfaction.

The cards are now used at 18 venues in seven countries, including the Johan Cruyff Arena in Amsterdam, the Albertina in Vienna and the Alcazaba fortress in Malaga. “The result of the project is a more motivated team, new horizons to pursue and a highly innovative product,” concludes Sala.

NUBART7

- Coordinated by Digital Tangible in Spain.
- Funded under H2020-Societal Challenges, H2020-SME and H2020-LEIT.
- cordis.europa.eu/project/id/855968
- Project website: nubart.eu
- bit.ly/2SuNikB

EXOPLANETS: THE RACE TO FIND NEW PLANETS AND LIFE BEYOND OUR SOLAR SYSTEM

For many years exoplanets, planets beyond our solar system, existed merely in theory and science-fiction storylines. While there were those who believed in their existence, there were no means of detecting planets light years away.

This, however, has changed radically over the last two decades with advances in technology and capabilities in observation, both on Earth and in space. Today, exoplanetary research is developing at a startling rate. There have been more than 4 000 exoplanets discovered outside our solar system, illustrating just how diverse the planets in our galaxy are.

With these scientific advancements, exoplanets were no longer an idea or part of a story, they’ve become real; and this **CORDIS Results Pack** will highlight some of the most exciting EU-funded research in the ongoing hunt for planets beyond our solar system.

To find out more, browse, download or order a physical copy of the Results Pack here:
cordis.europa.eu/article/id/411528





New disruptive system enables rapid maintenance checks of rail network

European researchers have developed an innovative mobile mapping solution for designing, installing and maintaining overhead line equipment systems more quickly and cheaply.

Railway infrastructure maintenance includes an exhaustive visual inspection of the catenary (overhead line) by an operator, which involves walking the whole network at least twice every year. These visual inspections are very costly, relatively inaccurate and often block the lines undergoing inspection for considerable periods, thereby reducing the network's productivity and competitiveness.

On average, the rail sector spends EUR 39 600 per kilometre of track on rail infrastructure maintenance, which accounts for 38% of total operating expenses. Since the EU has around 111 000 kilometres of railway infrastructure, total annual maintenance costs are over EUR 4 356 million. To become more competitive, Europe's rail sector must find ways to reduce these costs.

The EU-funded project tCat (Disrupting the rail maintenance sector thanks to the most cost-efficient solution

to auscultate railways overhead lines reducing costs up to 80 %) addressed this challenge, developing an innovative system that dramatically reduces maintenance costs related to overhead line equipment (OLE). "Our novel rail trolley is a real-time mobile mapping solution that facilitates and speeds up the design, installation and maintenance of overhead lines and supporting infrastructure that power electric trains," says project leader Cesáreo González Álvarez.

EASY TO TRANSPORT AND USE

Researchers updated an existing prototype developed by the Spanish company Telice SA which is much faster in conducting the mobile mapping of OLE operations in real time. "The initiative enabled us to conduct a major technological upgrade of our tCat measuring trolley, which dramatically improved its measurement speed



“*Mitigating risks, operational delays, shutdowns and wasted costs, time and productivity is now inexpensive thanks to tCat.*”

and has been tested in real operational environments,” explains González Álvarez.

The lightweight (about 26 kg) all-weather measuring trolley is foldable and easy to assemble in the field and includes light detection and ranging (LiDAR) sensors for use in the 2D profiling of the track environment. It also includes inertial measurement unit sensors for measuring track parameters and a global navigation satellite system for the positioning of static measurements.

In addition, the trolley employs machine learning algorithms for statistical data processing and the automation of the extraction of some parameters. tCat can also be connected to a cloud platform, where a remote user can access the information captured in the field. The data is then used to create customised reports such as pole and midspan profiles, and height and stagger tables and graphics.

A MAJOR STEP FORWARD

The system provides instant measurements of the height and stagger of the overhead contact wire, as well as other geometrical parameters such as clearances, odometer readings, railway track cant (crossing level) and slope (longitudinal level). According to González

Álvarez: “Mitigating risks, operational delays, shutdowns and wasted costs, time and productivity is now inexpensive thanks to tCat.”

Tunnel surveys can also be conducted for projects involving the electrification of existing non-electrified railway lines. “tCat produces as-built tunnel section profiles of old tunnels for defining tunnel clearance requirements in OLE designs. It can also determine the track’s position relative to the surrounding structures to ensure the train’s safe passage through the tunnel and whether the tracks are free of vegetation,” comments González Álvarez.

Thanks to the tCat OLE Mobile Mapping system, processes can now be performed between five and six times faster, reducing costs by up to 80 %. This makes it a disruptive and unique solution in terms of cost savings and preventive maintenance operations. “The project also enabled us to reach stakeholders in Spain, the UK, the US and other countries who provided key insights for product development and will continue to provide feedback on further improvements,” González Álvarez points out.

TCAT

- Coordinated by Telice in Spain.
- Funded under H2020-TRANSPORT, H2020-LEIT-ICT and H2020-SME.
- cordis.europa.eu/project/id/778608
- Project website: tcat.es

TRANSPORT AND MOBILITY

A new vision for ensuring the safety of road and rail tunnels

An innovative system using ground-penetrating radar to test for failures in a tunnel’s infrastructure paves the way towards significantly faster and improved inspections.

Today, engineers test the structural integrity of a road or rail tunnel by hitting the tunnel wall with a hammer and recording the reflected sound. Although this process has

the advantage of being remarkably simple, the downside is that it is time consuming. Furthermore, interpretation of the acoustic data is prone to errors, a factor that could



© Muratart, Shutterstock

have serious – if not catastrophic – consequences for the safety of a tunnel.

To prevent such disasters, Euromobilita, a Czech technology company, has created a new concept in ground-penetrating radar (GPR) for use in tunnel construction and maintenance. Called Tunnel Vision, the system uses rotating antennae to form 3D high-resolution images of the surface that can be easily interpreted by the end user. The soundness, economic viability and market potential of this concept was tested during the EU-funded TUNNEL VISION (Novel Subsurface Inspection Radar to Inspect Tunnels and Tunnels Linings for improved maintenance) project.

“We believe the creation of clear 3D augmented reality images will allow civil engineers to accurately determine failures in the tunnel’s infrastructure,” explains Ales Loncaric, Euromobilita technical director and TUNNEL VISION project manager. “By providing this, Tunnel Vision will improve a tunnel’s performance and resilience while reducing the risks, effects and costs of structural failures.”

ADJUSTING TO MEET END-USER NEEDS

Working with industry professionals and potential end users, project researchers proved the GPR technology’s ability to achieve the intended results while operating

“We believe the creation of clear 3D augmented reality images will allow civil engineers to accurately determine failures in the tunnel’s infrastructure.”

in a tunnel environment. The project also determined the costs of acquiring the required subsurface tunnel infrastructure inspection radar, including the unit price of the hardware, integration of the hardware with customer-owned rail vehicles, establishment of a capable data communication infrastructure, manufacturing partner software licensing fees, and initial staff training.

To ensure the system would be accepted on the market, project researchers also studied the needs of infrastructure managers. Here, researchers discovered that the proposed system was not appropriate, as infrastructure managers need to be able to place the antennae in the centre of the tunnel.

“The original concept used a rotating antenna that could only be positioned using a robotic arm, which was not practical for our targeted end users,” explains Loncaric. “As a result, we went back to the drawing board to redesign the Tunnel Vision concept.”

THE DISRUPTIVE TECHNOLOGY OF THE FUTURE

Once complete, the Tunnel Vision system will achieve surface measurements of up to 3 metres deep (compared to the 10 cm capability of traditional acoustic systems). Tunnel Vision will also significantly increase the speed at which inspections take place – from a maximum of 7.5 metres per hour to over 5 km per hour.

“By being able to scan deeper and faster, Tunnel Vision is positioned to be the disruptive technology of the future,” adds Loncaric.

TUNNEL VISION

- Coordinated by Euromobilita sro in Czechia.
- Funded under H2020-Societal Challenges, H2020-LEIT and H2020-SME.
- cordis.europa.eu/project/id/835567
- Project website: euromobilita.com/home/tunnel-vision



PROJECT OF THE MONTH

NeMo project wins prestigious mobility award in the MOBI Grand Challenge

This month we're celebrating the NeMo project, which has won a prestigious award for its work on creating the foundation for interoperable electro-mobility services.



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MOBI is a non-profit smart mobility consortium working with more than 100 forward-thinking companies, governments and NGOs to make mobility services more efficient, affordable, greener, safer and less congested by accelerating the adoption of blockchain, distributed ledger and related technologies in the mobility industry.

As a part of these efforts, the MOBI Grand Challenge was launched in 2018 and its dedicated MOBI Grand Challenge 2 Citopia explored new solutions for human mobility to create smarter and greener cities and improve overall quality of life.

And so, at the Challenge's awards ceremony held in Los Angeles in November 2019, the EU-funded NeMo (Hyper-Network for electromobility) project earned first place in the 'Most feasible' category due to the project's efforts to create an open and distributed ecosystem to enable the seamless interoperability of electro-mobility services.

“The decentralised NeMo 'Hyper-Network' enables the seamless interoperability of electromobility services among actors, who can easily interact, create innovative composite services and provide them via the open cloud marketplace.”

Angelos Amditis, project coordinator

A big congratulations to the NeMo team from everyone at CORDIS!

NEMO

- Coordinated by the Institute of Communication and Computer Systems in Greece.
- Funded under H2020-TRANSPORT.
- cordis.europa.eu/project/id/713794
- Project website: nemo-emobility.eu

If you are interested in having your project featured in 'Project of the Month' in an upcoming issue, please send us an email to editorial@cordis.europa.eu and tell us why!



A better understanding of stress responses in coral bleaching

Mass coral bleaching, which can result in coral death and the loss of valuable marine biodiversity, has been reported since the 80s, with 2016 witnessing the most significant to date. DENOCS set out to unravel the role of oxygen and nitrogen radicals in the stress response.

Coral reefs rely on the symbiosis of microalgae with a calcifying animal, to build the reef infrastructure. However, climate change is now threatening coral reefs worldwide by causing a symbiotic dysfunction known as 'coral bleaching'.

While scientists know that bleaching is a species-specific and stressor-specific response, the underlying cellular and

intercellular responses remain underexplored. It is known that nitric oxide (NO) and hydrogen peroxide (H_2O_2) are involved, but their sources, interplay and dynamics had not been investigated in corals prior to the DENOCS (The Double Edged Role of Nitric Oxide and Hydrogen Peroxide in a Coral Symbiosis) project, which was supported by the Marie Skłodowska-Curie programme.



“By better understanding the nitrosative and oxidative stress responses in corals, DENOCS helps efforts to quantify threshold concentrations and likely impact sites for more effective interventions.”

DENOCS was able, for the first time, to visualise stressor-specific NO production in an intact symbiosis using coral tissue cultures. The experiments showed that ‘typical’ coral bleaching-inducing stressors initiated NO production at the microalgae site. The team also showed that light stress alone could induce the same.

WHEN SYMBIOSIS BREAKS DOWN

Under environmental stress, the symbiosis between the animal host (cnidarians, of the order *Scleractinia*) and the microalgae *Symbiodiniaceae* living within their tissues breaks down. When the microalgae are either degraded or expelled, all that is then visible is the white, bleached looking coral skeleton underneath the almost transparent animal. If the stress conditions do not subside, the coral dies.

High sea surface temperatures in conjunction with high light are the key stressors leading to coral bleaching. However, different species of microalgae can respond differently to stress, and some corals can modulate their resilience by exchanging their microalgal symbiont with a more stress-tolerant species.

DENOCS used bioimaging and micro-environmental sensing in corals under stress to investigate if the coral animal or the microalgae are the main producers of cellular radicals (H₂O₂ or NO) in the bleaching response.

Using coral tissue cultures (from the coral *Fungia fungites*) subjected to thermal stress and high light under short-term (6 hours) and long-term (24 hours) incubations, the presence and location of NO within the symbiotic tissue arrangement could be mapped on a confocal microscope after addition of a NO-responsive fluorescence dye. The

team also found that low oxygen conditions could stimulate the production of harmful cellular radicals such as NO.

It was also found that different microalgal cultures (*Symbiodinium microadriaticum* and *S. tridactnidorum*) responded differently to NO stress. “When a coral hosts *S. microadriaticum* and the animal is releasing NO as a stress response to high temperature or light, the productivity of its microalgal symbiont will be lowered. This means that less energy will be transferred to the host compared to a coral harbouring a less NO-sensitive microalgal symbiont,” Verena Schrameyer, the postdoctoral research fellow in DENOCS, explains.

CORAL REEF MANAGEMENT

Coral bleaching is repeatedly highlighted by researchers and the media as one of the most devastating consequences of climate change. The DENOCS project helps explain in more detail what is going on, and how some of these stress mechanisms are similar to those in higher animals.

“By better understanding the nitrosative and oxidative stress responses in corals, DENOCS helps efforts to quantify threshold concentrations and likely impact sites for more effective interventions,” says Michael Kühl, project coordinator.

DENOCS’ technological advances could be used for further ecotoxicological work. The experimental techniques could, for example, be used for studies into how environmental pollutants like plastic leachates or other xenobiotics affect the production of cellular radicals and their critical thresholds for coral stress.

DENOCS

- Coordinated by Copenhagen University in Denmark.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/747464

How climate change impacts predator populations

Environmental changes hold unknown consequences for animal populations, including predators. Researchers are studying the genetics behind how predator populations are coping, using Eleonora's falcon as a model.

It is important to understand how plant and animal populations cope with climate change and what abilities they have to survive as global temperatures rise and environmental changes occur. Scientists now know that environmental changes can coincide with evolutionary changes in animals affected by climate change, but little is known about the role of environmental changes in genetic traits.

The EcoEvoClim (Ecological and Evolutionary consequences of predator-prey phenological match-mismatch driven by climate change) study, with support from the Marie Skłodowska-Curie programme, set out to study the role of genetic variation and plasticity in the evolutionary response of predators. The study, led by researcher Laura Gangoso, used Eleonora's falcon (*Falco eleonora*) colonies in the Canary Islands of Spain as a model system to look at changes in their colours associated with behavioural traits.

WIDE-RANGING IMPACTS

Climate change has caused these migratory birds to change their breeding habits, with those breeding in Europe and wintering south of the Sahara having advanced, while those wintering north of the Sahara have been delayed. "The Canarian population of Eleonora's falcons may be considered as a sentinel of environmental processes that occur at large spatial scales," Gangoso says.

The researchers investigated the role of genetic variation, through the different coloured plumage, and plasticity (the bird's ability to adjust breeding and hunting efforts). They quantified how climate change affects the link between peak food abundance and the timing of breeding in this specialist predator.

Gangoso and her team unravelled the mechanism by which Atlantic trade winds determine the viability of the Eleonora's falcon population from the Canary Islands.

"This study represents a nice example of the need to apply multidisciplinary methods to answer complex questions," notes Gangoso. They used field observations, GPS tracking of falcons, radar monitoring and simulation modelling of prey to integrate the impact of regional winds.

MONITORING AND MODELLING TO REDUCE UNCERTAINTY

The EcoEvoClim team developed a model that explains 90 % of the variation in annual productivity of falcons over a decade, providing a reliable predictive tool of population fitness. The study serves as a proof of concept linking climate conditions and animal populations through long-term field monitoring, sophisticated observation tools and mechanistic models.

Unfortunately, there is still some uncertainty about how climate change will continue to affect this population of



“Having a powerful, predictive model of population fitness will be the basis for accurate forecasting when reliable climatic models become available.”

falcons in the future. “Although the future is uncertain, having a powerful, predictive model of population fitness will be the basis for accurate forecasting when reliable climatic models become available,” reports Gangoso.

In assessing the role of genetic variation in the ability of populations to plastically respond to climate change, EcoEvoClim researchers analysed long-term data (2007–2017) on the falcons’ breeding performance with regard to genetic plumage colouration. They found that differences in the breeding tactics between males could be explained by cannibalism, especially when food supply

is low. “This suggests that mating patterns may interact with other factors and give rise to the observed higher breeding output of dark males only under certain environmental conditions,” explains Gangoso.

The project researchers are still analysing the eco-evolutionary response of predator populations to phenological (life cycle) mismatch due to climate change. “The project is a long-term project that I hope will be able to be maintained in the future,” Gangoso says.

ECOEVOCLIM

- Coordinated by the University of Amsterdam in the Netherlands.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/747729
- Project website: eleonorasfalcon.org/the-project/new-project

CLIMATE CHANGE AND ENVIRONMENT

Introducing peatlands to global carbon cycle monitoring

Despite only covering about 3 % of the Earth’s surface, peatlands contain around 33 % of all global soil carbon. The PEATmod project developed a methodology to include peatlands in the global carbon cycle, for more accurate climate models.

Predicting future climate change relies on models which simulate the interactions between the global climate system and the earth’s processes. The reliability of these predictions is dependent upon evidence-based representations of the underlying processes.

Carbon cycle models seek to represent the major stores and flows of carbon. Current global vegetation models, used to estimate carbon fluxes, often omit peatlands, leaving a knowledge gap about one of the largest terrestrial carbon stores, alongside the associated atmospheric gas exchange.

The EU-supported project PEATmod (PEATland modelling for global carbon cycle and climate models), working with state-of-the-art process modelling, developed

a methodology for assessing the knowledge gaps that would have to be addressed before peatlands could be introduced into global vegetation models. The results showed that peatlands are too diverse to be modelled uniformly; tropical peatlands require a different approach to that used for northern boreal systems.

IDENTIFYING KNOWLEDGE GAPS

Peatlands are an important component in the natural process of methane emissions, constituting approximately 20 % of global emissions.

Modelling carbon cycles more accurately is one of the key areas PEATmod has identified as needing to be addressed.

This will provide a better understanding of the role temperature plays in the soil decomposition processes.

The size of the current peatland carbon pool, alongside its possible reduction due to increased temperatures, makes this a key element to improve in models.

“The response of peatlands to changes in climate depends on their geographical position and current climate conditions. PEATmod specifically sought to investigate the drivers of methane emissions (such as temperature and hydrology). This is of special importance in the tropics. We also looked at how permafrost-melt will affect northern peatlands,” explains Marie Skłodowska-Curie Fellow Anne Quillet.

A conceptual model, based on expert opinion from scientists working globally, was developed to identify the biggest data gaps. The goal was to create a collaborative methodology to plug these gaps.

It became clear that the biggest data gaps were in understanding hydrological change. A lot of carbon can be lost during droughts when peatlands dry out releasing CO₂ into the atmosphere. River flooding, such as that seen in the Amazon, can frequently hinder carbon storage.

Seasonal flooding also causes greater methane emissions under the high temperatures of tropical systems. Although both of these effects are also observed at higher latitudes, they are of lesser importance in boreal peatlands

“Our identification of the critical drivers will help develop the next generation of global vegetation models for better estimates of both peatland carbon functions in the atmosphere and climate feedback effects on peatlands.”

because of lower hydrological variability, less regular and less extensive flooding and lower temperatures.

INTEGRATING THE PEATLAND MODEL

PEATmod's work contributes to the approaches being developed and rolled out for assessing carbon storage and release from peatlands, which as part of the Kyoto Protocol have to be calculated by every country.

Currently, the lead researcher is working with collaborators to further assess the impact that implementation of a new peatland model will have on global model simulations, with implementation of a tropical peatland module identified as the critical first step.

“Our identification of the critical drivers will help develop the next generation of global vegetation models for better estimates of both peatland carbon functions in the atmosphere and climate feedback effects on peatlands,” says Quillet. “This also has implications for the climate mitigation strategies of wetlands, agriculture, land-use and energy management.”

Indeed, some of PEATmod's results have already been adopted by other modelling groups, and the project's method, approach and results will be published in open access scientific journals.

PEATMOD

- Coordinated by the University of Exeter in the United Kingdom.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/658041
- Project website: researchgate.net/project/PEATland-modelling-for-global-carbon-cycle-and-climate-models





SPECIAL FEATURE

SATELLITES: A MINI REVOLUTION UNFOLDS ABOVE US

Editorial

One small step for Sputnik, one giant leap for satellite innovation

At the beginning of 2019, according to the United Nations Office for Outer Space Affairs (UNOOSA), nearly 5 000 satellites were orbiting the Earth, an increase of 2.68% on the previous year. Since the Soviet Union first launched Sputnik into orbit back in 1957, around 8 378 satellites have been sent up into outer space. Seven additional satellites are also orbiting planets other than Earth. However, not all of these nearly 5 000 satellites are still active – only around 2 000 are still functional, meaning that less than 40% of the satellites currently in orbit are fully operational.

For those nearly 2 000 fully operational satellites that are orbiting our planet, they're up there for many different reasons. Communications and Earth Observation is a major *raison d'être* for many of them, and was the sole purpose of most satellites launched in 2018. Indeed, most satellites are Earth-centric and are becoming an increasingly important component in the functioning of 21st century society. Meanwhile, a smaller percentage of satellites are sent up specifically to 'look out' into deep space, where they capture stunning images of stars, nebulae, exoplanets and other galaxies, providing invaluable data to help expand humanity's understanding of the universe.

But as more satellites are being launched up into space, satellite technology is rapidly evolving, and innovation is thriving throughout the sector. As the title of this issue's special section indicates, one of the key trends of recent years is that satellites are becoming infinitely smaller – with some weighing only 1 kg. From 2012 to 2016, the average satellite weight went down by almost 80% and since then, the number of small satellites launched in orbit has risen by

300%. Smaller satellites are cheaper to manufacture, can be mass-produced and can be launched in groups (called 'swarms'), meaning they have a lower launch cost. On the other hand, smaller satellites tend to have a shorter lifespan and their orbit around Earth is more likely to rapidly decay. Their size also limits the amount of hardware they can carry, and they lack large power and propulsion systems.

However, current trends seem to indicate the pros of smaller satellites are vastly outweighing the cons – the small satellite market is absolutely booming. The entire global satellite services market's total revenue is expected to exceed EUR 5 billion in 2021, up from EUR 2 billion in 2016, with the private sector playing an increasing role in satellite innovation.

So of course, European researchers and companies want to get in on the action and grab a slice of the cake, including many innovative SMEs. In fact, out of the seven Horizon 2020-supported projects we showcase in this issue's special section, three are funded through the dedicated SME Instrument. From pioneering work on new launch systems for the new generation of satellites, to cutting-edge research on how to ensure smaller satellites are able to work as a team and coordinate and communicate with each other, our special feature clearly highlights how Europe is reaching for the skies and is determined to play its role in this unfolding technological revolution.

We look forward to receiving your feedback. You can send questions or suggestions to editorial@cordis.europa.eu

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New generation of miniaturised cameras changes the face of the satellite market

Cost-effective, green and more efficient propulsion systems for small satellites

NanoAvionics has successfully devised a new generation of propulsion technology that addresses a major shortcoming of small satellites. The new system, which relies on ammonium dinitramide as a propellant, is already commercially available.

There is no stopping the exponential growth of the small satellite market. From 2012 to 2016, the average satellite weight went down by almost 80%. Since then, the number of small satellites launched in orbit has risen by 300%.

Yet, as the segment gets propelled by rising demand and new technology, actual satellite propulsion systems are falling behind. You could sum up their shortcomings in two words: hazardous and expensive. And whilst alternatives do exist, their performance generally disappoints.

FIRST OF ITS KIND

There is one exception though. "EPSS is a first-of-its-kind high-performance satellite propulsion system. It uses a non-toxic green chemical monopropellant (ammonium dinitramide), is 10 times cheaper than alternatives, and is 30% more effective than its closest competitors," says Vytenis Buzas, CEO of NanoAvionics.

The EPSS 2 (Enabling Chemical Propulsion System for the Growing Small Satellite Market) venture started in 2016 with the objective of developing and piloting low-cost, high-performance propulsion systems using an environment-friendly propellant for satellites weighing less than 150 kg. "The need for such a propulsion system was significant," Buzas recalls. "Propulsion systems enable satellites to perform complex tasks which are critical to delivering high-value services. These include precision flight in constellations, orbital manoeuvring, avoiding space debris, synchronisation and positioning of communication equipment and payload instruments, atmospheric drag compensation and subsequent lifetime extension, as well as de-orbiting at mission end."



“EPSS is a first-of-its-kind high-performance satellite propulsion system. It uses a non-toxic green chemical monopropellant (ammonium dinitramide), is 10 times cheaper than alternatives, and is 30% more effective than its closest competitors.”

A propulsion system basically enables small satellites to provide contemporary satellite services: remote sensing, radio and optical astronomy, space exploration for governmental and private science missions, atmospheric studies and weather forecasting, communications and broadcasting, navigation, security, search and rescue, and the Internet of Things (IoT).

With EPSS, such missions benefit not only from a green label and reduced cost, but also from significant thrust and burn duration.

A SIMPLE YET RELIABLE ARCHITECTURE

So how does it work exactly? “The EPSS inherits a relatively simple yet reliable architecture – consisting of a propellant tank, flow control block and a thruster – and utilises a monopropellant blend,” explains Erikas Knežys, CDO of NanoAvionics. “The propellant tank features an active thermal management system and uses a blow-down configuration with an elastomeric membrane separating pressurant and propellant. The flow control block, on the other hand, consists of a latching valve, pressure sensor, system

filter and two isolation valves in series acting as flight control valves. Finally, the thruster chamber features a catalyst as well as heaters. Firing of the thruster occurs when the Engine Control Unit (ECU) actuates the solenoid valves, thereby opening a flowpath of propellant. As the propellant flows to the decomposition chamber and is injected onto a pre-heated catalyst bed located inside the thruster decomposition chamber, the decomposition reaction begins and energy is released, generating thrust promptly.”

Reductions in manufacturing costs arise from the use of in-house optimised instrumentation and components, but also and most importantly from the catalytic system located in the decomposition chamber of the thruster.

Phase 2 of the SME Instrument-supported project was completed in September 2019. The system has already been brought to TRL 9 through orbital demonstration, and integration and flight with commercial customers’ satellites has begun. These customers can now benefit from the likes of longer mission lifetime, more efficient orbital control and shorter constellation deployment time.

EPSS 2

- Coordinated by NanoAvionics in Lithuania.
- Funded under H2020-LEIT-SPACE and H2020-SME.
- cordis.europa.eu/project/id/768434
- Project website: n-avionics.com/projects/propulsion-system-2-epss2

Advancing the feasibility of self-organising small satellite formations

This year will see the world's first in-orbit demonstration of a self-organising, three-dimensional formation of pico-satellites.

Satellites used for communication, positioning and Earth observation have historically been large, complex and expensive. But that's starting to change. Like computers and telephones, satellites are getting smaller and smaller – with some weighing just 1 kg. Since costs for the launcher are proportional to a satellite's mass, the miniaturisation of satellites is helping to lower mission costs. As a result, these satellites, known as pico-satellites, could soon work in formation and complement today's larger, more expensive satellites.

In 2020, researchers with the EU-funded NetSat (Networked Pico-Satellite Distributed System Control) project are set to demonstrate the world's first self-organising, three-dimensional formation control by four in-orbit pico-satellites. To learn more about this breakthrough – and what it means for the future of satellite-based services – we sat down with Klaus Schilling.

Schilling is professor and Chair of Robotics and Telematics at the University of Würzburg and coordinator of the ERC grant, which is being implemented at the Centre of Telematics, an independent research institute in Würzburg, Germany.

What is the main objective that the NetSat project set out to achieve?

Schilling: There's a major paradigm shift happening within spacecraft engineering. The single, large, multi-functional satellites of today are being replaced by groups of small satellites. In the near future, instead of sending one large satellite into orbit, we'll see larger numbers of networked, cooperating small satellites in space. The potential of distributed sensor networks in orbit with large baseline distances between the satellites will enable multi-point measurements and improve characterisation of the Earth's space environment, as well as Earth observation and telecommunications.

However, before this can happen, we must first understand how to get these small satellites to operate as a team, make them fly in formation, and have them communicate and coordinate with each other. That's what the NetSat



project is about: creating a technology demonstrator to prove the feasibility of a formation of small satellites that could serve as a platform for scientific experiments and, potentially, commercial applications.

What will be achieved during the in-orbit demonstration?

Prior to the demonstration, the project's focus was on developing the key control technologies needed to realise three-dimensional formation flight. For the first time ever, the in-orbit demonstration will validate this by controlling all four satellites in a self-organising formation.

Currently, almost all multi-satellite systems are used as a constellation, with each satellite being individually teleoperated from a ground control centre. What we're trying to do is to get the satellites to work as a team, or fly in formation, with relative attitudes and positions measured and exchanged via inter-satellite links. On this basis, control actions will be coordinated to avoid collisions and enable optimal geometries for the given observation tasks.

How is this development a 'game changer'?

Being able to control a group of pico-satellites and have them work as a team opens the door to a wave

of innovative applications in Earth observation and telecommunications. For example, by enabling the simultaneous observations of targeted areas from different perspectives, Earth observation systems will be able to generate innovative 3D images of the Earth's surface and atmosphere.

There's also the forthcoming CloudCT mission, which involves a formation of 10 small satellites that will use computed tomography principles to characterise the interior of clouds as a means of improving climate predictions.

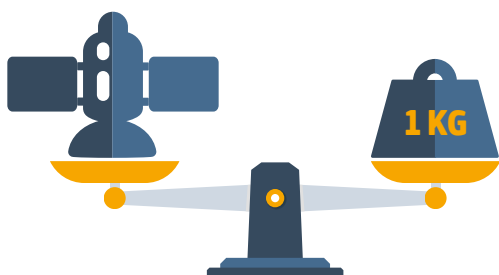
How has the project advanced the state of the art for pico-satellites?

To ensure the safe operation of a group of satellites within near vicinity of each other, we developed an autonomous collision avoidance scheme. This feature will, for example, help ensure that these satellites don't collide with the dramatically increasing amount of debris that is floating around space.

Many applications also need to point their high precision instruments or antennae towards a targeted area and be able to continuously adapt their orientation towards an observed object to compensate for their high speed of motion. For this purpose, we developed power-efficient miniature reaction wheels specifically designed to provide an unmatched level of turning accuracy for very small satellites.

Most importantly, we implemented a suitable small satellite system, with each satellite weighing only 4 kg yet still capable of being fully equipped with all the necessary subsystems for formation operations. These include

1 kilogram:
the weight of some
of today's smallest satellites



Klaus Schilling,
Coordinator, ERC grant
© Klaus Schilling

“ *There's a major paradigm shift happening within spacecraft engineering... Instead of sending one large satellite into orbit, we'll see larger numbers of networked, cooperating small satellites in space.* ”

an attitude determination and control system, an orbit determination system, a communications system capable of inter-satellite communication and satellite-to-ground communication, as well as electrical propulsion for orbit control and maintaining the formation.

What will NetSat's legacy be?

The complex, interdisciplinary software and hardware for operating groups of small satellites developed within NetSat is now ready for the launch, currently planned for June 2020. This system will encourage future distributed sensor network-based applications for new Earth observation approaches. This, along with the collision avoidance schemes, will be NetSat's legacy.

Any future plans following NetSat?

Following a successful NetSat in-orbit demonstration, the next step is to take advantage of the achieved formation flying capabilities for innovative application missions. Several projects have launched, each leveraging the NetSat system in the Earth observation context. For example, the Telematics earth Observation Mission (TOM), is using a formation of three small satellites to generate 3D images of the Earth's surface by photogrammetric methods.

NETSAT

- Hosted by the Centre for Telematics (ZfT) in Germany.
- Funded under FP7-IDEAS-ERC.
- cordis.europa.eu/project/id/320377
- Project website: bit.ly/2PnM838

Defining the future of electric propulsion for in-space operation and transportation

A consortium of European satellite manufacturers, suppliers and researchers are working to advance the state of the art in electric propulsion systems.

To reach its operational orbit and maintain its position in space, a satellite must be able to manoeuvre using its own thrusters. Traditionally, this has been done using chemical propulsion systems. However, things are changing.

While chemical propulsion does a good job at producing the enormous thrust needed to get a satellite into orbit, it is less adapted to propulsion once the satellite is in space. Furthermore, the chemical propellants and storage structure used in chemical propulsion systems are complex – and expensive.

A potential alternative is an electric propulsion system (EPS). By achieving thrust with high exhaust velocities, an EPS reduces the amount of propellant required for a given application. Any reduction in propellant mass can significantly decrease the launch mass of a spacecraft or satellite. This in turn results in the ability to use smaller launch vehicles to deliver a desired mass into a given orbit or a deep-space target – all of which lowers the costs of the entire mission.

Despite this potential, an EPS doesn't have the performance or maturity levels needed for wide-scale use. The exception is Hall-effect propulsion technology, which is the focus of the EU-funded CHEOPS (Consortium for Hall Effect Orbital Propulsion System) project.

"When it comes to high thrust density, Hall-effect propulsion technology is at the forefront," says Idris Habbassi, CHEOPS project coordinator and head of R&T programmes on space EPSs at Safran. "From the thruster to the cathode, Power Process Unit and Flow Management System, this project focused on providing the incremental technology changes needed to advance the state of the art in EPSs."

Led by Safran Aircraft Engines, the CHEOPS consortium is comprised of some of Europe's leading satellite manufacturers, including Airbus Space, OHB System and Thales Alenia Space, along with representatives of the EPS supply chain and academia.

ADVANCING HALL-EFFECT THRUSTERS

Hall-effect thrusters (HET) use a magnetic field to limit the electrons' axial motion. They then use this motion to ionise propellant, accelerate the ions to produce thrust, and neutralise the ions in the plume. In the CHEOPS project, researchers aimed to develop three different HET-based EPSs. These included a low-power EPS for low Earth orbit applications, a dual mode EPS for geosynchronous applications, and a 20 kW high-thrust EPS for exploration applications.

"Each of these proposed HETs are being developed according to market needs and by applying incremental technology changes to existing EPS products," explains Habbassi.

Other work included developing advanced numerical design tools for electric propulsion. "These tools further our understanding of the observable behaviour and interactions with the satellite platform and predict the performance of a given design," adds Habbassi. "This includes



“When it comes to high thrust density, Hall-effect propulsion technology is at the forefront.”

the use of alternative propellants and the ability to estimate a system's lifespan.”

BEYOND THE STATE OF THE ART

The project succeeded at pushing space propulsion technology beyond the state of the art. “CHEOPS addressed complex technologies that will enhance new types of future space missions, allowing for the use of smaller spacecraft carrying larger, more sophisticated payloads,” Habbassi says. “In doing so, we have enhanced European

competitiveness on electric propulsion systems at the global scale.”

All the consortium partners are now working to further mature the technologies for use in future space missions and to comply with all commercial and regulatory requirements.

CHEOPS

- Coordinated by Safran Aircraft Engines in France.
 - Funded under H2020-LEIT-SPACE.
 - cordis.europa.eu/project/id/730135
 - Project website: cheops-h2020.eu
- ▶ bit.ly/2OyWY5U

An innovative, cost-effective air-launch system for small satellites

The emerging small satellite sector needs a tailored, cost-effective method for launching their payload. To answer this demand, the EU-funded ALTAIR project has developed an air-launch solution.

Satellites are shrinking. Tasks that used to require large, complex and expensive satellites can now be done by a unit weighing no more than 150 kg. With this decrease in size comes a substantial decrease in cost. Whether it be for communication, positioning or Earth observation, more companies than ever – including SMEs – can now leverage the power of satellites.

There is however one substantial roadblock to the market uptake of small satellites: the launcher. Relying on the large launchers used for large satellites can mean that small satellites become somewhat of an afterthought. For example, the small satellite is launched either as a secondary payload or as part of a cluster of small satellites. What is needed is a dedicated, low-cost launch system tailored to the unique needs of small satellites.

This is where the EU-funded ALTAIR (Air Launch space Transportation using an Automated aircraft and an Innovative Rocket) project comes in. “The ALTAIR launch system aims to answer the needs of small satellite users, providing an affordable and adapted access to space services without the constraints of current rideshare or

cluster launch options,” says Nicolas Bérend, a researcher at the French Aerospace Lab (ONERA) and ALTAIR project manager. “In doing so, ALTAIR will boost space applications to the benefit of an increased range of users – from traditional satellite operators to academics, researcher centres and even start-ups.”

MULTIPLE BENEFITS

Traditionally, satellites are launched and put into orbit via expendable rockets that take off from the ground. In contrast, the ALTAIR system is based on an air-launch concept. The system consists of an automated aircraft that takes off horizontally with the launcher attached. When it reaches a high altitude (12 km), the rocket is released and ignited.

This system results in several benefits. “First, by starting the rocket-propelled flight at a high altitude, we reduce the drag encountered by the launcher and increase the rocket's performance,” explains Bérend. “Furthermore, because the air-launched rocket is smaller and consumes less propellant than an equivalent ground-launched rocket and the autonomous carrier returns to the launch



© ONERA

site to be reused, the ALTAIR system is both more sustainable and cost-effective.”

DEMONSTRATING THE AIR-LAUNCH SYSTEM

The project succeeded at defining and demonstrating the feasibility of an air-launch system adapted to the market needs of the small satellite segment. “We performed several flight experiments using the pre-existing small scale EOLE demonstrator at the European Space Agency’s Guyana Space Centre,” Bérend says. “These tests greatly increased the technology readiness level of some of the ALTAIR system’s most essential components, including the launcher release procedure and mechanism and the avionics.”

“The ALTAIR launch system aims to answer the needs of small satellite users, providing an affordable and adapted access to space services without the constraints of current rideshare or cluster launch options.”

Based on these tests, project researchers have created a roadmap for fully developing the ALTAIR system and a business plan for bringing it to market. They are now busy working to secure the funding needed to launch the development of the ALTAIR system.

“ALTAIR was a project of firsts – the first to thoroughly study a small satellite air-launch system at the European level and the first to safely test an automated and reusable system at the Guyana Space Centre,” adds Bérend. “Our results also pave the way for another European first: a reliable, cost-effective launching solution tailored to the needs of the small satellite sector.”

ALTAIR

- Coordinated by the French Aerospace Lab (ONERA) in France.
- Funded under H2020-LEIT-SPACE.
- cordis.europa.eu/project/id/685963
- Project website: altair-h2020.eu
- ▶ bit.ly/20tbeNq

A modular propulsion system for small satellites

An Austrian space tech company has used EU funding to develop a modular propulsion system for small satellites ranging from 1 to 500 kg.

From positioning to telecommunications and Earth observation, society is becoming increasingly dependent on satellite-based services. In fact, the global market for satellite services is expected to exceed EUR 5 billion in 2021 – up from EUR 2 billion in 2016.

Much of this growth can be attributed to a push away from the large, complex and expensive satellites of yesterday in favour of using clusters, or constellations, of small satellites – some weighing no more than a kilogram. Although these small satellites have lowered manufacturing costs, there remains a significant roadblock to achieving scale: the propulsion system.

“Because many of these satellites are launched without a propulsion system, they are quite limited in what they can do,” says Alexander Reissner, CEO and founder of ENPULSION, an Austrian space tech company. “Not only do they need to be replaced more often than bigger satellites, they are also limited in terms of orbit manoeuvres, flight formation, and passive deorbiting at end of life.”

With the support of EU funding, ENPULSION has developed a solution to the propulsion barrier. It is called the IFM Micro Thruster (The unique modular propulsion system suitable for all small satellites from 1 to 500 kg)



and is a compact, modular propulsion system specifically designed for small satellites ranging from 1 to 500 kg.

ADAPTING FIELD EMISSION ELECTRIC PROPULSION FOR SMALL SPACECRAFT

The IFM Micro Thruster is based on the design of the IFM Nano Thruster, which was developed for small satellites. ENPULSION specifically re-engineered this design for larger satellites of up to 500 kilograms. “The main goal of the project was to scale up the Field Emission Electric Propulsion (FEEP) technology from the already existing propulsion solution into a new, more advanced, and more capable product,” explains Reissner.

FEEP is an advanced electrostatic space propulsion system that consists of an emitter and an accelerator electrode and uses liquid metal as a propellant. Building on this technology, the IFM Micro Thruster has an input power of 100 watts, producing up to 1.5 mN of thrust and providing 50 kNs of total impulse – making it particularly well-adapted to small and medium-sized spacecraft.

Because the IFM Micro Thruster doesn’t contain pressure vessels or energetic chemicals, it can be launched from any rocket – or even from the International Space Station. Both the thruster and propellant are contained in a 14x12x10 cm module that can be bolted directly to any

“The main goal of the project was to scale up the Field Emission Electric Propulsion (FEEP) technology from the already existing propulsion solution into a new, more advanced, and more capable product.”

flat panel. A separate tank or fluid piping is not required, thus saving more space.

“The IFM Micro Thruster’s high specific impulse and unrivalled control precision make it the perfect solution for station keeping and attitude control,” says Reissner. “Furthermore, end-of-life operations can be performed at the most optimal operation point depending on remaining propellant quantities.”

FROM START-UP TO SME

Thanks to the support of EU funding, ENPULSION grew its team from just six to nearly 30 as it transitioned from being a start-up into an established SME. During the course of the project, the company became the first space tech SME to receive ISO 9001 certification. They were also able to establish relationships with key industry players, such as Airbus and Thales.

“We currently have 27 thrusters in space and, thanks to significant market demand, many more will be joining them soon,” adds Reissner.

IFM MICRO THRUSTER

- Coordinated by AMR Propulsion Innovations GmbH in Austria.
- Funded under H2020-LEIT-SPACE and H2020-SME.
- cordis.europa.eu/project/id/779196
- Project website: enpulsion.com/technology
- ▶ bit.ly/373Gkle

Ground station network as a service for next-generation satellites

As the space sector keeps rapidly expanding, businesses coming up with the best technologies to meet its new requirements are set to thrive. LeafSpace hopes to make the cut with a service-based approach to ground operations for small satellites.

There is a fundamental difference between space missions as conceived over the past 60 years and what

appears to be in store for the future. While past missions were few, highly expensive and led by government

agencies, the future playground will see private companies taking an increasing share of the spoils. Which brings us to one major question: what will happen to past operators' ground stations?

Looking at the list of ongoing Horizon 2020 projects, there happens to be one dealing with this very issue: Leaf Line (The first ground stations network enabling real-time, cost-effective, and easy access to micro/nanosatellite data), coordinated by Leaf Space, which aims to make ground stations suitable for the requirements of small satellite operators and the growing market they represent.

"Historically, the ground segment of space missions has mostly been designed, deployed and operated by mission operators themselves," explains Taylor Dorigatti, Business Developer and Sales Engineer at Leaf Space SRL and coordinator of Leaf Line. "Smaller satellites in comparison imply less stringent requirements and amounts of data to be transmitted per satellite yet require flexible operations and low latency. In other words, the current ground segment is an overkill."

TOWARDS A LEANER, MEAN SERVICE MODEL

Leaf Space's agenda consists in moving ground stations towards a service model, thereby considerably reducing management cost for this part of the mission. Let's take the example of in-orbit demonstration/verification missions: "Placing only a single or a few small satellites in orbit does not justify the costs of developing a proprietary ground segment infrastructure. It is more convenient to outsource this as a service to reduce cost while using a whole network of antennas providing more coverage, lower latency and higher performance," Dorigatti explains.

This is precisely what Leaf Line is about. The project, which has received funding under phase 1 and 2 of the SME Instrument, is creating a shared ground station network for the 'new' space market. As its whole infrastructure is proprietary, the entire service provision can be controlled internally, resulting in increased reliability. Thanks to a scheduler algorithm, the allocation of communication slots is optimised while complying with the specificities of each customer's requirements.

Leaf Space's objective is to deploy an operational infrastructure of about 20 ground stations worldwide in a couple of years. Four of these stations are already deployed and activated in Europe, and a fifth one is planned for activation in the Azores by the beginning of Q2 2020 along with two others in the US. "We already have an operational ground segment service that is being successfully used by our customers," Dorigatti enthuses.

FOCUSING ON FUTURE EXPANSION

With only 8 months to go before the end of the project, Leaf Space intends to continue prioritising the expansion of this network, as well as bringing new users on board for orbits which have yet to be supported. Ground station performance upgrades will also keep coming, to ensure that Leaf Space always remains a step ahead of competitors.

"Our customers are satisfied with the service provision. Considering that we are only in the initial phase of the Leaf Line network deployment, this is a very good sign for our future development and expansion. We have been able not only to attract but also to retain customers requiring ground segment as a service, who have given us credit for our flexibility and tailoring capacity," says Dorigatti.

The infrastructure will give global coverage by the end of 2020, continuing expansion until 2023 and beyond. In the meantime, Leaf Space will keep improving capacity and extending its customer base.

LEAF LINE

- Coordinated by Leaf Space in Italy.
- Funded under H2020-LEIT-SPACE and H2020-SME.
- cordis.europa.eu/project/id/806628
- Project website: leafspace.eu/leaf-line



New generation of miniaturised cameras changes the face of the satellite market

Miniaturisation is one of the biggest trends in today's satellite industry. One of the components at its heart is no other than a new camera developed with support under Horizon 2020's SME Instrument.



© SATLANTIS

Founded 6 years ago, SATLANTIS was quick to make a name for itself in the space industry, gaining support from the likes of Telefonica and Everis. The centre of all this attention is iSIM – a 15 kg satellite camera that is up to 10 times smaller, four times more precise and 80% less expensive than its counterparts.

Juan Tomás Hernani, CEO of SATLANTIS, discusses the achievements of the company since it first obtained EU support under phase 1 of the SME Instrument for an idea and a patent that is now worth over EUR 15 million.

What are the main commercial arguments in favour of iSIM?

Juan Tomás Hernani: The camera is not just a component, it is the heart of a mission and determines its entire cost. A miniaturisation of the camera by a factor of 4 to 10 (depending on the competitor you compare it with) provides a saving factor of up to 80% of the total mission cost. This is a real disruption when considering the average launch price of approximately EUR 30 000 per kg.

The second argument in favour of iSIM (Integrated Standard Imager for Earth Observation Microsatellites) is related to electronics and multispectrality. The high throughput of

on-board processing capacity delivers native sub-metre resolution to the customer in all multispectral bands (for example, we currently have four bands in RGB and NIR). This contrasts with other missions which also provide multispectral imaging, albeit at a worse spatial resolution than with panchromatic imaging and with a worsening of the spatial resolution as more bands are added. As a consequence, iSIM brings about a four times better precision, in addition to its competitive size.

What do these advances mean for satellite operations concretely? Could you provide one or two examples of use cases?

The main gift for operations is the birth of real-time applications. The fact that one complete satellite may cost a few million euros changes the customer paradigm: from a large CAPEX to be used over many years, to an OPEX in which new satellites are launched periodically with the latest technology available, and with increasing revisit times.

It is now possible to envision a constellation of three satellites only that would be able to cover European needs in terms of border monitoring. This includes for instance revisiting the Mediterranean coastlines every few hours, which is what we propose with the 390MED constellation.

What are the main difficulties you faced in the development process and how did you overcome them?

Extreme precision is crucial for a space camera to work at the diffraction limit, as iSIM does. Only 40 nanometres in lenses' surface roughness can change the camera behaviour. Such a level of precision is a big challenge that SATLANTIS could overcome thanks to the background and experience of its team, composed of space engineers from the best international competence centres in Argentina, France, Germany, Italy and the UK.

Besides, a substantial investment in infrastructure allowed the team to meet this extreme requirement. We

established SATLANTIS FACTORY, a key public-private financed initiative, to deliver it.

What were you able to achieve thanks to EU funding?

The first EUR 50 000 of the phase 1 SME Instrument arrived when SATLANTIS had a patent, an idea and one employee. Since then, we have developed the business plan and closed the first financial round with very large investors: Telefonica, Everis, Idom, Orza and public institutions like the Spanish government, the Basque government and the Bizkaia government.

The following EUR 1.7 million gave us credibility when facing banks, customers and other institutions to develop a more powerful company that has captured a total of EUR 15 million in 6 years. The contracting of JAXA for iSIM's in-orbit demonstration, along with the successfully passed reviews with both JAXA and NASA to launch iSIM to the International Space Station (ISS), were the last key milestones of the project and represent the zenith of our aspirations.

We are now a global leader of space cameras for small satellites, thanks to the SME Instrument.

How had the sector reacted to the emergence of this technology?

We were absolute pioneers of this disruptive miniaturisation technology, but now we have certain competition, as we initially expected.

The sector allows for the existence of large and small Earth Observation satellites with similar specifications, while the miniaturisation trend has pushed bigger players like Airbus, Thales or Maxar to start substantial corporate acquisitions and mergers.

Nevertheless, the sector is far from being stable. This market disruption is causing repositioning, mergers, etc. In the end, the space sector is a digital business of data, subject to huge competitive pressures and paradigm changes, and this transformation is felt at every single level of the value chain.

What are your follow-up plans, notably with regards to further EU funding opportunities?

SATLANTIS has bet on an industrial strategy of components, instead of a traditional space methodology



Juan Tomás Hernani
CEO of SATLANTIS
© Juan Tomás Hernani

“It is now possible to envision a constellation of three satellites only that would be able to cover European needs in terms of border monitoring.”

(although inheriting some baseline processes that are necessary to survive in the field).

This concept of 'product system' is delivering fast and efficient results into a family of iSIM cameras and satellites, from CubeSats and sub-metre multispectral imaging to high-resolution imaging in the infrared. The SATLANTIS roadmap is more meaningful than ever, moving around three independent axes: higher resolution and more multispectral bands, extended spectrum and satellite integration.

When do you expect the first satellites equipped with iSIM to be launched?

On top of the flight financed by the SME Instrument, we have two contracted launches.

The first is a second flight to the ISS in the context of the STP-H7 mission financed by the USA DoD in collaboration with SCHREC (a USA-based research centre). This mission, expected to fly in spring 2021, will allow us to test a different version of the camera, designed for CubeSats. Then, we have a UK mission for the oil and gas sector, financed by ESA and led by Open Cosmos, for which SATLANTIS supplies the camera. The launch is expected at the end of 2021.

Several commercial opportunities await the in-orbit demonstration results in June 2020, when SATLANTIS expects to end its start-up phase.

ISIM

- Coordinated by SATLANTIS in Spain.
- Funded under H2020-SME and H2020-LEIT-ICT.
- cordis.europa.eu/project/id/768278
- Project website: satlantis.com/payloads.html



LIFE AFTER...

Catching up with nanoCAVa: From Finland to across the world, innovative research on the climate effects of aerosols goes global

In December 2018, we interviewed then-Marie Skłodowska-Curie fellow Katrianne Lehtipalo on her innovative work on how aerosols contribute to climate change. We catch up with now-Professor Lehtipalo on how her research has been evolving over the last year since the formal end of her fellowship.



© Katrianne Lehtipalo

The nanoCAVa (Formation of nano-scale clusters from atmospheric vapors) project aimed to advance current understanding of the fine line between the gas and condensed phases of aerosols by studying the formation of nanoscale clusters from

atmospheric vapours. Thanks to recent breakthroughs in instruments able to detect atmospheric clusters and recently formed aerosol particles, Lehtipalo and her team were able to measure clusters in the atmosphere and study their formation process in the CLOUD chamber at CERN.

From CERN to worldwide

Following the CERN experiments, Lehtipalo and her team at the University of Helsinki have been exploring if the same mechanism works in the atmosphere using field data measured in different parts of the world. "For example, we have been looking at vertical variation of the smallest aerosol nanoparticles in the atmosphere using measurements onboard a

small aircraft," she comments. "We have also been studying more polluted atmospheres in the laboratory and conducted measurements, for example in China, to understand the connection between particle formation and air pollution."

Whilst their research has taken a distinctive global flavour, the team have still made good use of the CLOUD chamber at CERN, focusing on understanding aerosol formation in two completely new environments: the marine boundary layer and polluted megacities.

Marie Skłodowska-Curie: A vital step in a promising scientific career

Since the end of her fellowship, Lehtipalo has become an associate professor at the University of Helsinki and the Finnish Meteorological Institute. "I work especially with the measurements and data from the ACTRIS infrastructure (Aerosol, Clouds and Trace Gases Research Infrastructure), which aims to harmonise long-term

measurements of aerosols and reactive trace gases across Europe," she explains.

Her team is especially interested in including the measurements of the smallest nanoparticles into ACTRIS. This still requires a lot of work in developing the methods, but they hope to gain many new high-quality observations in future.

"EU funding was critical for the project's success," concludes Lehtipalo. "It made it possible for me to take part in large experiments and exciting field campaigns. All in all, EU funding had a decisive role in the fact that I'm undertaking a career in science."

NANOCAVA

- Coordinated by the University of Helsinki in Finland.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/656994
- Project website: blogs.helsinki.fi/lehtipalo

“All in all, EU funding had a decisive role in the fact that I’m undertaking a career in science.”

Katrianne Lehtipalo
Former project coordinator of nanoCAVa
© Katrianne Lehtipalo



ERA Chair identifies fake and adulterated foods

Complex supply chains can make food vulnerable to fraud either through adulteration or counterfeiting of products. Finding ways to assure food safety, quality and traceability is therefore of the utmost importance.

Food scandals, increased globalisation and the complexity of the food supply chain have created a demand for greater transparency in food production and tracing the origin of a food product or its ingredients. Furthermore, intricate supply chains increase the number of critical points where contamination can occur.

Fraud and food safety incidents put our health at risk, and food recalls, withdrawals, alerts and fake products cost the European food industry, and ultimately consumers, tens of billions of euro each year. High standards of food safety, quality (authenticity) and more secure ways to assure traceability, therefore, remain a priority for both consumers, producers and governments.

The EU-funded ISO-FOOD (ERA Chair for Isotope Techniques in Food Quality, Safety and Traceability) project addressed these challenges by establishing a European Research Area (ERA) Chair for isotope techniques in food

quality, safety and traceability based at the Jožef Stefan Institute (JSI) in Slovenia.

SOPHISTICATED ANALYTICAL METHODS EMPLOYED

Isotope techniques play a crucial role in analysis, producing large detailed data sets. This, in turn, has led to the development of sophisticated chemometric methods for data evaluation, which combined with the analytical data makes it possible to discriminate between an authentic and a fake product.

ISO-FOOD covered three main thematic 'pillars', the first of which focused on food authenticity. "This includes the development and application of analytical tools and infrastructure for verification of geographical origin, production origin (organic or conventional production) and species origin of food products," says project coordinator Milena Horvat.



“The new infrastructure has allowed the JSI to become the national leader in the use of isotopes and chemical analyses in determining food authenticity.”

Scientists conducted analysis based on elemental fingerprinting, molecular markers and supplementary and combined techniques supporting traceability (sugars, phenolics, fatty acids, molecular profiling). They also applied a range of analytical instruments and chemometric methods.

CONTAMINANTS STUDIED

The second pillar involved translating characteristics of precipitation, water, soil and lithology as well as agricultural practices into the fingerprints of local food products. “These can be used to determine the authenticity and provenance of food and feed products. We also used these signatures to create isotopic and multi-element maps, develop traceability systems and provide benchmarks for certification schemes,” explains Horvat.

The final research pillar concerned food safety and developing the necessary methods and tools to detect,

identify and characterise potentially hazardous chemical substances in food originating from polluted soil, air and water, and substances intentionally or unintentionally introduced during food processing. According to Horvat: “Contaminants studied include organic substances derived from agricultural produce, food additives and packaging, essential, non-essential and toxic elements and their species, nanoparticles, and radionuclides both natural and human-made.”

The ISO-FOOD project enabled the JSI to make a significant contribution to food safety and quality control, and establish itself as a leader in the field of isotopic and elemental techniques in combating food fraud. “The new infrastructure has allowed the JSI to become the national leader in the use of isotopes and chemical analyses in determining food authenticity so that it is now on par with leading European research groups in the field,” Horvat concludes.

ISO-FOOD

- Coordinated by the Jožef Stefan Institute in Slovenia.
- Funded under FP7-REGPOT.
- cordis.europa.eu/project/id/621329
- Project website: isofood.eu

FOOD AND NATURAL RESOURCES

Biofortifying crops with zinc for increased nutrition and food security

With climate change increasingly threatening global food security and the search for more plant-based diets that don't compromise nutrition, the hunt is on for new food sources. PMTFOS may have the seeds of an answer in the cereal sorghum.

Food security is about reliable access to food in general and also the necessary vitamins and minerals. The WHO estimates that 2 billion people suffer from ‘hidden hunger’, often a consequence of largely plant-based diets which can lack some micronutrients, particularly vitamin A, iron and zinc. Climate change is expected to exacerbate

this situation, with increased droughts threatening livestock and crop production.

In tandem, if the developed world is to attain a more sustainable way of life, it will have to follow a more plant-based diet, but the associated health benefits must



The WHO estimates that 2 billion people suffer from 'hidden hunger'

be balanced against the risk of deficiencies in essential micronutrients.

The PMTFOS (Plant metallothioneins as potential players in food security) project investigated a class of proteins called metallothioneins which transport and store metals in cereal crops. Type 4 plant metallothioneins are found in seeds of all flowering plants and the leaves of resurrection plants. They are loaded with zinc which is necessary for the functioning of at least 10% of all human proteins and involved in all major physiological processes. This also helps to bring seeds and leaves back to life after complete dryness. Metallothioneins may therefore enhance the nutritional value of cereals and help them withstand drought.

BIOPHYSICAL PROTEIN ANALYSIS AND PLANT EXPERIMENTATION

Metallothioneins are unique proteins with the highest content of metal ions such as zinc. The PMTFOS project characterised the metal-binding properties and physiological roles of sorghum metallothioneins, at the levels of both individual proteins and whole plants. It fostered a new collaboration with plant geneticist José Gutierrez-Marcos, Associate Professor at the School of Life Sciences, Warwick. This features the first application of CRISPR/Cas9 to edit metallothionein genes in thale cress, to explore their function in plants.

The research team, led by Claudia Blindauer, Associate Professor, produced pure sorghum metallothionein

“The analysis of the molecular background of sorghum drought-resistance will be crucial for other vital crops like wheat, barley, maize and rice.”

proteins by recombinant expression in bacteria in the presence of zinc, copper or cadmium, giving metal-loaded proteins. Following analysis using spectroscopic and spectrometric techniques, they found that each sorghum metallothionein has different metal-binding preferences, concluding that only seed-specific type 4 metallothionein favoured zinc over other metals, including toxic cadmium.

“This implies that type 4 metallothioneins have potential to biofortify crops with zinc,” says Marie Skłodowska-Curie Fellow Agnieszka Mierek-Adamska. “But we discovered that high similarity among type 4 metallothioneins from different plant species does not guarantee the same metal-binding properties. Future work needs to look at their metal loading in the plant.”

SAFE, NUTRITIOUS, HIGH QUALITY AND AFFORDABLE FOOD

PMTFOS focused on sorghum as a cereal plant with unusual drought- and heat-resistance. Currently a staple crop for 500 million people in Africa, America and the Indian subcontinent, it might become more prevalent in European diets as a climate change adaptation.

It may also be a potent source of nutraceuticals for fighting obesity and cardiovascular disease – providing this is not jeopardised by low bioavailable zinc.



The team is expanding the work scope to establish whether plant metallothioneins are involved in responses only to particular stresses or are general stress-response proteins, with great potential for new stress-resistant crops.

“The analysis of the molecular background of sorghum drought resistance will be crucial for other vital crops like wheat, barley, maize and rice. Its relatively small genome

(3.4 times smaller than the closely related maize) makes it an excellent plant model,” Mierek-Adamska adds.

PMTFOS

→ Coordinated by the University of Warwick in the United Kingdom.

→ Funded under H2020-MSCA-IF.

→ cordis.europa.eu/project/id/701492

FOOD AND NATURAL RESOURCES

Laser technique offers safe and efficient varroa removal from bees

As pollinators, bees are critically important to the environment and to the economy. With their number fast declining, the race is on to halt this decline. The V-laser may just hold the answer.

Pollination is where pollen is transferred from the male part of a plant to a female part, enabling fertilisation. Bees are responsible for the pollination of around 80 % of European crops and wild plants. Annually, it has been calculated that honey bees, bumblebees and wild bees contribute at least EUR 22 billion to the agriculture industry in Europe, EUR 265 billion annually worldwide. Alarmingly, despite this economic and environmental importance, over the last few decades the number of bees in Europe is thought to have decreased by almost 25 %.

Besides the use of pesticides, one of the key causes of the shrinking honey bee population is the varroa. Varroa reproduces in the bee hive, where it attaches to both immature and adult bees, feeding off their body fat, thereby weakening or killing the bee.

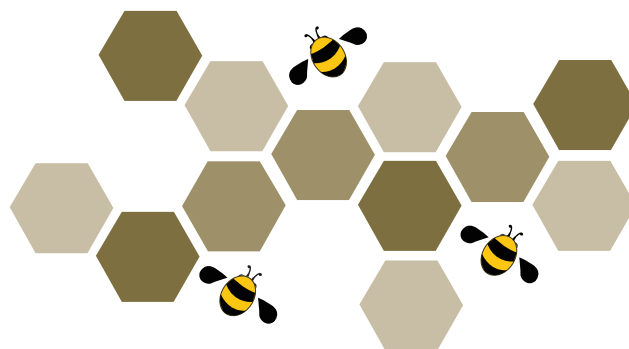
The EU-supported V-eliminator (Innovative solution for varroa fighting) project has developed the first micro-targeted laser-based system for the mass elimination of varroa on honey bees. It offers a much safer and more efficient solution than current alternatives (chemical and mechanical removal).

VARROA ELIMINATION

The V-eliminator system (with the product actually called V-laser) consists of a camera, galvo scanner, low power laser and single-board computer, positioned at the entrance of the hive. The system uses computer vision technology to track bees and detect potential varroa infestations. It is managed by software, which, as well as the computer vision algorithms to identify the mites, includes a control system which, on detection, burns the mites with the laser beam. The system can be powered by a solar battery or an AC adapter.

Crucially, unlike traditional methods of mite control such as mechanical removal which harms bees or chemical removal which may result in side effects for the bees, the V-laser process is safe for the bees.

“It all started with a beekeeper, who is also an inventor and was very unsatisfied with existing solutions. Initially it felt like a solution usually only seen in science fiction films. Now we are making it a reality,” reflects project coordinator Andrej Stanković, based at the Zorn Group in Slovenia.



Bees contribute at least **EUR 22 billion** to the agriculture industry in **Europe**, **EUR 265 billion** annually **worldwide**

“*It all started with a beekeeper, who is also an inventor and was very unsatisfied with existing solutions. Initially it felt like a solution usually only seen in science fiction films. Now we are making it a reality.*”

With both beam deflection optics (where a laser beam can be deflected on two axes for efficiency) and optical vision now operational, lab testing has been conducted on varroa mites to determine the necessary laser strength and shooting times.

THE CONTRIBUTION OF APICULTURE

Through pollination, bees and other pollinators ensure the reproduction of a range of cultivated and wild plants (key to global food production and food security) while also effectively preserving biodiversity. Efforts to mitigate the declining bee population are problematic, for example hand-pollination is extremely labour-intensive, slow and expensive.

“Using V-laser will benefit European beekeepers in three ways. Firstly, by increasing their competitiveness with lower production costs. Secondly, increasing yield, with the permanent elimination of varroa resulting in healthier

bees. Lastly, cultivating a revitalised interest in beekeeping,” says Stanković.

With a prototype now ready, the team are currently seeking investments to develop the technology for market-readiness. The anticipated steps to reach this point include: larger-scale performance testing in laboratory and real-life conditions; miniaturisation of the housing; integration of components; as well as improvement to the laser driver, galvo control engine and computer vision software.

V-ELIMINATOR

- Coordinated by Zorn in Slovenia.
- Funded under H2020-LEIT, H2020-Societal Challenges and H2020-SME.
- cordis.europa.eu/project/id/854176
- Project website: zornplus.si/projects



Novel, cost-effective materials could replace stainless steel

Researchers are busy developing a new generation of materials which could replace some critical raw materials and outperform stainless steel.

New intermetallic materials could substitute stainless steel in many important industrial products, particularly for use in extreme conditions where they need to be resistant to wear and corrosion.

Existing iron-aluminide intermetallics combine the properties of metals and ceramics but are difficult to translate into real products as they are not as ductile as stainless steel or as easily machinable or weldable compared to other metals.

“We want these new materials to have the properties of traditional intermetallics – high hardness, relatively low density and high corrosion and erosion resistance, but to give them some new properties,” explains project coordinator Costas Charitidis, professor of chemical engineering at the National Technical University of Athens.

“If they are less brittle and can be fully or partly weldable, then they can perfectly substitute highly ductile stainless steel, but being harder and lighter they would be better,” Charitidis says.

New materials were developed under the EQUINOX (A novel process for manufacturing complex shaped Fe-Al intermetallic parts resistant to extreme environments) project. The team built a porous preform, like a sponge, which was then infiltrated with liquid aluminium or iron-aluminium melts. These metals are more abundant and cheaper than chromium – a critical and strategic raw material for Europe – used in stainless steel.

“Another breakthrough is that we can machine these new intermetallic materials. We can also make moulds to produce the iron preforms that would imitate the shape of the final part,” explains Panagiotis Kavouras, senior researcher, National Technical University of Athens. “We

“We want these new materials to have the properties of traditional intermetallics – high hardness, relatively low density and high corrosion and erosion resistance, but to give them some new properties.”

have succeeded in creating complex-shaped bulk materials – not only bars or cylinders – with this process.”

DEMONSTRATORS

Two different demonstrators were built, and fitted for specific applications. One was a small car brake disc and the other an element for a liquid rocket engine. “These are real-world applications for the new intermetallic materials we developed,” Charitidis says.

The car brake was tested in a simulated environment and also underwent salt spray tests as part of the standard procedure to test resistance to corrosion. The liquid rocket-engine part was tested for erosion.

Patent applications for the two new processes, one for the production route of car brake discs and a different process for the blade part for the liquid rocket engine, have been filed. “These results demonstrate that the EQUINOX process has high potential, which will lead to actual industrial products,” Kavouras notes.

“Even though the project started close to the level of fundamental research, we applied not only laboratory-scale

testing but also industrial laboratory testing,” Kavouras says. “We are not at industrial scale yet. But we are close to pilot scale, which is a big leap.”

MAJOR CHALLENGE

“During the last months of the project we succeeded in producing a highly ductile intermetallic material, so we have strong evidence that the EQUINOX process can lead to a real breakthrough,” Kavouras adds.

A major challenge at the initial stages was investigating many different types of porous preforms and types of melts at different temperatures. The more than 2000 combinations of different parameters were reduced to a few dozen options for experimental trial and error, by using elaborate modelling and simulation experiments.

“The modelling and simulation were absolutely vital to the success of the project. These simulation steps saved us many years of arduous experimentation,” Kavouras concludes.

EQUINOX

- Coordinated by the National Technical University of Athens in Greece.
- Funded under H2020-ENVIRONMENT.
- cordis.europa.eu/project/id/689510
- Project website: equinox-project.eu

INDUSTRIAL TECHNOLOGIES

Predictive damage modelling helps reduce waste in mining pumps

Innovative new material modelling techniques are driving the creation of longer-lasting pump designs, decreasing waste and operating costs in the mining and energy sectors.

Vital industrial minerals, including copper, zinc bauxite and iron ore, can be pumped up to hundreds of kilometres across mine sites as they're processed from rough ore to usable minerals. Often highly viscous, subjected to intense processing pressures and combined with

corrosive chemicals, these mineral slurries wear away even purpose-built, heavy-duty pumps.

The APESA (Advanced Pump Engineering for Severe Applications) project is a collaboration between Weir Minerals

“ We focused on better understanding damage mechanisms to explore ways of limiting damage and using predictive modelling to make the evaluation of alternative approaches faster and more accurate. ”

Netherlands (WMNL) and five Early Stage Researchers (ESRs) placed at the University of Strathclyde, to explore the ways pumps are damaged and develop predictive models and damage mitigation techniques to improve the life of positive displacement (PD) pumps.

The EU's Marie Skłodowska-Curie programme support has made this industry-critical research possible, which has the potential to reduce waste and operating costs at mines around the world.

UNDERSTANDING POSITIVE DISPLACEMENT PUMP WEAR

PD pumps, which are used to transport viscous mineral slurries long distances, are typically designed for service lives of up to 25 years. However, the combined effects of corrosion, erosion and fatigue invariably result in material damage to the pumps over time, degrading performance and requiring replacement parts.

To understand the complex behaviour of these slurry pumps, the APESA team had to investigate interacting properties such as: the pump's materials; the size, shape and concentration of the slurry's solid particles; the slurry's chemistry; and the effect of the pump's flow design on slurry velocity and angles.

“For APESA, we reviewed the pump life cycle to identify areas where emerging technologies and new understanding could make a significant difference,” says Douglas Watson, Programme Manager at the Weir Advanced Research Centre. “We focused on better understanding damage mechanisms to explore ways of limiting damage and using predictive modelling to make the evaluation of alternative approaches faster and more accurate.”

The research improved understanding of material performance and the influence of both manufacturing processes and pump degradation on performance throughout its operational life. It also highlighted alternative materials and material conditioning techniques which could extend the operational life of pumps.



The research results will soon be published in the ‘International Journal of Plasticity’ detailing the novel cyclic plasticity material model developed under APESA and implemented for the evaluation of compressive stress on the fatigue life of low carbon steel in corrosive environments.

MINIMISING WASTE

The results are now being integrated directly into the design manuals and calculations used by the GEHO® brand PD pump engineering teams at Weir Minerals. The findings are so substantial that one of the ESRs has been specifically retained by the project's industrial partner to facilitate the knowledge transfer.

APESA research will extend the operational lifetime of Weir Minerals' PD pumps and reduce the amount of maintenance required to operate them: decreasing both waste and operating costs in the mining sector.

“This protects the competitive advantage of European industry – for both pump manufacturers and their supply base – at a time of increased competition from non-European equipment manufacturers,” says Watson.

The research team is now focussed on future modelling and simulation to investigate corrosion protection, in light of the mining water management systems being adopted to cater for future water scarcity challenges.

APESA

- Coordinated by Weir Minerals Netherlands in the Netherlands.
- Funded under H2020-MSCA-ITN.
- cordis.europa.eu/project/id/643159
- Project website: apesaproject.eu

Next-generation Authentication and Authorisation Infrastructure for research communities

Authentication and Authorisation Infrastructure controls access to online resources and user management. But with so many different systems, how do we enable collaboration? One project has come up with an answer that gives researchers secure access across systems.

Research spans many systems, platforms and geographical boundaries. The Authentication and Authorisation Infrastructures (AAIs) that manage trusted access to research services were typically developed independently, resulting in a lack of interoperability between them.

The EU-supported AARC2 (Authentication and Authorisation For Research and Collaboration) project addressed this challenge by delivering an AAI framework to facilitate interoperability. The project capitalised on the interest of major research infrastructures to collectively overcome the outstanding challenges preventing wider adoption of federated access.

AARC2 created the AARC Blueprint Architecture (AARC BPA), providing a technology-neutral blueprint that standardises the implementation of an AAI for research collaborations, accompanied by a set of policy documents and guidelines for its deployment.

THE PAN-EUROPEAN FEDERATED ACCESS SOLUTION

The AARC BPA is a suite of customisable software modules enabling federated access management for international research collaborations.

Federated access enables users to log in to a variety of services securely – while preserving privacy – with one set of credentials issued by their own organisation, typically a university or research centre (the Identity Provider).

“About 5 years ago, it became clear that federated access was the way forward, as it reduces the number

of credentials for the users and minimises the personal information shared with services,” says project coordinator Licia Florio.

After a needs analysis amongst the research communities, AARC2 chose eduGAIN as the underlying technological foundation to manage users’ identities. “While eduGAIN was already a global infrastructure, tried and tested by R&E communities, we wanted to move its adoption to the next level,” recalls Florio.

The team engaged with all the communities of the European Strategy Forum on Research Infrastructures (ESFRI). This enabled the project to run eight use-case pilots, testing the solution’s ability to meet integration (accessing services offered by multiple e-infrastructures) and data-rich requirements.

Some research communities already had a production AAI in place so were interested in enhancing it by adopting the AARC BPA, while others explored what it takes to deploy a BPA-compliant AAI.

“The pilots showed what worked and what needed adjustment. We also developed and delivered guidelines and training modules,” explains Florio.

As security and integrity were a key priority in such a federated environment, the AARC community advanced the Security Incident Response Trust Framework for Federated Identity (Sirtfi) to maturity. AARC also built the Scalable Negotiator for a Community Trust Framework in Federated Infrastructures (Snctfi) framework to ensure that the AARC BPA could be deployed in a secure manner.



“AARC2’s results will help researchers and students to collaborate more easily, getting access to online resources, facilitating the secure exchange of data needed for their day-to-day work.”

ALREADY BEING ADOPTED

Currently, AARC2’s work is being adopted by several research collaborations – including EU-funded projects – to shape their AAI, including: LifeWatch (for biodiversity and ecosystem citizen scientists), EOSC-Life (aimed at the life science community) and LIGO (supporting gravitational waves observation). The AARC BPA is also being deployed by the HPC community and the EOSC-Hub project and is the reference model for the European Open Science Cloud (EOSC).

“AARC2’s results will help researchers and students to collaborate more easily, getting access to online resources, facilitating the secure exchange of data needed for their day-to-day work,” says Florio.

AARC2’s material and training are currently available under a Creative Commons Attribution 4.0 licence to anyone operating research and education services or responsible for designing their AAI. The AARC community continues to evolve the AARC results via AEGIS and other existing groups.

AARC2

- Coordinated by GÉANT in the Netherlands.
- Funded under H2020-INFRA.
- cordis.europa.eu/project/id/730941
- Project website: aarc-project.eu
- ▶ bit.ly/36KNFal

Real-time data collection system boosts SME digitalisation

Recently unveiled data acquisition technology allows manufacturers to monitor their production lines in real time, maintain efficiency and process data for smarter decisions. The new plug-and-play solution provides the flexibility, modularity and scalability needed to equip the smart factory of tomorrow.

Digital technology and connectivity is making the manufacturing process increasingly intelligent and dynamic – the smart factory concept could soon become the norm. A network of cyber-physical systems capable of exchanging information, triggering actions and controlling one another is reinforcing the trend towards automation and data exchange in smart manufacturing.

FROM CUSTOMISED TO PLUG-AND-PLAY SOLUTIONS

When managing a mass production line, the primary goal is to track productivity, losses and overall performance. “The production line is made up of a long chain of separate and complex activities and a high number of discrete machines with different characteristics. The latter can vary in their brand, model, generation and technology. Due to their heterogeneity, the bespoke solutions for acquiring measurement data, further processing them and transferring them to a centralised area are very expensive, difficult to operate and not easy to integrate,” explains Javier Tourón, marketing director of Sistemas OEE.

With EU funding of the Smart OEE (Universal PlugPlay OEE Data Capture Equipment to improve the efficiency of industrial processes) project, Sistemas OEE developed a real-time data acquisition system for boosting the efficiency of monitoring, management and decision-making. Nowhere are its benefits more evident than in complex production lines with heterogeneous machines, where increasing numbers of measured values have to be processed ever faster. “Our Smart OEE solution is a real breakthrough thanks to its reliable and quick universal connection system that can provide simple and robust

connectivity to stand-alone machines from different vendors,” notes Tourón.

THE SYSTEM'S INNER WORKINGS

Smart OEE is a collection of software and hardware that allows the measurement of physical characteristics. Automatic data capture hardware collects information directly from the machines. The software system stores the data provided by the hardware, and offers real-time monitoring at all levels of plant management.

All information is automatically recorded in a multi-base software system that enables efficient management, analysis and exploitation of log files. Big Data is enabling manufacturers to gain real-time access to the incredible volume of data that their machines are producing.

The underlying Smart OEE technology is open-source, although it can also adapt to proprietary solutions when needed. The Smart OEE solution is composed of smaller services in the form of modules – microservices. This is a useful architectural approach as it makes each service scalable to handle increased tasks or requests.

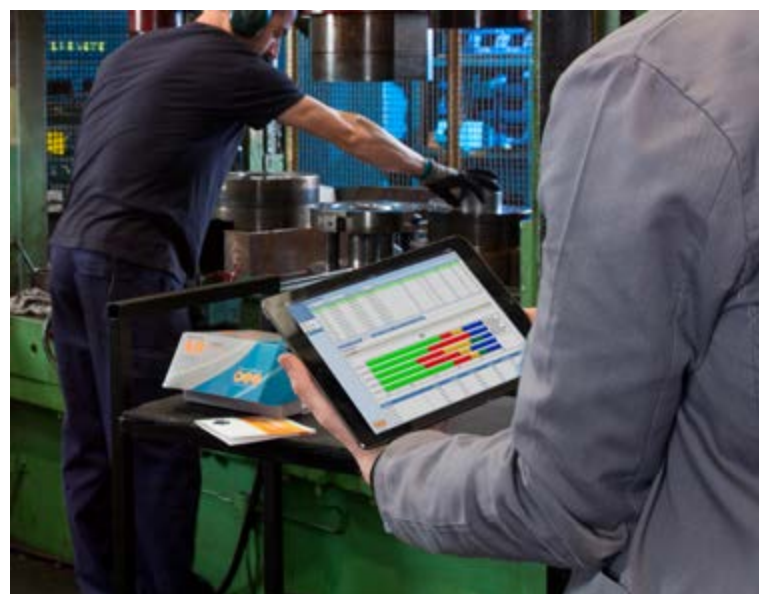
INDUSTRY 4.0 ADOPTION OPTIMISES PRODUCTION

The newly developed technology is part of what is known as cyber-physical systems – integration of computation, networking and physical processes that will affect all industry sectors within the Industry 4.0 (or ‘smart factory’) paradigm. “With its Smart OEE solution, Sistemas OEE introduces information technology and the benefits of mobile devices into the production line. What’s more,

“ With its Smart OEE solution, Sistemas OEE introduces information technology and the benefits of mobile devices into the production line. What’s more, it helps small and medium-sized enterprises (SMEs) enter the Industry 4.0 era and reap its benefits including increased, and importantly, quantifiable productivity. ”

it helps small and medium-sized enterprises (SMEs) enter the Industry 4.0 era and reap its benefits including increased, and importantly, quantifiable productivity,” notes Tourón.

Smart OEE will enhance the competitiveness of SMEs in the manufacturing industry, helping to decrease their production costs and facilitating decision-making around plant organisation and investments. Thanks to its modular nature and different functionalities, Smart OEE can benefit both automated and semi-automated production lines, even fully manual production systems. So far, Smart OEE has demonstrated a 5% increase in the operations efficiency of a plastic extrusion company and a 15% increase in the efficiency of product labelling in an agri-food company.



© Javier Tourón

SMART OEE

- Coordinated by Sistemas OEE in Spain.
- Funded under H2020-LEIT-ADVMANU, H2020-LEIT-ADVMAT, H2020-SME and H2020-LEIT-NANO.
- cordis.europa.eu/project/id/739013
- Project website: sistemasoe.com/en

DIGITAL ECONOMY

Opening up Europe’s written cultural heritage to people all over the world

Millions of people will get the chance to access historical documents and gain insights into the aspects of history that appeal to them thanks to the READ project. The innovative approach to digitalisation makes handwritten documents from European archives accessible as a result of handwritten text recognition and keyword spotting.

The READ (Recognition and Enrichment of Archival Documents) project set out to implement a virtual research environment in which archivists, humanities scholars, computer scientists and volunteers could work together.

The collective aim was the application of innovative technologies for the automated recognition, transcription and indexing of text to revolutionise access to historical documents.

“The National Archive in the Netherlands and the National Archives Finland started projects where millions of handwritten documents are made publicly available via handwritten text recognition and keyword spotting.”

“We wanted to be able to explore and access hundreds of kilometres of archival documents via handwritten text recognition and, by doing so, open up one of the last hidden treasures of Europe’s rich cultural heritage,” explains project coordinator Günter Mühlberger, head of the Digital Humanities Research Centre of the University of Innsbruck and a member of the Time Machine consortium. The project brought together several research groups and achieved scientific breakthroughs in fields such as handwritten text recognition, layout analysis and keyword spotting.

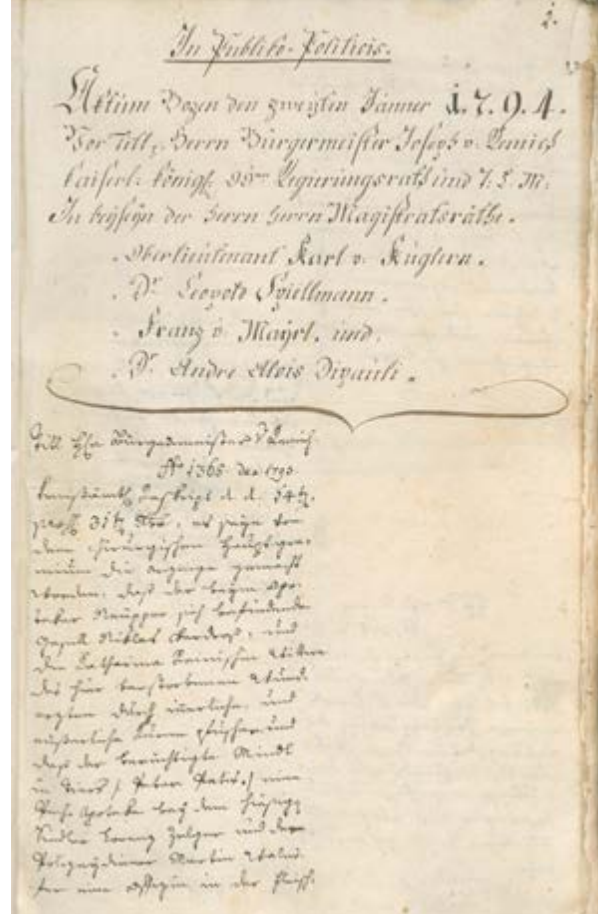
According to Mühlberger: “Along with these breakthroughs, we have set up the first, handwritten text recognition platform called Transkribus where non-technical users can train their own networks to recognise specific scripts. More than 27 000 users are currently registered in the platform; hundreds of them use the platform daily.”

Mühlberger is delighted to see how well the platform is being received by people working in areas as diverse as natural language processing and medieval history, saying: “Transkribus represents the largest training dataset of historical handwriting worldwide. Based on this overwhelming success we have set up one of the first European Cooperative Societies in the research and cultural heritage domain.”

BUILDING ON PAST WORK

READ was based on several previous projects, mainly Improving Access to Text and transcriptorium in which the basic research was carried out. “One of the most important success factors, however, was that the e-Infrastructure programme for Virtual Research Environments gave us the chance to create a fully-fledged service,” Mühlberger adds.

But however much of a head-start previous projects gave the team, there were still challenges to overcome, as is always the case! One such challenge was what Mühlberger refers to as ‘the layout analysis problem’. When it comes to handwritten text recognition, the first step in the processing pipeline is that the computer needs to know where there is actually text on a page. This might look like an easy task, but it was the hardest challenge at the beginning of the project.



© Bozen City Archive

“It was resolved by combining forces from several domains. First of all, a new concept of how to represent a line was introduced. Secondly, by far the largest dataset ever was created by integrating material from several archives. Finally, colleagues from the University of Rostock applied machine learning methods,” Mühlberger explains.

Their multi-pronged approach paid off. The result was that from about 85 % accuracy in finding lines on a handwritten page, the rate was increased to about 97 % accuracy.

The platform is gaining momentum. As Mühlberger says: “The National Archive in the Netherlands and the National Archives Finland started projects where millions of handwritten documents are made available via handwritten text recognition and keyword spotting to millions of users. These projects are among the first to be carried out with Transkribus and managed by the European Cooperative Society Transkribus.”

READ

- Coordinated by the University of Innsbruck in Austria.
- Funded under H2020-INFRA.
- cordis.europa.eu/project/id/674943
- Project website: read.transkribus.eu
- bit.ly/37NPhjG



The hunt for life on other planets is ultracool and getting warmer

The existence of life beyond our solar system is the stuff dreams are made of. A novel ground-based telescope network is detecting habitable planets and making a list for newly commissioned spectroscopic telescopes seeking signs of life.

Ever since the historical first discovery of a planet orbiting another sun-like star in 1995, more than 4 000 such exoplanets have been detected at an ever-increasing rate. They include gas giants similar to Jupiter (so-called hot Jupiters) and terrestrial ones, the real attention-grabber when it comes to exoplanets that could support life.

EU funding of the ambitious SPECULOOS (Searching for habitable planets amenable for biosignatures detection around the nearest ultra-cool stars) project has helped create a network of pioneering ground-based telescopes. Discovery of life on other planets may be around the corner rather than light years away.

WHEN YOU WISH UPON A STAR

Project coordinator Michaël Gillon's lifelong dream of finding life on other planets began to solidify with initiation of the SPECULOOS prototype in 2011 at the University of Liège's TRAPPIST 60 cm robotic telescope in Chile, to monitor about 50 of the nearest and brightest

ultracool dwarf stars. These stars are considered the best targets for detection of spectroscopic biosignatures with next-generation giant telescopes, among which is the James Webb Space Telescope (JWST) scheduled to launch in 2021.

By 2015, the SPECULOOS prototype had found a clear exoplanet signal at one of its 50 ultracool dwarf targets. Gillon continues: "In 2016, we acquired much more data, revealing the existence of seven temperate Earth-sized planets around this tiny nearby star. Now called the TRAPPIST-1 planetary system, all of these planets could harbour water in liquid form on their surfaces. And all of them are well-suited for detailed atmospheric studies."

The revelation led to a press conference at NASA's headquarters in Washington DC, USA and a flurry of publications, including in the prestigious peer-reviewed journals 'Nature' and 'Nature Astronomy'.

LIKE A NEEDLE IN A HAYSTACK

Despite the exciting successes of the SPECULOOS prototype, detecting exoplanets potentially habitable and dozens of light years away is no easy task. Astronomers often rely on a sort of mini-eclipse, a dimming of the light emitted by the star that happens with a predictable regularity lasting a predictable length of time, indicating it is caused by an object in orbit.

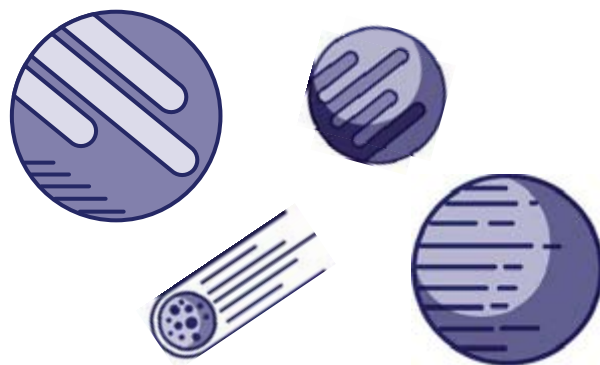
Aside from the inherent technical difficulty, the relative frequency of such planets around Sun-like stars is unknown. Finding more could take time and patience.

INTENSIFYING THE HUNT FOR HABITABLE PLANETS

There are about 1 000 ultracool dwarf stars close enough and bright enough to make the atmospheric study of Earth-sized planets possible with JWST. Gillon plans to follow them all.

Thanks to EU funding and an international collaboration, he has brought to eight the total number of robotic ground-based telescopes in the network. At four different locations, they cover both the northern and southern hemispheres to ensure maximal potential for detecting exoplanets during their transit across their own stars.

Gillon reflects: "It is remarkable that, after centuries of speculation, the existence of life beyond our solar system is now entering the realm of a testable scientific hypothesis. If one day we discover it, our vision of the Universe



Ever since the historical first discovery of a planet orbiting another sun-like star in 1995, more than 4 000 such exoplanets have been detected

and of our place in it will change forever. In the meantime, the project will probe the diversity of terrestrial planets in the galaxy."

SPECULOOS

- Hosted by the University of Liège in Belgium.
- Funded under FP7-IDEAS-ERC.
- cordis.europa.eu/project/id/336480
- Project website: speculoos.uliege.be/cms/c_4259452/en/portail-speculoos

SPACE

Chemical fingerprints of stars give clues to exoplanet make-up

A lot of headlines and research around exoplanet composition focus on measurements of their atmosphere. Although this is a good starting point for whether or not they can sustain life, determining the composition of gas and dust surrounding a newly formed star – the birthplace of planets – is key to understanding the planet's full chemical composition.

Stars are born in a maelstrom when massive, cold clouds of gas and dust collapse and ignite a star. Leftover material in a disk gives rise to boulders of varying sizes.

Eventually, large clusters of such boulders will be incorporated into planets that orbit the star. At the same time, a bewildering network of chemical reactions gives rise

to complex organic molecules that are trapped in the icy boulders around the star, and are eventually transported to the planets.

“Deciphering the chemical ingredients of material that give birth to planets will reveal the bigger picture of the origin and diversity of planets. Currently, a wealth of research is dedicated to measuring the atmospheric composition of exoplanets as well as planets of our solar system. Although this makes sense, those planetary characteristics are just a springboard for discussions around the habitability of exoplanets, which is ultimately determined by their birth material,” notes Mihkel Kama, coordinator of DISCO (Decoding planetary compositions using observations and modelling of planet-forming disks), a research project undertaken with the support of the Marie Skłodowska-Curie programme.

USING STELLAR ‘CONTAMINATED MATERIAL’ AS A PROBE FOR PLANETS

Hitherto research has given a preliminary understanding of oxygen and carbon abundance in protoplanetary disks. The primary goals of DISCO were to add several more elements to the toolbox of chemical composition analysis to improve understanding of how planets, and specifically habitable environments, originate.

Researchers pioneered a new approach called the ‘Contaminated A-stars Method’ (CAM) which applies to stars slightly bigger than our Sun. “The chemical element budget of planet-forming material close to a star is very hard to measure directly, so we were looking for innovative new methods to do this. While solar-type stars have

“We hope that this work is going to bring a breakthrough in understanding the properties of Earth and planets around other stars.”

churning convection zones, more massive stars are more quiescent. As a result, any material falling onto such a star, like blobs of planet-forming material or gas ejected from a hot close-in planet, would not mix into the star’s interior but would rather sit on its surface. This makes it easy for astronomers to measure their spectra and analyse the chemical imprint of the accreted material on their surface,” explains Kama.

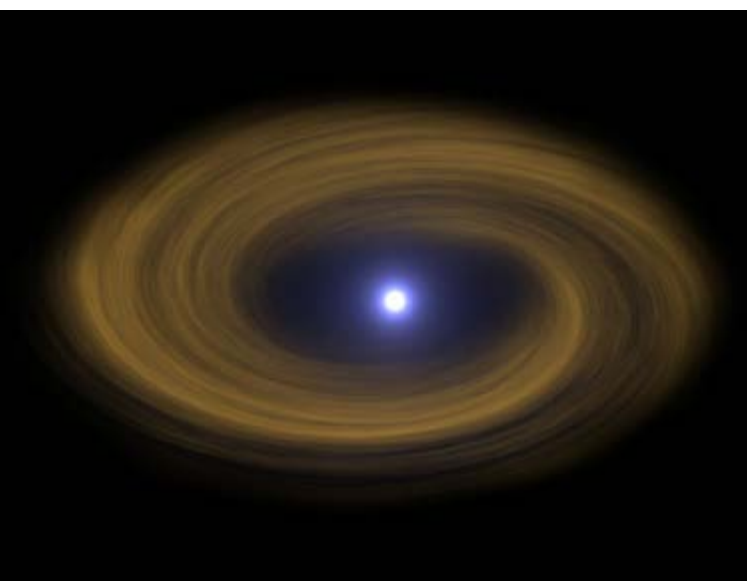
NEW CHEMICAL ELEMENTS DETECTED FOR THE FIRST TIME

Researchers studied several planet-forming disks surrounding young stars. Previously, the focus had been on carbon and oxygen, which was of limited use for understanding the composition of planets. Their research has led to impressive results. In particular, they succeeded in teasing out the precise fraction of sulfur atoms that were locked in solid particles prior to planet formation. This information, which is hard to obtain with any other means and can now be obtained for almost any element using CAM, provides a crucial input to planet-formation models used to predict the elemental composition of planetary solid cores and gaseous atmospheres.

The team has also tracked sodium, zinc, iron and magnesium particles locked in solid particles. “These are elements astronomers have been desperately trying to track down and characterise in planet-forming environments. We hope that this work is going to bring a breakthrough in understanding the properties of Earth and planets around other stars,” concludes Kama.

DISCO

- Coordinated by the University of Cambridge in the United Kingdom.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/753799





FUNDAMENTAL RESEARCH

Higgs pairs could yield new physics beyond the Standard Model

The discovery of the Higgs boson – the elusive ‘god’ particle – is as significant to physics as the discovery of DNA had been to biology. The long-sought particle highlighted some big questions about the nature of the Universe, and importantly, the need for new physics beyond the Standard Model.

For decades, physicists sought the Higgs boson – the odd particle that was the missing piece of the Standard Model (SM) puzzle. Eventually, the endurance and curiosity of researchers was rewarded in 2012 when the last remaining fundamental particle to be experimentally confirmed was detected by the Large Hadron Collider (LHC) at CERN.

While the SM beautifully describes what matter is made of and how it holds together, it is a flawed theory. The properties of the Higgs boson could help reveal more about the basic questions that the SM fails to answer. “The Higgs boson can be a stepping stone to our exploration of dark matter, the asymmetry of matter and anti-matter (CP-asymmetry), and a Grand Unified Theory of particle physics,” notes Stefano Moretti, coordinator of the NonMinimalHiggs project.

Funded under the Marie Skłodowska-Curie programme, researchers working on NonMinimalHiggs explored how

the Higgs boson can bring the world closer to understanding the fundamental composition of the Universe. Some of the key issues addressed were the following: Which new physics models better describe the fundamental composition of the Universe when all observed properties of the Higgs boson are considered? The work conducted will aid the search for new physics at present and future hadron colliders.

CLARIFYING THE ORIGINS OF ELECTRO-WEAK SYMMETRY BREAKING

In the SM, elementary particles acquire their masses by interacting with the Higgs field. The process is governed by a delicate mechanism called electro-weak symmetry breaking (EWSB) which remains amongst the least understood phenomena of the SM.

“Our models involving more than one Higgs boson or other scalar particles will help answer some of the most troubling problems in fundamental particle science, opening more doors for new BSM physics.”

The SM calls all the carriers of the EW force to have zero mass – this allows the electro-magnetic (EM) and weak nuclear forces to merge into a single EW force. However, unlike the massless photon that mediates the EM interactions, the bosons that carry the weak force have non-zero masses – the Higgs field breaks the EW symmetry of the boson masses.

“NonMinimalHiggs researchers successfully helped prepare the stage for the particle physics community to find the underlying beyond the Standard Model (BSM) structure responsible for the EWSB mechanism,” notes Moretti. Collaborative interdisciplinary research partnerships amongst many institutions searched for new Higgs boson states with the aid of new numerical tools.

As an example of their novel approach, NonMinimalHiggs researchers highlighted the need to consider the quantum interference effects in the study of charged Higgs states. This interference, which has not been considered in the experimental analyses conducted at the LHC, can completely alter interpretation of data. Their findings are reported here.

A SINGLE HIGGS IS NOT ENOUGH

NonMinimalHiggs produced more than 110 publications. The common denominator has been the construction of a variety of likely scenarios that embed the Higgs mechanism (in a non-minimal form) into new BSM scenarios. Studying how these frameworks manifest in earthly laboratory and space facilities will help reveal the hidden BSM physics that surrounds us.

What does this non-minimal form refer to? “The SM is built with only one Higgs boson, which is consistent with the scalar particle discovered at the LHC. This minimal version can sufficiently account for the mass-generation mechanism of particles, but is not generally a long-term cure for the SM’s ills. Our models involving more than one Higgs boson or other scalar particles will help answer some of the most troubling problems in fundamental particle science, opening more doors for new BSM physics,” concludes Rui Santos, one of the NonMinimalHiggs researchers.

NONMINIMALHIGGS

- Coordinated by the University of Southampton in the United Kingdom.
- Funded under H2020-MSCA-RISE.
- cordis.europa.eu/project/id/645722
- Project website: sites.google.com/view/risehiggs/home

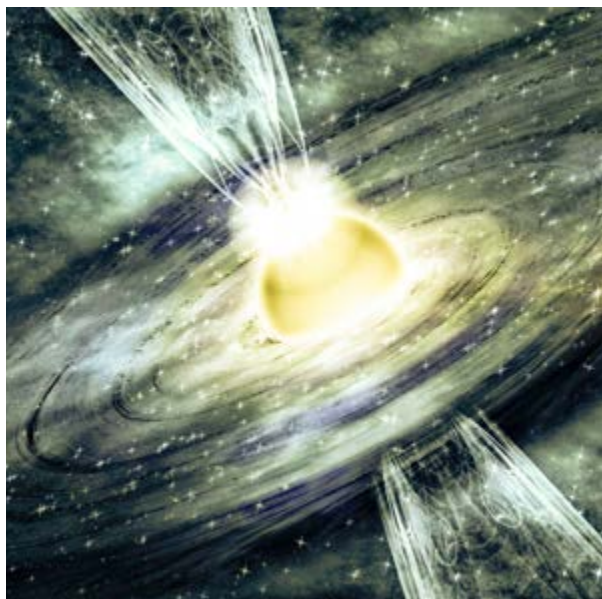
FUNDAMENTAL RESEARCH

EU enterprise probes some of the Universe’s great unanswered questions

In Star Trek, antimatter fuels the Starship Enterprise. But in the real world it’s still largely a mystery to scientists. The ANGRAM project studied a new method for more efficiently detecting antimatter in order to help resolve questions such as why there is more matter than antimatter in the Universe and how antimatter falls.

The interaction between matter and antimatter doesn’t just fuel the Starship Enterprise in Star Trek. It also fuels

unanswered questions about the Universe, which EU project ANGRAM (Antimatter gravity measurement: How



does antihydrogen fall?) set out to probe, trialling a new method for detecting antimatter, and making progress on the question of how antimatter falls.

Research fellow Angela Gligorova, with support from the Marie Skłodowska-Curie programme, simulated – and detected – antiprotons, to study their interaction with ordinary matter. Gligorova is analysing and comparing the simulations and hopes to publish her results in the next few months. “We carried out a study by annihilating antiprotons in different materials in order to validate existing physics models and to identify their weaknesses as well as methods for improvements,” says Gligorova.

ANGRAM’s preliminary results show that none of the current physics models describes the interaction between matter and antimatter accurately. “The research has shed light on aspects of the interaction, showing more work is needed in this direction,” comments Gligorova.

Supervised by Eberhard Widmann, Director of the Stefan Meyer Institute for Subatomic Physics at the Austrian Academy of Sciences, Gligorova secured invaluable time at CERN, the European Organization for Nuclear Research, to use the Antiproton Decelerator there which produces the antiprotons necessary for the formation of antihydrogen. But the fellow wasn’t able to complete the final goal, which was to carry out a 30% measurement of the gravitational acceleration for antihydrogen, because the antiproton beam at CERN is in high demand and only available for a limited amount of time.

The new antihydrogen formation method also took longer than foreseen. “In the end, there wasn’t enough

“ *Our study was the first direct comparison between experimental data and the current physics models.* ”

time left to measure the gravitational acceleration,” Gligorova explains. “Such an experimental result is important because it might reveal the reason why there is so much more matter than antimatter in the Universe, even though in the beginning, in the Big Bang, they should have been created in equal amounts.”

THE BEAUTY OF SETBACKS

The project trialled a moiré deflectometer to simulate the fall of antihydrogen in Earth’s gravitational field: a system made of two or three parallel gratings, coupled to a detector. Gligorova discovered that the interactions between the antihydrogen atoms passing close to the gratings and the atoms from the gratings produced an effect that was misleading when trying to measure the gravitational force.

Gligorova concluded that the tests required an even more sophisticated deflectometer, made of light instead of matter, but that instrument exceeded the resources available. “In research things don’t always go as foreseen and that’s the beauty of it. And that is progress too,” says Gligorova, sanguinely.

Gligorova’s work in a challenging field has already inspired young female scientists after she made a video for International Women’s Day.

The way ANGRAM combined two detector technologies for antiproton annihilations could inspire future experiments in antimatter. “Our study was the first direct comparison between experimental data and the current physics models for antiproton-nucleus annihilation at rest, where we saw how good and bad predictions were for the low energy region,” Gligorova concludes.

ANGRAM

- Coordinated by the Austrian Academy of Sciences in Austria.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/748826
- Project website: oeaw.ac.at/smi/funding/eu-projects/finished-eu-projects/angram



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→ workshops.ill.fr/event/196

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2
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World Autism Awareness Day

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→ promise.manchester.ac.uk/en/horizon-2020-promise-final-conference

8→9
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14→16
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ENIGMA Final Conference

→ enigma-itn.eu/training/enigma-conference

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