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European Commission

#98

DECEMBER 2020 – JANUARY 2021

# Research*eu

BRINGING YOU THE RESULTS OF EU RESEARCH AND INNOVATION

Securing the future of transnational Holocaust research

Advanced solution offers seamless Wi-Fi connectivity on buses, trains, ships and planes

New compact antenna designs poised to enhance nanosatellite communications

SPECIAL FEATURE

DATA PROTECTION: NEW TECHNOLOGIES TO PROTECT PRIVACY

# Editorial

# Innovative technologies and solutions to protect data privacy, a new COVID-19 breakthrough and SME-friendly robotics

## Welcome to this month's Research*eu magazine

As a prelude to writing this introductory editorial, your editor sat down and started making a list of all of the organisations – commercial, governmental and in-between – that currently store and have access to his personal data. Starting with official government agencies of the two countries that he's a citizen of, then big corporate entities, social media and online shopping sites, suffice to say, he gave up once he hit 25 (and there was still a lot more to go). As a mid-30s millennial who came of age in the MySpace and MSN Messenger era, your editor is probably around average when it comes to how many entities have his personal data.

But it was nonetheless a fascinating exercise to highlight just how important your digitised personal data has become to the modern economy. Liza Minelli once famously sang that 'money makes the world go round' but is that so true today? It could easily be argued that data has become an equally powerful second force that powers the Earth's rotation.

Europe has become a genuine world leader in ensuring individual rights and protections when it comes to personal data. Through its General Data Protection Regulation – the GDPR – that came into force in May 2018, citizens have been empowered to have more control over their data and all businesses must follow and comply with the same rulebook in the taking, storing and processing of personal data.

In this issue's special feature, we introduce you to seven EU-funded projects that have been working at the heart of Europe's drive for better data protection standards, working with enterprises to help them ensure they understand and are able to comply with the new regime, as well as look ahead to how rapidly developing digital technologies can remain faithful to the GDPR.

Meanwhile, in **Project of the Month**, we highlight an extremely promising new breakthrough in COVID-19 research, centred on a better understanding of how the virus became so infectious to humans, with this new knowledge being potentially game-changing in developing effective therapies against the disease. Then in **Life After**, we have a catch-up chat with the **ReconCell** project team, who have pioneered a cutting-edge workcell that makes robot solutions commercially viable for SMEs that otherwise may not have the time or resources to automate their production processes. Finally, we're happy to announce the return of **EU Agenda**, albeit highlighting a smaller-than-normal selection of online and in-person events that will take place in the New Year. However, we hope that as we move through 2021 and the mass vaccination drive begins in earnest, this will not be the case for the entire year!

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

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HEALTH

# Novel biodegradable bandage controls severe bleeding and leakage of body fluids during surgery

*One of the major problems during general surgery is controlling bleeding. An EU initiative developed an innovative biodegradable bandage to stop bleeding and body fluid leakage during surgical procedures.*

Standard surgical methods such as sutures and ligatures have been used for decades to prevent and stop bleeding. In many cases, such techniques have proven ineffective or impractical when dealing with severe haemorrhaging.

The EU-funded sFilm-FS (Fibrin sealant for anastomotic leaks and haemostasis) project developed a product composed of a biocompatible, bioabsorbable polymeric film with a biological glue known as fibrin sealant. Also named sFilm-FS, this human body-friendly bandage is used to prevent blood and body fluid leakage in internal organs. "The product is much more effective, faster and easier to use than any other standard of care," comments project coordinator Orgad Laub. It is absorbed by the body, allowing full and effective healing of the injured tissue. Faster recovery time means a shorter hospital stay and less burdened health system.

sFilm-FS is utilised when haemostasis – a process to prevent and stop bleeding – isn't effective for soft tissue bleeding. It is also intended for use during sealing in gastrointestinal surgery. "Unlike open surgery, for minimally invasive surgery treatment there are very limited tools to handle bleeding scenarios," explains Laub. "For sealing, such as gastrointestinal sealing, there is currently no registered device, so sFilm-FS will be a novel solution."

## UNPARALLELED STRENGTH AND SEALING ABILITY

The fibrin sealant attaches and fixes the polymeric film to the damaged tissue. The film seals the tissue, similar to a rubber patch that seals an air leak in a flat tyre. In the case of bleeding, the fibrin sealant accelerates the coagulation of the blood under the film. Unlike other products that contain similar components, sFilm-FS is based on the sealing capacity of the polymeric film.

Project partners successfully validated sFilm-FS by testing it on rats and pigs. Severe bleeding was stopped within 2 minutes in rat and pig spleen and liver punctures. sFilm-FS also successfully sealed gastrointestinal injuries. Toxicity tests demonstrated that sFilm-FS was non-toxic, even when using maximum doses, and all treated animals recovered without any side effects. EU regulatory agencies in Austria and Slovenia evaluated and approved the product for human clinical studies. Human trials started in September 2020.

> *"sFilm-FS is a novel surgical device that will help control severe and moderate bleeding and tissue sealing during both open surgery and minimally invasive surgery."*

## STEP CHANGE IN OPERATING ROOMS

Feedback provided by the United States Food and Drug Administration led to the development of a unique terminal sterilisation step that considerably improves the safety of sFilm-FS and slashes manufacturing costs. Thanks to the thin film that contains the fibrin sealant, the product could also be developed for minimally invasive

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surgery treatment. The project team is working on a laparoscopic tool that will extend the use of sFilm-FS to all surgical procedures.

"sFilm-FS is a novel surgical device that will help control severe and moderate bleeding and tissue sealing during both open surgery and minimally invasive surgery," concludes Laub. "These are considered unmet needs that will significantly shorten surgery and healing times." Ultimately, the project should improve safety and lessen the risk of post-operative complications while reducing mortality rates.

## SFILM-FS

- Coordinated by Sealantium Medical Ltd in Israel
- Funded under H2020-LEIT-BIOTECH and H2020-SME
- cordis.europa.eu/project/id/787441
- Project website: sealantium-med.com
- bit.ly/2FzjOZm

# Pioneering foam therapy offers hope to lung patients

*Acute respiratory distress syndrome is a leading cause of death in COVID-19 patients and also has a devastating impact on sufferers of other conditions. A breakthrough drug delivery device has demonstrated huge potential in treating this deadly lung condition.*



Acute respiratory distress syndrome (ARDS) is an inflammatory lung condition that has become the leading cause of death in COVID-19 patients. This rapidly progressing disease is characterised, among other factors, by the depletion of the lungs' inner liquid coating, necessary for the lung's expansion. This is exacerbated by the coronavirus.

"There is at present no effective treatment against this," notes the EU-supported LIFT (Liquid Foam Therapy (LIFT) for Acute Respiratory Distress Syndrome (ARDS)) project coordinator Josué Sznitman, associate professor of biomedical engineering at Technion – Israel Institute of Technology.

"Patients are mechanically ventilated with supplemented oxygen, in the hope that their lungs can heal themselves. However, about 40 % of those afflicted with ARDS are likely to die."

## BETTER DRUG DELIVERY

A key challenge in treating this condition is getting the medication to where it is needed within the lungs. Common devices, such as nebulisers, are unable to effectively deliver drugs to the lungs, since only small particles can be inhaled, so doses remain low. Direct instillations of liquids into the lungs lead to bad drug distribution, as liquids drain downwards with gravity.

The LIFT project sought to address this by developing a unique foam formulation and delivery device, to treat ARDS and, potentially, other lung conditions.

"We wanted to demonstrate, in this project, that delivery of our foamed surfactant, used to replace the lungs' inner liquid coating, could be an effective treatment," says Sznitman. "We wanted to show that our foam is superior to liquids which have been unsuccessfully used in previous clinical trials."

Using rat and pig models, the project team set about demonstrating the efficacy of its patent pending technology. A working prototype of the Liquid Foam Therapy (LIFT) drug delivery device was constructed, and preclinical experiments were carried out using rats first.

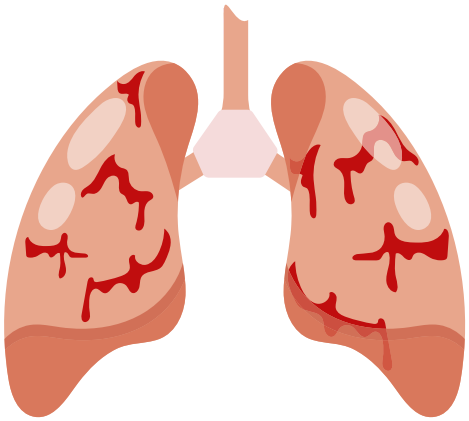
Following successful results in rats, they then used porcine lungs. "Pig lungs were used to see if the treatment and the device would be effective in achieving homogenous drug distribution in larger human-sized lungs," explains Sznitman.

## NEW LUNG TREATMENTS

The project team was able to demonstrate how foam can be effectively delivered to coat the inner lungs, opening the door to a new era of treatments for ARDS and other lung conditions.

The successful animal trials conducted during the LIFT project enabled the team to start preclinical trials in large animals. These will hopefully enable the team to start

**About 40 %** of those afflicted with acute respiratory distress syndrome **(ARDS) are likely to die**



clinical trials, treating – and ultimately saving the lives of – real patients. "The long-term goal is that this will become the gold standard for treating ARDS," says Sznitman.

The project team is also looking to broaden the use of this technology to deliver other therapies. "For example, we are exploring the possibility of delivering large doses of steroids to treat ARDS, including for severe COVID-19 patients," notes Sznitman.

"The results of the LIFT project have the potential to extend far beyond ARDS treatments," remarks Sznitman. "This drug delivery technology can be leveraged for other lung therapies, such as delivering stem cells directly to the lungs to treat conditions like chronic obstructive pulmonary disease (COPD)."

> *"This drug delivery technology can be leveraged for other lung therapies."*

To realise all this potential, a start-up company, called Neshima Medical, has been launched. The aim is to bring these life-saving treatments for lung disorders to market as quickly and as safely as possible.

"We plan to finalise the clinical prototype of our delivery device by the end of 2020, and then prepare for clinical trials," adds Sznitman. "We are confident that we will be bringing to market a breakthrough pulmonary drug delivery device, applicable across a broad range of lung diseases."

### LIFT

- Hosted by Technion – Israel Institute of Technology in Israel
- Funded under H2020-ERC
- cordis.europa.eu/project/id/813228
- Project website: biofluids.technion.ac.il/lift

HEALTH

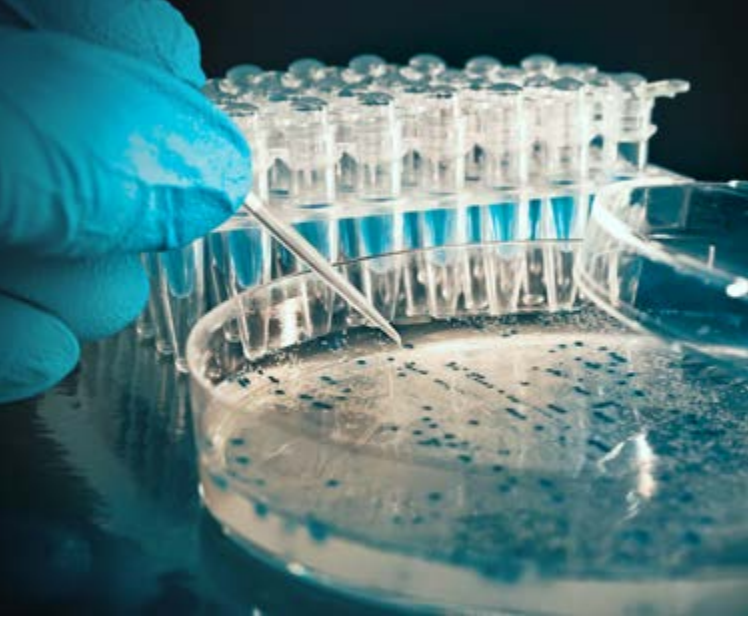
# The next generation of *in vitro* diagnostics

*There is a great unmet medical need for point-of-care assays to diagnose infectious diseases. A large European initiative addressed the gaps in in vitro diagnostics by training the next generation of researchers.*

As highlighted by the COVID-19 pandemic, diagnostics is a major limiting factor in the identification and treatment of microorganisms causing infections. This renders infectious diseases a major burden on public health and the global economy.

## A TRAINING NETWORK FOR *IN VITRO* DIAGNOSTICS (IVD) DEVELOPMENT

To address this problem, the ND4ID (New Diagnostics for Infectious Diseases) project offered a holistic training



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programme to prepare the next generation of researchers in the field of IVD. Undertaken with the support of the Marie Skłodowska-Curie Actions programme, ND4ID aimed to bridge the gap between technological innovation and clinical need.

ND4ID trained 15 early-stage researchers (ESRs) across the full breadth of disciplines spanning clinical, technological and market-oriented viewpoints. ESRs were selected from a wide range of scientific backgrounds such as clinical, biotechnology and electrical engineering.

Each ESR worked on a particular aspect of the diagnostics landscape, covering respiratory tract and urinary tract infections as well as antimicrobial resistance. The training commenced with identification of clinical needs and shortcomings in current IVD.

The participation of pharmaceutical companies in the project further offered young researchers the opportunity to familiarise themselves with the IVD development pipeline, including legal, financial and regulatory issues. "Alongside technological advances, the training of the students was the most important achievement of ND4ID," notes project coordinator Herman Goossens.

## ADVANCES IN IVD DEVELOPMENT

A point-of-care (POC) assay usually detects DNA, proteins or other molecules of the target microorganism. Given the low levels of these molecules present in patient samples, sensitivity is a key parameter in POC performance. "In any case, even with the best combination of technologies, an IVD must relate to the clinical need," says Goossens. Therefore, ND4ID activities included novel biomarker investigation and bioassay development as well as new diagnostics tools.

ESRs worked on projects that exploited the power of genome sequencing in diagnostics. They developed genotype tests for antimicrobial susceptibility and the identification of key virulence determinants of urinary tract infections.

> *"In any case, even with the best combination of technologies, an IVD must relate to the clinical need."*

Additional state-of-the-art bioassays were generated with high sensitivity and specificity for subsequent use in digital diagnostics. Switching from paper to plastic offered increased immunoassay sensitivity and better sample flow properties. Furthermore, emphasis was given to the high-throughput selection of antibodies to be used in IVD.

ND4ID addressed sepsis detection, which is currently limited by the low number of bacteria in blood. Through a method that concentrates blood bacteria, partners are hopeful to achieve increased sensitivity and significantly move the field forward.

## PROSPECTS OF ND4ID DELIVERABLES

To address the high cost of IVD, which limits their implementation in clinical practice, scientists developed a low-cost molecular device based on DVD technology. One student developed a simple digital dipstick that allows the rapid identification of microorganisms causing urinary tract infections.

Many of the ND4ID solutions, such as the next-generation sequencing test for antimicrobial susceptibility, will be directly exploited by the project's industrial partners. The antibody-screening platform will be promoted by a spin-off company from KU Leuven to provide antibodies to academic and industrial partners.

Overall, ND4ID has generated IVD innovations and paved the way for future research in the field. The developments further strengthen Europe's position in the internationally competitive arena of IVD technology.

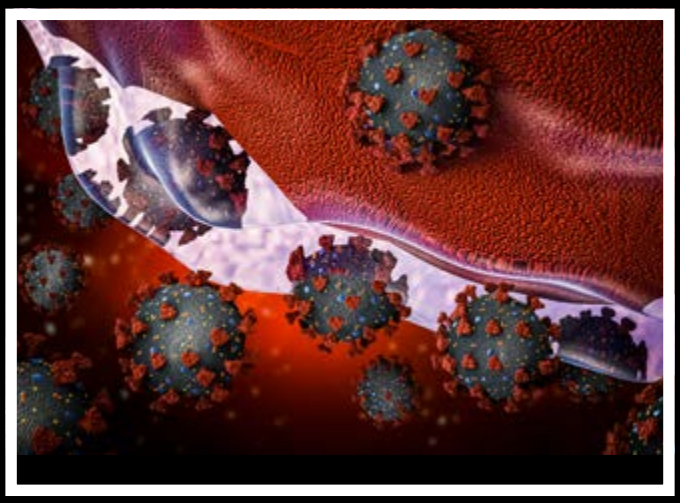
### ND4ID

- Coordinated by the University of Antwerp in Belgium
- Funded under H2020-MSCA-ITN
- cordis.europa.eu/project/id/675412
- Project website: bit.ly/ND4ID

PROJECT OF THE MONTH

# A new breakthrough in understanding how SARS-CoV-2 invades human cells

*This month, we're giving the Project of the Month accolade to the EU-funded CHUbVi (Ubiquitin Chains in Viral Infections) project, which is supported by the European Research Council (ERC). One of the project's three principal investigators, Yohei Yamauchi, has contributed to a potentially extremely important study that has discovered how the SARS-CoV-2 is so infectious and able to spread rapidly in human cells.*





> *"Could the Spike protein of SARS-CoV-2 associate with neuropilin-1 to aid viral infection of human cells? Excitingly, in applying a range of structural and biochemical approaches we have been able to establish that the Spike protein of SARS-CoV-2 does indeed bind to neuropilin-1."*
>
> Research team press release

Like all viruses, SARS-CoV-2 attaches itself and invades human cells by using a specific viral protein called the 'Spike' protein. In this breakthrough study, led by the University of Bristol in the United Kingdom, the research team used multiple approaches to discover that SARS-CoV-2 recognises a protein called neuropilin-1 on the surface of human cells to facilitate viral infection. This new knowledge could be potentially game-changing in developing antiviral therapies and vaccines to treat COVID-19.

Whilst we are specifically highlighting Yamauchi for his contribution to these results (as this is our remit), CORDIS also extends its congratulations to absolutely everyone involved in this promising breakthrough!

The full study has recently been published in 'Science'.

For more information, please see:

→ science.sciencemag.org/content/early/2020/10/19/science.abd3072

## CHUBVI

- → Hosted by the Friedrich Miescher Institute for Biomedical Research in Switzerland
- → Funded under H2020-ERC
- → cordis.europa.eu/project/id/856581
- → Project website: bit.ly/CHUbVi

**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!**

SOCIETY

# Securing the future of transnational Holocaust research

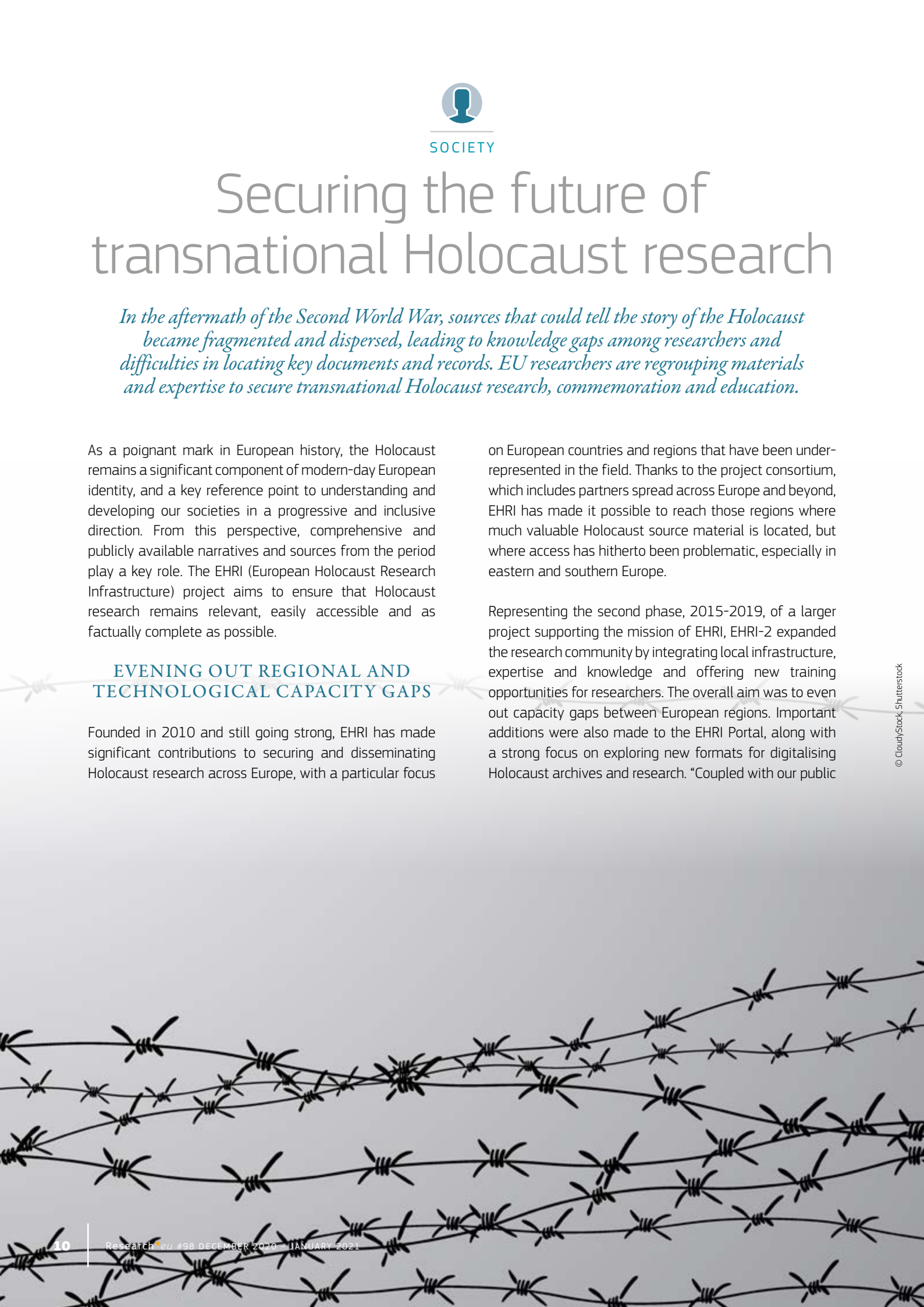
*In the aftermath of the Second World War, sources that could tell the story of the Holocaust became fragmented and dispersed, leading to knowledge gaps among researchers and difficulties in locating key documents and records. EU researchers are regrouping materials and expertise to secure transnational Holocaust research, commemoration and education.*

As a poignant mark in European history, the Holocaust remains a significant component of modern-day European identity, and a key reference point to understanding and developing our societies in a progressive and inclusive direction. From this perspective, comprehensive and publicly available narratives and sources from the period play a key role. The EHRI (European Holocaust Research Infrastructure) project aims to ensure that Holocaust research remains relevant, easily accessible and as factually complete as possible.

## EVENING OUT REGIONAL AND TECHNOLOGICAL CAPACITY GAPS

Founded in 2010 and still going strong, EHRI has made significant contributions to securing and disseminating Holocaust research across Europe, with a particular focus on European countries and regions that have been under-represented in the field. Thanks to the project consortium, which includes partners spread across Europe and beyond, EHRI has made it possible to reach those regions where much valuable Holocaust source material is located, but where access has hitherto been problematic, especially in eastern and southern Europe.

Representing the second phase, 2015-2019, of a larger project supporting the mission of EHRI, EHRI-2 expanded the research community by integrating local infrastructure, expertise and knowledge and offering new training opportunities for researchers. The overall aim was to even out capacity gaps between European regions. Important additions were also made to the EHRI Portal, along with a strong focus on exploring new formats for digitalising Holocaust archives and research. “Coupled with our public



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outreach activities, we truly progressed towards enabling digital approaches with wide public resonance," explains project coordinator Karel Berkhoff.

As a result of the project's efforts to expand and strengthen connections between members of the research community and to bring their resources, knowledge and expertise together under 'one roof', the EHRI Portal is now recognised as the go-to tool for studying the Holocaust from transnational perspectives. More than 150 000 archival unit descriptions were added in the course of this project, as well as 300 archival institutions and 17 country reports. "Our expectations for virtual access were exceeded," adds Berkhoff. "By October 2018, we averaged 11 600 sessions per month, and many users were located in eastern and southern Europe."

## LAYING THE FOUNDATION FOR MORE INCLUSIVE SOCIETIES

With EHRI-2 having ended in 2019, EHRI is now supported by two project consortia consisting of 25 partners from across Europe, Israel and the United States. It is currently transforming itself from a project into an established organisation. Legal, financial and strategic work is under way to have this permanent body fully operational by January 2025, the 80th anniversary of the liberation of Auschwitz.

> *"The recent rise of anti-Semitism, xenophobia and aggressive nationalisms demonstrates that Holocaust research is never a purely academic concern, but a prerequisite for open and non-discriminatory societies across Europe and beyond."*

Berkhoff emphasises that while the Research Infrastructure's primary impact is scientific, it has also assumed a wider social and political agenda: "The recent rise of anti-Semitism, xenophobia and aggressive nationalisms demonstrates that Holocaust research is never a purely academic concern, but a prerequisite for open and non-discriminatory societies across Europe and beyond." With its permanent establishment, EHRI will be a key resource for society as a whole – available to citizens and decision makers as well as researchers – making sure that the events of the Holocaust continue to inform our values and actions as we build the future of Europe.

### EHRI

- Coordinated by the Royal Netherlands Academy of Arts and Sciences in the Netherlands
- Funded under H2020-INFRA
- cordis.europa.eu/project/id/654164
- Project website: ehri-project.eu

SOCIETY

# Tracing the medieval roots of modern theories of mind

*Despite being referred to as the 'dark ages', the period produced models of how human perception is framed that have fed into European intellectual thought ever since. Textual analysis is shining a light on the origin and development of concepts we now use.*

The Aristotelian model of perception holds that we come to know objects by perceiving their sensorial properties, such as shape or colour. Whereas, in the Augustinian model it is our mind that actively drives the process. This is because operations of the soul, such as perception, could not be caused by material objects since the soul is immaterial. Here, what makes perception possible is the way we are tuned to encounter the world.

The EU-supported project RiP (Rationality in Perception: Transformations of Mind and Cognition 1250-1550) studied these two highly influential theories of mind to better understand medieval philosophy's dynamism. The team's textual analysis explains how medieval thinkers used notions of rationality, and how that relates to complex thought and behaviour.

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"While scholars knew the Augustinian model of active perception is found in multiple guises throughout the period, we traced the main lines of its development," explains project coordinator José Filipe Silva from the University of Helsinki.

The key texts have been made freely available for future research.

## RATIONALITY AND THE SENSES

RiP sprang from the belief that research on historical philosophical sources is essential for understanding the origin and development of concepts we now use. One such concept is the notion of rationality, on which many socio-economic models rest.

The project focussed on the medieval period – under-investigated considering the number of textual sources about which little is known. As it started around the 5th century and continued into the 16th, it is one of the longest of all the historical periods of thought.

"We can't dismiss the voices of those who wrote about these issues over 1 000 years of European thought. I would say they deserve a hearing! We wanted to make their texts available for consideration," says Silva.

Many of the sources RiP worked with were handwritten texts, predating print, and so the first task was to transcribe them. "The more I looked at them, the more I doubted traditional accounts of how medieval thinkers conceived perception of the external world. What was often presented was simplistic and overlooked alternative accounts beyond the dominant Aristotelian one," adds Silva.

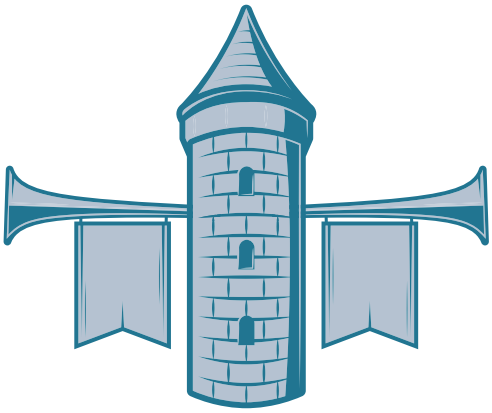
> *"Without research investments like RiP, we risk losing 1 000 years of European cultural production from one of the most dynamic periods of human history, which saw the birth of universities. What a waste!"*

Analysing the notion of rationality, RiP looked at what has been dubbed 'the flow of reason', which describes the relation between higher order, rational, cognitive powers and lower order sensory ones. RiP questioned the traditional account which posited consensus around the dominance of Aristotelian theory whereby the senses transmitted information to reason in a linear and separate manner.

RiP highlighted that for some authors, like Thomas Aquinas, human sensory power operates under the influence of reason in certain conditions. For Blasius of Parma, this implied no clear separation between sensory and rational powers but that perception, for example certain visual properties such as distance, requires the cooperation of both.

## TOWARDS MEDIEVAL THEORIES OF AGENCY

By offering new insights into a major period of European history, RiP provides a better understanding



The **medieval period** started around the 5th century and continued into the 16th – **it is one of the longest of all the historical periods** of thought

of the intellectual background to a common European conception of the mind.

"Without research investments like RiP, we risk losing 1 000 years of European cultural production from one of the most dynamic periods of human history, which saw the birth of universities. What a waste!" says Silva.

To follow up, the researchers will investigate medieval conceptions of what role (if any) rationality plays in the way human beings behave – and how this was seen as contrasted with animal action.

**RIP**

- Hosted by the University of Helsinki in Finland
- Funded under H2020-ERC
- cordis.europa.eu/project/id/637747
- Project website: blogs.helsinki.fi/rationality-in-perception

SOCIETY

# Open schools initiative pushes for inclusive and innovative societies

*By involving local communities in the teaching and learning process, European schools are becoming hotbeds of innovation.*

Open Schooling, as defined by the European Union, is when educational institutions partner and engage with families and local communities to enhance teaching and learning. Not only does this have a tangible impact on the students, it also puts education at the heart of society, making it integral to local community development.

"School leaders should set a vision for creating learning experiences that provide the right tools and support for all students to thrive. Teachers should be collaborators in learning, seeking new knowledge and constantly acquiring new skills alongside their students," says Sofoklis Sotiriou, head of research and development at Ellinogermaniki Agogi.

The OSOS (Open Schools for Open Societies) project believes European schools should be incubators of the exploration of ideas and of invention. In accelerating innovation, open schools could have far wider impacts.

OSOS has been designing and orchestrating a movement across the EU to transform schools into sites where science teaching is a shared responsibility between leaders, teachers and students. Open Schooling has spread: there are over 1 100 schools participating, in 12 member countries. There are numerous additional schools across the globe.

"Everyone benefits through the increase in their communities' science capital and the development of responsible citizenship," explains Sotiriou, OSOS project coordinator.

## FROM SCHOOL TO INNOVATIVE ECOSYSTEM

The collaborative activities mean students can move beyond textbooks and gain more direct and tangible experience. "In this way, students develop key skills and intercultural understanding and gain new perspectives on their own learning," Sotiriou notes.

OSOS activities stimulate real scientific work: the use of nanotechnology in different sectors; organic farming and healthy food; working projects with Europe's aerospace industry; and the analysis of data from large research infrastructures like CERN.

In the thousands of projects that have taken place so far, much of the inspiration comes from local needs, challenges

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and problems. Students have developed early warning systems for earthquakes in the south-east of Europe, which is prone to seismic activity. Others have developed drones to monitor the weather and the humidity of the ground and inform local farmers on the accurate use of water supplies, and performed quality control studies on local olive production.

Yet they also spread beyond Earth, says Sotiriou: "They have even designed experiments related to the development of sustainable colonies on other worlds which were sent to space with the Blue Origin mission."

OSOS projects have delved into the food production chain in cities and worked on ways to make urban areas more sustainable, through low-carbon emission and sustainable solutions for problems based on nature. Others have designed innovative systems for the production of energy based on wind power and sea waves.

## OPEN FUTURES

The EU contribution gave OSOS the chance to bring together a unique team of experts in science education, school organisation and innovation.

> *"Everyone benefits through the increase in their communities' science capital and the development of responsible citizenship."*

OSOS aims to evolve into a school innovation mentoring ecosystem, the School Innovation Academy, which will facilitate sustainable change by rewarding innovation in European schools.

"If we want a self-sustaining innovative and open culture in schools, we must empower system-aware people to create it, whilst avoiding simply creating interesting but isolated pockets of experimentation," Sotiriou adds.

### OSOS

- Coordinated by Ellinogermaniki Agogi in Greece
- Funded under H2020-Science with and for Society
- cordis.europa.eu/project/id/741572
- Project website: openschools.eu
- bit.ly/3152oew

TRANSPORT AND MOBILITY

# Advanced solution offers seamless Wi-Fi connectivity on buses, trains, ships and planes

*Whether travelling by land, sea or air, passengers demand Wi-Fi that is always available, unlimited and unrestricted. An EU initiative introduced a solution that makes Wi-Fi faster for travellers and less expensive for transportation companies.*

With data consumption growing 20-40 % from one year to the next, meeting passenger expectations for fast and reliable Wi-Fi is both expensive and technically challenging for transportation companies. The Estonian start-up RebelRoam, coordinator of the EU-funded project RebelRocket (10x better Wi-Fi for the passenger transportation industry), introduced an innovative on-board Wi-Fi data traffic optimisation solution to address this issue.

## DISRUPTING PASSENGER CONNECTIVITY

RebelRocket turned the solution into a market-ready product by further developing and piloting data traffic management algorithms and software. The solution enhances on-board Wi-Fi networks, making them faster for passengers, while reducing transportation companies' data consumption and mobile broadband or satellite costs by up to 80 %.

To do this, the innovation filters, shapes and accelerates data traffic. It filters and optimises the most bandwidth-heavy applications such as YouTube, Facebook and Instagram. Certain traffic like illegal content, background mobile activities and automatic updates can be blocked. This results in faster Wi-Fi speeds, more concurrent users, less data consumption and cheaper internet bills. The state-of-the-art traffic acceleration and data reduction algorithms make users' Wi-Fi 10 times faster. "The solution takes away the technical complexity of implementation since it's cloud-based, equipment- and network-agnostic, and can be conveniently operated remotely within minutes worldwide," explains project coordinator and RebelRoam co-founder Kaido Pähn.

> *RebelRocket drastically slashes mobile broadband costs, eliminates legal compliance risk from public Wi-Fi abuse, and creates a competitive advantage for transportation providers by increasing passenger satisfaction with a seamless Wi-Fi user experience.*

## GAINING MARKET TRACTION

After successfully meeting with potential customers from the bus and coach, rail, cruise and airline markets, project partners have gained a much deeper understanding of the specific problems they are experiencing. The most common issue is the high cost of providing the service and the poor quality of onboard Wi-Fi. They carried out communication and dissemination activities that showed a strong interest in improving the Wi-Fi experience and lowering the price passengers pay for such a service. These activities also revealed that the markets are in search of a hardware-agnostic solution to save costs on hardware upgrades as data consumption continues to grow.

"With data consumption and the popularity of video content growing every year, RebelRocket will help transport operators meet passenger demand for good quality Wi-Fi while staying within their budget realities," comments Pähn. The solution is now ready to be fully commercialised for use in buses, trains, ships and aeroplanes in the Baltics, Denmark, Finland, Germany, Norway, Sweden, the United Kingdom and the United States.

"RebelRocket drastically slashes mobile broadband costs, eliminates legal compliance risk from public Wi-Fi abuse, and creates a competitive advantage for transportation providers by increasing passenger satisfaction with a seamless Wi-Fi user experience," adds Pähn. As the travel sector slowly resumes operations in the new normal dictated by the pandemic, transportation companies will seek to reduce costs while still providing consistent if not better service to passengers. "Being connected has become more important now than ever before, and we must continue to support the industry in reducing their costs and providing high-quality Wi-Fi to passengers."

### REBELROCKET

- Coordinated by RebelRoam in Estonia
- Funded under H2020-TRANSPORT, H2020-LEIT-ICT and H2020-SME
- cordis.europa.eu/project/id/806295
- Project website: rebelroam.com

## HOW FRONTIER RESEARCH ADVANCES INNOVATIVE IDEAS AND PERSPECTIVES ON GENDER

The EU has made great strides over the past few decades in tackling gender discrimination. Measures have often been driven by organic social change, arising from the significant increase in women's participation in the formal workforce that began in the 1970s. Other contributing factors are more recent, such as social media campaigns to end violence against women and to break the silence about sexual harassment experienced in all types of workplaces and in society at large.

Whilst there is still more work to be done to achieve real gender equality, much of the progress made has advanced and consolidated the rights of women.

The common purpose of the 12 projects that feature in this CORDIS Results Pack is to challenge prevailing assumptions in mainstream science and society, and to shed new light on gender relations. This they do by harnessing a cross-cutting approach to gender that brings together perspectives of political science, sociology, history, international relations, law and philosophy.

**To find out more, browse, download or order a physical copy of the Results Pack here:** cordis.europa.eu/article/id/422455

# Speech recognition and AI help take the pressure off aircrew

*Air accidents have decreased in recent years, but when they do occur, the crew's workload is usually at its highest level. Therefore, augmenting crew performance during high-workload periods is of great importance and can help maintain flight safety.*



Aircrew workloads peak when faced with a combination of unpredictable situations: meteorological conditions; high-density traffic; system failures; and flight operations like take-off, climb, descent, approach and landing. The amount of information and number of actions that need to be processed by the crew may become unmanageable, affecting flight safety.

The EU-funded VOICI (Solutions for voice interaction towards natural crew assistant) project addressed this threat by developing an intelligent 'natural crew assistant' for the cockpit environment. The system comprises three main technologies, namely sound recording, speech recognition and artificial intelligence (AI).

This includes a cockpit-embedded speech-processing system that understands aviation terminology, as well as an array of low-noise optical microphones and optimised array processing for it. The VOICI system also features a new and more efficient speech synthesis, adapted to aviation terminology and noise levels.

## ASSESSED UNDER REALISTIC CONDITIONS

Project partners aimed to provide a proof-of-concept demonstrator capable of listening to all communications in the cockpit, both between crew members, and between crew and air traffic control. "The VOICI system should recognise and interpret speech content, interact with the crew, and fulfil crew requests to simplify crew tasks and reduce cognitive workload," outlines project coordinator, Tor Arne Reinen.

Researchers also developed a realistic audio evaluation environment for technology experiments. This facilitated the development of the crew assistant and enabled evaluation of its performance, including the speech capture and recognition technologies for use in a noisy cockpit, together with the intelligent dialogue system with automatic speech synthesis as its main output.

The audio testing environment involved a 3D physical model of a Falcon 2000S cockpit, including loudspeaker reproduction of noise recordings from a real flight. "We have demonstrated that the crew assistant is feasible under the very high noise levels of an aviation cockpit," Reinen explains.

## MULTIPLE BENEFITS

Speech capture is achieved through both the pilot's headset and an ambient microphone array. Speech recognition using deep neural networks and the dialogue system were developed explicitly for the cockpit environment and include aviation terminology and robustness to handle high levels of background noise. The systems function independently of cloud-based systems and employ dedicated language models for the cockpit scenario.

> *The VOICI system should recognise and interpret speech content, interact with the crew, and fulfil crew requests to simplify crew tasks and reduce cognitive workload.*

According to Reinen, all the algorithms underlying the dialogue system have been implemented and tested: from the Natural Language Understanding unit that understands natural requests to the Dialogue Core which handles the conversation flow. "Particular emphasis has been placed on the ability of the voice assistant to use contextual data," he notes.

By reducing crew workload, VOICI will contribute to: optimisation of operations, flight safety and crew awareness; better maintenance; reduced cost of operations; and generally higher efficiency and lower stress. "VOICI comprises both small and medium-sized enterprises (SMEs) and research institutes, and cooperation within the consortium will contribute to innovation and job creation," Reinen adds.

### VOICI

- Coordinated by SINTEF in Norway
- Funded under H2020-TRANSPORT
- cordis.europa.eu/project/id/785401
- Project website: sintef.no/projectweb/voici

TRANSPORT AND MOBILITY

# A toolbox to make level crossings safer

*A third of all fatal railway accidents occur at level crossings. A toolkit of safety measures provides solutions for every case and budget.*

On average, six people are killed and another six seriously injured every week on level crossings across Europe. "After suicide and trespass, the next biggest category of death and injury on railways is level crossing accidents," says Grigore Havarneanu, researcher in the project SAFER-LC (SAFER Level Crossing by integrating and optimizing road-rail infrastructure management and design). Level crossings are involved in just 1 % of road deaths, but 30 % of deaths on the railway.

Previous CORDIS projects have investigated ways to reduce the risk of death on railways from suicide and trespass. "Addressing the safety of level crossings was the logical next step", notes Havarneanu. As well as reducing death and injury, improved level crossing infrastructure will also reduce delays and disruption for all travellers.

## BARRIER METHODS

The EU-funded SAFER-LC project, coordinated by the International Union of Railways, brought together a consortium of 17 partners from 10 countries, including eight EU Member States and two associates, Norway and Turkey. Represented among them were railway industrial groups, road unions, research institutes, train operators and technology firms.

Half of all railway crossings in Europe are 'passive' with no barriers or active warning systems. The ideal solution is always to replace the level crossing with a tunnel or bridge, but often this is not physically possible, or financially feasible.

The consortium directed two streams of research, one focused on technical solutions such as smart communications between vehicle and infrastructure and another on psychological and behavioural solutions to encourage safer road user behaviour.

"We focused on new innovative solutions that are alternative options to the traditional 'upgrade' to a barrier crossing," explains Havarneanu.

## RED LINES

Adding smart sensors to passive crossings, for example, could not only warn approaching cars when a train is due but also warn train drivers if a vehicle is detected on the tracks. The SAFER-LC project ran a trial in Thessaloníki, Greece, where a fleet of 100 taxis was equipped with such sensors, the results of which Havarneanu says are 'promising'.

Alternatively, improved signage and environmental cues could encourage drivers not to take risks. "Some road users commit errors, or violations, just because the infrastructure is not self-explanatory, or is poorly constructed, or doesn't facilitate the desired behaviour," adds Havarneanu.

## THE RIGHT TOOL

The final outcome was a toolbox of 48 different solutions, made freely available online to policymakers, road and rail infrastructure managers, and civil groups.

The toolbox offers the best solutions that can be targeted at different types of level crossing and each is linked to studies showing the evidence to support it. These tools can be as simple as speed bumps before a crossing, paint or optical effects that slow drivers.

> *"After suicide and trespass, the next biggest category of death and injury on railways is level crossing accidents."*

"Each solution is published alongside its practicalities, financial cost, pros and cons, examples of use, effectiveness, expected effects and side effects, and links to other sites," notes Havarneanu, adding that no one solution can suit all cases, especially across different EU nations.

"Without EU support, such work would be impossible", says Havarneanu. "That's the beauty of it, we're very lucky to have this project and an interdisciplinary mixed team with different areas of expertise," he adds. "When you have all these people in one room, you have proof that the whole is greater than the sum of the parts."

### SAFER-LC

- Coordinated by the International Union of Railways in France
- Funded under H2020-TRANSPORT
- cordis.europa.eu/project/id/723205
- Project website: safer-lc.eu

CLIMATE CHANGE AND ENVIRONMENT

# Leaf-based miniature ecosystems reveal processes behind rainforest biodiversity

*EU-funded researchers have investigated the species interactions on leaves of rainforest trees to better understand why biodiversity is so high in tropical ecosystems and which processes shape biotic communities.*

Although they normally pass unnoticed, entire communities of living organisms can be found on the surface of leaves in tropical rainforests. These communities, known as epiphylls, are extremely diverse and include bryophytes (mostly liverworts), algae, fungi, bacteria and cyanobacteria, with more than 100 species on a single leaf. As with other tropical biotic communities, it is not clearly understood why these epiphyll communities are so diverse or how biodiversity is maintained.

Testing biodiversity in tropical rainforests can be challenging because of the slow dynamics of tree communities. By focusing on bryophytes and lichens, scientists can test biodiversity theories in an ecological system with much faster dynamics and easier replication than tropical rainforests, while maintaining similarly high levels of biodiversity.

The EU-funded EPIDYN (Life on a leaf: species interactions and community dynamics in epiphyll communities) project is the first study to explicitly address species interactions and community dynamics among epiphyll species within single leaves. "Due to the ephemeral character of their substrate and the small scale and relatively fast dynamics, epiphyllous communities offer an ideal system for studying primary succession and mechanisms explaining biodiversity maintenance in relation to environmental variables," says project coordinator Maaike Bader.

## EFFECT ON ECOLOGICAL SUCCESSION

A research fellow supported by the Marie Skłodowska-Curie Actions programme conducted research on Barro

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Colorado Island in Panama, monitoring leaves under different light and moisture conditions – the main limiting factors for bryophytes and lichens in tropical rainforests. By studying the species composition and spatial patterns on the leaves, they determined the order of their arrival and establishment and the interactions between the different organisms, enabling better understanding of the drivers behind community structure in epiphylls.

The team found that the succession of species on the leaves was characterised by an accumulation of species rather than a replacement of 'weaker' colonisers by more competitive species. "This differs from the classical model of species succession in plant communities," Bader points out.

Also, at the forest scale different successional stages (closed forest and forest gaps) differed in the species composition of the epiphyll communities, indicating the importance of forest dynamics for biodiversity. "We thus showed that habitat dynamics and succession processes at very different spatial scales interact to create these highly diverse ecosystems," observes Bader.

## A BETTER UNDERSTANDING OF EPIPHYLLS

These results will help understand how epiphylls from evolutionary and morphologically very different taxonomic groups (e.g. lichens and liverworts) grow together to form small-scale biotic communities. Bader explains: "Following the spatial patterns on the leaves through time, we saw that these changed from being mostly random on young leaves to more organised on older leaves, indicating a shift from random processes (chance arrival) to more deterministic processes, for example competition."

*"Following the spatial patterns on the leaves through time, we saw that these changed from being mostly random on young leaves to more organised on older leaves, indicating a shift from random processes (chance arrival) to more deterministic processes, for example competition."*

By following community dynamics on a highly replicated set of miniature habitat patches, EPIDYN is expected to add not only to understanding of epiphyll communities, but more generally to community ecology of sessile organisms. "We are still far from fully understanding the functioning of epiphyll communities, but it is important that they are not overlooked or forgotten when thinking about biodiversity and ecosystem functions," Bader concludes.

### EPIDYN

- Coordinated by Philipps-University Marburg in Germany
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/708585
- Project website: bryo64.wixsite.com/epidyn

CLIMATE CHANGE AND ENVIRONMENT

# Moss study evaluates climate change impact on Arctic ecosystems

*The role that mosses play in Arctic ecosystems – and how climate warming is affecting them – could help scientists to better understand how this fragile and critically important region is responding to climate change.*

High-latitude ecosystems, such as the boreal forests in northern Sweden and the tundra above the Arctic circle, are some of the regions to be hardest hit by climate change.

This is in part because sea ice and snow cover, which reflect sunlight back into the atmosphere, are melting. As this happens, the darker surface underneath absorbs more of the sun's energy and turns it into heat.

"Life in the Arctic is characterised by low temperatures," explains MYCOMOSS (Mosses as a gateway of nitrogen into northern ecosystems) project coordinator Anders

© MYCOMOSS, Signe Lett

Michelsen, professor in terrestrial ecology at the University of Copenhagen, Denmark. "This limits the rate of biological processes such as photosynthesis and bacterial activity. Basically, everything goes slower at lower temperatures."

These processes also include nutrient recycling, which takes place when microorganisms decompose dead organic material. One of these nutrients, nitrogen, is essential to life, as it is a building block for all proteins.

The long-term impact of climate warming on this process remains unclear. Understanding this was one of the driving factors behind the MYCOMOSS project.

## MEASURING NITROGEN FIXATION

MYCOMOSS, which was undertaken with the support of the Marie Skłodowska-Curie Actions programme, focused on the role of different moss species in the nitrogen cycle.

"Anyone who visits the Arctic can see that mosses are a dominant feature of the sparse vegetation," says Signe Lett, the postdoctoral scientist working on the project. "We know they import nitrogen via associated bacteria, but we still don't fully understand the ecological importance."

The project set about measuring nitrogen fixation (the process by which nitrogen in the air is converted into related nitrogenous compounds) in three dominant moss species across the tundra, exposed to different climates. Moss growth, moss nitrogen content and nitrogen leaching from the mosses were also measured.

The project used DNA methods to map fungal species present in mosses, and to assess whether fungi play a role in taking up moss nitrogen and passing this on to plants.

> *"This project has shown that the interactions between tundra organisms are complex."*

"What we found was that the nitrogen fixation rates in mosses differ across the growing season," adds Lett. "Their responses to warming and precipitation also vary according to the species. We also discovered that increased nitrogen fixation did not lead to higher nitrogen concentration in the moss, or higher leaching of nitrogen from the mosses."

## UNDERSTANDING FRAGILE ECOSYSTEMS

The project team is still in the process of extracting the latest data from the study. "We expect to be able to demonstrate that moss responses are key to understanding Arctic ecosystem responses to climate change," notes Michelsen.

"The question of whether vascular plants can access nitrogen from mosses through their fungal partners though is still unresolved. If we find evidence that this is the case, this study will importantly have identified mechanisms by which mosses may facilitate vascular plant growth."

In any case, the project has helped to shine a light on the tundra biome, a critical component for the world's climate. Large amounts of carbon are stored in dead organic material as permafrost.

The decomposition of organic material is impeded by low temperature and nitrogen availability. Understanding the link between the carbon and nitrogen cycles is essential if we are to make precise predictions about future releases of carbon from the tundra biome.

"This project has shown that the interactions between tundra organisms are complex," Lett and Michelsen agree. "The organisms in these ecosystems are tightly interwoven. If one parameter is changed, the whole system reacts."

### MYCOMOSS

- Coordinated by the University of Copenhagen in Denmark
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/797446
- Project website: signelett.weebly.com/myco.html

SPECIAL FEATURE

# DATA PROTECTION: NEW TECHNOLOGIES TO PROTECT PRIVACY

## Editorial

## Where Europe is truly leading the world

From our TV and film streaming accounts to our banking details, from online shops to our digital magazine subscriptions, it is now extremely common for people to constantly give away their private data to receive a steady stream of goods and services. And it doesn't just stop at consumerism. With the increasing digitisation of government and corporate services, many of our most intimate and private personal details have found their way into the online realm. Of course, social media and other tech giants are also likely to hold vast amounts of information on our lives, beliefs, professions, personal histories and spending habits. In today's ever-growing and expanding digital economy, personal data has become as valuable a commodity as cold hard cash.

So why do people so easily give away their personal data? For one thing, convenience. Enter your bank details and that shiny new thing you've been coveting will arrive by tomorrow evening, without having to even leave the house, even before COVID-19 confined so many of us. All of your medical records in one easily accessible online space? Excellent, no need to chase up doctors or seek out a specific hospital document from a mountain of possibly unorganised papers. And in 2020, where billions of us have retreated further into the online realm to find some escapism from the pandemic reaping its way across the physical world, even more individuals have parted with their personal data as a result who may not otherwise have done so.

Due to the data boom over the last two and a half decades and with such staggering amounts of personal individual data now sloshing its way around the world every day, from jurisdiction to jurisdiction and with the very real possibility of such data falling into the wrong hands or being used in ways that are not communicated to the individuals concerned, Europe takes data protection extremely seriously. In fact, it has become a world leader in the efforts to protect individuals' personal data. Its shining achievement amongst a number of recent online privacy-related legislative acts is without a doubt the General Data Protection Regulation (GDPR), passed in 2016 and fully applicable since May 2018. Years in the making and the source of a lot of, at times heated, political debate across Europe, it aimed to modernise the EU's data protection laws that had last been updated in the 1990s, at the very dawn of the Digital Age, and thus were thoroughly outdated and in need of an overhaul by the beginning of the 2010s.

Since the GDPR's passing into law, all companies across the EU have to follow the exact same rulebook when it comes to the processing and storing of personal data, resulting in strong protections for individuals, who have also been empowered by gaining more control over their data. Businesses, whether based in Lisbon, Vilnius or Nicosia, all have a level playing field to compete with each other.

EU-funded research has also had a key role to play in the EU's data protection regime, where projects have been hard at work supporting EU and national efforts to communicate widely on the changes and help support individuals and businesses adapt to the GDPR. The seven projects starring in this issue's special feature have been at the forefront of data protection research, with a key focus of more than one of them being the development of accessible tools that will help businesses and organisations ensure they not only fully understand their obligations but are complying with the rules of the GDPR. Others have looked at innovative methods to make sure fast-evolving new digital technologies, such as the cloud, are 'GDPR-compatible'. Overall, the results highlighted in this issue will no doubt contribute towards Europe's continued importance and leadership in the ongoing global debate on data protection.

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

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SPECIAL FEATURE

**DATA PROTECTION: NEW TECHNOLOGIES TO PROTECT PRIVACY**



# A helping hand for microenterprises grappling with the GDPR

*Many microenterprises in Europe seem to be missing the GDPR compliance train, with potentially disastrous consequences for their future. The SMOOTH project has developed an easy-to-use and affordable solution that will help them assess and improve their methods of gathering and storing customer data.*

Dealing with the constraints brought by the GDPR is already difficult enough for SMEs, but what of their smallest-sized members, microenterprises? For these actors responsible respectively for 30% and 21% of employment and value added in the EU, getting in line can easily seem insurmountable. Lack of expertise and limited resources make them particularly vulnerable to the consequences of non-compliance, which is precisely what the SMOOTH (GDPR Compliance Cloud Platform for Micro Enterprises) project set out to help them avoid.

Rosa Araujo, project manager at Eurecat and SMOOTH coordinator, depicts a bleak picture for the sector. "The fact that the GDPR applies to all types of companies, regardless of their size, is particularly problematic for microenterprises. Despite all their value and potential, they are often unaware of how the GDPR affects their business and can hardly afford professional guidance."

Araujo knows this for a fact. A survey conducted with 100 microenterprises at the beginning of the project showed that only 18% of respondents made use of informed consent forms when collecting personal data. As many as 76% of them do not know whether they collect the so-called 'special categories' of data – which encompass the likes of race and ethnic origin, political opinions, health data and philosophical beliefs. Even more alarming is the fact that only 35% of companies could attest to the fact that they applied basic security measures. The real problem is, most local hairdressers, florists and mechanics have no digital background or legal knowledge related to the GDPR.

So how do we solve that problem? "We have devised the SMOOTH platform to help those businesses," Araujo says. "It's an easy-to-use and inexpensive GDPR compliance

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assessment platform that provides guidance and recommendations to any sector of activity."

## CONTINUOUS IMPROVEMENTS

The SMOOTH solution consists of three tools based on state-of-the art research and technologies. SMOOTEXT analyses text documents related to the protection of personal data (cookie and privacy policy, informed consent form, etc.). SMOODATA automatically analyses businesses' databases to identify the presence of personal data, the nature of this data and its compliance with the data minimisation principle. Finally, SMONLINE monitors data collection from cookies by third parties in websites and mobile apps, as well as detects the evidence of ad targeting. All results are collected in a compliance report and delivered to the user in a PDF document.

"Our ambition is to create an ecosystem that will become the reference solution in Europe in helping microenterprises comply with the GDPR. As it evolves, the platform may incorporate other modules created by SMOOTH partners or third parties that expand its functionalities. These could include, for example, country-specific requirements, modules for larger companies or specific industries, or additional legal frameworks. The ecosystem created would move towards an overall solution covering all aspects of GDPR compliance," Araujo explains.

The SMOOTH platform is useful for National Data Protection Authorities, too. By using it, they can help their SMEs and other businesses to become GDPR-compliant, get statistical data about which type of enterprises are less compliant, and focus their efforts to help these types of companies.

*"Our ambition is to create an ecosystem that will become the reference solution in Europe in helping microenterprises comply with the GDPR."*

Beyond the platform, SMOOTH also developed a handbook and is actively promoting standardisation through a CEN Workshop Agreement (CWA). While the GDPR handbook provides guidance, examples, videos and links to external resources, the CWA will provide guidelines on key GDPR elements and principles to be taken into account, legal requirements, technical and organisational measures, and exemptions for low-risk processing.

Due for completion in January 2021, SMOOTH is now focusing on completing its second pilot of real-life scenarios with 60 companies providing feedback on the platform. This feedback will enable further improvements which Araujo hopes will help attract 500 microenterprises by the end of the year.

### SMOOTH

- Coordinated by Eurecat in Spain
- Funded under H2020-SECURITY
- cordis.europa.eu/project/id/786741
- Project website: smoothplatform.eu

# Engineers get a helping hand with GDPR compliance tools

*The EU-funded PDP4E project has taken an engineer's standpoint to the challenges generated by GDPR compliance. The tools it develops will help devise products, systems and services that protect the rights of EU citizens.*

The GDPR has had an impact on everyone, from service users to providers and even software engineers. For the latter, however, privacy engineering is a rather new concept that could easily be considered as abstract or of secondary importance. But that would be a mistake. From smart grids to big data, connected vehicles and banking, privacy engineering can never be discarded.

"Engineers need four types of tools," says Antonio Kung, co-founder of Trialog and coordinator of the PDP4E (Methods and tools for GDPR compliance through Privacy and Data Protection Engineering) project. "The first type focuses on privacy risk management, which helps engineers identify, assess and deal with privacy risks from a technical perspective. The second relates to the elicitation of privacy-related requirements, which would help engineers turn privacy constraints into tangible requirements. But that's not all. They also need a privacy and data protection by design (PDPbD) framework, as well as an assurance case ensuring that design decisions taken to ensure privacy and mitigate associated risks can be audited and assessed for GDPR compliance."

PDP4E provides these four tools with one goal in mind: enabling the widespread creation of products, systems and services that better protect the privacy and personal data of EU citizens. To do so, it leverages model-based engineering.

"The project leverages models – or processable representations of systems. These models have been developed by privacy experts and can therefore be reused by engineers," Kung explains.

Concretely, the project team has been working hard to integrate privacy by design and data protection with existent, mainstream software and system engineering methods. And for those tools that do not exist or are being developed, they provide open-source software that will guide a more privacy-aware development process.

"We assume the existence of two open communities for our ecosystem: an open model community for privacy, and an open source community for privacy engineering tools (within the Eclipse open source community). The open model community can share both privacy protection and privacy engineering models."

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## FROM CONNECTED VEHICLES TO SMART GRIDS

The solutions are being tested in the two innovative fields of connected vehicles and big data for smart grids. For engineers eyeing cooperation between autonomous vehicles, the compromises it entails for the privacy of drivers cannot be ignored. The purpose of PDP4E in this case will be to demonstrate how such compromises can be dealt with from a privacy by design perspective. Meanwhile, the case of big data in smart grids poses critical challenges in terms of privacy and data protection which the project is aiming to assess.

"A major problem in connected vehicles relates to location data, while data sharing in smart grids raises concerns related to de-identification (the algorithms needed to prevent smart metering from exposing users' life patterns and devices in use). At the end of the day, both use cases involve complex ecosystems involving multiple organisations. This shows that privacy protection models must also include organisational models," Kung notes.

> *A major problem in connected vehicles relates to location data, while data sharing in smart grids raises concerns related to de-identification.*

By the time the project ends, Kung and the PDP4E project partners hope to help nurture the privacy engineering community, and even foster the creation of an Alliance for Privacy and Data Protection Engineering. Their contribution to standardisation activities – notably their involvement in the development of the ISO 31700 standard (privacy by design for consumer goods and services) – certainly makes them well equipped to do so.

### PDP4E

- Coordinated by Trialog in France
- Funded under H2020-SECURITY
- cordis.europa.eu/project/id/787034
- Project website: pdp4e-project.eu

# Putting data privacy back into citizens' hands

*How do we finally give EU citizens back control of their own data? The answer could lie in a novel Privacy-Enhanced Dashboard developed under the EU-funded PoSeID-on project.*

The GDPR is a great step forward for data privacy, but it still leaves users with little means to monitor and control how exactly their data is being used. The PoSeID-on (Protection and control of Secured Information by means of a privacy enhanced Dashboard) project team aimed to fill the gap with what they call a "Privacy-Enhanced Dashboard". With this platform, consumers can retake control over their own data, and decide how much they want to share and with whom.

Francesco Paolo Schiavo, General Director at the Italian Ministry of Economy and Finance and coordinator of the project, accepted our invitation to answer a few questions about the new dashboard and its potential benefits for European citizens and e-service providers alike.

## Why do people need a Privacy-Enhanced Dashboard such as the one you propose?

**Francesco Paolo Schiavo:** The Privacy-Enhanced Dashboard is meant to protect personal data. It's an integrated and comprehensive solution safeguarding the rights of data subjects.

As they use the Privacy-Enhanced Dashboard, people will be granted concise, transparent, intelligible and easy access to their personal data. They will know how the latter is being tracked, control and manage their personally identifiable information (PII) processed by public and private organisations, and very much act as data controllers and/or providers.

It's all about making conscious decisions about who can process your own data: you can enable, restrict or revoke permissions in accordance with the data minimisation principle, as well as be alerted in case of privacy exposure.

## What would you say makes this solution particularly innovative?

The Privacy-Enhanced Dashboard integrates the cutting-edge technologies needed to ensure accountability and GDPR compliance as far as data processing and exchange is concerned.

One key innovation is the securitisation of our open architecture, by means of permissioned blockchain and smart contracts. This provides accountability, transparency and compliance with data protection law. Concretely, the dashboard traces all transactions. It registers user consent and grants a contextual guarantee of data erasure and reduction in identity traceability, all thanks to the mechanism of 'burnable pseudo-identities'.

Another innovation is the integration of state-of-the-art technologies within the Privacy-Enhanced Dashboard. These include cloud, access management according to eIDAS (electronic IDentification, Authentication and trust Services – the EU regulation on electronic identification and trust services for electronic transactions in the internal market) and privacy management with machine learning analysis.

**Francesco Paolo Schiavo**
PoSeID-on project coordinator
© Francesco Paolo Schiavo

*"The dashboard traces all transactions. It registers user consent and grants a contextual guarantee of data erasure and reduction in identity traceability, all thanks to the mechanism of 'burnable pseudo-identities.'"*

To reduce fraud, a Risk Management Module analyses data requests and sends warnings about likely fraudulent use. We also have a Personal Data Analyzer that monitors privacy risk using NLP to validate communication and messages.

All these features enable the Privacy-Enhanced Dashboard to offer most of the latest innovative ICT technologies in a box. Moreover, the Privacy-Enhanced Dashboard is user-friendly. It can even be used by organisations wanting to integrate their procedures within a GDPR-compliant tool.

## How do you ensure that this tool can counter the wide variety of data tracking methods currently used online?

There are three main aspects to consider here. First, the Privacy-Enhanced Dashboard is an integrated prototype that enables users to dictate how their personal data is shared with public and private organisations. The procedure is easy and accessible to all users.

Then, we use source components. This means that we can potentially integrate the dashboard with any public or private ICT architecture. Each single component or toolkit is made available individually so that EU organisations can integrate it within their own systems. This option can potentially guarantee high technological development and competitiveness, and the creation of new business opportunities within the EU market.

Finally, the Privacy-Enhanced Dashboard is also a cloud-based service (PEDaaS). Organisations without their own blockchain and/or cloud or that can't afford the cost of managing GDPR-compliant tools can use it too. In such a scenario, they simply access the PoSeID-on cloud service and use the Privacy-Enhanced Dashboard to monitor and control data processing.

## How does the tool work exactly?

Users' web dashboard is composed of PII processing information and services management: the first part


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shows PII tracking, while the second one is used for permissions management. You can access it by using your electronic IDentification (eID) accounts, which reduces the risk of identity theft and protects your privacy.

From the web dashboard, you can immediately see a risk score indicating your level of privacy exposure. The dashboard will also show evaluation results from several algorithms gauging how risky it is to allow third parties to see your personal data. There is a risk score for each service, and one for all data.

## What are the project's most important outcomes so far?

We have successfully developed the Privacy-Enhanced Dashboard, implemented four different use cases and integrated the Privacy-Enhanced Dashboard with other systems. The system is also fully compliant with the GDPR of technological e-services, including e-administration.

We are now proud to have a solution that empowers individuals with the control of their personal data, increases their confidence in e-services and provides new methods to facilitate the deployment of such services.

## What do you still need to achieve?

We are finalising our four use cases and proceeding with the full integration of the Privacy-Enhanced Dashboard. Final implementation is expected in December 2020.

### POSEID-ON

- Coordinated by the Ministry of Economy and Finance in Italy
- Funded under H2020-SECURITY
- cordis.europa.eu/project/id/786713
- Project website: poseidon-h2020.eu
- bit.ly/2JcRKgx

# New data analytics platform eases privacy concerns for owners

*Businesses in the digital era increasingly rely on data analytics for growth and survival. But does it necessarily mean that we have to sacrifice our privacy? Not necessarily. The EU-funded PAPAYA project has developed a new platform that promises to reinstate trust between data owners and third-party data processors.*

Data breaches have made consumers increasingly wary of personal data safety on cloud servers. With the General Data Protection Regulation (GDPR) now in place, the PAPAYA (PlAtform for PrivAcY preserving data Analytics) project aims to strike a delicate balance between privacy and valuable data analytics. Its technology is being tested in five real use cases, ranging from heart arrhythmia detection to mobile phone usage analytics.

Melek Önen, associate professor at EURECOM's Digital Security Department and PAPAYA coordinator, discusses the project's ambitions and achievements so far.

## What gaps in data privacy do you aim to close with this project?

**Melek Önen:** The PAPAYA project aims at addressing data privacy concerns arising when data analytics are outsourced to powerful but untrusted cloud servers.

Data analytics can help stakeholders leverage collected data to derive relevant information and make better decisions. For example, a healthcare agency can use data analytics to predict or detect the risk of pandemics. Data analytics can also help marketing or commercial companies in their decision-making. But there is a key issue. Despite all their value for the entities collecting them, data sets also contain highly sensitive information on the individuals from whom the data is collected. Data confidentiality and data subjects' privacy really are in jeopardy.

By adopting a privacy-by-design approach, our project aims to devise and develop a platform of privacy-preserving modules that protects the privacy of users on an end-to-end basis without sacrificing data analytics functionalities.

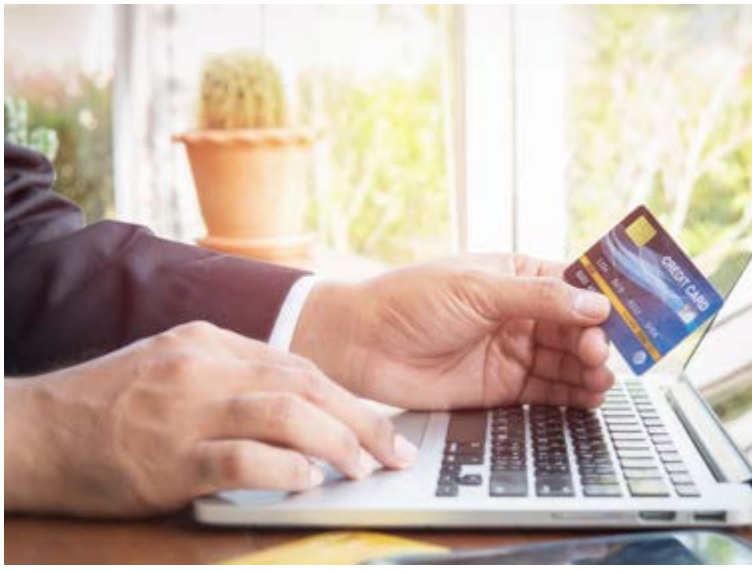
## How do you explain the current lack of prior measures aiming to strike such balance?

Society is facing ever-increasing data breaches causing serious damage. Many individuals have lost confidence in organisations' data security solutions and are more and more concerned about the safety of their personal information.

The European General Data Protection Regulation (GDPR) can reverse this trend, but it also means that companies are now looking for secure data handling practices. There is, now more than ever, a need for privacy-preserving data analytics that enable companies to operate on protected data, ensure their clients' privacy and keep the said data meaningful and useful.

The usual data protection techniques (namely, standard encryption techniques such as AES) are unfortunately not suitable for this new context as they prevent third-party servers from operating over the encrypted data. Data owners would rather need to first download the encrypted data, decrypt it and execute operations on the cleartext data. This is not possible when the data owner does not have the computational resources to perform operations on such a high volume of data, or when the algorithm to be executed is owned by the third-party server. One solution would be to provide the third-party server with the key to decrypt the data, but then confidentiality could not be ensured any more.





**Melek Önen,**
PAPAYA project coordinator
© Melek Önen

*Many individuals have lost confidence in organisations' data security solutions and are more and more concerned about the safety of their personal information.*

## How does your approach help overcome all of these problems?

PAPAYA develops privacy-enhancing technologies enabling protected data analytics. These analytics range from simple statistical operations to more sophisticated machine learning techniques such as neural networks. They provide significant protections to stakeholders whose data is being processed, while giving data holders/data controllers utility.

Our solution is in line with data protection by design required under the GDPR. Besides, the project also develops specific tools easing legal compliance with the GDPR and related privacy and data protection legislation for organisations using privacy-preserving analytics. The tools focus on the rights of people whose personal data is being processed – referred to as 'data subjects' in the GDPR.

## How does your platform work exactly?

The PAPAYA framework revolves around two main groups of components. First, the platform-side components that will be running on the non-trusted cloud server. Then, the client-side components that will be running on a trusted client environment (such as a smartphone).

The platform regroups privacy-preserving analytics modules for the following operations: neural network classification, collaborative neural network training, trajectory clustering, and basic statistics. On a high level, platform clients – namely stakeholders – send their queries to perform the requested analytics in a privacy-preserving manner and receive the corresponding output without leaking any privacy-sensitive information.

The framework also includes a data subject toolbox. It provides versatile tools for data protection by design by platform clients towards data subjects whose personal data is processed in their services. For example, data subjects can receive more information on the underlying privacy-preserving analytics service or on the disclosure of their data.

## Could you provide some concrete examples of use cases?

PAPAYA defines five use cases, each of them targeting different settings. One use case targeting healthcare applications (led by MediaClinics Italia, an Italian SME) consists of heart arrhythmia detection in a privacy-preserving manner. Under this use case, sensitive health data in the form of electrocardiograms (ECGs) is collected from a patient. The PAPAYA platform detects arrhythmia by using neural networks, without having access to these ECGs.

Another use case targeting telecom operators (led by Orange, the French telecommunications company) helps stakeholders extract mobility patterns using some trajectory clustering algorithms, all this without identifying each individual trajectory.

## What would you say are the project's most important achievements so far?

The project has developed privacy-preserving variants of a group of four analytics, namely neural networks (classification, collaborative training), trajectory clustering, counting and basic statistics. These modules use different advanced cryptographic tools such as homomorphic encryption, differential privacy or functional encryption.

Additionally, various user interfaces (UIs) have been developed to enhance transparency for data subjects and other stakeholders. These include an extension of the CNIL's Privacy Impact Assessment (PIA) tool, which helps PAPAYA stakeholders assess the impact of privacy-preserving analytics on privacy and security goals.

The tool is also much more transparent for data subjects. Our UIs explain how PAPAYA privacy-preserving analytics work, and our privacy engine tool takes data subjects' privacy preferences and rights into account.

## What do you still need to achieve?

The project is now in its validation phase. Our goal is to set up prototypes demonstrating the five use cases, as well as produce a platform guide that would help users easily operate the platform.

### PAPAYA

- Coordinated by EURECOM in France
- Funded under H2020-SECURITY
- cordis.europa.eu/project/id/786767
- Project website: papaya-project.eu

# New tools enable data sharing in good conscience

*Our most private and sensitive information will never entirely be safe unless we get the means to make appropriate data sharing decisions. The Privacy.Us project not only provides such tools, it built them based on extensive, unprecedented behavioural research.*

Data breaches and leaks of private information have made us increasingly wary of websites and cloud platforms asking too many questions. Sure, SSL certificates, incognito windows and the GDPR have somewhat eased these concerns. But does this mean we're finally using the internet as we should? The Privacy.Us (Privacy and Usability) project, undertaken with the support of the Marie Skłodowska-Curie programme, investigated common behaviours and developed new tools to make the web safer for us all.

As Leonardo Martucci, associate professor of Computer Science at Karlstad University and coordinator of Privacy.Us, explains: "The greatest threat to individual data owners remains the unintended/unexpected use or disclosure of their personal data. The GDPR was certainly a step in the right direction, and so is the increased public awareness resulting from reports of personal data breaches in newspapers. But even today, individuals continue to share their personal data inadequately."

To find out why this happens, Martucci and his team investigated our attitude and behaviour as we make privacy-related decisions online. They investigated how visual cues and graphical representations influence decisions to share or not to share personal data, as well as how the choice of not sharing may negatively influence how others perceive us.



## HOW WE SEE AND HOW WE ARE SEEN

"The results of our experiments on users' emotional state, visual cues and graphical representations of privacy policies show that individuals can be nudged towards deciding to share or not to share their data depending on how requests are displayed. This is important because it demonstrates that it is possible to influence user decisions," Martucci adds.

Such results also reinforce the idea that privacy-related decision-making is neither purely rational, nor purely irrational. There are actually many factors influencing such decisions. Some of them relate directly to our personality, while others – such as the context of the interaction – are purely extrinsic. Once developers and designers know exactly which factors are at play, they can develop usable security and privacy tools with user-centred designs.

This is precisely what the Privacy.Us team did, as they looked into very specific cases to identify measures making users more aware of their data privacy. In one instance, they took the case of gay men engaging on dating applications. Are they willing to disclose their HIV status? How does disclosing (or not disclosing) this highly sensitive information affect the perception of other platform users? Once the team found out, they proposed a number of design considerations mitigating user stigmatisation based on their choice.

Another issue the project focused on is NFC payment. "We have redesigned the NFC payment experience to improve its usability, security and privacy. The end result is an improved screen design and sensory feedback for NFC payment terminals. Besides, we looked into personal data leaks in mobile applications and studied the positive

impact of the GDPR on reducing the number of personal data leaks," Martucci notes.

A third, very contemporary example that the team touches upon is the overall lack of privacy-related graphical interfaces in IoT devices. "We suggest the use of nutrition-like privacy labels to be printed on the package of those devices, so that users can easily compare IoT devices and decide beforehand on conditions for sharing their personal data. These are similar to the labels that will be adopted by Apple's App Store starting in December 2020," says Martucci.

No matter the application, the Privacy.Us mathematical models can represent the interactive and reinforcing factors involved as users decide to share or not to share personal data. The project's security and privacy tools, its legal analysis on unfair data practices, and the proposed legal measures to preserve the privacy autonomy of individual users are all bound to help design better IT tools and applications that we can all use collectedly.

*"We suggest the use of nutrition-like privacy labels to be printed on the package of those devices, so that users can easily compare IoT devices and decide beforehand on conditions for sharing their personal data."*

### PRIVACY.US

- Coordinated by Karlstad University in Sweden
- Funded under H2020-MSCA-ITN
- cordis.europa.eu/project/id/675730
- Project website: privacyus.eu

# GDPR compliance automation for SMEs

*To comply with the General Data Protection Regulation, SMEs need all the help they can get. The EU-funded BPR4GDPR project has been playing its part with new tools and methodologies. These allow interested companies to automate the adoption of new measures while addressing key issues related to data privacy at any time.*

What do services dealing with health and social security data, a car dealership's customer relations and real estate agencies using cloud services have in common? Since May 2018, that would be the General Data Protection Regulation (GDPR). Or, perhaps more precisely, the extra burden coming with the creation of GDPR-compliant business processes.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The problem is well-documented, yet not fully addressed. Reaching GDPR compliance is far from easy, especially for SMEs with limited resources and know-how. Every day, such businesses face questions related to the interpretation of GDPR provisions and requirements, operational adaptation, and the appropriate technical measures to be deployed. Likewise, the relation with data subjects, the enforcement of their rights, the question of accountability and the management of compliance evidence have never been so sensitive.

This is the context in which the BPR4GDPR (Business Process Re-engineering and functional toolkit for GDPR compliance) tools were conceived. "We've come up with the first-ever range of tools that can consider most aspects of GDPR compliance across all phases of a business process life cycle," says Spiros Alexakis, member of the Board at CAS Software and BPR4GDPR coordinator. "These tools can automatically adapt and transform processes so as to make them compliant with privacy policies, both at design time and following execution."

BPR4GDPR essentially takes on the bulk of the GDPR-related stress endured by company staff, no matter

> *These tools can automatically adapt and transform processes so as to make them compliant with privacy policies, both at design time and following execution.*

how far they are with implementation. At design time, the project tools and solutions will help businesses understand when predefined behaviours and rules are not compliant and how to adapt. At runtime, they will provide solutions to support or enforce privacy policies. Finally, a posteriori, they will help investigate and analyse non-compliance circumstances.

## MULTIPLE OPPORTUNITIES

The project has four main outcomes, as Alexakis notes. "We first have the compliance ontology, a comprehensive privacy-aware access and usage control framework that regulates the overall system operation. Then, we have a privacy-aware re-engineering of business processes that automatically makes process models compliant with the GDPR. The third outcome is a framework to identify compliance discrepancies, and the fourth one is a runtime 'compliance toolkit'. It provides typical functionalities needed to implement GDPR measures such as encryption, anonymisation and data management tools; and it enforces the rights of data subjects."

The project team trialled its solutions in three pilots focusing respectively on sensitive data in the health and social security sectors, compliance-as-a-service for CRM services in car dealerships, and real estate agencies using cloud services.

"The three pilots, apart from common core needs, reflect different compliance requirements. The first round has provided us with valuable feedback in terms of functionality, performance and usability, which was then exploited during the second implementation phase. We are currently conducting the final round, which aims to thoroughly test the solutions, perform the necessary fine-tuning, and pave the way for the exploitation of results beyond the project lifetime," George Lioudakis, co-founder of ICT Abovo and BPR4GDPR policy framework leader, explains.

Renata Medeiros de Carvalho, assistant professor at Eindhoven University of Technology in charge of BPR4GDPR's scientific coordination and dissemination, is particularly optimistic about outcomes for partners. "We all have different expectations. Large software industries expect to increase their revenues either by offering compliance-as-a-service or by embedding compliance into their products. Meanwhile, technology and consulting SMEs expect a flexible and cost-efficient means to inject compliance into their offerings. Participating law firms benefit from a new consultancy tool for legislation codification, compliance assessment and implementation. Finally, the pilot organisations are now reconsidering their approach to compliance."

With a few months to go before completion, Alexakis says the project team will now focus on impact creation. This covers the dissemination of project results, interaction with stakeholders and commercial/non-commercial exploitation of project results.

### BPR4GDPR

- Coordinated by CAS Software in Germany
- Funded under H2020-SECURITY
- cordis.europa.eu/project/id/787149
- Project website: bpr4gdpr.eu

# Evolving cloud services get better, future-proof data protection

*The digital era is shaping up as one of cloud services dominance. With the GDPR now in force, experts have had no choice but to look into stronger and more flexible means to ensure the compliance of these services with privacy rules even as they continue to evolve.*

Privacy and security by design is at the very heart of the GDPR. On paper, it's a strong stance: It calls for businesses and organisations storing user data to integrate GDPR principles into new IT projects from the earliest stages of their conception. But the exponential growth of decentralised cloud services, with their constant morphing and evolution, could quickly sweep privacy by design into the dustbin of oblivion.

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Eliot Salant, project manager at IBM Haifa Research labs, has been aiming to provide a viable workaround under the RESTASSURED (Secure Data Processing in the Cloud) project. "Providing data protection and compliance with digital privacy regulations in a cloud environment is a challenging task. The public cloud is inherently untrusted, has a wide geographic distribution, and has a multi-stakeholder system where the data belongs neither to the cloud service provider nor to the stakeholder who orchestrates the computation. On top of that, we also have the highly dynamic changes in cloud services and infrastructures."

So how do we move on? "With mechanisms and cloud components for the runtime detection, prediction and prevention of data protection violations, as well as new techniques to secure data-at-rest in a cloud environment," Salant says.

## FIVE KEY INNOVATIONS

RESTASSURED aimed to help data controllers – that is, the entities legally responsible for determining the reasons for processing and how to process personal data while ensuring compliance with data protection. To do so, it focused on five key innovations. The first is the use of emerging hardware solutions such as AMD SEV and Intel SGX to provide secure enclaves for data operation. The second is the development of encryption for parquet files, which allow for highly efficient storage and querying of data for big data analytics. Additionally, the team focused on: means to assess data protection compliance in the running system; automated risk management; and the implementation of sticky policies to define data access, usage and storage rules.

"This is all very important," Salant notes. "The use of sticky policies for instance will help create Policy Decision Points (PDPs) and Policy Enforcement Points (PEPs) to regulate the flow of data across applications in the cloud. Meanwhile, the strong data protection offered by both the use of Parquet Modular Encryption (PME) and secure hardware enclaves can help provide a protected, regulated flow of data across EU-based cloud environments."

*"The social care use case was based on an actual product offering from a project partner, Oxford Computer Consultants (OCC). We wanted to see how this product, which focuses on both volunteers providing aid and those requesting it, could be migrated to the cloud."*

According to Salant, the PME is easily the most important achievement from the project. It has been officially accepted as a standard by the Apache Parquet community and made its way into a number of IBM products.

## REAL-LIFE TEST CASES

RESTASSURED solutions were extensively tested in the fields of social care and Pay as You Drive insurance. "The social care use case was based on an actual product offering from a project partner, Oxford Computer Consultants (OCC). We wanted to see how this product, which focuses on both volunteers providing aid and those requesting it, could be migrated to the cloud," explains Salant. "The distinct roles required strict role-based access enforcement for data. Meanwhile, the automated risk management developed in RESTASSURED was of great interest to OCC, both to analyse their current product and to find out the implications of bringing this product to a cloud environment."

The Pay as You Drive insurance, on the other hand, dealt with automobile telematics. The IoT personal data is captured on-premise and then transferred to the cloud, which implies GDPR restrictions on its processing, as well as restrictions on the data itself as the transmitting vehicle crosses national borders.

The project ended in December 2019, but development has continued ever since. Work on the PME is being continued under a number of other H2020 projects, while several RESTASSURED partners have since proposed a follow-on project called FogProtect (Protecting Sensitive Data in the Computing Continuum). FogProtect is scheduled to run through to the end of 2022.

### RESTASSURED

- Coordinated by IBM in Israel
- Funded under H2020-LEIT-ICT
- cordis.europa.eu/project/id/731678
- Project website: restassuredh2020.eu
- bit.ly/39hfmLQ

FOOD AND NATURAL RESOURCES

# Novel sensors monitor environmental threats to bees

*Bee populations are crashing, and we need to figure out why. Two new environmental sensors help fill in the knowledge gaps.*

Bees are in trouble. Since the early 1990s, Europe has seen an average population decline of 17-20 % per year, sometimes substantially more in certain areas. Today, about 10 % of Europe's 2 000 bee species are endangered. Since three quarters of crop plants depend on bee pollination, the decline in bee numbers threatens food production.

The decline is most serious in countries with industrialised agriculture, suggesting possible causes. A combination of invasive species, habitat loss and use of insecticides explains most of the losses. Thus, the EU banned outdoor use of the neonicotinoid family of insecticides, and established the 'EU Pollinators Initiative'. Nevertheless, much remains unknown.

## IN-HIVE AND FIELD SENSORS

Although commercial environmental sensors for monitoring beehives are available, they come with several key deficiencies. Therefore, the EU-funded IoBee (Beehive health IoT application to fight Honey Bee Colony Mortality) project developed two superior sensors. One is placed in beehives, the other in nearby fields. Together, the sensors monitor environmental changes and provide early warnings of any threat. Project researchers also developed a wireless sensor network and supporting applications.

The beehive sensor is installed at the hive entrance, and counts bees entering and leaving the hive in real time. "The beekeeper can then evaluate the strength of the foraging

© IoBee

> *As insects fly through the sensor field, the sensor automatically identifies their flight pattern and matches it with species in the database. So insects can be efficiently identified without need for trapping and manual counting.*

force, determine mortality rates in the field, and identify deviations in flight duration and nectar availability," explains project coordinator João Encarnação.

The sensor can also identify types of bees and hive pests. One way the sensor does so is via a technique called light extinction, which measures the size of an insect's shadow. The sensor also measures light scattering in various colour bands, identifying species by colouration.

A second optoelectronic sensor counts and identifies insects flying outside the hive. "As insects fly through the sensor field, the sensor automatically identifies their flight pattern and matches it with species in the database. So insects can be efficiently identified without need for trapping and manual counting," adds Encarnação. The sensor also measures pollinator density, which is an important parameter for agricultural production and ecosystem monitoring. No other sensor system can provide this information.

The sensors can be set up with an associated weather and air-quality station. All units send data to a cloud server via a cellular network. The team developed algorithms for automated data processing and software for visual presentation.

## ENVIRONMENTAL ALERTS AND FIELD TRIALS

The collated information can be used to alert authorities to environmental threats or pest outbreaks. This allows much more rapid and effective interventions than would have been possible previously.

Researchers conducted field trials in five European countries, plus the United States. Laboratory and field testing confirmed sensor identifications as being 95 % accurate. This will halve the costs of inspection and surveillance. Public and private customers, and authorities, gave very positive feedback.


Today, **about 10 %** of Europe's 2 000 **bee species are endangered**

The team has taken initial orders to equip 200 beehives, in three European and three other countries. These orders will be filled during autumn 2020. Next, the team plans to equip 5 000 beehives during 2021.

IoBee's new sensors provide better information about the threats affecting bees. This will help improve European environmental standards, and reduce the usage of pesticides.

### IOBEE

- Coordinated by Irideon in Spain
- Funded under H2020-Societal Challenges and H2020-Industrial Leadership
- cordis.europa.eu/project/id/760342
- Project website: io-bee.eu
- bit.ly/2HwZwkM

# Protecting crops by unravelling the mysteries of plant immunity

*Using pesticides to reduce crop losses caused by pests and disease damages the environment and contributes to climate change. An EU initiative explored alternative strategies to protect crops.*

After a first infection, plants respond more effectively to a second pathogen encounter by becoming resistant. This plant immunisation, or priming, involves a certain memory following the first exposure, lasting anywhere from a few days to entire generations.

"Experts consider priming the safest and most effective approach to boosting the endogenous plant immune system," comments Marie Skłodowska-Curie Actions fellow Ana López, who was responsible for the overall coordination of the EU-funded EPILIPIN (Deciphering the role of oxylipins in the epigenetic mechanisms controlling plant immunization) project. "They also agree that priming represents the perfect target for new crop protection strategies because it provides natural long-lasting resistance against pathogens." However, deeper knowledge of the mechanisms involved is needed to apply priming to crop protection. This research was undertaken with the support of the Marie Skłodowska-Curie Actions programme.



## SPECIFIC OXYLIPINS AND RELATED PROTEINS REQUIRED FOR PLANT IMMUNE PRIMING

Plant endogenous oxylipin compounds and epigenetic mechanisms are involved in priming processes. "Their specific contribution and the link between these two pathways haven't been addressed to date," notes López. "In line with EU concerns and priorities, EPILIPIN fills this gap in knowledge by exploring the use of natural compounds – oxylipins – in triggering long-term priming for improving crop yields while minimising agriculture's impact on the environment."

Researchers began by identifying the role of oxylipins in priming. They then positioned the oxylipin signalling upstream of the epigenetic machinery between the pathogen perception and the epigenetic changes mediating priming (memory). According to the findings, mitochondria play a key role in the oxylipin signalling pathway. Mitochondria's main function is to produce the cell's energy by respiration and to modulate cellular metabolism. Results also link the mitochondrial changes as an element in priming processes.

## SUCCESSFULLY APPLYING PRIMING TO CROP PROTECTION

The EPILIPIN team developed a working model in which the signalling triggered by the pathogen recognition and mediated by oxylipins induces mitochondrial changes that affect the deposition of the epigenetic marks underlying the memory of the stress (priming). Team members induced long-lasting resistance against different plant pathogens, including fungus, bacteria and oomycetes, protecting not just the treated tissues but the entire plant, and in some cases even the following generation. "The model doesn't just reinforce the role of oxylipins in priming procedures, it also positions the mitochondria as an interface integrating external signals and coordinating

> *EPILIPIN opens new avenues for the development of alternative, more natural and sustainable agricultural strategies – an EU priority.*

plant responses to environmental changes," explains López. "This could impact different fields, from epigenetics, plant defence and cell biology to ecology and evolution."

López believes the benefits of EPILIPIN are already tangible. "We have unravelled and positioned some of the elements in the signalling cascade between the pathogen recognition and the establishment of stress memory mediated by epigenetic mechanisms and conferring long-lasting plant protection."

"EPILIPIN opens new avenues for the development of alternative, more natural and sustainable agricultural strategies – an EU priority," concludes López. "Outcomes could facilitate the application of epigenetics in plant priming, which could mean a real breakthrough in future integrated pest management programmes that positively impact crop yields."

### EPILIPIN

- Coordinated by the Spanish National Research Council (CSIC) in Spain
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/746136
- Project website: epilipin.wordpress.com

FOOD AND NATURAL RESOURCES

# Better quality fish, longer shelf life thanks to low-cost, animal-friendly ice technology

*In Europe, almost one out of every three fish spoils before reaching our plates, resulting in about 3 million tonnes in losses. An EU initiative introduced technological solutions to improve fresh fish's quality and extend their shelf life.*



The main method for preserving fresh fish uses crushed ice, applied to the fish using the top icing technique along with cold storage at 2 °C. However, fish have a very limited shelf life with this procedure. Ice is an essential commodity in the fish industry because it reduces the growth of spoilage microorganisms and prevents fish surface dehydration. It is also used during fish slaughter and throughout the marketing chain, from storage and transport to shop counters. Every tonne of farmed fish needs 800 kg of ice for slaughter and preservation alone.

During fish slaughter, stress-related substances are released and severely affect flesh quality. With meat, a stunning process is mandatory before slaughter. "However, fish are very rarely subject to any stunning procedure due mainly to difficulties in management or the associated costs of available stunning systems," explains Nicolás López, coordinator of the EU-funded project ICE2LAST (Innovative

technology based on the integration of natural substances in ice to improve animal welfare and extend shelf-life of farmed fish). As a result, fish produced by aquaculture are subjected to long stress periods – up to 50 minutes – prior to death. "The aquaculture sector must improve slaughter methods to reduce animal suffering and needs new conservation methods to increase shelf life," he adds.

## INTEGRATING NATURAL SUBSTANCES INTO ICE

Project partners introduced ice technologies that integrate natural essential oils into crushed ice used for fish stunning, slaughter and preservation. Specifically, they developed two different yet fully complementary types of ice solutions: stunning ice and preserving ice for sea bream, sea bass, trout and salmon.

Thanks to the proven sedative and antimicrobial activity of these essential oils, stunning ice completely stuns fish in under 50 seconds at slaughter, while preserving ice extends shelf life by 50 %. Ultimately, less fish will be thrown away by retailers and consumers. The ICE2LAST team found that when the two innovative ice types are used together, shelf life is longer and the quality is better.

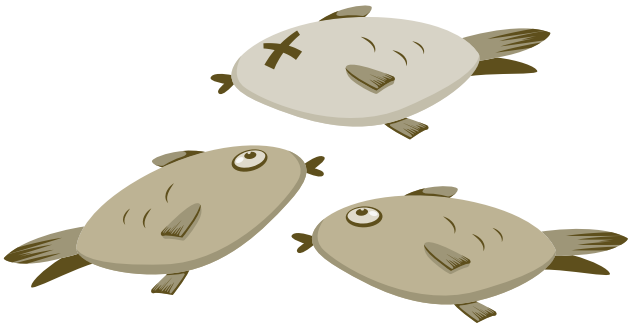
## BUSINESS OPPORTUNITIES AWAIT

Studies conducted by the partners show that market prospects for the aquaculture and retail sectors are great. There are ongoing discussions with Spain's largest food retailer, with more than 1 600 shops and over 25 % of the market share. The preserving ice will lead to a minimal increase in retail cost of 1-2 cents per kilogram of fish, making it an attractive choice for consumers. Following patent approval, commercialisation will focus on Spain, then other EU countries before branching out to Egypt, Tunisia and Turkey. New market segments have also been identified, such as the potential of preserving ice as a solution to increase the shelf life of fresh vegetables such as broccoli.

> *"Cost-effective solutions such as ours have the potential to contribute to aquaculture competitiveness and sustainability by improving the quality of European fish while promoting animal welfare."*

Europe accounts for as much as 25 % of the global fish market. The EU produces 6 million tonnes of fish food, about 20 % originating from aquaculture. To satisfy consumption, the EU imported 8.5 million tonnes of seafood products in 2014. It is expected to increase its domestic production to address the low rate of self-sufficiency in fish consumption, particularly through aquaculture promotion since catches will stagnate to address stock depletion. "Cost-effective solutions such as ours have the potential to contribute to aquaculture competitiveness and sustainability by improving the quality of European fish while promoting animal welfare," concludes López.

Almost **one out of every three fish** spoils before reaching our plates, resulting in about **3 million tonnes in losses**



### ICE2LAST

- Coordinated by CUBIPLAYA in Spain
- Funded under H2020-FOOD and H2020-SME
- cordis.europa.eu/project/id/804493
- Project website: bit.ly/31FZOwy
- bit.ly/35jwMW2

INDUSTRIAL TECHNOLOGIES

# Model-based technologies modernise European manufacturing

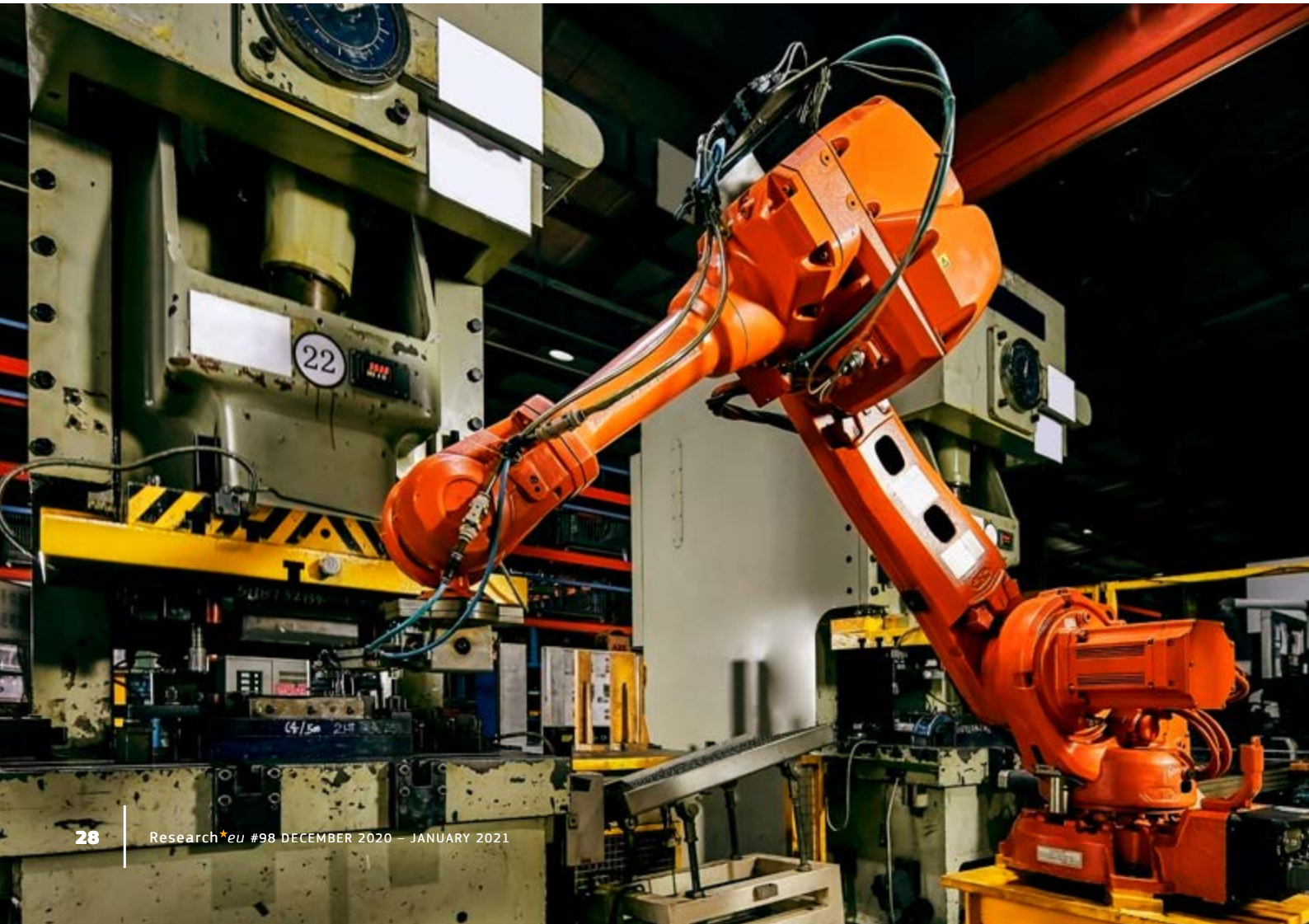
*European manufacturing has to catch up with foreign competitors. To do that, it's incorporating modern engineering methods and tools.*

In recent years, European manufacturing has been facing competition from other regions. This is especially true for the manufacture of electronic components and systems, which are becoming even more complex.

To regain competitiveness, European manufacturing needs to modernise, which means introducing updated engineering practices into its processes. This will translate into improved management of productivity, quality and safety.

## NEW MODEL-BASED TECHNOLOGIES FOR UPSCALING

Industrial manufacturing usually means complex systems and processes, involving multiple teams and serving several product lines at once. Tracing and monitoring, for the purpose of quality control, must be carried out while the processes are running. This is known as runtime. The so-called model-based technologies seamlessly integrate design and runtime aspects. Such technologies have already achieved productivity gains in certain applications.

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Yet, these methods need enhancement before upscaling to real industrial projects could be possible.

The EU-funded project MegaM@Rt2 (MegaModelling at Runtime – scalable model-based framework for continuous development and runtime validation of complex systems) introduces model-based technologies into this manufacturing context. The purpose of MegaM@Rt2 is to help European industry reduce development and maintenance costs. In contrast to the conventional approach of building a system and then testing whether it works, the new methods allow designers to preview and tweak systems during the design phase. MegaM@Rt2 developed a set of tools that aid continuous development and runtime of manufacturing processes.

## SCALABLE TOOLSET FOR MODEL-DRIVEN VERIFICATION

Researchers developed a total of 28 model-driven software tools, intended for real-life industrial projects. Most are distributed as opensource. "The tools are divided into three groups," explains Alba Torrado Gracia, project assistant. "These are holistic system engineering, runtime validation, and traceability and megamodelling." System engineering tools integrate and verify existing industrial practices. Runtime analysis means monitoring, testing and validation of processes while under way. The final set of tools relate design models with runtime models, and allow mapping between the two sets.

Together, the software tools allow feedback from runtime processes to affect the design stage. Information collected during the design phase improves the traceability and quality of the final product.

Although model-based technologies have been popular at the design phase, their use in runtime analysis has so far been limited. Therefore, one of the project's challenges was to make all the tools speak the same language of models. A second challenge was to make all tools interoperable, to provide a seamless experience for engineers. To this extent, many of the tools support the common trace format (CTF) for interoperability purposes,

> *The tools are divided into three groups. These are holistic system engineering, runtime validation, and traceability and megamodelling.*

and clear guidelines are provided on how different tools can be combined into tool chains supporting real-life scenarios.

With the improvements to the manufacturing of electronic systems, not only do the manufacturers become more competitive, but manufactured goods generally become more reliable. "This has an indirect impact on society, through accelerating the development and use of cyber-physical systems (CPS) scenarios, in transport and healthcare, where the impact is visible," adds Torrado Gracia. Such development also occurs in other fields, notably energy and telecommunications, where success is invisible to the consumer, but failures are particularly acute. This means that consumers benefit from fewer outages, as well as more reliable and cheaper energy provision.

Most of the existing consortium members united to submit a new funding proposal. If accepted, this will form a new EU-funded project called AIDOaRT.

### MEGAM@RT2

- Coordinated by Mälardalen University in Sweden
- Funded under H2020-LEIT-ICT
- cordis.europa.eu/project/id/737494
- Project website: megamart2-ecsel.eu
- bit.ly/2FWHp6X

# New concrete mixture and design tools extend energy infrastructure lifespans

*Old concrete recipes don't meet the new longevity demands for energy infrastructure. The answer is nanoadditives.*

The expected lifespans of major engineering projects are increasing. Projected lifespans used to be 25 years for energy infrastructure, 50 years for buildings and more than 75 years for bridges. Now, designers are expected to achieve lifespans of 100 years or more. This is for cost reasons. Investment in longevity at the construction stage pays off over the long term compared to repairing structures later.

In addition, infrastructure is moving into non-traditional locations, such as offshore. Many such locations are hostile to infrastructure. For example, sea air is highly corrosive; certain locations may be subjected to freezing conditions and ice abrasion, extreme heat or intense pressures. Despite such challenges, the requirement for infrastructure longevity still applies.



## NANOMATERIALS FOR A REINFORCED CONCRETE MIX

One key to achieving this requirement is new materials. The EU-funded LORCENIS (Long Lasting Reinforced Concrete for Energy Infrastructure under Severe Operating Conditions) project developed a new formula resulting in a novel mixture that doubles previous lifespans for concrete, even under extreme conditions of temperature, pressure, salinity and acidity (e.g., sewage plants).

The new concrete is mixed and poured normally. The fundamental difference is the new, nanostructured additives that LORCENIS researchers developed. "They allow hardened concrete to self-repair, via a calcium carbonate precipitation reaction," explains Christian Simon, LORCENIS coordinator. The additives also allow the concrete to self-cure, meaning to set. "So the additives mitigate shrinkage and crack formation. They also increase freeze-thaw resistance, while decreasing water permeability and absorption," adds Simon.

The nanomaterials additionally function as sensors. With software support, the sensors allow civil structures to detect and monitor stresses, and thus, to self-diagnose their own structural health.

## SUPERIOR PERFORMANCE

A second key element of extended lifespans is improved design tools. LORCENIS researchers developed and validated a new modelling approach, incorporated into an engineering software tool called 'SEBASTOS'. This greatly simplifies the computation time required in design. So the tool helps designers predict and optimise reinforced concrete in highly corrosive environments.

> *The nanomaterial fully repaired a concrete crack, leaving it strong and in good condition. We also achieved three times better resistance to ice abrasion than normal concrete. In concrete exposed to ocean winds and currents, the new mixture reduced chloride concentration around steel concrete reinforcing by 50 %.*

During the final year of the project, researchers tested the new material on pilot-scale demonstrators prepared with the new concrete mixture. Testing reflected the extreme conditions likely to be encountered in each of the project's four environmental scenarios: concrete infrastructure in deep sea and (sub)arctic zones, under mechanical fatigue, exposed to high-temperature thermal fatigue, and subjected to acid attack.

"Our results were outstanding," notes Simon. "The nanomaterial fully repaired a concrete crack, leaving it strong and in good condition. We also achieved three times better resistance to ice abrasion than normal concrete. In concrete exposed to ocean winds and currents, the new mixture reduced chloride concentration around steel concrete reinforcing it by 50 %," says Simon.

Finally, testing showed a 40 % improvement to the self-repair capabilities of concrete under hydraulic pressure, for crack widths up to 0.15 mm.

The functionality of the newly developed concrete material has been verified, raising the technology readiness level (TRL) from proof of concept (TRL3) to technology demonstration (TRL6-7).

LORCENIS partners have joined new initiatives, funded by both the EU and national governments, to continue development.

The outcome of LORCENIS has been concrete that performs well and lasts much longer, even in extreme environments. This will help make infrastructure projects in such environments more feasible.

### LORCENIS

- Coordinated by SINTEF in Norway
- Funded under H2020-LEIT-ADVMAT
- cordis.europa.eu/project/id/685445
- Project website: lorcenis-eu.com

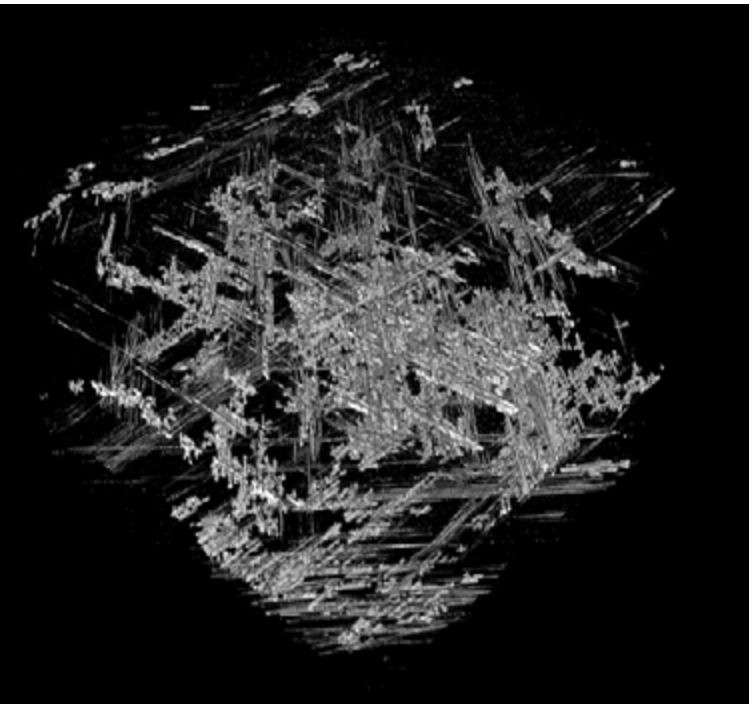
INDUSTRIAL TECHNOLOGIES

# A recipe for success turns composites manufacturing into a piece of cake

*Production of large and complex composite parts for the aerospace industry still relies largely on trial-and-error approaches to composite design. A new process simulation tool promises significant reduction in time, cost, errors and scrap, not to mention energy consumption.*

Manufacturing a part that meets specifications requires detailed knowledge of the processing parameters, the materials, and the behaviour of the materials during processing. Simulations are fundamental to successful delivery of high-quality components. Complex carbon fibre-reinforced plastic or polymer (CFRP) composites are a prime example, yet process simulation tools are lacking.

The latest generation of medium- and long-range passenger aircraft consists of 50 % or more composites by weight. The EU-funded TRANSITION (Tool-Part-Interaction simulation process linked to laminate quality) project has filled the critical need for process simulation, taking the guesswork and 'rework' out of CFRP composite manufacturing. It promises to enhance



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the competitiveness, not only of the European aerospace industry, but of any sector that relies on CFRPs.

## IT GETS COMPLICATED IN THERE

CFRP is a composite consisting of lightweight and high-strength carbon fibres embedded in a matrix, typically a polymer resin. These carbon fibre layers pre-impregnated with resin (prepregs) are widely used in aeronautical applications. Prepregs are layered in a mould and then cured in an autoclave. Extreme pressure provides mechanical force to remove trapped air and volatile materials, and very high temperature initiates cross-linking to form a rigid matrix. According to Dennis Bublitz, TRANSITION coordinator and chair of carbon composites at the Technical University of Munich: "The inherent variability in the manufacturing process leads to variations in the final part's quality, like uneven part compaction and porosity, increasing the risk of rejection. TRANSITION set out to meet these challenges by developing a process simulation tool to be introduced early in the design phase."

## SHINING LIGHT INTO THE BLACK BOX

Models simulate real-life scenarios and predict potential outcomes based on inputs. To do that well, they require extensive experimental data from numerous similar scenarios on which to base predictions. TRANSITION's experiments provided invaluable insight into factors influencing the porosity of materials subjected to various processing conditions, via micrographs and high-resolution micro-computerised tomography scans, or micro-CT scans. Scientists also developed and implemented a new methodology to measure pressure between the prepreg and the tool in the autoclave.

*"TRANSITION's process simulation tool facilitates cost- and time-efficient design of prepreg parts for autoclave manufacturing. By reducing 'trials' and rejection rates, the tool also minimises energy-intensive autoclave use and enhances manufacturing sustainability."*

As a result, the numerical process simulation tool implemented using the commercially available finite element (FE) software ABAQUS effectively describes compaction behaviour and calculates porosity. Bublitz summarises: "The model successfully predicted the thickness distribution after curing in the autoclave. Moreover, the distribution of the remaining porosity was predicted qualitatively. Therefore, the simulation results can be used to identify critical regions with high porosity in manufactured parts. Finally, the tool enables optimisation of the curing process in early design stages to achieve high-quality parts, reducing development time and cost."

TRANSITION has filled an important need with its FE-based simulation tool for complex autoclave processing. The methodology was presented at the 2017 Composites and Advanced Materials Expo and the tool is integrated into courses at the Technical University of Munich to expose students to practical applications. Bublitz concludes: "TRANSITION's process simulation tool facilitates cost- and time-efficient design of prepreg parts for autoclave manufacturing. By reducing 'trials' and rejection rates, the tool also minimises energy-intensive autoclave use and enhances manufacturing sustainability." The tool should also spur innovation, free now of the cumbersome shackles of the trial-and-error process.

### TRANSITION

- Coordinated by the Technical University of Munich in Germany
- Funded under H2020-TRANSPORT
- cordis.europa.eu/project/id/717145
- Project website: bit.ly/3jxuEgN

# Catching up with ReconCell: Major progress in bringing cutting-edge next-gen (and SME-friendly!) robotic solutions to the market

*The ReconCell project has developed a cutting-edge workcell that makes robot solutions commercially viable for SMEs that otherwise may not have the time or resources to automate their production processes. Featured in issue 87 of Research*eu magazine in November 2019, project coordinator Ales Ude had outlined how he and his team planned to commercialise further their product – we reconnect with him to find out how they've been getting on.*

Whilst ReconCell (A Reconfigurable robot workCell for fast set-up of automated assembly processes in SMEs) officially ended in February 2019, Ude and his colleagues have been working hard to strengthen the spin-out company, FlexHex, that had been created to advance their innovative workcell. "FlexHex has been very active in the last year. We've been approached by a large German automotive company, a Turkish and a Polish automotive supplier to deliver demonstration samples so they can examine the feasibility of our developed technology in new application areas," outlines Ude. "On top of that, we've also been in contact with a Spanish automotive supplier, but unfortunately due to COVID-19, this contract has been suspended for now."

## New additions and improvements to the hexapod

So, whilst FlexHex has received a lot of positive commercial interest, in parallel the team have also been striving to improve their signature hexapod technology, which is essentially reconfigurable fixtures with pneumatic brakes that are used to increase flexibility for assembly processes in robotic workcells.

"At the Jozef Stefan Institute (JSI), where ReconCell was coordinated, we have developed a new algorithm and software to automate the placement and configuration of the hexapod, which has substantially reduced the programming efforts for the utilisation of the hexapods," Ude says. "Then, my colleagues at FlexHex devised a new, smaller version of the hexapod and added sensors to the legs to control the pose of the hexapod."

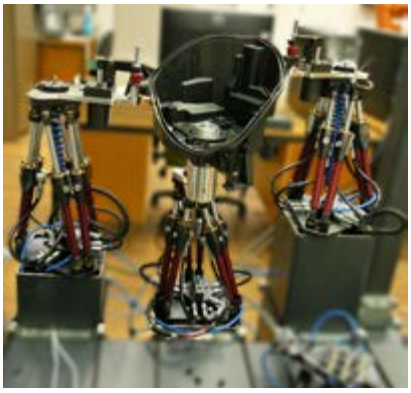
FlexHex has also started to develop simpler and more affordable breaks, which are needed to fix the legs of the hexapod. Finally, FlexHex acquired third-party funding from the very large Horizon 2020 DIH² project to upgrade the hexapods for welding applications.

**Ales Ude**
ReconCell project coordinator
© Jozef Stefan Institute

*"We've been approached by a large German automotive company, a Turkish and a Polish automotive supplier to deliver demonstration samples so they can examine the feasibility of our developed technology in new application areas."*

## New industrial partners, new horizons

The JSI, Slovenia's leading scientific institute, is also a part of another major Horizon 2020 project, the TRINITY robotics digital innovation hub. "Through this project, the ReconCell results are used as modules for demonstration experiments and the dissemination of advanced robot technologies and we hope to find new industrial partners through our collaboration in this project," explains Ude.



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Looking back on the ReconCell project, Ude states that even though some of the software technologies used had already been previously developed, the new ideas generated and the opportunity to test the technology in real industrial applications were all down to ReconCell. "In this respect, we can say with confidence that the EU funding through Horizon 2020 was crucial to our success," Ude concludes.

### RECONCELL

- Coordinated by the Jozef Stefan Institute in Slovenia
- Funded under H2020-LEIT-ICT and H2020-LEIT-ADVMANU
- cordis.europa.eu/project/id/680431
- Project website: reconcell.eu

DIGITAL ECONOMY

# Using behavioural models to upgrade User Interface design

*Indispensable to daily life, User Interfaces, through which we interact with computers, have to be accessible, understandable and attractive. COMPUTED drew on behavioural models from psychology to develop algorithms better suited to their design.*

Modern computational techniques can improve human-computer interaction (HCI) using combinatorial optimisation. Here, a function is specified, and numeric values are assigned to designs proposed by an algorithm. These values indicate how close each design comes to meeting the function required. This approach has changed several industries, from logistics to telecommunications, but hasn't yet been widely adopted for HCI.

Inspired by insights from cognitive psychology about human behaviour, the EU-supported COMPUTED (Computational User Interface Design) project adopted mathematical models and simulations for better User Interface (UI) design.

"The idea of using combinatorial optimisation and models from psychology originates from the 1970s, but until now nobody really knew how to do it," explains project coordinator Antti Oulasvirta, from Aalto University, Finland.

As well as further optimising keyboards and menus, for example helping the French government design their new Azerty keyboard layout, COMPUTED diversified the ways in which UIs can be optimised. These now include web pages and mobile apps, as well as virtual reality spaces. COMPUTED's advances were summarised in a recent IEEE Proceedings review.

## BORROWING FROM PSYCHOLOGY

UI designers typically use heuristics, or rules of thumb, such as 'place elements symmetrically for optimum aesthetics'. An experienced designer will have learned a large number of such rules. While these have served to make computers more accessible, they have significant limitations.

Sometimes the heuristic rules contradict one another. They usually also consider only one or two design decisions at a time. And their correlation with actual user experience and usability is quite weak. This means that designers trial many iterations of designs, making the process laborious and expensive.

COMPUTED's innovation was in its use of methodologies from a different discipline.

"I exploited my background in cognitive psychology. By adopting psychological models of performance, perception, learning experience and decision-making, we expanded what could be done with UIs," adds Oulasvirta.

For example, the team worked with visual attention models from psychology, to predict how users typically scan a display when looking for something. From this, they built an optimisation algorithm that can trial different UI designs, testing the likely impact on user experience at the rate of millions per second.

This approach has been applied to different design needs and combined to create a range of tools. These can be used when sketching and wireframing, without any specialist knowledge.

An example of the system in operation is the design of graphical UI layouts, such as those used for websites. The solution produces several designs based on the objectives of proper alignment, overall rectangularity and preferential placement of elements. The system ensures that designers get real-time design feedback, with new and diverse customised designs.

## STARTING UP THE START-UP

The code is already available for designers to try. The team plan to launch a start-up later this year to commercialise the design tools. Given the scope of UI design problems, with prohibitively large data sets even for algorithms, the team will exploit the power of deep learning.

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*The idea of using combinatorial optimisation and models from psychology originates from the 1970s, but until now nobody really knew how to do it.*

"It will take us a long time to get to the point where computers can design truly complex UIs, like those in airplanes, factories or even social media. Besides finding the right models and efficient algorithms, other challenges are related to language and semantics. Design is about communication," says Oulasvirta.

## COMPUTED

- Hosted by Aalto University in Finland
- Funded under H2020-ERC
- cordis.europa.eu/project/id/637991
- Project website: userinterfaces.aalto.fi

DIGITAL ECONOMY

# Fog and cloud computing work hand in hand

*The increasing usage of cloud and fog paradigms in tandem offers novel opportunities to develop new applications and architectural concepts that were never before possible.*

Cloud computing is almost infinite and an industry-wide game changer. But it's also fragile and latency-prone. Fog computing presents a number of potential advantages, specifically in relation to overcoming obstacles between physical and digital worlds.

By bringing cloud computing capabilities closer to the end device and users, fog computing can significantly extend the Internet of Things (IoT) services portfolio as well as market and business opportunities in the cloud sector. The EU-funded mF2C (Towards an Open, Secure, Decentralized

and Coordinated Fog-to-Cloud Management Ecosystem) project investigated methods and tools to support resource orchestration across fog and cloud environments. The increasing usage of both paradigms together offers unprecedented novel opportunities to develop new applications and architectural concepts.

## TOWARDS A SINGLE DIGITAL ECOSYSTEM

The project addressed the need for an open, secure, decentralised multi-stakeholder fog-to-cloud management framework that includes novel programming models, privacy and security. "The normalisation in the usage of cloud-based technologies, together with the expansion of IoT into a digital mesh, has completely changed the traditional point of view on cloud computing trends," explains Ana Juan Ferrer, the project coordinator. "Connecting people, devices and services into one single digital ecosystem is a real need for the coming years, and new solutions must be sought to meet user needs in a dynamic way."

Ferrer notes organisational change is inevitable as more companies from traditional sectors are embracing cloud services as a first step towards full digital transformation. "Lower barriers to enter into new markets, emerging business models and updated socio-economic structures are key factors creating new opportunities for businesses, overcoming obstacles between physical and digital worlds," she adds.

To support organisations' digital transformation, mF2C provided a coordinated management of traditional cloud architectures and novel fog ones. It offered unique capabilities for distributed execution of applications throughout IoT, fog and cloud environments.




> *Connecting people, devices and services into one single digital ecosystem is a real need for the coming years, and new solutions must be sought to meet user needs in a dynamic way.*

## SMART SYSTEMS AND SERVICES

But, as a horizontal solution, it's not easy to see results. For this reason, mF2C conducted three use cases. The first case related to emergency management situations involving building collapse. "The deployment of the mF2C architecture in the emergency situation management system has demonstrated a better reliability and quality of service, as well as improving the latency of a response to an alert situation when the software runs on the fog," reports Ferrer. "Moreover, thanks to the intrinsic redundancy provided by mF2C, the number of devices can be reduced without lowering the quality of service proposed, so hardware-associated costs can be reduced. In addition, the time response to emergency situations improves when the services are run locally, rather than on the cloud, and the emergency services are able to intervene faster, which can save lives."

The second case, related to smart navigation, provided owners and users with an insight into boats' status over the fog or the cloud, depending on network possibilities. The third case involved a new fog hub service developed for tracking people and objects indoors.

According to Ferrer, the project has allowed organisations to create or enhance market-ready products in different sectors. It also helped to generate new business opportunities for industrial stakeholders.

### MF2C

- Coordinated by Atos in Spain
- Funded under H2020-LEIT-ICT
- cordis.europa.eu/project/id/730929
- Project website: mf2c-project.eu
- bit.ly/35MPSmn

SPACE

# New compact antenna designs poised to enhance nanosatellite communications

*EU-funded scientists have demonstrated simple, inexpensive compact antennas that could expand the nanosatellite role in remote sensing and Space communications. The new designs improve antenna bandwidth, and allow better communication between Earth ground stations and satellites.*

Nanosatellites and picosatellites are distinctively low-cost classes of miniaturised Space platforms that are built to standard dimensions and shapes. Both are modular and can be stacked together to create larger crafts. Their utility in Space seems limited only by their size and the imagination of their designers and users. The private and public sectors increasingly rely on them for Earth observation as well as test-flying novel communications technologies.

The data that miniaturised satellites collect are as good as the signal they send to Earth, while the signal is as good as the antenna that sends it. Antennas for small satellites typically require dedicated real estate on the satellite bus and often require mechanical deployment after the satellite launch. This adds extra weight and occupies valuable space that could be otherwise used, while it may also raise reliability concerns.

The project CSA-EU (Highly Disruptive and Compact Antenna Systems for Small Satellites with Application to Surveillance, Environmental and Crop-Growth Analysis, Enabling European Union Dominance in the Space Industry), funded under the Marie Skłodowska-Curie Actions programme, proposed novel planar antenna designs that improve on existing designs in a number of ways. Importantly, they are more compact and eliminate the need for a deployment



mechanism – these advances are good first steps towards reducing the volume and cost of tiny satellites. Regarding their use, they are well-suited to Earth observation, where high-resolution, real-time imaging is highly valued.

## ENGINEERING PATCH ANTENNAS ON SOLAR PANEL SURFACES

Over the last few years, significant progress has been made in making patch antennas work well in tandem with solar panels. This merger saves space on the surface of nanosatellites. Patch antennas are also lower cost compared to other antenna types due to the ease of fabricating them on printed circuit boards.

In a first, project researchers developed a circular polarised dual-feed antenna placed above the nanosatellite solar panels. The antenna was fabricated from a conductive square mesh mounted on a transparent substrate material – a borosilicate glass layer. "The transparent material leaves intact the solar cell's original structure, and therefore does not compromise its performance. High values of transparency allow the solar panels to operate with high efficiency," notes George Goussetis, CSA-EU coordinator. Circular polarisation of the signal allows the satellite and the ground station to maintain communication even if the satellite rotates relative to the receiver. Overall, the antenna demonstrated good impedance bandwidth, a stable radiation pattern and minimum shadowing levels. Research results have been published by the IEEE open-access journal.

## INCREASING DIRECTIVITY USING END-FIRE ARRAYS

Another part of the research focused on the design of planar end-fire arrays. Emitting maximum radiation from one end, these antenna arrays improve signal directivity. The concept behind the newly developed antenna involved a parallel-plate waveguide launcher based on a substrate integrated waveguide. The satellite signal propagates through the substrate integrated waveguide which coaxes it into a pattern known as transverse electromagnetic (TEM). This was the first time researchers demonstrated TEM mode with planar wave front propagation. Again, IEEE has published the results of these important research works.

"Nanosatellites moving in low Earth orbits are moving across the sky during their orbit so they do not have a constant line of sight with the receiving antenna. The ultimate aim is to improve the ability of streaming high-resolution, real-time videos and images of Earth by making the most of the antenna's narrow field of view. This clearly involves optimising directivity and bandwidth," concludes Goussetis.

### CSA-EU

- Coordinated by Heriot-Watt University in the United Kingdom
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/709372

SPACE

# Massive stars could be born in clusters, lower-mass stars could leave 'home'

*Have you ever wondered where stars are born and whether they form in groups or alone? It seems like astronomers know more about stars themselves than about the cradles of their formation!*

In Space, dense regions in which gas and dust are contracting result in the formation of new stars. In visible light, this dust is dark, blocking the streams of the glittering stars behind, just as fog blocks our view on a misty day. When astronomer William Herschel observed such a cloud in the constellation of Scorpius in 1774, he

> *The research conducted by STARRY is an excellent example of how the analysis of the Big Data collected by modern scientific instruments, such as the Gaia telescope, will shape the future of astrophysics.*

is said to have exclaimed: "Truly there is a hole in the sky here!" Today, it is known that these dark patches are not empty regions, but rather cool, dark clouds which harbour most of the material necessary to form one or more stars.

## DO STARS FORM NECESSARILY IN CLUSTERS?

Some lucky young stars belong to beautiful clusters comprising dozens to hundreds of stars, whereas others roam the galaxy alone or with just a partner or two. The question that arises is whether stars are born all together in clusters or are grouped later in their lifetime. Which conditions favour low-mass star and massive star formation in clusters?

"Most massive stars are known to be deeply embedded in their dusty birth environments, which often makes them impervious to optical observations. To this end, we decided to look at young stars of intermediate mass, collectively known as Herbig Ae/Be stars. What's more, during their early stages, young stars do not affect the cluster environment in which they were born," notes Rene Oudmaijer, coordinator of the project STARRY (STARs that 'R' Young: When do stars form in clustered environments?), which was funded under the Marie Skłodowska-Curie Actions programme.

## PINNING DOWN THE STAR BIRTHPLACE USING ARTIFICIAL INTELLIGENCE

STARRY developed a bespoke artificial intelligence system that identified more than 2 000 stars with around an 80 % chance of being a Herbig Ae/Be star. The findings have been reported in the 'Catalogue of new Herbig AE/BE and classical Be stars: A machine learning approach to *Gaia* DR2' published in the Astronomy and Astrophysics journal.

The system analysed data from the Gaia Space telescope. Introduced in 2013, the data compiled by the Gaia telescope allowed researchers to determine the distances (using the so-called parallax) for approximately 1 billion stars. "This is an important, but often elusive piece of information for the study of celestial objects. To put it into perspective, Gaia's predecessor Hipparcos that flew 30 years ago provided such information for about 100 000 objects," adds Oudmaijer.

The next step was to look for clusters around these stars using data regarding their positions, motions and distances to other objects (stars in a cluster are located close to each other and have similar motions and distances). "Preliminary results allowed us to conclude that the massive objects are more likely to be located in the centre of their cluster than the lower-mass stars. The latter are either found alone or orbiting on the periphery of massive stars, like being the side result of the formation of their larger counterparts," explains Oudmaijer.

"The research conducted by STARRY is an excellent example of how the analysis of the Big Data collected by modern scientific instruments, such as the Gaia telescope, will shape the future of astrophysics. Artificial intelligence systems can identify patterns in vast quantities of data – and it is likely that in those patterns, scientists will find clues that will lead to new discoveries and fresh understanding," concludes Oudmaijer.

### STARRY

- Coordinated by the University of Leeds in the United Kingdom
- Funded under H2020-MSCA-ITN
- cordis.europa.eu/project/id/676036
- Project website: starry-project.eu

FUNDAMENTAL RESEARCH

# How graphics cards are helping to capture the rarest event in the universe

*Physicists have upgraded a detector at the Large Hadron Collider at CERN to hunt for rare particles that can shed light on how the universe was formed.*

The Standard Model of particle physics is our best current explanation for the laws of nature. However, it fails to explain phenomena such as dark matter, gravity at the quantum scale, and the observed imbalance between matter and antimatter in the universe.

## UNIVERSAL LAWS

Alternative models are waiting in the wings, such as supersymmetry. To test which of these theories is most accurate, Diego Martínez Santos, project coordinator of BSMFLEET (Challenging the Standard Model using an extended Physics program in LHCb), examined a subatomic particle known as a strange quark, or 's quark'.

On extremely rare occasions, the s quark decays in an unexpected way due to flavour violation. Measuring the rate of these occurrences would hint at which model was most accurate. "With the Large Hadron Collider (LHC) we have a detector that reconstructs particle decays, but wasn't meant to select strange quarks," explains Santos.

## VIDEO GAMES

Around 6 years ago, the physicists realised that the decay of the strange quark was something that could be recorded by a modified trigger system at the LHCb detector, one of the four main detectors at CERN.

His team, from the University of Santiago de Compostela, developed such a trigger system to run during the period 2016-2019. More recently, the system has been improved with GPU cards, more commonly used to render graphics in video games.

Strange quark decays do not deviate much from their initial momentum, making them hard to see against background noise. What's more, the Standard Model predicts that the unusual decay Santos was searching for has only a one in 200 billion chance of occurring, meaning that Santos was searching for as few as two incidences in all the data gathered from 2015 to 2018.

Other models predict far higher frequency – as often as once every 1 million events. "The goal is to find any deviation from the Standard Model: decays that the model comes close to forbidding," he says. "In other models, these events are not as suppressed, so we would be deciding which should replace the Standard Model."

## SLOW SCIENCE

The work was carried out with support from the EU's Horizon 2020 programme. "It would have been almost impossible to have conducted this research without the EU funding," notes Santos. As the main tasks are now complete, Santos and his team will go into 2021 analysing their data, searching for what may prove to be the rarest event ever recorded in the giant particle collider.

> *"The goal is to find any deviation from the Standard Model."*

Santos says his interest in analysing the physics captured in collisions lasting a billionth of a second comes from his desire: "To understand better the fundamental laws of nature." He adds: "Maybe, at some point in the future, perhaps centuries from now, there will be an application for what we discover. Sometimes it takes time to fully make use of breakthroughs that seem, initially, to be abstract."

### BSMFLEET

- Hosted by the University of Santiago de Compostela in Spain
- Funded under H2020-ERC
- cordis.europa.eu/project/id/639068

FUNDAMENTAL RESEARCH

# Removing restrictions of only whole-number solutions to Fermat's Last Theorem

*For centuries, mathematicians tried to solve Fermat's Last Theorem using only natural numbers. In a first, EU-funded scientists expanded this number system to include bigger number systems with exotic values.*

Natural numbers (positive integers) are not always enough to solve a problem. Over centuries, mathematicians realised this when seeking to solve Fermat's Last Theorem which states that no three positive integers x, y and z can satisfy the equation $x^n + y^n = z^n$ for any integer value $n > 2$. This simple statement became the most famous open problem in mathematics. It has tormented swarms of mathematicians for over 350 years ever since the lawyer and amateur mathematician Pierre de Fermat scribbled it in the margin of a copy of Diophantus' 'Arithmetica'.

Diophantine equations, name after Diophantus of Alexandria, are combinations of variables, exponents and coefficients, such as $3x + 7y = 1$ or $x^3 + y^3 = z^3$. Since

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ancient times, mathematicians have known how to work out whole-number combinations to solve Diophantine equations with two variables and no exponents larger than 2. The oldest known record comes from Plimpton 322, a Babylonian clay tablet believed to have been written about 1800 BC. The tablet which was discovered in 1920 contains 15 Pythagorean triples.

"A Pythagorean triple is a triple of whole numbers (x,y,z) that form the sides of a right-angled triangle. The corresponding Diophantine equation is $x^2 + y^2 = z^2$," notes Samir Siksek, coordinator of the GalRepsDiophantine (Galois Representations and Diophantine Problems) project that was funded under the Marie Skłodowska-Curie Actions programme. "Fermat's conjecture implies that if you push the exponent value above 2 then the equation is fundamentally different from Pythagorean triples."

## WILES' MONUMENTAL BREAKTHROUGH MOMENT

The only case of his theorem that Fermat actually proved and has survived intact is the case n = 4. Leonhard Euler found proof for n = 3, and Sophie Germain proved Fermat's Last Theorem for a very large set of prime exponents n.

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The complete proof was found by the British mathematician Andrew Wiles in 1995. It relied on three concepts: number theory, namely elliptic curves, modular forms and Galois representations.

"In the 1980s, Gerhard Frey proposed an astonishing link between Fermat's conjecture and a deep idea called the modularity conjecture for elliptic curves. Frey strongly suspected that the elliptic curves over the field of rational numbers are not modular. Frey's non-modularity was proven a few years later. Wiles proved Fermat's Last Theorem by proving the semistable case of the modularity conjecture," adds Siksek. Wiles' proof predicts that the residual Galois representation of that elliptic curve comes from a finite computable set of modular Galois representations.

## WILES' SOLUTION IS A PIECE OF A MUCH LARGER PUZZLE

Whilst Wiles succeeded in resolving Fermat's conjecture over the rationals, the proof strategy for many other Diophantine problems (including the Fermat equation over number fields) is insufficient. "Modern studies focus on Diophantine equations over other number systems as well. One can even think about towers of number systems, where the numbers are becoming increasingly abundant. It is natural to wonder whether the ideas of Frey, Wiles and others that led to the stunning proof of Fermat's Last Theorem can reveal clues to the Fermat equation over an infinite family of number fields of arbitrarily large dimensions," explains Siksek.

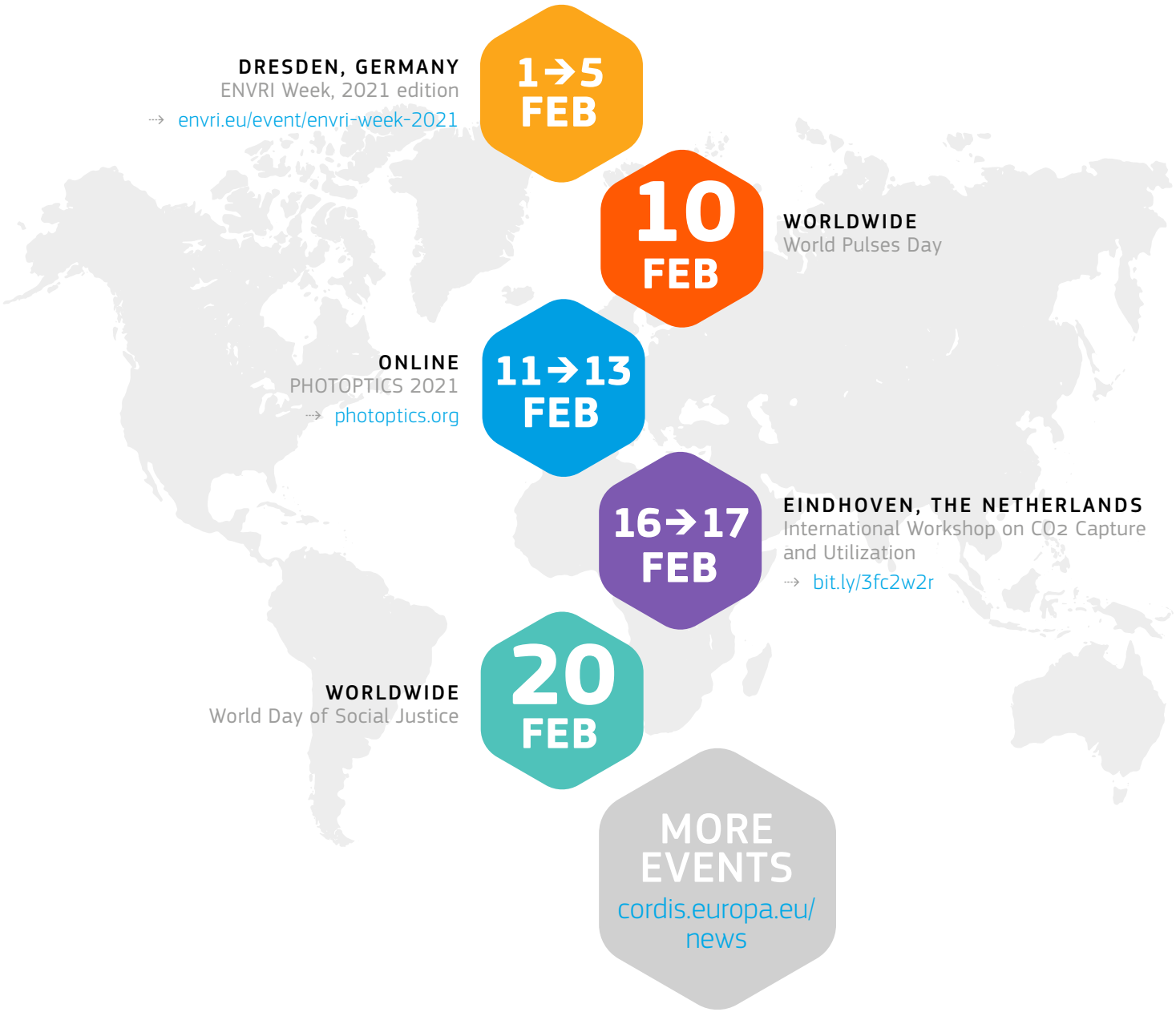
"Our study has been the first to consider the Fermat equation for towers containing infinite number systems. In particular, we succeeded in proving the asymptotic Fermat's Last Theorem over the layers of the $Z_2$ extension of the rationals," concludes Siksek who jointly worked with Marie Skłodowska-Curie Actions fellow Nuno Freitas. Project results are published on the project website.

### GALREPSDIOPHANTINE

- Coordinated by the University of Warwick in the United Kingdom
- Funded under H2020-MSCA-IF
- cordis.europa.eu/project/id/747808
- Project website: bit.ly/GalRepsDiophantine

AGENDA

# FEBRUARY 2021



**DRESDEN, GERMANY**
ENVRI Week, 2021 edition
⇢ envri.eu/event/envri-week-2021

**1→5 FEB**

**10 FEB**

**WORLDWIDE**
World Pulses Day

**ONLINE**
PHOTOPTICS 2021
⇢ photoptics.org

**11→13 FEB**

**16→17 FEB**

**EINDHOVEN, THE NETHERLANDS**
International Workshop on $CO_2$ Capture and Utilization
⇢ bit.ly/3fc2w2r

**20 FEB**

**WORLDWIDE**
World Day of Social Justice

**MORE EVENTS**
cordis.europa.eu/news

## 1–4 FEB

**ONLINE**

5th HBP Student Conference on Interdisciplinary Brain Research

The 5th HBP Student Conference provides an open forum for the exchange of new ideas among early career researchers working across various sciences relevant to the Human Brain Project (HBP). Attendees will be exposed to the data-driven brain research approach of the HBP and a space for extensive scientific dialogue, both intra- and interdisciplinary, among peers and faculty through a variety of discussion sessions, lectures and social events. It will take place virtually, organised and supported by the HBP Education Programme.

⇢ humanbrainproject.eu/en/education/HBPSC2021

Whilst at the time of writing all of these events were scheduled to take place, we advise all of our readers to regularly check the status of each event due to the continued uncertainty caused by the novel coronavirus epidemic in Europe – events may be cancelled, rescheduled or reformulated (e.g. switched to being a digital event only) at any time.

# CORDIS RESULTS PACK ON THE BLACK SEA

**In this Results Pack, we feature six projects that illustrate how initiatives from different marine disciplines have contributed to research on the Black Sea, with the participation of scientists and other stakeholders from the region.**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