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**SPECIAL FEATURE**  
**INFUSING THE DIGITAL**  
**INTO EUROPEAN**  
**EDUCATION**

# Editorial

## European education systems are getting a digital upgrade, how EU-funded research is revving up to fight COVID-19 and innovative robots on the assembly line

### welcome to this month's Research\*eu magazine

This month, we're going back to school – but probably not one that you remember fondly (or otherwise) from your own days in formal education. Indeed, education is rapidly evolving and one of the most exciting ways in which it is changing is how digital technologies are really starting to seep into the sector to equip our young people with the skills they need to prosper in a digitalised, globalised world economy.

As several project articles in our regular monthly sections clearly highlight, almost every aspect of our economy and society is gradually becoming digitalised or dominated by impressive new technologies, from manufacturing, through to preserving historical documents and even rescuing stranded sailors at sea. It is becoming increasingly apparent that for European economies to prosper, the education system itself needs to digitalise at every level, from kindergarten/playschool right through to university graduation and beyond into lifelong learning.

So, a digital revolution is underway in our schools and whilst the EU doesn't have formal competences in education (these are firmly in the hands of Member States), it does actively want to encourage the uptake of digital education, not just in subject matter but also in teaching methods as well. This is why the European Commission supports many innovative projects through the Horizon 2020 programme, and in this issue, we're going to meet seven of them. We definitely encourage you to explore further some of the impressive solutions developed by these projects – who knows, you might learn something new yourself!

Elsewhere in the magazine, our **Life After** feature catches up with the **ColRobot** project that designed an impressive robotic solution for on the factory floor and even aroused the interest of a major car manufacturer. And in **Project of the Month**, we actually feature two Horizon 2020 projects that are on the frontline in the ongoing mission to fight and better understand COVID-19. However, we must note that these are just two of several projects that are working on this incredibly pressing topic, and we at CORDIS wish them all the luck and perseverance they need to find credible answers and scientific solutions.

Due to the ongoing COVID-19 situation across Europe, we have decided to not include our regular **EU Agenda** feature in this issue as it seems highly likely that most, if not all, of the events that we would usually cover will not take place – turn to the back inside page for more details.

But don't forget to dip your toes into our nine regular sections – whilst sailors are arguably exciting (skip straight through to the Security section if that's what floats your boat), we also have a lot more on offer this month as well!

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

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# Genetically modified bacteria heal wounds in people with diabetes

*More than 6 million people in Europe suffer from diabetes-related difficult and chronic wounds that may lead to limb amputations. To address the large unmet medical need in this group, a European initiative developed an innovative therapy that relies on genetically modified lactic acid bacteria.*

Wound healing involves the recruitment of specific immune cells to the site where they initiate the tissue repair process. Patients with diabetes display a reduced healing ability alongside an increased susceptibility of acquiring wounds which translates into reduction in lifetime expectancy.

## ENGINEERING HUMAN CHEMOKINE PRODUCTION FROM BACTERIA

The EU-funded WHILYAS (Wound healing ILYA-style) project developed biological drugs that are produced at the actual wound site by lactic acid bacteria which serve as mini bioreactors. “Our approach tricks the body into thinking that the wound is much larger and thus accelerates the healing process,” explains project coordinator Evelina Vågesjö.

Researchers selected the CXCL12 chemokine well-known for its role in the regenerative process. However, due to its inherently short half-life, CXCL12 has been under-explored as a therapeutic modality. To overcome this limitation, WHILYAS researchers decided to produce the human chemokine continuously at the wound site by live genetically engineered lactic acid bacteria.

The ILP100 drug produced by Ilya Pharma is the first candidate to reach clinical proof of concept with topical application and comes in a freeze-dried formulation. The bacteria are revived immediately prior to application onto the wound by adding a small volume of buffer solution.

The key objective of the WHILYAS project was to accelerate development of the ILP100 drug candidate through toxicity testing in large animal models and in human subjects. The large animal repeated dose toxicity study has produced very good safety and efficacy results, with an acceleration of healing and a reduction of scarring. Researchers have scaled up the bioprocess and produced a GMP-cell bank for future use.

Results from the ongoing first human clinical trial in healthy volunteers indicate drug safety and local tolerability. Assessment of wound healing, scarring, blood flow and wound microbiome are secondary exploratory end points.

## CLINICAL IMPACT AND FUTURE PROSPECTS

Current treatment of chronic wounds is limited to the use of different dressings and an overuse of antibiotics, inducing a high cost that in industrialised countries may reach 4% of the total healthcare budget. The market for wound care is EUR 15 billion and the segment of diabetic foot ulcers is in the range of EUR 1.5 billion.

The rationale behind ILP100 development is to heal chronic wounds in patients with diabetes in a better, faster and more cost-efficient manner than any other drug or medical device available today or in the pipeline. With ILP100, chronic wounds could heal 66% faster bringing obvious improvement to the quality of life of patients. Apart from CXCL12, other human therapeutic proteins endogenously involved in tissue regeneration could be exploited.



“With ILP100, chronic wounds could heal 66 % faster bringing obvious improvement to the quality of life of patients.”

“To comply with drug development regulations of the EMA and FDA, we need to be innovative in each step and have the right expertise and mindset in the team,” emphasises Vågesjö. The non-clinical data generated during WHILYAS have initiated a financing investment round to fund two phase II clinical trials in different wound indications as well as consequent regulatory and commercial activities. “These activities are paramount to executing the strategic development plan of Ilya Pharma and bringing this next generation of biological drugs to patients fast,” concludes Vågesjö.

## WHILYAS

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- Coordinated by Ilya Pharma AB in Sweden.
- Funded under H2020-HEALTH.
- [cordis.europa.eu/project/id/804438](https://cordis.europa.eu/project/id/804438)
- Project website: [ilyapharma.se](http://ilyapharma.se)

# Disruptive diagnostic tool discriminates between viral and bacterial infection

*Antibiotic misuse most often reflects the difficulty in clinically discriminating bacterial from viral infections. To address this issue, European scientists developed an innovative test that will facilitate accurate diagnosis.*

Globally, an estimated 3 billion patients seek medical attention for suspected acute infection each year. Medical history, physical findings and other ancillary medical tests often do not provide definitive discrimination. Misdiagnosis of disease aetiology may alter the trajectory of patient care, resulting in unnecessary diagnostic tests or prescription of antimicrobials.

## HOST SIGNATURE DIFFERENTIATES BETWEEN BACTERIAL AND VIRAL INFECTION

Researchers in the EU-funded AutoPilot-Dx (Fast tracking market adoption of a novel immune-based diagnostic for improving antibiotic stewardship: automation, piloting and health economics) project developed a novel ELISA-based assay that accurately distinguishes between bacterial and viral infections. ImmunoXpert™ measures the circulating levels of three host proteins, tumour necrosis factor-related apoptosis-inducing ligand (TRAIL), interferon gamma-induced protein-10 (IP-10) and C-reactive protein (CRP). “These proteins exhibit distinctive expression and complementary dynamics in host responses against bacterial versus viral infection,” explains VP Scientific Affairs of MeMed, Tanya Gottlieb.

The signature based on these three host proteins was discovered and validated previously by the consortium in the large-scale prospective study ‘Curiosity’ with over 1 000 adult and paediatric patient infections. This signature, named BV™, displayed 92% sensitivity and 89% specificity across multiple pathogens, and superiority to biomarkers in routine use. It was further validated in two double-blinded external clinical studies enrolling over 1 300 children.

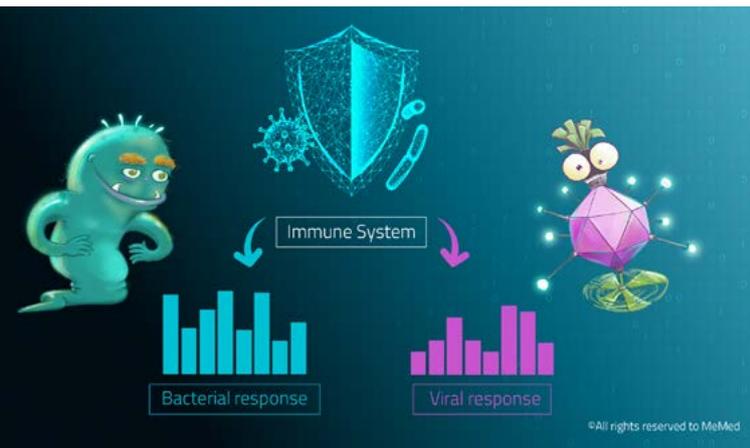
BV™ can be measured using the ImmunoXpert™ immunoassay manually or through the help of a robotic platform. The test result is a score between 0 and 100, with low scores indicative of viral infection and high scores of bacterial infection.

## CLINICAL IMPACT OF THE BV™ IMMUNE SIGNATURE

Fever accounts for 10-25% of paediatric visits to the emergency department and as many as 20% of these are due to an unidentifiable source. Diagnostic uncertainty is reflected by the variable increase in antibiotic prescription worldwide, leading to fundamental individual and global health consequences, including the rise of antimicrobial resistance. BV™ is uniquely positioned to improve the management of paediatric patients with respiratory tract infections and fever without source that account for roughly 50% of doctor visits.

To estimate the clinical utility of BV™, researchers calculated the potential of the assay to reduce unnecessary antibiotic use as 87% in children and 91% in adults. “BV™ represents an innovative and actionable tool that

“ BV™ is uniquely positioned to improve the management of paediatric patients with respiratory tract infections and fever without source that account for roughly 50% of doctor visits. ”



© MeMed

will help clinicians make better informed management decisions for patients with suspected acute infection, helping to fight antibiotic overuse without compromising patient safety,” emphasises Gottlieb.

The European market for ImmunoXpert™ diagnosis is estimated at over EUR 1 billion, with market entry points

being the emergency department and paediatric hospital wards. AutoPilot-Dx partners are also in the process of developing a point-of-care platform called Key™ that will enable the BV™ test to be performed when and where needed, and provide a result within 15 minutes. The launch has been scheduled for 2020 in Europe and then in the United States.

“The vision of our company is to decode the signals of the host response into simple insights that improve people’s lives,” concludes Gottlieb. Project partners are currently working on innovative host response-based diagnostics to help manage sepsis and plan to leverage the measuring capability of Key™ to bring novel tests to the market.

#### AUTOPILOT-DX

- Coordinated by MeMed Diagnostics Ltd in Israel.
- Funded under H2020-Societal Challenges and H2020-Industrial Leadership.
- [cordis.europa.eu/project/id/701088](https://cordis.europa.eu/project/id/701088)
- Project website: [autopilotdx.org](https://autopilotdx.org)

#### HEALTH

# ‘Total heart function’ models offer more effective treatment

*Heart models offer improved understanding of cardiac function in health and disease, so leading to better therapeutic strategies. InsiliCardio developed advanced electro-mechano-fluidic cardiac models for improved patient evaluation and treatment.*

Current tomographic imaging technologies provide a wealth of information about cardiac anatomy, structure and function at a very high, sometimes paracellular, resolution. Yet, personalisation or digital techniques that can fully exploit these rich datasets, and accurately represent patient anatomy and physiology, are still in their infancy.

Support from the Marie Skłodowska-Curie programme enabled the InsiliCardio (Image-based High-resolution In-silico Modeling of Total Cardiac Function) project research fellow to complete a feasibility study into the

simulation of personalised total heart function. This was represented in anatomically detailed, high-resolution models, including all three major physics (fluid, structure and electrics).

The modelling workflow demonstrated that electro-mechano-fluidic models of the heart are becoming more feasible. While still costly to construct, these models show promise as a tool for predicting response to medical interventions.

## SIMULATING TOTAL ELECTRO-MECHANO-FLUIDIC HEART FUNCTION

InsiliCardio combined inputs from wide-ranging disciplines. These included cardiology (cardiac arrhythmias, heart failure and therapies), biomedical engineering (model building, medical image analysis and mapping techniques) and mathematics (numerical methods and scientific computing).

This multidisciplinary approach enabled several studies to be conducted that showed the applicability of the computational models for clinically relevant cases.

For example, left ventricular wall stresses and bio-mechanical power are potential biomarkers for diagnosis and prediction of post-treatment outcome. However, these are not accessible within routine clinical procedures or through medical imaging. InsiliCardio modelling allowed these clinically promising biomarkers to be better assessed.

Another workstream created atrial (top chambers of the heart) mechanics models, finding that personalised measurements of wall thickness are necessary to accurately calculate local wall stress.

Peaks in atrial wall stress are associated with tissue remodelling causing fibrosis – considered a major risk factor for the development of atrial fibrillation. The team developed a simulation framework for investigating this link between local anatomy, mechanics and electrophysiology.

“In the short term, our models could improve patient selection, therapeutic planning and risk management, leading to clinical benefits,” says researcher Christoph

“ *In the short term, our models could improve patient selection, therapeutic planning and risk management, leading to clinical benefits.* ”

Augustin. “Specifically, models which can simulate biomarkers that are not available from imaging or clinical measurements, can support decision making in borderline and complex cases.”

## TOWARDS BETTER THERAPEUTIC PLANNING

Computational models of the heart will impact the lives of European citizens, both as industrial medical device development tools (MDDT), for the design and optimisation of cardiac devices, as well as by offering software as a medical device (SaMD), for diagnostic and therapeutic clinical applications.

The design and optimisation of cardiac devices, mechanical heart valves or stents could benefit from the work done by the InsiliCardio project.

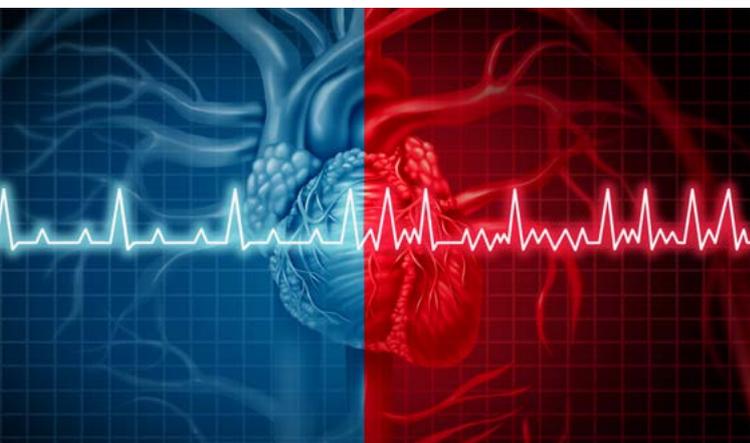
An open source version of the software called openCARP will be freely available for academic purposes. openCARP currently includes the electrophysiology simulator, with modules for mechanics and fluid dynamics forthcoming.

Taking the work forward, Augustin will use InsiliCardio’s data and models within the SICVALVES project, extending them to develop Growth & Remodelling models to further investigate maladaptive hypertrophy (the pathological thickening of a ventricular wall). This is a major risk factor for heart failure. The team’s goal is to help clinicians to plan therapies more effectively.

“In the future, we expect that computational models will be employed to assess the state of disease progression and to provide longer-term predictions of therapeutic outcomes,” says Augustin.

## INSILICARDIO

- Coordinated by the Medical University of Graz in Austria.
- Funded under H2020-MSCA-IF.
- [cordis.europa.eu/project/id/750835](https://cordis.europa.eu/project/id/750835)
- Project website: [ccl.medunigraz.at](https://ccl.medunigraz.at)

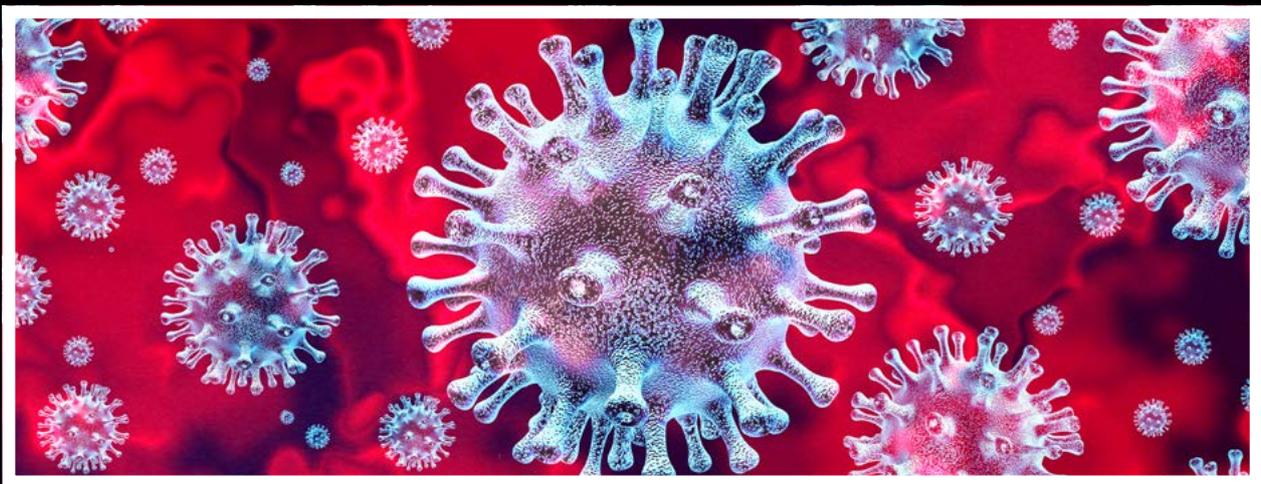




PROJECT OF THE MONTH

# Ramping up EU research excellence to combat COVID-19

*As the novel coronavirus, COVID-19, has taken a firm hold in Europe, several ongoing research projects have reoriented their work to focus on the outbreak. This month we're sharing our 'Project of the Month' feature between two such projects, PREPARE and EVAg/EVA-GLOBAL.*



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The **PREPARE** project ensures research preparedness of clinical treatment sites and the use of harmonised research protocols across Europe through their network of 3 000 hospitals and 900 laboratories in 42 countries.

Meanwhile, the **EVAg** team (which since January 2020 has formally morphed into a new successor project **EVA-GLOBAL**) has already made available more than 1 000 kits that support the diagnosis of the novel coronavirus, to 79 countries worldwide.

As a response to the outbreak, the European Commission launched an emergency request for expressions of interest for projects that will advance our understanding of the novel coronavirus epidemic to the tune of EUR 10 million.

*“ Carrying out clinical research in PREPARE will provide real-time evidence for clinical management of patients and for informing public health responses. ”*

Herman Goossens, PREPARE project coordinator

*“ Thanks to emergency research funding from Horizon 2020, we will know more about the disease. I am proud that following the progress made during the last years, our supercomputer centres stand ready to help researchers in their work to develop new treatment and vaccines. ”*

Mariya Gabriel, European Commissioner for Innovation, Research, Culture, Education & Youth

## PREPARE

- Coordinated by the University of Antwerp in Belgium.
- Funded under FP7-HEALTH.
- [cordis.europa.eu/project/id/602525](https://cordis.europa.eu/project/id/602525)
- Project website: [prepare-europe.eu/](https://prepare-europe.eu/)

## EVA-GLOBAL

- Coordinated by Aix-Marseille University in France.
- Funded under H2020-INFRA.
- [cordis.europa.eu/project/id/871029](https://cordis.europa.eu/project/id/871029)
- Project website: [european-virus-archive.com/](https://european-virus-archive.com/)

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](mailto:editorial@cordis.europa.eu) and tell us why!



# The interaction of EU institutions with civil society key to improving democracy

*According to the European Commission's 2017 'White Paper on the future of Europe – Reflections and scenarios for the EU27 by 2025', the EU acknowledges the need to become more democratic and move quicker with citizens. An EU-funded project shed light on how this can be achieved.*

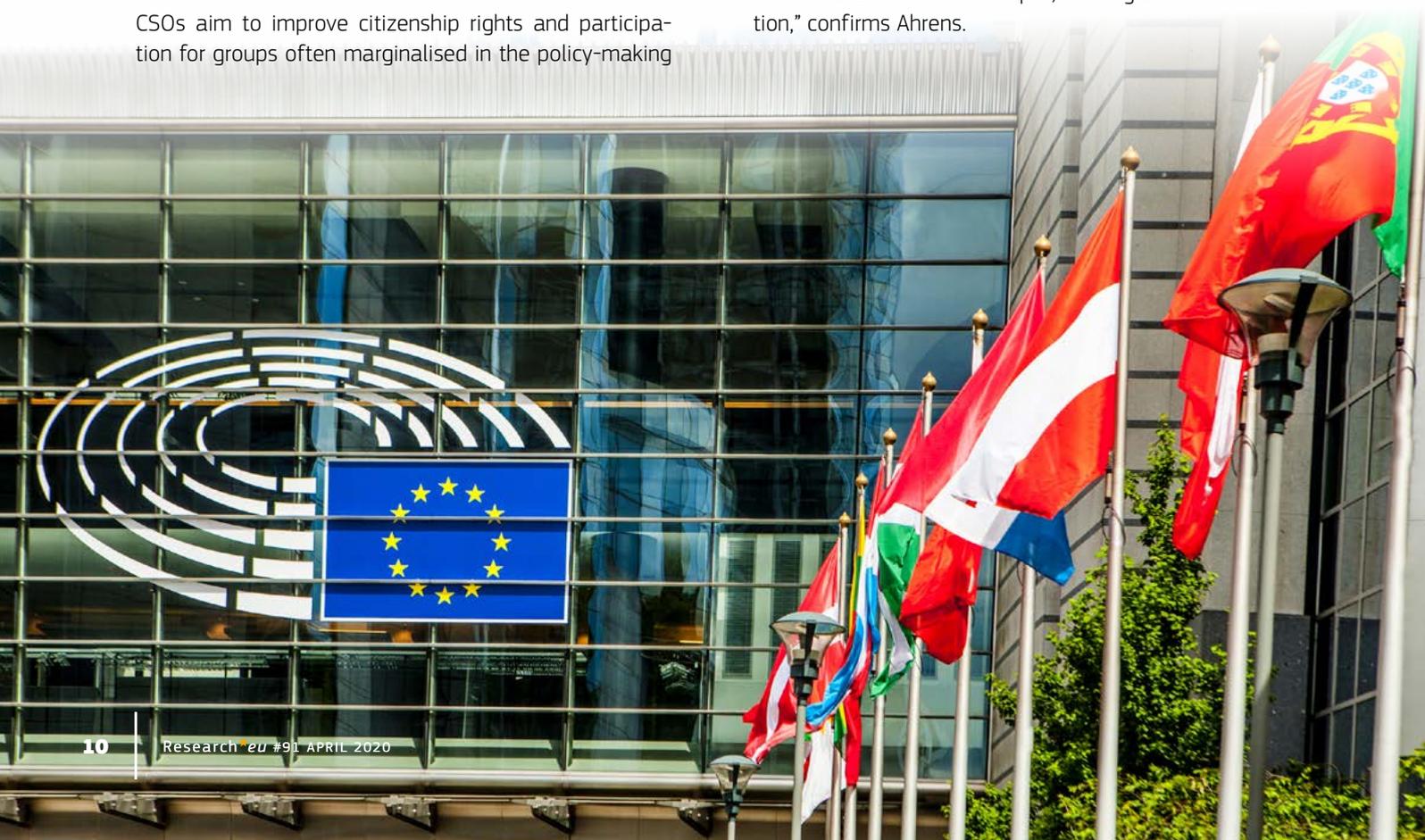
Petra Ahrens, a Marie Skłodowska-Curie Postdoctoral Fellow in the DemocInChange (Effects of Institutional Change on Participatory Democracy and the Involvement of Civil Society Organisations) project, explains: "One important element to improving democracy is through the interaction of EU institutions with civil society organisations (CSOs) as the voice of citizen interests." This led the project, with the support of Horizon 2020, to analyse the relationships between CSOs and EU institutions as a basis for supranational participatory democracy.

## UNDERSTANDING KEY GOALS

CSOs aim to improve citizenship rights and participation for groups often marginalised in the policy-making

process, because they address the grounds of discrimination formulated in Article 19, Treaty of Lisbon. "Therefore, core to the project was the examination of how the political participation of marginalised groups could be enhanced to improve supranational democracy," adds Ahrens.

In addition to extending scientific knowledge on the topic, the project's further goals were to improve academic dissemination skills, writing and networking and the dissemination of results to the broader public. "The goals mirror the deliverables that can be distinguished in the areas of research output, training and dissemination," confirms Ahrens.



“*The research results will be instructive for policy-makers and civil society activists in better understanding each other’s roles and positions and thinking about new, indicative ways of collaboration.*”

## KEY FINDINGS

DemocInChange provided a better understanding of the linkages between equality CSOs and EU institutions, the impact of the European Commission on CSO networks and their lobbying strategies, and the role of the European Parliament in involving CSOs. It also “coined the innovative term ‘equality CSOs’ for those organised around grounds of discrimination,” reports Ahrens.

By investigating equality CSOs, the project was also able to extend its research to questions of intersectionality. “This is when different grounds of discrimination overlap and constitute a specific way of structural discrimination that cannot be captured by focusing on the intersecting aspects separately,” the researcher explains.

As for the societal and political aspect of the project’s research, Ahrens highlights a key finding: “Compared to organised and well-resourced interests, for instance, multinational companies, equality CSOs have to operate within a much more constrained setting because they often lack the resources to fully carry out the work that they aim to do.” Voicing the interests of citizens is, however, limited by the EU institutions and their often

informal rules of who will be heard or invited to, for instance, informal arenas of policy-making.

The most surprising finding of DemocInChange, however, is that equality CSOs do not compete directly with each other over access to EU institutions. “Instead, equality CSOs react flexibly to changing demands and forge new alliances at the intersections of their specific mobilisation ground of discrimination,” reports Ahrens.

## MOVING FORWARD

The research results will be instructive for policy-makers and civil society activists in better understanding each other’s roles and positions and thinking about new, indicative ways of collaboration. Ahrens has continued with her academic career by becoming a guest professor at the University of Antwerp and a senior researcher in the European Research Council-funded project EUGenDem.

Ahrens adds: “Participating in EUGenDem allows me to deepen my research on supranational democracy by examining the European Parliament and its political groups’ role for gender equality and intersectional equality aspects.”

## DEMOCINCHANGE

- Coordinated by the University of Antwerp in Belgium.
- Funded under H2020-MSCA-IF.
- [cordis.europa.eu/project/id/702134](https://cordis.europa.eu/project/id/702134)
- Project website: [uantwerpen.be/en/staff/petra-ahrens](https://uantwerpen.be/en/staff/petra-ahrens)

## SOCIETY

# Inside the minds of ancient Egyptians

*An experimental project sought to understand how landscapes shaped the way religious, social and physical forces intertwined in ancient Egypt.*

How did ancient Egyptians perceive the world? This fascinating question was explored in the experimental MAP (Inside the Mind of Ancient People: the tangible and constructed landscape of the western Delta in the Late

Period (664-332BC)) project, which used ancient scriptures to learn how the physical environment shaped the minds of those living within it.

“MAP was a pioneer research project dealing with the definition of the constitution of space in ancient Egypt,” says Elena Tiribilli, principal investigator on the MAP project team.

The project sought to find specific points of contact where landscapes had profound effects on both individuals and collective Egyptian society, whose religious beliefs were closely linked to the physical world. “Ancient Egyptian religious elites conceived their external environment through mythical and symbolic interpretations, where the borders between religion and topography were much less clear than in modern perception,” emphasises Tiribilli.

MAP combined the critical theory ‘sociology of space’ with archaeological evidence to examine the fundamental links between thinking and space in relation to the geography of ancient Egypt.

The project focused on texts and the priests who wrote them, dating from the Late Period in Egyptian history (664-332 BC), from the western Delta of Egypt. It was during this epoch that ancient Egyptian scribes began documenting, canonising and codifying sacred regional geography.

“With all of the collected documentation related to these priests gathered together, there emerges a very dense and intricate picture, represented by many individuals with their families. The results have highlighted a complex social setting, consisting of an intricate web of relationships between people, the religious landscape, politics and territory of the First Millennium BC,” Tiribilli explains.

## CLASSIFYING THE DIVINE

New religious institutional figures known as ‘regionally specific sacerdotal officials’ arose in the Late Period, subjects which, until the MAP project, had not been extensively studied.

“The investigation of this kind of official had not attracted the attention of Egyptologists prior to our research, but they surely played a key role in the representation and ‘administration’ of the conceptual space inside the mind of ancient Egyptian society, since they were linked, through their epithets, to mythological and theological geographies,” Tiribilli says.

“Ancient Egyptian temple libraries contained a number of written texts, the so-called ‘cult-topographic manuals’, which provided lists of geographic places and religious

entities, which converted a physical geographical environment into an imaginary space through mythical and symbolic interpretations,” Tiribilli explains.

## INTO THE FIELD

The MAP project carried out a comprehensive study, taking six ancient Egyptian provinces into account. These provinces, from the second to seventh in Lower Egypt, are home to some of the most important religious centres such as the vast metropolis of Xoïs, and the ancient settlement of Kom el Hisn.

Thanks to the support of Horizon 2020 and the Marie Skłodowska-Curie programme, the MAP project was able to perform extensive museum and archive research and create a more detailed dataset related to these priests. Tiribilli carried out an archaeological survey in the western Delta to align archaeological, topographical and religious knowledge.

“The grant allowed me to investigate a relatively under-researched topic, and to shed new light on the relationships between people and the landscape during the First Millennium BC. I am also proud to have acquired multiple skills at the Department of Archaeology at Durham University, thanks to an inspiring and supportive team and to a flourishing environment,” Tiribilli concludes.

## MAP

- Coordinated by the University of Durham in the United Kingdom.
- Funded under H2020-MSCA-IF.
- [cordis.europa.eu/project/id/744977](https://cordis.europa.eu/project/id/744977)
- Project website: [egyptmapproject.wordpress.com](https://egyptmapproject.wordpress.com)



# Digital forensics seeks to enhance the preservation and analysis of our historical record

*Historical records are increasingly created and preserved as digital-only, yet many scholars lack suitable skills to carry out in-depth analysis. The DFitHH project created a framework to enhance future research.*

The digital revolution has transformed nearly every facet of society, including our shared historical record. Increasing amounts of documents and record collections in archives, legal repositories and public information stores are 'born-digital', as is the vast trove of information created each day from social media.

Yet even though such digital-born information is now integral to our cultural heritage, few scholars wield the skills necessary to carry out detailed analysis, and to draw relevant conclusions from the digital world with suitable integrity and accuracy.

The Horizon 2020-funded DFitHH (Digital Forensics in the Historical Humanities: Hanif Kureishi, The Mass Observation Archive, Glyn Moody) project, undertaken with the support of the Marie Skłodowska-Curie programme, explored the potential role of digital forensic methods for humanities research. Digital forensics is one branch of forensic science relating to the establishment of facts in the digital realm. The project uncovered what historians can learn from using these methods with born-digital records, and even how these new techniques affect scholars' understanding of terms such as text, document and records. It also showed how archivists should preserve

## PLANT HEALTH: PROTECTING PLANTS TO SAFEGUARD OUR FUTURE

Plants are the source of air we breathe and over 80 % of the food we consume. They play a critical role in achieving sustainable and competitive agriculture and forestry sectors and the protection of biodiversity and ecosystems. Therefore, keeping plants healthy is not only important – it is absolutely vital.

The achievement of healthy plants, however, is challenging for several reasons. For one, the trade and the movement of goods and people are facilitating the introduction, spread and establishment of plant pests and diseases.

Our latest **CORDIS Results Pack** features 10 Horizon 2020-funded projects devoted to tackling the threats to plant health.

To find out more, browse, download or order a physical copy of the Results Pack here:  
[cordis.europa.eu/article/id/413320](https://cordis.europa.eu/article/id/413320)



records in order to allow such research to take place in the future.

“It is incredible how much historians can learn from the materiality of born-digital records, provided archives preserved and processed them in a way that enables this kind of research,” says Thorsten Ries, a literary researcher at Ghent University.

## A FORENSIC APPROACH

The project used three born-digital archives as case studies: the personal digital archives of novelist, playwright and screenwriter Hanif Kureishi, technology journalist Glyn Moody, and the Mass Observation Project Archive. “The work with the archives resulted in awareness and advice for future improvement of archival workflows, tools and standards,” comments Ries.

The project was also motivated by the need to make born-digital records immutable, given how endangered digital records and formats are: “I was surprised to learn hands-on how fragile or even endangered born-digital historical records may be that are stored on present-day digital storage, especially in forensic terms,” admits Ries.

## GRANULAR ANALYSIS

“It was exciting to work with the archives and investigate types of historical file formats never analysed forensically before, types of forensic traces I rarely, if ever considered, including timestamp granularity, and the role of what seems to be data garbage in digital files,” Ries adds.

“Both myself and the project greatly benefited from the cooperation, the team spirit and the supportive, open and inspiring scholarly atmosphere.”

Historical digital forensic knowledge has an impact on present discourse as well. “Being able to verify and critically appraise born-digital historical records and assess their credibility is vital to historical scholarship. And this ability is important to our democratic discourse already today, as it ensures accountability and reliability of the historical record in the future”, says Ries.

Developing a successful cooperative relationship with his supervisor and collaborators at the Sussex Humanities Lab (SHL) was a very important experience for the researcher. “Both myself and the project greatly benefited from the cooperation, the team spirit and the supportive, open and inspiring scholarly atmosphere that makes SHL a great place to work at. And I hope I gave something back that made it even a little bit more excellent,” Ries concludes.

## DFITHH

- Coordinated by the University of Sussex in the United Kingdom.
- Funded under H2020-MSCA-IF.
- [cordis.europa.eu/project/id/794164](https://cordis.europa.eu/project/id/794164)
- Project website: [cradledincaricature.com/2018/04/17/msca-grant-award-digital-forensics-in-the-historical-humanities](https://cradledincaricature.com/2018/04/17/msca-grant-award-digital-forensics-in-the-historical-humanities)





# Optimising ocean energy, one wave at a time

*A multi-year project on harnessing wave energy generates useful results for an evolving green industry.*

When it comes to waves, Europe is truly blessed. The potential energy that could be harnessed along the continent's multiple coasts could cover around 10% of its electricity needs, while cutting carbon emissions and helping the transition to a carbon-free economy. EU businesses, keen to exploit this blue and green energy source, are racing ahead with research and development, and have put Europe at the forefront of the field.

Yet European engineers still have knowledge gaps about the full extent of the challenges related to operating wave energy technology in the open ocean. To this end, the OPERA (Open Sea Operating Experience to Reduce Wave Energy Cost) project embarked on a 31-month trial of an electricity-generating floating ocean device, to both test the viability of the technology, and harvest vast amounts of data critical to the advancement of the research field.

"OPERA's main goal is the long-term reduction of wave energy cost by at least 50%. We wanted to achieve this through the validation and de-risking of four industrial

innovations: novel biradial air turbines; advanced control algorithms; elastomeric mooring tether; and shared mooring systems. The team also set out to deliver open-access, high-quality open-sea operating data to the wave energy development community. This way, the project will avoid repeating early engineering mistakes and bring wave energy to the market more quickly," explains Pablo Ruiz-Minguela, head of wave energy at Tecnalia and OPERA project coordinator.

## FRUITFUL YEARS AT SEA

The device chosen to brave the open ocean, for three consecutive winters, was a floating wave energy converter, MARMOK-A-5. The conditions weren't easy for this hardy piece of technology, which draws energy from a wave-powered rotating air turbine. "MARMOK-A-5 has demonstrated survivability in rough seas up to 14 m maximum wave height and displayed increasing availability reaching 90%," says Ruiz-Minguela.



Though the prototype was designed to validate the technology's potential rather than focusing on energy production, it also generated some electricity, and was grid-connected through an umbilical power cable to an onshore substation. According to the results, a full-scale MARMOK device could generate enough energy to supply electricity to 150 households.

The OPERA research team also gained over 1 000 man-hours of operation and maintenance experience. The team feels confident in MARMOK's performance and robustness at sea. "The experimental results confirm that the innovations can improve turbine efficiency by 55 %, increase the overall power production by 30 % and reduce the peak loads in the mooring lines by 50 %," underlines Ruiz-Minguela.

Aside from its success as a proof of concept prototype, MARMOK gathered vast amounts of data during its time in the ocean. These data, which will be vital for companies operating in the wave energy industry, are grouped into five categories: environmental monitoring; mooring performance; biradial turbine performance; power output; and power quality.

### PASSING ON THE KNOWLEDGE

The testing delivered insights about making wave energy more competitive. "The wave energy community could leverage this information to better understand the sector challenges," says Ruiz-Minguela.

“A full-scale MARMOK device could generate enough energy to supply electricity to 150 households.”

Project partners are already using the new datasets to fine-tune their designs for wave energy technology and associated system infrastructure. Associated proposals based on the key exploitable results include a new floating device with a shared mooring configuration, new tethers for mooring systems, and advanced control algorithms.

"The operating experience in OPERA is not restricted to datasets. It also provided various lessons learnt and recommendations for the sector spanning data management procedures, application of international standards, planning of marine operations, as well as economics of wave energy, life-cycle and social benefits," Ruiz-Minguela concludes.

### OPERA

- Coordinated by the Tecnalia Research & Innovation Foundation in Spain.
- Funded under H2020-ENERGY.
- [cordis.europa.eu/project/id/654444](https://cordis.europa.eu/project/id/654444)
- Project website: [opera-h2020.eu](https://opera-h2020.eu)
- ▶ [bit.ly/2LpJM3](https://bit.ly/2LpJM3)

## ENERGY

# New Molten Salt Fast Reactor design increases nuclear energy safety

*Imagine a safe source of electricity that could meet our global needs for thousands of years, without generating carbon dioxide. Proponents of nuclear energy say it could deliver just that, with one project developing new safety features.*

According to a recent UN report, the world's population is expected to reach almost 11 billion by the end of this century, increasing the overall demand for energy provision.

Because of the greenhouse effect and climate change, there is an urgent need for large-scale energy solutions with low-carbon footprints.

Nuclear power is one such option. Indeed, the EU is the largest nuclear electricity generator in the world and nuclear energy is a fundamental component in the European Energy Roadmap 2050. Yet with memories of the Chernobyl and Fukushima-Daiichi accidents, safety and sustainability concerns must be met before widespread adoption can be achieved.

The EU-supported SAMOFAR (A Paradigm Shift in Reactor Safety with the Molten Salt Fast Reactor) project, under the Euratom research programme, has advanced the design of Molten Salt Fast Reactors (MSFRs) to deliver a breakthrough in nuclear safety and nuclear waste management.

Among its achievements, the project improved overall reactor design, developed integral safety assessment methods, designed freeze safety valves and generated better data about the behaviour of the salts used in the system.

### SAFE, SUSTAINABLE WITH OPTIMAL WASTE MANAGEMENT

The new generation of nuclear reactors are required to be designed with the highest safety standards incorporated from the outset. As outlined in the Sustainable Nuclear Energy Platform roadmap, the further development of fast breeder reactors and associated fuel cycles

“The project has led to many leading-edge code systems, instruments and innovations, and so has already helped position the EU at the forefront of the science needed for MSRs.”

is highlighted as particularly important due to their fuel efficiency, compared to burner reactors. “A breeder reactor produces more fissile material than it consumes, whereas a burner destroys more fissile material (mainly plutonium) than it produces,” explains Jan Leen Kloosterman, project coordinator.

SAMOFAR’s MSFR can operate either as a breeder reactor in the thorium fuel cycle with *in situ* recycling of radioactive elements (known as actinides) or as a burner reactor fuelled with plutonium and minor actinides, incinerating long-lived nuclear waste.

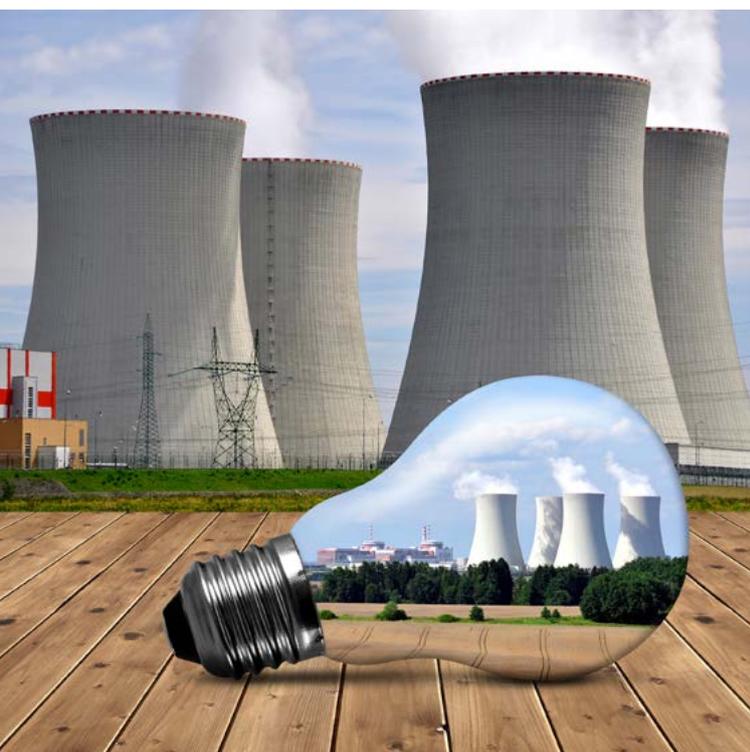
In the SAMOFAR-designed reactor, liquid salt carries the fuel and transports the heat. As the liquid salt is at ambient pressure, when heated it can expand freely, giving pronounced negative reactivity feedback. This means that if the reactor gets too hot, the fission reaction slows down automatically with the temperature stabilising to an acceptable level, as the passive decay heat is removed into the environment.

In the case of accidents, to remove decay heat, the fuel salt mixture will automatically be drained through ‘freeze plugs’ into fail-safe tanks. The fuel salt mixture is continuously cleaned in an integrated chemical plant.

The team ran a number of tests investigating the dynamic behaviour of internally heated fluid loops (such as molten salt in a reactor) and the properties of the fluid salt itself, looking at fission product release, thermophysical properties, freezing/melting phenomena and freeze plug performance.

Additionally, a software simulator was developed to demonstrate the SAMOFAR reactor’s response to operational transients (such as start-up, shutdown, load following, etc.).

“In conjunction with the tests, this gave us very useful insights into the dynamic behaviour and capabilities of the reactor, which were both excellent,” says Kloosterman.



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## FOR A STRONG EU NUCLEAR INDUSTRY

“The project has led to many leading-edge code systems, instruments and innovations, and so has already helped position the EU at the forefront of the science needed for MSRs,” concludes Kloosterman.

To take the work forward, the team is now advancing the modelling of the MSR and experimentally validating these codes to further ensure the avoidance of accidents.

## SAMOFAR

- Coordinated by Delft University of Technology in the Netherlands.
- Funded under H2020-Euratom.
- [cordis.europa.eu/project/id/661891](https://cordis.europa.eu/project/id/661891)
- Project website: [samofar.eu](https://samofar.eu)

## ENERGY

# Power-to-gas system enables massive storage of renewable energy

*Power-to-gas is bringing fresh momentum to the renewables field, providing a powerful approach to convert renewable power into ‘green’ hydrogen and methane. An EU-funded project developed flexible power-to-gas technology that offers the renewables sector an array of possible lucrative use cases.*

Over the last few decades, Europe has put in place some of the world’s highest environmental standards and ambitious climate policies to shape a sustainable future. Combatting climate change and reducing greenhouse gas emissions through efficient renewable energy systems are at the top of the agenda. Currently, the renewable generation capacity is estimated at around 20%, but according to the International Energy Agency, it is forecast to increase by 50% between 2019 and 2024. Certain countries already have plans to transition their electricity supply resources to 100% renewables by 2050.

These renewable energy scenarios bring many benefits, but also face significant challenges. Wind and solar power are highly intermittent – their electrical output cannot be used at any given time to meet society’s fluctuating electricity demands. “Energy storage plays an important role in balancing demand and supply, and helps create a more

**Renewable generation capacity** is forecast to **increase by 50%** between 2019 and 2024



“Thermoelectric power plant owners will have a chance to choose whether to sell or store the produced energy, avoiding the sale of low-priced electricity during low-peak hours.”

flexible and reliable grid system by decoupling energy production from its use. In the long term, the accumulated installed capacity can reach terawatt-hour values – this certainly calls for the development of new energy storage solutions,” notes Fabio Sarnataro, coordinator of the EU-funded ProGeo project.

### POWER TO GAS – A CRITICAL INGREDIENT IN THE ENERGY TRANSITION

While still in its infancy, power-to-gas (P2G) technology is one of the few viable options for large-scale energy storage solutions. Converting excess renewable energy into methane allows for storing high energy amounts for a long time in existing gas infrastructures. Researchers working on the ProGeo project successfully developed a 500 kW P2G modular unit. The system can store electricity by converting ‘clean’ hydrogen (obtained through water electrolysis) and CO<sub>2</sub> into methane with high flexibility.

“The ProGeo solution is essentially a process where excess or poorly profitable renewable electricity is used to power up an electrolyser and then gets stored in the form of methane for use at a later time depending on market demand,” explains Sarnataro. Methane is a flexible energy carrier that once purified can be used in manifold ways. “Converting renewable electricity into gas allows solar and wind power to be stored in the gas grid for several months. What’s more, methane provides a carbon-neutral fuel for heating and transport,” adds Sarnataro. Results from demonstration activities showed that the newly developed system can produce 25 Nm<sup>3</sup> of gas per hour, achieving 99% pure methane out of CO<sub>2</sub>.

### POTENTIAL DEPLOYMENT OF THE P2G SYSTEM

The ProGeo solution can highly benefit small thermoelectric power and cogeneration plants. The P2G system can be used to store the energy, in the form of methane, and when needed, be converted into electricity or heat. “Thermoelectric power plant owners will have a chance to choose whether to sell or store the produced energy,



avoiding the sale of low-priced electricity during low-peak hours,” explains Cristina Torrisi, Senior Public Funds Manager at Labor Srl.

What’s more, the ProGeo system can increase the sustainability of the P2G conversion process. Integrating the P2G system with a biogas plant not only will ensure a closed carbon cycle but can also prove particularly efficient: converting CO<sub>2</sub> contained in a biogas stream can almost double the amount of methane produced.

The ProGeo solution is one of the most efficient, cost-competitive alternatives to a low-carbon economy, helping maintain electricity grid balance.

### PROGEO

- Coordinated by PLC System SRL in Italy.
- Funded under H2020-SME and H2020-ENERGY.
- [cordis.europa.eu/project/id/717957](https://cordis.europa.eu/project/id/717957)

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# Cities come together to tackle mountains of waste

*Seven cities from the European Union united to test the best ways to reduce and recycle waste. The work on the Urban\_Wins project offers solutions to an emergency situation before it's too late.*

“The average EU resident generates about 5 tonnes of waste in a year, according to the latest figures collected across the 28 Member States by Eurostat. And disposing of all our waste has become a headache for local authorities, particularly for Europe’s towns and cities”, says Cinzia Vuoto, who heads environmental services in the city of Cremona in Italy.

“Although the percentage of recycling is high in Italy and in many other EU countries, the waste problem is an emergency situation,” Vuoto continues. “There aren’t enough plants able to really transform and recycle materials in a proper way, so that the material doesn’t lose its intrinsic value.”

Vuoto coordinated the Urban\_Wins (Urban metabolism accounts for building Waste management Innovative Networks and Strategies) project to tackle that emergency, pooling expertise and data from 24 EU cities in six countries and testing strategic plans in seven cities. Partners included local authorities, environmental associations

and waste disposal companies. The work is already helping authorities and consumers to share best practices and to cut back on waste production.

## GREEN EXPERIMENTS

Among the schemes tested, Cremona piloted a tariff system to charge residents based on the amount of waste they produced and is now producing a feasibility study to apply it across the city. It also tested a last-minute market where expiring products and food surpluses were donated to reduce the amount of good food being thrown away.

Bucharest in Romania focused on restaurants and bars with a ‘zero waste’ separation collection programme. The city council developed, debated and approved a waste plan for the historical centre, produced a mini guide on food waste prevention and management for restaurant staff and clients there and ran an awareness-raising campaign.



“ Although the percentage of recycling is high in Italy and in many other EU countries, the waste problem is an emergency situation. ”

Sabadell in north-eastern Spain started eco-awareness spaces to get residents talking and thinking about waste disposal.

“We really need to reduce waste production, especially packaging waste, which hasn’t been reduced in the last few years,” says Vuoto. Although in the EU waste production is decreasing, it isn’t happening fast enough given the pressure on landfill sites and the impact on the environment from landfill and incineration.

“There are also great differences between Member States,” adds Vuoto. “The starting point of the various pilot cities was very different. Urban\_Wins led to better knowledge, giving a full perspective of possible scenarios and it has allowed a real discussion with citizens.”

The project has produced a calculation model for designing waste strategies, and guidelines for drawing up programmes to introduce circular economies in cities, aiming to recycle waste and to use it to produce energy.

The project partners found, as Swedish teenage activist Greta Thunberg said at the COP25 climate summit, that



The average **EU resident** generates about **5 tonnes of waste** in a year

people are ready to make changes to their lifestyles to protect the environment.

“The cities were ready to face the proposals we presented on the project and enthusiastically welcomed the chance to discuss waste management, cutting waste and the principles of the circular economy,” concludes Vuoto.

#### URBAN\_WINS

- Coordinated by the City of Cremona in Italy.
- Funded under H2020-ENVIRONMENT.
- [cordis.europa.eu/project/id/690047](https://cordis.europa.eu/project/id/690047)
- Project website: [urbanwins.eu](https://urbanwins.eu)
- ▶ [bit.ly/31Ewvt9](https://bit.ly/31Ewvt9)

## CLIMATE CHANGE AND ENVIRONMENT

# New materials remove organic pollutants from wastewater

*Tertiary treatment of wastewater involves a range of physical/chemical processes for removing pollutants before it can be reused. Researchers have investigated a range of treatments based on advanced oxidation processes, filtration technologies and adsorption.*

New advanced technologies capable of improving or replacing conventional processes in wastewater treatment are necessary due to the growing number of xenobiotics present in aquatic systems at low concentrations,

typically in the micromolar or nanomolar range. Xenobiotics are chemical compounds that are foreign to plant and animal life because they do not naturally produce them. They include organic and synthetic compounds derived

from sources such as pharmaceuticals and are not easily removed by traditional water treatment procedures.

Although present in small amounts, xenobiotics can accumulate and potentially affect aquatic ecosystems and human health at large. Currently, the removal of xeno-biotics with conventional wastewater treatment processes is not always effective.

## APPLICATION OF NEW MATERIALS

Undertaken with the support of the Marie Skłodowska-Curie programme, the EU-funded Mat4treaT (Enhancing water quality by developing novel materials for organic pollutant removal in tertiary water treatments) project managed different approaches on the use of innovative materials and processes for water treatment. Scientists focused on the removal of 'contaminants of emerging concern', which include organic and synthetic compounds, derived from new sources such as pharmaceuticals that are becoming a major issue for citizens' health. The work was conducted by world leaders in the fields of graphene-based and other carbon-related materials, polymeric materials, oxidic ceramic materials, and hybrid inorganic-organic materials.

Consortium members comprised eight universities and two non-academic institutions committed to the development of novel materials for removing emerging pollutants via innovative integrated tertiary treatment of

water. "Project partners devoted much of their work to understanding process fundamentals, kinetics and mechanisms, development of new materials, modelling, process integration and scale-up," says project coordinator Giuliana Magnacca.

Scientists studied new materials for use as adsorbents, photocatalysts and active layers for the fabrication of membranes, testing them for pollutant removal from both model aqueous solutions and real water samples. They also developed several categories of materials for use in integrated technology for separation of pollutants from contaminated waters and their subsequent degradation.

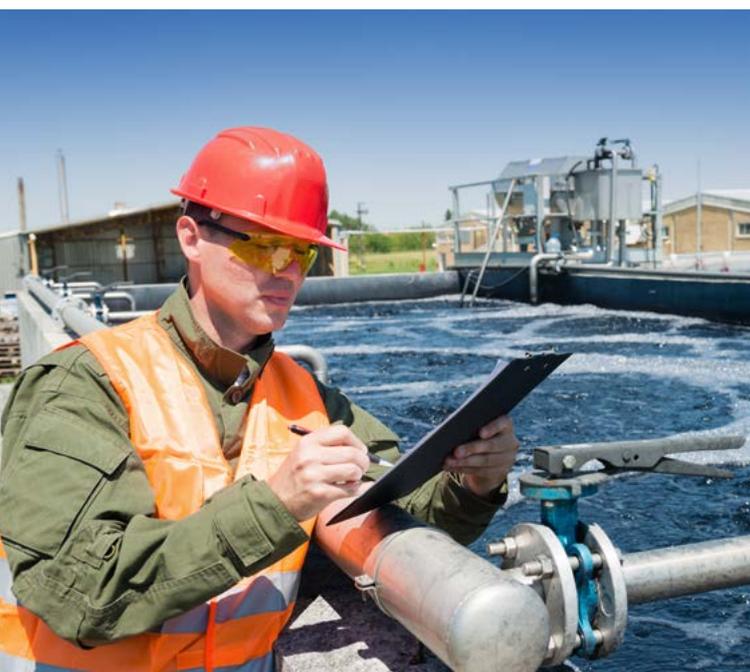
## COST-EFFECTIVE AND ENVIRONMENTALLY FRIENDLY

Researchers built two lab-bench devices for validating this approach. The devices are made of a membrane that acts as a filter, separating the contaminants from water. "The membranes are made of or contain materials that are activated by sunlight to produce active species capable of degrading contaminants to achieve their complete abatement," Magnacca explains. "Magnetic materials are also employed to entrap the contaminants when they are properly activated by the presence of organic molecules. After use they can then be removed very easily from water by a magnet."

"Once the best technology has been tested, it is possible to scale up the process in a pilot plant treating large volumes of water," comments Magnacca. Mat4treaT has successfully developed innovative low-cost materials for removing organic pollutants from wastewater. "In some cases, they are derived from humic substances extracted from composted refuses, therefore petroleum-free sources are employed for their production. Moreover, the use of humic waste, thereby valorising the organic component of refuse, supports the actions of citizens who separate their domestic waste," Magnacca points out.

### MAT4TREAT

- Coordinated by the University of Turin in Italy.
- Funded under H2020-MSCA-RISE.
- [cordis.europa.eu/project/id/645551](https://cordis.europa.eu/project/id/645551)
- Project website: [mat4treat.unito.it](https://mat4treat.unito.it)





SPECIAL FEATURE

# INFUSING THE DIGITAL INTO EUROPEAN EDUCATION

## Editorial

‘If you are planning for a year, sow rice; if you are planning for a decade, plant trees; if you are planning for a lifetime, educate people.’ – Chinese proverb

To be successful in the modern workforce, students need to be equipped with the skills that are most in demand from employers. The ability to write well, analyse and problem solve are the crucial classic ‘soft’ skills that are highly sought, but digital skills have become just as valuable and cherished. The global marketplace is increasingly dominated by technology, and the digital realm is seeping into all aspects of life and the economy.

But it’s not just tech-savvy graduates aiming for an entry-level role in an innovative start-up who need to worry about their digital skills. Industrial workers in sectors as diverse as manufacturing, energy and mining, as well as administrative staff and bank managers need to become fully comfortable in the digital sphere as well. By upskilling students with the digital skills required for a globalised world economy, everyone benefits – companies remain competitive and the economy is strengthened. At the same time, all workers, regardless of age, profession or income, should also have the opportunity to upskill themselves throughout their careers.

Digital skills need to be embedded right from the very beginning of formal education, in kindergarten/playschool right through to secondary school and tertiary education, whether that be university or a more vocational route. The education system itself and the very methods by which students learn and teachers teach must be adapted for the era

of digitalisation. In short, digital technologies have become an inseparable aspect of the learning process.

The EU does not have formal competences in the education arena but it does work on several initiatives that aim to help modernise education and training (such as those outlined in the Digital Education Action Plan) and provides funding through Horizon 2020 to promote digital technologies used for learning. In Horizon 2020’s 2018-2020 work programme, the focus is on supporting actions on smarter, open, trusted and personalised learning solutions to optimise digital learning and allow learners to engage and interact with both content and peers.

In our special feature this month, we’re meeting seven Horizon 2020-funded projects that have developed innovative solutions to infuse the digital into European education. These include one that has harnessed digital technologies to encourage entrepreneurship in youngsters, another that is using innovative online methods to bring books and reading to life, and finally one that has created a digital solution for encouraging more students to engage with STEM (Science, Technology, Engineering and Maths) subjects.

We look forward to receiving your feedback. You can send questions or suggestions to [editorial@cordis.europa.eu](mailto:editorial@cordis.europa.eu).

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DOIT: practical experiences for future innovators

## Bringing books to life by combining a child's imagination with innovative technology

*What better way to inspire a love of reading in children than to make the written work interactive, publish their own writing in e-books and get them to write about their ideas of life in space? This winning combination has been explored by the STORIES project with EU support.*

By integrating the latest advances in augmented and virtual reality (VR) and 3D printing technologies, the STORIES (Stories of Tomorrow – Students Visions on the Future of Space Exploration) project is giving children the chance to develop their own 'multipath' books to express their imagination and creativity. As Franz Bogner, project coordinator and Head of the Department of Biology Education at the University of Bayreuth, explains: "A multipath book is one which offers the reader various ways to explore the narrative within it. The authoring tool we developed allows students to interconnect their stories to create extended episodes encompassing a network of hotspots and hyperlinks."

The project case study involved students creating their storyboards and flip book type animations depicting life in the first Martian community. With the help of visiting scientists and engineers, they first learned about the challenges presented by such a hostile environment. In small groups, the students created their designs using commonly found materials, such as cardboard and paper cups. They then took their creations to the next level by recreating them as a virtual 3D model.

The students went even further with their stories by using the VR & AR Authoring Tool of the STORIES project's platform. To log in to the platform, all that teachers have to do is register themselves and the school they are working for.

Through an easy-to-use, powerful interface which has sophisticated authoring features, students were able to convert their models into digital form, and integrate texts, animation videos and music. These can then be collated



“Bringing personal experience into the classroom, and engaging students in new activities that are not normally possible, holds the potential to truly transform knowledge retention.”

to form virtual books which can be accessed by any existing device and operating system.

“Through the use of VR headsets and augmented reality, the e-books created by students come to life! Students can see their own rockets being launched right through the e-book page and they can also walk around the sustainable Martian colony they have built in the previous steps,” explains Gregory Milopoulos, project manager of STORIES, and Senior Educational Researcher at the R&D Department of Ellinogermaniki Agogi.

The team behind the STORIES project believes allowing students to create VR experiences as part of project-based learning and thinking of new applications for technology will allow for a real change in education.

“Bringing personal experience into the classroom, and engaging students in new activities that are not normally possible, holds the potential to truly transform knowledge retention. This has been verified by the results of the STORIES evaluation analysis. Some students naturally learn better by seeing, others by listening, others still by performing hands-on activities and STORIES can provide

teachers with resources that suit all three,” says Sofoklis Sotiriou, Director of the R&D Department of Ellinogermaniki Agogi.

The STORIES Digital Library consists of all the stories that were created by the participating students and of all the digital assets they used or created. Since this was a public deliverable, these are all open to everyone, so students can be inspired to create their own stories. Of course, commercial use of these stories or assets is not allowed.

The library consists of three main sections: the created stories; the public 2D and 3D assets; and the toolkits and guides for teachers. Items in the last two sections are available for download. Items in the first section are only available through the web and cannot be downloaded (at this stage) but they can be freely viewed on any PC, tablet or mobile. A right click of the mouse on the selected book will open up access to the 3D content.

## STORIES

- Coordinated by the University of Bayreuth in Germany.
- Funded under H2020-LEIT-ICT.
- [cordis.europa.eu/project/id/731872](https://cordis.europa.eu/project/id/731872)
- Project website: [storiesoftomorrow.eu](https://storiesoftomorrow.eu)
- [bit.ly/37dtBN1](https://bit.ly/37dtBN1)

# Online scenarios clear the path to digital competences

*DigComp is a cornerstone of the EU's strategy to boost digital skills in Europe. Thanks to work under the CRISS project, the framework is now making its way into classrooms, providing students and pupils with certifications for digital competences.*

The growing importance of digital competences in the job market is a considerable challenge for teachers in Europe. Unlike 'traditional' disciplines, the digital world is in a state of constant evolution. Keeping up with the pace requires education tools to evolve with teachers' needs, with programmes starting as early as possible.

This is pretty much what the CRISS project boiled down to: addressing the digital competence gap, whilst allowing teachers and national education systems to have a say in how to do so. The project consortium developed a new cloud-based digital learning ecosystem and tested it in over 535 European schools.

"Teachers could experience in real-life the use of a method and tool for acquiring digital competence. They now have a better insight and were pleasantly surprised with the results, which is perhaps the project's greatest impact," says Anna Palaiologk, Senior Research Consultant at EXUS and coordinator of the CRISS project.

The CRISS platform provides two components: a main component that offers all the functionalities and services required by both teachers and students, and an analytical component that allows for the evaluation of digital competences.

## BEYOND COMPUTER SCIENCE

Once connected to the main platform, teachers are presented with a list of learning scenarios they can use to teach digital skills and put them into perspective. For example, 'Alice through the screen and what Alice found there' helps students reflect on the impact technology has on the environment and how to reduce it, whereas a scenario such as 'Reach 20 first' teaches computational thinking and applies it to different situations. As Palaiologk points out: "Instead of isolating digital competence in the computer science class, CRISS integrates the use of digital tools into the wider school curriculum."

The platform includes a social network where teacher/student communication takes place, as well as a variety



of ICT tools which can be used by students to carry out the activities described in the scenarios. Two of these tools are provided by the CRISS team: Magellan, a platform for creating mixed reality experiences; and Portably, a multimedia content creation tool.

More than the technology itself, the main innovation of CRISS lies in its operationalisation of the DigComp framework for use in the classroom. The project adds an operational layer to this framework, which connects its competences with concrete indicators to assess student progress.

All in all, the operational concept extends digital competence to five areas and 12 sub-competences with their own performance criteria and indicators. The solution has been tested in six EU countries with seven pilots, and the latter were so successful that participating schools wanted to extend the piloting for another year after the end of the project, while more schools that have heard about the project wanted to join. The CRISS consortium is currently considering ways to keep collaborating with these schools and expanding the partnership to technology providers in more countries.

“Meanwhile, the CRISS framework and scenarios have an open access IPR. They can be integrated into any learning management system or personal learning environment already used in schools,” Palaiologk explains. “The platform components are ready to be purchased by any interested school. There is a trial version available and each component can be bought either in isolation or as a set of modules.”

CRISS is very likely to make a mark on the education sector at large. Its outcomes have potential to impact all actors, with more qualified students, schools that can better describe what they want in their procurements, and regional education directorates having a clear picture

of which policy actions are needed. The regional Government of Catalonia has already decided to adopt the CRISS methodology, while the Greek Ministry of Education also aims to use it in public schools.

## CRISS

- Coordinated by EXUS Software in the United Kingdom.
- Funded under H2020-LEIT-ICT.
- [cordis.europa.eu/project/id/732489](https://cordis.europa.eu/project/id/732489)
- Project website: [crissh2020.eu](https://crissh2020.eu)
- ▶ [bit.ly/3bqhsaX](https://bit.ly/3bqhsaX)

## Learning maths with a melody

*By introducing new pedagogical methods and cutting-edge technologies that integrate music into science, technology, engineering and mathematics activities, one EU researcher aims to increase students' problem-solving skills.*

They say there are two types of people: right-brained and left-brained. On the one hand, science, technology, engineering and mathematics, or STEM subjects, rely on the left half of the brain and are thus logic-driven. On the other hand, artistic activities, which use the right side of the brain, foster creative problem-solving.

“Problem-solving is one of the key skills for the 21st century job market, and teaching only STEM subjects is no longer sufficient,” says Vassilis Katsouros, a researcher at the Athena Research Centre’s Institute for Language and Speech Processing. “To prepare today’s school children for their future, schools need to begin teaching a science, arts, technology, engineering and mathematics – or STEAM – curriculum.”

Katsouros also serves as the coordinator of iMuSciCA (Interactive Music Science Collaborative Activities), an EU-funded project dedicated to introducing new pedagogical methods and cutting-edge technologies for integrating music into STEM activities.

### ONLINE WORKBENCH OF RESOURCES

iMuSciCA aims to demonstrate how schools can integrate the arts and STEM to teach students comprehensive

problem-solving skills. To do this, the project developed an online workbench of resources that teachers can use to incorporate musical activities into physics, geometry, maths and technology lessons.

With the iMuSciCA online tools, students use a computer to design a virtual musical instrument. To teach a physics lesson on wave theory, for example, a teacher can have the students design a string instrument and change



“*Problem-solving is one of the key skills for the 21st century job market and teaching only STEM subjects is no longer sufficient.*”

its length, thickness and string material to see how this affects the sound properties.

“I’ve also seen lessons where students used instruments to compose their own music or play in a band,” says Katsouros. “One class even created physical instruments via 3D printing technology.”

### A EUROPEAN FIRST

To date, over 300 students in schools located in Belgium, France and Greece have benefited from iMuSciCA-inspired lessons. Although each of these pilot lessons differed in how it used the iMuSciCA workbench, all resulted in the students benefiting from a deeper understanding of STEM subjects.

“iMuSciCA stands out as one of the first European projects attempting to combine an innovative STEAM pedagogical framework with a variety of technologies deployed in real educational settings,” adds Katsouros. “Based on the pilots conducted during this project, we are confident that iMuSciCA is well-positioned to be marketed as a means for adopting STEAM pedagogy and fostering creative problem-solving.”

Project researchers are now working to disseminate the iMuSciCA platform to more schools and integrate it into the emerging EdTech market.

### IMUSCICA

- Coordinated by Athena Research & Innovation Information Technologies in Greece.
- Funded under H2020-LEIT-ICT.
- [cordis.europa.eu/project/id/731861](https://cordis.europa.eu/project/id/731861)
- Project website: [imuscica.eu](https://imuscica.eu)
- ▶ [bit.ly/2W1BJOV](https://bit.ly/2W1BJOV)

## Online labs for more engaging STEM education

*Since 2016, Go-Lab has become the must-have ecosystem for teachers wanting to engage their students in science, technology, engineering, and mathematics education. Work under the Next-Lab project has brought major improvements that will further establish Go-Lab’s online laboratories in European classrooms.*

We’ve all experienced the shortcomings of ‘traditional’ science, technology, engineering and mathematics (STEM) education: learning about a topic from a teacher exposing theory is great, but without practical experimentations we can only scratch the surface of the subject.

Experts tend to agree that the solution lies in more engaged instruction. Next-Lab (Next Generation Stakeholders and Next Level Ecosystem for Collaborative Science Education with Online Labs) brings about its own vision of how to get there by extending the Go-Lab ecosystem, which provides an extensive collection of interactive online (remote and virtual) laboratories and dedicated support tools (learning apps). Together with multimedia material presenting directive information to students, these laboratories and tools generate what the project consortium calls ‘inquiry learning spaces’.



“Online laboratories in inquiry mode require students to conceptualise, experiment, and draw conclusions. Unlike hands-on laboratories which often work as recipes students have to follow, students can safely and easily perform free experiments so that they can genuinely build new knowledge by themselves,” says Ton de Jong, Professor of Instructional Technology at the University of Twente and Next-Lab coordinator. “But there are two caveats: students need to enter the inquiry process with sufficient knowledge, and they need support during the inquiry process.”

### AN ECOSYSTEM OF 45 APPS

Next-Lab’s unique combination of tools solves both problems by combining instructions and inquiry while providing learning support. The ecosystem offers 45 apps to help students come up with hypotheses, create a concept map, design experiments, draw conclusions, etc. It also offers a set of learning analytics apps which provide students with overviews of their learning activities or products, as well as comparisons with the behaviour and products of their classmates. “These learning analytics apps are meant to stimulate students to reflect on their learning,” de Jong explains.

Go-Lab has already had tremendous success over the past few years. The ecosystem has effectively become the standard for modern digital inquiry-based learning. It offers the largest set of online laboratories (over 600) in one place and has over 20 000 sessions per month. De Jong estimates that some 120 000 students have used Go-Lab in a real classroom situation, while the worldwide Go-Lab community of teachers keeps growing.

Compared to the original Go-Lab, Next-Lab’s iteration comes with a new design, interface and functionalities. “Besides the learning analytics apps, we have added

“ *Besides the learning analytics apps, we have added apps for primary education, collaboration facilities, a peer assessment option, a modelling tool and a portfolio facility.* ”

apps for primary education, collaboration facilities, a peer assessment option, a modelling tool and a portfolio facility,” says de Jong. “Under the hood, the existing ecosystem has been restructured to handle a larger number of users, improve system maintenance and meet GDPR requirements. The sharing platform has been reimplemented with up-to-date technology, and the ILS library has been replaced by a modern Graasp API.”

Looking at its evolution, it seems clear that Go-Lab is here to stay. The project consortium intends to generate revenues from courses and by offering labs from commercial providers, while the current Go-Lab system will remain free to use. New projects are already running, such as GO-GA, which is introducing Go-Lab to several African countries. Development will continue as well, with the project team already working on making existing apps more intelligent. “We also plan to extend the idea of combining interactive applications other than labs with multimedia material and apps dedicated to other learning approaches such as computational thinking,” de Jong concludes.

#### NEXT-LAB

- Coordinated by the University of Twente in the Netherlands.
- Funded under H2020-LEIT-ICT.
- [cordis.europa.eu/project/id/731685](https://cordis.europa.eu/project/id/731685)
- Project website: [nextlab.golabz.eu](https://nextlab.golabz.eu)
- ▶ [bit.ly/39qybJn](https://bit.ly/39qybJn)

# A digital highway from secondary school to university

*The next generation digital learning environment has started making its way into secondary schools, thanks to the Up2U project. Objective: facilitating students' acclimatisation to university tools and methodologies.*



environment. Up2U is meant to help them develop their digital skills and make the transition from secondary education to university much smoother,” says Erik Kikkenborg, Media Services Manager at NORDUnet and coordinator of the project.

Up2U therefore aims to bridge the technological and methodological gap between secondary schools and universities. It does so by means of an NGDLE ecosystem which facilitates more open, effective and efficient co-design, co-creation and use of digital content, tools and services. This ecosystem has been specifically built to deliver personalised, collaborative or experimental learning.

With Up2U, the LMS is no longer the central tool. The ecosystem works like a marketplace where users can pick the LMSs they need, knowing that they all integrate which each other and that achievements and progress can be transferred from one to another without ever compromising on user experience. The content is open and reusable by both teachers and students. As Gyongyi Horváth points out: “Up2U is a portable, open, pedagogy-driven digital ecosystem built with the learning community in mind.”

## TESTED IN FIVE MEMBER STATES, WITH MORE TO COME

The marketplace approach is particularly valuable when it comes to adapting to different contexts. The schools in our Up2U pilot countries – Germany, Greece, Hungary, Italy, Lithuania, Poland and Portugal – had varying levels of technology use and access. One of the prerequisites to project success was therefore to propose a system where all necessary components are integrated into a single platform, while also allowing some schools to use only those parts they don't have already.

“This leads to the requirement that software components be kept as loosely coupled as possible while still being integrated from a user experience perspective,” says Horváth. “The next challenge was then to convince school-teachers to work with the Up2U ecosystem and to use it with their students in classrooms. To accomplish this,

Excitement around learning management systems (LMSs) has not even died down, yet educators are already looking forward to the next big thing: Next generation digital learning environment (NGDLE).

Unlike LMSs which are primarily built around the needs of instructors, an NGDLE is an educational ecosystem where all aspects and actors of e-learning are interconnected seamlessly. An NGDLE could be such a great step forward for students, in fact, that the EU-funded Up2U (Up to University – Bridging the gap between schools and universities through informal education) project is using it as a basis for its attempt to bridge the gap between secondary school and higher education.

“We realised that the lack of digital skills is one of the main reasons why students drop out of university. After graduating, they enter tertiary education without the necessary background to cope with their new educational

“Up2U is a portable, open, pedagogy-driven digital ecosystem built with the learning community in mind.”

we developed the Continuous Professional Development methodology (CPD).”

The CPD is split into three modules: teacher training by the national training team, introduction of Up2U by teachers to their students, and knowledge sharing from level 2 teachers to level 1 teachers. “By using this CPD methodology, we speed up in-depth adaptation to the Up2U ecosystem inside pilot schools,” says Horváth.

Most of the pilot countries have already committed to running a national programme for the Up2U ecosystem after the project ends. Meanwhile, Israel and the UK have kick-started online education based on CPD methodology,

and the first non-project partner pilot has started in Slovenia. “We have received interest from more European countries like Armenia and Finland to start pilots in their countries. We support these pilots with the Get Started! course, an online training course based on the CPD methodology,” Horváth explains.

Up2U is scheduled for completion at the end of May 2020. The final phase of the project will focus on analysing the results of the pilots and implementing the sustainability plan for after the project’s end.

#### UP2U

- Coordinated by GÉANT Vereniging in the Netherlands.
- Funded under H2020-LEIT-ICT.
- [cordis.europa.eu/project/id/732049](https://cordis.europa.eu/project/id/732049)
- Project website: [up2university.eu](https://up2university.eu)
- ▶ [bit.ly/2Hc5h3J](https://bit.ly/2Hc5h3J)

## Innovative technology-enhanced learning makes STEM fashionable

*The NEWTON consortium has had enough of negative perceptions around science, technology, engineering and maths education. Over more than 3 years, they devised new teaching methodologies based on innovative solutions such as virtual reality and gamification to organise its return to favour.*

Students across Europe are increasingly disengaged with science, even though its importance in the job market never ceases to grow. So how do we reverse this trend? For the consortium running the now-completed NEWTON (Networked Labs for Training in Sciences and Technologies for Information and Communication) project, the answer is clear – if anything can get students back onto the science train, it’s technology-enhanced learning.

From March 2016 to August 2019, the project developed a set of new Technology-Enhanced Learning (TEL) mechanisms and built a platform targeting all stakeholders in education. Gabriel-Miro Muntean, Associate Professor with the School of Electronic Engineering at Dublin City University and NEWTON coordinator, discusses its results as well as future plans to increase its reach and further enhance its technology.

### What type of learning gaps did you aim to close with this project?

Gabriel-Miro Muntean: The NEWTON project has designed, developed and deployed innovative solutions for TEL in science, technology, engineering and maths (STEM) education. These solutions address the global problem of decreasing interest in STEM subjects. Many students tend to consider these subjects as either boring or very difficult and eventually become disengaged from STEM topics, especially if they are struggling to understand certain complex concepts or have lower grades.

TEL solutions in general, and NEWTON approaches in particular, offer avenues to improve students’ understanding of STEM subjects and increase their interest. We hope our solutions will not only play an important role in students’ immediate education at primary, secondary

or tertiary levels, but also contribute decisively to their future career choice.

### What would you say are the most innovative aspects of the NEWTON project, from a technological point of view?

The NEWTON project has designed multiple technology-rich solutions for adaptive multimedia and multiple sensorial media (multimedia) content delivery, virtual reality-enhanced learning, remote fabrication labs-based education, and gamification and personalisation-based teaching and learning.

These technologies are designed to be used as stand-alone or in conjunction with different pedagogical approaches. The project has also built an innovative Learning Management System called the NEWTON Technology-Enhanced Learning Platform (NEWTELP) which deploys the NEWTON project technologies and allows students and teachers to interact with content and courses in an innovative manner.

### Could you tell us more about these pedagogical approaches you focused on?

These include self-directed, game-based and problem-based learning. Deployment in real-life pilots across Europe has demonstrated that all of them improve the learning process.

However, the best results in terms of increase in learner satisfaction were achieved when NEWTON's game-based learning was employed, especially in the pilots involving primary school students. The use of virtual reality and virtual labs to introduce the circuit of water in nature, teach students about animals living in forests or in oceans, or immerse them in a virtual experience on the surface of different planets of our solar system were particularly successful.

### Looking back, what do you consider as the most important outcomes of the project?

NEWTON has shown that by making use of TEL and especially of innovative technologies, we can raise the quality of the learner experience, increase satisfaction, improve the learning process and maintain or even improve learning outcomes.

### Can you tell us more about the real-life validation? How did you proceed and with what results?

Validation was conducted across 20 primary, secondary and vocational schools as well as third-level education institutions, including schools with students with special learning requirements. It took place in six European countries – Czechia, Ireland, Italy, Romania, Slovakia and Spain – and involved three large-scale and 34 small-scale pilots. The pilots included diverse STEM disciplines ranging from earth science, geography and astronomy to programming and networking.

Our assessment of results followed a specifically designed toolkit. We targeted learning satisfaction, learning outcome, system performance and usability and involved over 1 500 students. The results are available in many scientific conference and journal publications and in a book.

### Have you been following up on the project's results since its completion? Do you have any plans to further develop your methods and tools?

The NEWTON platform and third-level educational content are still being used at Dublin City University – Ireland, the National College of Ireland and the Slovak Technical University of Bratislava in Slovakia.

The primary level content has been made available to the next generation of students in Irish and Romanian primary schools which took part in the NEWTON project pilots.





**Gabriel-Miro Muntean,**  
NEWTON Coordinator  
© GMMuntean

“ *The use of virtual reality and virtual labs to introduce the circuit of water in nature, teach students about animals living in forests or in oceans, or immerse them in a virtual experience on the surface of different planets of our solar system were particularly successful.* ”

They use the innovative NEWTON TEL methodology and content to complement their current education process.

Finally, selected NEWTON solutions will be used in collaboration with the coordinators of a business course at Dublin City University and with some secondary schools in the Basque Country. Some NEWTON partners are currently working on a new project proposal to enhance NEWTON

solutions with collaborative learner support and social media integration capabilities.

### What do you hope will be the long-term impact of NEWTON?

The results of the NEWTON project have impacted the life of the more than 1 500 students and teachers who directly participated in the pilots, along with many others since the end of the project. Our excellent results in terms of learning satisfaction and outcome may contribute to changing students' false impression that STEM subjects are difficult and/or boring, and hopefully they will help attract more of them to STEM careers.

#### NEWTON

- Coordinated by Dublin City University in Ireland.
- Funded under H2020-LEIT-ICT.
- [cordis.europa.eu/project/id/688503](https://cordis.europa.eu/project/id/688503)
- Project website: [newtonproject.eu](https://newtonproject.eu)
- ▶ [bit.ly/2OKLyvV](https://bit.ly/2OKLyvV)

## DOIT: practical experiences for future innovators

*In a digitalised world, the capacity to turn ideas into concrete innovation has become priceless. The DOIT toolbox aims to enable 6 to 16 year-olds to thrive in this new context.*

A memorandum for entrepreneurial skills in the digital market will soon be circulated across Europe. Its goal? Ensuring that, in the future, young people with a creative mindset can turn their ideas into innovations, improving the lives of European citizens.

It's not just wishful thinking. The organisations behind this memorandum have been working together under the DOIT (Entrepreneurial skills for young social innovators in an open digital world. A European Initiative) project since October 2017, and they have a major trick up their sleeves: a toolbox providing open educational resources under an open licence.

“A more engaging and practice-based approach is needed to provide young learners with the mindset and skills they need to become innovative citizens. What we suggest is to empower them through collaborative work on creative

solutions for societal issues,” explains Sandra Schön, senior researcher at Salzburg Research and DOIT coordinator.

### SHOWCASING THE DOIT TOOLBOX

The DOIT toolbox consists of an interactive city map with different ‘buildings’ or makerspaces. Each makerspace represents a different phase in the development process of a project and contains various materials. The ‘wall of failures’, for instance, is a training course that will help students in dealing with failures and setbacks during a project while remaining proud of themselves. The training materials cover all the steps of entrepreneurship, but first and foremost they push towards increased collaboration.

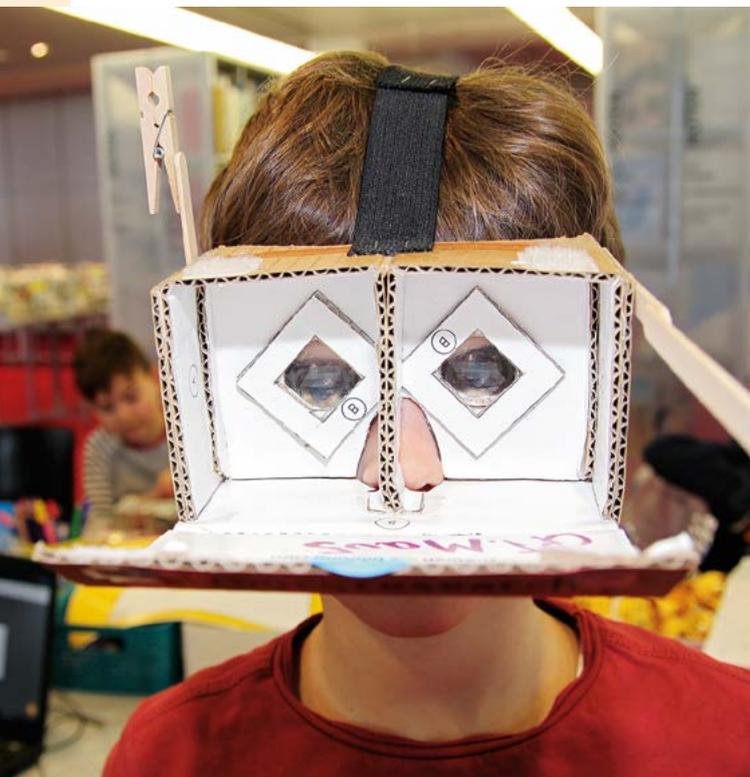
“This happens already in a growing number of makerspaces around Europe, where like-minded people get together and work on innovative projects using various

digital and other productive tools,” says Schön. “Some makerspaces have already been set up in pioneering schools. These can boost practice-based, engaging and meaningful learning of social entrepreneurship.”

The DOIT approach has been trialled and evaluated in pilots in 10 European countries. These pilots involved a total of 1 002 children from 6 to 16 years old, with the evaluation showing encouraging results such as increased creativity, self-efficacy and entrepreneurial intentions amongst participants.

“This was really unexpected,” Schön enthuses. “Existing research had shown lower self-efficacy scores following entrepreneurial education interventions for the targeted age ranks, mostly due to the realisation that being an entrepreneur is not easy and own competences may not be as well developed as needed. We were positively surprised to see this as not the case for the DOIT pilots: We could witness moderately to significantly higher scores in the younger (6 to 10 years) and older (11 to 16 years old) age groups after the pilot. Our guess is that the makerspace as an open learning space could be the factor for this positive development.”

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“ *This happens already in a growing number of makerspaces around Europe, where like-minded people get together and work on innovative projects using various digital and other productive tools.* ”

## INTEGRATING DOIT INTO EUROPEAN CURRICULA

DOIT findings and insights can be found across several reports and publications, including specific ones on how to reach girls, how to work with disabled children or how to work with pop-up makerspaces in schools. Now, the team will be focusing on getting the word out through its upcoming memorandum.

“Our objective is to get support for the integration of DOIT activities into European curricula and education policy strategies. Of course, this is a challenge, but the Council of the European Union’s Recommendation on Key Competences for Lifelong Learning makes us confident in our chances. Under point 2.5, the Council asks Member States to pay special attention to ‘nurturing entrepreneurship competence, creativity and the sense of initiative especially among young people, for example by promoting opportunities for young learners to undertake at least one practical entrepreneurial experience during their school education.’ Our memorandum, which suggests a DOIT experience for every young learner between 6 and 16 years old, would achieve just that,” Schön concludes.

### DOIT

- Coordinated by Salzburg Research in Austria.
- Funded under H2020-SOCIETY.
- [cordis.europa.eu/project/id/770063](https://cordis.europa.eu/project/id/770063)
- Project website: [doit-europe.net](https://doit-europe.net)
- ▶ [bit.ly/2HauDPi](https://bit.ly/2HauDPi)



# Identifying agricultural risk from emerging wastewater contaminants

*Growing antibiotic resistance is risking the health of future populations. As part of the problem stems from antibiotics entering agriculture via treated wastewater, PhytoPharm set out to explore how this happens.*

With increasing demand for freshwater resources due to climate change and global population growth, reusing wastewater has become a viable alternative for crop irrigation in water-stressed regions.

However, this wastewater is known to contain the residues of pharmaceuticals, including the many antibiotics that are prescribed for treatment. Although these occur as mixtures of multiple compounds in wastewater irrigation, little is known about the effect they have on soil and plant health.

Using barley as its model crop, the EU-supported PhytoPharm (Phytotoxicological Risk of pharmaceuticals in soils) project investigated the impacts of antibiotic mixtures. The researchers showed that plants in their early growth stages were most susceptible, with increased antibiotic exposure resulting in fewer seeds germinating.

This effect occurs at concentrations predicted for wastewater effluent. Furthermore, evidence suggested that the impacts of antibiotic exposure may be enhanced when combined with other stressors.

## CONTAMINANT PREDICTION

To address the challenge of determining representative mixtures of pharmaceuticals in wastewater, the PhytoPharm team developed an algorithm to predict antibiotic concentrations in wastewater effluents.

“Our approach can help predict the composition of environmentally relevant antibiotic mixtures resulting from the human use of antibiotics,” explains Marie Skłodowska-Curie research fellow Brett Sallach. “This model can be adapted to any locality and any pharmaceutical medicine where prescription data exists and at multiple scales.”



The model's utility was also demonstrated by evaluating potential hotspots of antibiotic resistance in rivers at the continental scale using EU pharmaceutical prescription data, further refined for the United Kingdom and to catchment scale for the village of Strensall, in England. This can be used to identify locations where antibiotic concentrations may cause increased risk of antibiotic resistance and which compounds are likely responsible.

## IDENTIFYING RISKS TO AGRICULTURAL SYSTEMS

The researchers utilised the algorithm to conduct a mesocosm study of barley irrigated with a synthetic wastewater composed of antibiotics at representative concentrations. "We evaluated the antibiotic impacts on a number of chemical and biological endpoints, including plant growth and productivity, net ecosystem exchange of greenhouse gases, microbial community structure, and the proliferation of antibiotic resistance genes in the soil," elaborates Sallach.

The team found that certain compounds are more mobile than others in the plant-soil system. However, they also showed that there was not a significant accumulation of antibiotics added by routine irrigation, indicating that the compounds are being degraded either biotically (microbial degradation) or abiotically through hydrolysis and photolysis.

Results also showed that despite a toxic effect in the early stages of barley growth, the mature plant was not

measurably impacted by antibiotic exposure. Regarding increased resistance, the team suspects that it is influenced more by length of exposure time, than increasing concentrations.

The transmission of greenhouse gases from the mesocosms was also measured and revealed subtle impacts on the net ecosystem exchange of CO<sub>2</sub>, resulting from antibiotic exposure. The team is now connecting changes in gas flux with changes in the structure of the microbial communities which produce them.

The PhytoPharm approach is already being used in a number of follow-up and breakout projects, for example with investigations into the impacts of other pharmaceutical compounds, as well as compositions from countries throughout the world.

Additionally, Sallach has just secured funding to research how antibiotics are degraded when taken up by plants and what mechanisms plants employ to detoxify these compounds.

## PHYTOPHARM

- Coordinated by the University of York in the United Kingdom.
- Funded under H2020-MSCA-IF.
- [cordis.europa.eu/project/id/706151](https://cordis.europa.eu/project/id/706151)
- Project website: [pure.york.ac.uk/portal/en/projects/phytopharm\(10e3b79a-94b4-41a5-96a8-3a0adb84c4a\).html](https://pure.york.ac.uk/portal/en/projects/phytopharm(10e3b79a-94b4-41a5-96a8-3a0adb84c4a).html)

## FOOD AND NATURAL RESOURCES

# Frequency generator helps protect honeybee colonies

*With honeybee populations declining due to pesticides and parasites, the EU imports about 200 000 tonnes of honey every year – but 20% fails to comply with EU standards. The FOG project rises to the challenge of protecting Europe's bees, with a special frequency generator.*

According to European Parliament research, there are 600 000 beekeepers maintaining around 16 million beehives. Their efforts help ensure the natural pollination of

crops and wild plants, contributing to environmental protection, food security and rural development.

“The basis of our invention was a chemical-free solution that wouldn't jeopardise our health or that of the bees.”

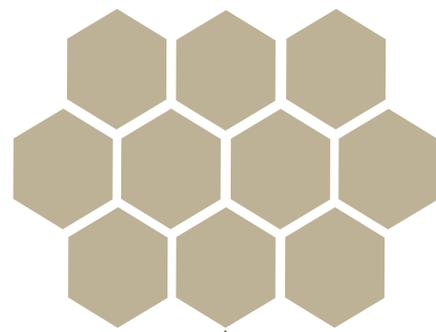
Yet, in terms of honeybee populations, stress factors have contributed to their widely reported declining numbers. The excessive use of agricultural chemicals have been lethal to colonies, with diseases and parasites compounding the damage. *Varroa destructor* (the bee tick) is considered the most harmful honeybee parasite, which is now causing a global epidemic.

The EU-supported FOG (Frequency protector generator for honeybees) project has developed a frequency generator which emits a signal lethal to target organisms, such as *V. destructor*, and so can protect bee colonies, and other animals, against various types of fungi and fungi parasites.

### GENERATING THE FREQUENCY

“The basis of our invention was a chemical-free solution that wouldn't jeopardise our health or that of the bees. We knew that certain frequencies can harm living organisms under certain circumstances, and conversely some can help, so we started to experiment with *V. destructor*,” explains Milan Kysel, project coordinator.

The basis of the FOG solution is controller software. This monitors and assesses the status of ambient parameters like temperature, lighting conditions, etc. and then sends the results to a frequency generator module. This module interprets the information to calculate the necessary



## EU imports about 200 000 tonnes of honey every year

variables, including target range and the timing of electric, acoustic and vibration signals. The signal is then transmitted to plants, animals, soil, etc. to fight the target mould or parasites.

The FOG device can be easily inserted into existing hives without the need for customisation. The size of the generator itself has been specially designed to be accommodated by the widest possible range of hive sizes.

### GETTING IT RIGHT

To date, testing the impact of the FOG generator on hives has been carried out in several locations and on several bee colonies, within a range of external influences.

“These tests have indicated that we need to further understand how FOG affects the long-term fertility of the queen bee. We were surprised by the impact of different frequencies on bee behaviour, which reinforces how fragile and vulnerable they are,” says Kysel. “So we won't start the series production of FOG until we are absolutely sure that we won't cause more harm than good.”

The team are currently working towards assembly of the equipment necessary to further test the impact of FOG on the longevity and fertility of the queen bee. This phase is anticipated to take around 2 years to complete, after which the team will have to complete the certification process and have the device approved by the necessary veterinary authorities.

### FOG

- Coordinated by Rimanec SRO in Slovakia.
- Funded under H2020-LEIT, H2020-Societal Challenges and H2020-SME.
- [cordis.europa.eu/project/id/836486](https://cordis.europa.eu/project/id/836486)





# Researchers use diamond and sunlight to turn carbon pollution into fuel and chemicals

*Diamond might be amongst the hardest materials known, but under sunlight it starts to lose electrons. This proved a boon for researchers working on the synthesis of different diamond materials that can be used to slash carbon dioxide emissions and produce valuable raw materials in the process.*

The concentration of CO<sub>2</sub> in the atmosphere is steadily increasing, and this causes many concerns regarding the impact on the environment. According to scientists, it is important to not only cease pumping megatonnes of CO<sub>2</sub> into the atmosphere, but also start removing what is already there.

Synthetic diamond exposed to light is a new possible approach to help fight climate change and provide a more sustainable supply of raw materials for certain industrial sectors. Several recent studies have shown some success in using synthetic diamond to recapture some of the CO<sub>2</sub> in the atmosphere and turn it into usable fuel and chemicals.

A novel approach from researchers working on the EU-funded DIACAT (Diamond materials for the photocatalytic conversion of CO<sub>2</sub> to fine chemicals and fuels using visible light) project yields two orders of magnitude better

“Combining the best materials and structures, the team reported the observation of the highest photocatalytic activity in diamond materials to date.”

photocatalytic efficiency than existing reactors that use similar processes.

Researchers demonstrated for the first time a whole range of diamond compositions that can reduce CO<sub>2</sub> to methanol and formate using visible light. They produced different types of nanostructured and doped diamond materials with functional groups on their surfaces in large quantities and reproducible quality.

Different active metal complexes and metal oxide coatings were assessed for their photocatalytic activity. Combining the best materials and structures, the team reported the observation of the highest photocatalytic activity in diamond materials to date.

### DIAMOND ACTS AS AN ARTIFICIAL TREE

Similar to real trees, which use CO<sub>2</sub>, sunlight and water to produce food, the developed synthetic diamond materials act like an artificial tree that uses the same ingredients to produce fuel and chemicals. "Where nature uses photosynthesis to produce glucose from CO<sub>2</sub>, we are producing methanol and formate on a carbon-based surface using green solvents and sunlight," notes project coordinator Anke Krueger.

The resulting methanol is an alternative biofuel that can be used to run cars. Formate, which can also be further reduced to other compounds, is a useful precursor material necessary to the chemical industry.

### DIAMOND'S UNRIVALLED PROPERTIES

Contrary to conventional wisdom, man-made diamond is a readily available material. It can be made from methane using a chemical vapour deposition process. Diamond films deposited on substrates are widely

available and are rather cheap, pose no safety concern and are environmentally friendly.

What's more, diamond has a unique property that has no analogue in other semiconductor materials. It possesses a so-called negative electron affinity – electrons can leave the diamond surface without an additional energy barrier when excited to the conduction band. "This is normally only possible when electrons are excited by short-wavelength ultraviolet light, but in DIACAT we experimented with a larger fraction of the sunlight. We noticed that diamond emits electrons with very high reduction potential; in turn the electrons can reduce highly inert molecules such as CO<sub>2</sub> and molecular nitrogen," explains Krueger.

This unique set of physicochemical properties enabled the researchers to actually realise a kind of artificial photosynthesis process where CO<sub>2</sub> is transformed into organic molecules with the help of sunlight and water.

DIACAT's groundbreaking technology is an important part of the overall EU efforts to combat climate change through CO<sub>2</sub> removal from the atmosphere. The technology will be more efficiently exploited in places where CO<sub>2</sub> is provided in high concentrations. This makes power stations, steel mills or cement factories preferred locations for implementing the technology in the future.

#### DIACAT

- Coordinated by Julius-Maximilians-University Wurzburg in Germany.
- Funded under H2020-FET.
- [cordis.europa.eu/project/id/665085](https://cordis.europa.eu/project/id/665085)
- Project website: [diacat.eu](https://diacat.eu)
- ▶ [bit.ly/2SDVfh7](https://bit.ly/2SDVfh7)

# Information system manages factory supply and production

*How might a factory process be optimised? A new information system organises everything.*

Factory operators are always looking to increase efficiency and production. Once, the personal knowledge of factory workers might have been key to improvements. Today, it is uncommon for any single person to know the complete picture, since processes are often distributed internationally and require integration with many suppliers.

Manually communicating with all parties concerning the establishment of supply chains, and production processes, is very time-consuming and difficult. Thus, factories need dedicated information systems that accelerate and automate such communications across the whole operation.

## INTEGRATED INFORMATION MANAGEMENT SYSTEM

The EU-funded COMPOSITION (Ecosystem for Collaborative Manufacturing Processes – Intra- and Interfactory Integration and Automation) project developed a new integrated information management system (IIMS). It simplifies many miscellaneous tasks, including optimising production and allowing rapid adaptation to changing market conditions. The system incorporates existing factory information tools. The project also developed a network supporting the exchange of data among factories and suppliers, which will facilitate entry into supply chains.

One key illustration of the system is its marketplace. This is a technical ecosystem in which clients can post requests for what they need, for which suppliers can then bid. The marketplace software automatically handles the negotiation process and presents the client with a ranked list of suppliers able to fill the request. The client can then select any supplier from the list. “This mechanism opens new opportunities for companies to get in contact, which would not be possible without this technology,” says project coordinator Marc Jentsch. “This is especially interesting for smaller companies which otherwise would have trouble finding new customers.”

## MAINTENANCE AND OTHER APPLICATIONS

A second aspect of the system is a predictive maintenance application for two pilot partners. Prior to development of the tool, both these partners operated machines that were maintained according to a fixed but suboptimal schedule. Maintenance generally took place too early, because that is preferable to it being initiated too late. COMPOSITION researchers developed sensors that monitor the machines. Data from the sensors, plus existing shop-floor data, yielded an optimal maintenance schedule.

The team provided eight different applications, used within six different use cases by project partners. Most partners use the IIMS system to improve minor details in established processes. For example, in one case, sensors are attached to shop-floor equipment to locate lost items; in another, recycling bins are monitored and indicate when they need emptying.

Big Data projects are currently very popular. However, a little-known challenge is that, prior to beginning any work, teams must obtain suitable data sets. “Accordingly, we had problems reliably gathering data,” says Jentsch. “Then there were not enough error cases in the data set for the algorithms to learn something.” The team addressed this by letting data analytics experts and pilot partners work together so each could contribute their domain knowledge to enable the algorithms to detect trends.

All applications will be continued, and several will be extended. The team also plans a further five joint exploitation activities. The results from COMPOSITION will combine with those of three other EU-funded projects, DIGICOR, NIMBLE and vf-OS.

The project translated several very complicated technologies into practical, real-world applications. These will



“ The project translated several very complicated technologies into practical, real-world applications. ”

help manufacturers coordinate and optimise all aspects of their operations.

#### COMPOSITION

- Coordinated by Fraunhofer in Germany.
- Funded under H2020-LEIT-ICT.
- [cordis.europa.eu/project/id/723145](https://cordis.europa.eu/project/id/723145)
- Project website: [composition-project.eu](https://composition-project.eu)
- ▶ [bit.ly/3bsrOXQ](https://bit.ly/3bsrOXQ)

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### INDUSTRIAL TECHNOLOGIES

# Innovative software tool opens door to next generation of alloys

*A team of EU researchers is designing a software-based tool for exploring, identifying and designing new thermodynamically stable nanocrystalline metal alloys with enhanced properties.*

Measuring just tens of nanometres across, metals comprised of nanocrystalline materials are often much stronger than conventional coarse-grained materials. However, despite this property advantage, scientists have been unable to predict the performance of nanocrystalline materials – a factor that significantly limits its market uptake.

Now, thanks to an innovative software tool called ICARUS-SW, this is about to change. “ICARUS-SW is a software tool that is designed to take into consideration the grain boundaries of materials,” says Stefanie Prenner, a

researcher at Brimatech Services GmbH and ICARUS-SW project coordinator.

“The result is a new solution that could pave the way towards describing and analysing thermodynamically stable nanocrystalline alloys.”

The ICARUS-SW tool is one outcome of the EU-funded ICARUS project, which was finalised in August 2019. During the 1-year ICARUS-SW project, researchers conducted an in-depth market review of the tool. This

included performing a competitive analysis, identifying potential users and investigating its technical and economic feasibility.

## KEY DIFFERENTIATORS

There are several commercial CALPHAD software products available on the market for simulating and modelling the thermal stability of alloys. What makes ICARUS-SW unique is its ability to make nano-specific calculations that not only take grain boundaries into consideration, but also offer the possibility of describing a material's nanostructure.

"These differentiators can result in new families of materials with unprecedented properties and performances in broad application areas," explains Prenner. "With ICARUS-SW, new structural materials, radiation-tolerant metals, engineered nanostructures for catalysis and energy production, lightweight alloys, and corrosion-resistant coatings could all become available, unlocking many of the challenges faced by science and technology."

Under the preceding FET ICARUS project, different nanocrystalline alloys (mostly Tungsten-based) were produced to validate the software code.

## A PREDICTIVE TOOL FOR EXPLORING

One key challenge for the project team was to define the most effective strategy for advancing the ICARUS-SW tool from scientific theory to a commercial product ready to compete in the thermodynamic calculation software market.

“*ICARUS-SW is a new solution that could pave the way towards describing and analysing thermodynamically stable nanocrystalline alloys.*”

In this context, the team identified and interviewed users and relevant stakeholders to learn more about their actual needs and requirements and about the strengths and limitations of existing solutions. They also interviewed manufacturers of similar software tools to assess the requirements from the side of the software vendor and to explore opportunities for collaboration.

"From this work, we identified an opportunity to position ICARUS-SW as a predictive tool for exploring, identifying and designing new thermodynamically stable nanocrystalline metal alloys with enhanced properties," says Prenner.

## A NEW GENERATION OF ALLOYS

The project explored the potential for the ICARUS-SW tool's contribution to the development of new families of materials offering not only unprecedented properties and performances, but also a range of other benefits. These include decreased product development time and costs, reduced reliance on imported critical raw materials, and an increase in European competitiveness in the field of engineered materials.

"We hope the project has laid the foundation for the development of a final product that will enable the design of an entirely new generation of alloys," adds Prenner.

## ICARUS-SW

- Coordinated by Brimatech Services GmbH in Austria.
- Funded under H2020-FET.
- [cordis.europa.eu/project/id/851644](https://cordis.europa.eu/project/id/851644)
- Project website: [icarus-alloys.eu/icarus-sw/about](https://icarus-alloys.eu/icarus-sw/about)
- ▶ [bit.ly/2xmL613](https://bit.ly/2xmL613)





LIFE AFTER...

# Catching up with ColRobot: A robotic mobile manipulator ready to go and tailor-made for industry

*In our special feature on robotics in the March 2019 edition of Research\*eu, we met ColRobot, an EU-funded project that had been working to revolutionise the use of collaborative industrial robots, specifically designed for use on production lines. We catch up with ColRobot's coordinator Olivier Gibaru to see what the team have been up to since we first interviewed him.*

For 3 years, ColRobot (Collaborative Robotics for Assembly and Kitting in Smart Manufacturing) worked on the development of collaborative robotics to help overcome some of the biggest common challenges in the automotive and aerospace industries, such as large backlogs of orders and the need for flexibility to meet market demands. The crown jewel of their innovative technology was a robotic mobile manipulator which acts as a 'third hand' for production line workers, able to move around the factory autonomously looking for pieces or tools and delivering them or holding them whilst the human operator performs another task.

## Working robotic wonders with Renault

At the time, ColRobot had been working closely with Renault, with one of its

mobile manipulators being designed specifically for the carmaker. "And since then, we have continued to work with Renault," says Gibaru. "Our work with them has branched out into working on additional functionalities, based on robust tools from the artificial intelligence domain, which is currently under investigation to simplify the in-factory collaboration between humans and to increase the system's overall autonomy."

In the long run, Renault would like to create an industrial robot based on ColRobot's mobile robot for autonomous screwing applications on the production line, reducing ergonomics issues and increasing efficiency. "ColRobot has been an excellent example of a continued post-project collaboration with a major industry player that is getting

our (mostly) EU-funded solution onto the market and tailor-made to the manufacturer's specifications and needs," Gibaru comments.

## Other ventures as well

It's not just the Renault production lines where the ColRobot team have continued to be active. "Since ColRobot's official end, some of our new projects have been investigating the potential of machine learning for a vast field of robotics applications, especially for robotic bin-picking applications," Gibaru elaborates.

But why bin-picking? "Because it's a low added-value operation but also a complex task, so it was therefore interesting to develop a mobile

collaborative robotic solution for industry," he responds.

Overall, EU funding was a huge benefit to the ColRobot team. "The greater outreach and the increase of our visibility through the ColRobot brand has been especially useful, as well as strengthening the confidence of our partners, both old and new, and industrial and academic," concludes Gibaru.

## COLROBOT

- Coordinated by Arts et Métiers Institute of Technology in France.
- Funded under H2020-LEIT-ICT.
- [cordis.europa.eu/project/id/688807](https://cordis.europa.eu/project/id/688807)
- Project website: [colrobot.eu](https://colrobot.eu)



Olivier Gibaru, ColRobot Coordinator © Olivier Gibaru

*“ ColRobot has been an excellent example of a continued post-project collaboration with a major industry player that is getting our (mostly) EU-funded solution onto the market... ”*

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# From genomics to 5G, intelligent resource allocation efficiently directs data traffic

*The amount of data available to us is increasing at unprecedented rates. An intelligent controller will help data centres more efficiently allocate resources in real time for increased performance with less energy and hardware, reducing the overall operational cost.*

Whether it is sharing scientific data on scales from quantum perturbations to cosmic events light years away or interconnecting people and their devices in the evolution of the Internet of Things (IoT), data centres must accommodate ever-increasing data traffic.

Automated smart provisioning and management of IT resources can significantly enhance the efficiency of data centres along with the satisfaction and productivity of end users. A software-defined infrastructure (SDI) can do just that, using software technologies for optimisation to intelligently meet demands in real time. SDI is a nascent technology and no large data centres currently exploit it fully to optimise their operation. The EU-funded Hi-OMICS (High Performance Genomics for Software Defined Infrastructures) project set out to prepare its SDI controller for market and a new era of data use.

## MORE (COMPUTING) POWER, LESS ENERGY

As project coordinator David Carrera of the Barcelona Supercomputing Centre (BSC) explains, “A traditional computer contains processors, memories and disks that are pre-configured. If you get a server with four accelerators, you cannot have eight without making physical changes to the equipment. In an SDI, resources are pooled. They are located somewhere in the data centre and can be dynamically attached to the servers through a fast interconnection network (40 or even 100 Gbps – 100 billion bits per second).” The SDI controller is the software component that decides what hardware components to connect to the servers and when.

Hi-OMICS built on the research of its predecessor project, Hi-EST, with the goal of commercialising the SDI controller for use in efficiently managing the workloads associated with computational genomics. The team focused on enhancing Somatic MUTation FINder (SMuFin), a program developed at BSC that compares sequences from normal and tumour genomes of the same patient to identify somatic sequence variation at base pair resolution.

As Carrera points out, “SMuFin, like any other genomics pipeline, does not use resources in a uniform way all the time. Our controller co-locates compatible workloads to reduce data centre hardware needs and the total cost of ownership for the facility.” The patent-pending new version of SMuFin achieves a 20-fold reduction in energy consumption and a twofold improvement in performance.

## INTELLIGENT ALLOCATION OF RESOURCES IN MORE WAYS THAN ONE

Although the SDI controller is having a significant impact at BSC, the Hi-OMICS market analysis determined that the genomics market was not yet fertile for uptake. However, it revealed tremendous potential for application to the 5G sector and IoT. Carrera did not require artificial intelligence to flexibly reallocate the team’s SDI controller. “Our start-up Nearby Computing commercialises SDI technologies for the 5G/IoT domain where they will benefit data centres of companies, including cloud providers, mobile network operators and large industries,” Carrera states.



“ *The patent-pending new version of SMuFin achieves a 20-fold reduction in energy consumption and a twofold improvement in performance.* ”

While the market analysis outcomes were unexpected, they spurred the team to bridge research and commercial applications. Established in July 2018, Nearby Computing now has 10 employees and is involved in several proof of concept activities in five different countries. As computer architectures continue to evolve toward ever more efficient operations, the company plans to make its mark on the new era of 5G/IoT data networks.

#### HI-OMICS

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- Hosted by the Barcelona Supercomputing Center in Spain.
- Funded under H2020-ERC.
- [cordis.europa.eu/project/id/768626](https://cordis.europa.eu/project/id/768626)
- Project website: [bsc.es/research-and-development/projects/hi-omics-high-performance-genomics-software-defined](https://bsc.es/research-and-development/projects/hi-omics-high-performance-genomics-software-defined)

# Smart distribution updates traditional cinema's business model

*People have a variety of ways to watch films so cinema numbers are dropping. One project spotted a gap in the value chain and built the first tool to close the filmmaker-cinema-audience loop; it not only helps build communities, but just might save independent cinema.*

Digitalisation has allowed cinema audiences to consume content with more flexibility choosing where, how and when they watch. 'Smart' digital platforms can also profile users for customised content. This leaves cinemas struggling to sell seats and retain a customer base.

The EU-funded ITDS (Intelligent Theatrical Distribution System) project used artificial intelligence and data analysis to predict likely box office outcomes.

The project website Movieday contains a platform, called ITDS, that hosts a portfolio of undistributed films. Using artificial intelligence and data analysis to predict likely box office outcomes, the platform proposes films for individual cinemas based on these projections and analysis of local audience characteristics. To date,

50 000 people have purchased 140 000 tickets, to see 110 movies, across 300 associated cinemas.

## REDUCING RISK FOR CINEMAS

ITDS's research shows that 83% of films shown in cinemas are big-budget Hollywood blockbusters, but these represent only an estimated 8.8% of movies made. The remaining films are often not shown in cinemas as distributors pursue a safe return on investment.

"Cinemas have struggled to adapt to modern content trends. Despite adding 3D features and showcasing bigger blockbusters with more elaborate special effects, they still seem paralysed by video on demand (VoD). They have not adapted their business model to the 21st century," explains Antonello Centomani, project coordinator.

With new filmmakers viewed as too commercially risky by the bigger distribution companies, largely because they have not yet developed a fanbase, the project team saw a gap in the market.

Research indicated that cinemas are also typically missing opportunities when they fail to promote films with local cultural connections or allow audiences to influence which films are screened. The project's game-changing innovation was to develop promotional campaigns which drive the presale of tickets through Movieday.

"ITDS connects the right parts of the value chain. Our accurate customer analysis introduces new talent to audiences, making that talent attractive to cinema owners, by reducing commercial risk," says Centomani.



By learning about its customer base, Movieday can more effectively craft a sense of community for shared film-going experiences. The prediction engine, powered by machine learning and its set of algorithms, can analyse customer behaviour to identify the best schedule for a given movie, further maximising attendance.

## FOLLOWING THE CROWDS

About 35 % of people attending Movieday events do not usually attend cinemas, and screenings of the promoted films record an average of 110 moviegoers (an average venue capacity being 200).

Targeted promotions have filled even the weakest time slots, achieving a 100 % audience increase for mornings and afternoons, and 80 % for the first days of the week. Research indicates that participating cinemas have increased their annual profit margin by 5 %.

Streamlining the film scheduling process, while building audiences, has the potential to benefit venues beyond cinemas, such as NGOs, schools, libraries or bars – fitting well within the aims and objectives of the EU's Digital Single Market Strategy.

“ ITDS connects the right parts of the value chain. Our accurate customer analysis introduces new talent to audiences, making that talent attractive to cinema owners, by reducing commercial risk. ”

More broadly it also supports community spaces, resources and activities, while also boosting local economies.

In order to fully implement the AI engine and data-analysis engine into their prototype, and scale up internationally, the project team are currently seeking further investment.

## ITDS

- Coordinated by Movieday Next SRL in Italy.
- Funded under H2020-Societal Challenges, H2020-SME and H2020-LEIT.
- [cordis.europa.eu/project/id/864403](https://cordis.europa.eu/project/id/864403)
- Project website: [movieday.it](http://movieday.it)

## DIGITAL ECONOMY

# Defining safety, security and privacy issues using drones in civilian airspace

*To increase the uses of civilian drones in European civil airspace, the SKYOPENER project has been developing updated system infrastructure.*

Drones, once used only by military forces, are now increasingly used by civilians. The uses vary widely, from a hobbyist taking photos to supporting farmers on agricultural lands. As a result, drones are increasingly being used in civilian airspace, which brings new challenges – not least more interactions with regional Air Navigation Service Providers (ANSP). SKYOPENER (Establishing new foundations for the use of Remotely-Piloted Aircraft

Systems for civilian applications), a Horizon 2020-funded project, has been developing a system to start tackling these new issues and ensure safety, security and privacy in the use of drones in European airspace.

As drone application widens into areas such as search-and-rescue, there is a greater need for accessibility, reliability and functionality over longer distances. Yet,

“Galileo’s inclusion in the multi-constellation concept and integration with other sensors can dramatically improve UAV navigation accuracy, availability, continuity and reliability.”

in European civil airspace, regulations require drones to stay within the line of sight of their operators, limiting their use significantly. By improving the navigation, security and reliability in the overall systems, it is possible for the policy to evolve as the technology does.

The main goal of the project was to improve drone navigation system reliability and security. This was demonstrated through on-ground tests, which showed increasing robustness against jamming, and increased precision from commands. “Using GPS and the EU’s space satellite Galileo in multi-frequency combinations results in improved availability. We can be more accurate by using dual-frequency measurements and more robust when it comes to interference,” explains Alexander Butler, Engineering Director at Viasat, referring to the SKYOPENER programme.

“Galileo’s inclusion in the multi-constellation concept and integration with other sensors can dramatically improve unmanned aerial vehicle (UAV) navigation accuracy, availability, continuity and reliability,” Butler adds.

Other aims of the project included increasing the situational awareness of drones, developing safety systems to mitigate against human error, and developing a system with interactive surveillance for drone systems.

SKYOPENER wanted to address the redundancy of certain communication systems, by developing a command system that uses multi-band satellite and radio. “We have demonstrated the ability to integrate a long-range and resilient hybrid communication system handing over between radio, cellular and satellite channels,” Butler says.

## SELF-INSPECTION

The inspection system works to integrate the drones and the underlying system. The idea is for the system to be used by civilian infrastructure operators, which will open up new avenues for professional applications for drones. The end vision for the SKYOPENER project is efficient, cost-effective solutions for civilian drone applications.



## FLYING TRIALS

The team carried out trials of the SKYOPENER system and drones in Switzerland. Here, they demonstrated the ability for a long-range, fixed-wing drone with a relatively small payload (3-5 kg) to collect and process sensor data of the same quality as those currently used by manned aircraft. “SKYOPENER has demonstrated that even with a limited payload capacity the data collected matches the quality of manned airborne platforms,” says Butler.

The tests were extremely successful and open up the project to expanding the overall system infrastructure. “The quality of data collected by the SKYOPENER system not only meets, but also exceeds the end-user requirements. The UAV is just one part of a large and complex system integration of many components,” Butler adds.

The problem now, Butler explains, is getting policy to match up to the team’s desire to do more testing: “Regulation is still a barrier for getting flight authorisation on a regular basis.”

## SKYOPENER

- Coordinated by Viasat Antenna Systems SA in Switzerland.
- Funded under H2020-LEIT-SPACE.
- [cordis.europa.eu/project/id/687352](https://cordis.europa.eu/project/id/687352)
- Project website: [skyopener.eu](https://skyopener.eu)



## SECURITY

# Robot lifebuoy automatically seeks out stranded sailors

*The iLifebuoy uses video, audio and sonar to locate men overboard, before heading out toward them at speed and notifying authorities along the way.*

With an increasing number of people heading to sea, cases of passengers falling overboard are also on the up. Not only has this caused higher numbers of drownings, but it also puts those carrying out rescue operations in waterways, rivers and seas at risk themselves.

Traditional lifebuoys require boats to get near to the stranded person and must be thrown correctly to help them. The whole process, from location to rescue, can take up significant amounts of time during which the man overboard (MOB) may have drowned.

The iLifebuoy (Saving human lives without endangering the lives of savers) project, funded by the EU, has been working on a nifty technological solution. A new product, iLifebuoy, is a revamped version of the lifebuoy, brought up to date for the 21st century. iLifebuoy is an autonomous robot lifebuoy, kitted out with sensors and electronic equipment that allow it to locate a stranded person in the water, and head out to them automatically.

A prototype has been created and tested successfully in multiple environments. The iLifebuoy team has secured a patent for the product and is working to finalise the ocean testing before the product ships out to international markets.

“iLifebuoy is intended to be applicable and be used in any situation where MOB can occur. Our largest initial target segments include cruise ships, passenger ships, private boats and yachts, as well as coastal infrastructure with a lot of pedestrian traffic – close to rivers, canals, sea,” says Dimitar Mitev, Marine PV Technologies Director and iLifebuoy project coordinator. He adds that the project is aiming to significantly reduce the number of MOB-caused deaths by cutting down the time to provide help by +80% (from 10 minutes to less than 2)!



## A VERY SMART BUOY

As soon as iLifebuoy touches the water, it instantly starts taking in data from the surrounding environment. It uses three in-built sensors – sonar, video and audio – to find the location of the MOB. With the stranded sailor located, it activates a water propulsion system, which propels it quickly to the distressed target. It also lets others know the situation en route, by broadcasting a Mayday signal on 16 channels, and providing the coordinates of its target.

iLifebuoy also takes in information from nearby smartphones. When a person is stranded at sea, eyewitnesses often film the incident. iLifebuoy can connect up to four smartphones over ship Wi-Fi and use the information to narrow down its search via a machine-learning algorithm.

It listens out for sounds that could be human distress calls, in several languages. It can also recognise human voices and uses noise-reduction software to drown out the background noise of the sea and hone in on the human calls. It then uses sonar pings to pinpoint the person, checking for reflections that suggest a kicking or splashing person. Importantly, people aren't required to wear any trackers in order to be located in the water and provided with help.

## MARKET OVERBOARD

Estimates suggest that there could be a demand for over 1.3 million units, with the market growing substantially over the next few years. iLifebuoy hopes to reach 2% of the total possible market within the third year of trading.

The team is now working to strengthen its intellectual property by securing patents in the largest potential markets in countries around the world. The plan is to do any final testing in the ocean and refine the prototype. Expect to see an iLifebuoy on a boat near you soon.

### ILIFEBOUY

- Coordinated by Marine PV Technologies Ltd in the United Kingdom.
- Funded under H2020-Societal Challenges, H2020-SME and H2020-LEIT.
- [cordis.europa.eu/project/id/855274](http://cordis.europa.eu/project/id/855274)
- Project website: [ilifebuoy.eu](http://ilifebuoy.eu)

## SECURITY

# Jamming technology safely neutralises threatening drones

*Drones are everywhere, and some are dangerous. Now authorities can deal with any that seem threatening.*

Drones are small, remotely piloted aircraft of either a fixed-wing or helicopter type. Once restricted to military applications, drones have burst upon the civilian market. They are mostly used as camera platforms, but increasingly for deliveries as well.

The rise of the civilian drone market raises security and privacy concerns. The same drone that delivers a pizza or parcel could also carry a terrorist payload.

This danger is real. For example, during 2015 alone, drones were used to smuggle contraband into British

prisons more than 30 times. During 2016, ISIS used consumer-grade drones for surveillance and to deliver bombs. Numerous other security breaches and incidents have already occurred, including at airports.

Security authorities need a way of neutralising threatening drones while allowing legal use, which the EU-funded KNOX (Cost advantageous and scalable drone alarm and protection system for urban contexts) project provides. The project team optimised the technology, demonstrated it in real operations and prepared the system for commercialisation.

## JAMMING EQUIPMENT

KNOX tracks approaching drones. Normally it is a pole mounted system, to be installed around secure facilities. Its flexibility and scalability allow it to have other configurations, including mounting on perimeter walls.

Components include radio detectors (known as Watchdogs), radio jammers (Dobermans), a radar system (called The Eagle), plus a control system (Iris/Argos). Watchdogs surround a building, with The Eagle placed in the centre of the array.

Watchdogs each scan a 60-degree angle, looking for signals between controller and drone. The Eagle scans in 360 degrees to detect propellers and to track the flight path. If any drones approach too closely, the Doberman jams their controlling radio frequencies.

“Jamming is illegal in most countries unless you are the police or military,” says coordinator Nanna Tribler of coordinating company MyDefence. Even then, it can be difficult to obtain approval. Although the team was aware of Danish approval restrictions prior to commencing the project, they still constrained the research to some degree. Nevertheless, researchers obtained special permits for testing at a Danish military base, and less restricted permits for Finland and Israel where jamming research is less controlled.

## SUCCESSFUL TESTS

Despite the obstacles, the KNOX team successfully tested the system in over 200 realistic situations. These included

“Our approach to jamming is now the most compact in the market and has proven to be very effective with minimum collateral damage.”

around prisons and at other sites including police stations, sports stadiums, city centres and military facilities. The system was also mounted on military vehicles. The tests successfully stopped infiltration of unauthorised drones into secure spaces. “Our approach to jamming is now the most compact in the market and has proven to be very effective with minimum collateral damage,” reports Tribler. From the testing, researchers developed a set of operating procedures.

The study also identified a need for registration and air traffic control of all drones, plus generally tighter regulation. Researchers will be making the case for such measures to relevant EU authorities.

Following successful trials, project members are considering applying for EU SME Instrument phase 3 funding. In the meantime, system development continues.

The project’s market research revealed likely new opportunities within the European defence industry. Ultimately, KNOX will be marketed as a cutting-edge, commercial anti-drone system.

Commercial availability will provide security authorities with hitherto unavailable options for neutralising threatening drones. This will mean increased security and safety for Europeans.

### KNOX

- Coordinated by MyDefence Communication APS in Denmark.
- Funded under H2020-SECURITY and H2020-SME.
- [cordis.europa.eu/project/id/768242](https://cordis.europa.eu/project/id/768242)
- Project website: [mydefence.dk/research-development/horizon-2020](https://mydefence.dk/research-development/horizon-2020)





# Memory storage when mice use their whiskers to detect texture

*Memory is a crucial life function that causes many diseases once it goes awry. Researchers have used state-of-the-art technologies to determine what happens in the cerebral cortex when mice twitch their whiskers to sense their environment.*

The EU-funded AG-GF (Behavior-dependent interactions between frontal and somatosensory cortices) project, with support from the Marie Skłodowska-Curie programme, aimed to locate where in the cortex information is stored for short-term memory purposes. “Thanks to the genetic and technological advances in neuroscience, we were able to simultaneously image activity of millions of neurons distributed across many different cortical areas,” explains Ariel Gilad, project coordinator at The Hebrew University of Jerusalem.

## STANDING STILL AS OPPOSED TO BEING ON THE RUN SHIFTS MEMORY LOCATION

Mice were tracked while using their whiskers to discriminate between two different textures after which they maintain the information in short-term memory for several seconds. “Surprisingly, we found that short-term memory was located in two very different areas, either in the frontal secondary motor cortex (M2) or in a newly identified area in the posterior cortex that we simply termed area P,” Gilad reveals.

It turns out the location of short-term memory is highly dependent on the mouse itself. In this type of task, each mouse tends to adopt a different behavioural strategy to solve the task. Some adopt an active strategy, moving and whisking during sensation, whereas others adopt a passive strategy, sitting quietly during ‘sensing’.

In the ‘hyper’ mice, short-term memory was located in M2. If mice were sitting quietly, short-term memory was not present in the frontal cortex but rather in area P. “Short-term memory is not related to only one area, but is rather flexible depending on the internal state of the mouse itself,” Gilad explains.

## OBSERVATION OF BEHAVIOUR KEY TO MECHANISM

In science, generally, individual differences are neglected. For example, an average across different animals yields a single value that supposedly best represents the population.

Gilad tells the story: “The breakthrough came as I was watching a video of a special mouse that alternated between active and passive strategies even on a trial-by-trial basis. Only by relating each trial to the corresponding activity map in the cortex, did the relationship between the internal state of the mouse and the location of short-term memory become clear.”

## WHISKING THE RESULTS INTO FUTURE RESEARCH

The plan is to expand observations to many other brain areas, such as subcortical areas and cortical areas that are hard to access. “I intend to study different cognitive processes such as perception, learning and sensory processing that should all come together to comprise a coherent intellect,” Gilad adds.

Imaging of specific cell types across the whole cortex is now possible, so, for example, cells belonging to a specific layer in the cortex or cells that inhibit activity can be pinpointed. It is also feasible to label cells that project from area to area and thus start mapping connections between different areas to better understand the brain as a network.

The brain is a dynamic and flexible entity, engaged in an ever-changing interaction between the internal and external worlds. Gilad reflects on the lessons learned from the AG-GF mice: “There are no two similar brains on Earth. Therefore, our scientific investigation must adopt



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a similar flexible and dynamic nature always keeping an open mind emphasising the variability and ambiguity of cognitive processes.”

#### AG-GF

- Coordinated by The Hebrew University of Jerusalem in Israel.
- Funded under H2020-MSCA-IF.
- [cordis.europa.eu/project/id/659719](https://cordis.europa.eu/project/id/659719)

### FUNDAMENTAL RESEARCH

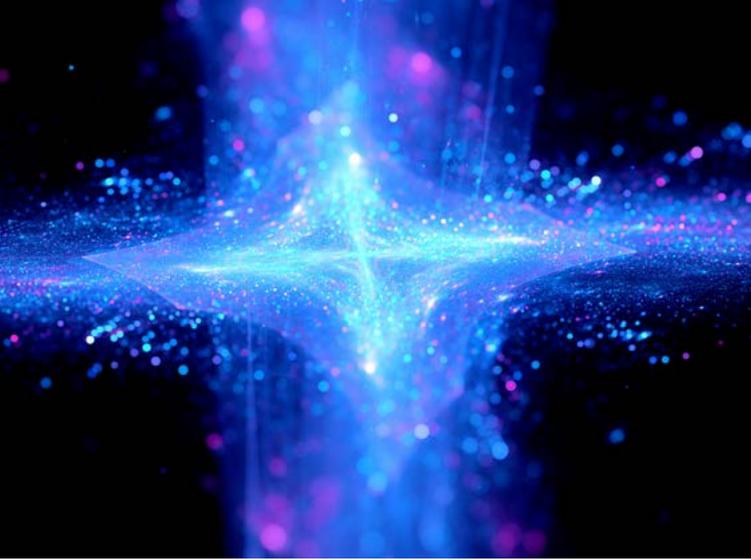
# Searching for evidence of New Physics

*The Higgs boson is an elementary particle, confirmed in 2012, which completes the Standard Model used to study elementary particles and their interactions. But more precise measurements of the Standard Model can hint at New Physics, as HEFTinLOOPS investigated.*

The Standard Model (SM) is a theory which encapsulates knowledge about the fundamental particles and their interactions. The Large Hadron Collider (LHC) in Switzerland is currently stress testing the SM by precisely measuring reactions among different particles. These measurements are compared with SM predictions to identify deviations which could point to New Physics (beyond the SM).

New Physics can be probed even when new particles are too heavy to be directly produced by collisions, as these modify the interactions of the already-known particles. By precisely measuring these interactions, researchers can extract the first traces of the New Physics.

The EU-supported HEFTinLOOPS (Effective Field Theory predictions for Higgs production processes at the Large



Hadron Collider) project used the theoretical framework known as Effective Field Theory (EFT) to compute the potential impact of undiscovered heavy particles on the various Higgs boson and top quark production processes, measured at the LHC. As the top quark and the Higgs boson are the two heaviest elementary particles, and have the least understood interactions, they play a crucial role in theories of New Physics.

The project, conducted with support from the Marie Skłodowska-Curie programme, provided theoretical predictions for the LHC's Standard Model Effective Field Theory (SMEFT) programme. It developed the tools needed by experimentalists and theorists for the task. HEFTinLOOPS also produced precise computations for various particle scattering processes, focusing on the production of top quark and Higgs as well as on the interpretation of LHC measurements within the SMEFT.

## PRECISE CALCULATIONS

HEFTinLOOPS set out to predict how the probability of producing a Higgs or top quark particle at the LHC would change if some as yet undiscovered heavy particles existed. To do so, the project first had to develop the techniques and computer codes necessary for the precise predictions that would allow the extraction of information about these particles.

To perform these computations, HEFTinLOOPS developed components of a Monte Carlo generator. This is a computer code which predicts how often a scattering process will occur at a collider. By doing so, it can calculate the impact of new interactions on the rates of Higgs or top quark production.

The researchers considered several modes for producing the Higgs particle, including a Higgs in association with a top quark, with Quantum Chromodynamics (QCD) jets and a vector boson, as well as double Higgs production. All these processes are important because they offer

“HEFTinLOOPS improves our understanding of the smallest constituents of matter and their interactions, helping answer some of nature's most fundamental questions.”

insights into how the Higgs particle interacts with the other particles of the SM, and with itself.

“The project involved a lot of analytical calculations, but also the coding of new results into computer tools. This was an important goal as it made the results available to the whole collider physics community,” explains Eleni Vryonidou, Marie Skłodowska-Curie Fellow.

When comparing theoretical predictions for top quark production with LHC data, the project found no significant deviations from the SM predictions, but by setting the most stringent constraints for new top quark interactions, it furthered the search for New Physics.

## TOWARDS NEW PHYSICS

HEFTinLOOPS produced the first precise computational tools necessary, accounting for uncertainties, for different predictions for Higgs and top quark production at the LHC, within the framework of EFT.

The theoretical results of the project and the associated tools have already been extensively used by the wider particle physics community to interpret their measurements, helping them pin down the scale and nature of the New Physics.

“HEFTinLOOPS improves our understanding of the smallest constituents of matter and their interactions, helping answer some of nature's most fundamental questions,” says Vryonidou.

Following the comparison of SM predictions for top quark production with LHC measurements, the next step will be to do the same for the Higgs boson.

## HEFTINLOOPS

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- Funded under H2020-MSCA-IF.
- [cordis.europa.eu/project/id/704187](https://cordis.europa.eu/project/id/704187)

# *You might notice that our usual EU Agenda feature is missing.*

**This is because, due to the ongoing COVID-19 situation across Europe, it's highly likely that many, if not all, of the events we usually highlight will not go ahead as planned.**

We hope that this will just be a one-off exception but, in the meantime, CORDIS aims to timely cover scientific news related to the outbreak in our regular online News section (available not only in English, but also in French, German, Italian, Polish and Spanish), which you can access through the following link: [cordis.europa.eu/news](https://cordis.europa.eu/news)

We aim to keep you up to date with regular news on how EU-funded research is contributing to the efforts against the virus, whether this is through vaccine research, new treatments or diagnostics. You can already get a sneak peek by flicking back to our Project of the Month feature where we highlight two projects that have reoriented themselves to help but there are also several others now fully engaged in COVID-19 research.

And don't forget to follow the dedicated CORDIS social media channels (which you can find on the back cover of this magazine), we'll also be using those to keep our readers and followers fully in the know about all EU-related COVID-19 news and updates.

Wishing all our readers good health.

The CORDIS Editorial Team



# RESULTS PACK ON DIGITAL CULTURAL HERITAGE

Whether it's a priceless Dutch Golden Age painting, a ruined Roman Forum surrounded by olive groves on a sleepy Mediterranean hillside or a more modern audiovisual masterpiece of the 20th, our cultural heritage can be both easily and permanently damaged or, in the worst-case scenario, even destroyed. Our latest Results Pack highlights 12 EU-funded projects that have developed numerous digital innovations that will help to ensure the preservation of Europe's precious cultural heritage.



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