



#86
OCTOBER 2019

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Outcome prediction
and personalised therapy
for leukaemia

Boosting maths learning
through cognitive training

Making it easier to
build robots for space

SPECIAL FEATURE
OCEANS UNDER THREAT:
PROTECTING AND PRESERVING
OUR MARITIME
ENVIRONMENTS

Editorial

Coming together to save the oceans and how caffeine really affects us

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

This is arguably our 'fishiest' issue ever: Our special feature this month focuses on innovative EU research to help protect and preserve the oceans in light of the major annual 'Our Ocean' conference taking place in Oslo, Norway, from 23–24 October. But wait, that's not all, our regular **Life After** feature has also been catching up with an EU-funded project that is simply fizzing with ideas on how to increase the competitiveness and diversification of the aquaculture industry.

Unashamedly using the hook of the high-level 'Our Ocean' conference, our special feature introduces you to seven Horizon 2020-funded projects that are providing innovative ideas and solutions to help humanity better protect and preserve the oceans for future generations. Especially as it truly is such a complex and mammoth task facing us – due to plastics pollution, biodiversity breakdown, climate change and overfishing (to name just four of many key challenges), the pressure really is on to devise, agree and implement solutions now.

Taking a more personal turn than is usual for this editorial, your editor was recently made starkly aware of the growing maritime crisis engulfing the world when they were gifted a dead piece of coral from Australia's Great Barrier Reef. It is as white as bone and with the naked eye indistinguishable from a common stone. There are entire beaches up and down the Queensland coast littered with thousands of such specimens. Closer to home in Europe, the effects of the sustained environmental breakdown of our oceans are becoming ever more evident.

What makes this environmental crisis more pressing is the fact that human existence is intimately tied in with the fate of our oceans. The oceans feed billions, millions in both the developed and developing worlds depend on them for their livelihoods, and they are still vital conduits for international shipping and communications. This is why we were passionate about covering such an important topic in this issue of *Research*eu* magazine and we wish the participants at the 'Our Ocean' conference every success in coming together to agree tangible solutions to overcome the immense challenges facing the oceans.

Finally, to jump abruptly to a rather different topic (but conveniently linked to our recent special feature on obesity in issue 84, go check it out!), our **Project of the Month** highlights one Marie Skłodowska-Curie fellow who has unearthed new evidence on how our morning cup of joe could be having an impact on our weight, specifically related to brown fat metabolism.

As always, you can dip in and out of our nine thematic sections showcasing the very best of EU-funded research in many diverse fields and until next month, if you have queries, questions, suggestions (but hopefully never a complaint), please feel free to drop us a line at editorial@cordis.europa.eu

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Outcome prediction and personalised therapy for leukaemia

The 'one size fits all' approach to medicine is slowly being put on the back burner. In the field of haemato-oncology, the move towards personalised treatments can already be seen in both cell- and chemotherapy. But the BioBlood project is taking these new approaches to the next level.

In the field of cell therapy, culture models used to investigate tumour cell behaviour and responsiveness to therapies are almost exclusively two-dimensional. They fail to capture the three dimensions of the bone marrow architecture and therefore generate only low-quality cells. BioBlood (Development of a Bio-Inspired Blood Factory for Personalised Healthcare) fills this gap with a new generation of 3D culture platforms.

"Our platforms offer a dynamic, 3D perfusion bone marrow biomimicry in a bioreactor. It produces multiple cell types simultaneously in an environment that is both serum-free and cytokine-free," explains Prof. Athanasios Mantalaris, PhD at Imperial College London and coordinator of BioBlood.

The stromal cells produced by BioBlood's platforms are based on input cord blood cells like those observed in bone marrow. One cord blood unit can be sustained in continuous dynamic culture for at least 8 weeks. This makes BioBlood's personalised *ex vivo* platform a viable solution for the production of blood cell components. In the future, it could be used for transfusion purposes or to discover personalised drug targets.

TOWARDS PERSONALISED CHEMO- AND IMMUNOTHERAPY

Personalised chemotherapy, on the other hand, is still faltering. Current doses for standard treatments are administered based on the height, weight and performance status of the patient. But so far, they have failed to consider leukaemia cell kinetics, or even how resistant mutations and microenvironmental factors could affect such cell kinetics.

BioBlood overcomes these limitations with the first-ever, *in silico* model for precision therapeutics and optimisation of treatment schedule and dose.

"We started this project by trying to improve the efficacy and safety of treatments. We have used *in silico* modelling of parameters obtained during routine diagnostic testing on patients with acute myeloid leukaemia (AML). Eventually, we could combine patient-specific and leukaemia-specific parameters with the pharmacodynamics and pharmacokinetics of standard chemotherapy drugs. We were also able to combine these elements with specific actions of chemotherapy drugs on the cell cycle, as well as account for the heterogeneity of different populations of normal cells as well as leukemic blasts," says Prof. Mantalaris.

From data acquired during patient diagnosis, BioBlood's mathematical *in silico* model can determine the response to therapy (complete remission, partial remission, relapsed disease and resistant disease). It can capture neutrophil dynamics during all cycles of chemotherapy, as well as help optimise treatment schedules and doses for improved effectiveness of the treatment and reduced toxicity.

"These outcomes were determined through retrospective datasets obtained from patients treated for AML. We are now in the planning phases of a prospective clinical trial to assess whether these outcomes can be dynamically predicted. If they can, this *in silico* model could lead to a step-change in how AML will be treated in future. It would allow for dynamic scheduling to increase chemotherapy efficacy and reduce toxicity," says Prof. Mantalaris.



“ *This in silico model could lead to a step-change in how AML will be treated in future.* ”

The *in silico* precision therapy platform can incorporate both standard chemotherapy and novel immunotherapies into its mathematical model. Whilst Brexit has jeopardised chances for an EU-funded follow-up project, the consortium has created a spin-out company called niChemo and intends to focus on the US market.

BIOBLOOD

- Hosted by Imperial College of Science, Technology and Medicine in the United Kingdom.
- Funded under FP7-IDEAS-ERC.
- cordis.europa.eu/project/id/340719
- Project website: erc-bioblood.eu/about-us

HEALTH

The metals that hold the key to curing cancer

A Spanish institute developed drug candidates containing metals to target cancer cells.

A Madrid laboratory developed families of drug candidates to treat cancer, using metals like iridium, ruthenium and osmium, during the 4-year EU-funded project MEMOTUMCELLMACH (Metalldrugs to Modulate Tumour Cell Machinery).

The IMDEA nanoscience institute, with support from the Marie Skłodowska-Curie programme, says its research on metallodrugs based on iridium, under the MEMOTUMCELLMACH project, shows they could be up to 200 times more



© IMDEA

effective against cancer cells than cisplatin – one of the most commonly used drugs for cancer patients.

“We now know that the iridium family of drugs is super potent,” says laboratory head Dr Ana Pizarro. “They accumulate in the mitochondria or power house of the cancer cell and exclusively so.” The team also developed a family of osmium-based candidates to control pH inside the cancer cell. “The impact it could have on cancer progression and invasion is scarily good,” Dr Pizarro adds.

The results make those families of drugs very good candidates for *in vivo* testing, says Dr Pizarro. The research has prepared the ground for more transition metals to be used in new cancer drugs.

Transition metal compounds are molecules usually containing one atom of a transition metal to which a series of other groups of atoms is attached. The bond between the metallic centre and the atom attached to it is not as strong as carbon with carbon but not as weak as the single hydrogen bonding. This makes it, as the project explains, dynamic for the time necessary for its use. “This dynamism is very easy to tune for us chemists,” says Dr Pizarro.

“The impact it could have on cancer progression and invasion is scarily good.”

MULTIPLE TARGETS

Scientists discovered the metallodrug cisplatin, which contains an atom of platinum, by chance in the 1960s, and it is still used in about 50 % of chemotherapy treatments worldwide.

But cisplatin and other drugs on the market don’t work for all types of cancers and sometimes affect healthy cells. “There is no single cause of cancer, there is no single target, so there is no single magic bullet,” says Dr Pizarro.

She focused on ways to get the metal compounds to switch ‘on’ to react and attack cancer cells while remaining inactive outside the cancer cells. That means they wouldn’t destroy healthy cells, causing pain and side effects in patients.

During the 4-year project, the researchers also investigated ‘nanocarriers’ – large particles that sometimes get stuck inside a tumour and could be used to make transition metal compounds more effective against the tumours. They researched the effectiveness of nanomaterials including plant viruses. “This is still work in progress but we are very excited about these side lines,” says Dr Pizarro.

The EU funding helped Dr Pizarro recruit her first doctorate student after setting up the laboratory at IMDEA 5 years ago. She believes more basic research is needed to understand the different causes of and potential cures for cancer: “I understand the need for immediate returns on research investment, but technology follows new knowledge. I don’t believe in the efficiency of doing it the other way round.”

MEMOTUMCELLMACH

- Coordinated by IMDEA in Spain.
- Funded under FP7-PEOPLE.
- cordis.europa.eu/project/id/631396
- Project website: nanoscience.imdea.org/es/investigacion/proyectos/item/memotumcellmach-metallodrugs-to-modulate-tumour-cell-machinery

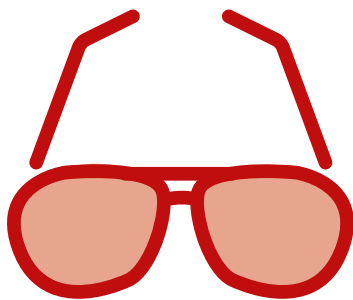
Using sounds to see, in a first-of-its-kind audiovisual system for the visually impaired

EyeSynth uses sonic landscapes to take advantage of the brain's interpretation power, in helping the visually impaired to better understand their environment in unprecedented detail.

The World Health Organization estimates that there are 285 million people globally living with vision impairment. With an ageing population, along with sight damaging illnesses such as type 2 diabetes, this figure is fast-growing.

With no known cure, the visually impaired rely on assistive devices, such as canes or guide dogs. However, while these methods avoid obstacles, they do not help people better understand their environment.

The EU-supported EyeSynth (Audio-Visual System for the Blind Allowing Visually Impaired to See Through Hearing) project has developed an audiovisual system for the visually impaired, consisting of glasses with embedded cameras which record surroundings in 3D. Through a microcomputer connection, the data collected is converted into abstract sounds conveying spatial information.



The World Health Organization estimates that there are **285 million people** globally living with **vision impairment**

A RADICALLY DIFFERENT SOLUTION

The starting point for the EyeSynth system was not technology, but the brain. "Our system does not describe the environment in words. We provide raw spatial information, and the user's brain decodes that. Co-design with our testers was critical to developing this user-friendly and effective interface," says project coordinator Antonio Quesada.

The team ran a large number of tests, calibrating the underlying algorithm based on user feedback, until the users were able to identify shapes and spaces, as well as measure depth and locate objects accurately.

"Designed to be intuitive, it takes users on average 45 minutes to an hour and a half to master the system enough to distinguish simple objects or move around the office avoiding obstacles," adds Quesada.

The system is composed of two main elements: the glasses and the image processing unit – a small CPU the size of a smartphone, with an internal battery that powers the system. A normal USB power bank can also be connected. The result is lightweight glasses, with ease of movement.

There are two high-quality (60 frames per second) image processing modes. In Tracking mode, only the image's 'central column' is analysed, with the user tracking left to right, similar to using a white cane. In Full Panoramic mode, the whole landscape is represented simultaneously, providing much more sonic information and making tracking unnecessary.

“Our system does not describe the environment in words. We provide raw spatial information, and the user’s brain decodes that.”

Based on daily need, in both modes, the adjustable analysis distance is 0.8 to 6 metres. Crucially, this range caters well for the detection of obstacles in the street. The 3D data is transferred into real-time acoustic representations reminiscent of ocean sounds, with their composition and timbre corresponding to the recorded shapes. These sounds are transmitted directly through the head bones, so the ears are free to listen.

“We decided not to use spoken language, partly as it is difficult to describe phenomena verbally, it would be too distracting, and we would have had to make different language versions,” explains Quesada.

As testing primarily involved blind users, the team are undertaking a medical study with Ophthalmology specialists at the Provincial Hospital of Castellón in Spain, to work with low-vision patients. Results so far have also been encouraging.

EMPOWERING TECHNOLOGY

EyeSynth extends the autonomy and independence of people with visual impairment, avoiding the problems



and accidents associated with physical barriers, while helping the user navigate unknown locations. The team aim to have the first batch in shops this summer.

“We will continue to upgrade the system with new features such as face recognition or text,” concludes Quesada. “To keep this working as empowering technology which helps in education, employment and leisure, and ultimately improves lives, we will continually listen to our users.”

EYESYNTH

- Coordinated by Eyesynth in Spain.
- Funded under H2020-LEIT-ICT and H2020-SME.
- cordis.europa.eu/project/id/757202
- Project website: eyesynth.com
- bit.ly/2ZbCPFL

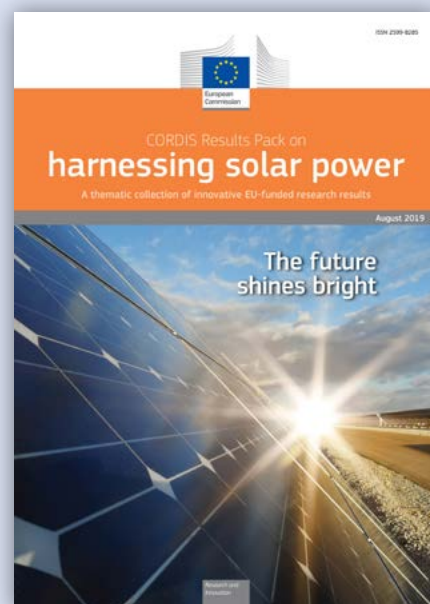
Our latest Results Pack focuses on 10 projects that are helping Europe to achieve its ambitious climate change and clean energy goals by upscaling how we can best **HARNESS SOLAR POWER**.

Solar power is a clean, abundant and increasingly competitive source of renewable energy and its further uptake will both drive technological innovation and support Europe’s economy through the creation of high-skilled employment.

Already solar power is making a key contribution to the European energy mix and has the potential to meet 20% of the EU’s electricity demand by 2040.

Check out the full Pack here:

cordis.europa.eu/article/id/405567





PROJECT OF THE MONTH

Relationship between caffeine and brown fat metabolism

The first study in humans to show that something like a cup of coffee can have a direct effect on our brown fat functions has been carried out with the partial help of the EU. CASCADE Fellow Dr Ksenija Velickovic was a member of the team whose findings could have major implications in the light of the increasing levels of obesity. Brown fat metabolism could, potentially, be key to finding a solution to the growing diabetes epidemic.



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Researchers combined both *in vitro* and *in vivo* models to examine whether caffeine could stimulate brown fat cells. For this purpose, they used mouse and human stem cells, which can generate both white and brown fat cells. They found that caffeine-treated cells increased their rate of metabolism and acquired characteristics of brown fat cells. The researchers then moved on to a human study by recruiting volunteers who drank either coffee or water, and measured changes in temperature of brown fat. Thus, with different models they have provided new evidence that caffeine and a coffee beverage can promote brown fat function.

The next step is to examine further which ingredients in coffee are responsible for brown fat activation. Once they have confirmed this, the team will investigate whether caffeine could have a beneficial effect on other metabolic disorders, diabetes and hypertension in particular.

“This is the first study in humans to show that one of the most popular drinks in the world can have a direct effect on brown fat function and could even help fight obesity. Our results suggest that apart from cold as the main physiological stimulus, brown fat can burn calories due to changes in nutrient composition. This could lead to reduced white fat in the body, which is associated with detrimental health effects. The potential implications of our results could impact on the pharmaceutical industry, who are looking for novel and validated models to treat obesity and related disorders.”

Dr Ksenija Velickovic, EU-CASCADE Marie Skłodowska-Curie Postdoctoral Fellow, School of Medicine, Nottingham, United Kingdom

CASCADE-FELLOWS

- Coordinated by the University of Nottingham in the United Kingdom.
- Funded under FP7-PEOPLE.
- cordis.europa.eu/project/id/600181

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

Boosting maths learning through cognitive training

The EU-funded SMARTICK project is improving maths learning by integrating a cognitive training feature into its online educational games.

Maths skills are in high demand but short supply. This puts Europe at a competitive disadvantage against the US and Asia, where students are learning the skills that today's high-skilled jobs demand.

One company helping to bridge this gap is Smartick, with its popular online method for learning mathematics geared to children aged 4 to 14. The method has children playing interactive maths games on their computers or tablets for 15 minutes a day. A key innovation is that the games continuously adapt to the student's current skill level and support the learning process with positive reinforcement.

Ready to take its method to the next level, and with the support of the EU-funded Smartick (Disruptive learning through the integration of mathematics and cognitive training) project, Smartick has integrated a cognitive training feature into the learning method. "In this project, we set out to demonstrate that cognitive training

– provided through online games – contributes to a student's learning of maths," says project coordinator Daniel González de Vega. "In other words, students learn more maths when teachers combine mathematical learning with cognitive training."

A SMART CHOICE

In this project, researchers wanted to measure the benefits of adding cognitive training (Smartick Brain) to learning mathematics (Smartick). To do this, they designed an online cognitive training platform that includes 12 unique games, each of which is specifically designed to build such cognitive skills as attention, memory and reasoning.

These integrations were then tested and validated in a study that ran for 3 months and involved 447 students at a school in Madrid, Spain. In the study, one group of students was presented the new cognitive games as a continuation of their standard mathematics lessons



“*Students learn more maths when teachers combine mathematical learning with cognitive training.*”

(Smartick Brain + Smartick), while another group only trained in mathematics (Smartick). There was also a third group that did not receive any training (control).

What researchers found was that the students who used both Smartick Brain and Smartick improved more than those who just used Smartick or those in the control group. “Furthermore, the students that used Smartick improved more than those that did not use the online learning method,” adds González de Vega. “Additionally, the more sessions they completed, the more their grades improved in mathematics.”

González de Vega notes that the tests did show certain nuances in relation to age and gender. For example, Smartick Brain seems to primarily affect younger students, with improvements being more evident in second and third grade than those in fifth grade. Likewise, although all children using Smartick Brain and Smartick saw improvement, the improvement was somewhat less pronounced in girls.

“Improving education with the help of technology is at the core of who we are as a company,” says González de Vega. “These tests confirm this belief, demonstrating the enormous advantages that technology and gamification bring to the learning of mathematics.”

EXPANDING INTO NEW MARKETS

Smartick Brain is now well-positioned to enter new markets in both Europe and Latin America, and in doing so, help millions of kids learn maths. “Thanks to EU support, Smartick can boost our growth to reach over 500 000 clients and generate EUR 100 million in revenue in 4 years, thus fulfilling our potential as one of Europe’s high-growth companies,” says González de Vega.

SMARTICK

- Coordinated by Sistemas Virtuales de Aprendizaje SL in Spain.
- Funded under H2020-LEIT-ICT and H2020-SME.
- cordis.europa.eu/project/id/730891
- Project website: smartickbrain.com

SOCIETY

Displacement of rural communities into model villages: techniques of military counterinsurgency

All over the world, the military have sought to cut the links between the population and guerrilla movements through the displacement and forced regrouping of rural and indigenous populations. EU-funded research has been looking into the use of ‘strategic villages’ and has uncovered interesting dichotomies.

The 70s and 80s were very significant periods for the history of Latin America. After a rise of revolutionary movements throughout the entire continent during the 60s, the

decades that followed were characterised by the emergence of military dictatorships that produced profound social changes in the region.



© Pamela Colombo, Shutterstock

Counterinsurgency policies were aimed not only at destroying guerrilla movements, but also at ‘winning the hearts and minds’ of the population. Among the different techniques used to pursue this goal were strategic villages: model villages designed to cut the population away from their old territories and loyalties.

The Marie Skłodowska-Curie-funded research, conducted by principal investigator Prof. Pamela Colombo under the StrategicVillages (Violent settlements: strategic villages and clandestine burial sites in Latin America) project, considered how forced urbanisation as a counterinsurgency measure was used to control populations and consolidate state power.

“The notion of uprooting populations and rehoming them in purpose-built villages, under the guise of improving quality of life, is not a new one. Strategic villages have been created in Africa and Asia in the context of decolonisation wars and with the support of the colonial powers. England built new villages in Malaysia and Kenya, the USA built strategic hamlets in Vietnam, and France created ‘centres de regroupement’ in Algeria,” explains Prof. Colombo.

“My fieldwork has allowed me to discover that, faced with similar ‘problems’ (in this case the loss of control of certain territories), States end up adopting very similar population regrouping policies,” Prof. Colombo adds.

At the time, the military doctrine in Latin America posited that the ‘improvement’ in the population’s living conditions would help to prevent civic support for rebel movements. Rural poverty and dispersal were conceived of as

being at the origin of revolutionary movements. “The territorial reconfiguration and infrastructure that has been inherited from that time continues to be used and inhabited today. My interest is not only to recover the history of the strategic village programme, but also to analyse the effects that this policy still has on present-day Latin America,” says Prof. Colombo.

She used a mixed methodology for her research, conducting archival work, interviewing government actors and conducting ethnographic work inside the strategic villages with displaced populations. In doing so, Prof. Colombo unveiled an interesting dichotomy.

“I found many references to different types of crimes and abuses committed during the occupation by the Armed Forces: forced displacement; destruction of previous living spaces; control and surveillance of daily life; arbitrary arrests; forced labour; public punishments, and even forced disappearances. However, I also found, in Argentina, that a big part of this same population still supports the military ‘civic action programmes’. The military might have arrived in their lives, but then, so did the State,” Prof. Colombo says.

There were many highlights during the period she worked on StrategicVillages, including the co-organisation of the exhibition ‘Violence in Space: Urban and Territorial Policies during the Military Dictatorship in Argentina (1976-1983)’ which she organised with Dr Carlos Salamanca, and with the collaboration of 30 researchers.

“During the period of the Marie Skłodowska-Curie grant, I had the wonderful opportunity of creating and consolidating my participation in a network of researchers. I benefitted greatly from the insight given by my supervisor Dr Elisabeth Anstett from the School of Advanced Studies in the Social Sciences and also from my co-supervisor in Argentina, Dr Claudia Feld, and the team at the Núcleo de Estudios sobre Memoria that hosted me as my third country institution,” Prof. Colombo concludes.

STRATEGICVILLAGES

- Coordinated by the School of Advanced Studies in the Social Sciences in France.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/654923
- Project website: strategicv.hypotheses.org

Putting the needs and rights of elderly citizens at the heart of urban solutions

The EU faces multiple, interdependent challenges in achieving sustainable regional development. Making its contribution, GRAGE has discovered and developed urban solutions for active and inclusive elderly citizenship.



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Three of the biggest challenges currently facing Europe – an ageing population, urbanisation and environmental change – are mutually reinforcing. As a consequence, building communities which are more attractive to live in (socially, economically, environmentally and culturally) requires transdisciplinary solutions.

In recognition of the complexity and breadth of the task at hand, the Marie Skłodowska-Curie action project GRAGE (Grey and green in Europe: elderly living in urban areas) drew from a diverse skill-set to identify topics, ideas

and initiatives that promote an active elderly citizenship across the three key research areas of: ‘construction and buildings’, ‘mobility and connecting people’, and ‘inclusive living, including urban agriculture and food’.

SPOTTING INTERVENTION OPPORTUNITIES

GRAGE emerged from concerns that the problems resulting from increased urban sprawl are usually tackled from

“ *We wanted to combine ‘smart and green city’ innovations with our efforts to boost inclusiveness for a more harmonious society.* ”

very technical perspectives, often missing the underlying social drivers and so opportunities to address them.

Consequently, the team realised that this calls into question the relevance of the dominant European urban development models which don't always adequately account for the impacts of demographic decline, continued natural resource depletion and, in the case of the project's specific research interest, an ageing population.

The team started by investigating the actual needs, values, opinions and behaviours of older people, then applied these to key thematic areas such as: human rights, buildings, resource efficiency, information and language technology and ageing society industries.

The researchers (from different disciplines, representing legal, economics, humanities and engineering perspectives) then drew on this knowledge to develop specific solutions. For example, within the ‘construction and buildings’ research area, guidelines and recommendations were created for an international certification standard to classify buildings according to how well they take account of the needs of elderly people.

“We wanted to combine ‘smart and green city’ innovations with our efforts to boost inclusiveness, for a more harmonious society,” says project coordinator Prof. Francesca Spigarelli.

These solutions have led to some noteworthy spin-offs. An example being the start-up initiative Senior Caring Nomads in the Netherlands. This is developing a digital platform for tourism in lesser-known, attractive, rural settings. It aims to connect organic and care farms with older adults (aged 60-75) interested in traveling and

volunteering, in exchange for affordable accommodation and free meals.

RIGHT TO THE CITY

GRAGE has resulted in several policies which could not only lead to more inclusive, age-friendly urban environments, but also actively engage older people in the governance of these environments.

“The protection of elderly human rights and the effectiveness of their ‘right to the city’ includes the participation of citizens in the democratic process and in city governance. We demonstrated that, in this context, access to digital information and communication technologies plays an important role, as these increasingly shape social policies,” says Prof. Spigarelli. “But this digital space isn't simply impartial. It can be inclusiveness or divisive, transparent or opaque, depending on what choices people make. So digital policies need to address the values of inclusive citizenship.”

This kind of social collaboration will likely spark a range of economic returns, with more targeted sustainability solutions leading to new business opportunities for European companies.

Currently, the team are developing a new proposal for further EU funding to investigate the link between innovation and law, while also looking at how blockchain technology could be used to improve citizen welfare and enable new forms of democracy within cities.

GRAGE

- Coordinated by the University of Macerata in Italy.
- Funded under H2020-MSCA-RISE.
- cordis.europa.eu/project/id/645706
- Project website: grageproject.eu
- bit.ly/2HxNR3L



Milestone reached on the road to a hydrogen economy

According to the Hydrogen Council, by 2050 18 % of global final energy demand could be met by hydrogen. With an eye on the future, the Hydrogenlogistics project developed a flexible, safe and efficient solution to supply hydrogen refuelling stations.

Hydrogen is widely used in a range of industrial applications, including food processing and oil refining. Recently, hydrogen-powered mobility and energy initiatives have become growth areas across Asia, Europe and the US, due to its vast potential to reduce emissions.

However, hydrogen's extremely low density means it's necessary to compress the gas to pressures of up to 700 bar or liquefy it at temperatures below -250°C to store and transport it. These options are technically challenging, inefficient and very expensive, as they require large infrastructure investment.

Since its foundation in 2013, Hydrogenious Technologies has focused on the commercialisation of a technology called Liquid Organic Hydrogen Carrier (LOHC) for the safe and efficient transport of hydrogen in liquid carrier oils. With EU support, the Hydrogenlogistics (Enabling the Hydrogen Economy) project engineered, constructed and tested, at industrial scale, a modular LOHC dehydrogenation system (ReleaseBOX) for supply to hydrogen refuelling stations (HRS) – one of the key markets for the technology.

This is the world's first LOHC plant operating with compression and pressure swing adsorption technology to produce high-pressure and high-quality hydrogen for HRS applications.

THE LIQUID ORGANIC HYDROGEN CARRIER (LOHC)

The concept of chemical hydrogen storage in LOHC has been known since the 1970s. The contribution of Hydrogenious Technologies was in identifying a suitable carrier fluid, dibenzyltoluene – a readily available low-price heat-transfer fluid, as well as optimising and scaling the chemical processes for a market-ready product.

"The storage density of hydrogen in LOHC is up to five times higher compared to conventional high pressure storage, meaning a cubic metre of LOHC can carry around 57 kg of hydrogen. This means increased transport capacity on trucks, trains or ships, resulting in reduced costs to customers," says Dr Martin Schneider, Head of Product Management at Hydrogenious Technologies.



The chemical storage in dibenzyltoluene is reversible and so this LOHC fluid can be recycled several hundred times. Furthermore, as the hydrogen carrier is non-toxic, hardly flammable and non-explosive, it can be transported at ambient conditions via the existing infrastructure for liquid fuels (pipelines, tank trucks, ships, trains).

A DRIVER OF THE COMING GREEN GROWTH REVOLUTION

Meeting the EU's target of an overall 80 % reduction in greenhouse gas emissions by 2050 will necessitate a drastic change in how the transport, heating and industrial sectors operate. Substituting fossil fuels with renewables in the mobility and transport sector will have to be combined with efficient ways to make volatile renewable energy available on mobile platforms.

Hydrogen is a promising option here, as it can be produced by renewable sources which 'split' water's bonded hydrogen and oxygen molecules, under a process called electrolysis. Additionally, it offers quick refuelling with a long range, even for large cars, trucks and busses.

Today, Hydrogenious can offer a StoragePLANT with a hydrogen uptake capacity of 12 tonnes per day and release units for the supply of 1.5 tonnes of hydrogen per day for industrial hydrogen supply or HRS applications.

Hydrogenlogistics' systems have been in field operation with a US-based industrial hydrogen supplier (United

“Through our LOHC technology, international large-scale hydrogen transport becomes technically and economically feasible. LOHC provides the missing link towards a global hydrogen economy.”

Hydrogen Group) since 2018. The team are currently constructing two units for an EU-funded project called HySTOC, with field testing planned for later this year. Additionally, preparation is underway to install a pilot unit at a commercial HRS in Germany, to be launched in 2020.

“Through our LOHC technology, international large-scale hydrogen transport becomes technically and economically feasible. LOHC provides the missing link towards a global hydrogen economy,” says Dr Schneider.

HYDROGENLOGISTICS

- Coordinated by Hydrogenious Technologies GmbH in Germany.
- Funded under H2020-LEIT-ICT, H2020-TRANSPORT and H2020-SME.
- cordis.europa.eu/project/id/757082
- Project website: hydrogenious.net/index.php/en/hydrogen-2-2/

TRANSPORT AND MOBILITY

Improved management, maintenance and safety for bridges

Climate change mitigation and adaptation efforts not only minimise risk to critical infrastructure, the public and the economy, but also present opportunities for innovations. One EU-funded project seized the chance to efficiently manage and maintain bridges.

It is widely accepted that climate change will shift balanced water cycles, making flooding more frequent, and so threaten bridge and transport infrastructure. Studies

have shown that of all bridge hazards, hydraulic hazards (scour) are the biggest cause of bridge structure failure (partial or complete).



An efficient and effective bridge management system involving monitoring and meteorological forecasting, means that engineers will be able to improve safety, reduce management costs and also be prepared well in advance for flood events.

The BRIDGE SMS (Intelligent Bridge Assessment Maintenance and Management System) project developed an automated, open source, cloud-based decision support and management tool, combining knowledge from hydrology and river engineering with that of industrial bridge management systems. With the protocols, architecture and communication channels in place and already piloted, the system is now ready for replication.

THE INTELLIGENT DECISION SUPPORT SYSTEM

Bridge inspection, assessment and maintenance relies on a range of knowledge, including: structural engineering; geotechnics; hydraulics; hydrology; materials; and transport management. BRIDGE SMS, with EU Marie Skłodowska-Curie IAPP project support, automated the combination of this knowledge to develop an intelligent decision support system for the assessment and management of the structural and hydraulic vulnerability of bridges over water.

“A new standardised approach for bridge inspections will automate bridge inspection and reporting processes,” says project coordinator Dr Eamon McKeogh. “In combination with weather and flood forecasting, this will allow bridge managers and site engineers to plan activities and reduce overall bridge management costs.”

The new bridge inspection method incorporates several components for both structural and scour inspection of bridges. With the support of a dedicated tablet, bridges can be rapidly inspected, with the data collected on-site. The flood forecasting and early warning, combined with a low-cost Internet of Things system for weather and river monitoring, helps decision-makers take preparatory measures in advance of hazardous events.

“In combination with weather and flood forecasting, this will allow bridge managers and site engineers to plan activities and reduce overall bridge management costs.”

All the bridge's information, such as geometry, photos and maintenance details, is combined and presented within a dedicated platform which consists of several modules such as Bridge Inventory and GIS layout. These can work independently and on separate servers, but all communicate with the central database and Bridge Inventory Module.

The platform also enables access to historic, current and forecasted information, can import and export data, and can be linked with various external databases.

The mobile inspection device is especially comprehensive, for addressing the problem of bridge scour – the removal of the river bed around the substructure and foundations due to fast flowing water. The forecasting system estimates flood discharges and the scour depth up to 10 days in advance of a flood event and uses an algorithm to combine this with bridge condition and foundation depth, to provide a vulnerability rating. These assessments have correlated well with manual inspections.

The pilot was conducted on two river catchments in County Cork, Ireland and further testing of the system was carried out on bridges in Croatia and Portugal.

The full product is nearly market ready, with certain customisation required for new users. “The new bridge inspection approach, tablet application and flood forecasting feature have especially attracted significant interest from relevant government institutions,” says Dr McKeogh. Two industry partners in Ireland and Portugal are already using the first versions. Meanwhile, the team is still working to improve the product, with the University of Zagreb already setting up a new spin-off company.

BRIDGE SMS

- Coordinated by University College Cork in Ireland.
- Funded under FP7-PEOPLE.
- cordis.europa.eu/project/id/612517
- Project website: bridgesms.eu



Role of Arctic warming in extreme climate events

Our knowledge of the processes linking Arctic warming (or Arctic amplification) to mid-latitude weather and climate is incomplete. However, a comprehensive understanding is crucial for accurate predictions of climate change, including extreme events.

Over the last three decades, the Arctic has warmed faster than the rest of the planet, going through unprecedented physical changes as shown by record low sea-ice and snow areas in summer. Impacts of these changes on weather and climate outside the Arctic region, as in northern Eurasia, may be substantial because the Arctic is an integral part of the global climate system.

Such impacts have possibly already been observed in the Northern Hemisphere in the last decade. They include increased numbers of heat waves, exceptionally cold

winters, and flooding, often of unprecedented strength and duration.

The EU-funded LAWINE (Links between warming Arctic and climate extremes in northern Eurasia) project aimed to better understand the complex processes that potentially link Arctic amplification with weather and climate in northern Eurasia, helping to reduce the damage caused by extreme climate events. This research was undertaken with the support of the Marie Skłodowska-Curie programme.



“*The enhanced predictability of extreme weather and climate events is an important factor for better societal resilience and adaptation.*”

OBSERVATIONS AND MODELS COMPARED

Scientists studied combinatory interactions of regional air-ice-ocean systems surrounding northern Eurasia. “We investigated the links of large-scale Atlantic weather conditions and sea-surface temperatures to atmospheric temperature and moisture over northern Eurasia, and the influence of the warm Arctic – cold Siberia pattern on the Northern Hemisphere atmospheric circulation,” says project coordinator Prof. Petteri Uotila.

These interacting systems, denoted as ‘teleconnections’, affect the regional weather and climate. “We hypothesise that Arctic amplification is affecting the Eurasian climate extremes by teleconnections along with other regions such as the Atlantic and the Pacific,” Prof. Uotila explains.

Scientific understanding of teleconnections is incomplete due to imperfect models and limited observations. Forecast models therefore still have many shortcomings and are far from perfect, which makes the identification of the physical mechanisms behind teleconnections challenging and the results uncertain.

Researchers addressed these knowledge gaps by investigating teleconnections linking the ocean and land surface characteristics to the occurrence of extreme climate events. “We compared observations and model output and selected the most realistic models in terms of their ability to represent teleconnections,” Prof. Uotila explains.

CLIMATE COMPLEXITY HIGHLIGHTED

The project designed, carried out and analysed climate change simulations to determine the mechanisms underlying teleconnections and improve the models’ predictive ability. This resulted in reduced uncertainties related to estimates of changes in climate extremes in Eurasia. According to Prof. Uotila: “We identified issues in coupled weather and climate models and retrospective analysis which decrease the accuracy of environmental forecasts.

We could then explain a number of physical mechanisms behind these issues.”

LAWINE results highlighted the complexity of the climate system, the relative importance of various teleconnections and their interactions. “For, example the regional effects of Arctic amplification in northern Eurasia are practically impossible to separate from simultaneously active teleconnection effects originating from other surrounding regions, such as the tropics and the Atlantic,” points out Prof. Uotila.

As extreme events can cause major damage and threaten human lives, better knowledge of mechanisms facilitating their occurrence and intensity is extremely important. LAWINE therefore directly benefits those who develop environmental forecasting models. This indirectly benefits the end users whose life and livelihood may depend on their accuracy. “The enhanced predictability of extreme weather and climate events is an important factor for better societal resilience and adaptation,” Prof. Uotila concludes.

LAWINE

- Coordinated by the University of Helsinki in Finland.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/707262
- Project website: orcid.org/0000-0002-2939-7561

Improved use of wetlands to remove uranium contamination from drinking water

The use of natural or constructed wetlands is often proposed for cost-effective, small-scale water treatment to tackle decreasing water standards for uranium (U) concentrations in drinking water. An EU initiative delved deeper into the transport and trapping of U in wetlands.

The transport of U is controlled by its redox state, which is either hexavalent (U(VI)) or tetravalent (U(IV)) in the environment. In its U(VI) state, U travels with water, but in U(IV) it's essentially immobile. "However, the long-term stability of U(IV) species formed isn't well understood," says Dr Rizlan Bernier-Latmani, coordinator of the EU-funded UMIC (Association of Uranium with Organic Matter- and Iron-bearing Colloids in Wetland Environments) project. A significant amount of U is mobilised, even in its reduced form, and contaminates the hydrologic network at several sites.

Previous studies suggest that the colloidal phase is responsible for the dispersion of U(IV) in watersheds, but

few occurrences of colloids containing U(IV) were reported in wetland environments. To date, no study has reported the occurrence of U(IV)-bearing colloids in wetlands not impacted by man-made activities. In addition, information is lacking on the processes leading to the formation of the present vector of U(IV) dissemination, that is, colloids containing iron (Fe) and natural organic matter (NOM), or Fe-NOM colloids. "Understanding these processes is crucial for predicting the efficiency of wetlands as traps for U water contamination," notes Dr Bernier-Latmani.

Project partners searched for new incidences of U(IV)-bearing colloids in wetland environments, including wetlands not affected by human-induced activities, and further characterised wetland colloids.

INVESTIGATING THE MOBILITY OF U IN UNPOLLUTED WETLANDS

The researchers found very small colloids containing U, organic matter and Fe in Switzerland's unspoiled mountain wetland of Gola di Lago. In these same samples, they also found significant proportions of U in reduced form – U(IV). "For the first time, we've reported that very small and potentially mobile U(IV) colloids form in a pristine mountain wetland," explains Dr Bernier-Latmani. The occurrence of U(IV) colloids in this wetland is noteworthy because U(IV) is generally considered immobile in remediation strategies. "The characterisation of U speciation in undisturbed environments, and particularly the determination of unexpected species, will hopefully help to explain why in some cases the use of wetlands for U remediation is successful, and in others it's not."



“UMIC allowed us to demonstrate the occurrence of U(IV) in natural wetland porewaters, likely in the form of organic colloids.”

The UMIC team showed that U(IV)-bearing colloids could form in both highly impacted and undisturbed environments, even though the porewater U concentrations are very low. This result is important in understanding the fundamental processes of U scavenging versus potential release through wetland environments. In environmental disturbances like climate change or changes to land management plans for such pristine wetlands, the U(IV)-bearing colloids present in the wetland porewaters could be mobilised downstream from the wetland. Therefore, the possible occurrence and formation of U(IV)-bearing colloids in wetlands should be considered in predictive

transport models, such as when planning water resource management or building remediation strategies based on bioreduction of U(VI) to U(IV).

“UMIC allowed us to demonstrate the occurrence of U(IV) in natural wetland porewaters, likely in the form of organic colloids,” concludes Dr Bernier-Latmani. “Our results should incite future models of wetland reduction of U(VI), to take into account the potential reduction of U(VI) into U(IV) colloids that are mobile and not necessarily trapped in the sediment material.” This research was undertaken with the support of the Marie Skłodowska-Curie programme.

UMIC

- Coordinated by EPFL in Switzerland.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/701542

CLIMATE CHANGE AND ENVIRONMENT

Does geography influence a species' risk of extinction?

The world is losing its biodiversity at an unprecedented rate, altering the functioning of Earth's ecosystems and their ability to provide clean air and water for society. It is now vital to understand the mechanisms underlying species extinction to prevent further biodiversity loss.

Species extinctions have a geographical component that is often overlooked in global models. In general, different populations of the same species face different risks of extinction – a population may have been extinguished in one area but remains numerous in another, for example.

Undertaken with the support of a Marie Skłodowska-Curie project awarded to Dr Marta Rueda, the EU-funded DRIVE (Quantifying the relative importance of natural and anthropogenic drivers of spatial variation in vulnerability to predict species extinction risk) project sought to increase understanding of the importance of spatial variation for

predicting the risk of species extinction caused by the drivers of global change. “We need to realise the impacts of human activity, like changes in land use, in both the present and the past. There is mounting evidence that human impacts in the past have been a determining factor in the diversity patterns that we see today,” says project coordinator Dr Eloy Revilla.

Researchers investigating the relative importance of natural factors and human activities in driving local populations to collapse focused on land mammals. They applied the latest advances in ecology, taking a multidisciplinary

The finding suggests human influence has already changed the ecological and evolutionary footprint of biodiversity that we see today.

approach involving biogeography, population modelling and wildlife conservation.

USE OF A BIOGEOGRAPHICAL TEMPLATE

The project comprised two different stages.

It first created a novel biogeographical template, which was then used to integrate the species' environmental context into ecological models. "The aim was to include the species' inherent vulnerability as a key intrinsic trait in models for determining species extinction risk in order to achieve more accurate predictions," explains Dr Rueda.

Scientists used state-of-the-art techniques and distribution maps of mammals obtained from the International Union for Conservation of Nature to develop analytically-derived hierarchical bioregions at different resolutions, ranging from the landscape size to the biome size or larger. “These showed that the world’s biodiversity can be coherently organised with a hierarchical structure of bioregions that include a local basis. These bioregions also help to answer questions concerning biodiversity organisation, evolutionary history and conservation,” explains Dr Rueda.

The information was applied to computer models that determined the environmental, ecological and evolutionary determinants of the taxonomic differences encompassed by bioregions to help researchers understand what they actually represent. They also studied different predictive scenarios that included factors known to contribute to the


shaping of bioregions globally, such as mountains and plate tectonics.

IMPACT OF HUMAN ACTIVITY

Key results showed that past anthropogenic impacts from the Late Holocene, around 2 000 years ago, can be detected in the configuration of the largest bioregions (or biogeographical realms). These are traditionally assumed to reflect the natural organisation of life that resulted from processes acting over millions of years.

This is consistent with the hypothesis that anthropogenic transformation of ecosystems has been extensive and began much earlier than previously believed.

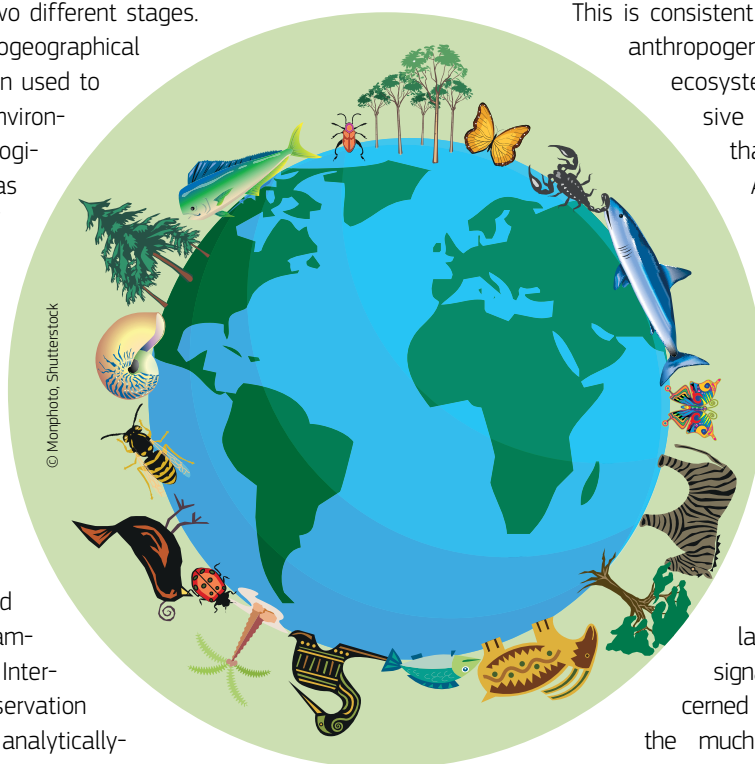
According to Dr Revilla: "The finding suggests human influence has already changed the ecological and evolutionary footprint of biodiversity that we see today."



DRIVE shows that if human impacts over the Late Holocene can result in such long-lasting and widely spread signals, we should be concerned about the effects of the much more widespread and severe changes that have occurred since the beginning of the industrial revolution. “The signal of current human land use will likely be detected by the future generations of biogeographers,” Dr Revilla concludes.

DRIVE

- Coordinated by the Spanish National Research Council in Spain.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/707587
- Project website: marta-rueda.com/drive-project



OCEANS UNDER THREAT: PROTECTING AND PRESERVING OUR MARITIME ENVIRONMENTS

Editorial

“No water, no life. No blue,
no green” — Sylvia Earle, oceanographer

From climate change and plastics pollution, to overfishing and the destruction of coral reefs, the world's oceans are reeling from human activities that together are building up into a terrifying environmental disaster. The future of human civilisation is dependent on healthy oceans (especially as they cover 71 % of the Earth's surface) and action needs to be taken now to safeguard their complex biodiversity for future generations. Luckily, hearts and minds are finally starting to come together to face these mounting challenges as part of the broader environmental movement but the Herculean responsibility of preserving our oceans will have to be taken up by everyone.

Better knowledge and increasing awareness of how human activities impact the oceans will be key to facing these challenges. Because humans will need to keep interacting with the oceans just as they have done since ancient times. The oceans are an essential conduit for international transport and communications, they provide food for billions, support millions of jobs worldwide and have a key role to play in transitioning towards greener, more sustainable energy. The oceans also have a crucial role to play in the regulation of our climate and alongside the (also under threat) rainforests, provide the oxygen we need to survive.

The EU as an international actor has taken up the challenge of working to preserve our oceans and its policy

priorities recognise not only the fundamental importance of the oceans and seas but also the sheer complexity of the problems that need to be addressed.

As always, sound policy is made with reliable evidence and innovative research. This is why our special feature this month is covering seven Horizon 2020-funded projects that are at the forefront of cutting-edge maritime research. From comprehensively studying how the Atlantic is being adversely affected by climate change, to preparing the fishing industry for future blue growth, and working out how unmanned drones can be utilised for better marine management, no stone is left unturned in the quest for truly healthier and more sustainable oceans.

From 23-24 October 2019, the annual prestigious 'Our Ocean' conference will be hosted by Norway, bringing together hundreds of policymakers, scientists, civil society and business representatives (and many other stakeholders) to discuss their experiences and identify solutions that will hopefully lead to concrete action to preserve and protect our oceans.

... because they're the only oceans we have.

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

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Deep Atlantic mysteries unveiled in the face of climate change

ATLAS is one of these projects you can't do justice to in a single-page article. For over 3.5 years now, a consortium of multinational industries, SMEs, governments and academia have been sailing across the Atlantic to assess its deep-sea ecosystems. In doing so, they've already managed to deeply enhance our understanding of the consequences of climate change as well as inform the development of better management policies and practices.

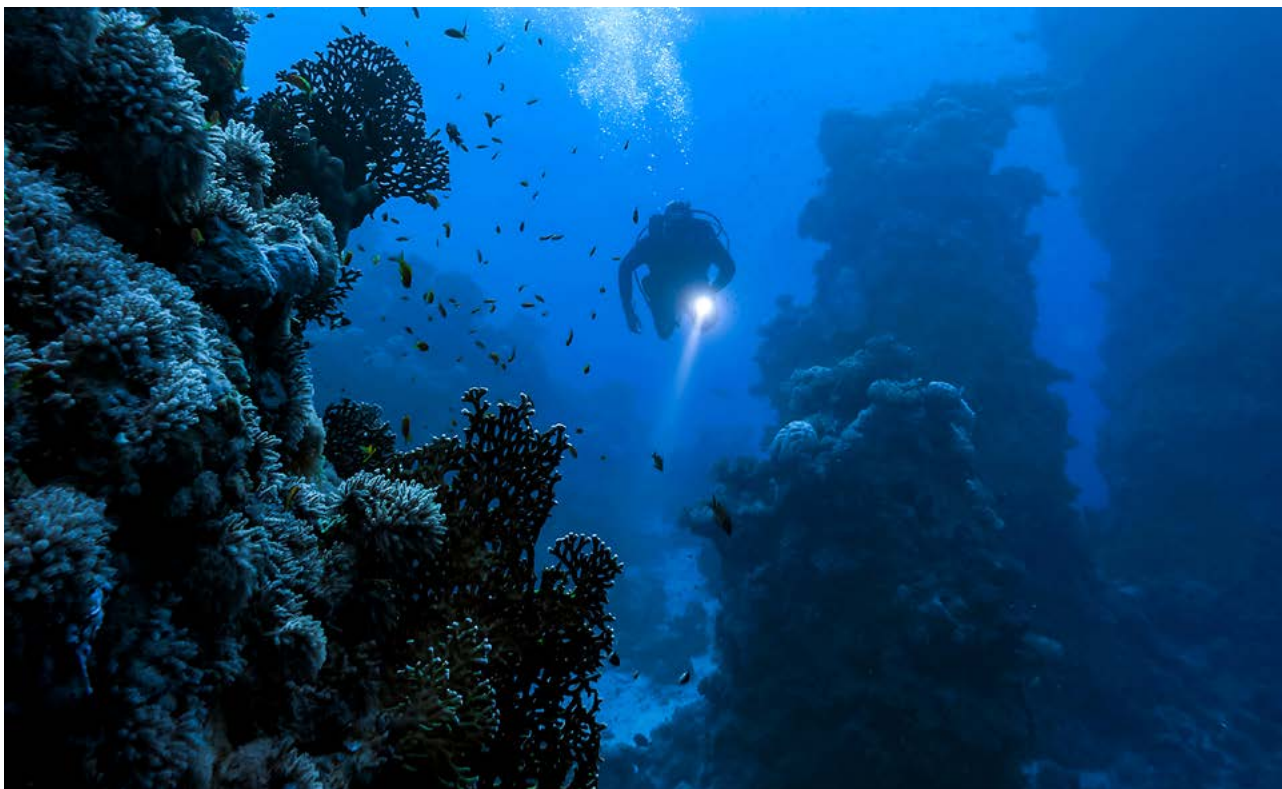
ATLAS (A Trans-Atlantic Assessment and deep-water ecosystem-based Spatial management plan for Europe) was born out of the realisation that, despite being one of the most studied oceans on Earth, the Atlantic still holds many mysteries. Plus, it is changing at a faster pace now than it has over the past 6 million years. How exactly it is changing, how we can expect it to keep changing in the future, and how we can better manage avoiding dramatic consequences are some of the questions at the heart of the project.

With 34 deep-sea missions, ATLAS has tackled subjects as varied as the connectivity of deep-water coral habitats, marine governance, the identification of vulnerable



Prof. Murray Roberts
Project coordinator of ATLAS
© Murray Roberts

“ATLAS has been providing input to critical UN negotiations aiming to create a new legal instrument for the conservation and sustainable use of biodiversity in areas beyond national jurisdiction.”



ecosystems and the fate of the Atlantic meridional overturning circulation (AMOC).

Prof. Murray Roberts, coordinator of ATLAS, discusses the project's approach, findings and expected impact.

What type of gaps in knowledge did you aim to fill with this project?

ATLAS focuses on understanding the ecosystems of the Atlantic's deep seabed. These are the most poorly known, yet also the ecosystems most vulnerable to growing human impacts from fisheries and deep-water oil/gas production. These ecosystems are also largely impacted by the wider consequences of global climate change such as ocean acidification, warming and deoxygenation, and the situation might just get worse if deep-sea mining becomes a reality.

The reality today is that the management of deep-sea ecosystems is very sectoral. Each stakeholder has its own way, from fishermen to oil/gas companies. Besides, these plans have been drafted with little ecological understanding. For example, Marine Protected Area designations take little to no account of ecosystem connectivity. ATLAS is creating mathematical models of how key areas are connected, by simulating how larvae would transfer across the Atlantic.

What are the most innovative aspects of your approach?

We ground all our work in the physics of the Atlantic. We then use this robust understanding of ocean currents to study ecosystem functioning, biodiversity/biogeography and connectivity. Moreover, we integrate socio-economic analyses and people's perceptions of deep-sea ecosystems into our work. The role of people and personal opinions is too often ignored or not taken seriously. Social science and policy are at the very heart of everything ATLAS does.

Can you tell us more about the expedition you organised? What was the extent of their missions and how did you proceed to pick the case studies?

So far ATLAS has led or participated in 34 offshore expeditions. If I had to highlight two of them, I would probably go for the 2016 MEDWAVES expedition led by the Spanish Institute of Oceanography and our 2-year collaboration with the Canadians to study sponge grounds in the Davis Strait.

The first expedition aimed to understand how Mediterranean Outflow Water influences the biodiversity and biogeography of seamounts and goes all the way from Spain to the Azores. The MEDWAVES team is exploring

important scientific ideas on how the Mediterranean and Atlantic are linked ecologically.

The second expedition required ATLAS working aboard the Canadian Coast Guard icebreaker 'Amundsen' to survey the area, assess food supply to the sponges and leave long-term landers from our partners in the USA that were collected earlier this summer. The 'Amundsen' expedition is a fantastic example of how ATLAS brought Trans-Atlantic partnerships together to deliver results that we wouldn't have achieved otherwise.

What would you say are your most important findings? Can you provide one or two concrete examples?

There are many to choose from. We have published 59 peer reviewed papers with 74 more currently in preparation. I could probably highlight the 'Nature' and 'Science' papers from the physics work package. The 'Nature' paper by Thornalley et al. in particular is important because it shows that the Atlantic's major overturning circulation – which regulates climate by distributing heat around the globe and whose potential shutdown inspired the 2004 blockbuster movie 'The Day after Tomorrow' – is already running slower than previously thought. It is even projected to keep slowing down with global climate change.

There are many other issues we could discuss, from microplastics to marine policy and economics, which were all covered by the project.

What are the main blue growth recommendations resulting from the project?

The main recommendations relate to the overarching importance of understanding ecosystems better. We need to know how they will respond to changing ocean conditions BEFORE we can develop management plans.

For instance, ATLAS has been providing input to critical UN negotiations aiming to create a new legal instrument for the conservation and sustainable use of biodiversity in areas beyond national jurisdiction – known as the BBNJ process. We were present at the preparatory committees and ongoing Intergovernmental Conferences. The 3rd IGC took place at the UN headquarters in August, and our policy team has done significant work there.

There are several other examples, including our work at Ocean Business earlier this year and deliverables still in development. For example, we've been looking into how the oil industry could adapt its operations in light of ATLAS findings.

What do you hope will be the long-term impact of ATLAS, especially in the face of recent accelerations in climate change-induced disasters and growing public awareness?

We hope the project will lead to better ocean management and we have engaged deeply in the science-policy process to make it happen.

We also place people at the heart of everything we do, which should help us have a long-term impact. For example, we have developed new educational materials in partnership with our educational lead at Dynamic Earth – one of Europe's largest earth science-focused visitor attractions in Europe – along with a new oceans gallery to showcase ATLAS work.

Do you have any follow-up plans?

Yes, there is a variety of plans ahead. The biggest example is a new H2020 project 'iAtlantic; an integrated assessment of Atlantic marine ecosystems in space and time'. I also coordinate this project. We have created a consortium that takes the ATLAS approach and expands aspects of its work to the entire deep and open Atlantic Ocean, by working with partners in Argentina, South Africa, Brazil, Canada and the USA.

ATLAS

- Coordinated by the University of Edinburgh in the United Kingdom.
- Funded under H2020-ENVIRONMENT and H2020-FOOD.
- cordis.europa.eu/project/id/678760
- Project website: eu-atlas.org
- <https://bit.ly/2ml6G0t>

CERES 'storylines' prepare the fishing industry for blue growth

CERES has investigated the exact consequences of different climate change scenarios for the fishing and aquaculture industries. A set of online tools provides stakeholders with invaluable data and suggestions for mitigation measures, to support blue growth across Europe.

The scientific community and the fisheries sector are only beginning to grasp the phenomenal impact climate change is having on seas' and oceans' ecosystems. Jellyfish taking over, over-fished populations struggling to keep up, or species like plaice having no choice but to go deeper from the sea's surface to survive are just some examples of drastic changes taking place underwater. Yet, the lack of significant actions to slow down these change is bringing up another, equally pressing question: How do we adapt?

The CERES (Climate change and European aquatic RESources) project has been aiming to fill in the blanks with one key objective in mind: helping the European fisheries and aquaculture sectors to get prepared. The project team has been investigating how climate change affects fish and shellfish species, as well as developing solutions to help stakeholders.

"The effects of climate change on fish and shellfish had been examined in previous (academic) research programmes. There had even been a recognition of the potential severity of climate impacts. However, there was little track record of European industry and scientists working together to examine these impacts," says Prof. Myron Peck, coordinator of CERES and Professor of Biological Oceanography and Fisheries Science at the University of Hamburg.

According to Prof. Peck, this lack of cross-sector cooperation had essentially resulted in the absence of rigorous climate adaptation measures – the kind that are desperately needed to keep industry on track.

LOOKING TOWARDS 2100

"A 'business-as-usual' climate change scenario such as IPCC scenario RCP 8.5 tells us that in 2100, European marine waters and fresh waters will have warmed by 2 to 4 °C. Rainfall will have declined in southern and increased in northern European areas, while more variable weather conditions (heatwaves, extreme storms) are expected. Under this scenario, fisheries targets are expected to shift towards the poles and/or deeper waters. This will result in both winners and losers across European regional seas," Prof. Peck explains.

Let's take the example of anchovies. Projections suggest that stocks will decline in the Mediterranean but increase in the Bay of Biscay. Similarly, Atlantic cod may decline in the southern North Sea but increase in the Barents Sea. Besides, both positive and negative effects are expected in aquaculture. The sector will need to prepare for greater risks of disease outbreaks. In fact, by 2050, the bioeconomic and social changes linked to climate scenarios will often be greater than the direct impact of climate change on species.

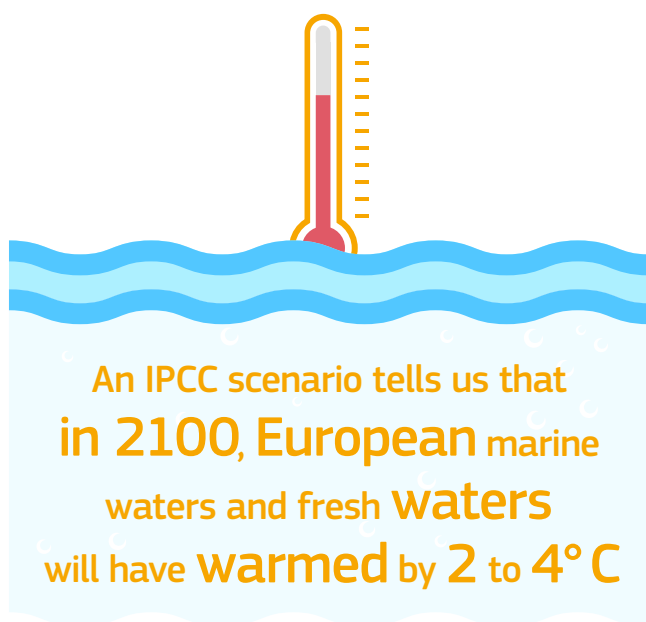
This is where CERES comes in. "CERES has been estimating which species of fish and shellfish will be profitable to grow or fish in specific areas under future climate. We provide broad advice for the two sectors, while more focused results are discussed in 25 'storylines' (case studies) providing more thorough coverage at the regional, species and business level," says Prof. Peck.

NOT ALL BUSINESSES ARE EQUAL

To help businesses find their way into these recommendations, CERES will provide a set of online tools. Using these tools should allow for better evaluation of the risks and opportunities related to fishing or farming specific species in specific locations, especially for smaller and artisanal businesses which are generally more exposed to the consequences of climate change.

"Farms with greater control over their production (large-scale sea cages) will be far less sensitive than those with much less





control, for example mussel farms relying on natural production. Similarly, large-scale industrial fisheries are better placed to cope than small artisanal fishers,” Prof. Peck explains.

Policy-making matters too, as flexible, climate-ready policies such as flexible aquaculture permitting or trans-boundary agreements for highly migratory fish stocks will be key to adaptation.

CERES

- Coordinated by the University of Hamburg in Germany.
- Funded under H2020-FOOD.
- cordis.europa.eu/project/id/678193
- Project website: ceresproject.eu
- bit.ly/2m1fVz

Mission: zero hunger and sustainable growth for the fisheries and aquaculture sector

Reconciling growing fish consumption with depleting stocks due to climate change will be one of the biggest challenges facing the European fisheries and aquaculture industry in the coming years. ClimeFish lends a helping hand with various prediction models and strategies.

Europe currently accounts for 8% of the world's fish production in terms of volume. It imports 70% of the fish and seafood it actually consumes. In fact, Europeans have never eaten so much fish. Put in the wider context of climate change and the decline in production it is causing, this poses serious challenges.

The ClimeFish (Co-creating a decision support framework to ensure sustainable fish production in Europe under climate change) project aimed to solve this delicate equation: meeting the growing appetite of European consumers while ensuring a sustainable management of declining fish stocks.

Mission impossible? Not with accurate biological production models considering the variety of species and production sectors, says Prof. Michaela Aschan, coordinator of ClimeFish and Professor in Fisheries Biology and Management at the Arctic University of Norway.

15 CASE STUDIES, SEVEN HABITATS

“A tailor-made approach is compulsory to produce reliable projections. This is why the ClimeFish consortium has picked 15 case studies across seven different habitats



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representative of marine aquaculture, freshwater lakes and ponds, and marine fisheries. Our models cover the most important species and the least resilient exploited fish stocks, the most productive aquaculture species, emerging species, and species vulnerable to perturbations such as temperature increase,” explains Prof. Aschan.

For pelagic marine fish species, for instance, the project team had to combine complex physical and biogeochemical

models taking into account all factors affecting migration with food-web models that predict the distribution of prey and predators. This was a colossal piece of work without which it would be impossible to predict the whereabouts of herrings or sardines at a specific point in time.

This is just an example. Demersal marine fish, continental fish from both cold and warm waters and aquaculture species – whether fed by farmers or through their environment – all required specific models for accurate predictions of biological production. Ultimately, the ClimeFish team hopes these models will enable zero hunger, good health and well-being, economic growth, industry innovation, and the sustainable utilisation of marine resources.

All case studies come with forecasting models identifying risks and opportunities. The project also devised strategies to improve long-term production planning and the policy-making process, which have been included in a framework including maps and charts, models, data for all case studies and decision support software (DSS).

“The DSS simulates and visualises the impacts of different climate change scenarios for three case studies, namely West of Scotland demersal fisheries, Hungarian pond production, and Greek marine aquaculture. It also encompasses economic impacts. We produced tutorials for stakeholders to make sure that they can easily understand and apply this tool for their needs,” explains Prof. Aschan.

CONTRIBUTING TO CLIMATE ADAPTATION/MANAGEMENT PLANS

Over the coming years, Prof. Aschan hopes that the project's results will contribute to the development and implementation of climate adaptation and management plans for both the fisheries industry and the ecosystems it depends on.



Europe imports 70% of the fish and seafood it actually consumes



“The main barrier to blue growth lies in how difficult it is for fishermen, producers, managers and policy-makers to make long-term plans, when they already have to deal with everyday challenges. The ClimeFish DSS allows them to plan for time periods of 10 years until 2060 under two different scenarios,” Prof. Aschan outlines. “We have worked closely with the European Commission’s DG MARE to ensure that the project’s input is aligned with the EU climate adaptation strategy, and we have already had good success so far in implementing guidelines and developing CAPs in the case study areas and countries.”

With the UK having recently developed national CAPs for aquaculture and fisheries, Prof. Aschan is confident that other countries will follow suit and use the project’s guidelines when doing so.

CLIMEFISH

- Coordinated by the University of Tromsø in Norway.
- Funded under H2020-FOOD.
- cordis.europa.eu/project/id/677039
- Project website: climefish.eu
- ▶ bit.ly/2mn3qlo

Enhanced detection, response and impact assessment of Arctic oil spills

Oil exploration at sea can lead to oil spills from drilling platforms, underwater pipelines or freight shipping. With increased interest in the Arctic as a potential shipping route, GRACE has developed improved mitigation tools.

Climate change may introduce new shipping routes in the Arctic. If these lead to oil spills, due to the area’s remoteness, conventional response equipment may not be

available within a reasonable timeframe and the cold and icy conditions may require specially adapted equipment.



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The EU-funded Research and Innovation Action project GRACE (Integrated oil spill response actions and environmental effects) conducted a range of tests to develop better monitoring, response and impact assessment tools. These culminated in the Environment & Oil Spill Response (EOS) analytical tool for environmental assessment to support oil spill response planning, soon to be freely available on the Internet.

OBSERVATION

The GRACE monitoring system measured oil in water in the open sea, principally in fairways, the likeliest location of spills. The main measurement method used was UV-fluorescence, which was tested on different platforms such as ships (FerryBox system), buoys (SmartBuoy) and other platforms (e.g. gliders, drifter buoys etc.).

The allied data management system allows users to see real time, high resolution data using web-based interfaces. The system can activate alarms when oil spills occur, as well as presenting data in graphs and tables to help users generate statistical probabilities of oil spills occurring.

A model was also developed of likely oil distribution for a coastal area near Tallinn in the Baltic Sea in the aftermath of a spill.

IMPACT ASSESSMENT AND RESPONSE

In the laboratory, GRACE studied the effect of oil components dissolved in water under an oil slick. The team overlaid water with oil, then after stirring for about 2 days tested the cells of a range of organisms present in the water, from copepods and mussels to zebrafish embryos and larvae. This was followed by measurement of physiological response to exposure.

The results showed that dispersed oil in the vast majority of cases was more toxic to the organisms than undispersed oil and that more refined oil seemed more

toxic than crude oil. "The results indicated that dispersants should be used with caution, especially in sensitive ecosystems such as the Arctic and Baltic Sea," says Kirsten Jørgensen, project coordinator at the Finnish Environment Institute (SYKE).

The team at RWTH Aachen University was also able to find links between genetic, metabolic and visual damage in biota due to oil. For example, they observed eye development disorders in zebrafish. Following this, GRACE defined a set of bioassays suitable for investigating oil spill impacts on organisms as well as the first prototype of a flow-through oil biosensor using hatched zebrafish embryos.

Mechanical recovery, dispersion, *in situ* burning and natural attenuation (doing nothing) were all evaluated for their effectiveness in tackling spills, across the four seasons. These strategies were assessed separately for their impact on species/organisms, from individuals to populations, at the sea surface, in seawater, on the seabed and on the shoreline.

This procedure was included in the EOS tool alongside guidance to assist users with the calculations necessary for decision-making.

WIDER BENEFITS

The EOS analytic tool is currently being tested at Aarhus University and the Greenland Institute of Natural Resources. The team expect to launch the free open source tool by the end of October 2019.

"Our work also promotes the business potential for companies in producing oil response equipment and monitoring services, as well as increasing public acceptance of offshore activities subject to thorough environmental assessments," says Jørgensen.

GRACE

- Coordinated by the Finnish Environment Institute in Finland.
- Funded under H2020-FOOD.
- cordis.europa.eu/project/id/679266
- Project website: grace-oil-project.eu/en-US
- ▶ bit.ly/2mc1601

The role that aquatic host-microbe interaction plays in pathogen emergence

Disease outbreaks in aquatic organisms are rising, most likely caused by climate change and eutrophication. Halting the loss of a key planetary resource may rely on insights from host-microbe interactions which can keep organisms healthy but also may help pathogens emerge.

Disease in aquatic organisms in several key animal groups is increasing, including mammals and corals. The rapid disappearance of once-common species, such as the black abalone sea snail, *Haliotis cracherodii*, or the oyster *Crassostrea virginica*, suggests a system out of balance or the introduction of a pathogen, or both.

Eutrophication (sewage and agricultural runoff), rising global temperatures (due to climate change), pollution, invasion of new/exotic species and the destruction of coastal habitats, all serve as stressors. But there is a dearth of data about the links between these and the health of marine organisms. There is however accumulating evidence connecting disease to the diversity of an organism's microbiome.

Microbiota enhances host function and contributes to host fitness and health – disturbing the balance between the host and its colonising microbiota appears to encourage diseases.

A BREAKDOWN IN RELATIONS

The EU-funded MICROCHANGE (Emergence of pathogenicity in the sea: altered host-microbe interactions in the face of environmental change) project, undertaken with the support of the Marie Skłodowska-Curie programme, studied the sea anemone *Nematostella vectensis* as a host, alongside its associated microbes, focusing on the family of bacteria *Vibrios*.

Vibrios are troublesome pathogens for aquaculture animals such as crabs and prawns. Some strains can induce severe illness in humans, such as gastroenteritis. Furthermore, 50% of coral pathogens belong to the family of *Vibrionaceae*.

While *Vibrios* are actually symbionts of several vertebrate and invertebrate hosts – such as fish, sea anemones, sponges, molluscs and zooplankton – there is evidence that under certain conditions, they can become pathogens.

For MICROCHANGE, the sea anemone *Nematostella vectensis* offered a model system for study due to its wide distribution around European coastal estuaries and ease of use in the lab. *Vibrios* had also already been successfully isolated from this species.

After the structure of the *Vibrio* population in the wild was determined, MICROCHANGE conducted lab experiments to test the stability of the host-microbiome relationship under a range of environmental stressors.

To test for the effects of nutritional stress, the freshwater polyp *Hydra vulgaris* was used, taking advantage of cells covered with a multi-layered carbon enriched coating that provide a habitat for a simple but core microbiome.

After exposing the animals to nutrient enriched environments, the researchers followed changes in their microbiome composition (using 16S rRNA gene high-throughput Illumina sequencing) and density (using plating).

“Our results suggested that microbial population density is a fundamental indicator of host health, and



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that nutritional stress contributes to alterations in the microbiome that may be linked to the deterioration of host health,” says Marie Skłodowska-Curie researcher, Dr Peter Deines.

The key implication of MICROCHANGE’s results is that altered environmental conditions can lead to a state of *dysbiosis*, whereby a microbiome’s ability to resist invasion is diminished, potentially leading to the emergence of pathogens.

MAINTAINING HIGH EU FOOD AND ENVIRONMENTAL STANDARDS

Diseases in aquatic animals directly affect humans, in terms of not only increased health risks but also the economic and social costs associated with degraded ecosystem productivity.

Increased understanding about the processes underlying healthy microbiomes and pathogen emergence can lead to water and ecosystem strategies which integrate resilience to climate change.

“We can observe links between environmental changes and increased disease on our doorstep ... Understanding these links contributes to EuroMarine’s vision of Blue Science for Blue Growth.”

“We can observe links between environmental changes and increased disease on our doorstep. For example, abnormally high temperatures in the Baltic Sea have coincided with unusually large numbers of *Vibrio* infections. Understanding these links contributes to EuroMarine’s vision of Blue Science for Blue Growth,” says Prof. Thomas Bosch, the project host.

MICROCHANGE

- Coordinated by Kiel University in Germany.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/655914

Improved unmanned aerial vehicles for better marine management

The drive towards maritime and marine activities in remoter and harsher environments demands new approaches and technologies. MarineUAS gave 16 young researchers the skills and knowledge to help develop these.

Europe’s vast coasts and economic areas that stretch far into the Atlantic and Arctic oceans are challenging to monitor and manage. Large research vessels, buoys, satellites and manned aircraft are usually deployed for this purpose, which as well as providing limited coverage, also come at high financial costs.

The oceans and coasts are therefore relatively under-sampled and there is a dearth of data with the required information about space, time and features.

Autonomous unmanned aerial vehicle (UAV) systems are being increasingly used as a solution. They offer high endurance, reduced cost, flexibility, rapid deployment and higher accuracy/resolution, with reduced risk for humans and the environment. But exploiting the technology is complex and requires inter-disciplinary knowledge

involving extensive field testing and airworthiness certification to meet the standards set by aviation authorities.

To help facilitate this, the EU-funded project MarineUAS (Autonomous Unmanned Aerial Systems for Marine and Coastal Monitoring) trained 16 early stage researchers across several countries, forging a collaborative environment which benefited from the partners’ extensive knowledge, field experience and facilities to improve the technologies.

MORE EYES IN THE SKY

The deployment of UAVs is intended to augment the capabilities of research vessels, providing scientists and government agencies with significantly more ‘eyes in the sky’. The design of the UAVs varies, ranging from



FUTURE-PROOFING MARINE MANAGEMENT

The protection and sustainable management of marine resources is an important policy aim for the EU, as outlined in its Strategy for Marine and Maritime Research.

multi-rotor machines with hovering and vertical-take-off-and-landing (VTOL) capabilities, to fixed-wing UAVs with long range, high endurance and speed.

The researchers were placed in leading European research groups where they had access to the necessary software and experimental facilities to develop and test new theories and technologies.

"No single nation has the full research competence required to adequately prepare Europe's researchers for these demanding tasks, which is why the consortium partners were so valuable," says Prof. Tor Arne Johansen from the Department of Engineering Cybernetics at the Norwegian University of Science and Technology (NTNU).

The researchers built and experimentally tested prototypes to improve wind measurement and smart processing, as well as methods for the safe landing of fixed-wing UAVs on small ships, and the UAVs' ability to withstand harsh weather conditions. Other characteristics, such as collision-avoidance enabling more efficient use of shared airspace, were tested in simulation.

Furthermore, the UAVs were given higher degrees of autonomy and intelligence, with some specially adapted to give them the ability to work in tandem with unmanned surface and underwater vehicles, for example for the exchanging of data.

"MarineUAS's results contribute in a number of ways, such as increasing the capacity and efficiency of maritime search and rescue, especially in the Arctic. Likewise, these technologies which monitor the environment, fisheries and borders for effective management of marine protected areas, also benefit climate science more widely, as they provide key indicators of climate changes," says Prof. Johansen.

Currently, the project's industrial partners have plans to use the technologies developed for unmanned air traffic management (UTM), inspection of coastal and maritime infrastructure, and with the deployment of all-weather UAVs that can operate from ships.

This research was undertaken with the support of the Marie Skłodowska-Curie programme.

MARINEUAS

- Coordinated by the Norwegian University of Science and Technology (NTNU) in Norway.
- Funded under H2020-MSCA-ITN.
- cordis.europa.eu/project/id/642153
- Project website: marineuas.eu

Building the energy-efficient, low-emission ships of tomorrow

The EU-funded LeanShips project has advanced a range of low-emission, energy-efficient technologies for shipping from research projects to real, market-ready innovations.

With 90 % of all world trade happening via shipping, there is an increasing need to lower the level of emissions created by the world's fleet. One way of making both new and existing vessels more efficient and less polluting is to develop solutions that are near market ready.

Bringing together suppliers, ship designers and builders, research institutes, and the end users operating the vessels, the EU-funded LeanShips (Low Energy And Near to zero emissions Ships) project has successfully advanced



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a range of low-emission, energy-efficient technologies from research projects to real, market-ready innovations.

“In LeanShips, we had the possibility of bringing past research results to market and really demonstrating the viability of the technologies,” says Pieter Huyskens, project coordinator and manager of research and development at Damen Shipyards Group, the project’s lead partner. “Most importantly, we showed how these technologies can reduce the shipping industry’s environmental footprint and, ultimately, create better ships and a better world.”

DEMONSTRATING MARKET READINESS

Through seven demonstrator, LeanShips researchers showcased how the technologies and ideas developed in previous research projects such as BESST, JOULES and GRIP could be applied to actual user needs. “It is cool to see how each of these demonstrators builds on experience from former collaborative projects, each being enriched with new partners that bring new areas of expertise to the table,” explains Huyskens.

The idea behind the project’s demonstrators was to provide the link between the green technology developed in prior projects and large-scale market uptake. “Each of the LeanShips demonstrators aimed at proving the technology’s reliability, its effectiveness at achieving energy and emission goals, and the economic gains achieved from adopting such technologies,” says Huyskens.

The demonstrators included, among others, using methanol as an alternative fuel, expanding the use of

“In LeanShips, we had the possibility of bringing past research results to the market and really demonstrating the viability of the technologies.”

energy-saving devices to ships with a controllable pitch propeller, and taking a holistic approach to reducing the emissions of passenger ships. One of particular interest involved the design of a powerful, versatile and energy-efficient tugboat. Thanks to a new hull shape, the boat benefits from more high-speed manoeuvrability – an essential capability when working in Europe’s increasingly overcrowded ports.

“With bigger vessels entering our ports, tugboats must have more power and be able to manoeuvre in less space,” says Robert van Koperen, mechanical engineer at Damen Shipyards Gorinchem. “This new hull shape enables us to better meet the demands of today’s ports.”

CHALLENGES AND ACHIEVEMENTS

It wasn’t all smooth sailing for project researchers. With many of the demonstrators being very close to market, they were highly vulnerable to market fluctuations. For example, when the oil and gas crisis hit mid-project, which had a significant impact on the business case for using natural gas as a marine fuel, researchers had to adjust accordingly.

That being said, Huyskens is extremely proud of what the project was able to accomplish: “Thanks to our diverse, multi-disciplined consortium, we were able to prove the potential of a range of innovative, green technologies. In doing so, we also showcased what Europe can do when we work together.”

LEANSHIPS

- Coordinated by Damen Shipyards Gorinchem in the Netherlands.
- Funded under H2020-TRANSPORT.
- cordis.europa.eu/project/id/636146
- Project website: leanships-project.eu/home
- ▶ bit.ly/2YIUMjn



New insights into crop evolution and adaptation offer increased food security

With the world's population set to reach almost 10 billion by 2050, the UN (FAO) warns that current food production will fall far short of need. With limited land available, the only realistic option is for increased yield and more efficient inputs, such as water and fertilisers.

With a wide range of plant growing conditions across Europe, there is a constant need for crop varieties adapted to new pests and diseases, as well as changing weather patterns and market requirements. Globally, a fast-growing population, along with climate change, is jeopardising food security.

The EU supported WHEALBI (Wheat and barley Legacy for Breeding Improvement) project was established to improve wheat and barley production and introduce new varieties alongside innovative cropping systems. Combining genomics, genetics and agronomy, the project collated data from the expressed genome sequences of over 1 000 wheat and barley genetic lines. The data will be useful for breeding programmes and crop management.

EVALUATING CROP DIVERSITY AND BREEDING LINES

As each plant contains thousands of genes, and with breeders typically seeking to combine multiple traits in one plant, developing successful varieties is complex, costly and time-consuming. Additionally, breeders are often trying to anticipate the needs of farmers, consumers and the environment years in advance.

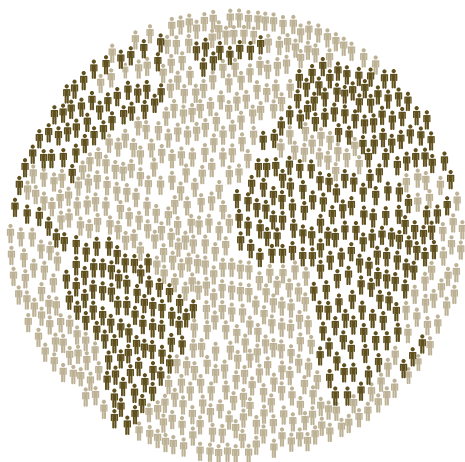
Biorepositories, called 'germplasms', simplify this process by functioning as seed banks containing collections grown according to rules of traceability and with the seeds stored for distribution for at least 10 years. This species diversity, when combined with next-generation genome sequencing, enables characterisation in unprecedented detail – offering a powerful resource for breeders.

The WHEALBI germplasm was characterised both in the field (in a nursery), across a network spanning from Scotland to Israel (i.e. a variety of climates), and using phenotyping platforms to perform whole genome scans for specific traits. Here, signatures of adaptive selection were explored, with alleles of candidate genes identified to reveal new variation associated with specific phenotypes.

"We obtained as much data as possible on the 1024 varieties selected, collecting information particularly about adaptive traits that lend tolerance to disease, frost and drought for example," says project coordinator Gilles Charmet.

Agronomy researchers were able to complete the genetic studies testing a subset of varieties (covering the observed





The world's population is set to reach almost 10 billion by 2050

range of diversity) in different cropping systems, including no-tillage (conservation agriculture) and organic husbandry.

The resulting, publicly accessible, collection of geo-referenced inbred lines of wheat and barley accessions (plant materials collected at the same time) offers unique access to the life history, traits and phenotypic data of these crops.

WHEALBI also produced exome, the coding part of the genome, sequence data for the barley and wheat varieties representing global diversity, with a focus on winter-grown varieties adapted to European agricultural conditions.

A SECOND GREEN REVOLUTION?

The project identified new crop management systems, evaluating their economic impact at both farm and EU levels. This could lead to a more competitive farming industry

“ We obtained as much data as possible on the 1 024 varieties selected, collecting information particularly about adaptive traits that lend tolerance to disease, frost and drought for example. ”

with increased yields and export earnings, alongside cost savings and enhanced processing efficiency.

By reducing pressure on natural resources, through the use of higher-yield and more climate and disease-resilient crop varieties, plant breeding can help sustain a more secure food chain. It can do so while also benefiting the environment (less pesticides) and biodiversity. Additionally, these innovations not only improve the quality, taste, convenience and seasonality of food, but also offer health benefits with new crop varieties, such as oats with enhanced levels of antioxidants.

The majority of the WHEALBI collection is freely available through a dedicated portal. “Here any scientist or breeder can request seeds for their own experiments, and use them freely either for research or for applied breeding,” says Charmet.

WHEALBI

- Coordinated by the National Institute for Agricultural Research in France.
- Funded under FP7-KBBE.
- cordis.europa.eu/project/id/613556
- Project website: whealbi.eu
- bit.ly/2Z2hUc2

FOOD AND NATURAL RESOURCES

Toxic soils and the impact of climate change

Examining the potential effects of climate change on soils already stressed by anthropogenic activities is crucial to establishing just how much these vulnerable areas will be impacted. The GLOBALTOX project sought to assess how the toxicity of multi-stressed soils may be affected under the current global warming perspective.

Climate change has the potential to critically impair the biotic (those related to living organisms) and alter the

abiotic components of terrestrial ecosystems. The situation may be far worse in those systems that face several

layers of environmental and man-made stressors, such as in anthropogenic-contaminated soils. The effects of toxic contaminants may worsen depending on the prevailing climate conditions, piling up the pressure and risking further degradation.

The EU's GLOBALTOX (Toxicity of anthropogenic multi-stressed soils under a global warming perspective) project assessed the sensitivity of different soil invertebrate species to toxicity changes in the soils, induced by single climate factors: air temperature, soil moisture content, atmospheric CO₂ concentrations, and UV radiation. The project also undertook to find out how the toxicity levels are affected under different climate change scenarios, simulated by combinations of multiple climate factors, using the soil invertebrates as bioindicators.

CONTRIVED ENVIRONMENTS

The team collected natural field soils affected by anthropogenic metal pollution from a former mining district in Portugal, and from a former agricultural area that received years of chemical waste from a nearby industrial complex. The soils were brought back to the laboratory facilities at the University of Aveiro, where they were air-dried and stored at 4 °C before being used in the experiments.

The team created combinations of different climate factors to house the soils, drawing on predictions of possible emission scenarios laid out by the International Panel on Climate Change (IPCC). They then measured changes in key soil parameters: pH, organic matter, nutrient cycling, metal availability and microbial community.

Soil-dwelling invertebrate species were used to understand the possible effects, at organism and population level. The species selected play crucial roles in the proper functioning of terrestrial ecosystems. The team looked at survival, reproduction and avoidance behaviour against contaminated soils, and measured body metal concentrations, enzymatic biomarkers and changes in gene expression in the organisms.

"In the first stage, we checked for the effects induced by alterations in single climate factors to know the specific effects of each of the climate factors selected," explains Dr María Nazaret González Alcaraz, Marie Skłodowska-Curie Fellow of the GLOBALTOX project. "In the second stage, we combined multiple climate factors in order to simulate the overall environmental climate conditions in a more realistic way."



SUPPORTING THE SCIENTIFIC COMMUNITY

The team found that the forecasted climate scenarios for the year 2100 might affect the performance of soil invertebrate species in anthropogenic metal-contaminated soils. The effects were particularly marked when dryness conditions in the soil were intensified by exposure to raised air temperatures. Furthermore, soils with highly acidic conditions and high metal content are among those most affected, resulting in increased toxic effects.

This is the first time, to the GLOBALTOX team's knowledge, that ecotoxicity risks of anthropogenic metal-contaminated soils have been evaluated under realistic, forecasted climate change scenarios using soil invertebrates as bioindicators.

"The results we obtained might have an important impact on the monitoring and management of anthropogenic-contaminated soils in the context of climate changes," says Dr González Alcaraz.

"The results provide clear evidence to support the aim of limiting the global temperature increase to 1.5 °C set by the Paris Agreement," Dr González Alcaraz adds.

The team is finishing the analysis of some samples and working on the publication of the results obtained. In the medium and long-term, the team wants to carry out the same tests on other types of contaminated soils.

GLOBALTOX

- Coordinated by the University of Aveiro in Portugal.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/id/704332
- Project website: globaltox.weebly.com



LIFE AFTER...

Catching up with DIVERSIFY: fizzing with ideas for aquaculture

One year ago, the DIVERSIFY project left important guidance to the aquaculture industry, with the promise of greater competitiveness and diversification of its production. What has the consortium been up to since then? Did the project results enable the commercialisation of new fish products? CORDIS investigated.

DIVERSIFY (Exploring the biological and socio-economic potential of new/emerging candidate fish species for the expansion of the European aquaculture industry) is the largest EU research project focusing on aquaculture to date. With a total budget exceeding EUR 11 million and a total of 40 partners, it comes as no surprise that the project continues to impact the aquaculture sector almost a year after its completion.

"There are at least five commercial operations in Greece that have greater amberjack growing in their sea cages, all produced from eggs or juveniles supplied by DIVERSIFY

partners," explains Dr Constantinos Mylonas, coordinator of the project. "Some of them have even sold fish to the market at a very good price, superior to EUR 12 per kg."

Greater amberjack was one of six species highlighted by DIVERSIFY for their market potential. For all these species, the project consortium designed innovative production methods. Grey mullet producers in Greece, for example, have already shown interest in producing and market-testing a grey mullet fillet in olive oil developed under DIVERSIFY. The product has the potential to become a game-changer in a sector that used to be unable to process the flesh of this fish. DIVERSIFY's results have been disseminated to fish farmers across Europe, so additional products can be expected in the future.

More research ahead

On the research front, DIVERSIFY partners have been very busy as well. A new Horizon 2020-funded project has been approved and will allow some of them to keep working on amberjack and meagre products, while



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other project partners will do the same on their own.

Several proposals have been submitted to National funding agencies, too. "In Greece for instance, the Hellenic Centre for Marine Research (HCMR) has been awarded four new projects. These encompass: the reproduction and larval rearing of greater amberjack; the genetic contribution to growth rates and the identification of influencing genes; the development of more efficient and effective moist diets for growth; and the development of genetic selection methods for meagre," says Dr Mylonas.

HCMR has also partnered with Bodo University and CCMAR to apply the methods used

in DIVERSIFY to solve reproductive problems in Senegalese sole, spotted wolffish and lumpfish.

"This effort would have never been possible without the support of the EU, as no country would have been able to put together and finance such an ambitious project," Dr Mylonas concludes.

DIVERSIFY

- Coordinated by the Hellenic Centre for Marine Research in Greece.
- Funded under FP7-KBBE.
- cordis.europa.eu/project/id/603121
- Project website: diversifyfish.eu
- bit.ly/2uXxmaZ



Dr Constantinos Mylonas

Project coordinator of DIVERSIFY
© Constantinos Mylonas

"This effort would have never been possible without the support of the EU, as no country would have been able to put together and finance such an ambitious project."



Novel manipulation of silicon carbide-based powder creates stronger, greener thermal spray

The EU-funded ThermaSiC project is developing the first silicon carbide-based thermal spray coating, providing end users with a stronger, more cost efficient and greener solution.

Silicon carbide's (SiC) extreme hardness, low friction coefficient and minimal density make it a highly attractive coating solution for a range of applications used by the petrochemical and chemical industries. The challenge, however, is that when heated, SiC becomes a gas and thus cannot be applied as a thermal spray. That is until now.

The EU-funded ThermaSiC (New generation wear and corrosion coating enabling European industry growth) project is set to disrupt the thermal spray market by developing the first SiC-based thermal spray coatings. "Our innovative wear-resistant material for coatings is based on SiC, which is well-known for its ability to withstand all sorts of wear, corrosion and high temperatures," says project coordinator Mr Gisle Østereng. "ThermaSiC is also a greener material than such competing materials as tungsten carbide, cobalt and chrome and is sourced from conflict-free zones."

A SUPERIOR POWDER PRODUCT

Seram Coatings, the project's lead partner, has long produced a SiC-based powder. The innovative powder contains an oxide layer around each SiC particle that enables the SiC to go through the thermal spray process and form a coating. In this project, Seram worked to demonstrate the effectiveness of ThermaSiC, a new powder product for thermal spray coating offering superior wear resistance, decreased weight and emissions, and an increased lifespan for the coated parts.

"Thermal spray is the most efficient and desired coating method for wear coatings in the industry," says Østereng. "ThermaSiC can be used by thermal spray guns to form coatings that have a lower cost than if they were made using traditional vacuum chamber methods such as CVD and PVD."



“Thermal spray is the most efficient and desired coating method for wear coatings in the industry.”

The project also worked to scale up Seram's manufacturing capabilities and finalise its intellectual property (IP), marketing and sales strategy.

Some of the project's key achievements include successfully scaling up production, moving production to Norway's largest industrial site, gaining a positive characterisation of the powder and coatings, and finalising a study on the market and value chain. The technology readiness of ThermoSiC was elevated by performing several internal tests, as well as with spray partners and independent third parties. In March 2018, the first very dense coatings were completed using the TopGun HVOF thermal spray system.

That being said, due to some unexpected complications with the other project partners, researchers were unable to prove ThermoSiC as a stand-alone product; instead as part of a blend of materials. “We are now commercialising the blend applications and are turning our attention towards

proving the product as a stand-alone solution for other applications,” explains Østereng.

ON THE VERGE OF DISRUPTION

Despite this delay, Østereng is confident that ThermoSiC is on the verge of disrupting the thermal spray material market by providing a stronger, cost efficient and sustainable solution. “ThermoSiC provides superior coating performance in corrosive and abrasive environments, as well as at high temperatures – up to 1 500 °C in air,” Østereng says. “As SiC is one of the world's hardest synthetic materials and possesses lower density than other coating options, ThermoSiC gives applications a longer lifespan, lower maintenance costs and a sustainably-competitive advantage.”

THERMASiC

- Coordinated by Seram Coatings AS in Norway.
- Funded under H2020-LEIT-ADVMANU, H2020-LEIT-ADVMAT, H2020-LEIT-NANO and H2020-SME.
- cordis.europa.eu/project/id/738789
- Project website: seramcoatings.com

INDUSTRIAL TECHNOLOGIES

Three metrology solutions for 3D nanoscale characterisation

As semiconductor devices increase in complexity while decreasing in cost, manufacturers are becoming more reliant on metrological-led optimisation, from lab to fabrication. METRO4-3D puts three promising options through their paces.

Moore's Law states that the number of transistors contained in an integrated circuit doubles approximately every 2 years. This growth rate results in increased circuit functionality, a reduction in the operational power needed and, crucially, reduced costs. But within the semiconductor industry, material and process developments, along with productivity and production control, rely on accurate metrology to optimise performance and minimise problems.

“As well as being useful in devices we use on a daily basis, such as mobile phones, semiconductor technology also plays an important role in life-science technology and many other domains. This project will contribute to a very wide range of applications.”



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The EU-supported METRO4-3D (Metrology for future 3D-technologies) project assessed the effectiveness of three metrological tools to investigate front-end and back-end processing for a variety of semiconductor devices.

ASSESSING DIFFERENT TECHNOLOGIES

Metrology increasingly needs to be performed on devices at the nanoscale. METRO4-3D set out to investigate technologies across the different areas of metrology: material (chemical), electrical and defect characterisation, using 3D analysis. To achieve this, the project adopted three tools for evaluation. Firstly, they used a Time-of-Flight Secondary Ion Mass Spectrometer (TOFSIMS) with a built-in scanning probe microscope (SPM) which profiles (in true 3D) the composition of materials and performs failure analysis. Secondly, they employed an automated tool for measuring sheet resistance (microHALL), by sampling electrical properties. Thirdly, they used an acoustic microscope, operating in a frequency range of up to 2 Gigahertz, to investigate defects such as cracks or delamination in the wafer-thin layers of the integrated circuits.

The assessment of the techniques started by first qualifying the basic characteristics of these tools, using references samples, before investigating devices of increasing complexity to establish the ultimate performance of the tools.

“Both the basic metrological theory and lab-based validation already existed for each of these tools prior to METRO4-3D, but their applicability within the semiconductor industry still had to be evaluated,” says project coordinator Dr Thierry Conard.

Several of the project results are noteworthy. To take the example of the microHALL work, the team was able to use the system to measure the electrical characteristics of a single fin (3D structures on which modern transistors are based) down to 20 nanometres. This result was unexpected as these dimensions are smaller than the probe sizes.

The TOFSIMS-SPM work demonstrated high-quality 3D profiling on fins of 500 nanometres and improved understanding of depth profiling of structures, down to 20 nanometres. The acoustic microscope allowed non-destructive inspection of hybrid bonds with resolutions of up to 1 micrometre and a detection limit down to a few hundred microns.

“Thanks to these tools, the combination of electrical, chemical and structural information collected on the same devices leads to a much better understanding of their relationship,” says Dr Conard. “Additionally, as the techniques are generic, they are applicable to a wide variety of devices/systems, beyond semiconductors. That said, some protocols remain device-specific.”

MORE THAN THE SUM OF THEIR PARTS

By providing insights into advanced process technologies and developing innovative failure detection tools, METRO4-3D helps reduce semiconductor manufacturing costs, resource wastage and time-to-market for new products.

“As well as being useful in devices we use on a daily basis, such as mobile phones, semiconductor technology also plays an important role in life-science technology and many other domains. This project will contribute a very wide range of applications,” says Dr Conard.

With all three instruments now commercially available, maximising returns from the combination of several metrologies is an area of future research for the team, as is the continual improvement of measurements protocols.

METRO4-3D

- Coordinated by imec in Belgium.
- Funded under H2020-LEIT-ICT.
- cordis.europa.eu/project/id/688225
- Project website: metro4-3d.eu

Glass curtain wall system to improve energy savings and well-being

Innovative glass façades have the ability to transform buildings inside and out. The Q-Air project created a new generation of innovative, energy-efficient panels that could impact everything from architecture to the environment – and boost worker well-being.

Modern society is continually searching for technical and organisational innovations that lower energy consumption. One way to do this is to change the energy consumption of wasteful buildings: within the EU, buildings are responsible for around 40% of energy consumption and 36% of CO₂ emissions.

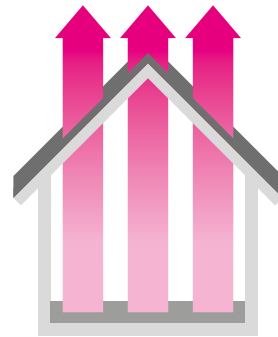
Carbon emissions from buildings are mostly associated with high heating demand during winter. With its innovative new façade system, Q-Air aims to respond to this challenge. The Q-Air (Sustainable Prefabricated Glass Façade with Performance Exceeding State-of-the-art Glass Façades) glass curtain wall – the only example in the world – is a next generation building product that looks set to define how sustainable glazed buildings can be constructed now and in the future. It uses an innovative, multi-chamber insulating core which delivers superior energy efficiency. The system maximises internal daylight and offers the highest living and working comfort, with 24-hour views to the outdoor environment and minimal external sun shading.

LAYERS OF SUCCESS

Based on scientific studies, the Q-Air system incorporates up to six layers of glass to create an innovative insulating core. The pre-fabricated system clots together to create an energy-efficient wall system for buildings which doesn't need any external shading devices. The system is fast, simple to install and low maintenance once it's up and running. The innovative design means Q-Air façades can be seamlessly tailored to the architectural and construction requirements of each individual building,

meaning a potentially-widespread adoption of the façade system across the EU and worldwide.

The fully transparent glass requires nothing to block out the sun, allowing the maximum amount of daylight and letting people see outside throughout the day. It also maintains a constant interior temperature, meaning no



Within the EU, buildings are responsible for **around 40% of energy consumption** and **36% of CO₂ emissions**

“It is a rare thing in the construction sector when something truly innovative comes along, but with state-of-the-art innovation, Q-Air is a real game-changer.”

cold draughts from the glass in winter, and no excessive heating coming from the glass during summer. Sound insulation means that people can work in peace, too.

“Q-Air is designed to provide exceptional thermal, visual and acoustic comfort which beneficially contributes to improved well-being and health of people inside the building,” says Dr Boštjan Černe, Head of Product Development at Trimo and Q-Air project coordinator.

Important new results were achieved during the project, such as perfecting the new aluminium and steel structural profiles – with higher load capacity and lower thermal transmittance – and the uniform sealing system across all structural profiles.

SETTING AN EXAMPLE

The project is helping to move the industry closer to a totally sustainable, near-zero energy building (nZEB). “Compared to state-of-the-art glass façade solutions, the reduction for heating is up to 10 times better, and three times better for cooling,” says Dr Černe.

The team’s research results and calculations have shown that the Q-Air system can diminish energy requirements

for heating substantially, even in northern countries, and can eliminate the requirement for heating in other countries. Heating demand can reach close to zero, as the system provides enough heat gain through visible light alone.

“It is a rare thing in the construction sector when something truly innovative comes along, but with state-of-the-art innovation Q-Air is a real game-changer, and something that sets the standard for energy efficiency. We are very proud of the great collaboration of international consortium partners from Slovenia, Germany, Italy and Sweden,” Dr Černe concludes.

Q-AIR

- Coordinated by Trimo Architectural Solutions d.o.o. in Slovenia.
 - Funded under H2020-Industrial Leadership and H2020-Societal Challenges.
 - cordis.europa.eu/project/id/737757
 - Project website: <https://www.trimo-group.com/en/products/facades-and-walls/q-air/q-air-project-h2020>
- ▶ bit.ly/2YJWgWj





Dream-like processes could help build more human-centric robots

If Europe wants to develop AI systems that are human-centric, these must be adaptive to human variability. The DREAM project drew on insights about the benefits of sleep, to propose a paradigm shift in how we design robots and AI.

Building an AI program applicable to any situation is very difficult, because all those situations, and their adapted behaviours, first have to be identified.

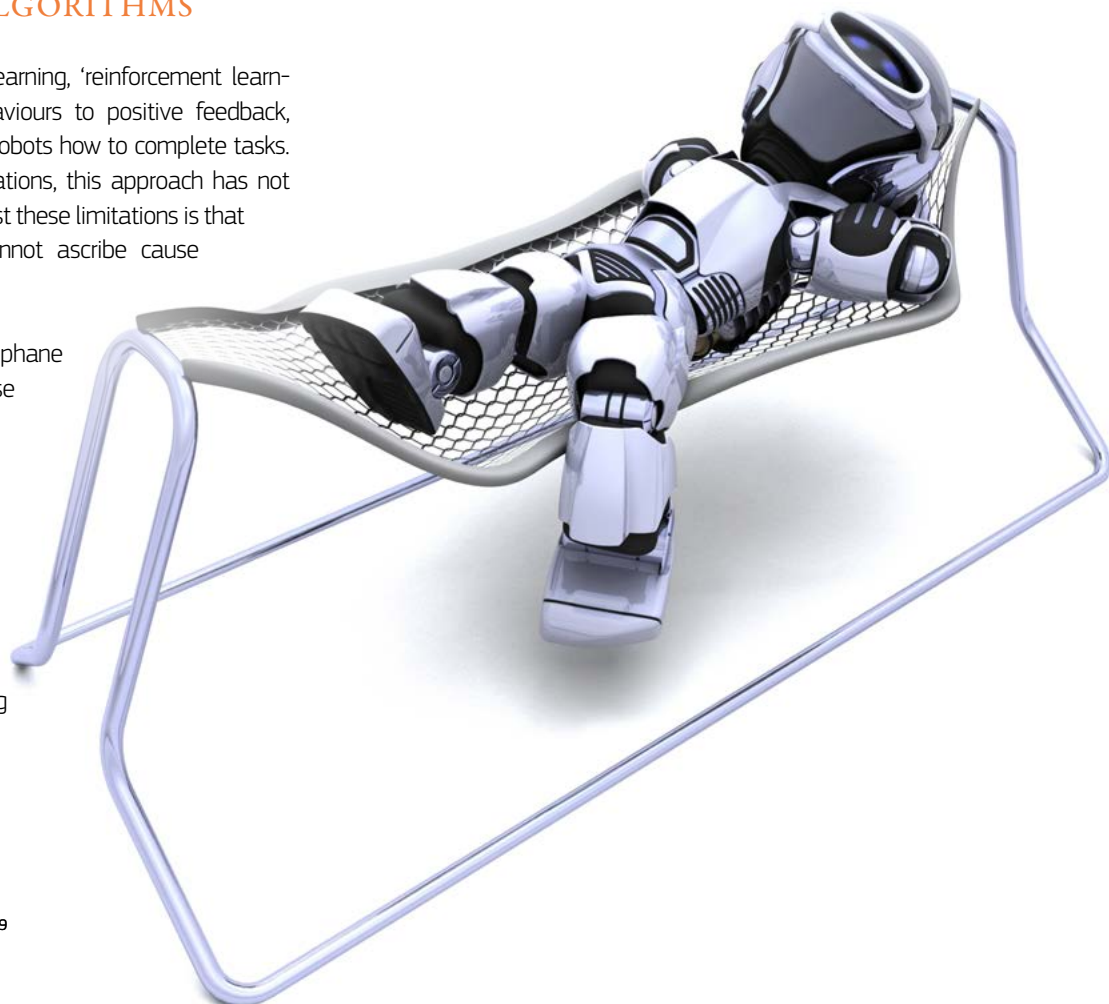
The insight that inspired the EU-supported DREAM (Deferred Restructuring of Experience in Autonomous Machines) project was that similar processes to those identified during sleep could help robots more easily acquire, organise and use knowledge and skills. Exposing robots to more open-ended scenarios in space and time, led the team to proposals for a new generation of robots.

ADAPTIVE ALGORITHMS

Within the field of machine learning, 'reinforcement learning', which links desired behaviours to positive feedback, has been suggested to teach robots how to complete tasks. However, due to several limitations, this approach has not yet been applied. Chief amongst these limitations is that the underlying algorithms cannot ascribe cause and effect.

As project manager Prof. Stéphane Doncieux explains, "Suppose the robot gets a numerical value signal as positive feedback, to really learn, the algorithm needs to know what state this value is associated with: is it due to its arm movement, to a button being pushed or to something else?"

DREAM reduced the amount of specific information necessary for a robot to accomplish a task, developing adaptive algorithms which could be applied to different scenarios, but still able to find appropriate solutions without continual modification. "Current learning algorithms often assume expert knowledge. In fact, naive learning offers opportunities if you can exploit it appropriately. This is reminiscent of what happens when animals and humans sleep," says Prof. Doncieux.



In practical terms, robot learning becomes a sequence of processes alternating interactions with the real world and exploitation of the data generated, rather than a single process.

During the 'awake' sessions, the robot observed the consequence of its actions to understand how the environment is structured. During 'dreaming', the robot explored, in simulation, many possible interactions, registering those that generated identifiable effects on a chosen object (e.g. moving it).

Now it could perform simple tasks but only within tight parameters, providing a kind of library of actions with which to train deep learning algorithms. Another 'dreaming' process based on such algorithms helped the robot to generalise them to other situations.

Other 'dreaming' phases were focused on transfer learning, to build upon the knowledge acquired. Various approaches were explored including transfer from short-term to long-term memory and transfer between different individuals (social learning), as knowledge acquired in a group has been shown to accelerate learning and make it more robust.

A NEW PARADIGM WITHIN GRASP

DREAM experimented with different humanoid robots PR2 and Baxter, for instance, focusing on object interaction using their arms.

“Current learning algorithms often assume expert knowledge. In fact, naive learning offers opportunities if you can exploit it appropriately. This is reminiscent of what happens when animals and humans sleep.”

“The robots distinguished which parts of the environments they can act on for a particular effect (like moving or lifting). Crucially, the proposed adaptation methods could deal with different tasks without modification. For example, depending on the effect we asked them to explore, they could generate ball handling or joystick manipulation,” says Prof. Doncieux.

Encouraged by their experiments, the team is now working at the theoretical level to shed more light on some of the building blocks of their approach, such as how robots can discover relevant behaviours, when little is known about what actions or states should look like.

DREAM

- Coordinated by the Sorbonne University in France.
- Funded under H2020-FET.
- cordis.europa.eu/project/id/640891
- Project website: robotsthatdream.eu

DIGITAL ECONOMY

From single-purpose devices to city-wide mobility improvement

The SETA project has pushed the smart city concept to the next level by exploiting existing single purpose devices for the greater goal of improving urban mobility. Applications in health and wellbeing are also expected.

Did you know that we all create an average 1.7 MB of data every second? At the scale of a city where millions of increasingly connected citizens go about their lives, this figure becomes truly mind-blowing. But for public

authorities, businesses and other organisations that know how to put all this data to good use, it's also a goldmine.

The transportation sector can particularly benefit from this abundance of data. With traffic jams, pollution and

“The anonymised data is collected by our architecture via mobile phones, sensors, etc.”

inefficiencies costing billions of euros each year, the SETA (An open, sustainable, ubiquitous data and service ecosystem for efficient, effective, safe, resilient mobility in metropolitan areas) consortium believes that better management of data could bring about major improvements.

“I believe that the main issue with current data management lies in how this data is collected for specific reasons and then left in databases,” says Fabio Ciravegna, Professor at the Department of Computer Science, University of Sheffield, and coordinator of SETA. “To give you an example, every city has hundreds of street cameras, probably even thousands. But each of these cameras is only used for a single purpose such as security or traffic, whilst it could in fact be used for many different purposes.”

The truth is, we are not there yet. Technical, administrative and political barriers often prevent the integration of existing datasets. At the same time, the large-scale nature of the data and its heterogeneity makes its reuse very difficult.

SETA solves this problem by integrating the data from road, bike, citizen and environmental sensors. Its technology can collect, process, link and fuse high-volumes of heterogeneous data and use it to model urban mobility. According to the project consortium, it also does so with a precision, granularity and dynamicity that would be impossible to achieve with state-of-the-art technologies.

SETA's mobile technologies can monitor people's mobility, and it has already released its apps to hundreds of thousands of citizens in England, and thousands in Spain. In parallel, the project consortium has also developed technologies able to turn every street camera into the equivalent of a loop sensor – that is, a camera able to determine vehicle speed and count. All data collected is then stored and brought together thanks to dedicated fusion and modelling technologies.

“We have used advanced neural networks for image analysis, large-scale architectures for data integration, advanced mobility models for tracking mobility via mobiles, and large-scale mobility modelling techniques,” explains Prof. Ciravegna. “The anonymised data is collected by our architecture via mobile phones, sensors, etc. It is made available to the fusion and modelling



algorithms. A platform for data and visual analytics then provides city managers with insights into city-wide mobility.” While existing methods only allow for modelling in core parts of the city with high granularity, SETA does so for entire metropolitan areas.

SETA's technology has already been adopted by a major governmental customer in England. It has used it to track hundreds of thousands of citizens for health and wellbeing purposes. The technology has also been adopted by the Birmingham City Council to track its 8 000 free bikes. Both activities will continue after the project's completion.

The University of Sheffield – which developed the citizen tracking technology – is planning to create a spin-off company. Applications in health and wellbeing, pharmaceuticals and mobility are expected. The project's video detection system is commercialised by Machine2Learn, the large-scale data city models by Aimsun (they are already used by several cities), and the large-scale infrastructure by Software Mind. Finally, methodologies for tracking car journeys are developed by The Floom Ltd.

SETA

- Coordinated by the University of Sheffield in the United Kingdom.
- Funded under H2020-LEIT-ICT.
- cordis.europa.eu/project/id/688082
- Project website: setamobility.weebly.com

Tailored buses for the shared economy

The EU-funded BUSUP project is a personalised, shared corporate bus service, ideal for companies located in places not served by traditional public transport.

With the appearance of new mobility services, millennials have shifted from car ownership to car use (i.e. car-sharing), ridesharing (i.e. Blablacar), and ride hailing (i.e. Uber). As a consequence, corporations located in Greater Metropolitan Areas (GMAs), where public transportation is limited, are struggling to attract talented young people who prefer to live in the city centre and refuse to commute if no direct mobility solution is available.

This is exactly the problem the EU-funded BUSUP (Multi-platform On-demand Crowdsourced Bus Transportation for Smart City Mobility) project is solving today.

ELEVATING BUSES FOR THE SHARED ECONOMY

When it comes to affordable, sustainable public transport, nothing beats taking the bus. The BUSUP project elevates this traditional mode of transport for today's shared economy. The result is BUSUP, a personalised, shared corporate bus service.

"BUSUP was created to provide a smart, medium-distance travel solution for corporations located in under-served suburbs and exurbs," says Eva Romagosa, the project's co-founder and Chief Innovation Officer. "We help these corporations solve their talent attraction and retention problems by offering the opportunity to join a network of private corporate buses, shared with other nearby companies, that they can use to provide employees with a sustainable and cost-effective commuting solution."

Every participating company has a personalised web booking platform where their employees can register, request a route, and book their monthly passes. Based on the data provided by the employees, the BUSUP algorithm identifies the optimal routes to maximise the offer and minimise the costs. BUSUP users can track the bus's location via an intuitive, easy-to-use smartphone

application. Similar to a ride-sharing service like Uber and Lyft, BUSUP does not own the buses, but instead partners with high-quality local bus operators that provide the services for their clients.

One of the most attractive features of the BUSUP platform is that corporations can share the costs of the routes not only with nearby companies, but also with their employees. "Some of our clients believe employees should be responsible for part of the costs so they value the service and unsubscribe when they are not actually using it," explains Romagosa.

According to Romagosa, the most important result of the project is not this technological solution, but the fact that BUSUP has successfully launched a new shared mobility service capable of resolving corporate commuting issues in GMAs. "The BUSUP solution helps our clients improve



1 bus means
**33 fewer cars
on the road**



Source: The BUSUP project



their talent attraction and retention strategies, cut their mobility costs in half, and significantly reduce their carbon footprint,” Romagosa says.

A MOBILITY SOLUTION FOR EUROPE

BUSUP commuting services are currently available in Barcelona, Madrid, Lisbon, and Sao Paulo. BUSUP also provides similar services to events like music festivals (i.e. Lollapalooza, RockinRio, etc.) and for private schools.

The project, which was finalised in December 2018, is currently serving more than 100 corporate clients and expects to close the year with EUR 2 million in revenue. This skyrocketing start has encouraged its founders to look further ahead: “We want BUSUP to be Europe’s leading corporate mobility solution,” says Romagosa.

“BUSUP was created to provide a smart, medium-distance travel solution for the corporations located in under-served suburbs and exurbs.”

BUSUP

- Coordinated by BUSUP Technologies SL in Spain.
- Funded under H2020-TRANSPORT, H2020-SME and H2020-LEIT-ICT.
- cordis.europa.eu/project/id/757004
- Project website: busup.com
- bit.ly/2Z73lyj



Making it easier to build robots for space

One of the barriers to building robots to work in space has been the lack of standard software to base the systems on. A Spanish-led team aims to plug this gap by developing a software framework specially designed with space robotics in mind.

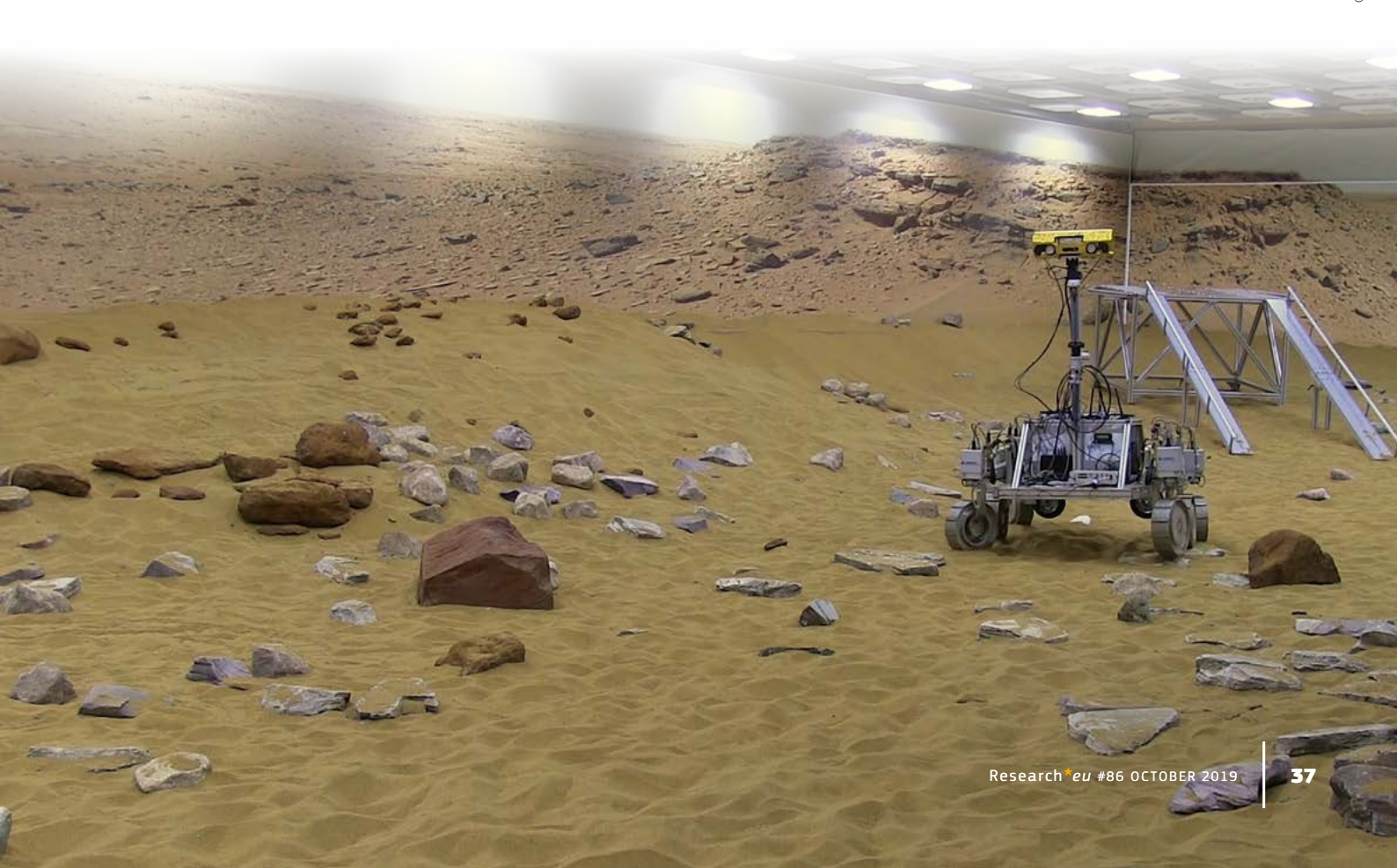
This kind of software includes tools to build robotic applications together with the middleware that sits between systems and allows them to communicate with each other, just as an Internet Protocol enables computers to talk to each other via the Internet. While people wishing to develop applications for terrestrial use have several software frameworks to choose from, until now there have been few available for building apps for space.

Based on open source technology, the ESROCOS (European Space Robot Control Operating System) project aims to be the first software framework for space robotics that positively encourages others to use it for building applications, thereby creating an ecosystem of reusable components.

ADVANTAGES OF OPEN SOURCE

One of the big benefits of using a standard form of software is that it allows software built by different organisations to talk to each other and create more complex systems, according to Miguel Muñoz, ESROCOS project coordinator and software engineer at GMV Aerospace and Defence in Madrid.

"If you are an expert in building robots with wheels and know a university that is good at robotic arms, when the software is open source you can put the two together and build a robot with both – you can develop in areas in which you are not an expert and others can benefit from your work," Muñoz says.



“We can’t say we will control the robot that will explore Mars, what we can say is we will provide a building block that makes it possible.”

The team developed the framework during 2017-2018, then validated it in three test scenarios – exploring planets, servicing satellites while in orbit and working in a nuclear environment – at the International Thermonuclear Experimental Reactor robotics test facility at VTT in Finland. “Because of the risks from radiation, nuclear facilities are a good candidate for using robots,” explains Muñoz, “as in space, the radiation affects the electronics, so systems must be able to withstand this.”

ENABLING THE FUTURE

Rather than building autonomous systems, the aim was to demonstrate that the software is fit-for-purpose and can act as one of the building blocks for the future development of space robotics as part of a broader European strategic research cluster. “We can’t say we will control the robot that will explore Mars, but what we can say is we will provide a building block that makes it possible,” adds Muñoz.

The ESROCOS framework provides advanced modelling capabilities, which means developers can spot errors

in their systems at an early stage, something which is common in other domains of software but still rare in robotics. It also offers flexibility: the current version integrates four technologies, including road-tested ones such as TASTE and Time and Space Partitioning. It also offers two new ones: BIP tools and kin-gen which are straight from the lab.

By being open source, it also avoids the need to depend on proprietary components. True to the principles of open source, the ESROCOS source code has been made available for other developers to use.

Members of the ESROCOS team are now developing the system further by taking it from the demonstration phase to real life projects under the second round of activities of the strategic research cluster. While the ESROCOS system is still at an early stage, “we hope people will contribute to this framework by improving it and by producing other open source tools which will work within ESROCOS,” concludes Muñoz.

ESROCOS

- Coordinated by GMV Aerospace and Defence in Spain.
 - Funded under H2020-LEIT-SPACE.
 - cordis.europa.eu/project/id/730080
 - Project website: h2020-esroc.eu
- ▶ bit.ly/3080qlp

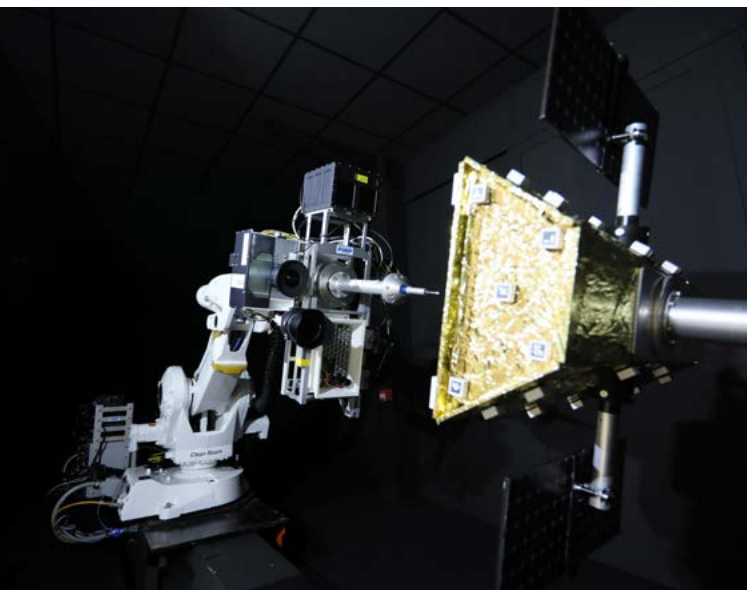
SPACE

Smarter sensors for autonomous space mission tasks

As robotic systems tackle more complex tasks in outer space, the sensors which provide the information to enable them to act autonomously need to be integrated for swifter feedback and more efficient control.

Repairs, resupply and refuelling of orbiting satellites and planetary rover exploration missions need near-human levels of capability and dexterity while operating autonomously. “Sometimes Ground (control) helps, closer to

Earth, where communication is easier. But in space there is a time delay so you need to make sure the system can do the mission planning and take decisions on its own,” explains I3DS (Integrated 3D Sensors suite) project



manager Sabrina Andiappane, R&D Study Manager and Future Projects Engineer at Thales Alenia Space, in Cannes, France.

Individual sensors used for navigation and other purposes are often produced commercially, usually with their own proprietary interface and software. The EU-funded I3DS project has integrated state-of-the-art sensors and detectors used in such missions to form a single suite and enhanced the software to improve real-time feedback and processing of the combined data to operate robotic systems.

It includes data from: visual sensors, such as high resolution, 3D and thermal infrared cameras; star trackers which orientate a vehicle using the stars; contact and tactile sensors that detect an obstacle; and remote sensors such as radar and lidar. It also includes illumination devices for use during eclipses or when there is no sunlight. A planetary rover, for example, needs all the sensors to make sure it's going in the right direction and for obstacle avoidance.

MODULAR SYSTEM

"These are smart sensors for smart missions, with pre-processing for the cameras, and the data is made easier to understand when it feeds into another system," Andiappane points out. Sensors have to be synchronised and run at a certain frequency, and the algorithms must run quite fast in order to achieve real-time operability. "It

“*In space there is a time delay so you need to make sure the system can do the mission planning and take decisions on its own.*”

was challenging to achieve this," Andiappane adds. The idea is to arrive at greater accuracy in comparison with any of the sensors acting in isolation. This involved specialists in data fusion and processing capabilities specifying, designing, integrating and testing the different architectures in an entire robotic system architecture.

The integrated platform is developed as a modular plug and play system. "There is a panel of sensors available and you can choose the ones you want. You can exchange one sensor with another, and it will still work. What we were not able to fully integrate was radar which is subject to special safety regulations for testing. This meant it could not be carried out during the project lifecycle," Andiappane explains.

CONTROL UNIT

The instrument control unit, which interfaces with all the different sensors and sends the right commands in the same software environment, is a 233 x 160 mm motherboard.

"We have proven that the system works, but there obviously needs to be more development to go into space. For space missions, all the electronics have to be radiation resistant," Andiappane adds.

The EU has funded several projects on space robotics in parallel with I3DS. As part of the follow-on EROSS (European Robotic Orbital Support Services) project, Andiappane says: "We will take the different building blocks, for example the sensors, and the other frameworks such as navigation, and we will integrate them further to work in an even bigger (robotic) system to demonstrate in-orbit servicing."

I3DS

- Coordinated by Thales Alenia Space in France.
- Funded under H2020-LEIT SPACE.
- cordis.europa.eu/project/id/730118
- Project website: i3ds-h2020.eu



FUNDAMENTAL RESEARCH

New cooling method brings quantum chemistry experiments to the lab

The QuCC project has successfully recreated chemical reactions at interstellar space temperature, by using a new setup for collisional experiments.

One of the biggest challenges facing molecular science researchers is the observation of chemical reactions at low temperature. This amounts to recreating interstellar space-like conditions – where reactions take place at several Kelvin – and it is indeed essential to describing the processes taking place within a deep quantum regime.

However, whilst the laser cooling of atoms has already revolutionised atomic physics, cooling molecules has proven to be a far more complicated task. To circumvent that problem, the QuCC (Chemistry of the Quantum Kind) project has been looking in history books. More specifically 50 years ago, when pioneer chemists Dudley Herschbach and Yuan T. Lee – both of whom received the Nobel prize in 1986 – devised a simple method for the cooling of any gas.

“This cooling method is based on an adiabatic expansion of gas from high pressure to vacuum,” explains Dr Ed Narevicius, coordinator of the QuCC project on behalf of the Weizmann Institute of Science.

But there was a glitch. During expansion, gas indeed cools to temperatures below 1 K. But the gas ‘cloud’ also accelerates to very high velocities. As two such cold gas ‘clouds’

carrying reactants collide at very high relative velocities, their collision results in temperatures above 300 K.

“We have solved this problem by conducting our collisional experiment in the moving frame of reference,” says Dr Narevicius. “We have merged two clouds using a very high magnetic field gradient. This simple step allowed us to reduce the collision energy by a factor of 1 000 compared to earlier efforts. This allows us now to routinely perform experiments that unveil different aspects of matter-wave properties in molecular collisions.”

Thanks to this breakthrough, the project team could demonstrate, experimentally, the elusive phenomena of quantum resonances in low energy reactive collisions. They found that, at low energies, particles that tunnel through a potential energy barrier may end up being ‘stuck’ next to, and orbiting, each other.

“These peculiar states can be observed by measuring reaction rate probability as a function of collision energy. Whenever collision energy matched the resonance position, we could observe a very strong, in some cases 10-fold, enhancement in reactivity. Surprisingly, energy reactions that were strongly suppressed at sub-Kelvin temperatures

proceeded as fast as they would at room temperature,” Dr Narevicius explains.

Using these quantum resonances as highly sensitive probes of molecular interaction, Dr Narevicius and his team have discovered new effects that are particularly important to the most abundant molecule in the interstellar space: hydrogen.

They notably demonstrated that molecular rotation structure plays a key role in interactions with other objects. Molecular hydrogen in the lowest rotational state behaves like a symmetric ‘ball’, whereas molecular hydrogen in the excited rotational state takes a different shape and reacts at a different rate. The team also found a new isotope effect that may dramatically change the rates of reactions taking place through quantum effects at low collision energies.

Now that the project has come to an end, the team plans to focus their future research on lowering temperature by another factor of 1 000. By doing so, they would reach

“We have merged two clouds using a very high magnetic field gradient. This simple step allowed us to reduce the collision energy by a factor of 1 000 compared to earlier efforts.”

the regime under which molecules have to follow either Bose or Fermi statistics. “This is a new frontier of molecular science, where many questions remain open and many possible applications are foreseen in the likes of chemical physics, quantum information and precision spectroscopy,” Dr Narevicius concludes.

QUCC

- Hosted by the Weizmann Institute of Science in Israel.
- Funded under FP7-IDEAS-ERC.
- cordis.europa.eu/project/id/617888

FUNDAMENTAL RESEARCH

Bekenstein-Hawking entropy of supersymmetric black holes finally explained

The Gauge/Gravity project has considerably advanced research on the famous duality at the heart of physics’ string theory. Its findings related to supersymmetric black holes’ entropy resonate with the recent acceleration of breakthroughs surrounding these mysterious celestial objects.

It is undoubtedly the biggest challenge that has been facing physicists since the beginning of the 20th century. Quantum mechanics and general relativity – while perfectly accounting for how nature works respectively at the tiniest and biggest possible scales – are seemingly irreconcilable. Of course, the problem may seem abstract to the layperson. But it became palpable on 10 April 2019 with the first-ever image of a black hole – the personification of incompatibilities between the two theories.

The biggest chance at reconciling general relativity and quantum physics lies in string theory. The potential of its conjectured duality between quantum theory and gravity is huge. But the truth is, there is still much work to be done before the gauge/gravity duality can provide proof that quantum theory and gravity, instead of conflicting, are rather equivalent descriptions of the same physics.



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“*We have opened a novel research line that consists in performing precision tests of the gauge/gravity duality.*”

“The broad aim of my project was to extend the gauge/gravity duality beyond the state-of-the-art as it now stands. I explored its remarkable physical implications as well as its relationships with various branches of modern mathematics,” explains Dario Martelli, Professor in Theoretical Physics at King’s College London.

Prof. Martelli’s efforts under the Gauge/Gravity (The Gauge/Gravity Duality and Geometry in String Theory) project were devoted to both sides of the duality. His work consisted in developing new methodologies – including geometric approaches to the study of string theory – as well as advancing existing methods in supersymmetric quantum field theories.

“We have opened a novel research line that consists in performing precision tests of the gauge/gravity duality. We used setups in which it was possible to achieve great analytic control on both sides of this correspondence. We obtained several extensions of the gauge/gravity duality as set out in the initial research proposal,” says Prof. Martelli.

Among others, the project led to two major achievements. The first one is the discovery of an ‘extremisation principle’ that controls a class of geometries relevant to string theory. It provides evidence of the gauge/gravity duality for a wide class of dual pairs. The second one is the explanation of the Bekenstein-Hawking entropy of certain supersymmetric black holes – a long-standing open problem in the gauge/gravity duality – in terms of a dual field theory computation.

All in all, these results provide compelling evidence that the gauge/gravity correspondence is the key to linking the extremisation principles governing the statistical properties of supersymmetric black holes with those characterising superconformal field theories, as well as a class of geometric problems in Riemannian geometry.

“Black holes remain one of the most intriguing objects in physics and have made a spectacular transition from theoretical constructs to concrete celestial bodies over the past few years,” Prof. Martelli notes. “The timing couldn’t be better for focusing my research efforts on investigating the fundamental nature of black holes. In particular, I plan to study black holes that arise in string theory. For that I will take the viewpoint of the gauge/gravity duality, which allows for relating these gravitational objects to concrete quantum theoretic setups. It is very exciting to live in this era of great scientific discoveries!”

GAUGE/GRAVITY

- Hosted by King’s College London in the United Kingdom.
- Funded under FP7-IDEAS-ERC.
- cordis.europa.eu/project/id/304806



AGENDA

NOVEMBER 2019

BRUSSELS, BELGIUM & MADRID, SPAIN

SESAR Joint Undertaking ENGAGE workshops

→ sesarju.eu/events/engage_workshops_2019

**5 & 12
NOV**

**10
NOV**

WORLDWIDE

World Science Day for Peace & Development

BREMEN, GERMANY

SpaceUp Space Academies

→ space-academy.eu/spaceacademies.html

**18→19
NOV**

**19→20
NOV**

BERLIN, GERMANY

CICERONE workshop 'Funding the circular economy'

→ cicerone-h2020.eu/2019/07/12/workshop-funding-the-circular-economy-in-europe

**21
NOV**

WORLDWIDE

World Philosophy Day

**26→28
NOV**

BUDAPEST, HUNGARY

EOSC Symposium 2019

→ eosc-portal.eu/events/save-date-eosc-symposium-2019

**MORE
EVENTS**

cordis.europa.eu/news

**13
NOV**

HELSINKI, FINLAND

The Future of Science Advice

This 1-day event brings together leading practitioners and scholars to reflect on emerging trends, weak signals and promising opportunities for developing next-generation science advice capabilities. Keynote speakers include the European Commission's Chief Scientific Advisors, senior members of the Finnish government, leading researchers and academy representatives from across Europe.

→ sapea.info/symposium

RESULTS PACK ON OCEAN PLASTICS

In this Results Pack, we introduce you to eight EU-funded projects that are aiming to help tackle one of the biggest environmental challenges affecting us today – the growing prevalence of plastic waste being found in our oceans which threatens to become an environmental catastrophe if left to continue.



Check out the Pack at:
cordis.europa.eu/article/id/401309



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