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MENTAL HEALTH,
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EPIDEMIC

Foreword by Commissioners Moedas and Navracsics



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Commissioner for Research, Science and Innovation



Tibor Navracsics
Commissioner for Education, Culture, Youth and Sport

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Editorial coordination
Birgit Alice BEN YEDDER

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A novel vaccine against prostate cancer

Prostate cancer represents one of the most common cancers diagnosed in men worldwide. Awakening the immune system to fight cancer and providing long-lasting immunity is emerging as a promising approach.

The immune system functions not only to protect the organism against microbial infections but also to survey and control malignant neoplasms. Immune cells scan tissues with the objective of removing newly malignant cells before they turn into fully formed tumours.

Harnessing the immune system to fight cancer has been explored for years with immunotherapy approaches employing a number of cytokines, engineered immune cells, antigens or even whole cancer cells as vaccines. Scientists from the EU-funded TLRPROSTATE (Chemical programming of Toll like Receptor 4: Design, synthesis and biological studies of prostate-cancer vaccines) project wished to generate and evaluate synthetic vaccines against prostate cancer using a different strategy. "Our idea was to chemically stimulate the toll-like receptors (TLRs) and therefore create an immune response," explains project coordinator Dr Juan Padrón.

A NOVEL APPROACH TO STIMULATING THE IMMUNE SYSTEM

TLRs constitute a central constituent of the immune system as they are expressed on innate immune cells and help recognise the intruding pathogens. In particular, TLR4 recognises a wide array of ligands, including lipopolysaccharide (LPS), a cell wall component of Gram-negative bacteria, responsible for macrophage activation and signal transduction. Intriguingly, recent evidence associates mutations in TLR4 with increased risk for prostate cancer.

"We wanted to programme the TLR4 receptor so that it signals when it detects a prostate antigen," continue Dr Padrón and Dr Miranda. In this context, scientists designed a bifunctional linker carrying a small molecule that binds an antigen on prostate cancer cells on one side and a weak agonist on the other side. The rationale was to trick macrophages into thinking that the prostate cancer cell is a bacterium and kill it. For this purpose, they designed the linker to target prostate specific membrane antigen (PSMA), a protein found to be overexpressed on the surface of the prostate cancer cells.

To generate the linker, researchers successfully developed a new synthetic route that expedites the process and also allows reaction scaling-up. The overall vaccine synthesis



“ Our idea was to chemically stimulate the toll-like receptors (TLRs) and therefore create an immune response. ”

process relies on simple purification techniques that allow production of up to 1 gram of compound. In addition, *in vitro* stability experiments were performed to validate the suitability of the linker for *in vivo* use, as well as efficacy assays to confirm linker binding to PSMA.

THE FUTURE OF PROSTATE VACCINES

Traditionally, prostate cancer is treated with pharmacological therapy but the majority of patients relapse and succumb to the disease. This clearly emphasises the need to discover novel therapeutic targets. The notable discovery of PSMA in recent years has opened up new avenues for the therapy of prostate cancer.

The TLRPROSTATE molecule successfully matches PSMA and can activate TLR4 receptors, inducing an immune response. Although *in vivo* efficacy studies are pending, researchers are optimistic that “the synthetic vaccine will soon be tested in clinical trials.”

Anti-cancer vaccines have received great attention over the years with, however, very little clinical success. Preventing the recurrence of potentially fatal diseases by stimulating the body's own immune defence system is an ongoing task. Improved insight into how the immune system works will undoubtedly help find a cure for various types of cancer, saving millions of lives and reducing healthcare costs.

TLRPROSTATE

- Coordinated by the Spanish National Research Council in Spain.
- Funded under FP7-PEOPLE.
- cordis.europa.eu/project/rcn/185878

HEALTH

A fundamental change in the delivery of robust, reliable and sustainable healthcare in the home

For many years European societies have been ageing. The prognoses are indeed unprecedented, for the first time we are approaching a time when the older members of the population will outnumber the younger. This obviously presents a challenge for all those who intend to provide care for older people within their own homes.

Fewer and fewer people at work, along with increasing numbers of individuals in need of care, combined with the limited availability of care professionals – all these factors demand the development and implementation of new, indispensable solutions to alleviate the pressure on care givers.

These new solutions must also be cost-effective – which makes the use of robots to assist the older people living in the community of particular interest. The EU-supported ENRICHME (Enabling Robot and assisted living environment for Independent Care and Health Monitoring of the Elderly) project set out to provide a basis for fundamental change



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in the delivery of robust, reliable and sustainable health-care in the home, through novel academic advances.

ROBOTS OFFER A ROUTE TO INDEPENDENT LIVING

The ENRICHME system consists of an interactive, mobile robot capable of moving autonomously in an elderly person's house. "This can periodically and discretely monitor the person's activities and some of their physiological parameters," explains lead researcher Dr Roberto Rosso. The robot is in constant communication with a smart-home system comprising RFID-tagged objects and various sensors in strategic points of the environment.

Although several multi-sensor solutions exist for human tracking and dynamic pose estimation, much work remains to be done on the long-term representation and semantic interpretation of human motion for activity recognition. In particular, previous approaches have mostly been based on numerical representations of human (and robot) motion behaviours, although their qualitative description is often the only necessary information for activity recognition.

NEW ADVANCES ENABLING GREATER INTERPRETATIVE ACCURACY

ENRICHME worked in the field of semantic interpretations of complex and long-term human motion behaviours, based on recent advances in qualitative representations

for robotics, in particular by exploiting multi-sensor (i.e. laser and RGB-D) solutions for people tracking and 3D pose estimation. Novel qualitative models of human activities were developed to monitor long-term motion behaviours of people in domestic environments.

"Such representations," says Dr Rosso, "can allow for a rich, yet compact, description of complex trajectories characterising much human motion, like walking between different places or executing physical exercises. They can also enable the recognition of long-term human activities."

LEARNING TO RECOGNISE 'YOUR' HUMAN, EVEN AS THEY CHANGE OVER TIME

Human recognition is also an essential requisite for social robots, which have to provide user-oriented services and establish long-lasting relationships with their owners. The current research addresses in particular the problem of identity verification with mobile service robots, which is robust in the face of changes over time.

Extending previous work in this area, which exploited the mutual benefit of simultaneous people tracking and recognition, novel algorithms were implemented for long-term human identification, making use of multi-modal recognition techniques (i.e. face, body size and volume) that adapt to typical changes in human appearance over days and weeks.

The project also worked on a wide range of interventions to improve cognitive functions through the use of games, exercise and the social interaction fostered by communication with the robot. ENRICHME points out these are all fundamental elements for initiating, maintaining and regulating interaction with our ageing population.

“User feedback is that independence of elderly people could be greatly improved through the many functions offered by our systems, such as calendar reminders, activity initiation, management of conditions, management of home, maintenance and improvement of cognitive ability,” Dr Rosso adds.

ENRICHME found that among the oldest people with multiple cognitive impairments (MCI), there are those who can be potential beneficiaries of interaction with the robot. “The TIAGo robot was real support for elderly people who want to live independently, by making it possible

“ *The TIAGo robot was real support for elderly people who want to live independently, by making it possible to increase cognitive, physical and social activity as well as by improving nutrition.* ”

to increase cognitive, physical and social activity as well as by improving nutrition,” Dr Rosso says.

ENRICHME

→ Coordinated by Elettronica Bio Medica in Italy.

→ Funded under H2020-HEALTH.

→ cordis.europa.eu/project/rcn/194090

→ bit.ly/2MKtsdF

HEALTH

AI improves identification of mosquitoes for better disease control

Effective control of disease vectors relies on fast, simple identification – currently missing in the regions most affected. An EU project offers an AI-driven solution.

Millions of citizens globally are infected by diseases spread by infectious mosquitoes, resulting in thousands of deaths, loss of income through ill health and a drain on national health systems. There is now evidence to suggest that climate change is introducing more mosquito-borne diseases into Europe. Comprehensive attempts to tackle the problem typically rely on accurate information about mosquito populations in a given area, and usually involve the periodic manual inspection of traps.

The REMOSIS (A novel smart trap station as an Internet of Things surveillance solution to remotely count and identify the species of disease-carrying mosquitoes) project developed smart traps to cut the investigative costs and the time commitment required. The device, called the

BG-Eye, successfully used machine learning to distinguish between different mosquito species, detecting species of special interest (like invasive disease vectors), and to distinguish between the sexes of the same species – information necessary for effective preventative action.

NOT ALL SPECIES ARE CREATED EQUAL

Not every mosquito species is equally interesting to researchers, especially when looking at cases of invasive species or the transmission of certain diseases. So it is important to be able to separate them. Until now, this could only be done by bringing those caught in traps to labs for manual identification. This process is clearly



“With the REMOSIS device, the surveillance and monitoring of disease vector mosquitoes will be quicker, providing reliable information almost in real time.”

precision with which the AI was able to separate species that are visually very hard to distinguish. After feeding the machine learning algorithms with more data, the system learned to distinguish between two *Anopheles* species that can only be otherwise differentiated using molecular methods.”

POLICING SOCIETY'S IMMUNE SYSTEM

The monitoring of potential disease vectors is in essence protecting society's immune system, whereby speed of threat detection results in faster control of that threat.

As Dr Rose summarises, “With the REMOSIS device, the surveillance and monitoring of disease vector mosquitoes will be quicker, providing reliable information almost in real time. This allows for highly focused, efficient control activities, with greatly reduced costs, much shorter reaction times and less impact on the environment.”

Currently the team are working on up to five prototypes, with the full functionality of the final product. These devices will be sent to different partners around the world to collect mosquitoes in various habitats and environments.

Every count will provide a typical electronic signature for these insects, and machine learning, algorithms and AI will be used to calibrate the technology. As the mosquitoes' signatures library grows, more complex habitats with many different mosquito species will be targeted.

REMOSIS

- Coordinated by Bioagents AG in Germany.
- Funded under H2020-Industrial Leadership & H2020-Societal Challenges.
- cordis.europa.eu/project/rcn/199119
- Project website: remosis.bg-counter.com

time-consuming and expensive, and often lends itself to inaccuracies, due to human error.

BG-Eye uses Artificial Intelligence (AI) capabilities to continually improve its identification of species of interest, leaning from past efforts. As the project coordinator Dr Andreas Rose explains, “The basic training is performed in the lab with lab-reared mosquitoes, where the device learns to identify the target species. The device is then introduced into the field, where its identification capabilities are tested and adjusted, if necessary. After this, it can utilise what it has learned autonomously.”

An important aspect of BG-Eye is that the device can perform when used in conjunction with commercially-available, fan-driven mosquito traps. This means that it can already be easily used alongside standard mosquito monitoring field tools. Until now, similar technologies only worked in laboratory set-ups with mosquitoes outside the airstream of a mosquito trap.

The BG-Eye detector unit is an upgrade of a device already on the market called the BG-Counter, which differentiates between mosquitoes and other insects by sucking the catch into the trap through a thin light barrier. However, the resulting signal is too short to differentiate the mosquito species, and so REMOSIS set about lengthening the signal and increasing the data points, meaning the insects had to be scanned for longer than had been originally anticipated.

The upgrade proved to be a success, as Dr Rose recalls, “A surprise, at least for the team biologists, was the

Maximising support for migrant youth across the EU

A large-scale study offers important insights into the main features of youth mobility within Europe. Policy and action recommendations include migrant support initiatives at national and regional levels for cultural and labour market integration as well as enhanced public awareness.

EU-funded research teams on the YMOBILITY (Youth mobility: maximising opportunities for individuals, labour markets and regions in Europe) project delved into wide-ranging aspects of youth migration within the EU. As Professor Thomas Faist, coordinator for the project's German case study, notes, the project's "main aim was to study the role of intra-EU mobility in the transition from youth to adulthood for young mobile people." It examined the causes and effects as well as short- and long-term implications of this process, exploring also scenarios and offering policy recommendations.

A COMPREHENSIVE STUDY

A total of 840 interviews were conducted in all consortium countries with young intra-EU migrants (Sweden

and United Kingdom), migrants and returnees (Germany, Ireland, Spain and Italy) and returnees (Latvia, Romania and Slovakia). The team also conducted an online experiment involving 511 individuals (262 students and 249 young employed people) in all YMOBILITY countries. Participants were asked to take fictional migration decisions based on incomplete information about the characteristics of destination countries.

Primary data and the results of secondary data analyses helped build future scenarios concerning youth mobility in European countries and regions. YMOBILITY also analysed existing migrant support policies at the EU and national levels, as well as national and regional good practice examples for migrant support.



The research considered different migrant categories with respect to skills and education, age groups (16 to 36), gender, geographic origin (nine European countries) and migration patterns (migrants, returnees and circular migrants). The findings reveal that individual outcomes of youth mobility comprise both material and non-material aspects such as human capital building, quality of life and social inclusion. The effects of youth mobility on population development, labour markets and regional development were also assessed in terms of territorial outcomes for source and destination countries.

OPTIMISATION OF OPPORTUNITIES FOR MIGRANT YOUTH

“The analysis of existing policies at the EU and Member State levels showed that many EU flanking policies are indeed reasonably successful in supporting intra-EU mobility,” says Prof. Faist. However, these policies often represent a piecemeal approach due to low levels of coherence between EU and national-level policies. Also, “different institutions at different scales operating in different sectors in migrants’ countries of origin and destination are often not well connected and also frequently not well prepared to address the particular needs of migrants and returnees.”

Research results clearly hint at young intra-EU migrants’ needs for greater information about their rights and access to sources of support. To redress such shortcomings, YMOBILITY policy recommendations target more efficient use of existing support measures. These are relevant to labour market and cultural integration, access to housing and improved use of social benefits. More benefits can also be

gained by strengthening civil society efforts in combination with national and supra-national government policies.

COLLABORATION AND DISSEMINATION

Project work has been presented in academic publications and newspaper articles, at conferences and workshops, and through radio and TV interviews. “Another important means of knowledge exchange was YMOBILITY’s interaction with secondary school and university students,” the coordinator reveals. Collaboration with civil society organisations and related projects also advanced work in the field.

Finally, YMOBILITY has published a series of 15 short movies. Titles include ‘My home and my family is now in Rome’, ‘I feel discriminated when I go back home’ and ‘Goodbye Rome, I go back to Bangladesh’.

Partners have planned at least one more special issue publication and intend to continue exchanges with civil society representatives. Insights gained during YMOBILITY are also pegged to live on in a newly proposed Horizon 2020 project on the integration of migrant children in the EU.

YMOBILITY

- Coordinated by the University of Rome in Italy.
- Funded under H2020-SOCIETY.
- cordis.europa.eu/project/rcn/194588
- Project website: ymobility.eu

SOCIETY

More sensitive modelling for better economic forecasting

How can policy makers avoid being wrong-footed by ‘black swan’ events such as the global financial crisis, when their modelling proves limited and rigid? One project employs sophisticated algorithms that use localised data for better forecasting.

The global financial crisis (GFC) that started in 2008 prompted a rethink of economic forecasting. Modelling has long been a standard management tool for central

banks for making assessments of the worldwide and domestic economic outlook, which then underpin monetary policies.



However, with economies ever-evolving, if the models don't incorporate the ability to reflect these changes, the ensuing policies, while perhaps suitable for the past, may no longer be viable. A large part of the challenge for economic forecasts lies in the difficulty of identifying these changes, the individual triggers which help shape macroeconomics, requiring corrective policies to offset negative consequences.

The EU-funded Post-GFC Monetary Policy (Forecast of time-varying effects of post-GFC monetary policy + a novel computing application) project proposed a new methodology which, by incorporating local data, sought a faster reaction to macroeconomic changes than existing methodologies allowed. The project found it bore fruit when taking healthcare pricing as an indicator of policy success but was less applicable to monetary policy, when looking at financial data.

USING LOCAL DATA AS PREDICTORS OF CHANGE

One of the problems with traditional economic models is that many operate according to linear regression principles, with constant coefficients. Here, effects are considered to be constant over time. However, as Marie Curie Fellow Dr Isabel Casas says, "Actually, in the real world, effects change over time as they respond to the wider economic climate or sudden unexpected economic or financial shocks." Consequently, these models can only really reflect very general trends, creating something akin to an average value of the changing effects.

One method for countering this limitation is to apply non-parametric regression, whereby the model itself is actually

constructed by the data, rather than being built from pre-determined predictors. Explaining the efficacy of the methodology Dr Casas says, "The relationship between any two variables changes over time, whether it be days, weeks or years. The methodologies we used can detect those changes automatically, giving a less biased picture of reality."

The project's information came from localised data as a way to represent time-varying effects. The researchers created a statistical package called tvReg, using the R programming language, which applied time-varying coefficient algorithms to the data. Due to their programming complexity, these algorithms have been, until now, largely the preserve of specialists.

The monetary policy application of the methodology used financial data, including variables measuring industrial production, short and long-term interest rates, inflation, foreign exchange data and Credit Default Swaps. However, the researchers found that the modelling did not throw up different predictive results to those generated by traditional modelling, concluding that this time-varying technique did not offer a significant advantage for this data.

On the other hand, when it came to the healthcare policy application, one approach they took was to look at the extent to which healthcare can be considered a luxury good within EU and OECD countries.

Their findings differ from previous results in the literature where healthcare was always positioned (based on price) as a luxury good in the EU. Dr Casas concludes, "Clearly the EU countries are converging to common policies, with the price of health care fairly stable over the years and cheaper than across the wider OECD countries, so we can see that health policies after 2008 in the EU are moving in the right direction."

The next step in the research is to focus on modelling that forecasts the behaviour of processes in other contexts, such as those for renewable energy production based on oceanic data, which includes information on swell, tide, wind or wave height. This will prove to be beneficial for both producers and consumers in the EU electricity market.

POST-GFC MONETARY POLICY

- Coordinated by the Basque Center for Applied Mathematics in Spain.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/rcn/198658

Reconstructing the paths of Roman travellers from Italy to Serbia

'All roads lead to Rome!' ... or so the saying goes. Many ancient roads and routes though, also led Romans far beyond boundaries of empire and state.



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An EU-funded project has marked a research first in considering, as a whole, a particular Roman route along the river Sava. The team mapped the Roman itinerary on the ground as well as connected archaeological sites, offering new information and understanding of this particular archaeological legacy.

The core goal of the RecRoad (From Aquileia to Singidunum (Belgrade), reconstructing the paths of Roman travelers) project was to map and reconstruct the paths of Roman travellers from Aquileia in north-east Italy to Singidunum – an ancient city known today as Belgrade, Serbia's capital. The river Sava originates in the Julian Alps of Slovenia, flowing through central and south-east Europe and draining into the Danube in Belgrade.

This Roman route along the river Sava was in the past considered a secondary route, albeit the first established

by the Romans in the first century BC. "Many parts of this itinerary had been almost forgotten by the archaeological research, due to the political situation of the Balkan region and to the lack of field research," notes Professor Francis Tassaux, project coordinator.

Mapping the roads, their remains and nearby archaeological sites targeted a better understanding of the relationship between the Roman roads and surrounding



RecRoad reviewed the definition and description of

475

archaeological sites along the path

landscape. Research aimed to determine the degree of reliability of information currently available.

SETTING THE MAPS OF HISTORY STRAIGHT, THE HIGH-TECH WAY

Satellite remote sensing analysis identified and confirmed the presence of 12 archaeological sites in Serbia, in the region of Sremska Mitrovica, where 70 km of the Roman road were surveyed in six days. Although some of these had already been found in another archaeological survey, their exact location had never been mapped.

Overall, RecRoad reviewed the definition and description of 475 archaeological sites along the path from and through Italy, Slovenia, Croatia, Bosnia and Herzegovina, and Serbia. Besides the study of published works, historical map cadastres, surveys showing land boundaries, were geo-referenced and imported in the GIS system built to map the Roman itinerary.



12

archaeological sites in Serbia were identified and confirmed thanks to satellite remote sensing analysis

RecRoad was the first archaeological research project that used Sentinel-2 images to detect the presence of archaeological buried remains. Project activities made it possible to define a methodology for exploiting these free satellite images, produced by the European Space Agency, in an archaeological context. A publication is currently being prepared on the methodology developed to process the Sentinel-2 images.

Generally, the research methodology developed and tested within RecRoad opens the way to new inquiries into the Roman roads' network. The structure of the geographical information defined for the RecRoad project has been used for the recently commenced AquitaViae project, which aims to map the Roman roads of the province of Aquitania.

A DISSEMINATION STRATEGY ON THE ROAD, LITERALLY

Project results have been partially published and disseminated through various actions, including public presentations and international conferences. Most notable, however, is one dissemination event involving a project hike with the lead

researcher, along the reconstructed Roman itinerary from Aquileia in Italy through Slovenia, Croatia, Bosnia and Herzegovina, to Belgrade, Serbia. The small group told the route's story, explained the project's research methods, and spread knowledge of the shared archaeological heritage in a geographical region still heavily marked by recent wars.



The ancient Roman route stretches across

5 countries

Italy, Slovenia, Croatia, Bosnia and Herzegovina, and Serbia

Tassaux notes two other major project achievements. The first concerns the creation and development of a network of cooperation between Croatia, France, Italy, Serbia and Slovenia regarding the renewed study on roads and, more generally, cartography and historical geography. This will mobilise new media of research and dissemination, provided by databases, geomatics and web mapping.

Last, the project's lead researcher exhibited great expertise in analyses and exploitation of the satellite images. "Her methodology," the professor states, "deserves to be diffused, particularly as it can be applied in other regions, in other periods and on other themes."

"We often think that we know everything that we need to know about Roman roads. But this is not true," offers Tassaux. "It is important to understand precisely where a road passed, even in the periphery of the Empire, to better unravel the relationship involving the Roman roads and the natural and human elements of the landscape," he adds. RecRoad outcomes contribute to ongoing discussion as well as new knowledge in this field.

RECROAD

- Coordinated by Bordeaux Montaigne University in France.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/rcn/199095
- Project website: reconstructingromanroads.wordpress.com



Holistic approach increases safety for two-wheeled vehicles

If we are to make the best use of urban transport, we need to increase safety for the most vulnerable users – especially those on two wheels. As well as new vehicle technology, this also needs improvements to rider behaviour and protective equipment.

Powered two-wheelers (PTWs), such as scooters and motorcycles, are often cited as an appropriate transport solution for Europe's increasingly congested urban environments. However, alongside their manoeuvrability, specially suited to city traffic, comes increased risk of personal injury or fatality, through crashes. This is due to a range of factors such as the limited visibility of vehicles and riders, inadequate personal protection, alongside difficulties in controlling PTWs to avoid accidents.

The MOTORIST (MOTORcycle Rider Integrated SafeTy) project has contributed to an improvement in the situation through three interrelated objectives. Firstly, it established training to augment riders' skills, drawing on in-depth analysis of accident data and investigations on rider behaviour during emergencies. Secondly, it developed advanced technical safety systems based on riders' behaviour. Lastly, it improved personal protective equipment for riders.

NOT JUST A TECHNICAL FIX

PTWs riders are considered to be the most vulnerable road users. This is due to the speed their vehicles travel at in relation to other transport modes and the fact that PTWs are not protected in the same way as other transport methods, for example by car compartments with crumple zones.

Additionally, there are difficulties on the part of other drivers to perceive the presence and speed of PTWs, referred to as 'conspicuity'. From a technical standpoint, PTWs have not benefited from the same safety advances as cars, with the comprehensive implementation of ADAS (Advance driver assistance systems), for instance. Finally, riding a PTW actually requires greater skill, in terms of both motor skills and cognitive skills, compared to car drivers.

This leads the MOTORIST project coordinator Dr Marco Pierini to comment that, "It is not possible to simply

install a new technological solution on motorcycles and immediately guarantee a reduction in accidents. Most of the new technologies, for best results, require that the bikers learn to use them properly first." This is seen, for example, with anti-lock braking systems where riders have to be trained to use the full potential of the system in the event of emergency braking, without holding back for fear that wheels will lock resulting in a fall. This training requirement will be even more pronounced with advanced technologies soon coming to the market.

The project's research was able to pinpoint the key parameters to characterise and predict the response of riders in emergency situations, with a focus on relevant crash scenarios such as those occurring at intersections. This enabled the team to create guidelines as a foundation for future training activities to increase rider competency and to further develop safety systems.

As Dr Pierini says, "A major outcome was the definition of a test protocol that elicits in the rider realistic emergency responses. For example, the protocol considers a PTW approaching a mock-up intersection with a car simulating the initiation of a turning manoeuvre across the PTW's path."

This protocol was tested both in riding simulator activities and in the field, with promising results for the analysis of rider performance under emergency situations and for the development of new training strategies which combine skills related to hazard perception and vehicle control.

INCREASED KNOWLEDGE FOR THE PTW SAFETY SECTOR

Aside from the societal impact of the project which contributes to a more holistic approach in reducing PTW road accidents, the EU-funded project resulted in tangible scientific results. Many of these Marie Curie Action Initial Training Network results, working through Early Stage



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Researchers and Experienced Researchers, have been published in journals, as well as shared at major conferences. Additionally, participation at public events has also given the team a chance to raise awareness about the problem of PTW safety.

Allied to this, while new Marie Curie Action proposals are under evaluation, a cooperative project funded by the EU, called PIONEERS, has been approved for going ahead

under the auspices of the EU's Smart, Green and Integrated Transport initiative.

MOTORIST

- Coordinated by the University of Florence in Italy.
- Funded under FP7-PEOPLE.
- cordis.europa.eu/project/rcn/111466

TRANSPORT AND MOBILITY

New aircraft seat protects passengers' health

Flying by aeroplane will soon be more comfortable thanks to a new state-of-the-art aircraft seat that is both healthier for passengers and friendlier to the environment.

Travelling on aircraft can mean long hours of sitting. This immobility exposes passengers to the risk of developing deep vein thrombosis (DVT), a blood clot that forms in the deep veins of the leg, either in the calf or thigh. Passengers are therefore encouraged to move about on long-haul flights to improve blood circulation.

The EU-funded HAIRD (Hybrid AIRcraft seating requirement specification and Design) project addressed this

problem by designing comfortable, healthy next-generation aircraft seating to help reduce the risk of passengers developing DVT during flights. "The lightweight seating is easy to dismantle and includes new materials that are highly recyclable and reliable in structure. Reducing the weight also has direct impact on the aircraft's fuel consumption and thus its CO₂ emissions," the project scientific coordinator Dr Pere Badalló explains.



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CHEAPER, LIGHTER AND EASY TO RECYCLE

Researchers took up the challenge of designing from scratch a new aircraft seat that is better, cheaper and more recyclable than those that are currently on the market. “By employing new materials that are easier to recycle, such as a new polyurethane-based cushion, we can reduce the seating’s environmental impacts,” Dr Badalló points out.

The footrest, dynamic seat base, and glass and bottle support are designed to reduce DVT risk, using simple surfaces to facilitate composite manufacturing. In addition, features like the armrest, footrest, headrest, tray table, glass and bottle support and mobile support are designed to be easily dismantled for recycling.

Work began with a detailed study of existing aircraft seating and the complex regulations associated with them, using computational tools to ensure weight reduction without compromising structural integrity. The team designed a new mechanical system for seats, allowing fast assembly and disassembly in the aircraft, reducing maintenance times and labour costs. Finally, a life cycle assessment was performed to guarantee improved sustainability of the new design.



95%
of the seat's weight
is recyclable



The weight of the
HAIRD economy class seat is
8.56 kg

AN INNOVATIVE APPROACH

Composite manufacturing techniques like sheet moulding compounds (SMCs), wet compression moulding (WCM) and prepreg compression moulding (PCM) with co-moulding of SMC were used to design and build the aircraft seat. “As complex geometries are not allowed with WCM and PCM, a new design concept was developed, enabling the use of these techniques for aircraft seating without losing structural reliability,” Dr Badalló clarifies.

The result was a new economy class aircraft seat for the Airbus A320 and an improved user experience in airline transport. “The weight of the HAIRD seat is 8.56kg and 10 kg for economy class and economy class plus respectively. Moreover, 95 % of the weight of the seat is recyclable. It is an attractive yet simple design comprising composite materials that increases passenger comfort, while reducing the risk of DVT,” Dr Badalló concludes.

The successful use of composite materials with semi-automatic production techniques to develop an innovative product using state-of-the-art materials makes HAIRD a market leader in next generation seating for aircraft. The project will benefit not only producers of aircraft seating, but also aircraft manufacturers and airline companies by increasing their competitiveness and reducing their carbon footprint.

HAIRD

- Coordinated by LEITAT in Spain.
- Funded under H2020-TRANSPORT.
- cordis.europa.eu/project/rcn/207650
- Project website: projects.leitat.org/haIRD



Ecosystem value to innovative water technologies demonstrated

Europe needs to overcome its water quality and water scarcity challenges through improved resource efficiency and nature protection. An EU-funded initiative has developed a framework that evaluates the impact of technical or management solutions for freshwater ecosystems on ecosystem services (ESS).

The DESSIN (Demonstrate Ecosystem Services Enabling Innovation in the Water Sector) project developed a method for determining the value of new approaches to address water scarcity and water quality challenges. The DESSIN methodology for valuing ESS can identify and quantify the benefits that human society freely gains from the natural environment, such as the provision of water for irrigation, and how this can be improved by new technologies or measures.

DESSIN has also tested specific technology solutions to tackle water scarcity and water quality challenges at five sites in Europe, and has applied the ESS valuation framework to provide evidence of their benefits. This twofold approach shows how innovative solutions in the water cycle can increase the value of services provided by freshwater ecosystems, while helping decision makers take informed decisions regarding their impact on the water body and their economic implications.



“One of the framework’s main advantages is its ability to integrate economic, environmental and societal dimensions.”

Project partners including scientists, water management organisations and end-users, technology providers and relevant public authorities tested and validated different innovative approaches at five demonstration sites across Europe, with a special focus on urban areas. “The solutions for a more resource-efficient and competitive water sector involved decentralised water treatment units, real time control of large-scale systems, sewer mining and storage of freshwater in aquifers,” says project coordinator Dr David Schwesig.

Work conducted at demonstration sites at Emscher in Germany and Hoffselsva in Norway contributed to ESS for water quality improvement in line with the Water Framework Directive (WFD). The initiatives developed at sites in Greece (Athens), Spain (Llobregat) and the Netherlands (Westland) were concerned with managing water scarcity.

BETTER DECISION MAKING

The ESS evaluation framework enables better decision making through the quantification of changes in ESS delivery, the evaluation of existing and innovative management measures, and policy instruments to improve the status of freshwater ecosystems. “One of the framework’s main advantages is its ability to integrate economic, environmental and societal dimensions,” explains Dr Schwesig. “This enables a monetary value to be applied to the impact of water management measures based on the new solutions, allowing a direct comparison of measures to provide arguments that support market uptake and practical implementation.”

A wide range of decision makers in the water sector who must decide about the most suitable technology or management option for a given situation will benefit from the ESS evaluation framework, including water boards, water utilities, policy makers and water managers. The framework can also be used by technology providers of new solutions to demonstrate the benefits they can provide.

WIDER UNDERSTANDING ACHIEVED

Knowledge gained on the quantification of changes in ESS can inform policies for the bioeconomy, the application of the ESS concept in the EC WFD, the Marine Strategy Framework Directive, biodiversity conservation, nature-based solutions and green infrastructure. It can also help in the design of new status indicators suitable for evaluation of the WFD Programme of Measures (PoMs).

The ESS framework and the case studies contained in DESSIN may also be used to support the implementation of the EC 2020 Biodiversity Strategy. Specifically, the ESS framework can be utilised to inform the ongoing need for ex-post assessments of management options for ecosystem restoration and biodiversity protection and conservation. “As the ESS Evaluation framework can also express benefits in monetary terms, it provides evaluations in a ‘language’ that is less technical and can be easily understood by the wider public. This is helpful in stakeholder dialogues, public consultation and participatory processes for discussing the various options to be implemented,” concludes Dr Schwesig.

DESSIN

- Coordinated by IWW in Germany.
- Funded under FP7-ENVIRONMENT.
- cordis.europa.eu/project/rcn/111429
- Project website: dessin-project.eu

Establishing why some tree populations survive drought while others decline

The EU-funded PERS-RELICT-CLIM project found that while tree population decline will occur under increased drought conditions, some populations will persist. The project set out to understand why, to better predict the consequences.

Climate change-type drought is disrupting tree populations and the distribution of tree species across the globe. Predictions suggest that rising global temperatures should drive tree species poleward and upward in elevation, as they track the climates to which they are adapted. It therefore also follows that population loss and regional extinctions should occur at species rear range-edges, that is, the most drought-prone areas of species distributions.

Although this prediction is well supported in the literature, evidence of rear-edge population persistence is also accumulating. The PERS-RELICT-CLIM (The persistence of relict populations under climate change) project looked

especially at relict populations. This is the most impressive example of persistence where populations remain geographically isolated in marginal climates, significantly dryer than that tolerated by the species.

FIELD, MOLECULAR AND MODELLING APPROACHES

The EU-funded PERS-RELICT-CLIM project was set up to propose a framework for research design and analysis of species' rear range-edges, and to demonstrate how such an analysis can improve the understanding of rear-edge population responses to increased drought conditions.



The researchers developed the methodological framework, drawing upon habitat, functional, genetic and demographic information. They established the study at the rear range-edge of the European beech tree (*Fagus sylvatica* L.), a species with significant ecological importance, yet which is highly drought-sensitive.

The field-based research assessed the impact of increased drought occurrence on the demographic responses of populations and the physiological performance of trees, and evaluated the contribution of microclimatic conditions to population persistence. The team also assessed whether habitat fragmentation resulted in genetic isolation and the loss of genetic diversity, evaluating the implications for future population decline. The modelling approach studied tree growth dynamics under different scenarios of climate change, using an extensive network of dendroecological data from across Europe.

The first results point to a higher resilience to drought than expected, in geographically isolated populations found in the most drought-prone habitats. At the same time, researchers discovered the core of the range was more strongly impacted by recurrent droughts.

Summarising the project results, the project coordinator Prof. Alistair Jump says, “Our project strongly suggests that we need to assess population decline from a different perspective, with an improved methodology. Our proposed framework has great potential to improve our predictive understanding of species rear range-edge dynamics.”

The empirical evidence that the project gathered suggested that rear-edge population dynamics are determined by complex ecological and evolutionary factors, and that they do not always respond neatly to predictions about the consequences of climate warming.

EXTENDING THE REACH

The results of PERS-RELICT-CLIM are likely to benefit a range of disciplines, from population ecology to

“*The proposed framework and the information gained in this project have the potential to increase the predictability of climate change impacts across a wide range of taxa and ecosystems.*”

population genetics and biogeography. The project’s information will improve our understanding of climate change impacts at the rear-edge of species distributions, helping to predict the consequences from regional extinctions and trophic cascades (food chain interactions), to carbon and water dynamics.

The project Research Fellow, Dr Albert Vilà-Cabrera, concludes, “The proposed framework and the information gained in this project have the potential to increase the predictability of climate change impacts across a wide range of taxa and ecosystems. It can be used to optimise conservation strategies to maintain the functions and services that rear-edge populations provide to human societies, such as the regulation of water and nutrient cycling, habitats for biodiversity.”

It is anticipated that factors, such as land-use changes or biological invasions, can be incorporated within the PERS-RELICT-CLIM framework.

Finally, the combination of field-based approaches with remote sensing methodologies also has the potential to improve the predictive understanding of rear-edge population dynamics.

PERS-RELICT-CLIM

- Coordinated by the University of Stirling in the United Kingdom.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/rcn/195244
- Project website: biogeo.org/ASJ/Relict_pop_climate.html

New weathering analysis accurately traces the geochemical flux beneath the Earth's surface

Weathering, by which rock becomes soil, has implications for the Earth's climate, metal ore management, pollution detection and food production. Using a new isotope method, the IsoNose project successfully followed the journey of chemical elements from rock to plants.

Harnessing natural resources at the Earth's surface is taking place at an unprecedented pace and scale. If this exploitation of soil, water and precious metals is to be sustainable, it has to become more efficient. Achieving this rests on better understanding of the transformative biogeochemical processes involved when chemical elements travel from rock to soil, into plants, through ground water, into river water and into ore deposits.

The EU-funded IsoNose (Isotopic Tools as Novel Sensors of Earth Surface Resources) project was established to use recent technological advances, especially within the field of mass-spectrometry, to explore the formation of these natural resources and so open the field for better practices. The project shed further light, not only on the way the Earth's surface transfers dissolved chemical elements but also on how metals shift their isotope fingerprint, as they are taken up by organisms.

MEASURING ISOTOPES WITH MASS SPECTROMETRY

Rock is converted into soil, (weathering), when water flows through rock fractures and the ensuing chemical reactions convert primary minerals into secondary minerals, with organic carbon accumulating near the Earth's surface and a soil layer left below. This process typically plays out over thousands of years.

Rock dissolution results in each of the chemical elements which had been trapped, such as magnesium, iron or zinc (taking metallic examples), following different pathways. Some travel into the newly formed soils, others are consumed by plants, with some dissolved into rivers. To learn more about the composition and transformation of metallic elements specifically, the IsoNose team collected host rock, weathered soil and sediment, as well as water samples, for lab analysis.



“*We have provided a scientific framework, with empirical data, for the better use of the Earth's surface resources in a manner which will not impair use by future generations.*”

Analysis depended on measuring the isotopes of these elements (their varying atomic weight or mass) in the samples. The researchers made use of so-called 'isotope fractionation' – the preference of certain isotopes (with heavier or lighter atomic weights) to move into a given material that formed at the Earth's surface by weathering, for example. This then hints at the likely causes of these transformations (such as climate change).

The team first weighed the samples to determine how much of each element they contained, with a process called chromatography then employed to separate the elements from each other. A mass spectrometer was then used to measure the isotopes by injecting the ionised isotope particles into a tube with an electric field, separating the lighter isotopes from the heavier ones, giving each sample an isotope ratio value.

As project coordinator Professor Friedhelm von Blanckenburg, elaborates, “Combining this existing method of ‘multicollector inductively-coupled mass spectrometry’ with a technique called femtosecond laser ablation turned out to be extremely powerful. The combination measured very precisely and simultaneously tiny shifts in the relative abundance of metallic element isotopes and chemical amounts on solids with a resolution of a few thousandths of a millimetre.”

TOWARDS IMPROVED PRACTICES AND EXPANDED SCOPE

From an environmental perspective, IsoNose's research can be used to explain how the Earth's surface has regulated climate and greenhouse gases, over millions of years. The techniques can also be deployed to identify sources of environmental contaminants, as well as to determine the effectiveness of remediation efforts.

Measuring metallic isotopes also increases understanding about how these elements came to be within rock in the first place, offering the mining industry insights for more sustainable extraction. As Professor von Blanckenburg puts it, “We have provided a scientific framework, with empirical data, for the better use of the Earth's surface resources in a manner which will not impair use by future generations.”

Another likely area of future research is to transfer these techniques to soil management practices, for food production which can more effectively meet the needs of a global population, now well in excess of 7 billion people and fast growing. Measuring metallic isotopes could help accurately track the pathways of mineral nutrients from soils to plants and so lead to more targeted fertilisers, as well as the establishment of biomarkers for diseases.

Concluding, Professor von Blanckenburg says, “Our researchers will use IsoNose as a platform from which to lead this emerging field into new areas including the geosciences, environmental forensics, biomedical sciences and mineral resource prospecting.”

ISONOSE

- Coordinated by the GFZ German Research Centre for Geosciences in Germany.
- Funded under FP7-PEOPLE.
- cordis.europa.eu/project/rcn/109250
- Project website: isonose.eu/home
- bit.ly/2MDahT3



SPECIAL FEATURE

MENTAL HEALTH, AN UNDERCOVER EPIDEMIC

Editorial

Breaking down barriers for better mental healthcare provision in Europe

World Mental Health Day is observed on 10 October every year, with the aim of raising awareness of mental health issues across the globe and helping facilitate patient access to robust, modern and comprehensive mental healthcare services. This is especially important as the issue of mental health in many countries, including those within Europe, is often seen as a taboo subject, with high levels of social stigma associated with mental illness.

Mental health encompasses a wide spectrum of conditions, with some of the most prominent in the public's mind arguably being depression-related illnesses. But other conditions that are firmly under the mental health umbrella include schizophrenia, Attention-Deficit/Hyperactivity Disorder (ADHD), bipolar disorder, anxiety, eating disorders, obsessive compulsive disorder (OCD), autism and post-traumatic stress disorder (PTSD).

Europe in no way fares better than other regions of the world with regards to levels of mental health affliction. The World Health Organisation (WHO) estimated in 2014 that 27 % of the adult population in EU countries (plus Iceland, Norway and Switzerland) had experienced at least one of a series of mental health disorders in the previous year. Other estimates put the figure of Europeans suffering from mental health distress to be as high as 38 % – an enormous burden on individuals, society, healthcare systems and the wider economy. The overall financial costs of mental illnesses,

in terms of both direct medical, as well as indirect costs, amount to more than EUR 450 billion per year in the EU. With such alarming figures for both human and economic costs, more action must be taken to tackle the widespread, yet still somewhat undercover, mental health epidemic.

Thus, in this the first special section of our newly revamped Research*eu Magazine, we're playing our part in raising awareness of mental health disorders and the individuals who struggle with them on a daily basis. We're doing this by showcasing some of the innovative EU-funded projects that have dedicated themselves to developing solutions (medical, technological and policy-based) to tackle the mental health crisis in Europe and worldwide.

Some of our featured projects have focused on frontline mental health services and the need to provide patients with better integrated and flexible care provision, in developed and developing countries. Others have been working on new treatments for specific disorders, such as aggression, schizophrenia and PTSD. A third group of projects have been advancing a very promising and exciting new field of research, specifically the use of innovative MRI scanners to better diagnose and treat mental disorders.

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

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Aggression aetiology unveiled, new treatments on the way

The biological foundation of aggression is a much-discussed issue, but our understanding of the mechanisms underlying it is still very limited. The AGGRESSOTYPE project sought to bridge this gap in order to help predict aggression and, ultimately, to explore new treatment options.

The dawn of human civilisation has made aggression – a common trait of all animals looking to predate or defend themselves – a deviant behaviour that can lead to maladjustment, social impairment and crime. The real question for psychiatrists, however, is twofold: How do our genes impact a patient's tendency to show maladaptive aggressive behaviour, and how can the better understanding of its aetiology lead to better prediction and treatment.

Funding under the five-year AGGRESSOTYPE (Aggression subtyping for improved insight and treatment innovation in psychiatric disorders) project, which will end in October 2018, is helping answer these questions. Barbara Franke, Professor of Molecular Psychiatry at the Radboud University Medical Centre and project coordinator, discusses its results so far.

There are some treatments available for patients with ADHD or conduct disorder. Would you say that those treatments are completely ineffective?

So far, options for treatment are really limited, with behavioural training and a small set of psychopharmacological agents which, whilst in general use, are often insufficiently effective. We argue that this is due to an insufficient understanding of the biological mechanisms underlying aggression.

How did you aim to tackle this issue?

Aggression aetiology is highly heterogeneous: given its different evolutionary roles in survival, different pathways towards aggression exist. In AGGRESSOTYPE, we took information from animal research as our starting point for subdividing aggressive behaviour. We found that two different types of maladaptive aggressive behaviour can be distinguished: impulsive, reactive aggression – where a person overreacts to perceived threats or internal frustrations – and proactive aggression – where aggression is used as a tool to reach a goal. It is known that different brain circuits support

these different types of aggression. We subsequently also found differences in the genetic contribution to the aggression subtypes.

Can you tell us more about the research process involved and your main findings related to the mechanisms underlying aggression?

We investigated the mechanisms underlying aggression subtypes at multiple levels. The first three levels consisted of: molecular genetic studies to find new candidate genes for aggression with a breakdown per subtype and gender; identifying alterations of gene regulation through epigenetics studies and direct analysis of gene-expression; and using neurons derived from human-induced pluripotent stem cells (iPSCs) to identify alterations in carriers of genetic mutations linked to increased (impulsive) aggression. We found alterations linked to aggression and its subtypes at all those levels. In the latter *in vitro* model system, we could actually show alterations in the communication of neuronal cells.

The other investigated levels include: the effect of aggression genes and genes for impulsivity disorders on the brain (we found subtle changes in total brain size which were in part accompanied by changes in the maturation of connections in the brain during early development); the study of aggression genes in zebrafish and mice which enabled us to identify underlying molecular pathways; and studies of brain circuits that are differentially involved in reactive and proactive forms of aggression. Finally, we conducted studies of populations at risk. One of our most notable findings was that people prone to proactive aggression will often be seen resorting to reactive aggression as well, whilst the reactive subtype exists without proactive aggression.



Professor Barbara Franke
Professor of Molecular Psychiatry at
the Radboud University Medical Centre
© Barbara Franke

“To innovate in pharmacological treatment, we developed a medium high-throughput screen for juvenile zebrafish together with the SME ViewPoint. This has recently been commercialised.”

What would you say were the most innovative aspects of your approach?

There are several novel and highly interesting aspects to our work. For me, the most important one is the strong integration across different disciplines. This allows findings to be translated from molecular identification to testing in animal and cell model systems within a single project, for example. We have very interesting data to show from this, such as the identification of a new candidate gene for aggression, RBFOX1. We are currently studying this candidate in more detail, also using mouse and zebrafish as models.

The project also focused on treatment. How did you proceed to find potential candidates?

Treatment is a second very important pillar of our project. We have been looking into new avenues for both non-pharmacological and pharmacological treatment.

As for the first, we are studying biofeedback as a potential new option for preventing aggravation of aggressive tendencies. We teach children to regulate their brain activity while viewing emotional scenes. The study is still ongoing, but pilots look promising.

For pharmacological treatment, we have been looking into the use of methylphenidate, the most frequently used ADHD medication, for treatment of aggressive behaviour in young prisoners with ADHD. This open label trial was a huge success, and we are now following up with a randomised controlled trial. In addition, we employ multiple activities to make sure that prisoners are provided with appropriate diagnostic services and medication, where necessary. We have started training prisoner mental health professionals, and we are planning to extend the programme across Europe. In many of those activities, we are supported by the European patient organisations for ADHD, represented by ADHD-Europe.



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To innovate in pharmacological treatment, we developed a medium high-throughput screen for juvenile zebrafish together with the SME ViewPoint. This has recently been commercialised. Using our automated screen, we have identified several promising compounds, which we have characterised in much detail.

What are your follow-up plans?

We are looking into different ways to extend funding for our work. Collaboration among most AGGRESSOTYPE researchers has been ongoing for more than 11 years as part of the International Multicenter Persistent ADHD Collaboration (IMpACT), and is also supported by an ECNP Network (ADHD across the lifespan).

We recently obtained an EU grant to investigate the role of nutrition and the microbiome in impulsive and aggressive behaviour (Eat2beNICE, led by Dr Alejandro Arias Vasquez), under which we can continue some aspects of our work in AGGRESSOTYPE. Importantly, we have also built close

collaboration with the three other EU-funded consortia on aggression and conduct disorder, FemNAT-CD, MATRICS and ACTION, with whom we are organising workshops, symposia and conferences, as well as Special Issues in different scientific journals.

Biological research of aggression has been a neglected issue for a long time, and it was highly commendable for the European Commission to award four projects with funding to work on this subject, which has such important implications for society. We hope that future EU calls will provide opportunities to continue the work started among our consortia in the years to come.

AGGRESSOTYPE

- Coordinated by Radboud University in the Netherlands.
 - Funded under FP7-HEALTH.
 - cordis.europa.eu/project/rcn/110072
 - Project website: aggressotype.eu
- ▶ bit.ly/2NIOH DU

Towards a better transition from child to adult mental care

For patients with mental disorders, the transition from child to adult services is often not as straightforward as it should be. The MILESTONE project is running EU-wide studies to identify existing problems and help clinicians overcome them.

Most mental disorders appear between child- and adulthood. It would therefore seem only logical to strengthen mental health services during this sensitive transition period. But the reality is quite different: This period is currently considered as the weakest link in the care pathway due to various discontinuities. New therapists or service, relocation, being seen as an adult rather than a child, or even moving into partnerships and parenthood are among the many discontinuities that young people can experience.

The MILESTONE (Managing the Link and Strengthening Transition from Child to Adult Mental Health Care) project specifically focuses on the discontinuity of care taking place as a teenager reaches the 'upper service boundary' of their child and adolescent mental health service (CAMHS). Do those who need specialist adult services, or universal or targeted services, actually get them? Can we help clinicians overcome barriers to a smooth service transition? What are the ethical issues linked to transitional care? Is transition included in the training

of mental health care professionals across Europe? These are some of the questions the project aimed to answer.

"Young people attending specialist CAMHS may not meet the threshold for specialist adult mental health services and



therefore automatically fall through the specialist-service gap, while others may refuse specialist adult mental health for various reasons. Discontinuity in care therefore happens when young people with mental health problems need it the most, and it applies to one in three patients in the UK," says Swaran Singh, Professor of Social and Community Psychiatry at Warwick Medical School.

The outcomes of patients who do not transition are currently unknown. To fill this gap, the MILESTONE team is conducting a cohort study capturing longitudinal information (over 24 months) on young people from eight European countries who have reached the upper age boundary of their CAMHS. Whilst the results won't be available until spring 2019, the project has already obtained significant insights.

"Our EU-wide mapping survey confirms that gaps in mental health service provision exist across Europe, mostly due to the lack of youth-tailored care pathways and the lack of connection between the two services. In most areas, there are no joint initiatives or common activities between these services," notes Dr Helena Tuomainen, Scientific Research Manager of MILESTONE.

The project's survey also highlights areas of concern related to CAMHS across the EU: poor service planning; paucity of standardised outcome assessments for service provision or performance; scarce or variable involvement of service users or their families; or the scarcity of interdisciplinary CAMHS and adult mental health services. According to Prof. Singh, clearer national policies are needed to shape service delivery and structure, and standardised national data collection systems with standardised tools should be developed to properly assess the delivery, take-up and effectiveness of treatment.

Another notable project finding is how the majority of EU countries have no specialised transition planning and how only two countries – Denmark and the UK – have national

or regional policies or guidelines in place for the management of individual service user transition. Besides, only in three countries is a standardised assessment of the needs of young people approaching the transition boundary routinely conducted.

The project team has also developed a transitional model based on a timely, standardised assessment of patients attending CAMHS. The model and its associated tool – the Transition Readiness and Appropriateness Measure (TRAM) – consider all relevant and important factors linked with transition well before the service boundary, granting clinicians enough time to implement a transition plan.

When completed, MILESTONE will provide a comprehensive yet nuanced account of the organisation, policy and practice of care for young people with mental health issues at the CAMHS-AMHS boundary across the EU, and a timely analysis of their outcomes and experiences. Prof. Singh is hopeful that this enables easier patient progress to meaningful adult roles.

"By raising awareness of the important topic of transition, we expect that the findings of MILESTONE will encourage services across Europe to question their structure and identify current weaknesses in the CAMHS-AMHS care pathway so that outcomes for young people and their families can be improved by adapting best evidence-based practice into their service provision," he concludes.

MILESTONE

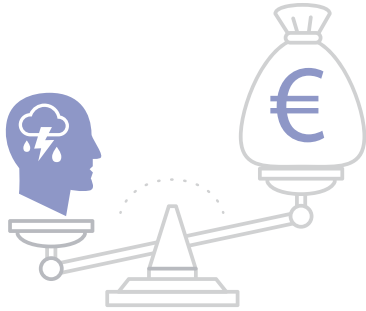
- Coordinated by the University of Warwick in the United Kingdom.
 - Funded under FP7-HEALTH.
 - cordis.europa.eu/project/rcn/110200
 - Project website: milestone-transitionstudy.eu
- ▶ bit.ly/2xvdWZH

Novel algorithms can predict psychosis before it strikes

Currently, the accurate prediction of psychoses relies on clinicians' best guess and experience. That may be about to change thanks to prediction algorithms developed under the PRONIA project.

Society's quest for ever more wealth, comfort and growth is driving citizens into a corner. Affective and non-affective psychoses have never been so widespread, to

the point where they've become the most expensive brain-related disorder in Europe. In affective disorders, the pattern is often the same: a sedentary, sunlight-deficient,



In Europe, psychotic and affective disorders cost

**€270bn
every year**

sleep-deprived lifestyle starting from a young age, combined with an increased use of drugs and growing emotional neglect.

“The cost for society is overwhelming,” says Prof. Dr Nikolaos Koutsouleris from Ludwig-Maximilians University of Munich. “Younger populations are strongly affected, and the resulting disability over their lifetime – due to the frequently relapsing course of these disorders – causes very high direct and indirect costs in 50 % of cases.” In Europe alone, psychotic and affective disorders amount to a burden of EUR 207 billion every year.

One might wonder how to rein in the rising tide of mental illness. According to Prof. Dr Koutsouleris, we’re looking at three main breaches in current countermeasures. The first is that, in most EU countries, preventive psychiatry is still in its infancy, with no suitable mental healthcare infrastructures in place. The second reason lies in how early recognition strategies are derived from group-level statistical analyses, making it very difficult to reliably identify individuals at risk. Finally, early intervention procedures (mainly psychotherapy) are also derived from group-level clinical trials which have not been tailored to produce treatment recommendations for individual patients. People at high risk are very difficult to recruit for these clinical trials.

The PRONIA (Personalised Prognostic Tools for Early Psychosis Management) project was built around this need for more representative studies and personalisation tools. “In PRONIA, we aimed to address the second shortcoming, that is, the need for tools that allow for a more accurate and representative measurement of risk in the single patient. We also tried to operationalise poor outcomes more broadly by including the likes of functional impairment in our prediction target, as well as to include more objective data in our prognostic tools such

“*PRONIA’s prognosis tools are tailored to populations highly at risk, where this risk has already been established by a clinician.*”

as neuroimaging, neurocognitive data and genetic or proteomic information.”

PRONIA’s prognosis tools are tailored to high-risk populations, where this risk has already been established by a clinician. They complement the ‘gut feeling’ that currently rules patient prognosis with a quantification of the actual risk.

“In the future, this could lead to a stratified preventive approach and a more rational allocation of therapeutic resources. The main innovation resides in how we trained machine learning algorithms to predict outcomes at single-subject level, by feeding them with sequentially-acquired multi-modal prognostic data,” Prof. Dr Koutsouleris explains. “In a sense, this mimics prognostic chains in real-world clinical settings. We add computer-aided support to these workflows to enhance medical decision-making at critical junctures in the process.”

Concretely, clinical experts will be able to use a tool provided with quantitative risk estimates – risk scores – across different domains, such as risk for disease transition or risk for functional impairment at six-month, one-year or two-year follow-up points. Such an approach could facilitate a more flexible, broader and more accurate quantification of risk in each patient, although it does not resolve infrastructural challenges.

The PRONIA consortium is in the process of drafting a business plan for a company that will test the prototype telepsychiatric decision support system in real-world clinical environments across different EU countries. “Obviously, when moving from bench to bedside many challenges will have to be addressed, including certification, patient safety and ethical considerations,” Prof. Dr Koutsouleris concludes.

PRONIA

- Coordinated by Ludwig-Maximilians University of Munich in Germany.
- Funded under FP7-HEALTH.
- cordis.europa.eu/project/rcn/110140
- Project website: proniamn.eu

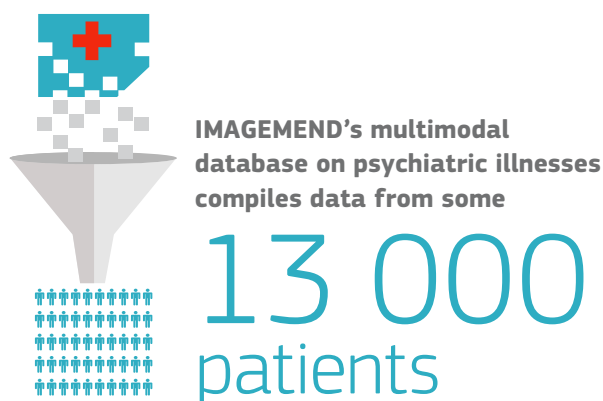
Novel imaging tools can identify the biological signatures of mental disorders

A novel MRI tool has enabled the IMAGEMEND project to shed some light on the biological markers characteristic of mental illnesses such as ADHD, bipolar disorder and schizophrenia.

Although extensively used to study mental disorders and rule out other possible somatic conditions (lesions, tumours, etc.), MRI equipment in psychiatric hospitals is not yet exploited to its full potential. The problem, according to partners under the IMAGEMEND (IMAGing GENetics for MEntal Disorders) project, arises from the fact that diagnostics for illnesses such as schizophrenia (SZ), bipolar disorder (BD) and attention deficit hyperactivity disorder (ADHD) do not take biological readouts into account.

“There are no readouts from MRI, or any other biological modality, that are currently used to aid in the (differential)-diagnosis, staging, course prediction or therapy selection of psychiatric illnesses. This is primarily due to the inherent biological complexity of these conditions, which itself results in small effect sizes of individual biological markers and a substantial overlap of predictive signatures,” observes Prof. Andreas Meyer-Lindenberg from the Central Institute for Mental Health in Germany.

Integrating these biological markers into predictive, reproducible and robust algorithms, however, would allow for more accurate diagnosis. It would also enable earlier, biologically-based selection of intervention which in turn would result in improved patient outcomes. As Prof. Meyer-Lindenberg points out, the exploration of such biological characteristics may not only aid in the clinical management of psychiatric disorders, but ultimately help redefine these disorders based on their underlying biology. “This would have a substantial long-term impact on personalised medicine approaches and the development of novel, more effective therapeutics,” he explains.



To make this possible, IMAGEMEND partners spent four years building one of the largest multimodal databases on psychiatric illnesses, compiling data from approximately 13 000 patients. The latter combines neuroimaging, genetic and environmental risk, as well as clinical data to enable advanced computational identification of diagnostic and predictive signatures.

“The project contributed to several large-scale analyses showing robust differences between different groups and between patients and controls. However, a central conclusion is that whilst structural changes in the brain can reproducibly differentiate schizophrenia patients from healthy subjects, a lack of specificity against related illnesses such as bipolar disorder is currently limiting their clinical utility,” says Dr Emanuel Schwarz, co-coordinator of the IMAGEMEND project.

Besides, these structural changes are broadly distributed across the brain, which hints at global brain structural alterations rather than regional, well-defined effects. According to Dr Schwarz, this has important consequences for future studies and highlights the need for stratification approaches to identify subgroups with similar and potentially more regionally-focused changes of brain structure.

Besides advancing the biological understanding of mental disorders, IMAGEMEND has also helped develop neuroimaging-based therapeutic intervention with a real-time fMRI tool integrated into connectivity-based neurofeedback analysis software.

"We are currently informing the scientific community on the utility of using structural MRI for diagnosis of schizophrenia. We hope that this will lead to collaborative efforts, which in turn will result in the development of biologically-based diagnostic and predictive tools," says Prof. Meyer-Lindenberg.

Such tools could ultimately change the clinical management of psychiatric illnesses to incorporate any biological readouts. Patients would then have access to more accurate diagnostics and more appropriate therapy, putting an end to repeated try-outs of medication, leading to faster remission and even preventing chronicity. Personalised

therapeutic approaches would minimise side-effects linked to treatment, and the identification of high-risk profiles prior to illness would facilitate preventative measures.

IMAGEMEND

- Coordinated by ZI Mannheim in Germany.
- Funded under FP7-HEALTH.
- cordis.europa.eu/project/rcn/109465
- Project website: imagemend.eu
- ▶ bit.ly/2D9Qbfv

One step closer to combined antipsychotic/antiobesity treatment

The METSY project has unveiled the links between psychotic disorders and metabolic co-morbidities. Its findings can improve the prediction of such co-morbidities, and also lead to new therapeutic options tackling psychosis whilst preventing metabolic complications.

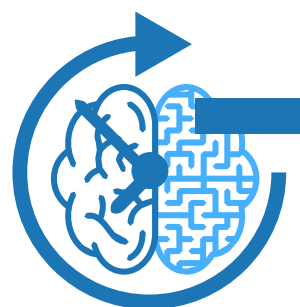
Although they're not supposed to be fatal, psychotic disorders such as schizophrenia can be very difficult to cope with. So difficult in fact that some patients will fail in their efforts to keep a healthy lifestyle and manage the side-effects of medication.

So far, this struggle has been thought to cause the high prevalence of cardiovascular disease, type 2 diabetes and metabolic syndrome amongst patients with psychotic disorders, and, ultimately, a life expectancy that's 15 to 20 years shorter than that of the average person. But what if there was more to it?

As Dr Matej Oresic points out, abnormal glucose homeostasis, hyperinsulinemia and accumulation of visceral fat can actually be detected in drug-naïve first episode psychosis (FEP) patients, independent of obesity. Hence the need to better understand the link between lipid metabolism and the metabolic co-morbidities of psychotic disorders.

"We considered that primary obesity and psychotic disorders are similar with respect to the associated changes in energy balance and co-morbidities, including metabolic syndrome. But the mechanisms linking the expansion of adipose tissue to these co-morbidities are unknown. Rather than demonstrating causal links, these similarities suggest that specific causes of – and metabolic disturbances associated with – obesity play a role in the development of psychotic disorders, potentially even before obesity develops," he says. In other words, lipid metabolism may be the link between psychosis and its associated metabolic co-morbidities.

This existence of such a link may offer new opportunities for the development of novel diagnostic tools, which was one of the purposes of the METSY (Neuroimaging platform for characterisation of metabolic co-morbidities in psychotic disorders) project. Using a multi-modal approach including a hybrid PET/MR system for brain imaging, mass spectrometry for the determination of circulating levels of endocannabinoids and other lipids, and integrative analysis of the acquired data using bioinformatics tools specifically developed by project partners, the team notably found a close association between endocannabinoid levels in the blood and CB1R availability in the brains of healthy individuals. This association happens to break down in patients with psychosis.



Psychotic disorders can potentially cause heart, diabetes and metabolic diseases and reduce life expectancy by

15 to 20 years

“Besides, our research suggests that FEP patients who gain most weight in the follow-up phase have a specific circulating lipid signature which is indicative of elevated liver fat, independent of obesity. From a clinical standpoint, this is significant because it may help identify patients at highest risk of developing metabolic co-morbidities associated with psychosis, and it may guide the choice of therapy,” Dr Oresic enthuses.

Besides helping to identify psychotic patients who are at the highest risk of developing metabolic co-morbidities and potentially leading to their prevention, METSY’s findings offer new opportunities to the diagnostic and pharmaceutical sectors. “The former can benefit from the identified biomarkers, while the latter can explore the possibility of combining antipsychotic and antidiabetic/antiobesity treatments in order to tackle psychosis as well as prevent metabolic complications,” Dr Oresic explains.

Follow-up research is already underway. This includes: additional studies to examine the role of fatty liver, and

gut-liver-brain axis in general, in psychosis and associated metabolic co-morbidities; studies of the endocannabinoid system in psychotic disorders; and the further development of tools and methods to analyse and interpret multi-modal data in psychosis studies.

“We intend to develop these approaches further, particularly those focusing on the integration of neuroimage and ‘multi-omics’ data, which in the future will also include gut microbiome (shotgun sequencing) data. Additionally, it is our intention to help bring the decision support tool developed within METSY towards clinical practice, as it has already been achieved in the domain of neurodegenerative diseases,” Dr Oresic concludes.

METSY

- Coordinated by the University of Turku in Finland.
- Funded under FP7-HEALTH.
- cordis.europa.eu/project/rcn/109989
- Project website: metsy.eu

Virtual reality for better diagnosis of mental disorders

As much as it's been trending over the last couple of years, we've only scratched the surface of virtual reality's (VR) unlimited potential. Nesplora Technology and Behaviour, a Spanish SME specialising in human behaviour analysis, is reminding us of that fact with a groundbreaking VR-based system for evaluating mental disorders.



Enter Nesplora Technology and Behaviour and its VR-based evaluation tools for mental disorders: A set of virtual reality glasses and headphones, with the patient entering a virtual environment. Reaction to stimuli and the ability to perform specific tasks in this environment will seamlessly provide a diagnosis, leaving clinicians enough information to pick the best possible treatment option.

Mrs Gema Climent, CIO of Nesplora Technology and Behaviour, discusses the VRMIND (Virtual Reality based Evaluation of Mental Disorders) project technology and the company's present and future plans.

What are the benefits of VR for evaluating brain disorders?

On the one hand, new technologies enable the evaluation of cognitive processes with an objectivity that traditional

Whatever the illness or health issue, diagnosis is never an enjoyable experience for patients. Those suspected of having mental disorders, for instance, will need to endure scans and tests of all kinds to find out where they stand and what treatment options they should consider. Besides the fear of the outcome, this is often an unpleasant and stressful experience.

paper and pencil tests can never achieve. We know what we are measuring at each moment, and that is recorded for a later interpretation.

More specifically, the added value of VR is the ecological validity that contributes to the neuropsychological evaluation, that is, the ability of a tool to reflect the true state of a patient in real life. By evaluating cognitive functions in a simulated real-life environment, we can predict more accurately how the patient's brain functions. We can then transfer the results of an objective evaluation to a real-world environment.

Can you tell us about the various tools you developed?

So far we have developed and commercialised a tool that evaluates attentional processes in children between six and 16 years old, through tasks that are carried out in a virtual classroom. This tool is called Nesplora Aula. We also have a variant of this tool, Nesplora Aula School, which focuses not so much on the clinical scope but on the educational one. It seeks to identify students' attentional strengths to reinforce their learning process.

Nesplora Aquarium, on the other hand, is aimed at the adult population to evaluate their attentional processes and working memory. In this case, the environment emulates an aquarium in which the person performs different tasks.

Currently, we are developing two more assessment tools, applicable to patients over 16 years old. Nesplora Ice Cream is designed to evaluate executive functions through exercises that are carried out in a virtual ice cream shop. In contrast, Nesplora Suite focuses on evaluating memory processes. For this, the patient goes into a furniture store.

How do these solutions integrate and compare with other approaches to diagnostics such as neuroimaging?

To carry out a diagnosis, the professional usually relies on tests and criteria of different kinds. In the field of mental health, depending on the disorder in question, we can resort to neuropsychological tests, neuroimaging techniques, tests of a more psychological nature, etc. The good thing about this variety of techniques is that they can complement each other. They provide different information and enable a more precise diagnosis.

Neuroimaging, to take your example, is very commonly complemented with neuropsychological tests when it comes to dementia. This helps the professional in establishing the type of dementia of a patient, which is determined

both by the area of the brain that appears to be affected as well as by the cognitive functions that show alterations.

How have you tested the technology and what can you tell us of the results of these tests?

All the tools that we develop at Nesplora Technology and Behaviour have a scientific basis. We carried out different studies to validate them scientifically.

On the one hand, we have normative studies that allow us to determine the normality curve for each age group and gender. This allows us to compare the results of a patient with those of his reference group, to know if he is within the mean or if, on the contrary, he deviates from it. We have extensive samples that allow reliable results for these studies. For Nesplora Aula, scales have been obtained for each gender in the following age ranges: 6-7, 7-8, 9-10, 11-12 and 12-14. For Nesplora Aquarium, three different age ranges have been identified for each gender: 16-40, 41-60 and 61 or older. In both cases, the results obtained coincide with the theory.

On the other hand, we also carry out clinical studies that consist in testing the discriminatory capacity between different disorders and their subtypes. Nesplora Aula was focused on patients with ADHD and other neurodevelopmental disorders. In convergent studies, however, we try to compare our tests with others that have been references until now. We are still developing these two types of studies for Nesplora Aquarium, since this tool is very recent.

What has been the feedback from practitioners so far?

It is true that on many occasions we have perceived a certain reluctance on the part of professionals to include new technologies in their 'toolbox'. This first barrier is due to a lack of knowledge, but once they know our tools the feedback we receive becomes very positive.

The most common comments are those related to the speed with which the tests are applied and the ease of doing so. In addition, a strong point for our clients is the good reception amongst patients, as the use of virtual environments makes our tools more attractive and increases motivation to be evaluated.

What are your plans for commercialisation?

We look for a global democratisation of our tools through the professional channel of neuropsychology, psychiatry

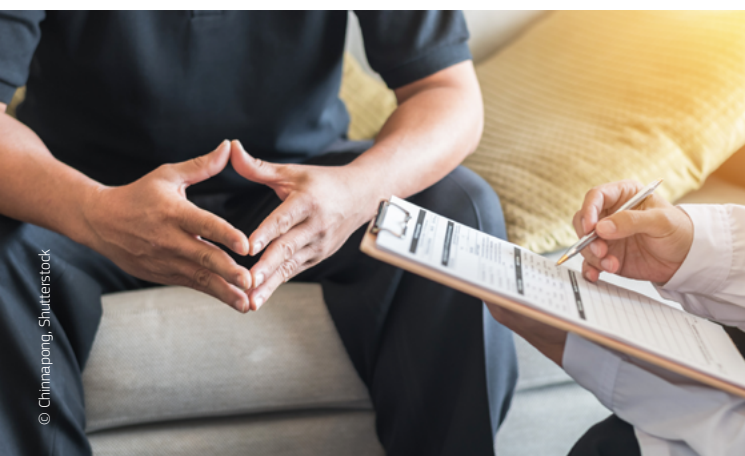
and neurology. Our customer segment is addressed to a clinical sector, principally to a professional collective of neuroscientists, but also hospitals, pharmaceuticals, insurance companies etc. There is another sector that will strongly extend the scope of our enterprise, and we intend to target it with new products that we will be launching soon.

VRMIND

- Coordinated by Nesplora Neuroscience Support Systems SL in Spain.
- Funded under H2020-SME and H2020-LEIT-ICT.
- cordis.europa.eu/project/rcn/207033
- Project website: nesplora.com/en/vrmind

Functional versus integrated mental health care

The aim of the EU-funded COFI project was to answer the question of whether continuity or specialisation of care is associated with more favourable treatment outcomes for those suffering from a mental illness.



Mental health disorders affect 38.2 % of the EU population. To reduce this burden, European countries are looking to improve the organisation of mental health care with often radical reforms. Despite their differences, all of these reforms focus on one central and controversial issue: should mental health care systems be functional or integrated?

COFI project coordinator and professor at Queen Mary University of London Stefan Priebe explains.

Can you briefly explain the difference between a functional system and an integrated one?

Whereas in functional systems different clinicians and teams (i.e., specialisation of care) are responsible for in-patient and out-patient care, in integrated systems the same clinician(s) are responsible for both the in-patient and out-patient care of a given patient (i.e., continuity of care). Although the difference between the two approaches has far reaching policy implications, surprisingly, there has been no sound research evidence to inform the debate.

Which is where the EU-funded COFI project comes in?

Yes. The aim of the COFI (Comparing policy framework, structure, effectiveness and cost-effectiveness of functional and integrated systems of mental health care) project was to answer the question of whether continuity or specialisation of care is associated with more favourable treatment outcomes for those suffering from a mental illness. To find out, we conducted studies in five countries (Belgium, Germany, Italy, Poland and the United Kingdom) where both approaches were used in routine care. Doing so meant we could avoid a confusion of country with approach. We recruited patients when they were first admitted to the hospital and followed up with them over a one-year period. Using this natural experiment approach, we were able to successfully investigate outcomes in real-world scenarios as opposed to experimental studies.

So, which system is associated with more favourable health and social outcomes?

Actually, what we found is that the approach to care – whether it be continuity or specialisation – has no significant impact on any clinical or social outcomes for patients one year after being admitted to a psychiatric hospital. This result was not only consistently found for the whole sample, it also holds true for different subgroups – including subgroups by country, diagnosis, age and whether or not the person had previously been admitted.

That being said, patients receiving continuity of care did report being more satisfied with their in-patient treatment, most likely because they are able to meet a clinician they already know and who is familiar with their problems.

Patients and clinicians also identified advantages and disadvantages for each approach, with advantages of one approach mirroring the disadvantages of the other. For example, with continuity of care, we found that many patients appreciate having an ongoing, trustful relationship where they do not have to tell their oftentimes stressful story each time they are treated by a different service. With specialisation, however, patients reported feeling that their clinician was focused on the specific service they were being treated in and they often appreciated having a new start with a new clinician following the crisis that led to the hospital admission.

These views on the advantages and disadvantages were consistent between patients and clinicians and across the different countries. Furthermore, anticipated and experienced discrimination was apparent for all patients, regardless of diagnostic group. This was particularly pronounced for patients with a primary diagnosis of schizophrenia and related disorders and anxiety and somatoform disorders.

Overall, despite being a hotly contested topic, our research concluded that regardless of whether patients are treated by the same or different psychiatrists across in- and out-patient care has no significant impact on any of their outcomes, at least as measured at the one-year follow-up.

What are the key takeaways of the project?

Based on our findings, we have made several important recommendations for treating mental illness. For example, if the aim of the treatment is to improve long-term outcomes for patients, costly reorganisations of mental health care systems should not focus on changing from integrated to functional care or vice versa. However, if the aim is to improve the patient's experience of in-patient treatment, then integrated care may be preferable.

Furthermore, although both approaches have strengths and weaknesses, organisational considerations in the local context and preferences of patients and clinicians may favour one of the two approaches. Patient preferences are particularly important when there is a choice between the two systems in the same service. In this case, potential advantages and disadvantages of each system should be considered.

I would like to point out that, to my knowledge, the COFI project is the largest prospective study conducted with psychiatric in-patients. Recruiting and interviewing more than 7000 patients with mental disorders within the first days of admission to acute hospital treatment and obtaining follow-up data on more than 5000 is quite the achievement



Stefan Priebe
COFI project coordinator and professor at Queen Mary University of London
© Stefan Priebe

“Despite being a hotly contested topic, our research concluded that regardless of whether patients are treated by the same or different psychiatrists across in- and out-patient care has no significant impact on any of their outcomes.”

itself. This is also a study where the value of the work conducted in five centres across Europe is clearly greater than the sum of its parts. Showing that similar results are found in countries with different traditions and different systems of health and social care significantly strengthens our conclusions.

What will the project's legacy be?

Many studies end with the conclusion that more research is needed, but not this one. COFI managed to answer one very important question that has dominated debates on mental health service organisation across Europe. The answer may not be popular with ardent supporters of either approach, but it is clear and scientifically sound.

Interestingly, one legacy might be that policy makers are more cautious with investing much time, energy and money into changing the organisation of mental health care from continuity to specialisation of care or vice versa. Thus, the legacy may be the avoidance of useless change rather than more change. It will certainly be interesting to see to what extent policy makers take our empirical and conclusive findings on board and consider them in future planning for the organisation of mental health care.

On a wider level, COFI raises questions about the effects of mental health service organisation in general. It suggests that more emphasis should be put on the content of treatments than on the overall organisation of services, as each approach comes with specific advantages and disadvantages.

COFI

- Coordinated by Queen Mary University of London in the United Kingdom.
- Funded under FP7-HEALTH.
- cordis.europa.eu/project/rcn/110146
- Project website: cofi.qmul.ac.uk



Intelligent ‘health-check’ for farms goes head to head with crop diseases

An agricultural intelligence gathering and diagnostic system collates crop, weather data and information about pests to alert farmers of plant diseases and other conditions that can cause crop damage.

Up to 60% yield loss in agriculture overall is due to plant diseases. But the effect on individual farms can be devastating, with the potential to wipe out whole harvests if not detected in time.

Scientists working on the EU-funded PCT (Plant CT – Making Plants Healthier) project have developed an agricultural intelligence, diagnostic and advisory system consisting of measuring devices installed in areas under cultivation. An array of device sensors collates data about the site, the soil, leaf conditions and localised weather conditions, as well as the presence of pests and

other pathogens, and matches it against a database of plant-specific diseases.

The remote comprehensive ‘health-check’ based on the on-site monitoring provides farmers with precise information on disease risk, acts as an early warning system and provides recommendations on how to act to prevent the disease.

“You spray only if you must,” says Csaba Arendas, CEO of QuantisLabs in Budapest, Hungary, the company that developed PCT. In Europe, a farmer sprays an apple



orchard on average 15 times during the growing season from March till August. For grape, an average of seven times. "If you use fewer [chemical] materials the cost of production is also lower, so timing is key," Mr Arendas says.

PCT's leaf-area calculations help accurately determine the amount of spraying material required and prevents overspraying. "For grape you can save one or two sprayings," reducing yield losses by 30%, and saving around 20% of pesticide use, he says.

ARRAY OF SENSORS

An array of sensors attached to a central unit the size of a laptop computer is affixed to a mast that is easily transportable and can be erected in a field without the need for specialised skills. The standard PCT model includes around a dozen sensors to measure air humidity, precipitation and temperature, soil moisture and temperature as well as leaf and canopy sensors and pest and spore detectors that count plant pathogens, including fungi.

"For spores and pest detection it's about a 95% detection rate, so precision is very high," Mr Arendas says, noting around 99% of plant diseases are caused by pests and fungal spores.

Measurements are uploaded to a server, and scientifically-validated algorithms and mathematical models are used to determine the probability of infection in a given area. This information is available in visual form and can be accessed by the user on any internet-connected device. "Not all farmers are super-experienced in disease identification. They want an easily-digestible, visual format and a simple answer to their questions of what to do," Mr Arendas explains.

The analysis is based on a huge data bank derived from thousands of years of agricultural knowledge and other data collected by the project team. "We have 10 scientists who did a huge study of the literature of major scientific articles in publications that we could utilise," Mr Arendas says.

QuantisLabs already had huge data sets and measurements from a previous SmartVineyard product. "The EU funding enabled us to extend the existing system for vineyards into a comprehensive system for different crops," he says. The system now on the market can be used for

“*Not all farmers are super-experienced in disease identification. They want an easily-digestible, visual format and a simple answer to their questions of what to do.*”

apples, olives, cocoa, coffee, rice and cotton, with other crops being added. Artificial intelligence and machine learning adjust the system to local patterns.

LOCALISED CONDITIONS

Minor differences in humidity or temperature can modify the appearance or intensity of a plant disease, and the plant's stage of growth also matters. "Some pests prefer to eat the leaves, others prefer the flowers. If these things match, there can be a huge infection," Mr Arendas explains.

Some of the sensor technology was brought in, some existing sensor technology was upgraded and other more advanced sensors were custom-designed and prototyped during the project. Many of the parts were tested in university laboratories and small private labs and included special weather-proof batteries and the solar-powered central unit.

PCT is already on the market internationally, with orders and pre-orders coming in from countries as far afield as Latin America for various crops, and work on versions for crops such as avocado being developed. Currently 80% of sales are based on a subscription model at €150 per month per device, with possibilities of upgrading to include more sensors. One device on average can scan 10 hectares. "Every three years you would get a new device, like a mobile phone subscription," Mr Arendas says.

PCT

- Coordinated by QuantisLabs in Hungary.
- Funded under H2020-LEIT-ICT & H2020-SME.
- cordis.europa.eu/project/rcn/196398
- Project website: plantct.com
- ▶ bit.ly/2Pt4Sg7

Sustainable ‘pestiSide’ for long-lasting grain protection

PestiSi, a safe, natural silica-based pesticide protects crops in storage and can eliminate toxic phosphine from the grain supply chain.

Corn, wheat and rice constitute 90% of cereal production globally, and around 40% of all calories in food consumed. Yet up to half of those harvested cereal grains, so vital for our daily diets, can be lost due to ineffective storage techniques related to pest infestation.

Up to
60%

of yield loss in agriculture is due to plant diseases

Chemical fumigation for insect pests using hazardous chemicals such as phosphine is gradually being phased out due to its harmful health effects and the added problems of greenhouse gas and climate change effects. The PestiSi (Cost effective solution against insects in long-term grain storage by natural diatomaceous earth) project aimed to complete a feasibility study to examine the technological and market viability of a novel silica-based insecticide, PestiSi. According to project coordinator Mr Laszlo Berta of Dunagabona Kft, Hungary, PestiSi is a “natural insecticide that can be applied during long-term grain storage based on a formulated, natural and siliceous rock known as diatomaceous earth (DE).”

Implementing a refined application method developed throughout the project, PestiSi exterminates all insects during the storage period of agricultural commodities and harvested crops with a long-lasting effect that is completely safe for humans and other mammals.



AMBITIOUS TARGETS

Project aims included a thorough examination of the most appropriate application method for wheat treatment at an industrial scale, as well as the development of a standardised protocol that accounts for various handling and storage techniques.

Isolated customer requests were also taken into consideration such as the optional need of removing PestiSi from the grain upon the storage period's completion.

SUCCESSFUL DEVELOPMENTS – SAFE AND EFFECTIVE

During the technological feasibility trials, PestiSi was tested and verified by a certified laboratory ensuring it is completely harmless on humans and other mammals. Another key result was the revelation that the amount of PestiSi required for the successful treatment of grain is well below the threshold set for inorganic dust traces by the Hungarian Wheat Standard Regulations. This signifies that PestiSi can harmlessly remain in the grain after the storage period has ended.

Test results also indicated the specified DE rate that is vital for successful grain protection. Also, the team completed an initial conceptual design for a prospective industrial treatment procedure.

PestiSi results revealed that the treatment is technologically feasible, following small-scale mixing optimisation tests that displayed effective grain treatment using PestiSi. The company's commercial strategy was also confirmed as viable, following a professional competitor analysis.

A KEY CHALLENGE

Whilst the researchers were aware that the amount of DE necessary for maintaining the grain free of insects is under the threshold set for inorganic dust traces, there is concern that buyers will insist on complete elimination of DE.

A cost-effective method of complete DE removal, at an industrial level, remains a key challenge that will need to be overcome in future R&D work regarding PestiSi.

“These companies need low-cost solutions and, with the help of PestiSi, could extend their business line towards sustainable storage practices. This way, the entire supply chain will ultimately benefit from PestiSi.”

A SUSTAINABLE PRODUCTION CHAIN

Berta claims that the company has already been contacted by potential buyers within the food industry who would like to base their production on grain that has been treated with DE. Having already established a technological roadmap, the next step would entail the development of an industrial-scale PestiSi technology.

To garner further interest from grain consumer companies, Dunagabona Kft has positioned its product as a technology that would contribute to the elimination of phosphine-based practices from the grain supply chain of SMEs, protecting the environment and human consumption.

When questioned on who would benefit from PestiSi, Berta pointed out that all parties involved within the grain production chain, including grain consumers themselves, would enjoy its advantages.

Dunagabona's commercial route targets both small and medium-sized grain producers and grain storage owners. “These companies need low-cost solutions and, with the help of PestiSi, could extend their business line towards sustainable storage practices. This way, the entire supply chain will ultimately benefit from PestiSi,” concludes Mr Berta.

PESTISI

- Coordinated by Pentele Mezőgazdasági Zrt. in Hungary.
- Funded under H2020-SME & H2020-FOOD.
- cordis.europa.eu/project/rcn/213249
- Project website: dunagabona.hu



PROJECT OF THE MONTH

A new ceramic-based solution for reusing wastewater

Following this year's hot European summer, water scarcity has been at the top of the news agenda over the past few months. New methods to not only conserve but also reuse water (including wastewater) will need to be developed to avoid shortages that could be potentially devastating for Europe's agricultural sector and natural environment.



© REMEB

This is why we have chosen the **REMEB** project as our inaugural **'Project of the Month'**, with its innovative use of ceramic membranes to help facilitate the cost-effective recycling of treated wastewater. The project undertook its tests of the technology in Spain, where water scarcity is already a critical issue. The project also hopes that its breakthrough in successfully treating wastewater will help to ease a lingering hesitation among authorities in some European countries to put treated wastewater back into general circulation.

Keep a look out for an upcoming **CORDIS Results Pack on Water Innovation**, which will feature a more comprehensive article on REMEB's successes.

“ I am very proud that we have been able to manufacture membranes from agricultural and industrial wastes, which will contribute positively to the circular economy. ”

Elena Zuriaga
Project coordinator



At present only

2.4%

of treated wastewater
in Europe is reused

REMEB

- Coordinated by FACSA in Spain.
- Funded under H2020-ENVIRONMENT.
- cordis.europa.eu/project/rcn/196817
- Project website: remeb-h2020.com/

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



Understanding the full potential of metallic foam

The EU-funded METFOAM project sought to better understand the mechanical behaviour of metallic foams and how these behaviours could be leveraged for real-world applications.

Although metal and foam may seem like polar opposite materials, when a solid metal's cellular structure is comprised of gas-filled pores, you get what is called metallic foam. Although metallic foam is ultra-light, it is also strong, thus making it a material of choice for a range of applications used in the automotive, aerospace and health sectors.

The EU-funded METFOAM (Multi-physical structures through the use of metallic foam sandwich panels) project set out to better understand the mechanical behaviour of these metallic foams. "What makes metallic foams unique is their ability to efficiently transfer heat, which is useful for cooling via the air flow within the foam," explains Project Coordinator Stefan Szyniszewski. "What we wanted to know was how we could better leverage these mechanical behaviours for the benefit of real-world applications."

METALLIC FOAM AND SANDWICH PANELS

For example, one area of focus was sandwich panels with metallic foam cores. A sandwich panel is a structure comprised of three layers and used in applications where a combination of high structural rigidity and low weight is required.

The objective of this research was to find applications where such panels could outperform conventional steel sections. "In essence, we were trying to understand a novel material and find its niche within infrastructure and mechanical applications," says Szyniszewski. "What we discovered was that sandwich panels can support loads that are 10 times higher than slender steel plates."

According to Szyniszewski, such sandwich panels could enable a new generation of railway bridge girders or wind turbine towers by eliminating the need for welded stiffener plates, which prevent local plate buckling. Such stiffeners

produce stress concentrations and require periodic maintenance because they are the roots of fatigue cracks.

CHALLENGES OVERCOME

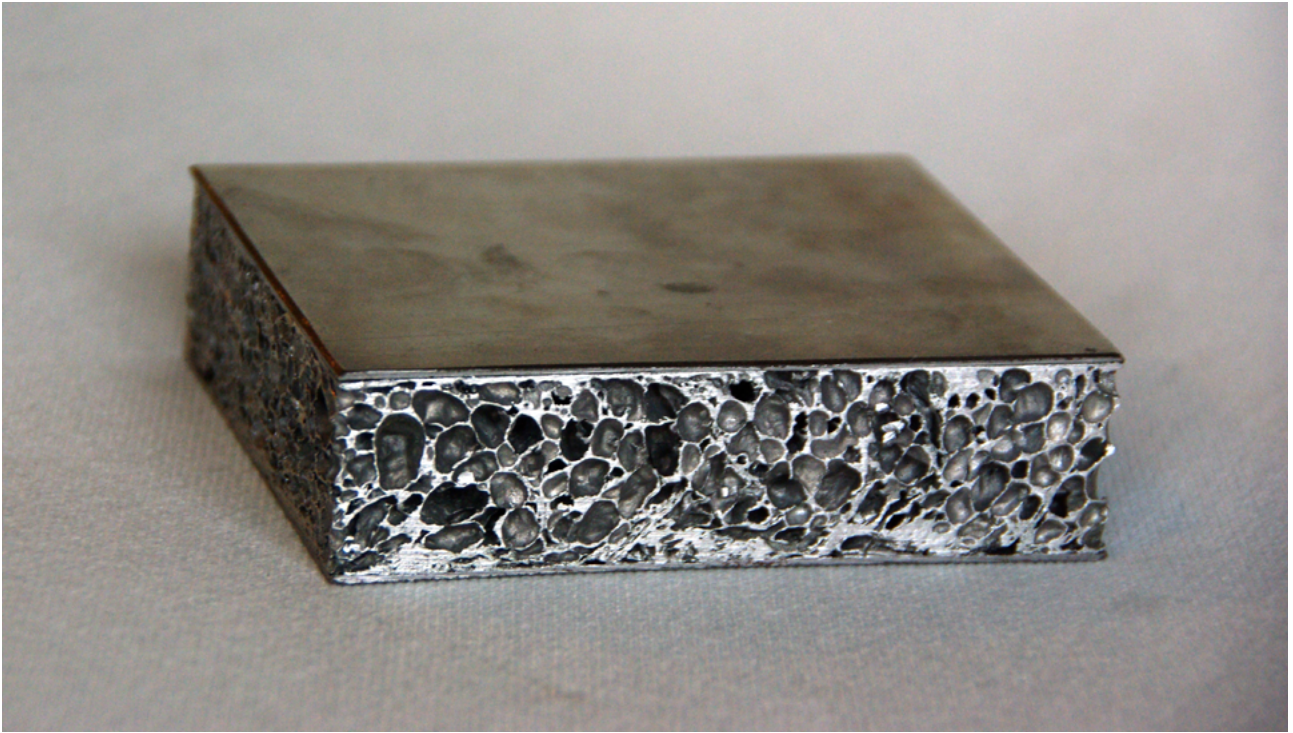
During the course of the project, Szyniszewski and his team had to overcome several challenges. For example, because sandwich panels are not reliable with face sheets less than 2 mm thick, researchers had to test a panel with the stiffness and strength equivalent to 5 mm steel plates. Unfortunately, this meant testing plates the size of an elevator shaft – something simply impossible with the project's 100 ton maximum capacity rig.

To overcome this challenge, researchers tested individual plates. "This required us to design special fixtures capable of providing rotational freedom of movement while also allowing us to transfer significant axial loads," says Szyniszewski.

NEW POTENTIALS FOR METALLIC FOAMS

Through these efforts, researchers discovered that adding ceramic spheres into metallic foams resulted in outstanding cutting resistance, which is unmatched by conventional bulk materials. "Ultimately, the METFOAM project proved that metallic foams can be used to produce new metamaterials with novel properties that are not achievable for bulk metals or ceramics," adds Szyniszewski.

Researchers also discovered that introducing porous surfaces into bluff bodies can reduce aerodynamic drag. "For example, a flow-facing porous surface triggers turbulence, a bit like dimples on a golf ball," explains Szyniszewski. "Having a porous medium in the leeside of the body reduces the base pressure and the intensity of the turbulence." He adds that such features could allow foams to be used on external surfaces.



Although the project is now closed, researchers are currently exploring civil engineering applications, such as transfer beams with extreme buckling resistance, that could benefit from the use of metallic foam plate components.

METFOAM

- Coordinated by the University of Surrey in the United Kingdom.
- Funded under FP7-PEOPLE.
- cordis.europa.eu/project/rcn/186933

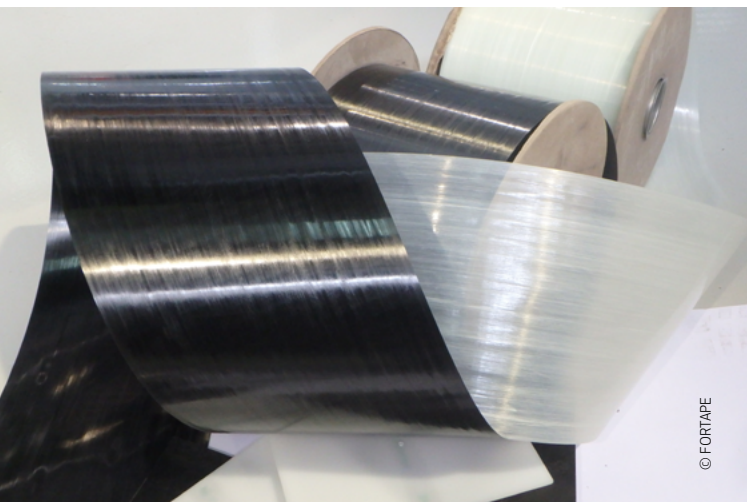
INDUSTRIAL TECHNOLOGIES

Making cars and planes lighter and cleaner using unidirectional fibre tapes

An EU initiative has developed a cost-effective way to produce unidirectional (UD) tape to manufacture and reinforce parts in cars and planes. The solution will make them lighter and more environmentally sound.

Automobiles are among the biggest culprits in generating greenhouse emissions, raising the costs for both the environment and manufacturers. One solution is to make vehicles lighter by using new materials such as UD fibre tapes. However, until now, these tapes have been costly and difficult to produce in sizeable quantities.

To address this issue, the EU-funded FORTAPE (Research on efficient integrated systems for the manufacturing of complex parts based on unidirectional tapes for the automotive and aeronautical industry, with the minimum use of materials and energy) project grouped 10 partners from five European countries covering the entire value



chain. The broad range of stakeholders was needed to develop new integrated technologies with the most efficient use of materials and energy. This was done to adapt UD tapes for use in vehicles and aeroplanes.

UD tapes can be used to enhance the mechanical properties of a plastic part. They can also be used to manufacture structural parts, consolidating and thermoforming several layers.

BARRIERS TO EXTENSIVE USE

But, this new high-performance material comes with some obstacles to widespread use in industry, says project coordinator Raquel Ledo Bañobre. The main hurdles are high consumption of resources, lower rates of automation, high production of defective materials and the subsequent rise in manufacturing costs.

“In global terms, industry needs to reduce vehicle weight in order to lessen greenhouse emissions and fulfil EU requirements using a cost-efficient solution,” she adds. “Despite their huge mechanical properties and lightweight potential, there were several issues that needed to be addressed to guarantee their extensive use in the industry.”

The project focused on three main axes: tapes manufacturing, part manufacturing, and the modelling of processes and parts. Three different technologies for fibre impregnation were researched to develop the innovative process in manufacturing UD carbon and glass fibre tapes with increased fibre content.

DRASTICALLY REDUCING PRICE

FORTAPE was able to optimise the manufacturing process to produce 16 tapes at a time at the right width. This helped to considerably slash the tape price.

Another output was an automated method to use UD tapes as reinforcement for a window regulator. This will help to meet cycle times and production volume needs for the auto industry. A window frame manufacturing process using fireproof polyamide UD tapes was developed for the aeronautical sector.

Also developed was a comprehensive model of the UD tapes as reinforcement to predict the mechanical properties of the part and the injection moulding process. Both aspects are key to introducing new materials in the automotive sector.

The most significant achievement is energy and material savings. FORTAPE was able to beat all targets on material savings. The goal for aeronautics parts was originally set at 75 %, and reached nearly 92 %. Similarly, the savings for automotive parts reached almost 57 % from 40 % initially. The project matched all but one target for energy savings. All EU requirements were fulfilled.

The technical and economic feasibility of the processes has been successfully demonstrated. To achieve industrial implementation, new adjustments and optimisations will be required. Bañobre says the plan is to continue to explore the possibilities of maturing the innovation and bringing it to the market.

“The reduction achieved in terms of material and energy consumption will enable companies to decrease their manufacturing costs and reduce the environmental impact,” she concludes.

FORTAPE

- Coordinated by the Automotive Technology Centre of Galicia in Spain.
- Funded under H2020-LEIT-ADVMANU.
- cordis.europa.eu/project/rcn/193428
- Project website: fortapeproject.eu
- bit.ly/2whS17z



End-to-end networking solution for low-power, cost-efficient and scalable datacentre networks

New networking solutions are urgently needed to satisfy the soaring demand for internet services which has led to an explosive growth in datacentre traffic. An EU initiative built on optical network infrastructure to favourably combine high bandwidth with reduced cost and power in contrast to existing datacentre networks.

Datacentres are the enablers for all types of digital goods and services. Booming demand for internet services is causing enormous growth in datacentre traffic. Datacentres need to grow and evolve in order to deal with the traffic. They must also tackle the resultant problem of increasing electricity costs needed to power bigger systems.

The EU-funded NEPHELE (eNd to End scalable and dynamically reconfigurable oPtical archItecture for application-aware SDN cLoud datacentErS) project proposed and developed a dynamic optical network infrastructure to deal with this issue. "Today's data-affluent society relies on datacentres to store and rapidly access massive amounts



of information,” says project coordinator Prof. Hercules Avramopoulos. “NEPHELE technology will provide a viable solution for seamlessly scaling capacity in datacentres.”

The growth is creating undue challenges for traditional network technologies. The most daunting one is scalability. Performance-wise, traditional architectures are designed for north-south traffic and face fundamental limitations to keep up with inter-datacentre traffic demand expanding along the east-west axis.

RAPIDLY GROWING DATACENTRE MARKET

NEPHELE's main objective was to strengthen Europe's industrial position in the field of cloud datacentre technologies by developing a scalable hybrid interconnect architecture for dynamically reconfigurable datacentres. The datacentre solutions market is expected to nearly double from USD 18.56 billion in 2015 to 32.2 billion in 2020. Many of the project's industrial partners are set to hold considerable shares across the value chain of this huge and swiftly developing market.

The developed network components comprise an architecture that allows network convergence over a transparent Ethernet optical datacentre network. NEPHELE leveraged mature/commercial off-the-shelf photonic component technologies. More importantly, it's the first to extend prominent software-defined networking (SDN) platforms with slotted time-division-multiple-access functionality, thus adding the capability to dynamically assign network resources directly at the optical layer. Fast resource allocation algorithms were developed and integrated as add-ons to the SDN platform.

Researchers took considerable care to develop the project approach on commercial off-the-shelf photonic components. This was done to avoid the often long maturation time of photonic technologies, which may hinder rapid exploitation.

SMOOTH INTEGRATION INTO EXISTING SYSTEMS

NEPHELE was also designed to fit current industry standards and norms, such as compatibility with Ethernet hosts,

“*NEPHELE technology will provide a viable solution for seamlessly scaling capacity in datacentres.*”

so that it can smoothly integrate into the existing optical networking ecosystem.

Using current pricing for the key optical components involved, NEPHELE equipment can provide significant cost reductions, with further savings expected in mass production. Substantial power consumption reduction is also expected, dramatically mitigating operating costs for network equipment energy and heating, ventilation and air conditioning.

Prof. Avramopoulos explains that NEPHELE is well positioned to claim a large share of datacentre-related markets, from network equipment datacentre software technologies to optical devices and datacentre storage equipment.

NEPHELE was successfully concluded in April 2018, leaving the consortium with motivation to pursue near-market exploitation, and to further explore future datacentre network architecture concepts and technologies.

“New networking solutions are urgently needed to sustain the booming growth in the cloud ecosystem,” concludes Prof. Avramopoulos. “NEPHELE builds on the enormous capacity of optical links and leverages hybrid optical-electronic switching to provision high capacity at reduced cost and power compared to current datacentre networks.”

NEPHELE

- Coordinated by the Institute of Communication and Computer Systems in Greece.
- Funded under H2020-LEIT-ICT.
- cordis.europa.eu/project/rcn/194293
- Project website: nepheleproject.eu
- bit.ly/2N8DPFg

Robots go to school

It might sound like something out of a 1980s sci-fi movie, but EU researchers have developed a talking, smiling robot to inspire storytelling and creativity in the classroom.



Classrooms today are becoming more and more hi-tech with interactive boards, laptops and web-based learning tools. Robots are also making their way into the curriculum.

A COMMUNITY OF SURFACE-BOTS FOR STORYTELLING

To usher in a new age of interactive learning, the EU-funded H2020 COBOTNITY (A community of surface bots for creative storytelling) project developed an affordable community of hybrid artificial agents called surface-bots. To be used in collaborative creative storytelling, they could help teachers to stimulate creative thinking and foster social awareness in children.

Surface-bots consist of a tablet attached to a portable robotic platform, allowing them to move while simultaneously exhibiting numerous facial expressions. They can also articulate short verbal cues and display an assortment of visual assets.

As demonstrated by the project, a typical play session with children in the classroom can include a variable number of surface-bots that are connected by a robotic operating system (ROS) overlay network, via WiFi. Aided by the ROS, dynamic control of the surface-bots enables content creation or story reenactment.

The importance of the project, explains the main project researcher Dr Alejandro Catala, lies in its capacity to strengthen and promote a change in the educational landscape: from occasional supporting tools at school to actual creative learning educational models in Europe. "We are exploring how innovative technology can be used in reshaping education for 21st century skills."

VALUABLE RESULTS

Results from the project are mainly related to assembling physical prototypes with affordable hardware and flexible software that supports the studies and pilots. One substantial outcome was an expandable research platform where system components can be reused and adapted to investigate a variety of experimental interactive solutions, not only throughout the duration of the project, but also in the future.

Valuable knowledge on the role that interactive small robots can have in storytelling activities was also acquired during the experiments. The researchers found that machines cannot fully respond to and carry out the whole range of physical interactions yet. Design of the interaction as a collaborative activity between artificial agents and users also needs to be addressed. This way, the behaviour of the agents can influence the user's actions and performance.

CHALLENGES ALONG THE WAY: KIDS WILL BE KIDS

The human aspect of the research created challenges simply because the main users of the surface-bots are children. However, as Dr Catala states, the "process was rewarding, even if we didn't get the expected results or fully workable data, as playing with our technology was a fun experience for the children, exposing them to unaccustomed digital systems and feeding their curiosity."

Throughout the duration of the project, technical and research-related issues were also encountered. The process of building an affordable and expandable IT system that enables child-robot interactions was an obstacle. The

system should use cheap robotic bases and tablets, 3D printed cases and commodity webcams. The goal is to eventually transcend a purely research-oriented environment, and implement surface-bots at schools and households with a limited budget.

CHILD-ROBOT SYMBIOSIS OF THE FUTURE

According to Dr Catala, interactive mediated technology needs to be designed to overcome current limitations. “There isn’t a plan for immediate commercialisation,” he explains. “More research is needed to optimise the underlying activities and provide more autonomous intelligent agents to support the labour of teachers. However, we are facilitating its introduction at schools by means of further pilot experiences, in which bachelor and master students are expanding the project results and experimenting with the technology.”

COBOTNITY foresees a symbiotic collaboration between agents and users in activities that possess shared or common goals. “Currently, we are working towards co-creation with agents, in which users and machines must cooperate to achieve common creative goals,” says Dr Catala.

Summarising, Dr Catala adds, “The next steps for the project include further development of an open robust platform to experiment and explore the issues addressed and provide more agent autonomy to facilitate deployment and eventual commercialisation.”

COBOTNITY

- Coordinated by the University of Twente in the Netherlands.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/rcn/201000

DIGITAL ECONOMY

Diamond-based sensors enable spintronics and next-generation MRI

Sensors developed under the DIADEMS project and capable of measuring magnetic fields with unprecedented accuracy are on the path to commercialisation. The technology has already spurred the creation of four start-ups.



The DIADEMS (DIAMond Devices Enabled Metrology and Sensing) project has come a long way since it was covered by CORDIS in 2016. At the time, the consortium aimed to use artificial diamonds to sense magnetic fields down to the nanometre. Now completed, DIADEMS has exceeded all expectations, and market applications – along with a potential new project – are on their way.

DIADEMS’ sensors are based on ‘nitrogen-vacancy’ (NV) colour centres in ultra-pure artificial diamonds: A single carbon atom in an ultrapure single crystal diamond is replaced with a nitrogen atom, and the neighbouring lattice site void creates a NV centre. This, in turn, enables the development of atomic-scale magnetometers with very high sensitivity for various applications.

“One of these applications is a wide field magnetic imager for monitoring electronic circuits. This is a new tool that is very convenient to use since it works at room temperature and in

“A total of four start-ups have also been launched by project partners: NVision, SQUTEC, QNAMI and QZABRE.”

ambient atmospheric conditions,” says Thierry Debuisschert, coordinator of DIADEMS for Thales Research & Technology.

“Other applications include: the experimental characterisation of read/write heads for high density hard disks to increase their capacity; nuclear magnetic resonance (NMR) boasting higher sensitivity, lower cost and a reduced magnetic field in MRI machines; new photonic devices increasing the detection efficiency of NV fluorescence; a spectrum analyser for the GHz range and the characterisation of domains in antiferromagnetic materials.”

With all that potential, it's no surprise to see side-projects sprouting across Europe. Project partner Attocube Systems, for instance, is currently developing a combination of an atomic force and a confocal microscope using a single NV centre as a sensor, for commercial use. Element 6, another project partner, has already enriched its portfolio with advanced materials based on NV centres. “A total of four start-ups have also been launched by project partners: NVision, SQUTEC, QNAMI and QZABRE,” explains Debuisschert.

“We have been very active since the end of the project,” he adds. “We aim for higher bandwidth, sensitivity and resolution, and we are also investigating new applications such as

the characterisation of microwave antennas or high sensitivity sensors based on diamond optical resonators.”

The consortium has also submitted a new proposal for further funding under Horizon 2020, which is currently under evaluation. Its objective would be threefold: developing advanced applications based on magnetic field measurement for the likes of electrical cars, early diagnosis of disease, biology, robotics, and wireless communications management. It would also aim to create new sensing applications to sense temperature within a cell, monitor new states of matter under high pressure and sense electric fields with ultimate sensitivity. Finally it could create new measurement tools to elucidate both the chemical structure of single molecules by NMR for the pharmaceutical industry as well as the structure of spintronic devices at the nanoscale.

“The new project would develop the necessary tools to achieve these goals: highest grade diamond material with ultralow impurity level; advanced protocols to overcome residual noise in sensing schemes; and optimised engineering for miniaturised and efficient devices,” Debuisschert points out. He hopes that these applications will emerge within the timeframe of the EU's FET flagship on quantum technologies.

DIADEMS

- Coordinated by Thales in France.
- Funded under FP7-ICT.
- cordis.europa.eu/project/rcn/110047
- Project website: diadems.eu

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40-year-old data keeps shedding light on the Moon's seismology

The 12 men who set foot on the Moon between 1969 and 1972 have left more than a few flags and symbolic artefacts behind. They also deployed five seismometers over the moon's surface that kept working until they were switched off in 1977. Forty years later, their measures still hold value for future space exploration.

Ever heard of moonquakes? The scientific community probably wouldn't have either if it wasn't for the Apollo seismometers. And this scientific value didn't simply disappear in 1977. In 2011, scientists obtained invaluable information on the moon's core by applying modern computing technology to Apollo seismometer data. Three years later, the same data helped physicists find out how to detect gravitational waves – small distortions of space-time that Einstein had predicted in 1916 but that no one could observe before.

As Prof. Heiner Igel from Ludwig-Maximilians-University puts it, “the fact that Apollo seismometers were first deployed nearly half a century ago and that we are still using their data is testament to the fact that engineers at the time nearly got everything right.”

Of course – as should be expected from any 40-year-old piece of tech – Apollo seismometers were far from perfect. Their bandwidth limitations and inconstant sampling interval, for example, would make them useless in current or future space missions. A better understanding of these limitations is crucial if we are to ever return to the Moon or go to Mars, as it would help push the limits of what can be learned from Apollo seismometer data.

This was precisely the point of the SeisMo (SEismology of the MOon) project led by Prof. Igel. As working with such old data is quite unusual for seismologists, the project aimed to clear the way by using ambient noise tomography to provide a more accurate model of the lunar crust and mantle. The project applied recent advances in the full waveform modelling of scattering at planetary scale



to the lunar crust, and explored entirely new routes for planetary seismology.

“As on Earth, seismology can tell us a great deal about the interior of a planet or moon,” Prof. Igel explains. “The Moon has been bombarded by meteorites over its entire history. Unlike Earth, it does not have processes such as rain or weathering to repair surface damage, so it remains strongly fractured. If we want future missions to be successful, we need as much information as possible about how seismic waves propagate on the Moon.”

Getting such information wasn’t an easy task. The seismic data recovered from the Apollo seismometers was initially recorded on digital magnetic tapes with timestamps representing the time of signal reception on Earth. It was later transferred to SEED (Standard for the Exchange of Earthquake Data) format, but Prof. Igel’s team discovered during the project that there were some timing-related problems with the original SEED files.

“We re-imported the medium-period data to SEED format, and made these data available via IRIS (Incorporated Research Institutions for Seismology). There are many gaps within the data caused by loss of signal or instrument problems, so we reconstructed the signal to be read in as a continuous record, with gaps within the seismic trace where necessary. The new files will be a valuable resource for analysing the structure of the Moon,” Prof. Igel explains.

Since the project ended in January 2018, Prof. Igel has been busy using Apollo data for two new projects and

“ We have re-imported the medium-period data to SEED format, and made these data available via IRIS. ”

already has more in the pipeline. “We are using the modelling tool Salvus, recently developed by ETH, Zurich, to model strongly scattering surfaces. By creating different possible models of the Moon’s surface, we are learning more about the structure of the Moon. We generate seismograms from our models and compare them with the Apollo data,” he says.

Another side project consists in looking at deep moonquakes, which occur at depths of around 800 km below the surface of the Moon. Prof. Igel is investigating how strongly clustered these quakes are, by comparing several minutes of the seismograms from each event.

SEISMO

- Coordinated by LMU Munich in Germany.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/rcn/195845
- Project website: cerinunn.com/seismo

SPACE

Space Internet of Things takes off

We know that current networks are not equipped to deal with the Internet of Things (IoT) and the exponential growth in connected devices it entails. Whilst Low Power Wide Area (LPWA) technologies will be crucial to cope with future needs, experts increasingly look towards satellites as a complementary solution, especially for scarcely populated areas. The IoTEE project is proposing a receiver/emitter device to make space-based IoT a reality.

Although the project was kicked off in 2017, IoTEE’s (Internet of Things Everywhere on Earth: a satellite based M2M solution) story goes all the way back to 2014 with the early development of TELDASAT – a low cost M2M

communication service using existing space-based infrastructure to provide IoT communications. The point of this ESA-funded project? Coming first on a market set to have a total of 2 billion LPWA device units by 2022.



At the time, opting for terrestrial LPWA – a wireless technology specifically designed to enable low cost and long battery life, large coverage and high capacity for IoT applications – was a no brainer, especially when comparing it to big satellites positioned in high orbits. But things have been changing recently.

“Unlicensed technologies like Sigfox or Lora, or licensed ones like LTE-M or NB IoT were largely preferred over large, expensive satellites,” explains Philippe Moretto, CMO of SAT4M2M. “But thanks to an accelerated pace of innovation and dramatically dropping costs in the space sector thanks to the likes of small satellites of less than 50 kg, space-based IoT can now seriously be considered as a cost-effective alternative.”

This is particularly true if you look outside future smart cities. As much as terrestrial technologies can be cost-efficient on the device front, setting up the network is expensive to the point where it can only make sense financially in the most densely populated areas. As Moretto points out, terrestrial networks currently cover about 2 % of the Earth’s surface, so bringing IoT to everyone – a key ambition in the EU’s digitalisation programme – would require closer integration between terrestrial and space technologies.

Since its creation, SAT4M2M has been building upon TELDASAT to develop the space segment of IoT, and the IoTee project is an integrant part of this plan. Using the International Space Station (ISS) as a testbed for the first-ever LPWA satellite, it focuses on the development of a

multi connectivity chip implementing a new communication protocol on the same frequency bands as Sigfox and Lora.

“Space LPWA is a complement to terrestrial LPWA. It’s the realisation of a truly global coverage, a network able to send several IoT messages per day using the ISS only. It is capable of managing simultaneously a high number of connections, and benefits from its small size, low cost and long autonomy – over 10 years. All that has been achieved through several years of R&D expenses and patents,” Moretto explains.

Space IoT is now considered as a ‘blue ocean’ market opportunity by investors and the space industry alike. SAT4M2M intends to serve 1 million units, and the company has received support from ESA and NASA. Although the project won’t end until January 2019, Moretto emphasizes how “the first results have already confirmed our early expectations and even surpassed them.” Whilst a launch date has yet to be announced by Airbus and Space X, he says that his company’s focus is on delivering good preliminary services as soon as possible in partnership with FUJITSU Electronics.

IOTEE

- Coordinated by SAT4M2M in Germany.
- Funded under H2020-LEIT-SPACE & H2020-SME.
- cordis.europa.eu/project/rcn/207924
- Project website: iot-everywhere.eu
- ▶ bit.ly/2BAZ7dl



LIFE AFTER...

Catching up with LARA: A second, better quality prototype to take on the market

The LARA project was set up in 2015 to develop a mobile device which, by combining technologies such as GNSS, Augmented Reality, GIS and geodatabases, could enable utility workers to visualise underground infrastructure related to supplies of water, gas, electricity, etc. This 'x-ray' type view would enable workers to be more precise in their tasks, bringing down overall costs, maintenance time and disruption to traffic.



Mr Konstantinos Smagas
Project deputy coordinator
of LARA
© Konstantinos Smagas

“We want to make sure that when we do launch, our product will truly get a great reception by the market.”

After testing the first prototype in the Greek city of Kozani, Mr Konstantinos Smagas, project deputy coordinator of LARA (LBS Augmented Reality Assistive System for Utilities Infrastructure Management through Galileo and EGNOS), in a Research*eu Magazine interview last year, anticipated market entry for their product by the end of 2017 – so what has happened since?

Mr Smagas continues the story: “Towards the end of last year we already had two clients from France and the UK ready to adopt our technology,

but despite the product itself being market ready, we realised that we did not have complementary services such as product support and distribution channels fully in place.”

The decision was then taken to delay the launch and use the time to make system improvements. As Mr Smagas elaborates, “Since the project’s end, we have been improving accuracy and usability for the end user, especially in relation to the software.”

Giving an example of hardware improvements, Mr Smagas cites the system sensors which

had been selected over two years ago, and so were now also eligible for an upgrade with the latest iterations.

With these improvements, the team is now considering making a second, better quality prototype. “Even though all our testing and prototype performances have been successful, and we have been market ready with good feedback from clients, we still believe that there is room for improvement,” Mr Smagas adds. “We want to make sure that when we do launch, our product will truly get a great reception by the market.”

Indeed, the LARA team’s attention to detail has so far paid off, winning them the European Satellite Navigation Competition, ESNC 2017 Award for the Madrid Challenge, in November 2017.

At the time of writing, the team were planning to launch a full demo of the system at

the premises of an interested party in the UK.

LARA

- Coordinated by Geolmaging Ltd in Cyprus.
- Funded under H2020-LEIT-SPACE.
- cordis.europa.eu/project/rcn/193818
- Project website: lara-project.eu
- bit.ly/2MNaRcS





Coupling models describe the kinetic processes in plasma

EU-funded scientists developed novel methods to describe the plasma state of matter and gases far from thermodynamic equilibrium using the kinetic theory of gases and the hydrodynamics of fluids.

Particle transport in plasmas or rarefied gases can be predicted by kinetic or hydrodynamic models. The former is based, amongst others, on Boltzmann kinetic equations that can be solved using either statistical particle methods and Monte Carlo simulations or a numerical solution of the kinetic equations employing discrete velocity methods. Fluid models, which apply for particles that are at thermodynamic equilibrium, can be derived from the kinetic equations, and describe the system on a macroscopic level.

Within the EU-funded HNSKMAP (High-order Numerical Schemes for Kinetic Models with Applications in Plasma Physics) project, scientists worked on hybrid kinetic-fluid models, combining the accuracy of kinetic solvers with the efficiency of fluid models.

DERIVING THE BEST OF BOTH WORLDS

The kinetic description is the most fundamental way to model plasmas and rarefied gases. In such models that access even the electron scale, each particle is described by a distribution function f in six dimensions. This function

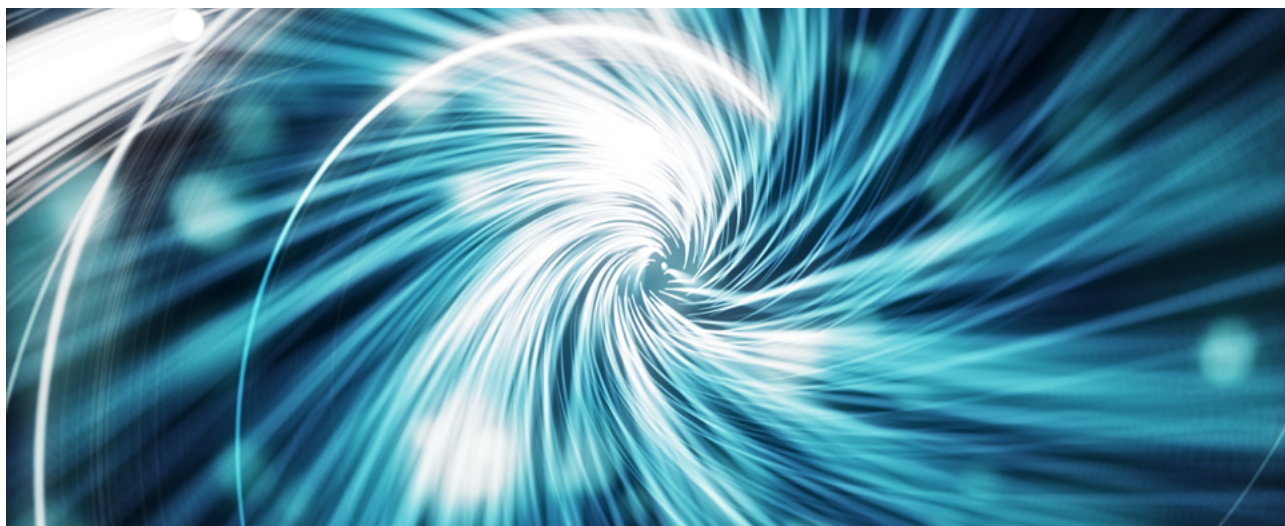
represents all there is to know about the plasma state: in other words, f represents the number of particles per unit volume having a given velocity at a certain time.

The fluid description refers to any simplified plasma model that deals with quantities averaged over velocity space, hence, with macroscopic quantities.

Fluid equations may be easier to solve but they have a limited range of applicability. "Unlike fluid models, the kinetic equation describes the thermodynamics of non-equilibrium processes, namely of particle systems whose distribution function is very different from the Maxwell-Boltzmann probability distribution," explains Prof. Francis Filbet.

As he further explains, "Compared to the fluid models, the distribution function provides more information about the particles such as their velocity distribution."

HNSKMAP's research was geared towards the use of hybrid kinetic-fluid methods, significantly narrowing down the use of kinetic descriptions only to desired



space regions. "A hybrid approach allows the modelling of complex thermo-fluid phenomena at the micro scale, circumventing the use of kinetic calculations that are computationally demanding, and have therefore a prohibitive cost," explains Prof. Filbet.

The newly developed hybrid method has simple indicators that allow determination of a coupling space region where the kinetic and macroscopic models are connected. "The selection of the coupling space region is key to the development of a robust hybrid method," notes Prof. Filbet.

Thanks to the coupling techniques of the computational algorithms for solving the kinetic equations with the macroscopic numerical methods for the Euler (fluid) equations, the proposed hybrid scheme degenerates to a finite set of quantities at discrete points spaced into a so-called grid or mesh. To characterise the space region with a finite set of functions, scientists developed a proper discontinuous Galerkin method that ultimately aided the analysis of continuous models and their hydrodynamic limits. "Our research concentrated on developing numerical analysis methods using a phase-space grid as opposed to particle methods. Rigorous mathematical analysis is essential to

optimise the number of mesh points and develop efficient algorithms," notes Prof. Filbet.

Another project highlight was the design of an asymptotic model for studying how Kelvin-Helmholtz instabilities generate vortices that propagate along magnetised plasma. Numerical simulations illustrated how an initial current perturbation causes these instabilities.

HNSKMAP focused on the fundamental computational challenges that arise when simulating plasmas of high-energy density or rarefied gas dynamics. Suitable for high-performance computing, the newly developed numerical methods help model differential equations that scale with the size of particle systems.

HNSKMAP

- Coordinated by Paul Sabatier University Toulouse III in France.
- Funded under H2020-MSCA-IF.
- cordis.europa.eu/project/rcn/194946
- Project website: math.univ-toulouse.fr/~ffilbet/HNSKMAP/hnskmap.htm

FUNDAMENTAL RESEARCH

Physicists use waveguides to boost the practical potential of Terahertz spectroscopy

Terahertz or THz radiation has the potential to seed transversal innovations in medicine, biology, material science and telecommunications, but its deployment is still held back by practical and technological constraints. The THEIA project has developed a specific flavour of THz spectroscopy that can operate inside waveguides.

The future deployment of compact THz spectroscopy systems has come one step closer thanks to the EU-funded THEIA (Route to guided TeraHertz backscattering Inspection and Analysis) project. The team has developed a system that can operate with waves confined in waveguides. The key is the ability to generate and process THz waves

directly inside the waveguide, which has been developed as part of the THEIA project.

Terahertz radiation, which sits on the electromagnetic spectrum between optical and microwaves, has unique properties. "Many complex materials of interest possess

“What we are trying to do is to shrink the apparatus required for THz spectroscopy for use in different engineering fields or for medical apps; in future, you might have a pen you could use to touch the skin to diagnose a pathology. Or you might be able to attach a small probe to a wall to diagnose its integrity.”

unique spectral ‘fingerprints’ in the THz spectrum. This means THz radiation can be used to recognise very complex compounds like polymers, amino acid, proteins, drugs or explosives,” says Professor Marco Peccianti, THEIA’s main researcher and professor of photonics at the UK’s Sussex University.

Cloth, textiles and many forms of packaging are transparent to THz which can serve a similar security purpose to X-rays. Unlike X-rays however, THz radiation is non-ionising and generally harmless to human health.

Although knowledge of the potential of THz waves has been around for a while, THz only became a realistic option for scientists with the advent of advanced laser technology, such as ultrafast lasers, in the 1980s. Over the past 30 years, THz waves have unlocked new ways to probe the natural world.

PLACING THZ INSIDE THE PIPE

THEIA has explored how to integrate waveguides into THz spectrometers. “Normally you generate a THz wave then you couple it in a waveguide using a lens or other optical components. THEIA has explored the alternative approach of generating the THz wave inside the waveguide and performing many of the functions of a normal spectrometer directly inside it,” says Prof. Peccianti. This not only delivers a THz signal where needed, but also serves to remove many bulky elements. “Potentially this would enable the technique to be used in ways that would previously have been impossible,” he says.

THEIA has developed various strategies towards this goal, including a new design, known as a two-wire THz transmitter, which consists of a two-wire waveguide electrically coupled to a THz photo-conducting antenna.

SMALLER, MORE EFFICIENT DEVICES

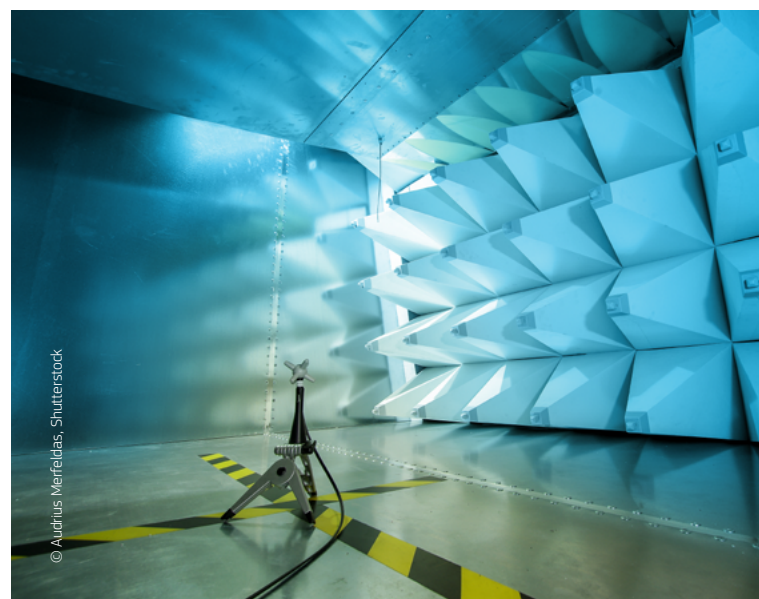
Terahertz technology is still in its infancy compared to fields such as microwave or optics. Only a few companies currently commercialise applications for real-world use and their solutions tend to be very bulky. The THEIA team aims to improve efficiency and enable smaller devices in future.

“What we are trying to do is to shrink the apparatus required for THz spectroscopy for use in different engineering fields or for medical apps; in future, you might have a pen you could use to touch the skin to diagnose a pathology. Or you might be able to attach a small probe to a wall to diagnose its integrity,” says Prof. Peccianti.

Funding from THEIA also contributed to establishing the Emergent Photonics Lab Prof. Peccianti co-founded with fellow scientist Alessia Pasquazi in early 2015. “The lab is a community of about 15 researchers, which is already a terrific result. Before THEIA, Photonics didn’t exist at Sussex,” says Prof. Peccianti. His team is now looking to harness the capacity of THz to accurately identify complex objects by building a THz microscope under the ongoing EU-funded project TIMING.

THEIA

- Coordinated by the University of Sussex in the United Kingdom.
- Funded under FP7-PEOPLE.
- cordis.europa.eu/project/rcn/186774
- Project website: theia.scienceontheweb.net





AGENDA

November 2018

BARCELONA, SPAIN

International Conference on Marine Data and Information Systems

IMDIS 2018

→ imdis.seadatanet.org

05→07
NOV

08→09
NOV

RIMINI, ITALY

Third European Nutrient Event
@ ECOMONDO

→ smart-plant.eu/index.php/europeannutrientevent3

WORLDWIDE

World Science Day for Peace and Development

→ en.unesco.org/commemorations/world-science-day

10
NOV

14→15
NOV

NANTES, FRANCE

Fifth FoodIntegrity Conference

→ foodintegrity2018-nantes.eu

BERLIN, GERMANY

Horizon 2020 Space International Information Day and Brokerage Event

COSMOS2020

→ h2020-berlin-space-info-day.b2match.io/

14→15
NOV

20→22
NOV

STRASBOURG, FRANCE

Fourth ASTERICS Virtual Observatory School

→ asterics2020.eu/event/fourth-asterics-virtual-observatory-school

COMING
EVENTS

[cordis.europa.eu/
events](http://cordis.europa.eu/events)

21
NOV

VIENNA, AUSTRIA

#InheritYourFuture Forum 2018

This forum will foster an exchange on promising practices that adapt how we live, move and consume for more sustainable lifestyles and better health. It is a pre-event to the Austrian EU Presidency conference on 'People's food – people's health: Towards healthy and sustainable European Food Systems.'

→ inherit.eu/inherit-your-future-forum-2018

Expanding the Horizon for EU Research and Innovation

The European Commission has now published its proposal for **Horizon Europe**, an ambitious EUR 100 billion research and innovation programme that will succeed Horizon 2020.

Building on the multi-disciplinary achievements and success of the EU's current and past programmes, Horizon Europe will boost Europe's scientific excellence, increase investment in highly skilled people and cutting-edge research, foster industrial competitiveness, strengthen innovation performance and tackle global challenges that affect the quality of our daily lives.

New features of Horizon Europe include the European Innovation Council, EU-wide missions involving citizens, reinforcing openness, streamlining European Partnerships and simplified rules.

Find out more at ec.europa.eu/horizon-europe

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