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SPECIAL FEATURE

THE DAWN OF THE GRAPHENE AGE



AGRICULTURE AND FORESTRY

NOVEL METHODS AND PRODUCTS FOR BETTER GLOBAL MONITORING OF AGRICULTURE

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TAKING ADDITIVE MANUFACTURING INTO THE SPACE AGE

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EDITORIAL

by the editorial team

THE HYBRID PATH TO GRAPHENE INNOVATION

Graphene has been presented as a miracle material since it was first isolated by researchers of the University of Manchester in 2004. From making our computers 1 000 times faster to enabling bionic devices, cleaning up radioactive waste or desalinating water in seconds, there seemed to be no limit to what we could possibly do with this one atom-thick crystal.

Yet, almost 15 years later, the truth is that graphene still has to fully deliver on its promise. The main problem used to lie in cost and mass scale production, although research efforts have enabled a significant price drop and scale-up of production capacities over the past few years. Whilst this remains an issue, stakeholders are now pointing at the lack of standardisation as the main obstacle on the path to commercial products.

'When combined with composites or plastics, for instance, graphene does wonders in terms of overall material strength or thermal conductivity.'

In Europe, it is hoped the Graphene Flagship will solve these problems. The EU's largest research initiative, the Graphene Flagship, has a EUR 1 billion budget and a network of over 150 academic and industrial research groups. Now approaching its so-called 'core 2' phase, the project has led to the submission of 37 patent applications and the launch of 17 products onto the market

over the past year. These include Airbus winglets made of graphene composites, a motorcycle helmet with graphene coating, a new viscoelastic graphene-polymer sensor, amongst others.

The common trait between all these innovations? The sidelining of what we could call the 'pure graphene' path, in favour of its combination with other materials to enhance existing products. When combined with composites or plastics, for instance, graphene does wonders in terms of overall material strength or thermal conductivity.

This month's issue of the research*eu Results Magazine puts the spotlight on some of the latest projects exploiting this potential. From smart textiles to graphene-reinforced polymers, health monitoring wearables and position sensors, our special feature section showcases how graphene can cast a wide net across multiple industrial sectors.

This section is followed by the usual thematic ones on health, society, transport, environment, agriculture and forestry, industry, information and communication technology, space and fundamental research.

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

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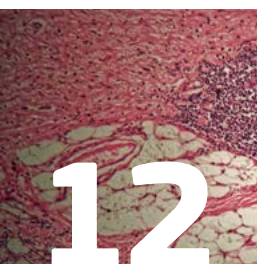


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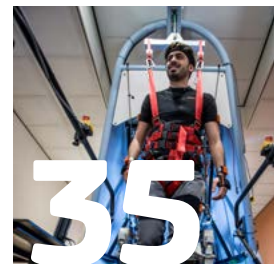
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SPECIAL FEATURE
THE DAWN OF THE GRAPHENE AGE

GRAPHENE-REINFORCED POLYMERS READY FOR COMMERCIALISATION

A four-year development process has led to the identification of the most suitable materials and production techniques for graphene-based coatings, adhesives and composites. Once the graphene market reaches maturity, these new products could appeal to a vast range of industries.

To this day, graphene remains expensive enough to discourage its large-scale incorporation into commercial products. But this hasn't been preventing researchers across Europe from moving forward with the development of materials and production techniques that can pique industry interest as larger batches of graphene become available at a lower cost.

The POLYGRAPH (Up-Scaled Production of Graphene Reinforced Thermosetting Polymers for Composite, Coating and Adhesive Applications) project features among these pioneering ventures. By bringing together 14 partners, including SMEs, companies, universities and a research centre, the project aimed to deliver industrial-scale quantities of graphene-reinforced thermosetting polymers.

"We tried to look at different ways to improve the thermo-mechanical and electrical properties of coatings, additives and composites," explains Maria Konstantakopoulou, Development Engineer at project coordinating company Coventive Composites. Once the target performances were defined, the team picked suitable polymers, outlined a range of graphite and graphene grades, and identified suitable exfoliation and dispersion techniques that would eventually allow them to scale up production whilst ensuring that graphene remained well-distributed in the final product.

As Ben Hargreaves, coordinator of POLYGRAPH, explains, the idea was to produce "on a scale that would be viable for other companies, enabling them to consider integrating our solution in their current or future products." Large-scale conversion of composite materials indeed remains an

obstacle to market adoption. Once project partners became able to produce as much as 100 kg of graphite and 25 kg of graphene per batch, it opened new horizons.

Many different composite materials were produced by the project consortium, and were then evaluated for their electrical conductivity and mechanical properties. The most promising coatings, adhesives and composites were used in demonstrator parts, respectively an aerospace structural element, a coated aerospace radome/fairing element, and a rear seat back panel for automobiles. Benefits include better structural behaviour, weight reduction, aesthetics, electrical properties and fire retardation.

"One of the main advantages of the graphene-reinforced composites resulting from this research and development process lies in their electrical properties, making them suitable for EMI shielding or for the de-icing of wind turbines," Konstantakopoulou points out.

Waiting for the right opportunity

Gary Foster, who acted as project manager on POLYGRAPH, says that commercial perspectives vary strongly for each of the three materials. "On the coating side, project partner HMG Paints can pretty much go straight to production because what we developed is not too far away from the products that they currently sell. Adhesives, on the other hand, are a bit more price-sensitive. It doesn't mean our partners won't be using those materials, but they just wait for the right moment in time where people will want that product."



The third product, a pre-impregnated composite fibre or pre-preg, was particularly important for Coventive Composites, as Hargreaves highlights: “Pre-preg development wasn’t originally programmed into the project as heavily as what we ultimately ended up doing. We also looked at other production techniques like infusion, but early work made it clear that pre-preg was going to be the optimum technique.” Both he and Foster agree that the company should now focus on finding the right niche market for this composite, and that future efforts should focus on finding out what potential customers need and how the product can be refined to meet their expectations.

Until then, the team will be looking at the evolution of graphene. “There is a need for a certain level of generalisation,” Foster explains. “For example, if we want to use our product in the aerospace sector, customers will need

certain fundamental data from graphene producers that currently they are not able to provide. These are obstacles that we cannot overcome on our end.”

With this in mind, the POLYGRAPH consortium has been working closely with the Graphene flagship, creating a link between academics and industry so that the former’s research better matches the needs of the latter. Eventually, this would allow Coventive Composites to bring to market innovative solutions for the likes of EMI shields or the de-icing of wind turbine blades.

POLYGRAPH

- ★ Coordinated by Coventive Composites in the United Kingdom.
- ★ Funded under FP7-NMP.
- ★ <https://cordis.europa.eu/project/rcn/110823>

SEAMLESS ELECTRONICS GIVE SMART TEXTILES A PUSH

We’ve been hearing about smart textiles for a while, but they have yet to make their debut in mainstream markets. The E-TEX consortium was built around the conviction that this lukewarm public reception was due to the absence of seamless solutions. They plan to solve that problem with graphene-based electronic devices built directly into fabrics.



fabrics, automotive textiles, medical appliances, and much more.

Currently, however, the growth of the smart textile market is hindered by the use of rigid devices or flexible ones with poor performance. As Prof. Craciun puts it, “all these technologies are based on components glued onto fabric, which defies the ambition for a mechanically flexible and low-weight technology needed to preserve the properties of the textiles we are used to and want to wear.”

The solution could arise from groundbreaking advances in atomically thin materials, and more specifically graphene. Its flexibility, high electrical conductivity, optical transparency, thermal stability and ease of processing into different structures indeed make it an excellent candidate for a new generation of smart textiles.

“We have embarked on exploring the uncharted territory of woven smart textiles made of intertwined graphene-enabled electronic fibres,” Prof. Craciun explains. “We decided to focus on two types of electronic fibres: capacitive touch-sensors and light-emitting devices. With our solutions, an information display could be used on clothes to change their colour for security alerts, or medicine alerts to provide assistance to children or senior people. More complex displays combined with communication technology could lead to textile GPS,

phones and monitors that show and govern the usage of drug implants. We can even think of applications in the fields of security and energy harvesting.”

To allow for compliant and robust contact between the devices and the textiles, the former must bend and stretch to accommodate strains. With its atom-thick carbon layer, graphene fits the bill, and its biocompatibility further facilitates its application to smart textiles.

Graphene fused with PP fibres

Although not yet completed, E-TEX has successfully developed electronic fibres with functional devices based on graphene, directly fabricated on polypropylene (PP) textile fibres. PP fibres are ubiquitous in textile for applications ranging from healthcare, security and defence to daily life clothing and fabric. This is due to their lightness, low thermal conductivity and high stain resistance, and also to how they exhibit extreme mechanical flexibility at low temperature and resistance to bacteria. All this, whilst being recyclable and ecologically friendly.

To maintain PP fibres’ characteristics, the team came up with a method to make insulating PP fibres conductive, by coating them with atomically-thin graphene, as well as a non-invasive manufacturing process for the fabrication of electronic functions on PP fibres that’s compatible with industrial

“Electronics seamlessly integrated into fabrics represent the ultimate form of smart textiles.” It is this belief that led Monica Craciun, Professor of Nanoscience and Nanotechnology at the University of Exeter, to kick start the E-TEX (All-organic devices in textiles for wearable electronics) project in 2016. According to her, market success requires soft, safe, stylish, comfortable and colourful fabrics that discreetly and unobtrusively include a whole host of additional functionalities. Such a ‘smart’ offering could easily find a prominent place in markets like clothing, home



processes. “We have achieved graphene electronic fibres with touch-sensing and light-emitting functionalities. By creating woven arrays from such fibres, we could demonstrate pixels with different sizes that can be integrated in future textile displays and devices for position sensitive measurements,” Prof. Craciun enthuses.

This breakthrough has already piqued the interest of industry. CenTexBel, the scientific and technical centre for the Belgian textile industry, sees “potential for a disruptive technology with a wide array of potential new applications.”

Until then, the team will aim to demonstrate other types of electronics integrated in textiles, notably small

and discrete audio earphones and microphones using graphene electronics to generate sound waves.

E-TEX

- ★ Coordinated by the University of Exeter in the United Kingdom.
- ★ Funded under H2020-MSCA-IF.
- ★ <https://cordis.europa.eu/project/rcn/203315>

GRAPHENE-BASED NANOCOMPOSITES FOR 3D-PRINTED ELECTRONIC DEVICES

A novel combination of layered graphene and thermoplastics could soon bring the potential for 3D printing to market applications requiring conductive materials.

Rapid prototyping is well-known for its convenience and cost-effectiveness. With a 3D printer, businesses can reduce the design-to-product timing, saving significant amounts of money in the process. But whilst the technique itself is well-oiled, materials still present room for improvement.

“Currently, 3D printing technology can be classified depending on the material used for printing prototypes.

“The new composites already present better mechanical strength and thermal resistance than polymers without graphene loading.”

Thermoplastics like ABS or PLA are amongst the most used materials: They can easily be moulded, are very cost-effective, and the former property makes them the material of choice for additive manufactur-

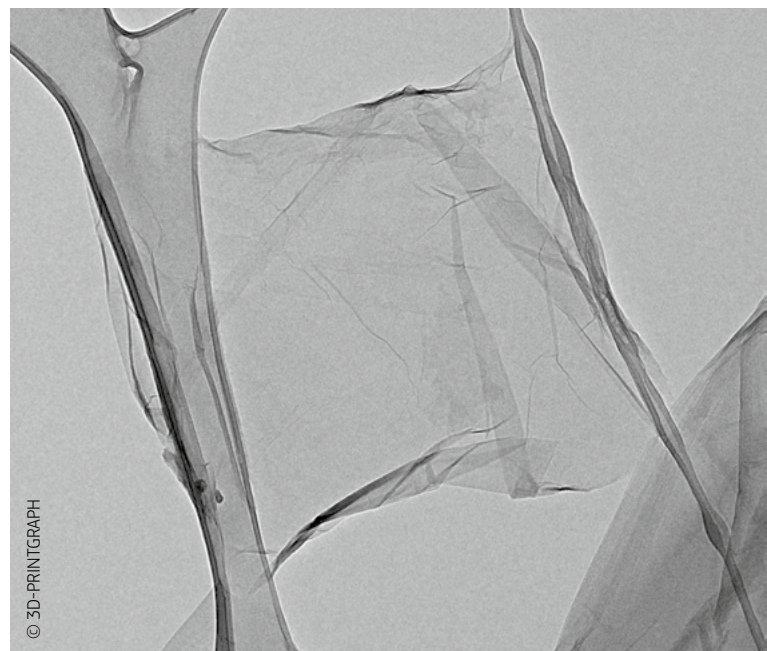
ing,” says Dr Maria Soria, Researcher in solid state chemistry at the Institute of Material Science of Barcelona (ICMAB).

But easy moulding is not only a quality. In fact, it can quickly become a disadvantage, since the material’s resistance depends on a temperature gradient (a physical quantity that describes in which direction and at what rate the temperature changes the most rapidly around a particular location): Thermoplastics quickly become unusable when printing prototypes that require special thermal resistance. Furthermore, they have no conductivity, which also limits their use.

With this in mind, it seems only natural that researchers would look for new materials with better structural and conductive properties. Graphene, with its high conductivity, its mechanical strength and its hierarchical pore structures and porous channels, is an ideal candidate.

“The idea would be to use graphene or its derivate whilst maintaining the associated advantages of thermoplastics, such as the ability to be moulded. We believe that using graphene-enhanced nanocomposite materials in 3D printing could have a disruptive impact on the market,” Dr Soria explains.

Thanks to funding under the 3D-PRINTGRAPH (Graphene reinforce composites for 3D printing technology) project, Dr Soria has embarked on a two-year venture to ‘merge’ layered graphene with the lowest melting point polymers for use in future 3D-printing. If successful, the project could open the door to the fabrication of electronic devices like batteries, sensors and radiofrequency antennas.



© 3D-PRINTGRAPH

“We’ve already carried out the synthesis and characterisation of PLA, ABS, PCL and PCL-Diol composites with graphene, which first required graphene synthesis. We used graphite as a precursor and, by means of its oxidation and subsequent chemical reduction, we obtained a Reduced graphene oxide (RGO) with similar properties to graphene. From there on, we synthesised the composites with a load of 4% in graphene, obtaining materials with apparent homogeneity in all cases,” Dr Soria explains.

Although the project won’t be completed until the end of August, the new composites already present better mechanical strength and thermal resistance than polymers without graphene loading. But 4% graphene – the maximum amount that allows for maintaining suitable viscoelasticity and adhesion in the end material – is not enough to provide conductivity, the researchers found.

“We now have to explore new ways to homogenise the polymer-graphene mixture, or even to increase the amount of graphene in the mixture to ensure there is contact between the graphene layers and to facilitate the conductivity,” says Dr Soria.

Besides this work, which is central to the project, Dr Soria and her team have been developing nanocomposites based on

photo curable polymers and graphene, to ensure that the milestones of the project can be maintained and to improve the general effectiveness in the research. As she points out, this adds to the groundbreaking nature of the project.

Should everything go according to plan, the consortium plans to partner with Hewlett-Packard in Barcelona to test

the developed graphene nanocomposites on their 3D printers.

3D-PRINTGRAPH

- ★ Coordinated by CSIC in Spain.
- ★ Funded under H2020-MSCA-IF.
- ★ <https://cordis.europa.eu/project/rcn/202418>

GRAPHENE QUANTUM DOT DETECTORS FOR NEXT-GENERATION HEALTH MONITORING WEARABLES

Bulky health monitoring systems could soon become a thing of the past thanks to new devices developed under the GRAPHEALTH project. In fact, these devices could help shape future flexible electronics and smart wearable markets.

Health monitoring, especially during exercise, was one of the very first applications allowing smart wearables to graduate from a nice technological concept to actual, marketable products. However, extended health monitoring to detect all kinds of health markers quickly tends to become bulky. This means that, up until now, engineers have had to find the best compromise between functionality and comfort: Only a limited number of components could be integrated, making the whole system much less appealing than it could be.

A solution, according Dr Frank Koppens from the Spanish Institute of Photonic Sciences (ICFO), would lie in the inherent properties of Graphene quantum dot (GQD) detectors – photodetectors with characteristics derived from graphene and semi-conducting quantum dots. GQD detectors would indeed enable a flexible, compact and wearable system for constant monitoring of consumer health and muscle health of athletes during exercise or after injury.

“Our photodetector is very sensitive to light for a very broad wavelength range, from 300 to 2200 nm. And most importantly, it is flexible,” Dr Koppens explains. “This is made possible by the fact that the detector can be placed on basically any flexible substrate. It’s just a few hundred nanometres thick, so it’s excellent for integration into wearable sensors.”

The use of graphene is key here, as it provides for an ultra-thin conductor with very high conductivity properties, notably electronic mobility. Furthermore, graphene can easily be transferred to flexible substrates and can cover relatively large areas.

“It works as follows,” Dr Koppens explains. “Light, be it from an LED device or from the environment, enters the skin, after which it interacts with

the tissue and blood vessels. There, it is partially absorbed, but also partially bounces off the skin, in which case it can be picked up by the detector. Now, if the blood veins expand and contract due to heartbeat, the photodetection signal will modulate as well. In other words, the heartbeat is directly visible from the photodetection signal.”

This is, of course, just an example. The technology, which was developed under the GRAPHEALTH (Hybrid quantum dot and graphene wearable sensor for systemic hemodynamics and hydration monitoring) project, has demonstrated its capacity to be used for the likes of oxygen monitoring as well. Other important health markers will also soon be detectable. The GRAPHEALTH photodetector is compatible with current flexible electronic manufacturing processes, which means no major investment costs should be expected by industry.

“We have made several prototype wearable devices – including one for the wrist and a patch that is more like a thin sticker – and we have shown that these can be produced with

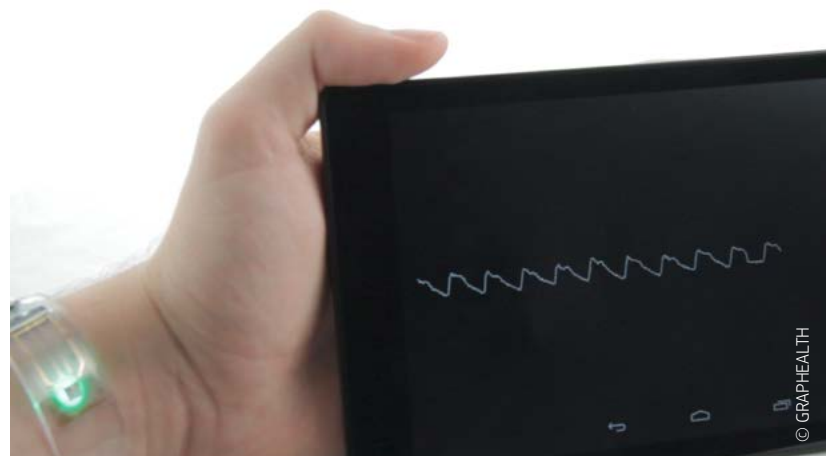
scalable large-area graphene,” Dr Koppens says with enthusiasm.

Now that the project has come to an end, Dr Koppens and his team intend to make the GRAPHEALTH system more versatile by integrating more health markers. They also want to develop a completely integrated health patch, which would include not only the patch itself but also the electronics, wireless power transfer and wireless data transfer.

“It’s difficult to make any predictions regarding potential commercialisation, as flexible electronics and wearables are very young markets. We can create a very large range of different wearables, and integration into existing wearables, such as combining with a smart watch, can also be considered. The challenge now is to make wise choices on which application to focus exactly,” Dr Koppens concludes.

GRAPHEALTH

- ★ Hosted by ICFO in Spain.
- ★ Funded under H2020-ERC.
- ★ <https://cordis.europa.eu/project/rcn/207370>





INTERVIEW

GRAPHENE-ENHANCED POSITION SENSORS SOLVE ALL INDUSTRY PROBLEMS AT ONCE

Position sensors in the automotive sector represent a market of almost USD 4 billion. Graphene-enhanced ink formulations developed under the GRAPHENESENS project could soon cut their production cost by 45 % whilst increasing their lifetime.



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Does the very high production cost of graphene mean that its potential cannot translate into actual benefits for commercial applications? Looking at a project such as GRAPHENESENS (Development of Graphene based Contact Position Sensors), we would be tempted to say no.

By using graphene-based nanocomposite coatings for the development of novel position sensors, the project has actually managed to overcome the three main disadvantages of current solutions: poor wear characteristics leading to long-term unreliability; limited accuracy because of surface roughness leading to noise; and high cost due to the use of precious metals to manufacture the sensor's wiper.

All in all, the project has successfully created a new potentiometer unit with screen printed resistive tracks using graphene-based inks, a wiper head unit combining a low-cost substrate with a graphene-based coating, and a 48-pulse encoder base unit using notably a graphene-based barrier coating. The automotive and motorcycle markets are targeted, and prestigious brands are already queuing up.

Pufinji Obene, Operations Director at Precision Varionic International and coordinator of GRAPHENESENS, walks us through the project's outcomes and its potential to change the position sensor market.

★ What did you aim to achieve with this project?

Pufinji Obene: A lot of people talk about graphene itself and potential uses, but the truth is that graphene is quite expensive to use in its pure form. It means that breakthroughs using solely graphene will tend to take place only at lab scale.

But we also know that graphene has incredible properties, be it electrical conductivity, mechanical strength or smoothness. So we thought, why not look at an application-specific system, taking a pure graphene layer and manufacturing it into an ink formulation, and finally see the difference between the same application with and without graphene?

GRAPHENESENS focused on graphene for contact sensors in the automotive industry, but our research can find applications in position sensors of all kinds.

★ What added value did you hope graphene would bring to these products?

It was essentially about durability, especially if we are talking about graphene-enhanced sensors for the likes of antennas, accelerator pedals, encoders, motors or even robotics.

An accelerator pedal, for instance, requires long-life inks with specifications foreseeing 2 million cycles, and tests



that see the system go through as many as 7 million cycles. The question is, can I use graphene to enhance the lifetime of this product? If I can, then adding just 1 or 2% of graphene in an ink formulation – which is a very small percentage – can make a huge financial difference.

★ **Would driverless cars be a potential application as well?**

Yes. Self-driving cars use radomes to protect radars, but these tend to freeze over and therefore can't get the signal in. So, one of the projects we are working on with one of our customers is to use our solution as a heating element. We coat polyamide with a low viscosity graphene ink that has very good adhesion to the substrate and high conductivity, so it can heat up the radome with very low power.

★ **We mentioned durability as a strong advantage, but what about cost?**

To get back to our contact position sensors, a game changing advantage is the fact that we can use our graphene to coat the potentiometer's wiper. Usually a wiper would be made of a highly precious metal like Paliney, which is very expensive. By using a cheaper material and coating it with our graphene system, we can get a much cheaper (in the order of 5-10 times cheaper) wiper than we would have with Paliney.

We can actually use the graphene both on the tip of the cheaper wiper and for the potentiometer's conductive circuit. This graphene to graphene interface allows us to have a perfect balance between the wiper's wear characteristics and the electrical properties of the ink.

★ **Were you able to quantify the benefits of this system?**

We conducted a comparison between products with graphene and without graphene, and the benefits are tremendous. We were able to halve the thickness of the printed ink, and our Aerosol Assisted Ion Deposition (AAID) technique to coat the cheaper wiper reduces its cost by 80%. Overall, we managed to get a 45% cost reduction in making contact sensors.

★ **How about your plans for commercialisation?**

We are already making prototypes for two or three automotive suppliers strictly on the wiper side, and two of them are also working on the long-life ink, but that's confidential in terms of IP.

Some of our customers have issues on the wiper side and they need the new product as soon as possible. Now the challenge is to reach

an industrial production scale, and we will have to go for an SME Instrument phase 2 project to make this possible.

We are also contemplating other markets besides automotive, so all in all, we hope to have something on the market within the next two-three years.

★ **Looking back, would you say that your project is a case in point of what can be achieved with graphene?**

I think it is. Right now the market requires applications of graphene for real-life scenarios. I don't think graphene is ever going to be useful for society in its pure form until we can take a single layer of it and place it onto a circuit board. In the meantime, we should use graphene as an enhancer and focus on making practical products. This is what we did with GRAPHENESENS.

“By using a cheaper material and coating it with our graphene system, we can get a much cheaper (in the order of 5-10 times cheaper) wiper than we would have with Paliney.”

GRAPHENESENS

- ★ Coordinated by Precision Varionic International in the United Kingdom.
- ★ Funded under H2020-SME.
- ★ <https://cordis.europa.eu/project/rcn/207986>

LBL TECHNOLOGY APPLIED TO GRAPHENE OXIDE

An EU-funded project has successfully demonstrated that graphene oxide can be assembled with other materials to produce dense polymer composites. This breakthrough could lead to applications in optoelectronics and energy conversion, among others.

Graphene is often presented as a supermaterial for its out-of-the-ordinary strength, thinness, conductivity and optical properties. But its potential reaches a whole other level when combined with other materials of different natures. By creating these hybrid materials, graphene properties can be tweaked. This provides researchers with new and exciting prospects for applications, and it can also guarantee better integration of graphene in devices.

With this in mind, Dr Sergio Moya from CIC biomaGUNE kick-started the HIGRAPHEN (Hierarchical

Functionalization of Graphene for Multiple device fabrication) project in March 2014. Using layer-by-layer technology – a simple procedure for the functionalisation of surfaces based on the stepwise deposition of oppositely-charged molecules or materials – he aimed to develop a versatile, generic procedure for the fabrication of hybrid devices coupling graphene with polymeric, organic and inorganic materials.

“The driving force behind layer-by-layer (LbL) assembly is the electrostatic interaction between the

assembled components,” Dr Moya explains. “Initially, this technique has been developed for the assembly of polyelectrolytes, that is, polymers with multiple charged monomers. But it has since been extended to multiple components: Layer-by-layer film polyelectrolytes can be combined with nanoparticles, with lipids, cells, graphene oxide, etc. It offers a simple and powerful way to engineer interfaces while avoiding covalent chemistry, and it has potential in many applications – from nanofiltration membranes to optoelectronic devices, smart coatings and drug delivery.”



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The project went a step further by specifically focusing on the combination of graphene oxide with metal and metal oxide nanoparticles, as well as polyelectrolytes, whilst contemplating potential applications in energy storage and catalysis. Although the LbL technique is widely used in surface engineering and thin film fabrication, HIGRAPHEN's use of LbL to assemble heterogeneous components with graphene oxide is particularly innovative.

Together with his team, Dr Moya first proceeded by synthesising different nanomaterials such as ZnSe quantum

dots, magnetic nanoparticle, and electroactive polymers like polyaminobenzylamines (PABA), before integrating them into LbL films with multiple components including graphene oxide. From thereon, the HIGRAPHEN team integrated the assemblies into macroscopic anticorrosive coatings and devices for optoelectronic applications and energy conversion.

“One of the main challenges we faced was to obtain a dense arrangement of graphene oxide in combination with polymers. This led to the development of different approaches to coat the

“Although the LbL technique is widely used in surface engineering and thin film fabrication, HIGRAPHEN's use of LbL to assemble heterogeneous components with graphene oxide is particularly innovative.”

graphene oxide and combine it with nanoparticles,” Dr Moya explains.

All in all, the project's most important outcome is the demonstration that graphene oxide can be assembled to produce dense polymer composite, and that it can be easily integrated with metal nanoparticles for catalysis. Whilst HIGRAPHEN will only come to an end in March 2018, Dr Moya says that project partners are already pursuing interesting new research directions based on project outcomes for device fabrication and catalytic applications.

HIGRAPHEN

- ★ Coordinated by CIC biomaGUNE in Spain.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/109020>

INTERVIEW

USING GRAPHENE FOR FLAWLESS TUNNELLING ACCELEROMETERS

An ERC Proof of Concept grant is enabling Aalto University to work on a novel concept for a tunnelling accelerometer using graphene's unique properties. If successful, the project could appeal to industries producing high-precision applications.

Accelerometers are used in a wide range of applications, from navigation systems in aircrafts to motion sensing in cars and portable electronic devices. But the most demanding applications require high-resolution accelerometers which are both very large and very expensive to manufacture.

For such applications, which include the likes of microgravity measurements, acoustic measurements and seismology, the use of tunnelling accelerometers could seem self-evident. A giant step ahead of their conventional counterparts, they can be produced at much lower cost whilst

providing unmatched precision. Yet, their commercialisation is still hindered by a complex fabrication process and long-term instability.

Enter the GRATA (Graphene Tunneling Accelerometer) project, which is developing a first-of-its-kind – and already patented – tunnelling accelerometer design using graphene. Its technical advantages, which include smaller size, wider bandwidth, simpler fabrication and natural stability, are already turning heads within industry. Among other things, it could enable the production of high-end sensors based on graphene.



© Pertti Hakonen

PROF. DR PERTTI HAKONEN

Prof. Dr Pertti Hakonen, who is in charge of the project, discusses his tunnelling accelerometer concept, its development process and prospects for commercialisation.

★ **What shortcomings of tunnelling accelerometers were you aiming to tackle with this project?**

Prof. Dr Pertti Hakonen: The lack of long-term stability of silicon-based, metal-coated tunnelling sensors is the main shortcoming we tried to overcome. The sensitivity and bandwidth will be improved as well.

★ **Why do you think graphene can be a suitable solution to achieve this objective?**

Graphene is known to have superior mechanical properties (light, strong, robust carbon crystal) and good electrical conductivity (no need for metal coating). We are experienced in dealing with details such as tension in graphene MEMS structures. The nature of the material and our

know-how make the graphene accelerometer a potential solution.

★ **What were the main difficulties you faced in making these new graphene accelerometers a reality?**

The manufacturability (and reproducibility) is the main challenge when switching from lab samples to future accelerometers to be called a product.

★ **What would you say have been your most important achievements so far?**

We have proven that the tiny gap is not prone to collapse, even in air, which is crucial for its reliability. The core patent has been filed, and one more with related materials is on the way.

★ **What do you still need to do before the end of the project?**

We need to build more prototypes which are properly packaged, and collect more data out of the lab.

★ **What kind of sensor applications do you have in mind?**

Machine vibration monitoring – the most widespread method to determine the health of rotating equipment – would be an example. This is valuable for safety and smart maintenance in modern industry, especially in the era of the Internet of Things.

★ **How close would you say you are to potential commercialisation?**

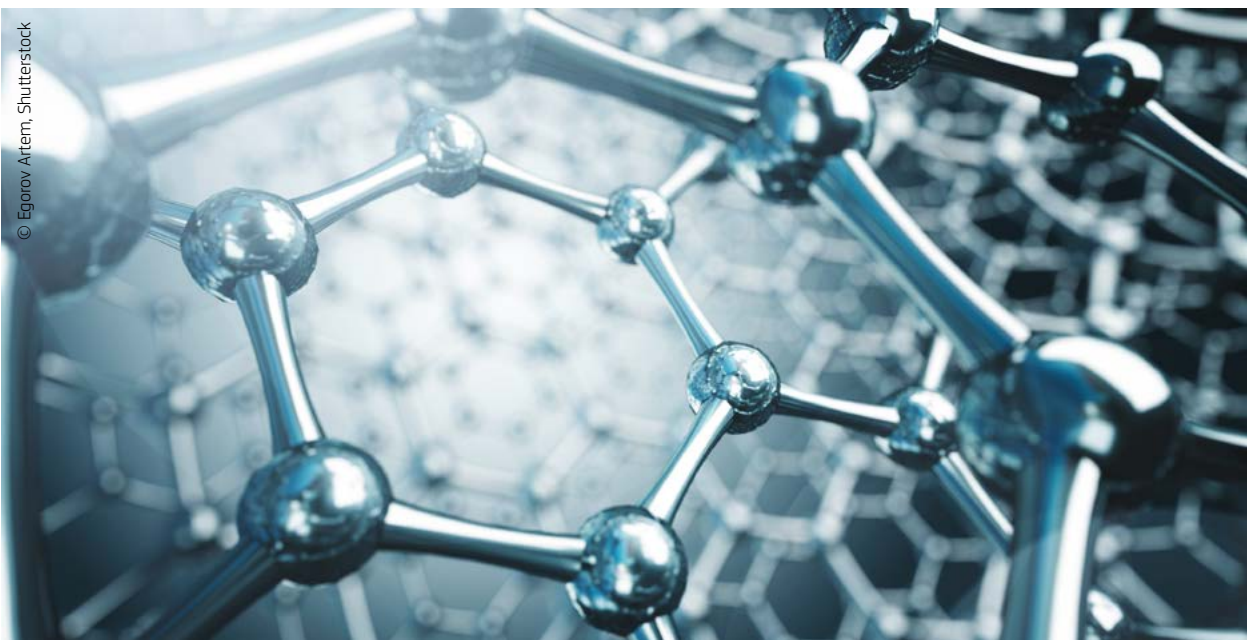
This is hard to say. Commercialisation takes much longer and requires different means than what we had available for our research work in the lab environment. However, with the key IPR filed and more field data being collected, we are on the right track towards the goal of commercialisation.

GRATA

★ Hosted by Aalto University in Finland.

★ Funded under H2020-ERC.

★ <https://cordis.europa.eu/project/rcn/209157>



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HEALTH

HOW THE BODY FIGHTS INFECTION CAN PROVIDE CLUES TO STOMACH CANCER RISK

Mapping immune responses to the *Helicobacter pylori* germ by tagging the antibodies produced in the body can shed light on how stomach cancers develop, EU-funded scientists have found.

EU-funded scientists working on the HELICOMARK (Antibody-responses to *Helicobacter pylori* and tumour proteins as biomarkers for early gastric cancer) project have found ways to assess stomach cancer risk in blood samples using the body's immune response as a tool.

Around 700 000 people die each year around the world from stomach cancer, the third most common cause of cancer death. Together Japan, Korea and China account for almost 70% of all cases but it is also common in Latin America and Eastern Europe, and patients generally have a poor survival prognosis.

A major cause of stomach cancer is the *Helicobacter pylori* germ. "H. pylori as a bacterium is very genetically variable and the variation more or less follows ethnicity, with East Asian versions of H. pylori being more carcinogenic," says project coordinator Professor Samuel Lundin, a professor in the department of Microbiology and Immunology at the University of Gothenburg, Sweden. "We have been analysing in very high detail the antibody responses to H. pylori to pinpoint the more risky H. pylori bacteria present in blood samples, and analysing how this is associated with stomach cancer risk."

Peptide arrays

Researchers produce peptide arrays to profile a patient's immune response to

H. pylori by synthesising peptides on a glass chip. "Technologies are available that allow us to add one amino acid letting it react, then washing it away and adding another amino acid till a peptide sequence is produced on the glass chip," Prof. Lundin explains.

Serum samples from Nicaragua, where there is a high risk of stomach cancer, and Sweden, were added to the 200 000 peptides on the chip. "Depending on the antibodies produced, some of them will bind to some of the peptides. Then you add another antibody that is fluorescently labelled so you light up those peptides," Prof. Lundin says.

"The assay shows the existence of these antibodies, so what we are doing is mapping the antibodies by using the peptide chip," he explains. "From this we get a score of how well the antibodies have bound to peptides, and to which of the 200 000 peptides."

This produces a specific 'fingerprint' for each person which can then be compared with those who developed the cancer.

Mapping proteins

"We mapped all the proteins that will elicit an antibody response if you have H. pylori, and all the epitopes of those proteins (the parts of the proteins to which antibodies bind)," says Professor Lundin. "We have shown that only two or three of those epitopes are

diagnostic in patients, the others produce antibodies even if the patient doesn't have H. pylori."

This method of mapping the epitopes has been patented. "We identified the peptides, where, if the patient has antibodies to them, we know there is a high risk of developing stomach cancer," Professor Lundin explains.

The key to the project's success was access to blood samples as well as biopsies from the same person. "We can culture the bacteria from the biopsies and analyse the person's H. pylori strains using genomic analysis," he continues. "The same person's antibody response is analysed to see the peptide sequences they respond to. "It's uncommon to have all of this information together and that was crucial for us."

Professor Lundin received a three-year Marie Curie grant that funded two years in Perth, Australia, working with Nobel Laureate Barry Marshall, one of the two scientists who discovered H. pylori.

HELICOMARK

- ★ Coordinated by the University of Gothenburg in Sweden.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/186498>

UNDERSTANDING THE ROOT CAUSES OF MENTAL DISORDERS

An in-depth look at how neural circuits in our brain control certain behaviours – and what happens when these malfunction – could increase our understanding of mental illness and lead to better treatments and health policies.

The CELLSYNCRICUITS (Cellular and synaptic dissection of the neuronal circuits of social and autistic behavior) project focused on synapses, the spaces between neurons that facilitate the transmission of information in the brain. Scientists believe that synaptic dysfunction could be a root cause of certain mental disorders such as schizophrenia and autism.

“Finding out what is going wrong in the brain of a patient with a mental disorder could help us come up with new ways to mitigate suffering and find cures,” explains Dr João Peça from the University of Coimbra in Portugal, recipient of a Marie-Curie Action Career Integration Grant and coordinator of the CELLSYNCRICUITS project. “In this respect, looking at the role of synapses has helped us understand how information in the brain is conveyed, and how synaptic malfunctions might lead to behavioural disorders such as autism or schizophrenia.”

This research could also influence future discussions on social policies. “We have found evidence for example that

“The long-term consequence of early life adversity could play a role in an individual’s integration in social groups later on in life.”

early life interaction between mother and infant is a critical aspect in the normal development of social animals,” says Peça. “If this is true, then this interaction could be dramati-

cally more important for complex beings like us. This could be an important insight for future discussions on, say, maternity leave.”

Synapses and neural circuits

The CELLSYNCRICUITS project examined neural circuits at multiple levels of complexity. Using rodents as a model, the project zoomed in on the role of individual proteins that sit in synapses, examining what function they perform in modulating information. It then zoomed out from this single molecule approach to examine how neural circuits might control behaviour. This research – at both the single gene level and the circuit level – sought to achieve a more holistic understanding of brain function.

“We tried to identify whether certain neural circuits are responsible for specific social behaviours,” explains Peça. “Understanding autism is a big focus in my work, and I want to understand how certain genetic elements can lead to a disease state.”

Early life adversity

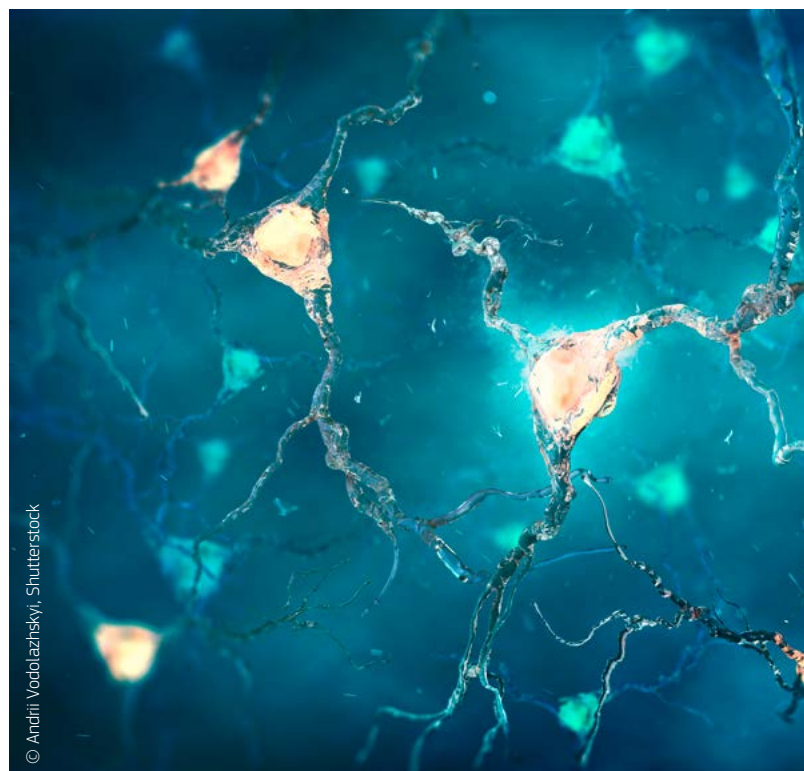
The project also assessed how stress can impact social behaviour, through an examination of how early life deprivation and adversity can have repercussions in later life; for example, if an infant is separated from its mother.

“We found that environmental factors can indeed trigger dysfunctional social behaviours in adulthood,” says Peça. “The long-term consequence of early life adversity could therefore play a role in an individual’s integration in social groups later on in life. Also, as early life stress is a factor that will always be with us, we should perhaps think about building strategies that more effectively mitigate the social impact on affected individuals.”

The Career Integration Grant, which funded this pioneering research, has also had a positive impact on Peça’s early career in neurobiology. “This was the first grant I received while setting up my independent laboratory, and it has had a huge influence on my current work,” he says. “The grant enabled me to get my lab up and running, and most importantly to become recognised and integrated within the Portuguese scientific community. This grant has been a big help in terms of building up my independent research.”

CELLSYNCRICUITS

- ★ Coordinated by the Center for Neuroscience and Cell Biology in Portugal.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/109400>



NEW SOLUTIONS FOR DIAGNOSING AND TREATING ANTIBIOTIC-RESISTANT BACTERIA

Infections caused by antibiotic-resistant bacteria are a widespread health problem. To help, the EU-funded PNEUMONP project has developed new ways to both diagnose and treat infections caused by antibiotic-resistant bacteria.

A patient suffering from a respiratory tract infection caused by a bacterium goes to the doctor for help. To treat him, the doctor tries several different types of antibiotics, none of which is successful. This is because the bacteria causing the patient's infection are resistant to the most common types of antibiotics available.

This by no means is an isolated case. Every year, millions of people suffer from infections caused by antibiotic-resistant bacteria. In fact, the problem is now so widespread that the World Health Organisation (WHO) regards it as one of the major current global health crises.

In response to this crisis, the European Union has funded many research projects aimed at solving the problem, including PNEUMONP (Nanotherapeutics to Treat Antibiotic Resistant Gram-Negative Pneumonia Infections). "The objective of the PNEUMONP project was to develop a novel solution for diagnosing and treating infections caused by antibiotic-resistant bacteria," says Project Coordinator Iraidia Loinaz.

A better diagnostic kit

One solution was the development of a diagnostic kit to identify the bacteria causing the infection within a single sample. Using Polymerase chain reaction (PCR) technology, the PNEUMONP multiplex kit screens for more than 30 of the main antibiotic-resistant genes. Running on standard lab equipment, the kit has the added benefit of being relatively cheap to use.

Thanks to this kit, doctors can now easily get a diagnosis at a very early stage of the disease, immediately treat with the proper antibiotics and likely save a life. "Using the kit, a doctor can quickly identify whether a patient is infected with an antibiotic-resistant bacterium and prescribe the proper treatment – all within as little as just three hours, whereas conventional methods take up to 48 hours," explains Loinaz.

The diagnostic kit will receive clinical approval in 2018 and will then be released onto the market.



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Coupling antibiotics with nanocarriers

But what about those bacteria that are extremely resistant to antibiotics, where no antibiotic is available to treat the resulting infections? Here, PNEUMONP researchers created new antibiotics.

For instance, the project explored the antibacterial properties of the M33 peptide, developing a specific form of the molecule that has proved effective against such infections as *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*. Researchers also studied the AA139 molecule, another promising antimicrobial peptide.

To ensure the efficient and safe delivery of these new antibiotics, researchers also looked at coupling the M33 and AA139 molecules with nanocarriers. Nanocarriers are nanomaterials used as a mode of transporting another substance.

As a proof of concept, the new antibiotics in nanocarrier form were delivered in aerosol form and tested against an antibiotic-resistant bacterium responsible for serious respiratory tract infections. "Attaching antibiotics to nanocarriers allows for the delivery of various combinations of antibiotics without an increase in risk to the patient," says

Loinaz. "Early tests of several combinations demonstrate that this approach does improve the performance of antibiotics, and there were no signs of resistance to the new antibiotics."

The project has also been developing a manufacturing process that will allow for scalable production of the nanosystems – crucial if these new antibiotics are to break into the highly regulated pharmaceutical sector.

Overall, the PNEUMONP project successfully demonstrated the positive effect of coupling antibiotics with nanocarriers for treating multi-resistant bacteria-based infections. "We are still far from having a new medicinal product in clinical trials, but we have generated knowledge on the systems and we really think nanotechnology will help in the design of a new generation of drugs," adds Loinaz.

PNEUMONP

- ★ Coordinated by the CIDETEC Foundation in Spain.
- ★ Funded under FP7-NMP.
- ★ <https://cordis.europa.eu/project/rcn/110689>
- ★ Project website: <http://www.pneumonp.eu>
- ★ <http://bit.ly/2F49yUH>

EYE CARE EXPERTISE FOR AN AGEING POPULATION

Encouraging excellence in vision science will help ensure that Europe's ageing population does not lead to a crisis in eye care.

Comprehensive and sustainable eye care has the potential to improve the quality of life for millions of citizens, and enable countries to better manage healthcare costs. "Given our ageing populations, it is obvious that Europe and indeed the world as a whole will need more highly qualified professionals working in the field of vision science," says AGEYE (Aging eye) project coordinator Prof. Robert Montés-Micó from the University of Valencia in Spain. "We sought to tackle this through experience-based training, cross-disciplinary research projects and career development."

Vision science is, quite simply, the study of vision. Experts in this field – who aim to expand current knowledge on the complexity of the eye and the visual process – include specialists in ophthalmology and optometry as well as more broadly biologists, neuroscientists, physicians and psychologists, to name but a few.

The social and economic importance of this field of research continues to grow, just as the global population continues to age. "This demographic change has become a major health concern," continues Montés-Micó. "An important challenge in vision science is understanding the effects of ageing on the structure and function of the visual system, in order to bring forward new therapies and methods for restoring visual capabilities."

Understanding the eye

The AGEYE project set out to advance scientific understanding of how the eye's structural and physiological changes occur with age, in a sustainable manner. This was achieved through training 10 early-stage researchers and two experienced researchers in state-of-the-art concepts and leading-edge research techniques essential to the study of the human eye's behaviour. The project also provided strong career-management skills and solid professional connections in order to help researchers capitalise on the project results and continue their learning.

"The study of ocular ageing and its implications in old people's visual function constitutes an important training area for young researchers," says Montés-Micó. "It also represents an important challenge. As this is a multidisciplinary research field, it requires knowledge and expertise in anatomy, physiological optics, psychophysics, physics, optometry and technology."

The project also wanted participants to attain a greater insight into changes in eye structure that occur with age, taking into account that a large amount of economic and human resources is devoted to cataract and presbyopia (loss of near focusing ability that comes with age) treatments.

Advances in eye care

From this initial work, the AGEYE project moved on to investigating how the visual system responds to different stimuli. By combining this information with imaging data of the crystalline lens, project participants put forward new ideas

of how ageing influences aberrations to known anatomical changes in the eye.

New systems were developed for modelling the surface of the eye and identifying the position of some ocular structures more accurately than with traditional imaging techniques. In addition, this project investigated which complaints referred by patients are related to aging processes occurring in the visual system, and whether these may be objectively determined and correlated with those complaints.

Finally, consortium partners shared their experiences and know-how in therapeutic solutions for cataract and presbyopia (contact and intraocular lenses), allowing for a deep understanding of the advantages and drawbacks of currently available options.

"In summary, the project has helped to increase knowledge in the ageing processes occurring in the human eye, while training new scientists who can contribute towards improving the quality of life for increasing numbers of aged people," said Montés-Micó.

AGEYE

- ★ Coordinated by the University of Valencia in Spain.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/111465>
- ★ Project website: <http://www.ageye.eu/>

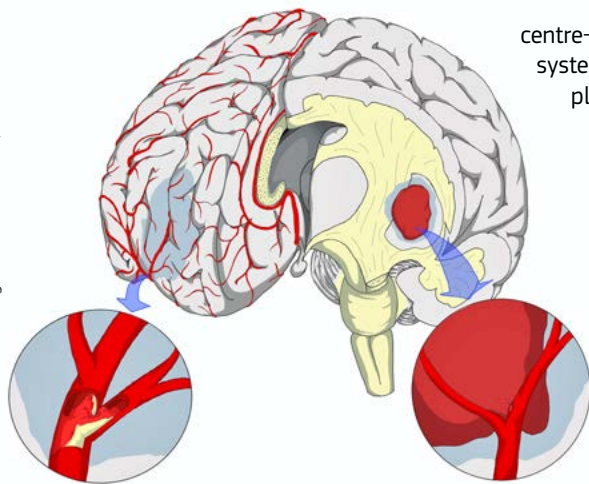
"Europe and indeed the world as a whole will need more highly qualified professionals working in the field of vision science."



FIRST DIGITAL THERAPIST ENABLES STROKE PATIENTS TO RECOVER AT HOME

Around 6 million people every year require long-term, intensive and effective motor rehabilitation programmes after a stroke – a daunting prospect, especially in terms of cost. The EU project SWORD's digital therapists are offering patients physical, interactive rehabilitation in the comfort of their own homes for a viable, sustainable solution.

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centre-based regime until the SWORD system. Robotics solutions for example, are complex, costly and demand constant supervision from a trained clinician.

The stroke wearable operative rehabilitation device (SWORD) system – straight to the point

The SWORD system with two interconnected parts – the rehabilitation interface and the core – incorporates high intensity, repetitive but personalised exercise. Moreover, it provides feedback on performance and is geared for optimal success.

A series of sensors records the motor performance of the patient and sends the data to a mobile device – tablet or mobile phone – giving all-important feedback on performance to the patient and relevant clinical teams. “Positive reinforcement comes in the form of visual and audio feedback directly provided by SWORD's digital therapist,” explains Dr Bento. When the patient hasn't got the movement quite right, the clinical team is immediately alerted by the digital therapist so they can act by, for example, reducing the difficulty of the exercise.

Randomised placebo controlled clinical trials on the wearable interface proved that intensity of training increased and the probability of errors occurring reduced. The results can be accessed in Nature Scientific Reports.

All information is analysed and evidence-based data-driven decisions are derived at the cloud platform, the SWORD core. The analytics framework brings together rehab data streams, pharma data, machine learning algorithms and the physicians' notes for Big Data production. Armed with data from the global network, the clinician has access to the patients' past, present and future progress.

The EU-funded SWORD (Advanced Analytics Platform for Stroke Patients Rehabilitation) project has created a digital therapist that enables an integrated exercise programme via a mobile device that uses body sensors and machine learning algorithms to monitor progress and give real time feedback to patients and clinical teams. “The catalyst for the idea came from when my brother suffered a car accident and was in need of intensive physical rehabilitation. At that moment, I realised that if we want to open up access to more sustainable and high-quality rehabilitation services, we have to perform a paradigm shift through the use of new technology. And that's what we did,” recalls Dr Virgílio Bento, project coordinator.

Since then, scientists have shifted their focus to the millions of people every year that suffer strokes and require ongoing long-term intensive physical rehabilitation treatment. The problem with centre-based physiotherapy for recovery is that the patient must visit the premises, requiring scarce and costly specialist human resources.

Despite fierce interest in technologically-based alternatives and an explosion in research efforts, there had been no viable alternative to the traditional

From patient to institution: Benefits at all levels

The obvious benefit to the patient is accelerated progress in terms of physical rehabilitation due to practice. Moreover, the system brings with it a flexibility whereby the patient can be anywhere for treatment, at home or in a group therapy session in the gym. Physicians have the chance to deliver better therapy for their patients and can access a huge system for appropriate data. Care centres could also reach out to more patients without an increase in operating costs.

The SWORD system is endorsed by some of the most important rehabilitation centres in Europe. These include centres in Belgium, Spain, Italy, Portugal and Sweden that are either using the system or recommend it from observation of trials. Together with the largest rehabilitation group in the United States (Genesis Rehab Services), this interest has validated the SWORD system as a global and promising commercial solution in the stroke rehabilitation market.

Dr Bento's vision for the SWORD system is to democratise physical rehabilitation treatment for stroke patients enabling everyone in the world, despite their economic position, to have access to high-quality therapy in the comfort of their homes.

SWORD

- ★ Coordinated by Sword Health SA in Portugal.
- ★ Funded under H2020-SMEINST.
- ★ <https://cordis.europa.eu/project/rcn/197357>
- ★ Project website: <http://www.swordhealth.com/>
- ★ <http://bit.ly/2CowVoZ>

“I realised that if we want to democratise access to more intensive and high-quality rehabilitation services, we have to perform a paradigm shift through the use of new technology.”



SOCIETY

LESSONS FOR AN ECONOMIC CRISIS OF THE PAST

Today's financial crisis is not that different from the economic crisis between the two world wars. The interplay between the economy and politics – from corporatism to governance – played a key role in both crises.

Europe's recent economic crisis is reminiscent of the crisis during the interwar period, leading academics to ponder the similarities and differences of both. The EU-funded ITEPE (Institutional transformation in European political economy – A socio-legal approach) project studied the similarities from a new perspective. "Such crises aren't primarily caused by economic developments but by short-circuiting the legal infrastructure that structures social exchanges in society, particularly between economy and politics," says Professor Poul F. Kjaer from ITEPE. "The economic and social ramifications are more effects than causes of deep-seated societal crises that emerge from the slow erosion of the legal system," he explains.

From corporatism to governance

During the interwar period, corporatism – like today's governance – had organised social relations between economy and politics. Cartels controlled politico-economic sectors from coal and steel to automobiles and textiles. In addition, law was considered an obstacle

preventing the unfolding of societal energies. "Weimar Germany saw the erosion of the law leading to a crisis, with similar developments throughout Europe," illustrates Prof. Kjaer.

After WWII, neo-corporatism began representing highly centralised state-tied legal frameworks that separated economy from politics and structured political processes. This provided a very stable framework for post-WWII Europe. ITEPE found however that the turn to neo-corporatism wasn't so much due to national compromises between political parties but was imposed through transnational arrangements, allied occupation regimes, the Marshall Plan, and the European Coal and Steel Community. "Both the German post-WWII 'social market economy' and 'golden age Keynesian welfare state' were to a large extent a transnational construct," says Prof. Kjaer.

Post-WWII arrangements began faltering after the 1970s as mass education, new technologies and globalisation emerged. Self-regulation and deregulation became preferable to government regulation, just as governance today distinguishes between public and

private spheres through outsourcing and public/private partnerships.

Moreover, while corporatism focused on society as political community, governance emphasises society as an economic community, thereby limiting the role of public institutions and institutionalised politics. Governance also sees legal instruments as obstacles that produce red tape, preventing societal energies from unfolding. This has been linked to the shift away from lawyers who dominate state activities to economists, ultimately contributing to the 2007 financial crisis.

For example, Greece's political economy based on closed professions – more like interwar corporatism – became infused with contemporary governance ideas, creating a very explosive cocktail. In contrast, Germany – a state run by lawyers rather than economists – was only superficially affected by the turn to governance.

Future economy based on post-governance

These examples are crucial for debates on globalisation and transnational

integration such as through the EU, especially since academics, politicians and the media often portray integration as a threat to the welfare state and labour markets. “ITEPE debunks the myth about the exclusively national origin of the post-WWII welfare state,” clarifies Prof. Kjaer.

As an ideology and social praxis, contemporary governance turns interwar

corporatism upside down by focusing on the economy rather than politics, but still produces similar effects because both seek to break down the legally mediated distinction between politics and economy. “We must move away from the very notion of governance and the world view it represents,” concludes Prof. Kjaer. “We need to enter into a post-governance world developing a new philosophy of state/society relations which

brings the virtues and status of law and legal formalism back in.”

ITEPE

- ★ Hosted by Copenhagen Business School in Denmark.
- ★ Funded under FP7-IDEAS-ERC.
- ★ <https://cordis.europa.eu/project/rcn/105530>
- ★ Project website: <http://www.itepe.eu>

DISCOVERING THE VISUAL CULTURE OF HUMANITARIANISM

Researchers with the EU-funded HUMANITARIAN PASSIONS project turned to classical art and Christian iconography to understand humanitarian visual culture from an aesthetic and historical-artistic point of view.

To better understand the role that mass communication plays in contemporary humanitarian crises, researchers working within the EU-funded HUMANITARIAN PASSIONS (The Survival of Christian Iconography in Contemporary Representations of Pain: a Visual Studies Approach) project conducted an in-depth study of pain and how pain is depicted within Western iconography. To do so, researchers looked at the relationship between the images of contemporary humanitarianism and the iconography of the Passion and Works of Mercy found within Western art.

“Our hypothesis was that Christian iconography constitutes a database of images that the media relies on when reporting on a crisis,” says project researcher Francesco Zucconi. “By doing so, these crises convey a specific moral attitude to the audience.”

From this hypothesis, Zucconi, along with his colleague Giovanni Careri, set out on an elaborate investigation of humanitarian visual culture from an aesthetic and historical-artistic point of view.

A storyline of assistance

The research team relied heavily on the iconography of the Works of Mercy found in Caravaggio’s masterpiece *The Seven Works of Mercy* (1607), in addition to the general iconography associated with the Passion of the Christ. From this initial work, Zucconi and Careri were able to define the necessary framework for recognising the persistence, survival and reformulation of such themes as ‘feed the hungry’,

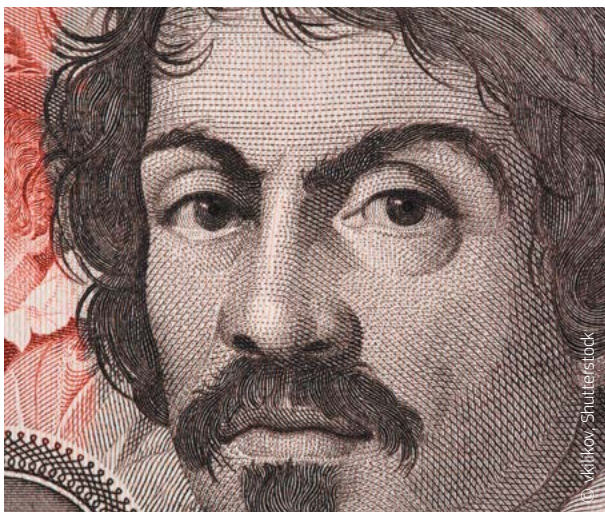
‘refresh the thirsty’, ‘clothe the naked’, ‘shelter the pilgrims’, ‘visit the sick’, ‘visit the imprisoned’ and ‘bury the dead’ in contemporary forms of humanitarian communication.

“Here we were able to show how these forms of assistance, which are readily represented in the iconography of the Works of Mercy, constitute a typology for describing and understanding such a heterogeneous field of discourse as contemporary humanitarian communications,” explains Zucconi. “This was the first time that the controversial question of the origins of humanitarianism was addressed with detailed reference to Christian iconography instead of through a social sciences lens.”

Next, researchers began to look for references to these typographies in contemporary disasters. They focused their attention on communication campaigns produced by the United Nations, Doctors without Borders, Amnesty International, the International Red Cross and Red Crescent, and Caritas Internationalis. “By examining the interrelationship between the immanence of gestures of pathos that materialise in catastrophic situations and the transcendence of the representative models by means of which suffering has been forged over centuries in the West, we investigated humanitarian communications as a form of secularisation of Christian iconography,” says Zucconi.

The visual culture of humanitarianism

Although there have been various academic studies on the representation of pathos in Christian iconography, on media representations of suffering and on humanitarian communication, the existing literature lacks any current research regarding the point at which these fields intersect. “This project has helped overcome these rigid disciplinary divisions and to develop a new methodology that is capable of opening up the history of European art to matters concerning images in the contemporary world,” says Zucconi. “In this regard, the project has fostered the development of a critical perspective on the history of the visual culture of humanitarianism.”



HUMANITARIAN PASSIONS

- ★ Coordinated by the School of Advanced Studies in the Social Sciences in France.
- ★ Funded under H2020-MSCA.
- ★ <https://cordis.europa.eu/project/rcn/195617>
- ★ Project website: <https://humanitarianpassions.wordpress.com/>

THE IMPACT OF POST-SECONDARY EDUCATION ON LABOUR MARKET OUTCOMES

From school to work: Researchers have applied state-of-the-art statistical techniques and methodologies to advance our understanding of how post-secondary education affects labour market outcomes.

It is widely accepted that education pays off in better jobs and higher salaries. But how much does post-secondary schooling really improve labour market outcomes? This is the question researchers set out to answer with the EU-funded PSE RETURNS (Labor-market returns to postsecondary education in Europe and the United States) project. Headed by Dr Christopher Jepsen, project coordinator, the study focused on quantifying the value of labour market returns in both Europe and the United States.

Three research streams

Building on an existing project, initial research investigated the labour market and educational outcomes in relation to the United States' General Education Development (GED) test. This work was done in collaboration with colleagues from the University of Missouri and University of Kentucky.

In collaboration with colleagues from the University of Missouri, the second theme looked at the labour market returns to for-profit colleges and universities in the United States. The team has published a related working paper under the IZA Discussion Paper Series.

Finally, the third research stream examines labour market outcomes of post-secondary education in Europe. To study the labour market returns to vocational post-secondary education in Finland, PSE RETURNS is collaborating with colleagues from the Turku School of Economics, Labour Institute for Economic Research and University of Jyväskylä, Finland.

Post-secondary education increases employment and earnings potential

Research on the GED employed regression discontinuity to compare people barely above and barely below a threshold.

"For the GED test, we find no discernible difference in employment and earnings between individuals who barely pass the test and individuals who barely fail the test," said Dr



Jepsen. "The wider implication of this finding is that having a test like the GED in Europe is unlikely to improve labour market outcomes under the assumption that the results in Europe would be similar to the results in the US."

Using a person fixed effects methodology, research on for-profits in the United States revealed that attending such institutions is associated with earnings improvement of 25% or more within the first five years of labour market entry.

"The main implication of the results on US for-profit colleges and universities is that there may be scope, at least in the US, for the private sector to provide post-secondary education that benefits students," explained Dr Jepsen.

Research on vocational programmes in Finland used the same fixed effects methodology together with a matching methodology. "Compared to individuals with no post-secondary education, students who attend vocational bachelor's degree programmes in Finland have higher annual earnings of approximately EUR 3 500, or 13%, and employment gains of 2.5 percentage points after 10 years," noted Dr Jepsen. Further, the study showed that five years after attending vocational master's programmes

"Attendance at post-secondary education ... is associated with improved employment and earnings outcomes."

individuals have higher earnings of around 8%.

More flexibility is better!

The project's most important finding is that attendance at post-secondary education (whether at for-profit colleges/universities in the United States or at vocational bachelor's and master's programmes in Finland) is associated with better employment opportunities. The work also contributes an improved way to estimate labour market returns. In turn, it emphasises the importance of using a more flexible model for estimating labour market returns to education.

With project research still ongoing, Dr Jepsen is confident the "results regarding US for-profit colleges and universities have the potential to inform best practice guidelines for calculating labour market returns to education."

The project team is actively disseminating the results. Some of the most important publications include: 'Labor-market returns to the GED using regression discontinuity analysis' (Journal of Political Economy), 'Second chance for high-school dropouts? A

regression discontinuity analysis of post-secondary educational returns to the GED' (Journal of Labor Economics) and 'More skilled, better paid: Labor-market returns to vocational postsecondary education' (Oxford Economic Papers, forthcoming).

PSE RETURNS

- ★ Coordinated by University College Dublin in Ireland.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/109768>

COULD FARMING BE THE REASON BEHIND POST-NEOLITHIC WEALTH DISPARITIES?

Wealth distribution can tell us much about a society but when it comes to prehistoric civilizations, a lack of written record makes that hard to trace. New research draws on house size to trace wealth disparity, with interesting results.

Charting wealth distribution gives us an insight into the character of a society: where power was situated, possibilities of social mobility, the ebb and flow of trade. In prehistoric cultures where there are no written records, the presence of indicators of wealth, such as grave goods or objects that have been imported, has been put forward as a way to identify wealth. But the former are not household goods and the latter could have found their way into a site without necessarily having been 'bought' by those living there.

These 'proxies' for wealth, according to a letter recently published in the journal 'Nature', do not answer the many questions surrounding disparity, such as the relationship between farming and a society's wealth, or the impact of sociopolitical dynamics. The researchers suggest using house size distributions that provide, they suggest, a consistent metric.

The study is based on data gathered from a research team that analysed 63 archaeological sites across four continents, dating between 9000 BCE and 1500 CE. It is one of the first studies to use archaeological data to measure inter-household inequality between Old and New World sites.

More efficient farming generated wealth

Their research, in part supported by the EU's AGRICURB (The Agricultural Origins of Urban Civilization) project, suggests that the higher wealth disparity identified in post-Neolithic

Eurasia was initially due to the availability of larger animals that could be domesticated. People became less nomadic and more dependent on agriculture. The rich became richer as the ancient farmers who could afford oxen, cattle and other large animals increased their crop production. This created profit, which was then amassed and passed on, causing wealth inequality. The study revealed that house-sizes point to the inequalities being much higher in Old World Eurasian contexts.

"High degrees of inequality did not contribute to long-term stability in ancient societies," says Anna Prentiss, a professor in the Department of Anthropology at the University of Montana and one of the paper's authors. "That is something that should concern us, given the extraordinary high degree of inequality in our own society."

Wealth as a tool of militarisation and expansion

The flow and circulation of wealth lead to the development of a mounted warrior elite, suggest the researchers. Such warriors would have been instrumental in expanding polities, (political units that cohere via identity, ability to mobilise resources, or governance) to sizes that were not possible in North America and Mesoamerica before the arrival of Europeans.

The paper consolidates a generally held view, based on comparative studies of farming societies: that the greater the surpluses a society produced, the greater the levels of inequality in that society. The need for ever greater access to land also leads to disputes over resources, war, conquest and geographical expansion.

AGRICURB recognised that farming is a pivotal moment in human history, setting the stage for the emergence of class-based society and urbanisation. The project, which closed at the start of 2017, took a novel, interdisciplinary approach combining archaeobotany, plant stable isotope chemistry and functional plant ecology to gain new insight into early farming and its relationship with early civilization.

AGRICURB

- ★ Hosted by the University of Oxford in the United Kingdom.
- ★ Funded under FP7-IDEAS-ERC.
- ★ <https://cordis.europa.eu/project/rcn/106898>
- ★ Project website: <https://agricurb.com/>



TRANSPORT

DESIGNING THE SEMI-TRUCK OF THE FUTURE

The two new semi-trailers designed by the EU-funded TRANSFORMERS project offer better aerodynamics and load efficiency, thus helping to reduce energy use by over 30%.

Today's semi-trailer combinations are very much a one-size-fits-all solution, optimised for a limited number of use cases and for maximum payload. In light of an ever-increasing need for transport efficiency and optimisation, there's a need to rethink the design of these semi-trailers.

"Nowadays, truck-trailer combinations are not optimised with respect to their missions," explains Paul Adams, project coordinator for the EU-funded TRANSFORMERS (Configurable and Adaptable Trucks and Trailers for Optimal Transport Efficiency) project. "Ideally, future trucks and load carriers will be easily adaptable for each load and mission, and the vehicle combination able to automatically adjust itself to the actual driving environment"

The two different semi-trailers designed by the TRANSFORMERS project represent a major step towards achieving this 'truck of the future'. With a trailer mounted electric driveline supporting the conventional diesel tractor and trailers designed to address both aerodynamics and load efficiency, the TRANSFORMERS semi-trailer combinations offer the potential to reduce energy use by over 30% (in energy/km.tn).

Hybrid-on-demand

The TRANSFORMERS project successfully developed and demonstrated a range of innovations that improve transport efficiency within the road haulage industry. The project brings these innovations together in semi-trailer combinations that are easily adaptable so they can be optimised for each transport mission.

For example, one of the key innovations developed by the project is the Hybrid-on-Demand (HoD) feature. This feature integrates regenerative braking, supplementary propulsion and intelligent energy controls in the trailer that adapt to the mission profile and are capable of interacting with existing and future trucks. "The major advantage of this approach over the classic vehicle hybridisation approach is that only minimal changes to the truck are

needed," explains Adams. "This in turn allows for new options in mission rightsizing."

The HoD system works by recapturing braking energy in heavy traffic or when it is necessary to restrict the vehicle's speed when descending hills. The energy is stored in a battery until it is later used to drive the electric motor that supports the conventional diesel engine. Unlike a conventional hybrid driveline, the diesel engine is on the tractor, while the supporting electric driveline is on the trailer.

Other key outcomes of the project included: a loading efficiency optimised design for the inside of the trailer, including an innovative double floor; mission-based configurable aerodynamic designs for the overall truck-trailer, including unique moveable roofs; and a pre-standardisation electric HoD tractor-trailer communication framework that supports a broad market introduction and lays the foundation for future R&D activities.

A significant increase in efficiency

The project has achieved a 10% reduction in fuel use and up to 33% or more increase in load efficiency. "By reducing the fuel consumption and simultaneously increasing the load efficiency, the TRANSFORMERS project was able to demonstrate that they can reduce energy consumption per ton per kilometre by more than 30% for some transport missions compared to today's state-of-the-art truck-(semi)trailers," adds Adams.

TRANSFORMERS

- ★ Coordinated by Volvo Technology AB in Sweden.
- ★ Funded under FP7-TRANSPORT.
- ★ <https://cordis.europa.eu/project/rcn/110632>
- ★ Project website: <http://www.transformers-project.eu>
- ★  <http://bit.ly/2HjjRFi>

INTELLIGENT AIR BAGS READY FOR MARKET DEPLOYMENT

The EU-funded I-VALVE project has brought artificial intelligence to vehicle airbags, providing tailored protection and making driving safer.

The ability to predict and react to crash conditions in a split second could help save many lives. According with the World Health Organisation (WHO) around 1.25 million people are killed in road traffic accidents every year, and between 20 and 50 million more people suffer non-fatal injuries.

With the help of an SME Instrument Phase I grant, Spanish firm Magom has taken steps to address this unacceptable situation by applying artificial intelligence (AI) to airbags. A special valve takes into account the speed, passenger position and passenger height at the point of collision. Seat belt tension and the intensity of airbag deployment can then be automatically modified. The purpose of this specific project was to assess market viability.

“We have contacted potential customers and three have already demonstrated their interest in the project results,” says I-VALVE (INTELLIGENT VALVE FOR PERSONALIZED SAFETY AIRBAG) project coordinator Antonio Rovira from Magom, Spain. “This includes a market leading airbag manufacturer present in more than 20 countries.”

Safer driving

The driver’s airbag has become an integral part of car design. While thousands of lives have been saved thanks to this critical advance in driver and passenger safety, airbags themselves can cause injury or even death if not properly installed or used. The I-VALVE project sought to examine the market potential of an innovative membrane that can be intelligently programmed to provide the driver or passenger with protection tailored to their needs.

“Many innovations have been developed since the introduction of the driver’s airbag by Mercedes-Benz in 1981,” says Rovira. “These include new airbag functions and sensors to achieve higher safety performances.”

I-VALVE takes this one step further by introducing AI into airbag design. “AI is already being used in autonomous driving applications,” notes Rovira. “We

saw that it could be used to activate passive safety systems in a crash or pre-crash environment, by taking into account the speed, passenger position and passenger height.”

Low-cost solution

Magom’s key innovation is a silicon valve integrated into the airbag, which adapts the physical reaction of the airbag depending on the situation.

“If the passenger is a girl weighing 30 kg for example, a normal airbag will fully deploy before she reaches it, which means that it will be far too hard when she makes impact with it,” explains Rovira. “A man weighing 180 kg on the other hand will take less time to hit the airbag in a crash, so a normal airbag will often not be fully deployed in time. What our valve does is help to adjust airbag function to the real situation without sensors, software or moving parts.” Demonstrations using the prototype airbag resulted in significantly reduced damage to crash test dummies.

Another key strength of the I-VALVE innovation is that it is a low-cost solution to a significant societal and economic problem. This should help the

firm to bring the innovation to market, and ensure its installation at all levels of vehicles.

“We have set a target of reaching 6% of the worldwide niche market share of front and side airbags, and achieving an annual profit of EUR 5.4 million, three years after commercialisation starts,” says Rovira. “We also plan to increase our staff to 28 people and hope to enter the US market in 2022.”

I-VALVE

- ★ Coordinated by Manufacturas Goma SL in Spain.
- ★ Funded under H2020-SMEINST.
- ★ <https://cordis.europa.eu/project/rcn/208017>
- ★ Project website: <http://www.magom.com/en/>

“What our valve does is help to adjust airbag function to the real situation without sensors, software or moving parts.”



COMMUTING BECOMES FASTER, CHEAPER, CLEANER AND MORE SOCIAL

A revolutionary carpool application is enabling commuters in France's Paris region to get to work faster, save on costs and meet new people. The concept, which is now expanding to other locations in Europe, also reduces emissions and minimises road traffic.



The sharing economy is taking on yet another sector as more and more people choose to carpool. While 70% of Europe's commuters drive to work, almost always in the vehicle by themselves, carpooling has started to move from long-distance trips to short-haul trips.

A pioneer in this respect has been Karos, which launched a smart mobility platform, through the EU-funded Karos (Integration of a dynamic and predictive short distance carpooling offer into route planner services) project, in Paris that enables shared rides to the workplace based on artificial intelligence (AI), mobile technologies and big data. Founded in 2014, the company has successfully built partnerships with large companies that subsidise the service to the benefit of their employees.

Technology makes carpooling smart

"Karos transforms empty car seats into public transportation networks and connects them with mass transit," says the company's cofounder and president, Olivier Binet. "We improve the daily commutes of users who save time and money, and they get to meet new people." The unique inter-modal carpooling platform achieves this by learning users' daily mobility habits, predicting their next trips, and connecting them automatically to all other users who match their itinerary and their commuting time.

"The Karos app enables our users to carpool in a very seamless and flexible manner with different people at different times," explains Binet. "They aren't stuck with the same person every day at the same time." The app, which was launched in 2016, has attracted as many as 80 000 users already. The number of carpool trips with Karos has grown by 9% over the last 15 months, with a very high satisfaction rating from users based on Android and Apple app download feedback. "On average, our users save

24 minutes per trip compared to traditional public transport and save EUR 82 per month compared to driving alone."

The app's success is based on powerful geolocation and AI technologies, without relying on battery-draining GPS technology. It predicts users' trips over the next five days and matches them automatically with others. "In addition to recommending optimal routes that minimise detours, the app proposes the best door-to-door itinerary combining carpool and mass transit," reveals Binet.

A cleaner urban transport mode for Europe

The future also looks bright for the app as Karos expands to Bordeaux, France's sixth largest city. "We are also working with a large number of French and European urban areas to launch the service in 2018," says Binet.

From an ecological perspective, the Karos carpooling solution has already reduced CO₂ emissions by 102 tonnes and NO₂ emissions by 248 kg. "Increasing the load factor of cars is a great way to keep making all these trips, resulting in fewer cars on the road and fewer emissions," explains Binet. "The potential for CO₂ and NO₂ emissions reduction is very significant." If more cities in Europe and indeed around the world start adopting the technology, citizens will begin enjoying the benefits of less congested roads, faster road trips and less pollution in cities.

Karos

- ★ Coordinated by Karos in France.
- ★ Funded under H2020-SMEINST.
- ★ <https://cordis.europa.eu/project/rcn/207149>
- ★ Project website: <https://www.karos.fr/>
- ★ <http://bit.ly/1hWgcjw>

NETWORK FOR NOISE

Cutting down noise inside vehicles requires a new understanding of the relationship between acoustics and design. The ENHANCED network has trained a new generation of engineers and developed the tools they need to enable quieter cars.



Trying to listen to the radio or have a conversation in a car is often made more difficult by exterior noise and vibrations. Engineers try and design vehicle interiors with reduced noise levels but the mechanisms involved in doing this are not fully understood. The EU-funded Initial Training Network ENHANCED (joined Experimental and Numerical methods for HumAN CEntered interior noise Design) was created in 2013 to train the next generation of noise reduction researchers to solve this problem.

“The aim has been to network PhD-level researchers within a group of expert institutes,” explains the network coordinator Professor Paolo Castellini of the University Politecnica delle Marche (UNIVPM), Ancona, Italy. The project’s academic partner was joined by global engineering and technology company, Siemens – a world leader in software for simulations and experimental testing of vibro-acoustic phenomena. A third partner, non-profit association AIVELA, assisted with project events and dissemination activities.

“Nowadays, the automotive industry is asked to fulfil ever more demanding requirements for noise reduction and passenger comfort,” explains Castellini. “International legal restrictions on

noise, air pollution and increasing customer demand for acoustic comfort means that automotive companies have been driving more and more resources into acoustic treatment and isolation.” Design engineers are asked to solve this big challenge at low cost and therefore a great deal of effort has gone into the modelling of noise numerically. These models can then help to fine-tune vehicle design, diagnose potential noise sources and predict the effects of proposed design modifications such as changing the types of materials used.

Understanding how different materials can affect acoustics is not always straightforward. Materials usually have a solid and fluid component, for example the air in materials’ pores. The interaction between the two phases is responsible for how a material absorbs or magnifies acoustic effects. Finding the right types of absorbing materials could drastically improve interior noise levels.

To do this, experimentally-validated models are needed. According to Castellini, in the past, “the deviations between experimental measurement and predictions indicated that we needed to improve the numerical models.” The network has provided a

“Nowadays, the automotive industry is asked to fulfil ever more demanding requirements for noise reduction and passenger comfort.”

forum to do this. “Another big challenge lies in accurately measuring experimental data to describe the acoustics inside a vehicle cabin and characterise the contribution of exterior noise sources,” he adds. The network has developed specialised acoustic imaging techniques to identify noise sources and how noise is distributed, so as to be able to evaluate the contribution of individual sources such as road noise, wind noise or engine noise.

The network also focused on recreating or ‘auralising’ the sound within a vehicle. Analogous to visualisation, auralisation involves generating a simulation of the sound environment. The data collected during the project allowed the creation of a Virtual Car Sound (VCS) simulator.

The ENHANCED project, which ended in July 2017, has helped strengthen European industry’s ability to tackle the technical challenges of vehicle acoustics. The UNIVPM and Siemens are hoping to cooperate on a future training network, together with additional industrial and academic partners. They are also collaborating on other acoustics projects including the use of microphone arrays to measure and quantify sound as well as measuring the acoustics of rotating machinery.

ENHANCED

- ★ Coordinated by UNIVPM in Italy.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/109177>

ENVIRONMENT

UNDERSTANDING SEDIMENT TRANSPORT PROTECTS AGAINST CLIMATE CHANGE EFFECTS

Scientists are now better able to predict the evolution of river, estuarine and coastal formations thanks to an EU-funded initiative, making vulnerable communities more prepared for the impacts of climate change.

Transport of sediment in rivers, estuaries and along the coast can result in significant morphological changes that increase the occurrence of floods and storm surges. In addition, morphological changes in reservoirs and in the vicinity of man-made structures may damage water supplies and energy networks, and dramatically increase the risk of structural failure. This will result in economic losses, threaten human life, disrupt the social fabric and damage natural ecosystems. Impacts on sediment transport will also be exacerbated by climate change; therefore it is vital to have advanced knowledge of sediment transport and to train future engineers in this field.

The EU-funded SEDITRANS (Sediment transport in fluvial, estuarine and coastal environment) project formed a European network to coordinate research and training activities that addressed the challenges posed by sediment transport. The network comprised six academic and four industrial partners and provided a comprehensive interdisciplinary training-through-research programme to 12 early-stage and four experienced researchers. This included workshops, winter and summer schools, conferences, the drawing up of guidelines and secondments with industrial partners.

Researchers focused on coastal and river flows and reservoir sedimentation and interactions with man-made structures. "The goal was to deepen knowledge of sediment transport mechanisms and their relationship with flow hydrodynamics in order to better understand and predict the evolution of river, estuarine or coastal morphology," says project coordinator Professor Athanassios Dimas.

Better models developed through partnership

Project partners developed algorithms for modelling sediment transport in river and coastal flows and for inland and offshore turbidity currents or debris flows. Models were created along three paths, beginning with a two-phase continuum model and a resolved particle motion model for bed sediment transport. Suspended sediment transport was modelled using advanced coupled fluid-flow/sediment-transport models where the large-eddy simulation approach was applied for the closure of turbulence.

Lastly, two-layer modelling of open-channel flows or gravity currents was coupled with sediment transport and bed morphodynamics. "Modelling was based on advanced numerical methods, for example the immersed-boundary method for the imposition of boundary conditions on complex geometries and the use of parallel computations," explains Prof. Dimas.

Experiments were also conducted for sediment transport in rivers and coasts and for sediment-laden density undercurrents in reservoirs and submarine canyons. These, together with high performance computing, were explored jointly by academic and industrial partners in real engineering applications.

Accurate prediction tools benefit society

Results were integrated into morphology predicting tools for use in the engineering realm by well-trained practitioners. In addition, results from the field experiments enabled crucial advances to be made in the conceptual models upon which the simulation tools were built.

According to Prof. Dimas engineers will benefit directly from the new models and experimental data. “The frequency and magnitude of disasters associated with or caused by excessive morphological dynamism are likely to increase due to climate change,” he comments. “Hence, the prediction tools developed by the project for planners will have profoundly positive societal impacts.”

SEDITRANS supported the coordination of research and educational activities in sediment transport at a European level, increasing Europe’s competitiveness in these important technical and scientific fields. Prof. Dimas concludes:

“The emphasis on numerical models and experimental data will advance research and engineering in sediment transport, addressing large-scale problems concerning planning and protection against floods and erosion.”

SEDITRANS

- ★ Coordinated by the University of Patras in Greece.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/109789>

BRINGING JOINED-UP THINKING TO URBAN PLANNING



Sustainable development needs good urban and environmental planning. Through developing an integrated modelling approach, the EU-funded GEOSINPO project is giving policymakers the planning tools they need.

Making the right decisions in urban and environmental planning is not easy for policymakers. How will self-driving cars change commuting patterns? How would a new train station impact neighbourhood business? And how might urban development affect local water quality? All these decisions will be affected by today’s changing economic situation and global factors, such as population growth, migration, urbanisation and climate change. The GEOSINPO (Geo-Spatial Modelling Informing Policy) project aimed to make taking such decisions a little easier by developing an integrated approach to modelling aspects of environmental change – from land use to transport infrastructure to air quality.

Completed in July 2017, the three-year project was led by Marie Skłodowska-Curie research fellow Harutyun Shahumyan, from University College Dublin (UCD) and scientific advisers

Professor Brendan Williams, UCD and Professor Gerrit Knaap, of the University of Maryland.

“Often it is hard to estimate the full impact of a policy as it may lead to a chain of unforeseen changes,” explains Shahumyan. “Integrated models should have more power to predict outcomes of various scenarios. GEOSINPO aimed to integrate existing computer modelling tools and bring as much additional information as possible to bear on urban planning issues, including demographic, economic, transport and natural resource data.”

Modelling on Baltimore-Washington and Dublin

During the project Shahumyan spent two years working with the National Center of Smart Growth at the University of Maryland, United States. Their state-of-the-art models for the Baltimore-Washington region are able to simulate the feedback between, for example, the use of the transportation network and the development of housing, plus energy-use models can be added to determine energy requirements or pollution impacts.

The project goal was to similarly couple independently developed models into an integrated user-friendly modelling suite for the Greater Dublin region. “Our approach allows us to couple independently developed models without changing their source codes, programming languages or file formats, so it is very versatile,” explains Shahumyan.

Using the examples of the Baltimore-Washington and Dublin regions, Shahumyan and colleagues tested their methods using real data and urban policy problems. For example, they showed, in the Baltimore-Washington region, that the rapid adoption of electric vehicles could encourage more compact

growth, use of public transport, improved air quality and reduced greenhouse gas emissions. The ability to combine environmental models into urban development policy-making has been an important advance and Shahumyan says, “it will help us to assess how social-economic changes in Ireland will ultimately impact water quality in coastal areas such as the Liffey Catchment and Dublin Bay.”

Future development scenarios

The research has also resulted in interesting future development scenarios being investigated, for which there would otherwise be minimal evidence to inform decisions. “In the Dublin region, the often-neglected issue of how regional development affects water pollution was analysed and for different scenarios we looked at the impact on water quality by 2026,” says Shahumyan.

The approach developed by the project allows for the addition of new models relatively easily and both teams in the US and in Ireland intend to use it. Shahumyan has been awarded a further fellowship to continue his research. “We hope with our new enhanced platform, we can improve public policymaking and strategic planning both in Ireland and internationally and that this will contribute to ongoing sustainable development,” concludes Professor Williams.

GEOSINPO

- ★ Coordinated by University College Dublin in Ireland.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/185917>
- ★ Project website: <http://shahumyan.org/project-geosinpo/>
- ★ <http://bit.ly/2Hkkgac>

IMPACT OF GLOBAL WARMING ON TROPICAL FOREST SOILS

Soil microorganisms in tropical forests play a key role in the ecosystem's carbon cycle. However, scientists are concerned that these microorganisms may be adversely affected by increased global temperatures, causing uncertainty in global carbon cycle models.



The EU-funded TROPICALCARBON (Tropical forest soil carbon storage and microbial diversity under climatic warming) project directly addressed this uncertainty in the light of future temperature changes using different approaches. The aim was to determine how soil chemistry and biology (in the form of functional biodiversity) regulate soil carbon storage under climatic warming.

Researchers studied the effect of temperature on microbial diversity along a 3.4 km elevation gradient in the Peruvian Andes. They showed how temperature effects on the nitrogen cycle are closely linked to soil microbial metabolism by measuring changes in extracellular enzymes along this elevation gradient.

Further investigation revealed that certain carbon-degrading extracellular enzymes produced by microbial communities along this elevation gradient showed different temperature responses at different elevations. Such temperature-adaptive responses of enzymes support the idea that microbial communities can adapt to temperature change, regulating their metabolic rates (or enzymatic rates) with consequences for carbon storage.

These findings were included in a collaborative global soil study, which found that 'adaptive' responses of microbial respiration rates were greater in soil from colder sites and in soils with high carbon-to-nitrogen ratios. The project also

found evidence that temperature was directly driving both the diversity and the community composition and plants and soil microbial communities along this gradient.

Soil translocation experiments were also conducted, whereby 50 cm deep soil monoliths were reciprocally transplanted between four sites along the gradient. It was found that carbon chemistry played a fundamental role in determining the rate of decomposition under warming. It was also shown that temperature-adaptive soil carbon recycling responses occur through changes in the composition of soil microorganisms.

TROPICALCARBON also investigated short-term warming responses of lowland tropical forests in Panama. The analyses of soil microbial respiration and physiology demonstrated how phosphorus could play a pivotal role in regulating the stability of deep (below 50 cm) stores of soil carbon in tropical forests.

TROPICALCARBON

- ★ Coordinated by the University of Edinburgh in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/108600>

AGRICULTURE AND FORESTRY

NOVEL METHODS AND PRODUCTS FOR BETTER GLOBAL MONITORING OF AGRICULTURE

According to the United Nations, food production needs to grow by 70% worldwide, and up to 100% in developing countries to meet the demands of a global population that will exceed 9 billion by 2050. Sustainable and well-balanced planning and management of agricultural resources are key to achieving this.

In 2011, the Group of Twenty launched the Group on Earth Observations' Global Agricultural Monitoring (GEOGLAM) initiative to improve crop forecasts and increase transparency in agricultural production. The creation of an operational global agricultural monitoring 'system of systems' based on Earth observation (EO) and *in situ* observations would help to accomplish these objectives.

The need for long-term information on agricultural dynamics

EO-based information systems, which are currently mostly focused on short-term agricultural productivity forecasts, need to be improved in order to assess the various aspects of cultivation practices and their impact on productivity and the environment. This is a key requirement for exploring possible paths towards the long-term sustainability of agriculture. "SIGMA, as part of Europe's contribution to GEOGLAM, actively networked with expert organisations worldwide in a common effort to enhance existing remote sensing-based agricultural monitoring techniques," says Dr Sven Gilliams, project coordinator for the EU-funded SIGMA (Stimulating Innovation for Global Monitoring of Agriculture and its Impact on the Environment in support of GEOGLAM) project.

SIGMA developed innovative methods and indicators to monitor and assess progress towards sustainable agriculture. Focus was on the evaluation of the longer-term impact of agricultural dynamics on the environment and vice versa. To achieve its goals, the project implemented capacity building and data management activities in research and monitoring organisations in Europe, Africa, Asia and Latin America.

SIGMA strengthened national and global agricultural management capacity, and facilitated knowledge exchange through several

training sessions, modules and materials on remote sensing-based agricultural monitoring.

The remote sensing-based methods identify, map and assess: agriculture and cropland changes, globally, regionally and locally; changes in agricultural production levels and shifts in cultivation practices; and environmental impacts of agriculture. The methods "contributed to the establishment of a global observation system for assessing the impact of cropland areas and change in the environment," explains Dr Gilliams. "This will strengthen global agricultural monitoring by improving the use of EO for crop production estimations."

Pooling environmental, agricultural and remote sensing expertise for optimised global monitoring

Project partners ensured data interoperability and accessibility to the GEOSS Data-CORE – a distributed pool of documented datasets with full and open unrestricted access – to support the development of a global 'system of systems' for crop monitoring. This was done by coordinating the collection of EO and *in situ* data and their dissemination, and facilitating data sharing and exploitation among the larger agricultural monitoring community and wider scientific community. They also created new local and global maps of agricultural systems. A database of all products is freely available on a dedicated project server.

An international partnership was established, comprised of GEO Agricultural Community of Practice members and GEOGLAM stakeholders. An active network of agricultural and environmental monitoring and research organisations in Europe, Asia, Africa and the Americas was created. The global network will remain active thanks to GEOGLAM and Joint Experiment of Crop Assessment and Monitoring.

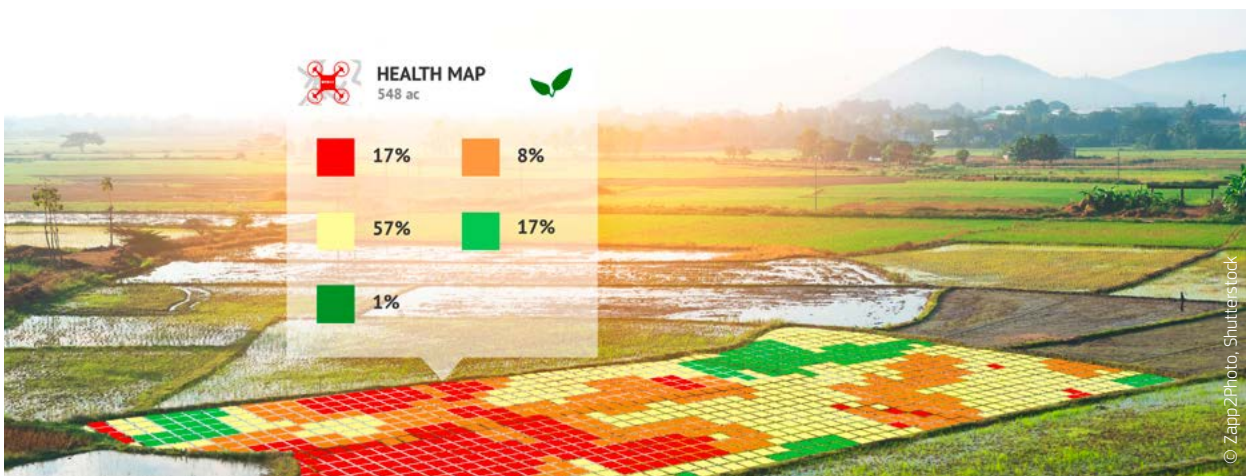
According to Dr Gilliams, the new products and methods will help policy- and decision-makers to better understand how ecosystems and agricultural sustainability is influenced by changes in cropland distribution and cultivation practices. "SIGMA gathered European and international partners well renowned in agricultural monitoring," concludes Dr Gilliams. "As such, the key components are in place for a global agricultural monitoring system that will bring together and harmonise monitoring efforts around the world."

SIGMA

- ★ Coordinated by the Flemish Institute for Technological Research in Belgium.
- ★ Funded under FP7-ENVIRONMENT.
- ★ <https://cordis.europa.eu/project/rcn/111201>
- ★ Project website: <http://www.geoglam-sigma.info/Pages/default.aspx>
- ★  <http://bit.ly/2Hheoic>

ENHANCED SATELLITE IMAGES EXTEND PRECISION AGRICULTURE

Satellites are without doubt becoming more and more relevant to everyday life, bringing also a growing number of benefits to the agricultural sector. An EU-funded project is using enhanced satellite data from the Copernicus programme to increase European crop production and improve environmental sustainability.



Precision agriculture (PA) uses satellite imagery to manage farms with a high degree of accuracy. A key development in PA is the EU's Copernicus programme for Earth observation (EO), whose Sentinel satellite missions provide a wealth of information about growing conditions and crop health, which is used to improve agricultural efficiency.

Sentinel-1 provides all-weather, day and night radar imaging of land and sea, while Sentinel-2 provides high-resolution optical imaging for land services such as imagery of vegetation and soil water cover. By monitoring crop conditions and soil properties and mapping tillage activities, the satellites can help assess land use, predict harvests, monitor seasonal changes and support the implementation of sustainable development policies.

Forecasting key performance variables

The AgroRadar (Using Copernicus Earth Observation radar data to disrupt Precision Agriculture) project is developing algorithms and data models to process Copernicus' EO Synthetic aperture radar (SAR) data. The resulting images are more detailed and precise than those from any other PA service in the world. Project coordinator Professor José Rafael Marques da Silva explains: "SAR imagery is obtained through a SAR active sensor that sends a specific electromagnetic radiation to the Earth and reads the electromagnetic radiation that comes back, providing information about the Earth surface and crops."

The images produced by AgroRadar enable farmers to forecast key agronomic performance variables. They are used to improve the application of fertilisers as well as the detection

of crop anomalies due to soil, water, pests, disease and other factors. According to Professor Marques da Silva, "The images can also be used to forecast crop trends and foresee agronomic best practice as well as potential economic issues, in order to improve farmers' return on their investment."

An all-weather solution

SAR imagery has an advantage over optical data as it is not affected by clouds or fog. This allows full use of the five-day imaging timeframe available through the Copernicus Sentinel satellites and the creation of weekly reports for end users such as farmers, who need to take management decisions on a week-by-week basis. "SAR imagery, although technically more complex, can be correlated with optical imagery to create exciting new applications for agricultural management," says Professor Marques da Silva.

In addition, SAR data can be used to resolve specific issues that cannot be tackled using normal optical satellite data, such as the estimation of biomass under forest canopy for the production of fire maps. Other examples include estimating the yield of shaded coffee and tomato crops, and precise yield calculations for rice, vineyards and olive groves. It can also help to identify over-watered areas and leaks, and map water-based plants and eutrophication.

Increased PA services

Besides using remote sensors, AgroRadar will also benefit farmers in the near future by integrating data from proximal sensors (like those used in the Internet of Things) with

AGRICULTURE AND FORESTRY

other agricultural data, such as for soil, plants, water, pests and fertilisers. By applying this Big Data approach, which combines both human and artificial intelligence, farmers will be able to maximise crop yields and quality while protecting the natural environment.

Agricultural maps produced from the data will also enable independent estimates of cultivation in any given country, which can help efforts to ensure food security in vulnerable areas. AgroRadar therefore goes beyond current PA services by providing low-cost solutions to small and medium-sized

farms, and new services to asset owners (such as banks and insurance companies) and to government agencies for use in fire prevention and controlling subsidies.

AGRORADAR

- ★ Coordinated by Agroiinsider LDA in Portugal.
- ★ Funded under H2020-SMEINST.
- ★ <https://cordis.europa.eu/project/rcn/207939>
- ★ Project website: <http://www.agroiinsider.com/>

ENSURING THE QUALITY OF CHICKEN MEAT PRODUCED IN THE EU

An EU-funded project has developed technology to assess the quality of chicken meat trimmings, potentially boosting the competitiveness of the EU processed meat market.

Chicken meat that has been removed from the bones by a machine must be labelled as 'mechanically deboned' under EU rules. However, this label pushes down the price of meat, holding back the competitiveness of the sector.

The EU-funded MEAQUAS (Automated and objective characterization of comminuted meat properties for valorization of high quality processed meat) project aimed to boost the competitiveness of chicken meat produced in the EU with innovative tools to assess the quality of mechanically deboned meat. This will allow high quality mechanically deboned meat produced in the EU to be identified and compared to lower quality mechanically deboned meat which is often imported from outside the EU.

"MEAQUAS aims to become the new industry standard for the quality of meat removed by machine, boosting the competitiveness of the EU's meat industry which comprises around 25000 companies working in the production of meat products," says Poul Erik Damkjær, MEAQUAS project coordinator.

Project scientists have developed a new method to automatically analyse and grade the meat using novel staining markers that highlight muscular structures. The software then uses image processing algorithms to quantify the degree of degradation in the meat.

MEAQUAS' technology quantifies the loss of structural integrity in the chicken meat, a key indicator of the meat's quality and a way of proving that mechanically deboned meat is of the same quality as hand-removed meat.

MEAQUAS hopes that regulatory bodies will define criteria for different meat qualities using the results of the project's measuring technology. Ultimately, quality screening will enable high quality mechanically deboned meat to be labelled simply as 'chicken meat', improving its market value.

Whole chickens to chicken pieces

A few decades ago, chicken was widely sold as a whole chicken. However, from the 1990s chicken parts started being sold separately as thighs, breasts and wings. After separating the bird, small parts of the chicken are left over – known as the trimmings – which can be used for minced meat products. These parts are made from muscle which is high quality meat.

However, the meat from the trimmings is commonly separated using a machine to rub the meat off the bones. "During the 1980s, so-called food experts decided that this meat could only be of poor quality since it was removed mechanically," explains Damkjær. "In fact, they started a false campaign that led consumers to believe that entire chickens were being run

through a mincing machine, giving the impression that mechanically removed meat contains bones, skin, feather remains, giblets, intestines etc.," he adds.

As a result, mechanically removed meat gained a poor reputation and began to be shunned by customers. Reflecting consumer concerns, new EU rules came into place that required products containing mechanically removed chicken to be labelled as Mechanically Deboned Meat (MDM), while products containing chicken trimmings removed by hand could be labelled simply as chicken meat.

Today, mechanically deboned chicken has a value of around EUR 0.60 – EUR 0.90 per kilogram, while hand-boned trimmings are worth EUR 1.60 – EUR 2.80 per kg because they can be labelled as 'meat'. If products produced by machine could be labelled to reflect the quality, meat could be sold at a higher price benefitting the meat sector.

The project focussed on chicken meat, but test runs of the technology on different meat – pork and turkey – were positive. With some fine tuning, the staining techniques developed by MEAQUAS can be adapted to most animal species, potentially becoming of enormous benefit to the EU's slaughter industry.

MEAQUAS

- ★ Coordinated by Robert Damkjær AS in Denmark.
- ★ Funded under H2020-SMEINST.
- ★ <https://cordis.europa.eu/project/rcn/208166>
- ★ Project website: <http://damkjaer.dk>



INDUSTRY

NEW MATERIALS FOR LIGHTER, MORE EFFICIENT STRUCTURES

The EU-funded INCOM project has used cellulosic nanofibre to reinforce composite sandwich structures, thus reducing their weight and increasing their sustainability.

The EU-funded INCOM (Industrial Production Processes for Nanoreinforced Composite Structures) project has developed technologically and economically viable solutions and production methods for lightweight structures based on advanced sustainable materials geared towards packaging, vehicles, sporting goods and aeronautical applications. “Essentially, we helped develop and manufacture lightweight, sustainable and durable composite sandwich structures for a range of different applications,” explains Lisa Wikström, INCOM project coordinator. “The key to our success was the use of new ways for manufacturing cellulosic nanofibre, or CNF, a nano-scale material derived from cellulose found in biomass and bio-waste, which is used to reinforce the composite sandwich structures.”

Lightweight sandwich core structures create new opportunities for decreasing the weight of composite structures and/or replacing petroleum-based raw materials in composites. For example, sandwich composite materials can replace monolithic structures in many applications, thus saving input materials, reducing the overall weight and generating less waste at the product's end of life. Sandwich structures with low cost core and increased performance skin materials yield lightweight and cost-effective composites. Moreover, the reduced use of materials in sandwich composites, compared to monolithic structures, reduces their environmental impact. In transportation and aviation, lightweight structural materials mean fuel savings and a reduction in CO₂ emissions.

Manufacturing CNF

Specifically, the project developed a range of products, including: rigid nanocellulose fibre-biopolyurethane composite foams, extruded and particle foamed bio-based polylactide foams, cellulose fibre reinforced honeycomb structures, and polycarbonate honeycombs with outstanding fire-smoke-toxicity performance. To do so, the project used two approaches for manufacturing, modifying and processing CNF. The first involved the fibrillation of cellulose in a pre-polymer using basket bead milling. The second involved fibrillation of bioresidue-based cellulose in aqueous media by grinding and developing a quality assessment tool for optimising the process.

Pilots implementing both CNF production routes were then performed with various industrial partners. CNF reinforced resins were used to manufacture composite and lightweight sandwich structures, for which three types of cores were developed: expanded NFC reinforced bio-based PU foam, bio-based thermoplastic foam, and thermoplastic honeycomb. Furthermore, industrially viable production methods were also developed.

“CNF reinforced bio-PU foams were found to perform at the same level as commercial PU foams,” says Wikström. “We also found that the addition of CNFs further improved the compressive strength and modulus of the foams.”

Potential for a big impact

The project led to the development and upscaling of a number of novel composite structures and viable processing techniques, each presenting a high potential for commercialisation. Furthermore, these solutions have led to new and improved production methods and sustainable and/or cost-efficient product demonstrations, which will likely lead to new commercial products and product families.

“With the results achieved by the INCOM project, the composite industry now has better possibilities for production using enhanced, more environmentally friendly and less hazardous processes and materials, resulting in products with reduced weight, optimised performance and improved end-of-life disposal,” adds Wikström. “The combination of new manufacturing processes with new materials and surface treatment concepts promotes new design and creates employment opportunities, particularly for product development and engineering in Europe.”

INCOM

- ★ Coordinated by VTT in Finland.
- ★ Funded under FP7-NMP.
- ★ <https://cordis.europa.eu/project/rcn/109049>
- ★ Project website: <http://www.incomproject.eu/>

HOW UNVEILING ZEOLITE'S STRUCTURAL DEVELOPMENT WILL BENEFIT FUTURE SYNTHETIC DESIGNS

Expanding the zeolite 'window of flexibility' offers materials science more control over the design and designation of Metal-organic frameworks (MOFs) for their catalytic properties, introducing new applications.



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Researchers drawing on work conducted by the EU-funded GROWMOF (Modelling of MOF self-assembly, crystal growth and thin film formation) project have successfully used molecular simulations to better understand the structure of zeolite aluminosilicate.

These insights will be valuable to efforts being made to design 'hypothetical' synthetic versions, intended to offer a wider range of material science applications for these excellent catalysts, filling a gap in the market.

The 'window of flexibility'

A zeolite is a special type of rock which can trap water within it and is associated with 200 minerals. Zeolite aluminosilicate has so far supplied chemistry with useful catalysts, enabling a wide range of products from industrial chemical processors to cat litter.

While the tetrahedral framework structure of zeolites creates the perfect shape, surface area and chemical activity for effective catalysts, their industrial adoption is hampered by the narrow variety of frameworks available. Much research has been expended into the generation of millions of new hypothetical versions to be synthesized, but success has so far been limited.

The team, publishing in 'Royal Society Publishing', explored the so-called 'window of flexibility', whereby the zeolite framework structure allows scientists a degree of atomic manipulation, while keeping the overall structure intact. Previous research had indicated that this phenomenon is present in almost all known naturally occurring zeolites, the only exception being goosecreekite. At the same time, it is uncommon in the hypothetical structures created by scientists, suggesting its existence

would make that hypothetical a good candidate for synthesis.

Offering hope for the location of more promising candidates, the researchers adopted simulation techniques to demonstrate that using softer constraints in the manipulation of the 'bar' parts of the zeolite tetrahedral structure could open the window of flexibility around aluminium sites. Using this technique, the team were even able to find evidence of a flexibility window in goosecreekite.

Advancing materials science

The study complements the team's recent investigation of flexibility and the extra-framework content in faujasite. Additionally, it builds on their work to extend the methodology of geometric simulation software to better understand MOFs. MOFs are three-dimensional structures with metal corners and organic

molecule linkers and are considered to be amongst the most exciting developments in nanoporous material science, as they offer a near infinite range of material combinations. Applications mooted by GROWMOF include gas separation and drug delivery.

GROWMOF was set up with the understanding that for MOFs to reach their potential, more predictability in their synthesis was required, alongside a

better appreciation of the resultant material properties, as well as of the full pathway from molecular assembly to crystal growth and thin film formation.

Towards this end, this latest study clearly demonstrates that geometric simulation for framework structures can be extended beyond its original remit of modelling silica (SiO₂) systems. The researchers are confident that the work could fundamentally transform our

understanding of how MOFs form at a variety of length scales, while opening up new research avenues for the targeted synthesis of MOFs.

GROWMOF

- ★ Hosted by the University of Bath in the United Kingdom.
- ★ Funded under H2020-ERC.
- ★ <https://cordis.europa.eu/project/rcn/194531>

NEW TURBINE TECHNOLOGY TO BOOST MICROMACHINING EFFICIENCY

The development of miniature radial turbines looks set to make high-speed manufacturing spindles – from micromachining to paint spraying machines – much more energy efficient.

In a world where competing resources and increasing pollution are making our lives more challenging, industry is looking at how to make equipment and machinery more energy efficient and cost effective. The EU-funded OpTEMUS (Optimising turbo-spindle efficiency for machining at ultra-high speed) project researched how to improve the energy efficiency of ultra-high speed spindles used in precision machine tools.

The early investigations of the OpTEMUS project revealed that the energy efficiency of existing commercial turbine spindles ('turbo-spindles') is typically less than 20%. Aiming to increase spindle efficiency and power-to-weight while lowering costs, the project team proposed a new 90-degree radial-inflow type turbine for micromachining spindles.

To improve spindle performance, the OpTEMUS team articulated a low reaction and highly loaded radial turbine stage design that achieves high turbine efficiency whilst minimising inertia, weight and size. Computational fluid dynamic

simulations were used to determine key design parameters such as blade thickness, number of blades, rotor outlet blade angle, and the radial gap between rotor and stator. The

new design also boasts low turbine thrust forces to reduce the axial load on the spindle bearings, as well as low blade speed that helps in manufacturing the rotor using a magnesium alloy for further inertia savings.

The new prototype turbine rotor, which has an outer diameter of 25 mm and inlet blade span of 1.9 mm, was built using an aluminium alloy. The prototype spindle weighs less than 300 g and has a static radial stiffness (at toolholder) of 0.66 N/μm.

The newly developed turbo-spindle has been operated successfully up to 100 000 rpm and has clocked over 24 hours of running time. To measure torque and power output, the prototype turbo-spindle was attached to a high-speed electric motor/generator and loaded with a range of resistors. Maximum turbine power output of approximately 100 W and

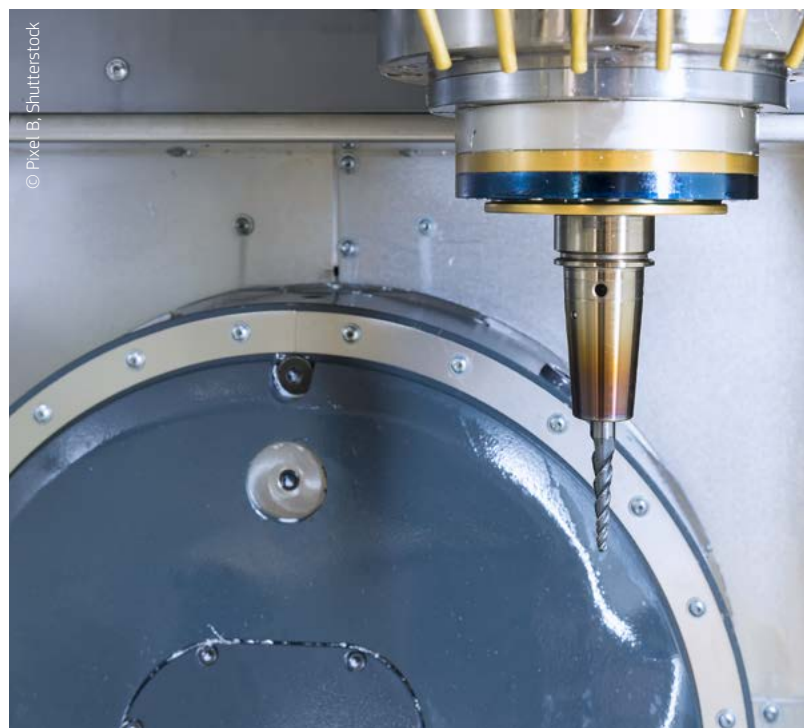
efficiency of over 50% have been achieved to date, thus demonstrating the performance improvements possible.

Armed with these positive results, the OpTEMUS team joined forces with industrial partners to submit two funding proposals for further research projects. In addition, the team has been investigating commercialisation options for the new technology, including its potential benefit for power tools, paint spraying equipment and medical/dental devices. Once the project's outcomes are fully exploited, industry is poised to benefit from much more efficient manufacturing equipment.

OpTEMUS

- ★ Coordinated by Queen's University Belfast in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/186224>

“Maximum turbine power output of approximately 100 W and efficiency of over 50% have been achieved to date.”



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NANOTECH-ENHANCED AYURVEDA FOR HEALTHIER FOOD

Ayurveda has been practiced in India for over 5 000 years. Yet, this alternative medicine consisting essentially of massage therapies and special diets has never really broken through into European markets. An EU-funded project is using nanotechnology to bring Ayurveda compounds to industrially-processed food products.



“Nanoparticles entrapment can be used to mask the unwarranted change in the food products’ organoleptic properties.”

In Europe, Ayurveda is considered as a pseudoscience. But even though evidence is lacking to support its scientific claims, some of the ingredients at the heart of the Ayurveda diet have gathered some scientific attention for their assumed virtues. According to Prof. Ian Norton, Chemical Engineer at the University of Birmingham, some of these ingredients – which he calls Ayurvedic bioactive compounds (ABC) – deserve rigorous scientific investigation to see whether they could help control chronic health problems such as obesity.

This begs an important question: If they have so much potential, how come ABCs have not been integrated into our food? Prof. Norton says there are three main reasons for this. The first is a lack of sufficient scientific research and safety studies to tailor Ayurveda ingredients to European foods, which are in fact very different from Asian ones, along with the difficulty in obtaining approval from concerned authorities. Then comes the issue that the addition of Ayurveda compounds will change the organoleptic property of food. To put it simply, Ayurveda-enhanced food will become more spicy and sour than what most European consumers can handle.

Finally, there is the way we make food here in Europe. “Unlike Asian countries where people cook food daily, Europe and other developed countries use more industrially-processed food products which have a longer shelf life. This extended storage time means that there is a greater chance of losing the properties and benefits of these compounds.” This is particularly problematic, as Ayurveda compounds are notorious for their instability. They are sensitive to light, temperature, pH or oxygen, which means that adding them to industrially-processed food would require an innovative delivery technology.

According to Prof. Norton and his team, nanotechnology might be just the candidate, as it can increase the stability, bioavailability and acceptability of these Ayurveda compounds. “Nanoparticles can be used to encapsulate sensitive bioactive compounds within nano-compartments to protect them from degradation due to exposure to heat, light, oxygen, etc. Similarly, in the gastro-intestinal tract, these nanoparticles can be used to increase the bioavailability of Ayurvedic compounds by increasing their dissolution velocity in biological fluids, cellular uptake and stability. Furthermore, nanoparticles entrapment can be used to

mask the unwarranted change in the food products’ organoleptic properties.”

This so-called ‘nanocrystals technology’ was the core focus of the NSEF (Nano Structured Emulsion Foods) project. Thanks to EU funding, the team aimed to fabricate ABC nanocrystals as well as use these nanocrystals as edible pickering particles to control emulsion functionality.

“In general, nanoparticles (both amorphous and crystals) are fabricated by using a bottom-up approach, a top-down approach or by combining the two. In our study, we used a bottom-up approach to fabricate nanocrystals of curcumin,” Prof. Norton explains. Although these nanocrystals have yet to be incorporated into real food products, the preliminary results were satisfactory and the team is now hoping to move forward, boosted by interest from various players in the food processing industry.

“We are currently looking for funding to further explore the feasibility of using Ayurveda for the benefit of European citizens and also an industrial collaboration to take our research beyond academic pursuit,” Prof. Norton concludes.

NSEF

- ★ Coordinated by the University of Birmingham in the United Kingdom.
- ★ Funded under H2020-MSCA.
- ★ <https://cordis.europa.eu/project/rcn/195551>

INFORMATION AND COMMUNICATION TECHNOLOGY

ROBOTIC EXOSKELETONS GET THE BALANCE RIGHT

Being mobile while maintaining balance is no easy task, especially for the elderly or injured. EU research has looked into getting there, ultimately without crutches.

Maintaining balance and avoiding falls can be very challenging for the elderly, spinal cord injury patients or workers performing difficult, strenuous tasks. Key examples are very common in the construction industry, lifting heavy loads, mountain rescue or simply for moving around if impaired physically.

Exoskeletons available at the moment and their shortcomings

The EU-funded BALANCE (Balance Augmentation in Locomotion, through Anticipative, Natural and Cooperative control of Exoskeletons) project has researched and designed exoskeletons that provide support for standing and walking, while avoiding falls. "Future applications are foreseen in rehabilitation training and in advanced support of the elderly and, of course, in all such cases, falls should be avoided and balance maintained," states Dr Jan Veneman, project coordinator.

Currently, state-of-the-art exoskeletons are used to provide mobility for paralysed spinal cord injured patients for short periods of time. Exoskeleton products provide weight support through the standing leg and swing motion to provide support in the swing leg.

However, they don't have any means to manage the overall posture or to maintain balance. In these cases, use of crutches, hand support bars, an overhead harness or even human assistance helps prevent a fall.

BALANCE systems and novel robotics

The main thrust of the BALANCE research was measuring human balance control and how to apply it in robotic systems. Algorithms incorporated loss of balance as measured in real time during movement. Novel robotic devices that pushed humans in a specific direction measured the components of balance control and how it was achieved. The researchers also modelled human balance and how people react to movement support.

Completely new approaches where the exoskeleton provides zero resistance to the user (transparency control) and with head rotation initiating turning in position of the exoskeleton were developed. A first, researchers used an exoskeleton to successfully support reactive stepping to pushes while standing and walking.

One major drawback of current wearable motion capturing systems is that metal

structures and electrical components distort their measurements. BALANCE, in collaboration, further developed a wearable motion capturing suit to be robust when faced with magnetic disturbances to overcome this problem.

From the gait lab to the human-cooperative robotic exoskeleton arena

Project researcher ingenuity was the driving force behind the EMY exoskeleton co-developed with other projects that suffered from substantial delays. A mitigation strategy had to be formulated, which involved replanning the whole of the second half of the project and the use of LOPES II and BAR-TM. Developed by other members of the consortium, LOPES II is a treadmill-based exoskeleton and BAR-TM is a pelvic support robot.

Taking BALANCE deliverables into the movement rehabilitation centre, project results were used to assess and train balance in stroke patients via robotic devices developed from BALANCE research. The project also significantly contributed to various spin-off initiatives including the European Network on Wearable Robots,

safety standards under the International Organisation for Standardisation and the International Electrotechnical Commission for personal care and medical applications of exoskeletons and the establishment of a benchmarking network in Europe.

“Concrete steps towards commercialisation together with patents have been obtained for three solutions – the magnetic-immune motion capturing

suit, the algorithms to measure quality-of-balance in real-time, and BAR for balance assessment and training in stroke rehab,” explains Dr Veneman. “Now the project has finished, every partner will proceed with development of their own contributions to the BALANCE project.”

Dr Veneman’s view of the future for robotics in this rapidly expanding area is that “The ultimate goal is to have the

exoskeleton seamlessly cooperate with the human user.”

BALANCE

- ★ Coordinated by Tecnalia in Spain.
- ★ Funded under FP7-ICT.
- ★ <https://cordis.europa.eu/project/rcn/106854>
- ★ Project website: <http://www.balance-fp7.eu/>

UNDERSTANDING RESISTANCE DRIFT IN AMORPHOUS SEMICONDUCTORS

By working out experimentally, and with computer models, why phase change memory devices suffer from resistance drift, researchers with the EU-funded DIASPORA project are laying the groundwork for a whole new generation of hyperdense non-volatile DRAM chips.



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Memory chips in common devices like computers, smartphones and USB drives usually save one bit of digital information in each of the chip’s tiny memory cells. To do this, a bit, which can have a binary value of either 0 or 1, is stored as a voltage across a capacitor.

But if many bits could be stored in each cell, memory chips could store far more data. Two bits per cell would double memory capacity, say, whilst three bits would triple it, and so on. A class of substances called Phase-change materials (PCMs) could implement such multibit storage but, because their electrical properties are not understood well enough, the DIASPORA (Drift In Amorphous Semiconductors – A Partnership Of Rüsclikon and Aachen) project set out to try to comprehend them.

Phase change materials like Germanium antimony tellurium (GST) can exist in two molecular phases: an ordered crystalline-structured phase, and a disordered amorphous one. When sandwiched between two electrodes, passing different electric currents through a tiny blob of GST heats the material and reversibly changes it from one phase to the other.

The real prize: multibit memories

But the GST blob does not have to exist entirely in one phase or the other: it can be a bit of both. The ratio of amorphous to crystalline material in the memory cell can be varied by applying different heating currents – and each mixture of the two phases has its own characteristic resistance.

“The ability to set different resistance values would enable the storing of more than one bit of information in a single phase change material device,” says DIASPORA project coordinator Abu Sebastian at IBM Research in Zurich, Switzerland. With four resistance values, for example, the cell could represent the four logical states that a two-bit memory could store: 00, 01, 10 and 11. And with eight resistance values, it could represent three bits, and with 16 resistance values, four bits. So it has potential to be a powerful multiplier of memory capacity.

Drifters spoil the party

But while PCMs hold great promise, there’s a problem: the resistance of GST in its amorphous phase drifts upwards over time, which could make a multibit phase change memory unreliable. “So our goal in DIASPORA was to gain a deep understanding of the underlying physics of this resistance drift,” says Sebastian, so it can be defeated in future multibit devices.

To understand drift, a team led by Sebastian and Martin Salinga, DIASPORA project lead at RWTH Aachen, in Germany, undertook electrical, spectroscopic and optical experiments on nanostructured PCM devices at varying temperatures to investigate how the resistance of GST changes. They also investigated how defects in the material’s molecular structure significantly exacerbate resistance drift. They then used their experimental data to create computer simulations that have led to the synthesis of the most quantitatively accurate description of resistance drift in PCM devices to date.

Their pioneering model demonstrates how the root cause of the resistance drift is the spontaneous structural ‘relaxation’ of the amorphous material. “The amorphous state over time evolves towards an energetically more favourable ideal glass state,” says Sebastian.

What’s next for PCM?

DIASPORA’s findings, and its revolutionary computer model, are a significant step towards helping researchers create reliable multibit PCM memories. “The ability to store three or more bits in a single PCM device will be a game-changer in terms of storage capacity and cost effectiveness,” predicts Sebastian. “It could also enable applications that go way beyond memory such as brain-inspired computing, where PCM devices can serve as neuronal and synaptic elements in what is known as a neuromorphic computing system.”

In future research, Sebastian hopes to build on DIASPORA to explore the design of novel phase change device architectures that mitigate resistance drift – and also work out just how small a piece of confined phase change material can be and yet still operate as a memory device.

DIASPORA

- ★ Coordinated by IBM Research GMBH in Switzerland.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/109723>

OPTIMISING BROADBAND INTERNET CONNECTIONS

The EU-funded INSPACE project uses Space division multiplexing (SDM) technology to create a sustainable broadband connection.

The internet and broadband applications that we all use on a daily basis via our connected devices require huge amounts of bandwidth. The associated broadband traffic, especially for video-based applications, increases with an annual growth rate of more than 50%. If society wants to keep pace with such developments, it must continuously upgrade the capacity of its backbone broadband networks in a way that is both scalable and cost effective.

Using SDM technology, the INSPACE (Spatial-Spectral Flexible Optical Networking: Enabling Solutions for a Simplified and Efficient SDM) project is ensuring the sustainability of today's broadband internet based society. "Our objective was to develop innovative networking solutions that offer network capacity scalability beyond what current solutions offer and in a cost-efficient and power-effective way," says Project Technical Manager Ioannis Tomkos. "What we achieved were significant conceptual and technological advancements in the area of optical networking, many of which are now being used by renowned research groups around the world."

Core fields of development

The project focused on three core fields of development. First was the implementation of an advanced software-defined and controlled high-throughput network node. This in turn required project researchers to first design and develop new hardware that could simultaneously handle the network traffic coming from multiple network directions and fibre links.

Second, the project developed new optical fibre transmission models and impairment mitigation solutions. "This ensured that we could achieve excellent system performance and signal transmission over very long distances, as is required in core networks," explains Tomkos.

Last but not least, the project developed algorithms for optimising network resources. These algorithms have built-in control plane extensions to efficiently support the effective handling of all available resources in the optical frequency/wavelength (i.e. multiple wavelengths/frequency slots) and space (i.e. multiple fibres) dimensions.

A competitive edge

Working on these aspects put INSPACE researchers at the forefront of the Optical Networking field of SDM – a topic that was in its infancy at the time the project first launched. "Over the duration of the project, INSPACE was in fierce competition with other major research programmes happening around the world, including Japan and the US," says Tomkos.

However, it was the project's unique addition of spectrally-flexible optical networking concepts to the SDM approach that gave INSPACE the edge. "We accomplished this by implementing the so-called spatial integration of

optical network elements for a spectrally-flexible optical network based on super-channels," explains Tomkos. "We did this in a way that their use can be shared for multiple parallel WDM systems running over multiple spatial dimensions, thus creating the potential for huge capacity scaling and cost-per-bit reduction through optical fibres/components integration and sharing."

According to Tomkos, the entire optical communications/networking scientific community anticipates that SDM, in combination with spectrally flexible optical network solutions (i.e. what INSPACE touts as 'Spatially-Spectrally Flexible Optical Networking': SS-FON), will become the key solution to the looming capacity crunch.

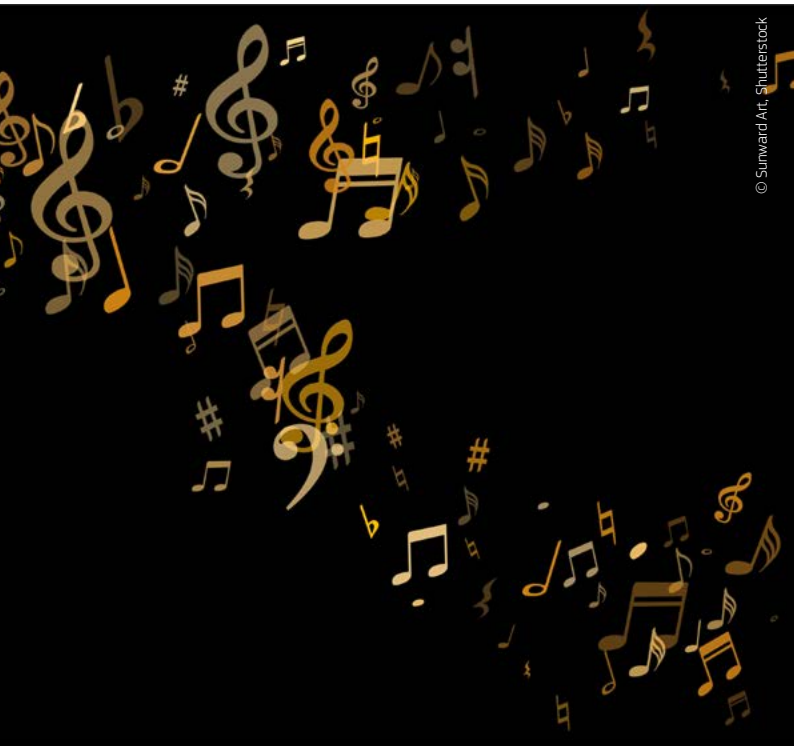
INSPACE

- ★ Coordinated by Optronics Technologies A.B.E.T.E. in Greece.
- ★ Funded under FP7-ICT.
- ★ <https://cordis.europa.eu/project/rcn/189132>



SOUND-TO-NOTATION APP MAKES NOISE IN THE MUSIC INDUSTRY

A hybrid technology drawing inspiration from virtual assistants and apps such as Google Translate is now available to musicians across the world. Using it allows for translating sounds into music notations with unmatched accuracy.



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For the laypeople who simply want to enjoy music in their car or through headphones, music notation's complexity has always been off-putting. Not only is it uneasy to read, but it's even harder to write fluently, especially when dealing with polyphonic musical sound. It is nonetheless a crucial process: many musicians would agree that notation makes for better music.

For these musicians, something as revolutionarily easy as a Google Translate for music notation would be a dream come true, as Prof. Sven Ahlbäck of Swedish company Doremir Music Research AB underlines. "Musical ideas, songs or tunes, can suddenly pop up in your mind, and when it happens it is important to catch the idea quickly before it vanishes. To notate music by hand or on computers has always been a slow process that takes time to master and requires you to analyse the syntax of the music, to recognise time signature, tempo, key, etc. Being able to go straight from musical idea to music notation would mean important time-savings for many musicians."

They need look no further: ScoreCloud, a virtual notation assistant available as PC/Mac software and an iOS app, is now available for download under both free and monthly paid plans, thanks to support under the SME Instrument. You can think of it as a virtual assistant like Amazon's Alexa or Apple's Siri, spiced up with an instant-translation feature: sing or play an instrument, and ScoreCloud will notate the music for you, from which point you can develop your ideas into arrangements and composition within the app. Thanks to the my.scorecloud web service, you can even share your notations with the world.

"For many years, I have been researching how people perceive musical structure and found that this research could be used for building computer software that makes music notation automatically," Prof. Ahlbäck explains. "This is how ScoreCloud was born, so as to help all musicians – from beginners and music amateurs to professionals – who need to have their music played by someone else or want to develop it by means of music notation."

Music complexity isn't a barrier either. As Prof. Ahlbäck points out, ScoreCloud's cognitive modelling mimics how we perceive music and tries to come up with a music notation that is not only accurate, but actually readable. It will differentiate between several voices and simplify the musical score, just like a human musician who notates music would.

Making ScoreCloud able to cope with this complexity is actually the very reason that pushed Doremir to seek EU funding. "A major issue for automatic music notation has been to analyse polyphonic musical sound, in which more than one note sounds simultaneously. Just a few years ago the level of performance of polyphonic pitch recognition was far from sufficient to produce musical scores from common polyphonic instruments such as piano or guitar. We wanted to see if, by using the most modern technology in combination with cognitive modelling, we could break this barrier to make automatic music transcription from polyphonic sound a reality. The EU funding gave us this possibility," says Prof. Ahlbäck.

Looking back, the polyphonic pitch transcription system developed under the DOREMIR (Automatic music transcription of polyphonic audio) project even exceeded initial expectations. Prof. Ahlbäck speaks of a performance setting a world record. "Beta tests resulted in people describing ScoreCloud as the 'missing link' between sounding music and music notation. We have also received interest from other software companies that want to make use of our technology," he enthuses.

Although the project was completed in September 2017, Prof. Ahlbäck and his team have 'a long line of products' in the pipeline, including cross-platform apps targeting singers, songwriters or children who want to learn about music. "This technology makes it possible to analyse the content of music on a level never seen before, which in turn opens the door to applications in the likes of musical content search, music recommendation systems, etc. We are also currently releasing a musical message app, which musifies messaging. The possibilities are endless," Prof. Ahlbäck concludes.

DOREMIR

- ★ Coordinated by Doremir Music Research AB in Sweden.
- ★ Funded under H2020-SMEINST.
- ★ <https://cordis.europa.eu/project/rcn/197135>
- ★ Project website: <http://x-score.eu/>
- ★ <http://bit.ly/2GfP6zT>



SPACE

TAKING ADDITIVE MANUFACTURING INTO THE SPACE AGE

EU-funded researchers have developed an additive layer manufacturing process – based on applying metallic powder – that can create parts for space missions, manufacturing tools and industrial moulds.

Additive layer manufacturing is a resource and time-efficient industrial process that applies material, layer by layer, to create 3D parts. Sectors ranging from aerospace through to mould manufacturers have identified this technique as having great potential for reducing the amount of raw material needed to begin with. What the 4M (Development of a Machine for Multi-Material Manufacturing) project has done is to add a great deal of flexibility to this process.

“The main goal of the 4M project was to develop elements of a unique additive layer manufacturing process based on metallic powder,” explains project coordinator Dr Erich Neubauer from RHP Technology, Austria. “This metallic powder, consisting of particles of some tens of micrometres, is

injected into a plasma torch that is applied like a manual welding torch.”

The results are currently being analysed at the feasibility level by the European Space Agency, and the project team is also hopeful that the process could have potential in the manufacture of turbine parts for hydropower generation.

Digital slicing

While the plasma torch was the starting concept from the hardware side, the project team also developed a software system that takes the electronic file of, say, a cup, makes a 3D picture and applies a slicing algorithm. Each layer of the cup, digitally cut up by the software, is then fed through the 4M system to the hardware – the torch – which builds up a real 3-D

cup using the plasma torch to melt the metallic powder.

Lightweight, flexible solutions

One of the elements that make the newly-developed system innovative is that it works with several different materials at the same time. The plasma torch can be fed through several nozzles with different materials in sequence or at the same time.

Having developed a prototype of the plasma torch and additive manufacturing system, the team investigated several different material systems. “This concept allows us to manufacture multi-material shapes,” says Neubauer. “If we take our cup example again, we could build up the lower section in one

SPACE

material, and the upper part in another.” This allows manufacturers to put in functionality, which is important for applications like space. “Here we could add a lightweight component for example, and then add something else to increase hardness.”

Indeed, space has been a key driver of this technology. Components used in space generally need to be lightweight and not very large, which means that the additive manufacturing concept is very interesting in terms of cost savings and lead time reduction. Starting with a big block of metal for example

means that the amount of material that sometimes needs to be subtracted by machining to produce the part you need can be up to 90%.

The additive manufacturing concept pioneered by the 4M project by contrast only uses the amount of metallic powder needed to build up the object required and only a residual amount of material needs to be finally taken off through subsequent machining.

Neubauer believes that the way forward now is to focus on further refinement. “Our original idea had been to develop systems that we could then

commercialise, but I don’t feel we are yet at this level,” he says. “This would require much more investment. What we want to do instead is to establish a manufacturing centre that duplicates our set up in the project. This will provide products and parts on demand.” The company is currently in negotiations over establishing this facility.

4M

- ★ Coordinated by RHP Technology GmbH in Austria.
- ★ Funded under H2020-SMEINST.
- ★ <https://cordis.europa.eu/project/rcn/197185>

DISCOVERY OF A RING AROUND THE DWARF PLANET HAUMEA

The dwarf planets beyond Neptune’s orbit have remained relatively mysterious due to how far away and small they are. Researchers supported by the EU-funded LUCKY STAR project, recently reported unexpected findings, including the first object in the solar system beyond Neptune to have a ring.

Located beyond Neptune, Haumea is one of five dwarf planets, a new category adopted by the International Astronomical Union in 2006 to accommodate new planetary findings. Haumea was first recognised in 2008 and compared to the other dwarf planets, Pluto, Ceres, Eris and Makemake, has remained the least understood.

Researchers, supported by work from an EU-funded LUCKY STAR (Exploring the outer solar system beyond Neptune using stellar occultations) project, recently reported that they had used prediction models, coupled with observations taken in January 2017 by 12 telescopes across 10 European observatories, to accurately measure for the first time, Haumea’s size, shape and surrounding environment.

Using stellar occultation to measure up

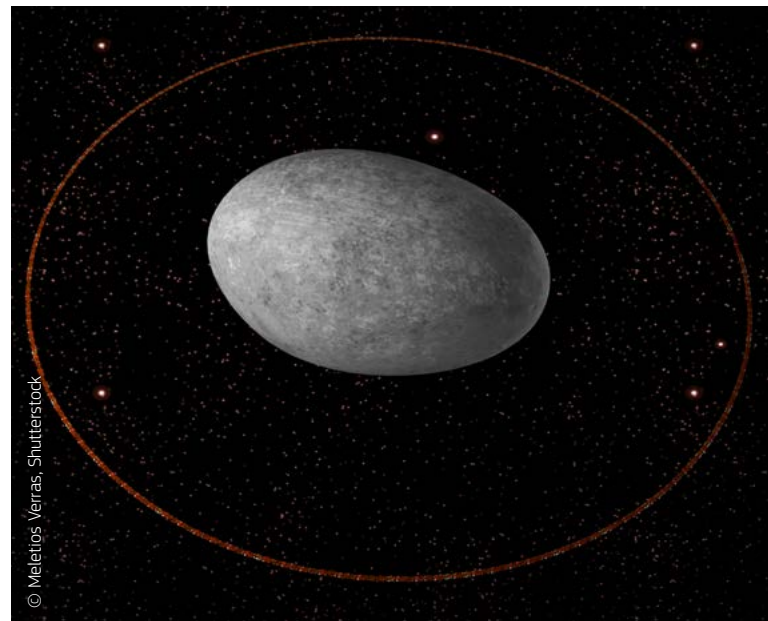
It was previously known that Haumea took 285 years to rotate around the sun and that it was shaped like a rugby ball. However, as the researchers reveal in *Nature*, by exploring an area beyond

Neptune’s orbit known as the Kuiper Belt, they also discovered Haumea has a ring surrounding it which is estimated to be 290km in radius, 70km in width and with a

50% opacity. Previously it was thought that rings were principally to be found around the four outer planets of Jupiter, Saturn, Uranus and Neptune.

The Haumea ring rotates around the planet three times more slowly than the planet rotates around its own axis. According to Dr José Ortiz, one of the paper’s authors, the 70 km wide ring is probably made of rock and ice. These frozen particles could be a result of the debris created by the impacts from stray rocks.

It has also been suggested that the ring could have been created by the planet itself, as Haumea spins unusually fast, rotating once every 3.9 hours, and so could be hurling



particles out into orbit. Additionally, the ring was discovered to be relatively remote from the planet (about 1 000 km above), which may be due to the ellipsoid shape of the planet.

Haumea’s diameter is around one third the size of Earth’s moon and its longest axis is almost as long as Pluto’s diameter. Additionally, the planet has a large moon on the same plane as the ring, as well as a second smaller one.

Secrets from the outer Solar System could prompt a rethink

Until this latest finding, failed attempts to find rings around Pluto resulted in the proposition that no object farther afield than Neptune could sustain rings. Additionally, it had been thought that rings were chiefly the preserve of giant planets until, in 2014, the same researchers discovered rings

“The region could hold clues to the origin and evolution of the planetary system as a whole.”

surrounding asteroid-like objects known as Centaurs, orbiting between Jupiter and Neptune.

Exploring the outer Solar System beyond Neptune is viewed as being highly scientifically instructive as the region could hold clues to the origin and evolution of the planetary system as a whole. It still contains unaltered primordial material and so ultimately holds a memory of early planetary migrations.

The EU-funded LUCKY STAR project was set up to study Trans-Neptunian Objects (TNOs) and leads the field in using the technique known as 'stellar occultation', whereby shapes,

atmosphere and rings of bodies are revealed as they pass in front of the light emitted by stars.

LUCKY STAR

- ★ Hosted by Pierre and Marie Curie University – Paris 6 in France.
- ★ Funded under H2020-ERC.
- ★ <https://cordis.europa.eu/project/rcn/199073>

MAPPING DARK MATTER IN THE UNIVERSE

An EU-funded project has developed new tools to map dark matter distributions around the largest structures in the universe such as galaxy clusters.

One of the most surprising discoveries of the previous century was that ordinary matter makes up less than 5% of the universe's mass. Although astronomers have not yet observed dark matter directly, they are confident that it exists because of the gravitational effect it has on galaxies.

Mapping dark matter distributions may help answer fundamental questions regarding the underlying model of gravity that helps create galaxies or galaxy clusters, Einstein's general theory of relativity, the microscopic properties of dark matter and the impact of baryonic feedback. Unfortunately, current numerical research on the influence of dark matter on large-scale structures makes significant oversimplifications in estimates. This does not allow researchers to capture

subtle differences between structure formation models.

Within the EU-funded WEBMAP (Mapping the dark web of the cosmos) project, scientists helped overcome this problem by developing techniques and tools that utilise the whole morphological information provided by sky observation maps.

The project team successfully developed a computer tool to characterise the 2D morphology of dark matter maps that is based on computer vision algorithms. Extracting up to 3 000 unique image descriptors from image data, the algorithms allowed researchers to use this data to classify dark matter maps of unknown origin.

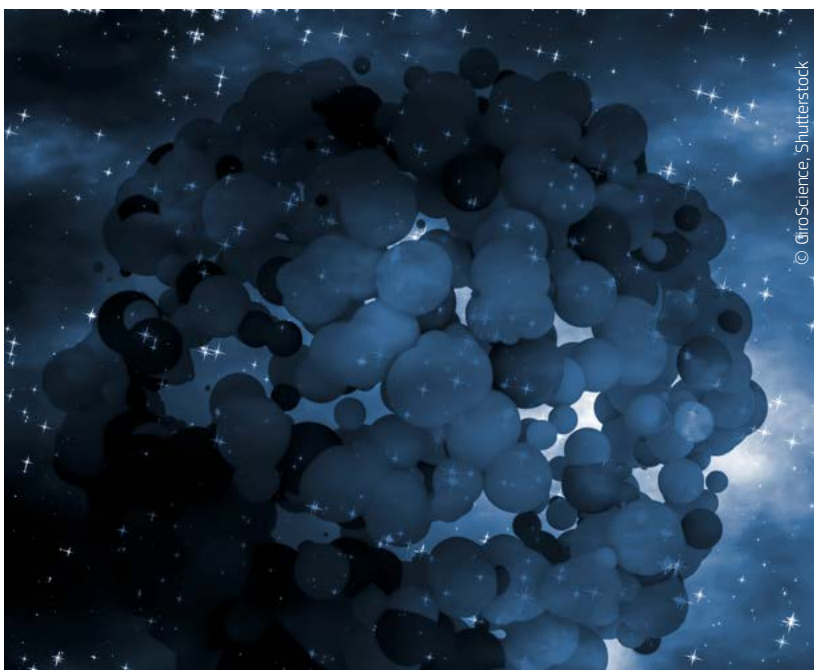
As dark matter distributions cannot be observed directly in the sky, WEBMAP researchers designed another tool to

"The algorithms allowed researchers to use this data to classify dark matter maps of unknown origin."

map this distribution from available observational data using the mass mapping technique.

Numerical data was also applied to observational data. The first data set used was the Cluster Lensing And Supernova survey with Hubble (CLASH). This is a multi-wavelength census of 25 galaxy clusters that uses the Hubble Space Telescope instruments to map the largest gravitationally bound systems in the observable universe. Using mass mapping techniques, researchers produced multi-resolution mass maps of these clusters and also analysed for the first time the multiple images of a gravitationally lensed supernova.

Mapping dark matter distribution will help shed more light on the nature of dark matter and bring us a little closer to answering great cosmological questions. Project results have been presented in 19 peer-reviewed journals, two press releases and a feature article.



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WEBMAP

- ★ Coordinated by the University of Oxford in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/186430>

SHARED VIRTUAL REALITY WORKPLACE FOR SPACE SCIENTISTS IN EUROPE

An EU initiative has developed an infrastructure for collaborative workspaces for space science and missions.

Space exploration missions have produced huge data sets that are potentially of great value to research, and for planning and operating future missions. However, current expert teams, data and tools are fragmented. This prevents such valuable data from being of great use through collaborative activities.

The EU-funded CROSS DRIVE (Collaborative rover operations and planetary science analysis system based on distributed remote and interactive virtual environments) project created the foundations for collaborative, distributed virtual workspaces for European space science. Overall, the aim was to allow remote scientific and engineering experts to collectively analyse and interpret combined data sets using shared simulation tools.

CROSS DRIVE partners developed distributed and collaborative infrastructure based on advanced immersive virtual reality tools. This was done to better analyse and manage planetary spacecrafts' scientific data and operational activities.

To support space data analysis and space operations, the workspace incorporates advanced technological solutions for central storage processing, 3D visualisation and virtual presence in immersive virtual reality environments.

In order to demonstrate the usefulness of the workspaces for European space science, project partners carried out three case studies by exploiting state-of-the-art science data sets. The cases involved mars atmospheric data analysis, rover landing site characterisation and rover target selection during its real-time operations.

Specifically, scientists shared and correlated atmospheric data, analysis and simulations based on actual main Mars satellites, compared data for geology and geodesy, and benchmarked satellite- and ground-based Mars atmospheric measurements. Data took into consideration the European Space Agency's Mars rover missions of 2016 (ExoMars Trace Gas Orbiter), 2018 and 2020.

A website was set up to disseminate project results and encourage collaboration among the scientific and research communities. As such, it contains a public portal and a scientific community portal.

CROSS DRIVE contributed to improving data analysis and exploitation of space-based observations. This will allow scientists to not only work together by using each other's data and tools, but also do so between missions.

"The workspace incorporates advanced technological solutions for central storage processing, 3D visualisation and virtual presence."

CROSS DRIVE

- ★ Coordinated by DLR in Germany.
- ★ Funded under FP7-SPACE.
- ★ <https://cordis.europa.eu/project/rcn/188842>
- ★ Project website: <http://www.cross-drive.eu/new/index.html>



FUNDAMENTAL RESEARCH

NEW RESEARCH SHOWS PHONONS ARE CRUCIAL IN QUANTUM INTERACTIONS

Understanding why two entangled particles hundreds of miles away can affect each other has been one of the most pressing questions in physics today but phonons, or quantised vibrations of a crystal, play a far more important role in the physics of correlated materials than previously thought, according to the EU-funded DCCM project.

DCCM (Dynamically controlling the properties of complex materials with light) researchers found that phonons dominate most correlated-material interactions, in contrast to a strongly held view in the scientific literature that labels electron-electron interactions as the most likely key influencers. If scientists can discover how to harness the amazing properties of these quantum materials, it could lead to a new wave of technology and innovation.

Using light, the project team explored the properties of the materials, and showed that light-induced transitions from insulator to metal phases were caused by light affecting the crystal vibrations, and were not in fact due to a change in the electron-electron interactions.

“These results are important because they challenge the majority of models currently describing these materials,” says project coordinator Prof. Simon Wall of the Institute of Photonic Sciences (ICFO) in Spain. “They suggest that there is a ‘missing ingredient’ that may help us make a breakthrough in our understanding.”

New technological developments

The findings may eventually lead to novel innovations in technology. Correlated materials have a lot of potential due to their spectacular properties, such as high temperature superconductivity and the ability to switch between insulating and metallic states at elevated temperatures. But without knowing exactly how these materials exhibit these phenomena, it is difficult to incorporate them into new devices and systems. Another issue arises because scientists need to separate the materials to study them further, but since the electronic and spin interactions compete on a similar energy scale, this is not easy to do.

An in-depth understanding of quantum materials at the nanoscale level is also needed before they can be effectively incorporated into new technologies, as strong competition

between the interactions of electrons and magnetism at this scale can lead to drastic changes. Another result of the project was the development of a new imaging technique that allows scientists to view a range of phenomena in quantum materials for the first time, and this could enable researchers to further explore the nanoscale properties of these materials.

The kinds of devices that could potentially be developed include high temperature superconductors that could replace the expensive magnets in MRI machines or particle accelerators, both of which currently need to be cooled to extremely low temperatures in order to function correctly. The magnetic and electronic functionality of quantum materials could also be used in new non-volatile high-speed memory.

Lattice anharmonicity and the origins of high temperature superconductivity

The next steps for the DCCM researchers involve further focus on the role of phonons in high temperature superconductivity. They will take part in the project SEESUPER, funded by the European Research Council (ERC), which aims to examine whether lattice anharmonicity can explain the origins of high temperature superconductivity. Lattice anharmonicity allows phonons, which would normally be independent, to couple together. This coupling can, in turn, modify how electrons interact with the lattice and could be a factor that enhances superconductivity. The aim will be to apply the techniques developed in DCCM to examine how nanoscale defects and phase separation modify anharmonicity and if this can explain the origins of high temperature superconductivity.

DCCM

- ★ Coordinated by the Institute of Photonic Sciences in Spain.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/109399>

GENETIC TRACKING PROVIDES CLUES ON THE DEVELOPMENT OF THE BRAIN'S COMPLEX CIRCUITRY

A unique genetic marker technique has shed light on how nerve cells in the developing brain are generated and form the circuits that determine behaviour and cognitive activity.

The brain is made up of billions of cells of different types organised into sophisticated networks which determine the functions of the brain. EU-funded scientists from the MOMECODE (Molecular Mechanisms of Cerebral Cortex Development) project are using novel ways of marking particular cells to understand how the nerve cells or neurons develop and interconnect during brain development. omoid protease-substrate complexes.

The scientists use genetic markers to colour-code and track the neurons' path as they find their rightful place in a particular brain area, the developing cerebral cortex. "When a neuron is born from a neural stem cell, usually it migrates some distance to the specific area where the cells wire up into so-called circuits," says Simon Hippenmeyer, assistant professor at the Institute of Science and Technology, Austria, where he set up a laboratory after returning from Stanford University, United States, re-establishing himself in Europe with an EU Marie Curie grant.

A genetic technique called Mosaic analysis with double markers (MADM) allows researchers to visualise small groups of neurons or even individual neurons at the single cell level and genetically manipulate them at the same time, Dr Hippenmeyer explains.

Comparing red and green-marked cells

The technique helps researchers navigate through dense networks and precisely follow individual neurons. Red and green fluorescent protein markers are encoded in the mouse genome to label certain types of neurons, and a genetic mutation can be introduced. The two healthy neurons in one colour and sick neurons in the other are then compared to understand how the cells behave in healthy and diseased conditions. "The MADM technique allows us to do this at highest resolution, so we can do certain types of quantitative analysis that were not previously possible," Dr Hippenmeyer says.

Tagging a cell while also introducing a genetic modification into that cell is technically challenging. "There is no other comparable technique that allows us to do this easily at the high precision level that MADM can," says Dr Hippenmeyer, explaining that researchers usually need to compare two different animals, one that is sick and one that is healthy, rather than seeing the cells side by side in a 'mosaic'.

Fixed neuron output

The ability to count single cells led to the discovery that there is a clear period of neuron fabrication during brain development. "There is a fixed output of about eight to nine neurons per single neural stem cell, which is always uniform," Dr Hippenmeyer says. "This discovery was unexpected because most stem cells in different organs reproduce at an unpredictable rate."

Stem cells must perfectly tune their output otherwise there are too many or too few – leading to a brain that is either too large or too small – and there is a lot of genetic influence on this process, he says.

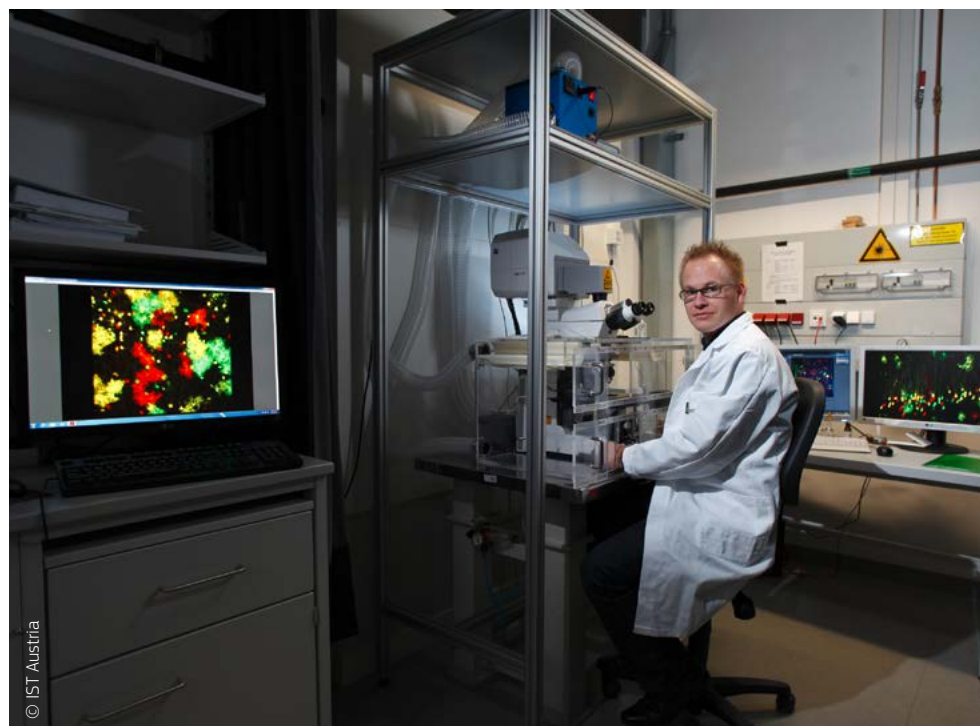
"We are trying to understand the natural mechanisms in the stem cells that give rise to a brain of the correct size."

Although the MOMECODE experiments are conducted in laboratory mice, eventually this could also shed light on human brain development and perhaps evolution.

Many psychiatric disorders may be caused by subtle changes in brain architecture. The cell-highlighting technique can be replicated using candidate genes that may be disrupted in psychiatric diseases or dementia to see how these changes affect the brain. Such approaches may shed light on the basis of neurodevelopmental diseases and help to understand why human brain development is so sensitive.

MOMECODE

- ★ Coordinated by the Institute of Science and Technology Austria in Austria.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/109626>



DNA CAN CARRY MEMORIES OF TRAUMATIC STRESS DOWN THE GENERATIONS

Animal and human investigations indicate that the impact of trauma experienced by mothers affects early offspring development, but new research is also discovering that it is also actually encoded into the DNA of subsequent generations.



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Violent acts, such as those encountered during warfare or terrorism, obviously have a profound impact on mental health, not only for the surviving victims but also for the perpetrators. The individuals involved are often at the mercy of a pernicious cycle of destructive thoughts and behaviours.

In an effort to enable more effective humanitarian interventions, the EU-funded MEMOTV (Epigenetic, neural and cognitive memories of traumatic stress and violence) project is investigating the full scale of the mechanism by which these stressful experiences actually shape memories. The team's recently published findings indicate that individuals undergoing a negative response to traumatic stressors, can actually pass this on to subsequent generations through DNA processes.

The role of DNA methylation in stress transference

The MEMOTV team is investigating the transference mechanism at the epigenetic, neural and cognitive levels in humans, as well as exploring how these traumatic memories contribute towards mental suffering within different cultural settings.

Publishing recent findings in the journal *Translational Psychiatry* the researchers outline how they investigated genetic changes seen in epigenetic patterns, by studying maternal stress experienced during pregnancy in the favelas of Rio de Janeiro, Brazil. The researchers gathered saliva samples from a total of 386 people – grandmothers, their daughters and grandchildren. They also collected

information from the grandmothers and daughters about their experience of violence within their partnerships and communities before, during and after pregnancy.

Combining both datasets the researchers were able to make predictions about the DNA of the grandchildren of those grandmothers who had experienced violence while pregnant with the mothers, for five locations within circulatory regulation genes. They were able to conclude that violence experienced during pregnancy leads to different DNA activity in children, known as methylations, whereby the genome reacts to the environment by activating or deactivating genes. The methylation took place regardless of whether the violent source was a partner or came from within the wider community.

Methylation is considered an epigenetic mechanism as it is not the genetic sequence itself which is altered but rather the legibility or activity of the coded information. Methylation patterns are an evolutionary device which makes it easier for an organism to adapt to its environment. In this instance the researchers hypothesise that the methylation patterns might result in children more fearful or alternatively more aggressive as an adaptive behavioural response. The researchers suggest that in the future prenatal DNA methylation patterns could be used as biomarkers for psychological health and risk to psychiatric disorders.

Remoulding 'maladaptive plasticity'

The starting point for the MEMOTV project was an understanding that the entire human organism, including the

parts responsible for information processing – principally the brain, immune and endocrine systems – is shaped not only by original experiences, but also crucially by the memories of these experiences. By employing the Epigenome-wide association studies (EWAS) approach to determine DNA methylation patterns, the team has been able to offer evidence that exposure during pregnancy to violence influences genetic activity which is carried into the grandchildren's generation. This lasting change in the brain's organisation and function can be self-perpetuating whereby a stage dubbed the 'defence cascade' can be triggered by events, often subtly, resulting in undesirable behaviour.

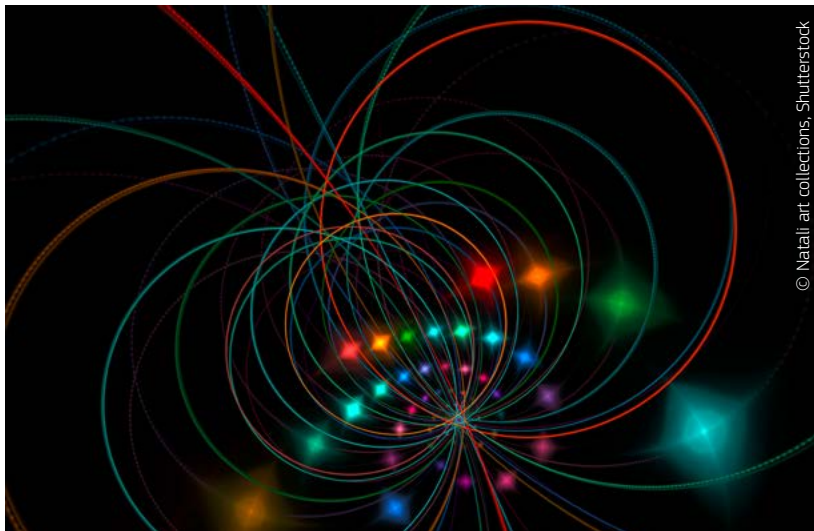
With obvious implications for the rehabilitation of the perpetrators and victims of violence, MEMOTV hopes that more

knowledge about the mechanism by which this maladaptive plasticity unfolds, will result in the prevention and even reversal of its consequences. Towards this end, the team is also pursuing its investigations within a German trauma clinic, the townships of South Africa and a Burundi peace corps. Information gleaned from these settings is viewed as being representative of human response at large, and with high data variability, it is anticipated that the findings can then be meaningfully applied to the rest of the population.

MEMOTV

- ★ Hosted by the University of Konstanz in Germany.
- ★ Funded under FP7-IDEAS-ERC.
- ★ <https://cordis.europa.eu/project/rcn/109534>

NEW STRING THEORY MODELS OF THE EARLY UNIVERSE



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“The project team identified a new inflation model that utilises quantum gravity effects to assist inflation.”

String theory is by far the most promising candidate theory of quantum gravity. Experts on particle physics, cosmology and string theory joined forces in an EU-funded project, producing pioneering realistic string theory models describing the birth of the Universe.

Having strutted onto the scene some 30 years ago, string theory seeks to provide elegant and simple explanations to deep questions of fundamental physics.

One strand of research conducted within the EU-funded STRINGLEEF (String compactifications, their low energy effective field theories and applications to physics) project focused on furthering the understanding and description of compactifications of 10-dimensional string theory down to a 4D universe through advanced mathematical tools. Based on the

compactification models, the second strand of research was geared towards addressing fundamental problems in cosmology and particle physics, and providing experimental predictions that can be tested in current and upcoming experiments.

Extending quantum mechanics from single localised particles to fields that exist everywhere, quantum field theory is the general framework describing cosmology and particle physics. Not all field theory models of the Universe can be consistently embedded in quantum gravity. Researchers studied consistency constraints on promising models of cosmology, showing that some model classes are inconsistent and identifying new string theory models that satisfy the necessary properties. Research results provided further insight into the properties of string theory itself and the connection of string theory to cosmological models.

The fast accelerated expansion that the Universe is believed to have undergone in its first moments of birth is extremely sensitive to quantum gravity effects and is difficult to embed in string theory. The project team identified a new inflation model that utilises quantum gravity effects to assist inflation. The model has distinctive signatures that can be tested in upcoming cosmological observations.

Primordial gravitational waves are produced during inflation, but their amplitude is not fixed by inflation. Researchers identified a strong upper bound on the amplitude of primordial gravitational waves from string theory that will be probed by next-generation primordial gravitational wave detectors.

STRINGLEEF work contributes to the long-term scientific goal of understanding the origins of our Universe, its composition and evolution. Results can also be connected directly to experiments and observations, driving future experimental programmes, which can in turn stimulate novel technological developments.

STRINGLEEF

- ★ Coordinated by the University of Liverpool in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ <https://cordis.europa.eu/project/rcn/189884>

EVENTS

APRIL
23▶24

Brussels, BELGIUM

CONFERENCE

CIVITAS URBAN FREIGHT CONFERENCE

The EU-funded CITYLAB, NOVELOG, SUCCESS and U-TURN projects are coming together at the 'CIVITAS Urban Freight Conference', in Brussels, Belgium from 23 to 24 April 2018.

The CITYLAB, NOVELOG, SUCCESS and U-TURN projects join forces to invite participants along to the two-day CIVITAS Urban Freight Conference that will feature presentations, posters and exhibitions, break-out and training sessions, workshops and awards.

The projects will explore the tools and policy recommendations they have generated, aimed at reducing the impact and cost of freight and service trips in urban areas.

Participants will discuss new cooperation models for engaging and supporting public and private actors, the future of urban logistics, as well as specific topics such as stakeholder cooperation, policy and regulation, planning for freight, technology, data collection and management.

For further information, please visit:
<https://www.polisnetwork.eu/public-events/506/61/CIVITAS-Urban-Freight-Conference>

APRIL
25

Sosnowiec, POLAND

CONFERENCE

CLAIR-CITY ANNUAL CONFERENCE

The EU-funded CLAIR-CITY project will be HOLDING a conference in Sosnowiec, Poland, on 25 April 2018.

The conference theme for 2018 is 'Protecting citizen health: Mitigating air pollution from domestic heating and transport' and the event will feature a range of invited speakers, as well as colleagues from the CLAIR-CITY project and members of their Advisory Board.

The CLAIR-CITY (Citizen Led Air pollution Reduction in Cities) project will apportion air pollution emissions and concentrations, carbon footprints and health outcomes by city citizens' behaviour and day-to-day activities in order to make these challenges relevant to how people choose to live, behave and interact within their city environment.

To explore this in more depth, the event will consider the issues of air quality and how these relate to climate change and public health. It will focus on: understanding the challenges of urban air quality in relation to domestic heating and transport, and sharing best practice and cutting-edge solutions from cities and regions around Europe and the world.

For further information, please visit:
<http://www.claircity.eu/get-involved/conference-2018/>

APRIL
26

Kinsale, IRELAND

SYMPOSIUM

LIST_MAPS INTERNATIONAL SYMPOSIUM

The EU-funded LIST_MAPS project will be HOLDING its annual symposium in Kinsale, Ireland, on 26 April 2018.

Contamination of foodstuff by pathogenic microorganisms is a major safety issue and a burden to the food industry. Many routes may lead to food contamination from farm to fork.

The symposium will address several facets of the ecology of foodborne pathogens. Titled 'Foodborne pathogens: from farm to pharmacy!' the event revolves around four sessions:

Session I Biodiversity
Session II Habitat colonisation
Session III GI tract and infection
Session IV Regulation

The EU-funded LIST_MAPS (Training and research in *Listeria monocytogenes* Adaptation through Proteomic and Transcriptome deep Sequencing Analysis) project is a network dedicated to the training of innovative young researchers in the field of Microbiology and Systems Biology.

It focuses on *Listeria monocytogenes*, an ubiquitous pathogen that is the EU's leading cause of mortality and food recalls due to foodborne pathogens, costing the EU millions of euros per annum in medical care and associated costs in the food sector.

For further information, please visit:
<http://blog.u-bourgogne.fr/list-maps/conference/programme/>

EVENTS

For more forthcoming events:
<http://cordis.europa.eu/events>

APR.
26▶27



Bremen, GERMANY

CONFERENCE

ELIPTIC FINAL CONFERENCE

The EU-funded ELIPTIC project will be HOLDING its final conference in Bremen, Germany, from 26 to 27 April 2018.

The conference will set out the outcomes of a project on different approaches to e-bus technology. ELIPTIC worked to overcome policy, technical and operational hurdles on the way to an electric transport society and identified potential business cases.

The project covered three main areas for exploiting electric public transport infrastructure: electric buses integration, an enabler for electric-mobility with multi-modal and shared mobility options plus energy efficiency with different recuperation approaches.

Attendees will have the chance to hear project results and network with 33 partners and 11 different Electric bus sites, from all over Europe.

For further information, please visit:
<http://www.elliptic-project.eu/news/horizon2020-civitas-project-elliptic-final-conference>

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