IMPACTING LIVES

*The University of Surrey
Impact Acceleration Account*
2014/15 review

Detecting drugs from a fingerprint

Trustworthy voting

Providing a verifiable voting system for the State of Victoria

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Saving patients' lives with maths

Using an ECG signal to detect sepsis in patients

Eradicating wrinkles with space technology

Plasma system for cosmetic surgery and other medical applications

EPSRC
Pioneering research and skills

UNIVERSITY OF SURREY

SURREY CENTRE FOR CYBER SECURITY (SCCS)

The Surrey Centre for Cyber Security (SCCS) is one of 13 Academic Centres of Excellence in Cyber Security Research (ACEs-CSR) recognised by GCHQ and the Engineering and Physical Sciences Research Council (EPSRC). These centres are based within UK universities conducting world-class research in the field of cyber security.

Primarily formed from academics and researchers from the Department of Computer Science and the Institute for Communication Systems (home of the 5G Innovation Centre), the SCCS also brings in expertise from other departments including Mathematics, Surrey Business School, Sociology, Psychology and Law to focus upon three principal themes:

- **PRIVACY AND DATA PROTECTION**
- **SECURE COMMUNICATIONS**
- **HUMAN-CENTRED SECURITY**

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UNIVERSITY OF SURREY

One of the elements that distinguishes research at the University of Surrey is our strong ethos of working closely with industry partners.

Continuing the excellent work which started with the Knowledge Transfer Account (2009–2012), Surrey was successful in securing further EPSRC funding though an Impact Acceleration Account (IAA). This tranche of funding ran from October 2012 through to September 2015, enabling a further 45 innovation projects to be supported through collaboration with external partners. The projects addressed key industry and societal challenges, providing an interdisciplinary approach to developing solutions: from monitoring building materials in unstable environments to creating trustworthy e-voting systems. All of the IAA-funded activities were selected to maximise the impact of the investment.

The objective of the IAA has been to provide short-term pump priming support to bridge the funding gap between research and potential commercialisation, often referred to as the 'valley of death'. Funding from the IAA has been a key element in exploiting research, with many of the projects going on to secure additional funding to support the activity along the road to commercialisation.
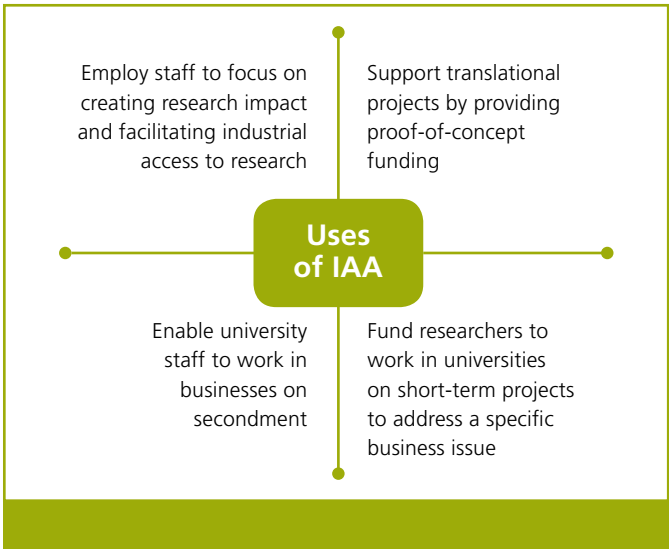
Above all, the Surrey IAA has enabled us to increase our engagement with external partners and to accelerate the impact of our EPSRC research, while also embedding a culture of industry collaboration within the University's academic community.

The University of Surrey is pleased to receive a further 18 months of funding from the EPSRC, taking our existing programme through to March 2017. This gives Surrey the opportunity to further build our pipeline for creating impact from research, through discovery to innovation.

Michael Kearney

Vice-President and Deputy Vice-Chancellor, Research and Innovation University of Surrey

Metric diagram of IAA from Dowling Report

Employ staff to focus on creating research impact and facilitating industrial access to research

Support translational projects by providing proof-of-concept funding

Uses of IAA

Enable university staff to work in businesses on secondment

Fund researchers to work in universities on short-term projects to address a specific business issue

CONTENTS

Saving patients' lives with maths

❱ Using an ECG signal to detect sepsis in patients

Academic: *Dr Philip Aston*

Over 37,000 people die every year in the UK after contracting sepsis, and detection is often too late for successful treatment. A project at the University of Surrey has demonstrated that diagnosing patients by analysing an ECG signal using a novel mathematical method could be the key to early diagnosis.

The IAA project, conducted in collaboration with King's College London and Data Sciences International (DSI), built on previous work which demonstrated that sepsis could be detected early by analysing blood pressure signals.

The drawback of blood pressure monitoring is that it is invasive (with a catheter inserted into a blood vessel). In this project, the method was therefore adapted to use an ECG signal which is monitored non-invasively (using a skin-patch), and more routinely, in hospitals.

The researchers have successfully developed code for analysing ECG signals and are now testing this, using data from animal models and patients, to see if it can robustly predict the early development of sepsis.

This technique can potentially be applied to a diverse range of clinical scenarios, including the detection of cardiac arrhythmias or adverse effects of drugs on the heart. It has already been tested on patients' responses to verapamil (a drug which alters heart contraction) using DSI archive data.

Dr Aston says:

"The next step will be to develop a system that uses the data to automatically monitor patients, triggering an alert such as a red light when certain criteria are met. Being able to monitor patients automatically and analyse the results in real time could potentially save lives."

Ensuring compliance

❱ Developing an international financial compliance regulator

Academic: *Dr Bogdan Vrusias*

Identifying and understanding all of the rules that apply within a regulated industry is a challenge, especially when developing new products, moving into new markets or for new personnel. An IAA-funded project has developed an exploratory and decision-support tool to address this problem.

The system uses natural language processing to discover compliance-related regulations that might apply to a company or product, and displays these in a meaningful way. In developing the solution, the University of Surrey and partner Technotomy Ltd worked closely with Neural Insights, a global strategic management consultancy firm specialising in highly regulated industries, based in the Surrey Research Park.

Initially focusing on the financial services industry, the tool enables the automatic analysis of the Financial Conduct Authority (FCA), the Prudential Regulation Authority (PRA) and similar national and international data sources. It presents this information as a graphical map, categorising types of documents and showing links and dependencies. The algorithms for the natural language processing and the representation of semantic relationships used for the tool were developed under a previous EPSRC research project.

The core benefit of the system is to reduce the high costs that companies pay to identify and comply with financial regulations, while also removing the international barriers which make mapping to different national rules a difficult task. In addition regulations are constantly changing; so by assisting companies to stay up-to-date, the tool will help to maintain compliance, reinforce corporate social responsibility and counter financial crime.

A live version of the system is now being used to demonstrate and trial the concept, both internally by Neural Insights and externally with a major international banking organisation.

Hyperuniform disordered materials

❱ Flexible platforms for photonic integrated circuits

Academic: *Dr Marian Florescu*

An IAA project with US company Etaphase has explored a new class of photonic materials that enables the development of photonic integrated circuits, which offer great benefits over conventional electronic circuits in terms of energy efficiency, bit rate and flexibility of design.

Unlike electrons, photons travel at the speed of light and do not interact with each other, potentially enabling tasks to be performed in parallel, saving time and money. However, until now there has been a challenge with controlling the flow of photons within a circuit in a compact and energy-efficient manner.

Researchers in Surrey's Advanced Technology Institute (ATI) collaborated with Etaphase to develop a new class of materials – known as hyperuniform disordered (HUD) materials – which would overcome this challenge, providing a viable solution for the manufacture of photonic integrated circuits. By creating a device based on a cavity structure, the team has demonstrated that the materials have fewer constraints in terms of the design of the connections and the circuit itself, enabling the manufacture of more compact circuitry. In addition, the HUD materials offer three times better temperature stability, meaning large savings in the energy needed to cool devices.

One of the most important applications for this technology will be large data centres where a photonic-based circuit solution could greatly reduce energy used and the resulting environmental impact. The research has resulted in the filing of a patent, and Etaphase is now working on commercialising the technology.

"The new materials we are proposing enable remarkable design freedom, including the realisation of waveguides with arbitrary bending angles impossible to achieve or
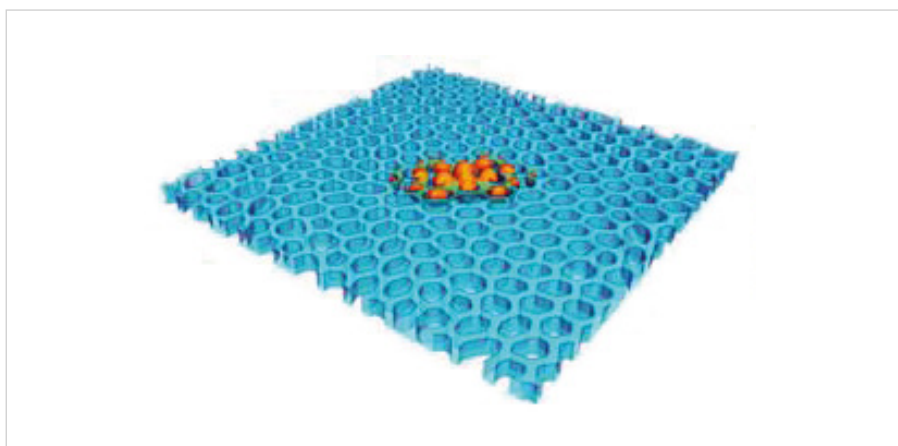
HUD platform supports both HUDsian and photonic crystal cavities. An isolated, purely HUDsian cavity

even imagine in periodic materials, which demonstrates their potential as building blocks for precise manipulation of photons in planar optical microcircuits," says Dr Florescu. Ruth Ann Mullen, CTO of Etaphase, adds: "Surrey's very close academic collaboration with us was a critically important force-multiplier to the inclusion in Etaphase's emerging component catalogue of an electrically modulated resonant optical cavity with sub-volt sensitivity."

Another IAA-funded project is being carried out to investigate further a new class of amorphous photonic materials recently discovered at Surrey. These materials, which offer a range of useful properties, could have huge potential not only for conventional areas of structured materials, such as integrated photonic integrated circuitry, but also for applications such as heat-rejecting window films and paints to improve the energy-efficiency of buildings and vehicles.

> **"The new materials we are proposing enable remarkable design freedom, including the realisation of waveguides with arbitrary bending angles impossible to achieve or even imagine in periodic materials, which demonstrates their potential as building blocks for precise manipulation of photons in planar optical microcircuits."**
>
> Dr Florescu

Detecting drugs from a fingerprint

❱ Detection of drugs in fingerprints

Academic: *Dr Mel Bailey*

Drug testing conventionally involves the collection of blood, urine or saliva. Mass spectrometry techniques developed in an IAA project have enabled a non-invasive, high throughput test that detects drug use from a single fingerprint.


Dr Bailey, Dr Costa and team

The project, led by Dr Melanie Bailey, has demonstrated that by using a technique known as Desorption Electrospray Ionisation (or DESI), which involves carefully controlled spraying of a solvent onto a fingerprint slide prior to analysis, it is possible to determine whether a person has taken – rather than merely handled – cocaine. Someone who has taken the drug will excrete traces of benzoylecgonine and methylecgonine, leaving chemical traces in their fingerprint residue.

Dr Bailey's original research into applying mass spectrometry techniques, funded by the IAA, has led to further collaboration between Surrey and researchers from the Netherlands Forensic Institute, the National Physical Laboratory, King's College London and Sheffield Hallam University.

With the drug-testing market worth several billions of pounds worldwide, the impact of the research could be far-reaching. Drug testing is used routinely by probation services, prisons, courts and other law enforcement agencies, but traditional testing methods have limitations. For example, blood testing requires trained staff; urine testing brings privacy concerns; and testing of bodily fluids can represent a biological hazard.
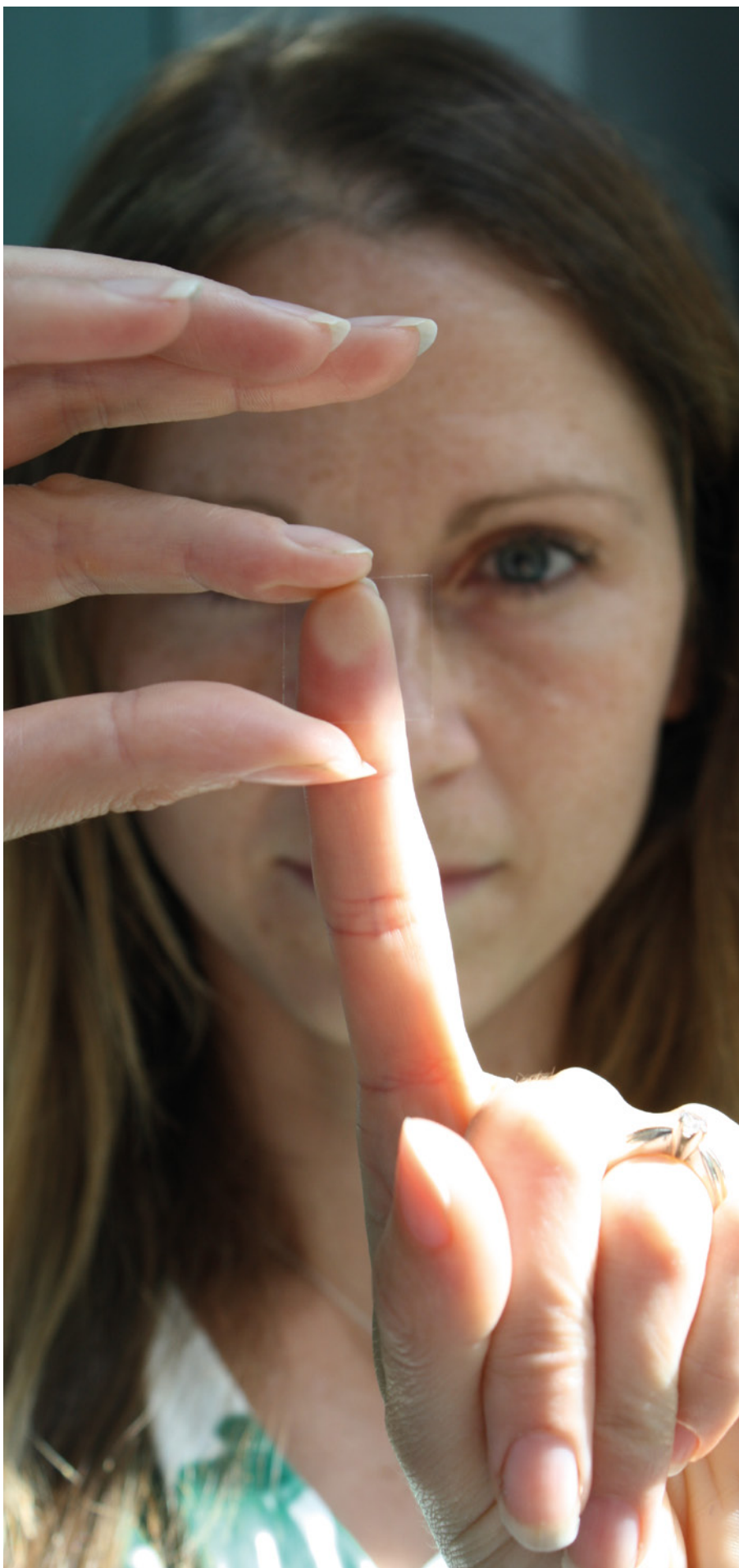
Dr Melanie Bailey demonstrates with a fingerprint

With the drug-testing market worth several billions of pounds worldwide, the impact of the research could be far-reaching

Dr Bailey comments:

"This research is exciting because it offers a new opportunity for high-throughput, non-invasive drug testing which – since it is based on a fingerprint – is more secure and harder to falsify than other methods."

Innovation to commercialisation

❱ **Validating research ideas in the marketplace**

Six projects supported by the current Impact Acceleration Account at Surrey have been accepted onto the ICURe – Innovation-to-Commercialisation Programme – a collaboration of the SETsquared Partnership, the Higher Education Funding Council for England (HEFCE), and Innovate UK, designed to move ideas and innovations out of universities and into the marketplace, where they will have the greatest impact.

The SETsquared Partnership is the enterprise collaboration between the universities of Bath,

Bristol, Exeter, Southampton and Surrey. It supports high-tech start-up companies, provides student enterprise and helps researchers and academics realise the commercial and social impact of their research.

The ICURe pilot is focusing on commercially promising research projects undertaken at SETsquared and affiliated universities. The programme funds teams for three to six months of intense market assessment to determine whether there is a market for products or services that utilise their research; and then, where there

is evidence of market demand, it helps them to lisence or spin-out the research into a company.

Participating teams present their opportunity to an options panel which includes investors, business managers and Innovate UK who offer expert guidance to the team on development pathways that will result in commercial success. Projects that possess strong market potential will have the opportunity to secure further grant funding for new company creation.

Water versus cement

❱ **Measurement standards for NMR characterisation of cement**

Academic: *Professor Peter McDonald*

NMR techniques are increasingly used in cement research and development but lack a standardised means of measurement or analysis. The result is that data evaluation and comparison is problematic – a challenge addressed by two Surrey-NPL projects funded by the IAA.

Cement is the glue of concrete and its production accounts for about 5 per cent of global man-made CO_2 emissions, so industry is continually looking at ways of making more sustainable cements. Since a large proportion of concrete is used to repair existing structures, improving durability could also have a major impact on the environment. Understanding the role of water in cement is key to solving both problems.

Over the last two decades, academics in the University of Surrey's Department of Physics have been instrumental in developing an answer to this problem. As a member of Nanocem – a major consortium for cement research run out of École Polytechnique Fédérale de Lausanne (EPFL) – Surrey helped to pioneer the use of nuclear magnetic resonance (NMR) techniques, which are based on magnetic resonance imaging (MRI) technology commonly used for scanning in the healthcare environment. NMR was found to be

an excellent way of measuring how much water there is in cement, how it is distributed among pores, and how water gets in and out of the cement.

Professor Peter McDonald, who has been involved in this research since its inception and leads the IAA projects, explains, "As more and more people started to use NMR – including cement manufacturers – it became clear that there was considerable variability in the results, depending on factors such as the sample preparation and the strength of the magnets used for scanning.

"We recognised that in the early days of MRI medical scanning, the community got together to develop standard protocols so that doctors receiving results knew what they were looking at. We therefore approached the National Physical Laboratory (NPL), as experts in metrology, to work jointly on a similar solution for the cement industry."

In an initial IAA project in 2014, the team successfully identified a stable reference material that mimicked cement in order to calibrate equipment. The current IAA project has built on this work by conducting round-robin trials of a proposed standard. This has involved the measurement of cement and reference samples on equipment at a range of cement and NMR equipment manufacturers' premises to ascertain the degree of variability demonstrated by different instrumentation.

While the cement manufacturers involved are informally adopting the standard already, following the completion of the current IAA project, NPL will begin to formalise this so that companies across the UK and globally can adopt the same common standard.

In the future the aim is that others will be able to buy a software add-on to adapt their existing equipment. In addition, the research points to the fact that there is a market for a much smaller machine than the currently used benchtop versions.

Professor McDonald explains: "We foresee the development of a scanner no larger than a can of baked beans. This would be relatively cheap to produce and simple to use, featuring a 'traffic light' system of green, amber and red lights to indicate that a sample is 'good', 'average' or 'bad'.

"A machine like this could be used in cement manufacturers' test labs beside a production plant. However, an even bigger potential market for this technology would be in the field, with consulting engineers who assess build quality or degradation."

Dr Roger Morrell of NPL comments: "The transient nature of cement cure and the wide variety of instrument types and test sample formats mean that it's vital to be able to make comparisons between different situations in order for the technology to move forward towards quantitative measurement."

The economics of biorefining – a collaborative approach

❯ Multiscale modelling within business and environmental environments
❯ Bioresource knowledge and data system targeted for downstream conversions (BioTARG)
❯ Value chain analysis platform for biorefining processes

Academics: *Dr Franjo Cecelja, Dr Madeleine Bussemaker, Professor Richard Murphy, Dr Jhuma Sadhukhan*

Close collaboration with the University of Surrey for three IAA-funded projects has enabled Bio-Sep Limited (BSL) to test the economic feasibility of its bioseparation process, which allows the production of high-value chemicals from biomass.

Driven by concern for the environment, there is an ever-increasing focus worldwide on the possibilities of cheaper chemical intermediates from 'green', carbon-friendly products, with the global biomaterials market currently worth an estimated $64.7 billion. An SME operating in this market, BSL has developed and patented an innovative process to extract a variety of valuable chemicals from woody and other lignocellulosic biomass for use across the food, pharmaceutical, cosmetic, textile and energy industries.

In order to check that this technology was economically viable, the company realised they needed a tool to enable a value chain evaluation, and approached the University of Surrey because of its renowned expertise in process modelling.

In an initial collaborative IAA project, the team from Surrey's Centre for Process and Information Systems Engineering (PRISE) successfully built a technology process model using data provided by BSL together with a value chain model (VCM), and performed a techno-economic assessment using feedstock (sitka spruce), geographical, transport and energy data from Scotland to validate the model. This led to two further projects, also co-funded by the IAA, which have drawn on academic expertise within Surrey's Department of Chemical and Process Engineering and its Centre for Environmental Strategy (CES).

The second project looked at the creation of a dynamic database which would give the user access to up-to-date information on feedstock availability, prices, product demand and other factors in order to help their decision-making process. Headed up by Professor Richard Murphy of Surrey's CES, this project – known as BioTARG – involved building into the original model data gathered from across the world on different types of lignocellulosic feedstocks and different types of outlets.

The third project arose from a realisation that the model developed in the first IAA project – although sound – needed to be capable of automatically integrating the data amassed during the BioTARG project. At the same time it was felt that the original VCM would benefit from some improvement to make it less complicated to operate. With these goals in mind, the project team has improved the operator interface to make it more user-friendly.

"This will enhance the usability of the model, both for BSL and in a wider sense for consultancies looking at opportunities to do biorefining for all different types of feedstock," explains BSL director Geoffrey Drage. "The overall concept is much wider than the original one we were looking at, and has much greater impact."

The IAA route has been a successful one for BSL. Geoffrey comments: "As a small SME we were not in a position to be able to employ a consultancy, so the IAA route has been an excellent opportunity for us. The funding has enabled us to access the modelling skills of experts in this field, while for the University it has enabled researchers to use their skills to build something that could have wide application.

"The key for us has been to insist right from the beginning that we visit the Surrey campus every couple of weeks or so to see the team, understand what's going on and address any problems that arise. While this has meant devoting considerable time to the projects, it has resulted in an outcome that meets the needs of our business."

BSL director Kenneth Day adds: "The shape and size of IAA projects (lasting six to ten months on average) is relatively easy for a business like us to run with. Rather than having a complex bureaucratic process, all decisions have been taken within the four walls of the campus, which has enabled us to move reasonably quickly. In the future we have every reason to stay engaged with the University of Surrey."

It has also been a successful experience for the University. Lead researcher at Surrey, Professor Franjo Cecelja, says: "I've been impressed with the level of involvement Bio-Sep has taken on throughout the projects. The partnership has worked very well – and continues to do so – because of clear expectations, detailed planning and a flexible approach that has allowed us to modify our plans as we've gone along."

Having proven the underlying technology through the collaboration with BSL, the University team is now actively investigating commercialisation of the model with different industries.

Lignocellulosic biomass is a generic term for dry matter from plants. It can be broadly classified into virgin biomass (e.g. trees, bushes and grass), waste biomass (e.g. agricultural and forestry by-products and waste) and crops grown specifically to serve as a raw material for the production of biofuels or chemicals.

Trustworthy voting

❱ Routes to market for trustworthy voting systems

Academic: *Professor Steve Schneider*

The successful deployment of an end-to-end verifiable electronic voting system in a state-wide statutory political election – a worldwide first – paves the way for greater democratic participation in elections and accessible voting for everyone.

Governments around the world are investing in electronic voting but experiences in the USA and the UK have shown that there are major obstacles to be overcome to ensure that systems are secure and widely used. Using funding from the EPSRC and the IAA, this project set out to develop a generic model for electronic voting, supported by the necessary business infrastructure, which would be usable in real large-scale elections.

Led by Professor Steve Schneider, the research team then worked with the Victorian Electoral Commission in Australia to provide a platform for the State of Victoria election which took place in November 2014.

Based on the principles of open source software, which enables independent examination of the code, the verifiable voting system allows voters to check that their votes have been accurately recorded, while encrypting receipts so that votes remain completely secret. This protects against fraud and fosters greater trust in the electoral process.

The system features a printed ballot form with the candidates listed in a randomised order. The voter makes their selection and then destroys the list of candidates, retaining and casting their marked preference list for verifiable tallying. Voters are given a receipt they can actually understand and recognise

their vote, instead of a receipt of unintelligible encryptions. 80 per cent of sampled voters stated that they would tell others about the system.

With voting compulsory in Australia, the election authorities are obliged to make every effort to enable citizens to vote, so better accessibility for blind, partially sighted and motor-impaired voters was a key requirement. Elections also need to cater for the broad range of 20 languages spoken by Victoria's citizens, as well as expatriate Australians living in other countries around the world. In addition, since Victorian elections are based on the single transferable vote, the ballot is very complex, with voters

Prof Steve Schneider demonstrates the system

1.9%

A total of 1,121 votes were cast, with a very low level of spoilt ballots:

1.9%, compared with 4.3% for paper voting

4.3%

required to rank a list of around 40 candidates in their preferred order.

Surrey's verifiable voting system was able to meet each of these needs and provide a chain of links all the way from the initial casting of the vote right through to the tallying, reassuring voters that their vote was cast as they intended. By incorporating an audio interface, the system enabled blind and partially sighted voters to cast a fully secret vote in a verifiable way.

> **"The deployment went smoothly and our evaluation found the electors accepted the new verification measures without any issues, making good use of the new security facilities."**
>
> Craig Burton of the
> Victorian Electoral Commission

The system was deployed for the last two weeks of November 2014 for 'early voting' at 24 voting centres in Victoria, where it was offered to particular target groups of voters (the blind, partially sighted and motor-impaired). It was also made available to all voters at the Australia Centre in London.

In this controlled deployment, the verifiable voting system ran perfectly, with no need for rebooting throughout the two-week period. A total of 1,121 votes were cast, with a very low level of spoilt ballots (1.9 per cent, compared with spoils that have been as high as 10 per cent for paper voting). A survey of voters in the London election found that 75 per cent preferred the electronic system to paper voting.

Craig Burton of the Victorian Electoral Commission says: "The deployment went smoothly and our evaluation found the electors accepted the new verification measures without any issues, making good use of the new security facilities. In addition, for the first time, the Commission had interest and support from information security specialists who had previously been critics of our e-voting. The approach of the solution and its capability are such that it will remain appropriate and would scale for the foreseeable future".

In separate tests, the system proved to be capable of handling a million votes, and was able to respond to individual voters within ten seconds and to accept 800 votes within a ten-second period.

Following the success of the verifiable voting system at the Victorian election, Professor Schneider and his team are looking at opportunities to commercialise and roll-out the system.

Professor Schneider comments:

"The original EPSRC research project was concerned with the principles of verifiable voting systems, but the opportunity to develop our design to a real-world implementation for a real election was too good to miss. The IAA provided funding for us to develop generic open-source election code, forming a platform that provides a basis for systems for particular elections. We used the platform to underpin the system commissioned for the Victorian State election. The IAA funding was critical to us achieving the world's first verifiable voting system used in a state-wide election."

Mining the deep web for business

❱ InfoClew – building time-dependent information networks from the deep web

Academic: *Dr Bogdan Vrusias*

Web searches conducted by businesses often fail to find the information they require because of a lack of sophistication in the mining tools available. Surrey researchers have developed a new technique that is faster, more accurate and cost-effective.

Despite recent efforts by the major search engine companies to introduce clever ways to retrieve meaningful information from the web, searches conducted by businesses are still problematic because data is unstructured and often hidden in the 'deep' web. This IAA project aimed to fill the gap in the market, enabling users to locate, retrieve and visualise meaningful contextualised information about businesses, and present this information concisely and coherently as the company's 'profile'.

The project was co-funded by the IAA, Technology Strategy Board (now Innovate UK)

and local technology company Technotomy. Surrey academics and Technotomy worked with UK Trade & Investment and FDI Marketing Associates to develop and implement a concept for the foreign direct investment (FDI) market.

The system they have developed identifies potential foreign investors in a cost-effective way that is automatic, visual and offers accurate, current and relevant information. The system can search the web to identify candidate companies of a certain profile, for example, those that are likely to expand their operations into a foreign location.

These techniques can easily be applied to other business requirements, leading to numerous potential applications.

Technotomy has since been extending this technology into developing a more generic tool for identifying and measuring web indicators for any type of industry. Their recent merger with another local SME, iVeridis, to create Synoptic Technologies has given access to major clients and enabled the underlying platform to be applied to new areas such as demand and supply management and technology discovery.

Understanding NHS cancer data

❱ iMalthus – extending the Malthus cancer treatment demand model

Academic: *Professor Norman Kirkby*

Upgrading the Malthus programme – used nationally to predict demand for radiotherapy – iMalthus offers higher accuracy, better reporting and faster results, providing a valuable tool to NHS Trusts.

With over 120,000 cancer patients undergoing radiotherapy treatment every year in the UK, the ability to predict the demand for radiotherapy is an important factor in the smooth running of NHS Trusts.

The original Malthus tool uses information on treatment schedules, combined with cancer incidence statistics from the National Cancer Intelligence Network, to predict demand for

radiotherapy across England. Developed by researchers at the University of Surrey and Cambridge University Hospitals NHS Foundation Trust, in collaboration with the National Cancer Action Team, the tool has become a national standard across NHS Trusts, with NHS commissioners required to use the system to justify purchases of new radiotherapy equipment.

The IAA project was aimed at developing an enhanced version of the tool – iMalthus – by integrating research code into the clinical version, providing a seamless pathway for the tool to be upgraded. At the same time, a number of improvements were added, including a data refresh which enables users to run simulations at local level, and the option to export data from the tool directly to Microsoft Excel, enabling more efficient reporting.

Test results of iMalthus at Addenbrooke's Hospital have been very successful: in fact , the enhanced tool runs faster than the clinical version, rendering the clinical version essentially obsolete.

Malthus – Monte Carlo application for local radiotherapy treatment and hospital usage statistics.

Optimising training time for eye surgeons

❯ MASTERS (Minimal Access Surgery Training, Evaluation and Reporting Software)

Academic: *Dr Lilian Tang*

Assessing the work of trainee eye surgeons has until now relied on human feedback which may not be objective or consistent. A new system developed at Surrey, together with Moorfields Eye Hospital, uses novel software to solve this problem.

The new tool, developed at the University of Surrey, is known as MASTERS (Minimal Access Surgery Training, Evaluation and Reporting Software), and analyses videos of live surgery, feeding back objective information to the trainee surgeon. Building on previous research at Surrey funded by the EPSRC, the IAA project – co-funded by Moorfields – has refined the computer vision algorithms behind the software to develop a commercially viable product.

Lead researcher Dr Lilian Tang worked closely with Moorfields' Director of Simulation Training George Saleh to develop the MASTERS system, which will initially be used for cataract surgery training, then adapted for other surgical procedures. The system assesses the dexterity of the surgeon by monitoring the tiny movements made by instruments in the surgical field.

"With the amount of hours trainee surgeons spend in the operating theatre having been reduced under the European Working Time Directive, it is particularly important that surgical training is as time-efficient as possible," explains Dr Tang. "The benefits of the MASTERS system will be faster, more consistent training, with resultant benefits to patients through reduced errors and cost savings for the NHS."

Mobilising the elderly

❯ Protocols and test environments for assessment of mobility (walking) in the older person

Academics: *Professor David Ewins, Dr Khim Horton*

The well-being and independence of older people will have a huge impact on healthcare costs in the future. A project assessing the mobility of over 65s has provided important data for the development of new robotic solutions.

This IAA project was conducted in partnership with Blatchford & Sons Ltd (Basingstoke, UK), a company specialising in rehabilitation solutions for the healthcare industry. Blatchford is one of the key partners in the EU AAL EXO-LEGS project, aimed at developing lower body exoskeletons to help older people move around and perform normal daily living tasks.

The project had three main outcomes:

- A systematic review was conducted of published work on mobility in the over 65s.

- A suite of tools was created to facilitate assessment of mobility over a range of terrains, such as steps, ramps and uneven ground for this age group.

- Focus groups were held with older people and their carers and partners to identify the key issues affecting their mobility, and their perceptions on how technology could address these issues.

Professor Ewins comments: "This IAA project has facilitated and given direction to academic–industrial collaboration in a rapidly growing area of healthcare." Professor Saeed Zahedi, Technical Director at Blatchford adds: "The University team has done an excellent piece of work. The IAA project has raised a number of important issues that Blatchford needs to review with colleagues in the company and with the EXO-LEGS consortium. The outcome of the IAA project is proving pivotal in the design and acceptability of future external walking-assistance device assistive technology products, as well as in identifying key functional characteristics that need to be addressed at a fundamental biomechanical level."

Research into mobility is continuing at Surrey using the assessment tools developed as part of this project, with help from Research and Enterprise Support.

EXO-LEGS is a European project funded by the Active Assisted Living Programme. The project brings together end-users, industrial companies and research organisations to specify the indoor and outdoor mobility needs of elderly people, to help them continue living independently for as long as possible.

Solving the Cocktail Party Problem

❱ quaudio® – improving speech intelligibility using acoustic source separation with audio frequency

Academics: *Professor Banu Gunel (Associate Professor), Mr Martyn Buxton-Hoare (Director Technology Transfer, University of Surrey)*

Improving the range of the quaudio® microphone – a novel technology developed at Surrey to enable localisation of separate sound sources – could have a huge impact across a range of applications, from smart watches to mobile phones to hearing aids.

Replicating a human's ability to isolate noises is a challenge that the sound recording industry has been addressing for some years. While microphone arrays provide one solution, and are used in applications such as games consoles, they require bulky packaging and do not give a perfect localisation.

The quaudio® microphone, which was developed at the University of Surrey in 2010 in a project led by Associate Professor Banu Gunel, features four microphones in a very compact arrangement to localise sounds using acoustic pressure gradients. The concept was further improved by Dr David Nugent, CEO of Elucidare Ltd, with the introduction of four inexpensive omnidirectional micro-electro mechanical systems (MEMS) microphones.

The recent IAA project, conducted in collaboration with Elucidare, has funded the next stage of evolution for quaudio®, improving the range over which the hearer can accurately determine the sound source – a need highlighted during discussions with a major international consumer electronics company.

Dr Nugent redesigned quaudio's® compact packaging to accentuate pressure gradients between neighbouring MEMS and used automated microphone calibration to overcome the poor tolerances of low-cost MEMS microphones. He then successfully built a prototype, which has demonstrated the improved localisation accuracy requested by the major international consumer electronics company, and wrote a White Paper on the research; as a result a further patent protecting the technology will be filed by the University of Surrey.

The global potential for quaudio® is vast. Dr Nugent explains: "Smart watches are becoming very popular but the problem is that they don't actually lend themselves to audio applications: the user has to bring the watch to their mouth, restricting their activities. By incorporating quaudio®, you could interact with your smart watch at arm's length, which would really improve the user experience."

Other potential applications include conference mics, which could give users access to translation into their desired language, and solutions for people with impaired hearing.
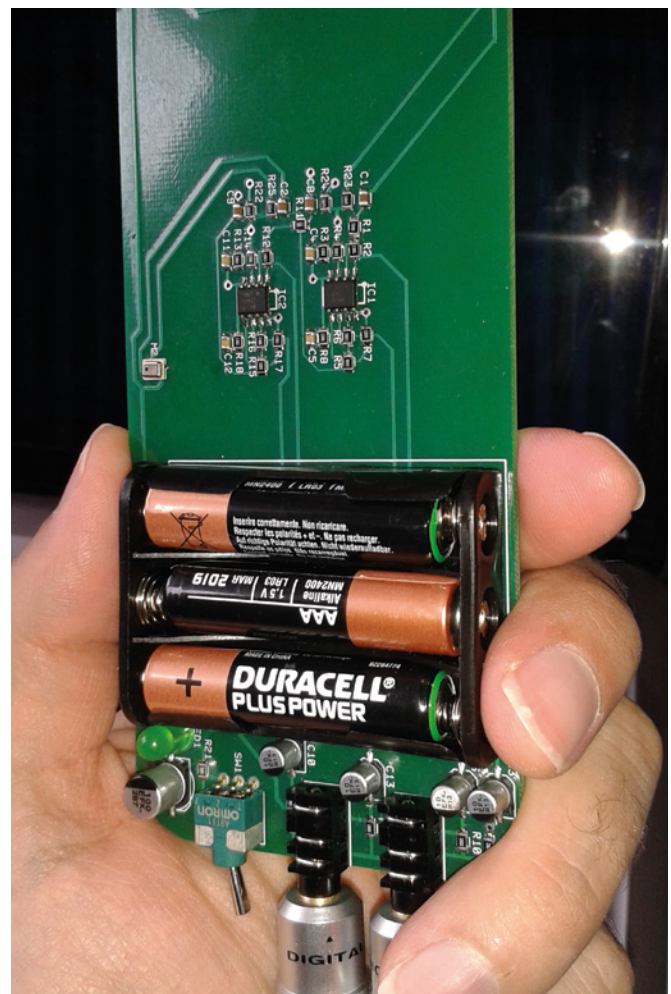
quaudio® technology

quaudio® is now available for licensing; interested parties should contact Dr David Nugent at david.nugent@elucidare.co.uk

Towards next generation communications: 5G

❯ Implementation of the FBMC-IOTA system for encoding digital data

Academic: *Pei Xiao*

The development of a new system for encoding digital data in broadband wireless communications offers a more efficient solution than the current OFDM technique and will play an important role in the 5G era.

The 5G network – the next generation of mobile and wireless communications – is needed to support the ever-increasing demand for mobile data and the emergence of the Internet of Things (IoT), through which billions of devices will become connected. With the 5G Innovation Centre (5GIC) – the only centre of its kind in the UK – hosted on campus, the University of Surrey is well placed to define the technologies that will underpin the 5G network.

One of the issues being presented by emerging technologies is the encoding of digital data. The orthogonal frequency division multiplexing (OFDM) technique currently in use offers limited spectral efficiency (the rate at which information is transmitted) and is sensitive to Doppler shift (changes in wave frequency). This limits the number of connections in a cell and creates problems while the device is moving.

Developed by Surrey's Institute for Communications Research (ICS), the new filter bank based multicarrier system employing isotropic orthogonal transform algorithm (FBMC-IOTA) offers a number of benefits over the OFDM technique. It provides improved energy and spectral efficiency, relaxed synchronisation requirements (which is beneficial for sporadic traffic generated by smart phones, for example), and more efficient carrier aggregation, enabling increased bandwidth. In order to create a fully functional prototype, the team succeeded in resolving a number of practical issues, including overcoming intrinsic interference and improving time synchronisation and equalisation (the reversal of distortion).

As a result of the IAA project, the 5GIC has built the world's first FBMC-IOTA prototype in collaboration with the Centre's industrial partner, Aeroflex, a leading worldwide provider of specialised test and measurement equipment and microelectronic solutions.

The FBMC-IOTA prototype was demonstrated at the Mobile World Congress in Barcelona in March 2015.

The 5GIC – bringing together leading academic expertise and key industry partners, the 5GIC hosts the UK's only large-scale testbed for prototyping technological solutions, and is helping to define the global approach to 5G as it moves towards standardisation.
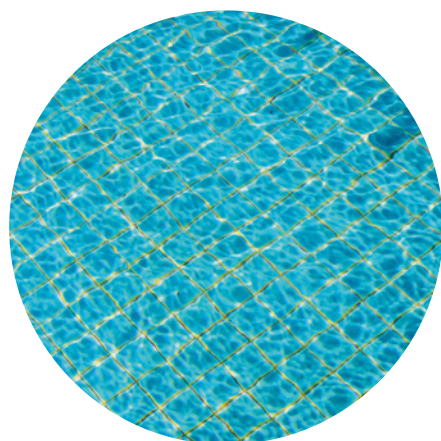
Warm and algae-free

❯ Enhanced, energy-efficient swimming pool covers

Academic: *Dr Steven Clowes*

The growth of algae is a constant problem for swimming pool owners, while heating a pool can represent a huge expense. A project by Surrey's Advanced Technology Institute (ATI) has succeeded in addressing both problems.

During a previous Knowledge Transfer Project (KTP) with Plastipack Ltd, specialist manufacturer of swimming pool and water storage cover materials, a new premium pool cover material was developed which enabled maximum water heating from solar radiation while inhibiting algae growth.

The IAA funding enabled the team to show that an enhanced energy-saving product could be achieved by applying materials science to engineer the required optical properties, significantly improving the thermal insulation. The ATI was able to draw on its expertise as an internationally recognised leader in the field of photonics, and provide state-of-the-art facilities including its optical characterisation suite,

chemical preparation laboratory and electron microscopy facilities.

The project demonstrated proof-of-concept and tested a number of potential additives to low-density polyethylene for their optical and thermal insulation properties, paving the way for a manufacturable solution in the future. It cemented the relationship between Plastipack and the ATI at Surrey and has led to a further KTP, enabling Plastipack to capitalise upon the ATI's expertise in the ways that light interacts with matter. Commercialisation of the product will enable Plastipack to move further into the profitable high-performance market and reinforce its market-leading position.

Pain-free parking

❯ Smart Personal Parking eXperience (SPPeX)

Academic: *Dr Mehrdad Dianati*

Eight hundred cars are parked every second in the UK; with significant urban congestion caused by drivers trying to find parking close to their destination, there is an urgent need for more efficient use of parking spaces.

Building on previous research concepts, the aim of the IAA-funded project was to develop a baseline prototype of the Smart Personal Parking eXperience (SPPeX) integrated IT system to pave the way for a commercial product. The resulting prototype uses proprietary sensing techniques to acquire and match driver location with accurate parking space occupancy data in real time, guiding the driver to an available or reserved parking space.

The vision is to fully automate the process of parking, from finding an available space to the payment of parking spaces, building in flexibility for users to vary their length of stay. This integrated parking solution would enable parking operators to benefit from better utilisation of their parking spaces and reduced management costs.

An Innovate UK-sponsored feasibility study of the system has been carried out in Stockport town centre with direct support from Stockport Metropolitan Borough Council, and there are plans to run a small-scale trial of the SPPeX system in Guildford in the near future. Together with external partner Accelogress Ltd, the research team has now applied for further funding for prototype development and trial implementation of the SPPeX system.

800

parked every second

Why buildings collapse

❯ Application of theoretical models against progressive collapse of flat slab concrete structures

Academic: *Dr Juan Sagaseta*

Current building regulations are based on engineering intuition and experience of structural failures dating back to the early 1970s. The urgent need for accurate theoretical models to ensure the robustness of concrete buildings was the driving force behind this IAA project.

Considering progressive collapse when designing structures such as buildings or bridges is a relatively recent development. The concept of robustness was first introduced in building regulations in the UK in the early 1970s after the Ronan Point collapse in 1968, triggered by a domestic gas explosion. Accidental loads such as vehicle impacts against columns in underground car parks or a local fire inside a building are possible events, which in some cases have led to structural failures and loss of lives in the last decade.

Lead researcher Dr Juan Sagaseta of the University of Surrey's Department of Civil Engineering collaborated with multinational engineering company Arup to address the huge knowledge gap that exists in modelling the structural response of these types of concrete structures. Current building regulations in the UK are based on outdated prescriptive rules with little supporting scientific evidence, and knowledge focuses on static rather than dynamic situations. The IAA project took an innovative theoretical dynamic model and applied it to real structures.

The research team first reviewed available literature on the subject and then applied a model (developed by Dr Sagaseta for a previous EPSRC project) to a known UK office building, establishing its probability of failing based on different local damage scenarios.

Dr Sagaseta explains: "Our achievement has been to use a theoretical model to solve real, complex issues, and to reduce uncertainty by enabling the design of more robust buildings.

"Our next step will be to write guidelines based on our findings which could ultimately be incorporated into UK building regulations. Since there is a similar lack of knowledge elsewhere, they could potentially become part of Eurocode and used in countries across Europe, as well as in US regulations. The impact could be significant."

Ronan Point collapse (*The Daily Telegraph*)

Helping animals to get well soon

❱ Carbon nanotube based textiles for tissue regeneration in animal patients

Academics: *Dr Alan Dalton, Dr Izabela Jurewicz, Professor Roberto La Ragione*

The growth of the pet industry in the UK and advances in veterinary medicine mean that referral veterinary practices are now performing joint replacement operations on cats and dogs on a weekly basis. This IAA project has demonstrated a new technique for growing cartilage which could reduce the cost of surgery and speed up rehabilitation for animal patients.

The project focused on the creation of a new textile made by weaving together fibres of carbon nanotubes, and has demonstrated that it is possible to grow canine cartilage cells on this type of textile.

The technology has the potential to revolutionise joint replacement surgery (used when animals develop conditions such as arthritis). Since the carbon nanotube textile has a 3D structure rather than a flat structure, it can be wrapped around an animal's joint during surgery, enabling the cartilage to be repaired quickly and reducing discomfort for the animal.

While the research to date has focused on cartilage cells, the technique could also be used to grow other types of cells, potentially opening up applications such as bone repair after the removal of a tumour, and tissue and bone growth following amputation.

The project has drawn on expertise from both Surrey's Department of Physics and its School of Veterinary Medicine, and has been conducted in close collaboration with Fitzpatrick Referrals. Bringing together a multidisciplinary team to develop innovative solutions to improve both animal and human healthcare, the project is strategically aligned with the One Health – One Medicine focus of the University.

Dr Rebecca Lewis explains: "We have demonstrated that carbon nanotube textiles provide an environment where cartilage can be grown. The next stage will be to experiment with manipulating the textile in order to get the cells to produce better cartilage. Cartilage grows best when you have healthy levels of joint movement, so it's about manipulating the textile to mimic this."

Dr Izabela Jurewicz says: "Since textiles can be produced fairly cheaply, this technology could lead to less expensive treatments, as well as providing a better repair mechanism for animals."
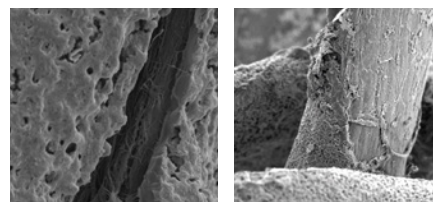
CNt textile coated in cartilage
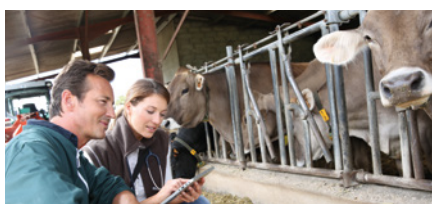
Big data for animal health

❱ 5G for animal monitoring

Academics: *Professor Klaus Moessner, Professor Alasdair Cook*

Bringing together data on animal health could improve animal welfare and productivity in farmed livestock. 5G – the next generation of mobile communications – has the potential to enable intelligent animal-health surveillance.

In the same way that eHealth offers enormous opportunities to improve healthcare across the world, it also heralds a new era for veterinary science. With new diseases in animals emerging constantly, learning more about the health of animal populations has never been more important. The collection and

analysis of big data will be crucial in enabling effective animal-health surveillance.

Academics from Surrey's School of Veterinary Medicine and its 5G Innovation Centre are collaborating with vets from Westpoint Veterinary Group to develop a database system to monitor calf health. Using the system, private vets visiting individual farms will record their observations and submit them to a database, enabling them to monitor health trends within each farm. The full

dataset will enable a better understanding of calf health across all participating farms.

Professor Cook says, "On an individual level, the farmer and the vet can compare results with the previous observations and can see what might need to be improved or altered. However, that small amount of data feeds into all the information we receive from the other farms which enables us to evaluate what factors contribute to good calf health."

The project is being enabled by Surrey's leading expertise in both veterinary medicine and 5G communications, building on its development of Pathpal, an app created for recording post mortem findings that is being used to deliver a project for the Department for Environment, Food & Rural Affairs (DEFRA).

Eradicating wrinkles with space technology

❯ Plasma system for cosmetic surgery and other medical applications

Academic: *Dr Aaron Knoll*

The plasma technology used to drive spacecraft has huge potential for medical applications. The development of a hand-held plasma device could transform the way cosmetic surgery procedures and wound treatment are delivered.

Plasma technology is capable of producing chemicals such as nitric oxide and other radicals that can sterilise and deactivate bacteria and help to heal wounds. The temperature and surface energy delivery of plasma technologies can also be controlled in order to reduce epidermal and superficial dermal thickness. A team of researchers from the Surrey Space Centre (SSC), in collaboration with spin-out company Fourth State Medicine (4SM), plastic surgeons and medical professionals, has succeeded in modifying this technology to enable it to operate at atmospheric pressures outside the vacuum environment of space, opening up a range of medical possibilities.

The main outcome of the IAA-funded project has been to take this laboratory concept and transform it into a working prototype: a portable medical plasma device suitable for clinical testing.

The hand-held device can both remove the upper layer of skin and sterilise the treatment area, enabling applications in common cosmetic procedures such as wrinkle removal and fine line reduction. With over four million cosmetic and aesthetic procedures conducted globally each year, there is clear potential for commercialisation, and the plasma system already has the support of a number of cosmetic-surgery organisations.

Since plasma kills bacteria, the technology also opens the way for applications such as the treatment of diabetic ulcers and open wounds, as well as trauma-related operations like managing acute bleeding. The portable prototype has generated a number of additional avenues of research, including a wound-care collaborative study with the University of Manchester, and a histology study on human tissue being undertaken with Broomfield and Springfield hospitals. The device has also been used to investigate application on fresh grains in collaboration with cereal manufacturer Weetabix Ltd.
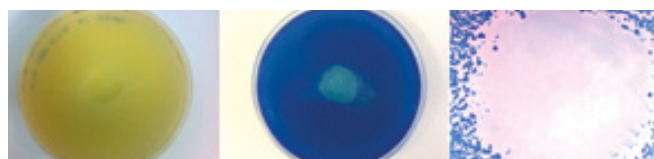
The system sterilises wounds by killing bacteria such as MRSA

Dr Tom Frame, founder and CEO of 4SM and an SSC Research Fellow, comments: "We have had significant results across a range of histopathology studies and microbiology evaluation, which demonstrates a high level of efficacy across our commercial applications."

Dr Aaron Knoll, principal investigator for the IAA project, says: "The use of plasmas for medical treatment is an emerging field of research, with a significant potential benefit to humankind. We've barely scratched the surface of what this technology can do, and already we've seen very promising results."

Following the project, trials are underway to evaluate the clinical benefits and effectiveness of the technology on human skin samples and bacteria samples. In March 2015 the prototype device was named by the Royal Academy of Engineering as one of the seven most promising innovations to come from UK universities, bringing significant funding which will be used to commercialise the prototype over the next twelve months.

> **What is plasma?** Plasma is the fourth fundamental state of matter (the others being solid, liquid and gas). Created when a gas is energised to the point that some of its electrons break free from its nucleus, plasma can be accelerated and steered by electric and magnetic fields, giving it practical applications in areas such as manufacturing, energy and lighting.

Low-cost, flexible touchscreens

❱ Inexpensive nanostructured touchscreen electrodes

Academic: *Dr Alan Dalton*

An IAA project suggests that graphene-treated nanowires could soon replace current touchscreen technology, allowing for more affordable, flexible displays and significantly reduced production costs.

The majority of today's touchscreen devices, such as smartphones and tablets, are made using indium tin oxide (ITO) – a material also used in solar cells, EL (electroluminescence) lighting and a variety of other optical and electronic applications. However, ITO is in short supply and expensive, currently costing over $30 per square metre.

Work at Surrey, conducted in collaboration with touchscreen manufacturer M-SOLV, has demonstrated that graphene-treated nanowires can be used to produce flexible touchscreens at a fraction of the current cost.

The Surrey team developed a unique process for creating hybrid electrodes – the building blocks of touchscreen technology – using films of silver nanowires and graphene/carbon nanotubes. The process is relatively simple, environmentally friendly and scalable, representing significant cost savings over current technology. The graphene-based solution costs around $5 per square metre to produce.

Having demonstrated that the process is scalable, the project team then developed laser patterning methods to pattern the hybrid films for touchscreen applications using M-SOLV patented technology.

Dr Dalton says:

"The growing market in devices such as wearable technology and bendable smart displays poses a challenge to manufacturers. At the moment, this market is severely limited to materials which are both very expensive to make and designed for rigid, flat devices."

Sounds and pictures

❱ Light tags for augmented paper and packaging

Academics: *Professor David Frohlich, Dr Radu Sporea, Dr Janko Calic*

Paper has been with us for many thousands of years and has properties that we still value in the digital age. Rather than replacing paper with e-readers, this project aimed to connect paper to digital information – particularly sound.

Researchers at Surrey had already explored the possibilities of connecting paper to the web and developed an interactive newspaper that could be read with wireless headphones.

However, one of the challenges was in printing the required interactive zones and associated electronic components on the paper itself. Light tags, a new printed electronics technology, aim to provide a solution to this. Using a new technique for identifying hand and finger movements as the document is read, this research could

pave the way for a number of new commercial applications in the print and packaging industry.

The IAA project endeavoured to prove that the technology was feasible and to gather feedback from both end-users and industry representatives on practical uses and applications. To achieve this, Surrey's Advanced Technology Institute and the Digital World Research Centre worked in partnership with the Welsh Centre for Printing and Coating at Swansea University. Sample light

tags and two application demonstrators were developed and shown in focus groups. These included 'talking packaging' for furniture, which guides users through pictographic assembly instructions, and a glossy photobook which plays a soundscape for each page on a soundbar in the same room **(can be seen in action at vimeo.com/album/3430190).**

The team has now filed a patent for the technology and won a new 'commercialisation to innovation' (ICURe) grant to investigate the market for augmented print and packaging.

Behind the scenes at the museum

❯ Augmented reality to enhance cultural experiences

Academic: Dr Helen Treharne

A new mobile app based on augmented reality and indoor localisation technology is radically changing the way visitors interact with museums and gallery spaces.

As the use of augmented reality (AR) on mobile phones has risen in popularity, several AR apps have been developed to enhance visitor experiences in museums, galleries and other cultural spaces. However, wide-scale adoption of these tools has been hindered for three reasons. Firstly, bespoke development is required to integrate content, which is beyond the means of the UK's 1,900 regional organisations. Secondly, no effective indoor positioning technique is available that can reliably link to augmented content based on a visitor's location. Thirdly, technologists developing apps tend to focus on getting the technology working rather than on usability or content.

An initial IAA project at Surrey developed a prototype Android app capable of overcoming these barriers, enabling exhibition visitors to enjoy a richer, deeper cultural experience, and gallery owners to better understand how visitors are interacting with their space.

The resulting 'Let's Explore' app offers a cost-effective solution by combining the use of visitors' own mobile phones with image recognition and positioning using Bluetooth Smart Beacons (such as the Apple iBeacon). Using the app, visitors are able to access additional information on paintings or historical objects through a combination of oral histories, film, photographs and maps. The technology also recognises where visitors are as they move around an exhibition space, helping curators and gallery visitors to track how their exhibits are viewed.

The app was successfully trialled at two galleries in Surrey – The Lightbox in Woking

'It was enthusiastically received, demonstrating a clear market for the technology.'

The 'Let's Explore' app on trial at The Lightbox, Woking

and Watts Gallery in Compton – in order to evaluate the needs of curators, the expectations of the public and the requirements of the technology. It was enthusiastically received, demonstrating a clear market for the technology.

Following the trials, a second IAA project was launched – in partnership with Pervasive Intelligence Ltd, Visit Surrey, The Lightbox and Watts Gallery – to develop a production-ready AR app and supporting infrastructure. This project focused on creating the web system to support the product, developing a business

plan to define how 'Let's Explore' could be rolled out to cultural organisations, and establishing links to both cultural organisations and commercial partners. One of the key findings of this second phase of the development was the need for cultural organisations to be able to look after their own content. Typical apps for a museum or gallery are bespoke and hence cater for only one exhibition with no changes to the content. This approach is expensive and places a limited lifetime on the app. In contrast, the approach taken by 'Let's Explore' is to enable cultural organisations to enter and maintain their own content and release it to the mobile app simply, time and time again without any bespoke development.

Matthew Casey, Managing Director of Pervasive Intelligence Ltd, says:

"The launch of 'Let's Explore' is the culmination of a lot of hard work in understanding the needs of cultural organisations and their visitors, and our approach to solving some of the key problems associated with wide-scale adoption of digital interpretation. Without the support of the University or the EPSRC, this project would not have been possible and this demonstrates the commitment of the University of Surrey to turn research into impact."

'Let's Explore' launched in February 2015: **lets-explore.com.**

Breathe easy

❱ Developing a low-cost, highly effective, portable spirometer

Academic: *Dr David Birch*

A revolutionary 'Sneezometer' measures human breathing accurately enough to catch the speed of a sneeze – something that no other commercially available system can do as inexpensively or effectively – paving the way for wide use in respiratory diagnostic medicine.

While current systems are generally only able to measure average breathing rates, the spirometer developed at Surrey draws on advanced fluid sensor technologies to offer a simple, low-cost and non-intrusive diagnostic solution. The technique used to create the device was enabled by 3D printing technology, with all of the prototypes 'printed' around the internal electronics.

Dr Birch explains: "In the University of Surrey Aerodynamics and Environmental Flow research group we have developed a number of new instruments for measuring things that nobody has measured before. The spirometer was initially developed to address a tricky flow-measurement problem, but a chance discussion with a health professional revealed the potential for the idea in the healthcare field."

This realisation prompted Dr Birch and his team to create an operational prototype within a period of just three weeks – a very rapid development cycle – and to apply for IAA funding.

"SEHTA (the South East Health Technologies Alliance) was approached and, when we explained that the unit we were demonstrating was not a mock-up but a fully functional, operational prototype, was very interested in getting involved," says Dr Birch.

IAA funding has enabled the research team to develop a production-ready prototype and produce ten units of the device for clinical trials, which will be conducted in collaboration with SEHTA. A patent application for the device has been submitted and a spin-out company is being formed in partnership with a medical instrument marketing specialist.

Portable, highly sensitive and time-accurate, the spirometer could be used in the diagnosis of a variety of chronic and acute respiratory conditions including asthma, obstructive sleep apnoea (OSA) and hypopnoea. Breathing disorders are highly prevalent in both the developed and developing world, and constitute a heavy burden both to national healthcare systems and to the lives of patients. While one in twelve people in the UK is currently receiving treatment for asthma, OSA affects 3 to 5 per cent of adult men and 2 to 5 per cent of adult women.

While one in twelve people in the UK is currently receiving treatment for asthma,

OSA affects 3 to 5 per cent of adult men and 2 to 5 per cent of adult women

In addition, the spirometer may have other uses, such as the monitoring of neonatal infants and the training of elite athletes. Believed to be the most sensitive flow meter in existence, the technology could also have applications outside of spirometry. Market analysis already carried out by SEHTA has confirmed that the spirometer is two orders of magnitude more sensitive than any other device currently available, with four times the resolution; it is also at least twice as fast.

Dr Birch comments:

"This project has arisen from our highly specialised expertise in wind-tunnel measurement, and is a great example of how fundamental research can sometimes result in incredibly beneficial technologies in an entirely unpredictable way. In this case, a simple tool developed at Surrey for fundamental turbulence research has evolved into a medical instrument that could affect the lives of millions of people suffering from chronic health conditions, and reduce costs for healthcare providers."

The University of Surrey, along with the University of Strathclyde, was selected to enter into a partnership with the Department for Business, Innovation and Skills (BIS) to lead the world-renowned National Physical Laboratory (NPL), a global centre of excellence in measurement and materials science.

The new alliance will see the two universities and NPL collaborate to bring together their long experience of working with business and industry and their complementary academic strengths. Working with BIS and NPL, the successful bid will help to shape the scientific priorities of the UK.

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