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**Introduction to the Knowledge Transfer Network’s Sensors and Instrumentation Group**

The Knowledge Transfer Network (the KTN) is the UK’s innovation network. We bring together businesses, entrepreneurs, academics and funders to develop new products and services. Whether this means farmers talking to sensor specialists about sustainable agriculture; or materials scientists talking to laser scientists about 3D printing—we exist to put innovation to practical use.

The Sensors and Instrumentation Community connects the supply chain of technology developers to end-users and system integrators. We engage strongly with UK and international networks to pinpoint challenges and opportunities for exploitation. This means the KTN is well-informed to deliver workshops and other activities dealing with the issues which matter to the community and thus address key challenges and opportunities for the benefit of the UK economy.

The ‘half-life of knowledge’ is shortening, so we must connect business with research faster than ever before.

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**David Lockwood OBE**  
CHAIRMAN  
KNOWLEDGE TRANSFER NETWORK  
connect.innovateuk.org
CENSIS

Tackling the afternoon slump suffered by office workers may not seem like the most obvious way to demonstrate the broad potential of the Scottish sensors and imaging sector, but the vast number of applications this technology can cover is perfectly illustrated in the latest project to receive funding from CENSIS - the Scottish Centre for Sensors and Imaging Systems.

At the heart of the project is a smart building energy management system, developed by Glasgow Caledonian University (GCU) and Scotland’s Gas Sensing Solutions (GSS). It monitors air quality and has an impressive range of other applications to improve working and living conditions, as Ian Reid, chief executive of CENSIS, explains:

"Intelligent automation is going to be a growing theme of future technology. These kinds of projects illustrate the opportunities for businesses and researchers to come up with ideas which make a genuine difference in society."

CENSIS is one of eight Innovation Centres funded by the Scottish Government, Scottish Enterprise and Highlands and Islands Enterprise. Its central goal is to bring together commercial innovation and academic research, with the aim of driving economic activity in Scotland.

As well as connecting industry and academia, CENSIS provides project management and technical support, so that researchers can focus on their research.

The centre was officially launched in 2014, with a five-year grant of £10m from the Scottish Funding Council. The smart energy management system collaboration is just one of around 150 R&D projects CENSIS plans to launch in this timeframe, along with providing training for a new generation of experts.

To best target the challenges and opportunities in the field, over the past year, CENSIS has been conducting research of its own: mapping the Scottish research and industry landscapes.

And it’s also looking to exploit one of the key growth areas of the early 21st century: the Internet of Things (IoT). CENSIS is looking to work with industry to develop standardised tools to analyse generated data; robust solutions that would be published and reviewed to allow others to take advantage of the progress made.

System architecture is another focus for CENSIS, as well as imaging, sensing in the subsea industry and robotics and automation. In all these areas there is a focus on collaborative projects, allowing cross-pollination of ideas to create an environment of innovation, with the structured support of CENSIS project management.

For further information, visit censis.org.uk

Energy Harvesting for Autonomous Sensing

Energy harvesting is the conversion of ambient energy to electricity, which can be used to power electronic components and systems. Ambient energy sources include vibration, light, heat and movement, which would otherwise go to waste. This can therefore be described as 'free energy,' but not in the pseudoscientific way that often blights the term.

Energy harvesting has the potential to operate low power electronics where there’s no conventional power source, eliminating the need to run wires or make frequent visits to remote or harsh environments to replace batteries. The amount of energy available in most energy harvesting situations is low, perhaps a few milliwatts and even then, not on a continuous basis. So there’s clearly a limitation to what can be powered, and the energy balance – the difference between the energy generated and the energy required to power the system - is usually the limiting factor.

In 2011, the Technology Strategy Board (now Innovate UK) identified energy harvesting as a key emerging technology. Market reports predicted 1,000% growth for energy harvesting technologies from 2011 to 2020. Together with the Knowledge Transfer Network, we arranged a number of workshops for the energy harvesting community. Their requests largely fell into four categories:

- Invest in demonstrators
- Help build critical mass
- Create a coordinated programme
- Support to build and nurture capability

The first thing we did was to set up a 'Special Interest Group,' or SIG. It’s still going strong, with over 500 members, and has been responsible for a number of publications on technologies, standards, capability mapping etc. The group is accessible at https://connect.innovateuk.org/web/eh1

In 2012, we launched a collaborative R&D feasibility and demonstrator competition, providing up to £1m for projects using low-power energy harvesting technologies for autonomous sensing. The aim was to invest in energy harvesting companies and demonstrate the feasibility of the technology in powering autonomous sensors and systems.

We received 29 proposals; the majority integrated energy harvesting with power management, sensing devices and some form of data transmission. Ultimately, we were able to fund 10 high quality projects covering a range of modalities including vibration, thermal and solar. They ranged across applications including building control, engines, rail-track, water pipes, process monitoring and structural health. Seven of these projects were led by SMEs.

MYRDDIN JONES
LEAD TECHNOLOGIST OF ELECTRONICS, SENSORS AND PHOTONICS AT INNOVATE UK
THE CASE FOR A NEW SENSORS TECHNOLOGY CENTRE IN THE UK

Sensors – the key to many aspects of industrial and societal strategy
The UK is good at sensors. It’s strong in sensor research and adept at sensor manufacturing, particularly for high value applications. It’s clear that sensors are a UK strength which already contributes significantly to the UK economy. The Internet of Things will, in its widest context, drive major societal benefits in smart cities, smart energy and smart agriculture; it has the potential to transform UK manufacturing and encourage re-shoring through smart factories (Industry 4.0) and smart logistics. It’s really the Internet of Sensors.

Put more simply, technological developments, largely driven by mobile computing, have enabled cost effective sensor systems to become ubiquitous; they can be easily linked together to collect data about all aspects of the world we live in and allow more things to be measured, controlled, recorded and analysed.

Coupled with capacious data storage and big data analysis techniques, ubiquitous sensors enable a world where performance - of products and people - can be monitored and fed back to us. This data can be used to advance future design, or controlled to improve performance, efficiency and the relevance of the information we receive.

It is difficult to think of a more transformative area of technology, or one with more relevance to the challenges facing the UK today. These facts present a good case for the UK mobilising and co-ordinating its sensor communities, in order to encourage innovation and investment. Clear benefits arise from better networking and more joined-up thinking, yet somehow we are still working in a diverse and somewhat disjointed manner, with many islands of innovation. So why is this and what can we do about it?

One cause seems to be that government policy and public perception (which tend to go hand in hand) are focussed on vertical industries (automotive, aerospace, defence, and pharmaceuticals, for example). Recent government policy has been very effectively directed here.

Excellent innovation facilities, such as the UK Catapult centres, have been modelled loosely on the German Fraunhofer model and designed to help innovation come out of universities and progress through the difficult early stage of maturity, until it’s ready for commercial exploitation by industry. But these centres have tended to focus on vertical industries. This is fine, but it does risk missing the point that these verticals rely on technology (like sensors) that is developed ‘horizontally’ and may have been made for entirely different applications.

At present, there is no Catapult specialising in sensor technology, despite the clear importance of sensors to key industries and to the UK economy.

Without a similar focus on horizontal technologies, such as sensors and electronics, the whole fabric does not hold together – we have the warp without the weft.

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Without a similar focus on horizontal technologies, such as sensors and electronics, the whole fabric does not hold together – we have the warp without the weft.

The Sensors and Instrumentation Leadership Committee (SILC) was formed in order to try and pull this fabric together. Its aim is to provide a focus for coordination by joining up industry, academia and government to build a cohesive and connected sensor community in the UK.

One of our immediate tasks is to propose a way of coordinating the country’s sensor research and development, making expertise and resources available to all companies working in the area. This is not a task to be underestimated, particularly because 84% of UK companies working on sensors are SMEs.

Like other technologies, sensor development suffers from the classic ‘Valley of Death’ paradigm, the gulf between proof of concept research by universities and a fully tested and commercialisable product.

There are facilities that can help sensor companies cross the Valley of Death. The excellent CENSIS, based in Glasgow, helps companies link up with sensor research in Scottish universities; Liverpool’s new Sensor City aims to provide a similar service. These are excellent initiatives but they’ve come about through the work of inspired local teams, rather than as a result of cohesive UK-wide, strategic planning. SILC is aiming to propose, to government, a way of utilising these and other existing bodies, augmented by additional facilities which do not yet exist, to provide a coordinated and connected support structure for UK companies.

We will be engaging with the sensor community on this topic during the remainder of this year, to make sure that what we propose is exactly what’s needed. If you have a point of view, please send your initial comments and ideas to me here: graeme.philp@gambica.org.uk

I look forward to hearing from you.

Dr Graeme Philp
CHAIRMAN OF THE SENSORS AND INSTRUMENTATION LEADERSHIP COMMITTEE
The Innovation Database

It’s not unusual for a company to have a product or scientific method of gathering and examining information that could be easily adapted for forensic use and not realise it; the forensic science market can be a daunting prospect to the uninitiated.

To make it easier for companies and academics to access this market, the KTN’s Forensic Science Special Interest Group (FoSci SIG) has produced a centralised on-line resource: the Innovation Database. This database details the specific problems faced by the forensic science community and includes named contacts who could even become your first customers.

The database is divided into three areas: Challenges, Contributors, and Stakeholders.

Challenges
The Challenges section covers a range of disciplines in forensics - from the development of new fingerprinting techniques to more efficient deployment of crime scene investigators and reducing the sample volume required for drug analysis. Designed to be easy to search, the database has four filter types to narrow down a selection: Forensic Discipline, Forensic Process, Criminal Justice System Process and Operational and Innovation. It’s not necessary to know the specifics of what you are researching so, even with no particular forensic discipline in mind, a search can be focused by choosing areas related to your product or service: Collection of evidence, presentation of evidence and custody procedures, for example. But, if searching for something very specific, you can also easily locate it.

Contributors
Each challenge has a link to its contributor – an individual, or a report generated by the SIG in some cases. Contact details are provided for anyone who wants to discuss the topic further, and there are links to other challenges contributors may have submitted, as well as stakeholders they’re linked to. If you’re interested in working on a solution to a challenge, it’s good practice to discuss the exact requirements with the original contributor.

Stakeholders
Listed stakeholders include companies, academic institutions and organisations involved in forensic science. This section provides not only contact details and information on current projects and capabilities, but also key data on the partnerships each stakeholder can offer, and the type of association they’re looking for. For a company looking to take its first steps into the forensic market, finding a suitable partner from the stakeholders in the database might be a great first step.

The future
The innovation database is designed to evolve and grow as the challenges facing the forensic science community change and shift. To encourage discussion, each challenge is supported by an online forum, and there’s an opportunity to submit new challenges and register new stakeholders. The more interaction the database has, the more effective it will be as a resource, so we’d encourage you, the sensors community, to become involved.

Forensic Science SIG members can access the database at http://tinyurl.com/FoSciSIG
SECTION 1: FORENSICS

Given the technological wizardry displayed on TV shows - such as CSI, Dexter and NCIS - it's amazing that any crime goes unsolved. Unfortunately, real life and actual police-work isn't like that. Where TV merges the boundaries of science fact into science fiction, the Criminal Justice System (CJS) has to rely on solid, proven technologies, some of which are surprisingly low-tech.

Searching for and identifying blood at the crime scene is one of the most important activities undertaken by forensic scientists. Most current approaches depend on the investigator being able to see a blood spot or stain, which is then subjected to a presumptive chemical test prior to the collection of a sample. All current tests are subject to false positives and they may also deter subsequent DNA analysis. At a crime scene, there is presently no easy way to systematically process large areas for blood contamination, nor of determining the age of a sample once a blood spot is found.

What is sorely needed is a system that can detect 'invisible' traces, where perhaps blood has been washed away; a system which can identify the substance as blood, rather than something of a similar colour, such as a food source. It should be non-contact, non-destructive and, given today's financial constraints on the CJS, it must be cost-effective.

In pursuit of these aims, Dr Meez Islam and colleagues at Teesside University have come up with a technique which not only detects blood traces, but also estimates their age, without contaminating the evidence. Their new approach uses hyperspectral imaging to take a series of photographs at different wavelengths, which are digitally stitched together to form an 'image cube.' It's a fully portable system and can produce a full spectrum of any point in a photograph. It also allows discrimination between a blood sample and a background material, which may be of a similar colour, in near real-time.

The technology was showcased at the KTN’s Forensic Science R&D Technology event. It’s a cutting-edge approach which has also led to a new company, Chemicam, spinning out from Teesside University. Chemicam recently won funding to progress its ideas from the Small Business Research Initiative (SBRI) call, ‘Location and Discovery of Forensic Material.’
BIOSENSORS FOR HEALTH

Bioelectric therapy: sensors and microelectronics pave the way for the therapeutic revolution

For centuries healthcare has been dominated by mechanical and chemical intervention. But now, supported by ever-improving sensing technology, modern healthcare is enabling accurate diagnosis of disease to enable early medical treatment and therapy. Nevertheless, significant improvements for medical intervention technologies are still necessary, although a tricorder type medical device remains a remote dream. However, recent, rapid developments in micro-sensors and microelectronics - and better understanding of human physiology - are bringing us a step closer to another healthcare revolution. It holds the promise of a radically different approach to treating common illness and disease.

Particularly exciting is the use of electronic impulses, which interact precisely with human nerves, and could correct bodily malfunctions or stimulate biological responses to fight disease. So-called bioelectronic therapy could, for instance, see implantable micro-devices sending signals to a patient’s sensory optic nerve, enabling blind people to regain their vision; it could be used to stimulate motor neurons, giving control over prosthetic limbs.

Recent developments in micro and nanotechnology have enabled the fabrication of micro-sensors which could be easily implanted inside an organ, such as the human eye. Nano-electrodes would interact with specific nerves for the precise application of electronic impulses.

Clinical trials in the UK have, to date, seen 12 participants fitted with a ‘bionic eye,’ and clearly demonstrate the potential of bioelectronic implants. The ‘bionic eye’ is a 3x3 mm² microchip, containing 1,500 light-sensitive micro-sensors, which converts light into electronic signals, and is designed to replace light-sensitive cells in the retina lost to diseases such as retinitis pigmentosa. The device works by producing signals to stimulate the nerve in the retina.

“I am able to detect light and distinguish the outlines of objects. I have even dreamt in very vivid colour for the first time in 25 years, so a part of my brain, which had gone to sleep, has woken up! I feel this is incredibly promising and I’m happy to be contributing to this legacy.”

Led by Professor Robert MacLaren of the University of Oxford, the trial has enabled patients to regain ‘useful vision’ just weeks after undergoing surgery. Mr Millar, a trial participant who had been blind for many years reported: “I am able to detect light and distinguish the outlines of objects. I have even dreamt in very vivid colour for the first time in 25 years, so a part of my brain, which had gone to sleep, has woken up! I feel this is incredibly promising and I’m happy to be contributing to this legacy.”
CASE STUDY

Applied Nanodetectors

Helping people manage chronic diseases such as asthma, pneumonia, tuberculosis and COPD - a collection of lung diseases which includes bronchitis and emphysema - is just one goal of innovative nano-sensor developer and supplier, Applied Nanodetectors, formed in 2004.

Their sensor arrays can be integrated with mainstream semiconductor processes and manufactured at high volume, offering real time monitoring applications such as point of care diagnostics (POC) and the detection of volatile organic compounds (VOCs).

The company claims the sensors they produce for the environmental, healthcare and medical markets, worldwide, are highly sensitive but compact and benefit from low power consumption.

Early diagnosis, better prognosis

For respiratory diseases, breath analysis is a particularly exciting application of these Applied Nanodetectors arrays.

Crucially, an accurate diagnosis usually results in early treatment. The initial symptoms of pneumonia, for instance, are very similar to those for viral chest infection. A misdiagnosis can lead to a delay in treatment and a potential hospital stay.

The technology can detect even small quantities of volatile organic compounds. The process is non-invasive and, after chemical analysis, data is fed back to the patient and produces a fingerprint for early disease detection and diagnosis. Physical characteristics, such as humidity, can also be detected.

The Applied Nanodetectors device has a further advantage: due to combination of chemical selective layers modifying the surface of a nano structure, it can sense different chemical markers concurrently. A variety of chemical sensors provide the flexibility to monitor many-varied markers, which may indicate different diseases.

Dr Victor Higgs, the company’s founder and Managing Director believes the potential benefits could have significant impact:

“COPD and asthma are classically not very well controlled. Huge numbers of work days are lost annually to both,” he says. “It’s been estimated that respiratory disease costs the EU 380bn annually. It has a massive impact on all of our lives.”

Help for asthmatics

An asthmatic’s condition can change very quickly, so regular monitoring is beneficial; similarly, for COPD, early intervention can minimise exacerbation. A thousand deaths a year could be avoided with more proactive controls.

Biomarkers are known to increase 4-6 weeks before a serious attack and Applied Nanodetectors’ asthma breath analyser can discern change through daily condition testing, enabling proactive treatment.

Asthma affects one in five families. But biomarkers can provide a solution. Children and the elderly are particularly likely to benefit from the technology. The device is standalone and designed so that carers can easily adapt prescribed medication for elderly patients. With children under 11 likely to be poor at recognising the symptoms of ill-health, they also benefit from regular, non-invasive, breath analysis.

Changing from a reactive to a proactive system could be as simple as an over-the-counter breath test; with 21st century nanotechnology, life for those with chronic respiratory diseases may soon become easier.
THE ACCELERATED AIR REACHES SPEEDS OF 1500 km/h IN THE JET NOZZLE

THE FAN SHIFTS 1.2 TONNES OF AIR A SECOND

THE BLADES ROTATE AT 10,000 RPM

AIR ENTERS THE CORE COMPRESSED TO A 50TH OF ITS NORMAL VOLUME, WITH A TEMPERATURE OF ABOUT 700°C

IN THE COMBUSTOR, THE AIR IS MIXED WITH KEROSENE AND BURNED TO REACH TEMPERATURES OF 2,300°C
The UK aerospace sensors market is worth an estimated £6.9bn and employs over 40,000 people. The aerospace sector is one of the UK’s largest and proudest, and measurement technologies are a vital part of it; monitoring systems can enhance safety, as well as the performance and costs. There are also many roles measurement technology can play in aerospace, and many avenues for innovation.

This was the background to ‘Sensors in Aerospace,’ an event produced by the KTN in late 2014. Featured were speakers Pete Loftus, Head of Measurement Engineering at Rolls-Royce and Brian Allen, Leader – Structural Integrity Technology at Air Division QinetIQ.

Their two very different perspectives presented a unique snapshot of measurement innovations which can build on the UK’s leadership in Aerospace Technology.

**Measurement for Propulsion**

Measurement devices in propulsion systems are expected to operate in some very challenging conditions (see infographic below). The devices might be expected to operate in the searingly hot temperatures of a combustion chamber or in the dirty environment of a fuel system. Any advances on the accuracy or operational range of such devices will be well received, whether this is achieved by remote monitoring, or the development of cheaper, smaller, more rugged devices from MEMS technology.

A vision for sensors and instrumentation for propulsion could be summarised as strong, innovative embedded measurement systems driving standards and innovating in application. The focus here should perhaps be on systems – to include not just the sensor device, but the network infrastructure, data and power management.

Energy harvesting, which promotes wireless operation, is a big area of interest due to weight issues in wiring, a huge factor in aircraft design. It’s clear, however, that any new device must work in conjunction with existing systems and so a systems-level approach is needed.

**Condition Based Monitoring**

Integrity and health was the focus of Dr Allen’s talk on condition-based monitoring (CBM). The alternative to CBM is interval-based maintenance, which inevitably means throwing away good components. The possibility of monitoring equipment during operation and basing maintenance on real-time information would enable significant costs savings.

Intrusive maintenance is also a risky business. The removal of devices and testing can cause unintentional damage to an aircraft. Compared with interval based intervention, aircraft non-availability was reduced by 10% and mission aborts by 60%. This level of reliability is vital, not only for military operations but in civil aviation too, where the costs for maintenance based mistakes are huge (see infographic). Given the tight margins and the large penalties imposed, shutdowns, delays and cancellations can easily bankrupt an airline.

**Ways forward**

Ultimately, there’s a clear need for multi-parameter sensors which harvest energy and communicate wirelessly. Opportunities exist in embedding these sensors to gather more data, creating more accurate models through smart data analytics and thus reducing uncertainty. But the systems level approach requires that measurement systems need to be modeled in their entirety for ultimate benefit, with consideration of the coupling between the sensor and the measure.
The main purpose of the six-monthly Intelligent Sensing Programme (ISP) events is to draw the community together, primarily to network, but also to hear from cutting edge developers on the opportunities and challenges in the sector. A private tour of the Williams F1 collection provided a welcome bonus for ISP delegates.

With an established background in aerospace, the event’s Chair was Pete Loftus, Head of Measurement Engineering at Rolls-Royce. He acknowledged the value of the event, in bringing cross-sector, UK-wide measurement developers together to focus on an area of such vital importance to the economy.

Unsurprisingly, autonomy was a prevailing theme and delegates were party to talks from across the entire technology chain.

The first keynote, Will Maddern, Leader of the Nissan LEAF project at the University of Oxford, detailed the state-of-the-art research undertaken in the area, and the technical difficulties inherent in moving to complete autonomy. Roger Hazelden, of TRW Conekt, presented a technology supplier’s perspective, describing the status quo in low cost automation.

The day’s second keynote was Paul Widdowson of Jaguar Land Rover. His fascinating presentation was entitled ‘Sensing for ADAS & Automated Driving – a vision of present and future needs.’ Advanced Driver Assistance Systems, or ADAS, are designed to aid the driving process. Mr Widdowson outlined end user needs, as well as social attitudes to the varying levels of autonomy in cars.

Turning to practical support for companies wishing to inno-
The Oxford team providing the control systems for the UK’s first driverless cars

Oxbotica, specialist provider of autonomous control system technologies and a recent spin-out from Oxford University’s Mobile Robotics Group, is a key player in the UK government’s £19m Autodrive project. Launched earlier this year, it's a highly ambitious venture, which will see trials of driverless cars taking place in UK cities over the coming years.

A vital element of the project is the implementation of a Low-Speed Autonomous Transport System (L-SATS), which will see 40 self-driving pods carrying members of the public on routes around Milton Keynes city centre, linking in to key transportation hubs and car parks. Oxbotica will develop and provide the entire autonomous control system and sensor sub-system to the L-SATS pods, to enable real-world operation of the driverless vehicles in urban and pedestrianised areas.

“It’s important that the UK invests not only in its research institutions and the technology that underpins autonomous self-driving vehicles, but also that it supports and builds companies that can exploit and deliver this technology to the market,” said Oxbotica’s co-founder Professor Paul Newman.

“It’s time to transition the UK’s leading edge intellectual property in mobile autonomy from our research institutions to global markets in a coherent and integrated fashion. We created Oxbotica to accelerate this transition, and we are now in a superb position to deliver world leading autonomy tech into the L-SATS project, which will be the first of its kind to demonstrate such a substantial implementation of real autonomy.”

Themed around the role of sensors in the Internet of Things, the next ISP event will be in Summer 2015.
SMART PACKAGING
The two fundamental technical purposes of packaging - protection and functionality - make it a key area of focus in research and innovation. Although shielding food from adulteration or spoilage, and thus minimising waste, must be carefully balanced against the use of excessive packaging ending up in landfill. But what if we could improve on packaging’s functionality; what if, in addition to protecting food, it could also communicate useful, commercially valuable, messages to the consumer or manufacturer? Supply chain history is just one example.

Exploring the opportunities and challenges in the integration of intelligence into packaging was the premise behind a workshop organised by the KTN last November, in York. In particular, the event drew on a report written by Biosciences KTN, supported by Innovate UK, the Food and Drink Federation and Edinburgh Science Triangle. This report lists Smart/Intelligent Packaging as one of 10 pre-competitive challenges for the industry. The report highlights key opportunities for exploration including:

- Smart sensors for product spoilage
- Authenticity and quality
- Smart materials, which react and adjust their protective functions according to external stimuli
- Diet control – packaging that interacts with smart devices, e.g. apps and sensor devices, to monitor dietary intake, control allergies or diabetes
- Personalised packaging solutions, providing customised shopping experiences through large-scale ‘big data’ systems
- Connectivity – novel packaging solutions that connect consumers

So, plenty of opportunity and a huge potential market. But where should a developer start? Cheap RFID devices? Functional inks? Augmented reality?

What does the consumer want?

To best explore what’s achievable in this field, and how smarter packaging might bring added benefit to a manufacturer or consumer in the future, it’s crucial to understand that the way in which consumers buy food and drink is changing. The most obvious move is away from a big weekly shop at a large supermarket to increased popularity in on-line, discount and convenience store shopping.

Customer trends and preferences are a crucial consideration as, unless the perceived benefit to them is clear, why should they pay for it? But there are areas where the consumer might be happy to pick up a fractional cost increase. Information on ripeness, freshness and shelf-life can help them to make more informed choices, and solutions that provide a better confidence in the product’s origins may also be desirable.

Smarter packaging can improve the overall user experience. Combined with smart analytics, it could provide better suggestions to linked products. Shopping habits may also reveal correlations driving sales factors.

The role of packaging extends into the home. It can provide cooking, serving, nutrient and advertising information. Could we streamline this to a more ‘personalised’ experience? Some of the data cluttering up current packaging could easily be accessed via a smart phone, which would relay only the information the customer needs or wants. This accessibility would need to be balanced with legislation which dictates what information must be displayed.

What does the manufacturer want?

Confidence in the food and drink industry was shaken by the discovery, in 2013, of horsemeat in some UK food products. The scandal highlighted the susceptibility of a multi-faceted (often international) supply chain, and created a new level of consumer interest in food security. The industry relies heavily on consumer confidence and there is clearly an incentive for manufacturers to carefully monitor produce and demonstrate due-diligence in processing. Electronic and sensing devices are available for on-pack, ‘passport-style’, traceability, which is accessible via a smartphone, ensuring product security, authenticity and ultimate conditions for storage or processing.

Smart packaging solutions can also deter shoplifting, which costs UK retailers £335m a year. Visibility of anti-theft solutions on packaging is itself a deterrent but hidden, connected, solutions could trigger CCTV and have the added benefit of reducing reliance on staff intervention.

No future for augmented reality?

Brands have seized upon the possibilities of augmented reality and, with smartphone use in the UK set to grow, we can expect more high-tech campaigns. But, while developers and manufacturers of augmented reality apps are excited by the technology, analysts warn that they’re often unclear about what key benefits they’re trying to deliver to users.

Innovation in this industry should add functionality – thus the rule must be ‘no gimmicks,’ unless there is a practical reason, increasing ‘brand love’ for example.

Packaging solutions must also take into account practical elements. They should, for example, be easy to apply, with no need for retrofit to an assembly line; they shouldn’t obscure artwork, should be microwave safe and should balance sustainability with functionality.

What’s perhaps most important to consider is that, while there are many opportunities to adopt new technologies in the food and drink industry, their take-up is inhibited by the sector’s conservative nature, and requires the commitment of the entire packaging supply chain. New ‘connected packaging’ solutions also need industry standards. Ultimately, legislation may be the best way to drive some of these opportunities forward, as the cost to benefit balance may be hard to justify without it.
Plastic electronics goes by a bewildering variety of names, not all of which adequately describe an emerging field - one of the fastest growing technologies in the world - which many experts say will revolutionise the electronics industry.

The names most commonly used are plastic, flexible, organic and printable electronics or, most recently, TOLAE (Thin-film, Organic and Large Area Electronics). Essentially, it’s a multi-disciplinary technology which enables circuits to be printed or deposited onto a range of surfaces (both rigid and flexible) and so opens the door to a new generation of innovative products that can be produced more cheaply and in a more environmentally-friendly way than previously viable. The potential for manufacturing is huge.

Plastic electronic devices can vary significantly in design and complexity. In the simplest design case, a few circuit elements are attached to a substrate. Sensors, resistors, capacitors, inductors and switch elements can all be printed onto the substrate material along with conductive traces to create the circuit layout. Active elements, such as LEDs, transistors and integrated circuits are directly attached using conductive adhesives.

Laser-printed paper-based sensors are already being developed by the UK’s Optoelectronics Research Centre (ORC), with the aid of an Engineering and Physical Sciences Research Centre (EPSRC) research grant. The sensors can be used to detect biomarkers in cancer patients and those suffering from infectious diseases. The technology has transformative potential, cancer patients could be treated in their own homes, closely monitored to see how they are responding to chemotherapy. The sensors would also be telemedicine-enabled, allowing transfer of valuable clinical diagnostic information between patients and their care team through a mobile.

Stretchable electronics, logic and memory and thin film sensors are believed to hold huge growth potential as R&D progresses. The products created with these new materials and methods are often cheaper, flexible (such as bendy screens and clothes with digital displays), thinner and lighter. Printed electronics can be integrated into almost anything from intelligent packaging, to protect goods, prevent counterfeiting or detect when products are past their shelf life, to low-cost solar cells in the fabric of buildings and vehicles.

The technology is the gateway to edible, foldable, rollable, conformal, wearable, biodegradable and other electronics and of vital interest to industries as diverse as consumer goods, healthcare, transport and architecture.
Wearable Sensors

The worldwide market for wearable sensors is forecast to grow significantly over the coming years, from 67m units in 2013 to 466m in 2019, according to analysis source IHS Technology. A key finding is that the shipment of sensors for wearables is forecast to grow more than twice as fast as the market for the end product. This growth indicates a transition towards more sophisticated multi-purpose devices.

To date, most interest has been in the ‘easier-win’ wearable solutions – fitness and well-being for example – where tried-and-tested technology, such as a heart-rate monitor, records data and provides users with individualised analysis. The data can also be transmitted to the user’s GP and more widely shared, with the NHS for instance. Certain data may also be valuable to the police or military.

But analysts believe that wearables are about to get more advanced, with multi-functional sensing technologies. The types of sensors used in wearable technology are changing, according to IHS data. There’s a move away from pedometers and heart-rate monitors towards motion sensors and MEMS, as well as increased integration of sensors into the interface, providing new ways to seamlessly interact with technology.

The confluence of microelectronics, ubiquitous wireless connections and energy harvesting is enabling highly networked, autonomous sensor platforms in sectors such as aerospace and smart infrastructure. This will also provide the basis for more advanced multi-functional wearable devices.

For any wearable application, purpose and context need careful consideration. End-user engagement during all stages of design and development is vital. Taking just data factors as an example, consideration must be given to management and security, as well as user confidence in the data itself. For devices that can transfer data in real-time, this is even more important.

Whether it’s a data issue, a question about user testing or any other development requirement, the KTN can provide a helping hand. The diverse communities of end-users the network brings together can identify challenges of commonality and tackle them using multi-sector approaches. Drawing on a wider knowledge base has the additional benefit of diluting the risks associated with innovative products such as wearables.
MICRO & NANO DIRECTORY

As key enablers in the development of high performance, low energy sensors, micro and nanotechnology have received significant interest over the past decade. The availability of new types of tools, techniques and materials with unique properties has fuelled innovation. Research is taking place for a huge variety of applications, in sectors from defence and healthcare to diagnostics, anti-counterfeiting and optics.

The UK has a strong academic research base and it's important that companies can tap into this, to gain knowledge and to utilise facilities. To this end, the KTN has produced an academic directory that is available online at no cost.

This directory contains not only contact information, but also lists the facilities available and an institution's current research projects.

The first edition features some 30 academic institutions, those that responded to the KTN's contact request. The hope is that the directory will expand in future editions, as more institutions submit their details.

The online directory is located on the Sensors and Instrumentation Community Documents page. If your institution would like to be included, please email: felicity.carlysle@ktn-uk.org

THERE IS PLENTY OF ROOM AT THE BOTTOM

"The name of this talk is 'There is Plenty of Room at the Bottom' – not just 'There is Room at the Bottom.'

What I have demonstrated is that there is room – that you can decrease the size of things in a practical way. I now want to show that there is plenty of room. I will not now discuss how we are going to do it, but only what is possible in principle. In other words, what is possible according to the laws of physics. I am not inventing anti-gravity, which is possible someday only if the laws are not what we think. I am telling you what could be done if the laws are what we think; we are not doing it simply because we haven't gotten around to it."

PROF. RICHARD FEYNMAN, 1959

In his now infamous 'There is Plenty of Room at the Bottom' lecture at the California Institute of Technology, Caltech, physicist Richard Feynman considered what might be possible by the manipulation of matter on the atomic scale. In particular, he was very interested in the impact such 'nano-engineering' might have on computing, medicine and microscopy.

Feynman issued two daring scientific challenges during his lecture – one to create a motor no larger than 1/64 in 3 and the other to shrink the Encyclopaedia Britannica onto the head of a pin.

The first challenge was achieved shortly after it was issued. As only the standard tools - tweezers and microscopy - of the time, were used, the achievement is impressive, although it somewhat misses the point.

The other challenge, to shrink the Encyclopedia Britannica, went unsolved until 1985, when it was partly achieved by a Stanford graduate who inscribed the entire first page of A Tale of Two Cities onto a pin using an electron beam.

Although, at the time, the impact of Feynman's revolutionary thinking was limited, his 'Plenty of Room at the Bottom Lecture' established his reputation as one of the greatest minds in physics. The event has gone down in history as a key factor in the nanotechnology revolution. Thankfully, Feynman's assertion that "we are not doing it simply because we haven't gotten around to it" is now untrue, evidenced by the miraculous devices we take for granted everyday.
litres of water are used to create each vehicle it produces. Suddenly, threats of water scarcity became relevant. In order to produce more efficient vehicles, JLR has started using lightweight aluminium. However, producing primary aluminium requires large quantities of energy and water. On the other hand, using recycled aluminium consumes 95% less energy and reduces water consumption. JLR has decided to invest in a range of recycling initiatives to develop technology in this area and to further reductions.

By targeting water use throughout its operations and across the supply chain, JLR has already reduced consumption per vehicle by 17% (from a 2007 baseline).

Moving forward, the company is creating a focus group to address water use in its manufacturing operations outside the UK. It’s paint shops are a key focus in water reduction, as this is where most of the water is used.

The Horizons online, interactive tool can be accessed at http://horizons.innovateuk.org and support using this tool can be accessed by contacting horizons@ktn-uk.org

JLR’S KEY HORIZONS BENEFITS

REDUCED WATER USE PER VEHICLE BY 5% IN 2012/13

WATER USE PER VEHICLE DOWN BY 17% FROM 2007 BASELINE

OVERALL EFFICIENCY MEASURES HAVE LED TO A 23% REDUCTION IN ENERGY USE PER VEHICLE

JLR’S CHALLENGE

Reduce water use during vehicle manufacturing

Problem: Rising product demand is outstripping the supply of water, an increasingly scarce natural resource. Currently, it takes about 140,000 litres of water to create each vehicle JLR produces. As the company starts to move its manufacturing outside the UK, water use management will become an even bigger issue.

Solution: A JLR 2020 sustainability goal is to evaluate water impacts across operations and improve efficiency. The company has already invested £9m in UK-wide efficiency measures between 2010 and 2012.

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Mark Littlewood
HEAD OF SENSORS AND INSTRUMENTATION
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Mark leads the sensors team, working with the Sensors Systems and Instrumentation communities. This role includes a focus on biosensing activities and he is also the coordinator of the Forensic Science Special Interest Group.

Following a BSc in Biochemistry from the University of Hull, Mark moved into research positions at the Universities of Leicester and Manchester. In 1993 he moved to South Africa where he took up a research post and, later, a junior lecturer position at the University of the Witwatersrand in Johannesburg. He completed a PhD in signal transduction mechanisms associated with cell differentiation and returned to the UK in 1998.

Mark was the Associate Director of Laboratory Operations with DNA Sciences, a Cambridge-based pharmacogenetics company, whilst completing an MBA at the University of Warwick. He has worked in various sales and marketing roles at Sigma Aldrich and laboratory automation company, NextGen Sciences. He has worked in knowledge transfer since 2005, supporting academics, large-scale industry, SMEs, Research Councils (PPARC, STFC, BBSRC, EPSRC and NERC) at the Sensors & Instrumentation KTN, ESP KTN and with QI), a technology-marketing consultancy. He joined the KTN as a full time member of staff in March 2013.

Matt Butchers
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After completing his Masters in Physics at Exeter University, Matt moved to the Midlands to begin his EPSRC funded doctoral programme in experimental physics, looking at the interaction of high-energy X-rays with magnetic materials. The aims of the PhD were to develop experimental and data analytic techniques to extract new information from the measurements.

After completing this project, Matt accepted a design and development position at a York University spinout, focusing on the commercialisation of academic projects and the upgrading and distribution of scientific equipment.

Now living in London, Matt works for the KTN’s Sensors and Instrumentation community, coordinates the activities of the Industrial Mathematics community and leads the Uncertainty Quantification and Management in High Value Manufacturing Special Interest Group.

Felicity Carlysele
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Felicity completed a BSc in Biochemistry at Royal Holloway, University of London, and then moved to Scotland for a Masters in Forensic Science at the University of Strathclyde. She’s recently completed her PhD in Forensic Chemistry at the same university. The focus of her research has been on the characterisation of explosive precursors using high-resolution spectroscopy.

Felicity spent nine months working part-time for the Forensic Science Special Interest Group on the development of their innovation database. In July 2014 she became a full time employee at the KTN, splitting her time between the Forensic Science Community and Sensor Systems, where her focus is on instrumentation. Currently based in Glasgow, one of her main roles is to increase the KTN’s interaction with the sensors community in Scotland.

Liqun Yang
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Liqun obtained a BEng and MEng in Metrology and Instrumentation at Harbin Institute of Technology in China, and a PhD in novel biophotonic sensing technology at King’s College London. After completing a three-year Post-Doc fellowship on optoelectronic sensing at Robert Gordon University, he joined ClavusSmithKline (CSK) R&D in 1996, where he worked as an in-house technology consultant, providing innovation support to scientists developing new drugs. After nine years at CSK, he spent a further three working with start-up companies developing novel sensing technologies for the oil & gas industry and for biopharmaceutical measurements.

He’s worked in knowledge exchange and transfer, within UK universities, for the past three years as a Research and Enterprise Manager at the University of Essex and as a Business Development Manager at King’s College London. In these roles, his main responsibilities are looking after programmes, supporting academics in developing projects, collaborations with industry and other research commercialisation activities.