science SCOTLAND

THE ROYAL SOCIETY OF EDINBURGH

Issue 16 Autumn 2014

Cutting Edge Research from Scotland

SPECIAL ISSUE:

Innovation Centres

www.sciencescotland.org

Foreword

SIR JOHN ARBUTHNOTT

Investment coupled with initiative makes innovation possible

The eight new Innovation Centres being established in Scotland are intrinsically innovative in several ways. Not only are they ambitious in terms of the plans to develop new business solutions and stimulate industry progress, but they are also being set up to deliver social benefits as well as economic impact.

The other innovation is that all the new Centres are "industry-led," bringing university researchers together with business to deliver what industry needs, rather than doing original research then searching for someone to buy it. If there is no existing demand, the Innovation Centres simply will not fund the research.

For the Scottish Funding Council (SFC), which is backing the Centres with up to £120 million over five years, the project is also a change in direction in several important respects. The budget is significant and so are the pressures to invest the funds wisely. The SFC is used to building bridges between academic researchers and business, but the new Innovation Centres will create a new emphasis on economic and social impact as well as industry-led innovation – in other words, applied research.

Economic impact is easy to define but hard to measure. The Scottish Government wants to see new jobs created, new companies emerging and new skills acquired by the workforce. It wants to see new innovative products and services reaching the market, generating revenues and boosting exports, and it wants to see inward investment. That is why the Innovation Centres are not getting government grants – they are getting investment. And the Government wants a return.

Established and emerging industries

Oil and gas, construction and aquaculture are established major industries where innovation could make a huge contribution in the future, whilst industrial biotechnology is a relatively new field which promises spectacular gains, along with sensors and imaging systems – another old science being powered by new digital technology. Data science (the Data Lab), stratified medicine and digital health may not yet have the same public profile, but they also have great economic and business potential.

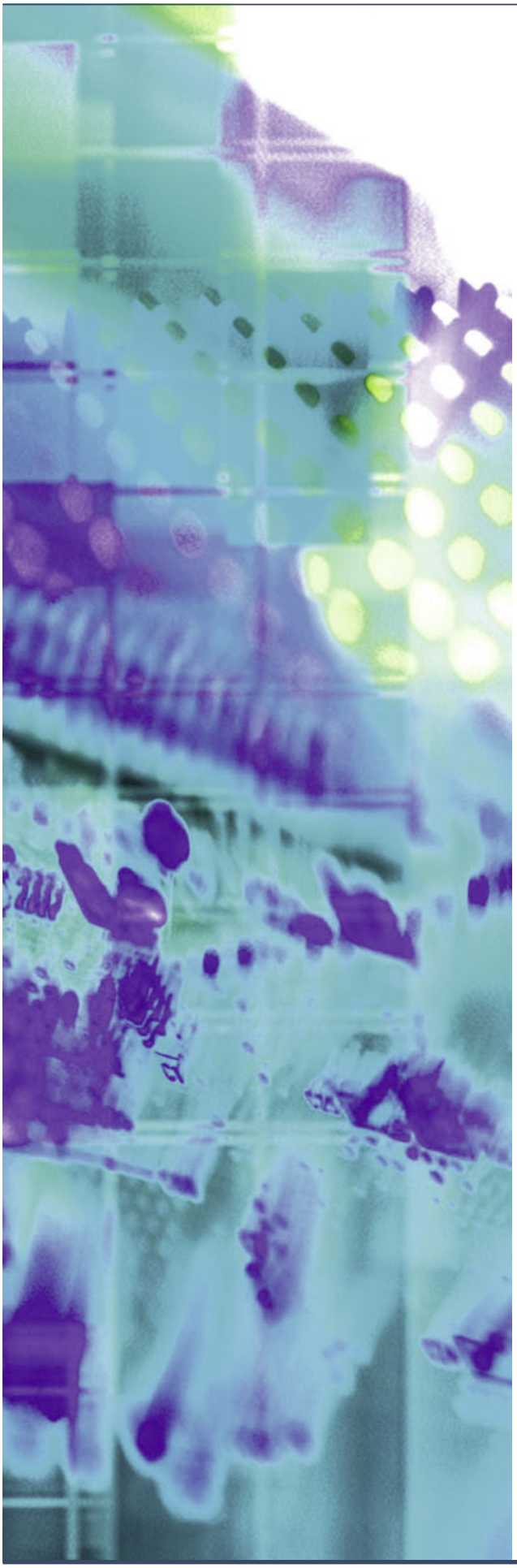
Social impact will be difficult to measure for most of the Centres, but data science, stratified medicine and digital health will have more obvious effects on people's lives and government policies. Data science will help business analyse mountains of data, but will also help governments analyse social behaviour and health-care requirements; and also support the emergency services as well as defence and security. Stratified medicine and digital health will revolutionise health care, not only via personalised medicine and new digital technologies but also by reducing costs and making budgets easier to plan.

Perhaps the most interesting feature of the eight new Innovation Centres is cross-fertilisation – reflecting the inter-discplinary nature of most modern science. Collaboration is not a new thing for researchers in Scotland (e.g., the university alliances in informatics, physics and life sciences) but the connections between the new Centres are already extensive. For example, data science uses sensors and imaging systems for many of its applications, including a new generation of wearable health-care devices which may emerge from DHI, providing information which helps to develop solutions for stratified medicine. Data science can also help oil and gas improve recovery rates, and help planners estimate housing requirements – which links to construction. Using the latest generation of sensors, developers can then build more sustainable and more intelligent buildings, whilst their colleagues on fish farms use sensors to monitor water and fish populations, generating data for the Data Lab – and so on.

Other industries may also have new Innovation Centres in the future, or continue to deliver world-class research without being part of the programme – for example, life sciences and informatics.

But the eight new Innovation Centres profiled in this special issue of Science Scotland are a welcome initiative, backed by a significant investment, which will hopefully breathe new life into traditional industries and create new ones – as well as new technologies and business solutions not dreamed of before.

Sir John Arbuthnott MRIA,
President of the Royal Society of Edinburgh



Contents

www.royalsoced.org.uk
www.sciencescotland.org

ISSN 1743 – 6222 (Science Scotland Print)
ISSN 1743 – 6230 (online)

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Innovation Centres: **Scotland takes the initiative**

The Scottish Funding Council (SFC) is investing up to £110 million in core funding for eight new Innovation Centres over the next five years. The idea is to set up centres of excellence that have a wider economic and social impact by building bridges between academic researchers and business – generating wealth and creating new jobs by developing new innovative solutions in response to demand from industry and government in Scotland and beyond...

How do you encourage innovation? There will never be a single solution, but collaboration between academic researchers and business is a good place to start, and Scotland already has a world-class research base and industry partners who know they will need to be more innovative to sharpen competitive edge. The prize is not just economic benefit and business success but also quality of life, improving public services, including health and social care, as well as government policies.

Collaboration and the wider benefits of innovation are what inspired the creation of eight new Innovation Centres in Scotland as part of an ambitious plan developed by SFC, in partnership with Scottish Enterprise (SE) and Highlands Islands Enterprise (HIE), over the last three years. In the past, SFC and other funding bodies have focused on much smaller-scale initiatives, such as the innovation voucher scheme managed by Interface.

"These smaller-scale projects have been highly successful and Interface is a wonderful example of that success," says Professor Albert Rodger, a member of SFC's Board and Chair of the SFC's Research and Knowledge Exchange Committee, "but we want to scale up the ambition, and we also think the time is ripe for a more joined-up and more strategic national plan. The Innovation Centres have a key role to play, but they are not the only solution – they are part of the overall strategy."

The Innovation Centres will facilitate collaboration across different sectors and amongst different government organisations, complementing rather than replacing or duplicating what they are doing. For example, the Innovation Centres already work very closely with SE and HIE, and Interface will continue to connect academic researchers with business, providing innovation vouchers (worth £5,000 – £20,000) and liaising with the Innovation Centres, which in turn will direct business traffic to Interface, if that's the right thing to do. "The Innovation Centres will be compatible with the existing infrastructure," Rodger explains.

Another major role will be developing new university courses and other educational materials, with £2 million set aside each year to fund courses in novel areas – many subjects, such as industrial biotechnology, stratified medicine, digital health and big data simply didn't exist just a few years ago, so SFC wants to ensure it empowers the next generation of highly-skilled staff, innovators and entrepreneurs in these areas.

Innovation Centres

Supported by The Scottish Funding Council, Highlands and Islands Enterprise and Scottish Enterprise.

The strategy develops

Right from the start, SFC was conscious that it didn't have all the answers and that it would be a mistake to decide all the details before getting industry and university feedback. The first call for proposals went out in April 2012, with SFC in partnership with SE and HIE. The idea was to make "more strategic use of knowledge exchange (KE) support, investing in larger-scale initiatives that have the capacity to stimulate sustainable structural changes in linkages between academic and industry, rather than funding small-scale KE projects," and the first step was to open up a dialogue with interested parties in industry and institutes of higher education (HEIs).

The objectives were clear, "to translate both innovation and knowledge from academia into businesses to drive international competitiveness and hence economic growth;" but even though the funding was available in principle, the details of how to achieve this were not carved in stone.

SFC was offering "an opportunity for HEIs to define and strengthen their role as partners with industry in delivering business demand," creating an environment for innovation to flourish and supporting the development of a new generation of researchers and entrepreneurs; but it was up to industry to state its case and individual sectors to show their commitment before any Innovation Centre would open its doors.

To "simplify the innovation landscape" would require a lot of careful assessment, as well as creative discussion.

In weighing up the first applications for funding, SFC was looking for strong industry buy-in from the start, as well as strong market demand – rather than encouraging blue-sky research. The business partners had to be prepared to contribute cash resources "relative to scale," to demonstrate commitment and ensure the Innovation Centres would be fit to deliver. As a measure of future success, the Innovation Centres would also have to demonstrate "significant impact" for the HEIs and business partners, and attract funding from additional sources in the UK and Europe. SFC was also aware that the Innovation Centre for any one sector might have to be tailored to its individual requirements – in other words, one size does not fit all.

In the process of establishing the first eight Innovation Centres, SFC itself has had to undergo a culture change as much as its industry and university partners. "We realised we had to take the lead in bringing them together," says Rodger. "We've also learned a lot during the process, not just about the different sectors, but the points of common interest as well – we're creating a joined-up community and the crossovers between them are becoming more apparent as the programme develops."

About SFC

The Scottish Funding Council (SFC) is responsible for funding teaching and learning provision, research and other activities in Scotland's 25 colleges and 19 universities and higher education institutions, with a budget of approximately £1.5 billion a year.

Innovation Centres: The vision

The Scottish Funding Council's vision for the Innovation Centres is to use the "research excellence" of the Scottish universities as a platform for collaborations across the whole of Scotland.

The Innovation Centres "will create sustainable and internationally ambitious open communities of university staff, research institutes, business and others to deliver economic growth and wider benefits for Scotland."

www.sfc.ac.uk/innovationcentres

Scotland's first eight Innovation Centres

Stratified Medicine Scotland Innovation Centre (SMS-IC)

Innovation Centre for Sensors and Imaging Systems (CENSIS)

Digital Health Institute (DHI)

Oil & Gas Innovation Centre (OGIC)

Scottish Aquaculture Innovation Centre (SAIC)

The Data Lab

Construction Scotland Innovation Centre (CSIC)

Industrial Biotechnology Innovation Centre (IBioIC)

Introduction

RESEARCHERS CONDUCT FINAL TESTS AT MACPHIE OF GLENBERVIE – AN INNOVATIVE USER OF SENSORS IN MANUFACTURING.

The story so far

The call for proposals has been in two stages. The first wave of applicants (30in total) led to the creation of the first three Innovation Centres: CENSIS, DHI and SMS-IC. According to Rodger, these three sectors were ready for business because they were already mature in terms of industry involvement in Scotland and were also used to working in collaboration with researchers, as well as having strong demand for innovation.

"We didn't want to over-engineer the concept," says Rodger. "We wanted industry and academia to articulate their own response. Our job was to bring different people together. But first, industry needed to believe in the concept, and we also needed to bring academia with us."

The second wave of applicants was able to learn from the first wave, with industry leading the bids. "The industry focus is vital," says Rodger, "and we also wanted the Innovation Centres to be led by CEOs from industry rather than the academic sector." The result was the creation of the Aquaculture, Construction, Industrial Biotechnology, Oil and Gas and Data Science Innovation Centres, all expected to be fully operational in early 2015.

Future plans may go in several directions, but building on the experience so far, Rodger believes that the shape of any future Innovation Centre will depend on demand from the industry partners in these sectors. The Innovation Centre model may not be appropriate to every single sector, and Interface or other initiatives, such as knowledge transfer partnerships (KTP), may continue to be a more effective solution. Some industries are much more fragmented than others, with many very different types of companies and applications involved, and they may not have the same kind of industry leadership or academic community driving them forward, even though they are major contributors to the Scottish economy. For example, many companies working in fields such as visualisation or graphic design could be part of the ecosystem, working with several existing Innovation Centres rather than needing to be a Centre on their own.

Now that the first eight Innovation Centres are up and running, SFC is able to review progress so far. The governance and modus operandi of the Innovation Centres are now much more clearly established and future Innovation Centres will be able to draw on existing good practices for inspiration, saving time and money in the process. Funds have been set aside for education, infrastructure and capital equipment, in addition to the money for each individual Innovation Centre. "We don't want to see any failures," says Rodger, "but in the unlikely event of that happening, we will have learned much."

The priority is economic impact, says Rodger, in terms of new jobs, companies and skills. "We also have clear international ambitions in terms of inward investment and exports – for example, the IBioIC is already part of a huge global industry. We've created the first eight Innovation Centres, and the programme is gaining momentum – and that means universities becoming even more attuned to the idea of more rapid exploitation of research and creating a collaborative innovation culture, with industry leading the way."

Art of the possible for health and social care

DIGITAL HEALTH INSTITUTE (DHI Scotland)

ADMIN HUB: **University of Edinburgh**

FUNDING: **£11 million (initial investment)**

WEBSITE: **dhi-scotland.com**

The ideas could come from citizens, social workers, carers, nurses, doctors, paramedics, community groups or hospital porters – or emerge from an academic research lab or industrial workshop – but the innovative products for digital health and social care that eventually go on the market, based on those original ideas, could generate millions of dollars in sales and save countless lives in the process.

Not every idea for digital health will translate into medical, welfare or business success. Some ideas will fail because they are not practical or economic and some will fail because they are not innovative enough, but innovators must be encouraged to give it a try and receive the support they deserve, no matter where they come from in the medical or social care spectrum. Sometimes the idea may lead to nothing, but the person who conceived it may be "talent-spotted" by another organisation and go on to develop a digital product which does prove successful. What matters is to make sure clever people and ideas are not lost and sweep away the obstacles laid in their path.

Digital health will be one of the keys to the future of medical and social care, and the challenge facing government, as well as academics and commercial developers, is how to make the most of the commercial opportunities created by digital health, deliver better health and social care via digital technologies and harvest the innovative ideas for products which come not just from scientists and engineers but also from the people who use them. The other challenge is to bring all these people together to create teams which are greater than the sum of their parts, to develop new solutions. Scotland has come up with the answer by setting up the Digital Health Institute (DHI), bridging the gap between the different stakeholders in digital health and empowering them to "collaborate and co-produce products and services that will be transformational."

What is digital health?

Digital Health is the use of information and communications technologies as health-care solutions, taking advantage of the latest advances in mobile technology and sensor technology to reduce inefficiencies, improve access to services (especially in remote areas), reduce costs, increase quality and make medicine more personalised. Digital health technology could also be designed "to empower people to be equal partners in the design and delivery of their own health-care services," not only monitoring and managing their own health but also providing feedback which could help with the development of future solutions.

The hardware used includes a range of wireless devices, wearable devices, sensors and software sensing technologies, microprocessors and integrated circuits, delivered via the Internet, including social networks as well as mobile/cellular networks.

The Groupe Speciale Mobile Association (GSMA) predicts that the mobile-health market will generate global revenues in the neighbourhood of US$23 billion by 2017, with Europe becoming the largest mobile-health region by 2017, with revenues of US$6.9 billion.

THE DHI BRINGS A WIDE RANGE OF PEOPLE AND ORGANISATIONS TOGETHER.

"Many of them haven't even spoken to each other before," says Brendan Faulds, Chief Operating Officer of the DHI, "so one of our first jobs is to build a network to enable information to flow, and create a community where there is a clear focus on doing something with the talent we have in Scotland and the innovative ideas that talent produces."

Some ideas can be "breathtakingly simple," says Faulds. For example, care professionals in East Lothian came up with new ideas to enable people suffering from dementia to remain at home for longer by monitoring everyday actions, such as safe use of the cooker. Good ideas like that can easily get stuck in endless layers of bureaucracy, but the DHI is going out of its way to encourage people to come forward, so they can by-pass conventional routes. Engagement teams are taking a proactive approach to reach all sectors of the health and care community, whilst government leaders in health and social care also drive the search for new ideas – ensuring both a 'bottom-up' and 'top-down' approach.

This strategy is also beginning to pay off in terms of new projects: "In the last two months alone," says Faulds, "the number of ideas received has quadrupled compared to the previous two months." Conferences and other public events will also play a key role in discovering ideas.

According to Faulds, the technology is moving so fast, it is hard to keep track of advances, and this can lead to lots of duplication of effort which the DHI can help researchers to avoid, at the same time as supporting the development of collaborations and matchmaking people and organisations.

Collaboration

The DHI is a collaborative partnership between public and private organisations, bringing together the country's leading health and care operators, academic researchers and technology businesses at home and abroad (the companies present at the DHI launch included IBM, Philips, Deutsch Telekom, Celesio, Continua Health Alliance and Lockheed Martin), "to speed up research and development in order to produce innovative new technologies that will transform the quality of people's lives and help Scotland become an exporter of world-leading products and services."

The DHI has three interwoven objectives: academic, business and civic success. Apart from improving the performance and cost-effectiveness of health and social care in Scotland as well as the patient experience, the chief aim is to make an economic impact by nurturing new companies and helping them develop new products, taking advantage of Scotland's academic resources and boosting the research base in the process, including the funding for a doctoral programme and a new MSc in digital health.

Another aim is to "build the global reputation of Scotland as a centre of innovation for digital health," engaging international companies whenever they have something to contribute. For example, if a company from China or Poland approached the DHI with an idea for a digital product, it might be introduced to a research team who could help them progress it, as long as there were benefits for Scotland in terms of job creation, inward investment, funding and research, or delivery of a new product.

"The ideal project will press all the buttons for academic, business and civic objectives," says Faulds, "and our membership so far – over 200 individuals, businesses and health and care organisations from Scotland and beyond – reflects the full spectrum of the industry."

Whilst Scottish Enterprise continues to focus on funding new businesses, the DHI will aid in assessing potential projects (including viability testing), steer them towards the appropriate funding, particularly for any research that is needed, and offer business advice.

One of the DHI's initial priorities is recruitment of members, offering services such as:

- Onsite facilities to develop digital health & care products and services
- Collaboration opportunities to build partnerships or access the supply chain
- Testing services with DHI and health and care providers, including the NHS and Local Authorities, to accelerate the approval process
- Evidence-based evaluation and approval processes provided by Scotland's academic community
- Support to bring new products to market and to export them globally

In some cases, what may be needed to get a new product to market is not so much the science as an understanding of market potential – for example, health economists may have a key role to play in evaluating and developing a product.

Why digital health?

Many countries around the world are facing a major crisis due to the pressures of an ageing population and the health problems associated with rapid economic growth – for example, increased levels of cardiovascular illness and diabetes in developing countries.

Current models of health and social care cannot easily scale up to meet these demographic challenges, despite recent technological advances. A meeting of the Scottish Parliament Finance Committee in February 2013 highlighted the fact that the public sector 'funding gap' will increase to almost £3 billion by 2016 –17. It was noted that "the cost of a primary care consultation would need to be reduced by more than 38 per cent for spending on primary care for those above the age of sixty-five to remain constant in real terms by 2033." And digital health interventions are recognised as key to the solution, because they are more cost-efficient and empower both patients and healthcare professionals.

"The Scottish Ambulance Service has a vision of delivering more care locally in patients' own homes or communities through the enhanced utilisation of telehealth technology. Our partnership with the DHI has helped us gain access to people that we would never have been able to access within our service. This has filled a huge gap in our skillsets to enable the expertise to be provided in a way that is not commercially driven. This helps us maintain the independence that we require to develop the right technical and operational solution for patients and staff alike, and will place the Scottish Ambulance Service at the forefront of world-class ambulance provision for patients in the community,"
Pamela McLauchlan, Director of Finance at the Scottish Ambulance Service

GERRY EGAN, CLINICAL PARAMEDIC

"The advances in technology and connectivity will help make care safer and more efficient, and improve decision support for paramedics," **Gerry Egan, Clinical Paramedic**

Why Scotland?

With 19 universities to draw on for support, some of which are recognised as leaders in informatics, life sciences and medicine, plus a healthy SME sector with an excellent record for developing digital products, the DHI has solid foundations to build on. Scotland also has a good reputation for progressive healthcare services, and a willingness to embrace innovation. NHS24, acting on behalf of NHS Scotland and the Scottish Government, is a "three star" Reference Site. Reference Sites provide the European Innovation Partnership on Active and Healthy Ageing with examples of a comprehensive, innovation-based approach to active and healthy ageing – coalitions of regions, cities, integrated hospitals or care organisations that help to demonstrate how innovative practices could be transferred to other European contexts.

Scotland's geography is also a relevant factor. On the one hand, it is easy for people and organisations to network because they are clustered together in a relatively small area, and on the other hand Scotland has a scattered population in remote areas where demand for digital health (particularly telehealth) is strongest, making it ideal as a test-bed for future research.

Profile

How does it work?

The DHI has adopted a three-pronged approach to bring ideas to market, assessing them according to their stage of development – conceptual, ready for testing and ready to commercialise.

The Digital Health Exploratory identifies potential projects based on current intelligence – scanning the research horizon for innovative ideas. This has already led to an exciting new project called 'The Future Ambulance,' engaging paramedics and patients to help improve the ergonomics of the ambulance itself and develop new devices – for example, a device to measure the levels of proteins (troponin) released in the blood when the heart has been damaged, so patients can be tested in the ambulance instead of waiting 30 minutes after getting to hospital. Another basic idea is to move the monitor screens in the ambulance so that paramedics can focus on their patients at the same time as watching multiple screens.

The **Experience Laboratories** provide an environment where users (service users, carers, clinicians, practitioners and third sector organisations), businesses and researchers can collaborate and prototype healthcare solutions. Managed by a team of researchers and designers, including several from the Institute of Design Innovation at the Glasgow School of Art, the DHI labs in Forres replicate real life conditions to test new technology, as well as study services, roles and behaviour, "often the biggest barrier to successful innovation." The labs are interested in gathering qualitative data as well as quantitative data. For example, they can analyse the interaction between the physician and patient, focusing on behaviour. The labs are also where "creative meets technical world", with design a key part of the science involved, enabling products to function as well as possible before moving on to the prototype stage.

Ideas which prove successful in the Experience Laboratories may become candidates for further research, development and exploitation. One of the prototypes recently tested in a lab is a new device to help people in remote areas self-monitor for melanoma, using a special camera to photograph their skin, then sending the image to consultants, via the Internet.

"The experience lab gave us immediate access to the patient experience, good and bad, of our proposed digital intervention. This was immensely useful. We've done six months of research in one day."
Dr Peter Murchie, Clinical Consultant at the University of Aberdeen, who came up with the idea for the melanoma project.

"We created a basic prototype of the skin examination application and simulated the experience of using it in the home. This allowed us to quickly test the concept with potential users and with the staff who would deliver the new service, generating a wealth of insights and practical ideas to shape the design from the perspective of the users." **Gemma Teal, Design Researcher at the Glasgow School of Art**

"The Experience Labs ensure that the patient's point of view is listened to."
Sheila Bruce, Volunteer

The Experience Labs have also been involved with the Future Ambulance project, organising three labs in a dialogue described as "the art of the possible." The project has three elements: first, the paramedics act out real-life scenarios which are then re-run accommodating novel ideas, to analyse what difference new solutions may make; second, group discussions; and third, individual sessions, finding out in detail what the paramedics think. This is all part of an inter-disciplinary team approach which aims to co-create and co-design new solutions from the ground up, rather than develop a solution then impose it on users.

The Digital Health Factory helps members progress solutions much closer to market, providing technical resources, including access to expertise and test environments, business mentoring and help with funding. Its aim is to develop commercialisable solutions to real-life health challenges, and one of its projects is a collaboration with Health Alert 24, working with parents and NHS Fife to develop a device called 'My Little One' – a tablet-based system which allows parents to view their new-born babies via Wi-Fi and a camera in the cot.

What next?

The future of the DHI could go in virtually any direction, just as digital technology could also develop in any direction. At the moment, more and more ideas are being submitted, especially apps. As mobile phone technology advances, it could become the major platform for digital health, while wearable devices will also increase in importance. But no matter what trends emerge and how successful the DHI is, the technology is only part of the story, and the vision remains very clear: to establish Scotland at the forefront of digital health and care technology.

"The DHI will not be judged on any individual project output," says Faulds. "Not every innovation we help to develop will become a commercial success or lead to a breakthrough in healthcare, but our success will come from how well we facilitate projects and promote the importance of digital health, bringing interested parties together. We may be involved from the earliest stage all the way through to commercialisation, or we may only get involved briefly. It is hard to do an 'elevator pitch' to explain what the DHI is, because it covers so many fields and has such a wide stakeholder base. Getting everyone speaking the same language can be difficult, but we're making a difference already in terms of new projects, and concrete examples that everyone can relate to will help more people understand what we are doing – and hopefully also contribute ideas in the future."

More experienced Experience Labs

"We have the opportunity to build on current practices and develop them," says Elizabeth Brooks, Design Director of the DHI's Experience Labs. "We work together as an inter-disciplinary team to facilitate the creation of new solutions, targeting research to unpick the subtleties that lie behind design in a shift away from purely quantitative studies to more qualitative work, developing ideas as a team with the participants in the Labs – ideas that we would never be able to create on our own."

The Labs are developing existing methodologies, building on experience gained and, in the process, creating a design-led environment for innovation in digital health – and a new toolkit for product design.

"We don't want to jump to solutions," says Brooks. "If someone comes to us with a solution, we may pull back and ask what problem it's trying to solve, then focus on the process involved, so we help build the right product." Brooks says this approach is more holistic and complex, involving more people than traditional methods, with designers a critical part of the team from the start, along with users and potential patients, engineers, psychologists and technologists. According to Brooks, the role played by the designers is based on classic craft design, visualising the solution and working closely with clients and the rest of the team to produce the solution, as part of a completely integrated development process.

"In Scotland, approximately 10 –12 per cent of all babies are admitted to a special care baby unit because they are either premature or just too poorly to remain with their mothers. We hope that My Little One will help to overcome the sense of isolation by allowing mothers to see their baby at a time when they are unable to be close"

Dr Sean Ainsworth, Consultant Paediatrician & Neonatologist.

A win–win solution for medicine

STRATIFIED MEDICINE SCOTLAND INNOVATION CENTRE (SMS-IC)

ADMIN HUB: **University of Glasgow**

FUNDING: **£8 million (initial investment)**

WEBSITE: **www.stratmed.co.uk**

Pharmaceuticals and healthcare are about to change forever – thanks to a better understanding of the genetic background and molecular mechanisms of disease and individual responses to medical treatments, using a new approach to medical science and patient treatment called stratified medicine. And Scotland is emerging as the ideal place to develop and showcase this 21st-Century medical science.

Stratified medicine requires collaboration across many branches of science, as well as the cooperation of a large group of patients. By analysing blood and tissue samples from a large number of people, whose data is anonymised, researchers can divide them into 'stratified' groups based on the link between their DNA profile and their responses to the drugs they are prescribed, so that future treatment of patients with similar profiles can be customised to particular drugs – instead of trying different treatments one after another until you find one that will work.

This new approach will not just improve the way many chronic diseases are treated, but also change the way that drugs are developed, and the structure of the global pharmaceutical industry. Patients will get treatments more precisely calibrated to their needs, and governments and healthcare providers will be able to rationalise annual budgets. Pharmaceutical companies will find a new route to survive in an increasingly competitive environment by being able to better predict the outcome of their clinical trials, thus making the R&D model more sustainable. New healthcare companies will also emerge, specialising in various aspects of medical science, where information technology will frequently play a key role.

The development of stratified medicine is being driven by advances in science and technology, including the emergence of high-speed genetic sequencing and a new science called bioinformatics, which analyses patient records; much the same as finding trends in other 'big data' sets. And Scotland is well placed to be a major player in this 'game-changing' science by setting up a new Innovation Centre for stratified medicine – an initiative with implications far beyond the borders of Scotland.

Problems and solutions

Stratified medicine has been described as "a win–win solution for healthcare" because it offers benefits to everyone – from individual patients to large corporations.

Everyone wants better, more predictable treatments and everyone wants lower costs. But the success rate for new drugs is falling, and pharmaceutical companies are beginning to struggle – only one in every 70 new pharmaceutical development projects reaches the market. For many drug developers, "the goalposts have moved" and they've been forced to change their attitude to risk as a result.

Pharmaceutical companies develop new products over a 10–15-year timescale, at an average cost believed to be in excess of £1.2 billion. A successful drug approval may generate significant profits for a limited number of years (money which is needed to support new research projects). When the drug's patent runs out, the profits shrink rapidly due to generic drug competition. How do they replace that source of revenue when it takes so long and costs so much to develop new drugs? The metrics are not good.

After several years in 'discovery,' the drugs enter clinical trials – to be tested on humans – and many of these frequently fail at this stage because they don't perform significantly better than placebos. It is estimated that out of the £595 billion spent by the global industry on pharmaceuticals in 2011, £393 billion went to develop therapies "which did not produce the desired effect." This not only means a loss of investment and profits, but also adds to future costs, and if the process is repeated again and again, the corporation could go out of business – and who would develop new drugs? Current projections on the rate of new drug approvals indicate that the predicted revenue streams will not keep up with the loss of revenue from drugs whose patents will expire in the near future.

To 'fail' its trial does not necessarily mean that the new pharmaceutical is not effective – it may simply not be effective enough on average for the trial population that typically is chosen to represent the entire spectrum of the disease – referred to as 'all comers.' But what if new drugs could be targeted at groups of 'stratified' patients, not just the whole 'all comers' population, and thus increase the chances of success for drug discovery? Instead of always aiming to develop 'gold-medal' drugs, the pharmaceutical companies could develop more 'bronze-medal' drugs. Because these would be targeted at only a sub-set of patients, they would generate less profit per drug, with a higher probability of success in the clinical trials. By making the drug trials more predictively effective, albeit for a smaller segment of the patient population, the idea is that this could significantly impact the future of the pharmaceutical industry in a positive way. This is the solution that stratified medicine could soon deliver, via a collaboration between government, healthcare providers, information technology companies, genetics specialists and pharmaceutical companies in projects such as the SMS-IC – the Stratified Medicine Scotland Innovation Centre in Glasgow.

What is stratified medicine?

Stratified, or 'personalised', medicine identifies subgroups of patients who respond in different ways to different therapies, based on their distinct genetic profile. This allows the pharmaceutical industry and healthcare providers to develop treatments tailored to the needs of individual groups of patients – to make the right decision and ensure that the right patient gets the right treatment at the right time.

According to Professor Iain McInnes of the University of Glasgow, "only a proportion of patients will respond well to any given treatment," but in those people such treatment could make a critical difference – the challenge is to know in advance who those people will be for any given medicine, then develop drugs which target the correct patient group right from the start. "That will bring us the optimal chance of achieving long-term remission, which is what patients tell us they value most as a target," he adds.

This new approach to healthcare and pharmaceutical development will have an impact not just on patients but also health service providers, government and the pharmaceutical industry.

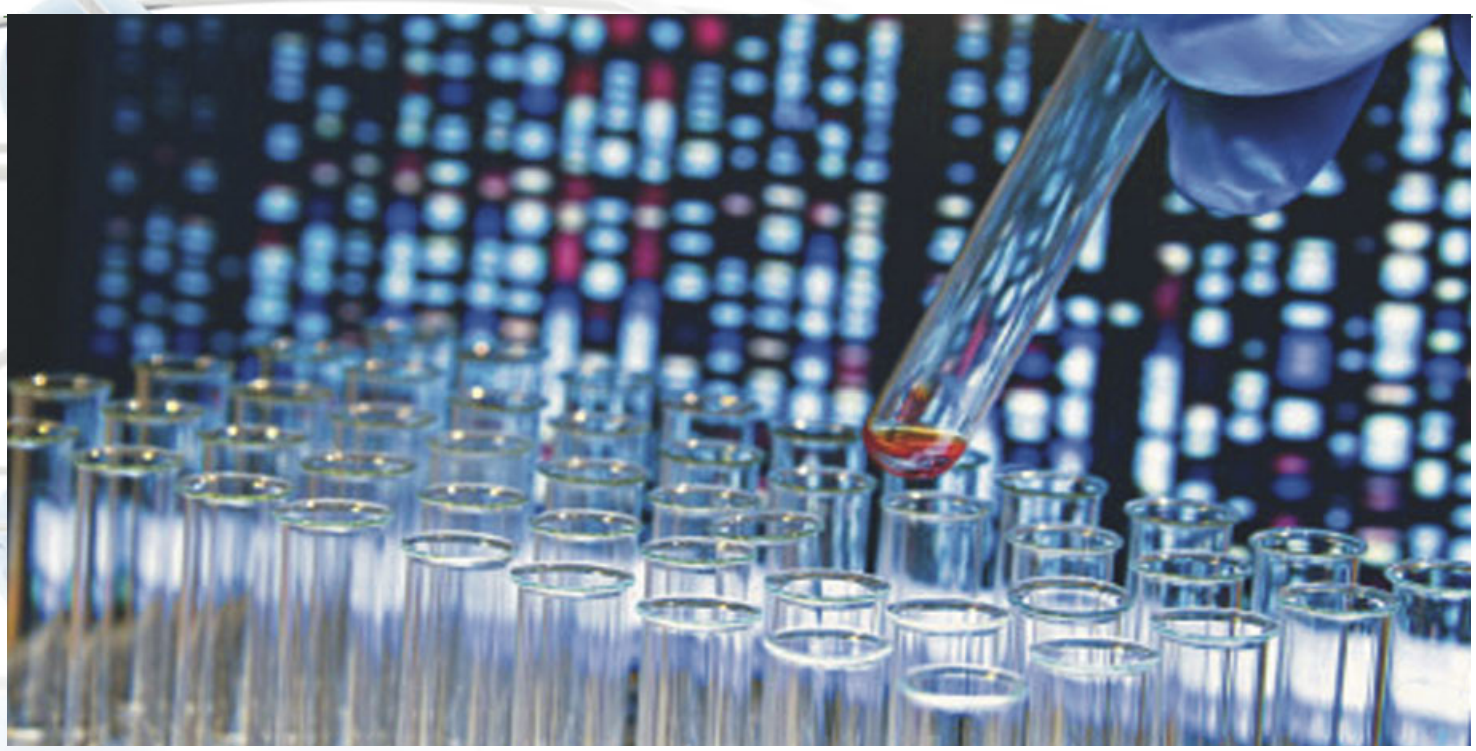
For patients, it promises significant improvements in treatment, including safer drugs, shorter waiting times for treatments to begin, and faster recovery. Drug therapies will be less 'hit or miss' and offer a much higher rate of success. Fewer patients will receive a treatment only to discover some time later that it will not be effective – for example, sufferers from rheumatoid arthritis who may wait up to two years to find the right treatment, and may suffer liver damage as a result. As one researcher put it: "Patients don't want to wait two years for nothing to happen – they simply want the medicine to work as soon as possible."

Health service providers such as the UK's National Health Service (NHS) also stand to reap enormous benefits, not just by offering their patients better standards of health care but also by reducing waste and lowering the total cost of treatments, as well as the overall budget for drugs – an estimated ten per cent of which is spent on diabetes alone. In addition, stratified medicine will make it easier to identify people who are likely to experience adverse reactions to drugs, and thus increase safety at the same time as lowering risks.

For government and society at large, the economic benefits will extend beyond savings in healthcare by getting people back to work quicker because they are receiving better treatment and recovering sooner, thus reducing the burden on the social security budget and other expenditure.

The pharmaceutical industry will benefit in a number of ways. Instead of having to develop drugs for the whole population, they will be able to target specific genetic groups. Drugs which may have failed clinical trials because they only treated a small percentage of people may reach the market sooner because they are effective for that group of people. In other words, no single drug will cure every form of cancer in every person, but many different drugs may be effective for specific groups of people. Drug development will also be more effective because the 'target' will be better defined from the start, and fewer drugs will be rejected because they are not 'cure-alls.'

Profile **Stratified Medicine Scotland Innovation Centre (SMS-IC)**



The SMS-IC

Currently based in the Thermo Fisher Scientific site at Paisley, the SMS-IC will move into the new South Glasgow Hospitals Campus during 2015. Researchers will have access to sequenced human genomes and clinical data, and a new Clinical Research Facility for stratified clinical trials. With initial funding adding up to £20 million, including £8 million from the Scottish Research Fund, the Centre involves a consortium of universities (Aberdeen, Dundee, Edinburgh and Glasgow), NHS Scotland (NHS Grampian, NHS Greater Glasgow, NHS Lothian and NHS Tayside) and two key business partners – Thermo Fisher Scientific and Aridhia Informatics. Other supporting industry partners include GSK, Astra Zeneca, Novartis and Quintiles, as well as Scottish companies Arrayjet, Axis Shield, Biopta, DestiNA Genomics, Fios Genomics and Sistemic Ltd.

The SMS-IC Core laboratory is equipped with a state-of-the-art SMART laboratory comprising a suite of Ion-Torrent® nextgenDNA sequencing platforms and a purpose-built high-capacity compute platform provided through its industrial partners, Thermo Fisher Scientific and Aridhia Informatics. This capability allows the team to generate whole genome sequence data from anonymised patient samples to assemble the sequence data and compare this with clinical data relating to response (or the lack of response) to drug therapy. The facility has the capacity to sequence over 1,000 individuals per year, and this could be further enhanced by moving to multiple-shift operation.

The SMS-IC will initially focus on developing new treatment regimes for chronic diseases, including cancer, diabetes, rheumatoid arthritis and respiratory and cardiovascular diseases. Professor Anna Dominiczak, Vice-Principal and Regius Professor of Medicine at the University of Glasgow, believes that stratified medicine will change the way we practise medicine, and said when the Centre was announced: "The SMS-IC is a once-in-a-lifetime opportunity to combine our strengths in life science, NHS health delivery and academic medicine to produce world-leading innovations for treatment of chronic diseases. The UK spends £124 billion on health care each year, including £12 billion on medicines, so even a small increase in efficiency through better targeting of treatment would save the UK a significant amount."

According to Professor David Newby of the University of Edinburgh, who is Director of Research and Development for NHS Lothian and a member of the SMS-IC Executive Board, the benefits of the new Centre will be felt throughout Scotland, and the regional health boards will each contribute specialist studies. For example, NHS Lothian has specialists doing research on cardiology and ovarian cancer, tracking outcomes based on patient profiles. It is also using innovative imaging methods "to identify unstable coronary plaques," as part of a stratified medicine study.

> **"Scotland is both big enough and small enough to be a leader in stratified medicine – big enough in terms of the available data and small enough to make it easier to bring different organisations together"**




LEFT TO RIGHT: PROFESSOR ANNA DOMINICZAK OBE FRSE, PROFESSOR DAVID NEWBY FRSE, DAVID U'PRICHARD AND PROFESSOR IAIN MCINNES FRSE.

"The aim of these studies and the work of the SMS-IC is to optimise the use of patient records, to deliver the right treatment for the right patient, and better overall health care," says Newby. "Scotland is both big enough and small enough to be a leader in stratified medicine – big enough in terms of the available data and small enough to make it easier to bring different organisations together."

The new Centre will pioneer procedures, processes and ultimately engagement with the NHS, for what could become full genetic-based clinical trials. It will also act as the accelerator for genomics, biomarker and companion diagnostics and bioinformatic research in Scotland, including its SME base, "catalysing interactions between clinical academia, informatics and computer science across Scotland and with world leaders in big data provision and analytics."

Another major aim is to invest in developing academic entrepreneurs in Biomedical Informatics, providing new specialist post-graduate courses in Applied Genomics and Informatics.

An independent economic impact assessment has forecast that the Centre could generate more than 300 jobs and contribute up to £68 million to the Scottish economy over its initial five-year funding period. The Centre also aims to attract enough funding from industry partners to become self-sustaining within five years.

David Sibbald, Chairman and CEO of Aridhia, said: "The SMS-IC is a globally significant programme to determine the future of health care in the 21st Century. With the cost of sequencing an individual's genome continuing to fall rapidly, we need to understand how to find and unlock the associations with clinical and patient data in order to improve diagnosis and to personalise the treatment of disease to the individual patient. By combining our expertise with our academic, clinical and commercial partners, we can change the way healthcare is delivered forever, and create economic growth for Scotland."

As well as joining forces to develop new solutions for health care, the partners in the SMS-IC recognise the need to win the hearts and minds of the general public, convincing people it is in their interest to be 'stratified' according to their genes, and allow their patient records to be used in research, with appropriate measures in place to ensure confidentiality by 'anonymising' all individuals involved. The SMS-IC and leading clinicians involved will also need to work closely with government agencies and regulators to enable stratified medicine to become a standard component of healthcare provision, promoting the benefits in terms of better health outcomes and economics. Another major task will be to educate the next generation of medical doctors so they are equipped with the knowledge to take full advantage of stratified medicine in the future – for example, learning more about genetic population distributions.

The SMS-IC will not only partner with leading organisations such as Thermo Fisher Scientific and Aridhia, but also help smaller companies interact with healthcare providers such as the NHS. The new Centre will also seek to partner with healthcare providers, academic researchers and pharmaceutical companies in countries all over the world. Other exciting initiatives are emerging in Estonia, Saudi Arabia, England and the USA, and it is hoped that these projects can ultimately collaborate to advance the science and raise Scotland's profile in the medical world.

Why Scotland?

Scotland offers several advantages as a stratified medicine development centre, including the unfortunate fact that the country has high rates of cancer, diabetes and cardiovascular illness – the major killers in developed countries.

The patient base is not just large, but easier to study, because the population also tends not to move far from home – annual mobility is roughly one to two per cent, compared to about nine per cent in major cities such as London.

Integrated electronic patient records also make it easier to analyse trends, with most people served by a single health service provider – the National Health Service (NHS) – rather than multiple agencies. This means that researchers can drill down into details at the same time as seeing the 'big picture,' using 'big data' to measure the effectiveness of individual treatments, as well as identify national patterns.

In a recent interview in *Holyrood Magazine*, the Chairman of the SMS-IC, David U'Prichard, said: "Scotland probably has the highest-quality patient information base in the world." He also thinks the partnership between Thermo Fisher Scientific and Aridhia, combined with access to NHS data, will allow Scotland "to pioneer a concrete, results- and business-oriented application of the grand theory of 'stratified medicine' more speedily than elsewhere in the world."

U'Prichard is also confident that the SMS-IC will have real 'proof-of-concept' data within three years, and "blaze the trail for similar, even larger, projects in Europe, the US and Asia, and rapidly build a position as a – maybe the – global centre of excellence for population-based phenotypic/genotypic analysis."

The Scottish NHS's e-Health systems can provide high-quality, patient information across different disease populations, "probably better than anywhere else in the world," he added. Combined with genomic data, "this will allow new drug development to be much more sharply and effectively focused, promising greater and potentially faster therapeutic benefit to patients, and I believe our development of SMS-IC will result in clinical trials of new drugs in Scotland using stratified medicine approaches."

Measuring up to the challenge

INNOVATION CENTRE FOR SENSOR AND IMAGING SYSTEMS (CENSIS)

ADMIN HUB: **University of Glasgow**

FUNDING: **£10 million (initial investment)**

WEBSITE: **www.censis.org.uk**

Custard and carbon dioxide, diagnostic tools for blood pressure, oil and gas pipelines, engines and intelligent buildings, laser beams and new algorithms from research into detecting gravitational waves – all are part of a normal day's work for the CEO of the Innovation Centre for Sensor and Imaging Systems CENSIS, Ian Reid.

Sensor and imaging systems (SIS) are amongst the most rapidly evolving fields in science and technology, reaching into virtually every aspect of business and everyday life. They help drive safety, quality, efficiency and system performance in a wide range of industries, from aerospace to aquaculture, and provide the foundation for a diverse range of products and services. Sensors and optics have been around for centuries, but what is driving innovation in the industry today is not just recent breakthroughs in the basic technology (the tools we use to measure and detect things) but also a dramatic acceleration in computing power, as well as data analysis methods and how we present the information collected from networked sensors.

To understand the underlying science is also a challenge for industry and academics, and this is reflected in the fact that CENSIS supports a number of studentships in new industry-focused joint research degrees, as well as securing additional funding from the SFC for up to 20 MSc students from September 2014, focusing on SIS as well as learning how to be entrepreneurs.

CENSIS

For Reid, the major theme for CENSIS is to meet the needs of industry and make a contribution to the national economy. "Our major customer is industry, and that means we will focus on demand-led innovation rather than technology push." That doesn't mean that CENSIS will ignore what's going on in the country's research labs – far from it – but if it wants to make an economic impact, its target will have to be business results, by cutting costs, reducing energy consumption and increasing profitability, as well as boosting Scotland's earnings from exports in terms of SIS technology itself and products which have benefited from SIS in their manufacturing process.

Another example of how economic value could be created using SIS might be to extend the life of assets deployed in the North Sea by condition monitoring, potentially adding billions of dollars to company profits – and also government tax revenues. According to Reid, the world market for oil and gas exploration is worth an estimated £57 billion a year, and this could also be a huge market for Scottish companies exporting SIS solutions.

The key to success will be bringing the different stakeholders together to share their concerns and explore the potential for working together. For example, industry will talk about the need to improve manufacturing processes or develop new tools which could cut costs and make better use of resources. And researchers will report what they are doing in their labs and describe the kind of breakthroughs they expect in the future. The idea is to build relationships between the relevant parties, to develop new solutions or adapt existing solutions – for example, using sensors first developed for the oil and gas industry to monitor the density of fluids in a food manufacturing plant (see Case Study 3).

Ultimately, says Reid, the objective is to change the culture – how universities and business work together, building mutual trust and respect, and trying to understand each other's needs and concerns, "bridging the gap between concepts and commercial solutions."

CENSIS will also help business articulate what it requires. "Creating economic value may be a black art in many respects," says Reid, "but if more people understand the art of the possible, they will express their needs better and get better results from researchers."

> **"bridging the gap between concepts and commercial solutions"**

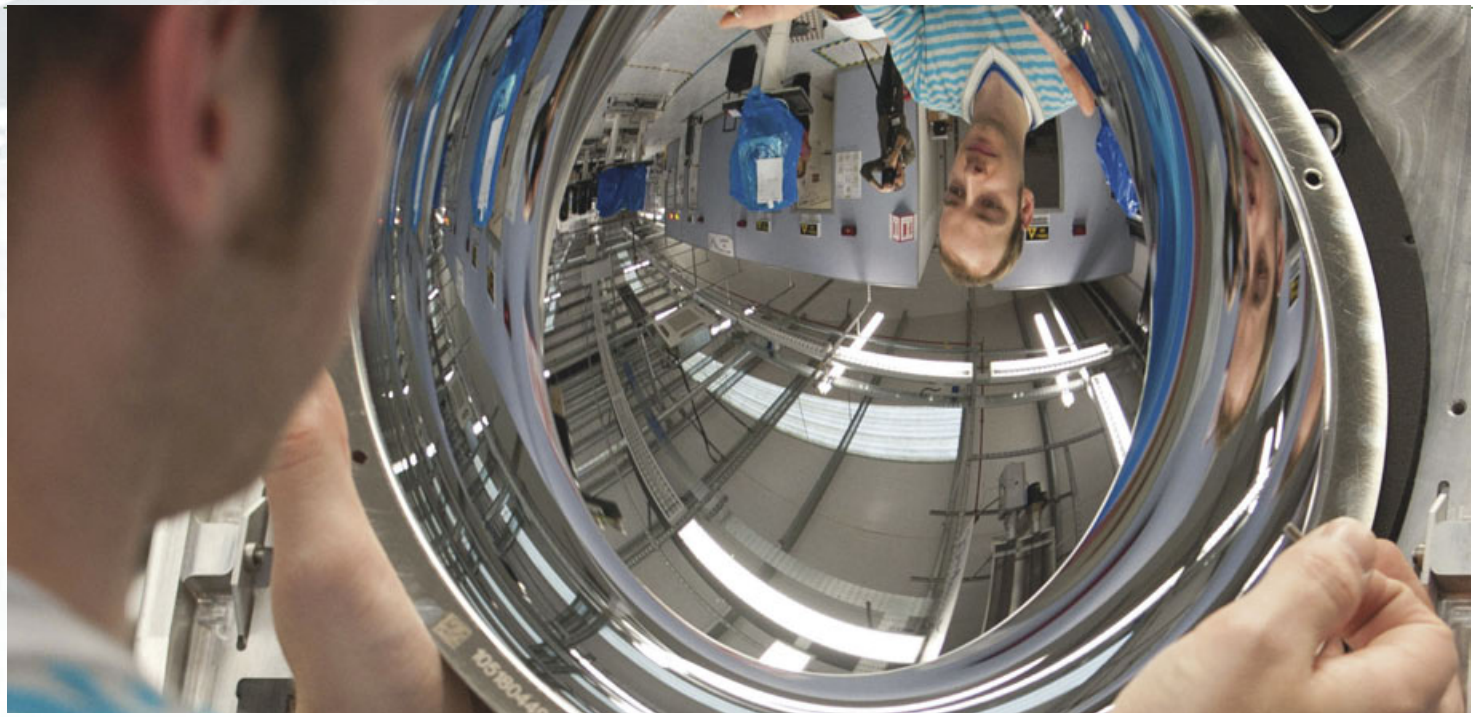
SIS: The Facts

Scotland has a total of about 140 companies working in SIS technologies, and together they contribute £2.5 billion per year to the Scottish economy.
The global sensor systems technology market is expected to grow to an estimated US$605 billion by 2015, with wireless solutions expected to grow by over 48 per cent a year.

SIS: The technology

Sensor and imaging systems (SIS) are built on a broad technological base, and the sensors are becoming increasingly intelligent in terms of how they measure things (detecting changes in temperature, vibration, density, pressure, etc.), collect and analyse data, and communicate with other devices, converting raw data into information that can be used to make decisions – by human beings or automatically.
The initial challenge is to turn the data into a usable signal, and in many cases link up distributed systems. Some sensors also store and process the data locally. But the ultimate challenge is to turn that data into useful information for visualisation and presentation, to improve performance or help design better new products or systems.

Profile **Innovation Centre for Sensor and Imaging Systems (CENSIS)**



THE ELLIPSOIDAL MIRROR USED BY GLASGOW UNIVERSITY IN THE OPTOS PROJECT.

The SIS industry is changing so fast it is hard to keep track of the most recent breakthroughs and the latest applications, and understand the changing industrial landscape. "Every time you look at it," says Reid, "it seems to get more complex." SIS is also becoming increasingly inter-disciplinary, no longer focusing "just on the sensor and data but on the system and information and how this is managed, collected and presented back in usable and useful formats."

Scotland, says Reid, is an excellent environment for SIS because it has a world-class research base, as well as many industries which have a strategic requirement for innovative SIS solutions, including oil and gas, utilities, renewables, defence and security, transport, life sciences, the built environment, subsea (including unmanned vehicles), robotics, aquaculture and food processing. And CENSIS will investigate what SIS solutions are needed by industry and explore how researchers can meet those requirements.

The funding structure

CENSIS was set up last year with £10 million from the Scottish Funding Council (SFC), and will use the money to support new R&D projects, longer-term research tackling common challenges and needs, and employee training and development, including secondment – organising industry events, workshops and clinics, etc.

The projects are designed "to accelerate research outcomes into new products or services." They will be partnerships between academics and business, and will either be "short and sharp" collaborative research and development projects lasting 6–18 months or strategic research projects lasting 2–3 years, authenticated by industry partners to ensure they have commercial potential and relevance to real-world problems.

Some projects are already advanced, including a collaboration between Dunfermline-based Optos and the University of Glasgow to develop new eyecare solutions (to correct optical aberrations and improve image quality in scanning laser ophthalmoscopes), and another to develop a new sports medicine device which brings together the University of the West of Scotland with Cumbernauld-based Gas Sensing Solutions. Other projects include the use of Hyperspectral Imaging (HSI) in the water environment (AECOM and the UK Astronomy Technology Centre), and the development of low-cost magnetic transducers (Renishaw and Heriot-Watt University). As time goes by, CENSIS itself will get more involved and "be part of the delivery process" by providing in-house technical resources for projects, especially for small and medium-sized enterprises (SMEs) which may not have enough of the key engineering resources available – for example, people with experience in new product development or introduction, system design, fast prototyping and project management.

"Our job is to identify the industrial challenge and scope the proposals," says Reid, "then explore the solution space to identify the best researchers to develop the solutions and rise to the challenge."

Another role which CENSIS will perform is the sourcing of funds, helping researchers or business partners present the best case for support – for example, from Scottish Enterprise, Highlands and Islands Enterprise, the Technology Strategy Board (TSB), or European funds such as Horizon 2020.

The MSc degree in SIS will include modules to develop the entrepreneurial skills of the students and prepare them for the business world, whilst the other new programmes will include EngD (Engineering Doctorate) and CDT (Centre for Doctoral Training) post-graduate research degrees.

Reid believes it will be vital for the industry in Scotland to provide input into these courses, so the technical challenges it faces will help shape the programme. Placements in industry will also play a key role in training the next generation of SIS experts, who will need to be up to speed in a rapidly changing environment.

In terms of outreach, CENSIS has already organised a series of special events and is considering the idea of getting involved in a conference on SIS, where Scottish researchers and businesses could showcase their talents.

Main objectives

CENSIS aims to become "the predominant source of expertise in SIS industrial R&D in Scotland," setting its sights on the UK and international markets. It is a partnership between the universities and industry, set up "to create opportunities for the exchange of talent and market growth, stimulate inward investment and showcase Scotland's SIS capabilities."

Its mission is to deliver sustainable growth in Scotland's SIS industry by focusing on the following aims and objectives:

1. Accelerate the transfer of SIS technology from the science base to industry through collaborative R&D, knowledge transfer, and commercialising academic IP to meet industry needs.
2. Be a beacon for economic development and wealth creation through the development of a strong innovation ecosystem, combining the skills, knowledge and expertise of all the partners and working across traditional supply chains.
3. Align university research with longer-term, strategic opportunities for innovation, creating economic impact by funding applied research to meet needs identified in collaboration with industry partners.
4. Stimulate a more entrepreneurial and innovation-driven culture amongst the research and industrial base to increase the absorptive capacity of indigenous companies.
5. Integrate communities of researchers and innovators across the supply chain with networking activities designed to encourage collaboration.

The initial target was to launch about 150 SIS projects over the first five years, but according to Reid, there is also flexibility to look at a smaller number of higher-value projects – depending on industry drivers.

The major themes will be:

- System Engineering & Integration
- Advanced Devices & Fabrication
- Advanced Analysis & Visualisation
- Imaging & Optics
- Signal Processing, Communications & Networking
- Remote & Distributed Sensing Applications

RESEARCHER DR SUMANTH PAVALURI AT MACPHIE OF GLENBERVIE – WHERE SENSORS HAVE REVOLUTIONISED PRODUCTION.

Economic value

For Reid, the new job is a challenge he welcomes, following a career which spans GEC-Marconi, Pulse Engineering, Rood Technology and QinetiQ, "the world's biggest sensor company." Scotland is also a logical next step for someone who can see its potential in terms of research and industrial uses. "The SIS business in Scotland is valued at about £2.5 billion a year, but that's just the tip of the iceberg," he says. The value added could be enormous, from extending the lifespan of oilfields to improving the efficiency of wind farms – or even more efficient ways of making mayonnaise (see Case Study 3).

As someone who describes himself as "an industrialist at heart," with a first degree in physics and experience in dealing with the academic sector, plus a knowledge of company start-ups and new product launches, Reid also understands the different worlds of business and research and the need for return on investment. He recently told the newspaper *Scotland on Sunday*: "We need to begin solving real industry problems – and make money."

If you can measure it, says Reid, you have the foundation for a new kind of business. And CENSIS will measure its own success not just in terms of economic impact – and money – but also by how much it changes the culture by getting industry to work in closer partnership with Scotland's universities.

"It's an interesting challenge," says Reid, "because it will involve so many disciplines. But for me the real excitement lies in the reconfiguration of these disciplines, creating a viable ecosystem for SIS in Scotland and ensuring that CENSIS has a role in the industry's future, as well as a broader agenda in reaching out to international markets."

CASE STUDY 1
Eyeing the future

CENSIS has contributed £50,000 out of a total investment of £200,000 to a joint project between the University of Glasgow's specialist Imaging Concepts Group and Optos of Dunfermline, a leading provider of diagnostic eyecare solutions including retinal imaging devices. The partners aim to improve the image quality of the scanning opthalmoscopes developed by Optos – to correct image warping and "make complex eye exams more accessible to remote locations and the developing world."

"Our aim is to remain the market leader in laser scanning opthalmoscopes for eye health care," says Alex Warnock, chief operating officer of Optos, "and to continually push the boundaries of what is possible with our technology, and this research partnership will enable us to do that."

Another Optos project will involve the company working with the University of Glasgow's gravitational waves research group, which has developed an algorithm for detecting patterns in gravitational waves that could be adapted for retinal scanning to improve image quality.

CASE STUDY 2
A sporting chance

Gas Sensing Solutions (GSS) has established itself as a leader in the development of innovative carbon dioxide sensors for use in different environments from buildings to engines, and helped by £15,000-worth of support, the company is now working with the University of the West of Scotland (UWS) to test and develop a new solution for sports medicine – a lightweight device to monitor breathing. The research involved ten people wearing special respiratory masks and running on a treadmill while the equipment did 27,000 simultaneous measurements for evaluation.

"We knew the SprintIR device was just as accurate in measuring carbon dioxide production as existing lab-based equipment, but we needed scientific tests to prove it," says Des Gibson, CEO of GSS. "Our partnership with CENSIS and UWS has helped produce the hard evidence required, paving the way for a device that could change the market and open up significant commercial opportunities for GSS in a multi-million pound industry."

CASE STUDY 3
A saucy business

Oil and gas may seem a million miles away from food production, but a device originally developed to monitor the density of fluids in oil pipes is being adapted for use in a factory turning out bechamel, custard and hollandaise sauce, thanks to funding from CENSIS. Macphie of Glenbervie makes the different products using the same basic equipment, switching from one product to another as demand requires. The problem it faced was that flushing the pipes out with water and waiting for the water to run clear, then waiting until there was only sauce in the pipes, was wasting valuable time and resources, so the challenge was to make the process more cost efficient by using a new type of non-invasive, microwave-based sensor, now being developed in partnership with Heriot-Watt University's MISEC Research Group.

The industrial biotechnology revolution

INDUSTRIAL BIOTECHNOLOGY INNOVATION CENTRE (IBioIC)

ADMIN HUB: **University of Strathclyde**

FUNDING: **£10 million (initial investment)**

WEBSITE: **www.ibioic.com**

If you designed the ideal country to become a global centre for industrial biotechnology, it would look a lot like Scotland – with a few million hectares of farmland attached.

Even though it does not have enough land to support the mass production of biofuels (which currently account for a large proportion of the market), Scotland does tick most of the boxes for industrial biotechnology:

1. it has a well-established food and drink industry (most notably whisky) as well as a significant agricultural sector to provide the by-products (e.g. biomass) and basic feedstocks for many biotechnological processes (e.g. enzymatics and fermentation);
2. it has a world-class life sciences industry with ambitious targets for growth;
3. it has a strong chemical industry in Grangemouth, with a focus on petrochemicals – providing the skills, expertise and logistics that are needed to develop a capability in industrial biotechnology;
4. its marine resources (including aquaculture and its very long coastline) are among the world's richest;
5. its universities and other academic institutions (including the James Hutton Institute and SAMS – the Scottish Association for Marine Science) have leading researchers working in strategic areas such as synthetic biology and industrial process design, with a good track record of developing highly transferable technologies.

Profile **Industrial Biotechnology Innovation Centre (IBioIC)**

PHOTO BY PETER BARR

This combination of natural resources, industrial experience and scientific expertise puts Scotland in an excellent position to be a major force in industrial biotechnology, just as it has already established itself as a world-class player in the petrochemicals sector. And according to the CEO of the IBioIC, Roger Kilburn, the way the oil and gas industry has grown in Aberdeen over the last 40 years could serve as a model of how industrial biotechnology could also develop in Scotland in decades to come.

In fact, adds Kilburn, history can teach us some valuable lessons about the possible future trajectory of industrial biotechnology – a science which has only got "serious" over the last ten years. In the early 20th Century, the petrochemical industry did not exist and chemical engineering was only just being invented – e.g. the Haber-Bosch process which enabled mass production of ammonia and nitrate-based fertilisers, revolutionising agriculture and "detonating the population explosion," as well as aiding the production of explosives themselves. Similarly, the pharmaceutical industry has been transformed over the last 15 years, with seven of the world's top-selling drugs now based on breakthroughs in biotechnology. And Kilburn believes that synthetic biology will soon have a similar impact on industrial processes as well as on the energy sector and how we deal with waste.

"About 100 years ago, we saw the emergence of industrialised chemistry," Kilburn explains, "and now the same thing is beginning to happen with biology."

Industrial biotechnology promises to be just as "disruptive" in its impact on the global economy as chemical engineering was a century ago, and what is driving it today is the dramatic decrease in the cost of genome sequencing – which is halving every year and "creating unforeseen and unpredictable opportunities" such as the production of new chemicals and drugs.

In Scotland, says Kilburn, industrial biotechnology could transform the industrial landscape, at the same time as providing a new lease of life for existing facilities, such as the giant petrochemical complex at Grangemouth. It may also lead to the construction of a biorefinery in central Scotland – one of the first wave in Europe – if all the sums add up and all the conditions are met.

The catalyst for industrial biotechnology is synthetic biology and our ability to manipulate genes, but the driving force is the need to find an alternative to the oil-based economy – the industry may still be worth $3 trillion a year, but fossil fuels won't last forever and there is a growing recognition of the need to cut carbon emissions. Thanks to advances in biology, everything now made from fossil-based carbon will soon be made using a new generation of more sustainable biotechnological materials.

> **"We are no longer limited to what biology is, but how we can use it to do what we want – including the improvement of manufacturing processes and energy use"**

We need to shorten the carbon cycle, says Kilburn, replacing what we burn (as fuel or for consumer goods) by replanting in regular cycles, instead of relying on finite deposits laid down million of years ago. Ultimately, this could lead to the creation of a "bio-economy," using more renewable energy and making better use of resources in industrial processes, as well as making possible advances in the development and manufacturing of new materials and products.

"We are no longer limited to what biology is, but how we can use it to do what we want – including the improvement of manufacturing processes and energy use," says Kilburn.

Industrial biotechnology will inevitably be a major part of the economy in the future. Apart from the fundamental science involved, the major challenge facing scientists now is economic viability and issues of scale, and this is where the great opportunities lie.

Some of the possible technologies may seem exotic – for example, using bacteria to eat up waste products and convert them into something more useful (bioremediation), or developing a new kind of bacteria resistant to hostile environments such as alcohol or acid – but the benefits promise dramatic advances in areas such as agriculture and healthcare, as well as addressing the climate change challenge. Some of the advances may seem relatively simple – such as improving the way we brew beer – but they all add up to potentially huge gains in terms of both the economy and the environment.

Red, white, blue and green

The new Industrial Biotechnology Innovation Centre "will harness the combined intellectual horsepower of 13 higher education institutes and create a single portal for industry, focusing on all four 'colours' of industrial biotechnology. It also aims "to accelerate and de-risk the development of commercially-viable, sustainable solutions for high-value manufacturing in chemistry-using and life science sectors," and is a key element of the Scottish Government's National Plan for Industrial Biotechnology, which is being delivered by SE and HIE.

According to the Scottish Finance Secretary, John Swinney, Scotland's chemical industry is the country's second top exporter – worth £3.7 billion per year – and the IBioIC could add £130 million to the Scottish economy, helping the country transform from a largely fossil fuel-based to an industrial biotechnology-inclusive economy.

The 'four colours' represent the sectors with the most to gain from advances in industrial biotechnology, from a Scottish perspective. For example, the 'green' is agriculture, food and drink, which could benefit from the development of new more sustainable feedstocks, as well as providing the raw materials (e.g. by-products from distilleries and forestry) needed to fuel a new biorefinery. The 'blue' represents the marine sector (materials and organisms), with Scotland well placed to take advantage of its coastline and other resources – for example, by developing new techniques to stimulate algae production using photobioreactors (big fermentation tanks with lights inside), as well as boosting seaweed production. This will not just be a more efficient source of feedstocks for fish farms (rich in valuable omega three oils) but also provide food for human consumption as well as numerous other by-products, including the ingredients for fertiliser.

The 'red' stands for the pharmaceuticals industry (including human health and cell therapies), which is seeking to be more sustainable, as well as developing smarter solutions, taking advantage of industrial biotechnology in areas such as fermentation, catalysis and cell factory production. In Scotland, the drug development industry has been highly successful and will benefit greatly from future advances in industrial biotechnology. The 'white' is industry, where industrial biotechnology will help transform production processes and produce more sustainable energy through integrated bioprocessing and by recycling municipal waste and agricultural by-products.

What is industrial biotechnology?

Industrial biotechnology is "the use of biological resources (including plant, algae, marine life, fungi and micro-organisms) to produce and process materials into products such as pharmaceuticals (including vaccines and antibiotics), high-value chemicals, materials and energy, using cells (from plants or animals) or parts of cells as biocatalysts. The modern industry is gathering momentum largely due to recent advances in science such as genomics and synthetic biology, but the roots of the industry lie in more basic activities such as distilling and brewing.

The benefits of industrial biotechnology include reducing the consumption of water and energy in manufacturing processes, and the reduction of waste. In the energy sector, industrial biotechnology can be used to generate power using biomass or biofuels. In pharmaceuticals, it is used in drug development as well as production – e.g. to improve fermentation techniques. In agriculture and aquaculture, it provides new sources of lower-cost feedstocks, and helps reduce waste by making better use of by-products such as woodchips. Ultimately, industrial biotechnology could help replace fossil-based fuels – producing energy as well as raw materials for new consumer products, drugs and food.

The educational supply chain

One of the key objectives of the IBioIC is skills development, including the establishment of a new collaborative MSc programme in Industrial Biotechnology, as well as collaborative PhD programmes and studentships, an HND programme (in partnership with Forth Valley College and Glasgow Kelvin College) and apprenticeships. The collaboration with industry will involve MSc students spending half of their time in an industry placement, whilst also giving them the chance to broaden their knowledge by taking modules in a range of different subjects such as marine biology, synthetic biology or bioprocessing. The collaboration will also pool the resources of 14 universities, each of which has something different to offer. From September 2014, the Centre will also fund nine PhD students, with business skills part of the programme.

The Vision

The Industrial Biotechnology Innovation Centre (IBioIC) was set up to accelerate and de-risk the development of commercially viable, sustainable solutions for high-value (speciality & commodity) manufacturing in chemistry-using and life science sectors. It aims to be "an innovation and growth engine yielding substantial economic impact and delivering increasing and sustainable wealth creation, prosperity and employment in Scotland." The economic target is to contribute £1–1.5 billion of Gross Value Added to the Scottish economy every year – an increase from an estimated £190 million today – and create up to 1,500 jobs over the next five years.

FINANCE SECRETARY JOHN SWINNEY (LEFT) GETS THE LOWDOWN ON THE IBIOIC FROM CHAIR IAN SHOTT (CENTRE) AND CEO ROGER KILBURN (RIGHT).

To support this four-pronged strategy, the Innovation Centre's industry partners have identified five major themes:

1. sustainable feedstocks (including unconventional gases as well as marine and terrestrial crops);
2. enzymes and biocatalysis/biotransformation;
3. cell factory construction and process physiology;
4. downstream processing;
5. integrated bioprocessing.

According to Kilburn, the Centre will focus on research concepts "close to commercialisation," with proof of scale key to success – in other words new products capable of having global impact and making a significant contribution to the Scottish economy. The IBioIC will sign intellectual property (IP) agreements with the companies under its wing, dealing with every case project by project, and may license solutions to users, but owning IP is not its priority – it simply wants to see solutions being developed and exploited in Scotland, as well as exported worldwide.

The bottom line

According to a report produced four years ago by the IBLF, the global industrial biotechnology sector is expected to grow to a value of £360 billion a year by the year 2025, and the target for Scotland is to increase production from about £190 million today to about £1 billion in 2025 and £2–3 billion by 2030, with the UK as whole contributing a total of about £12 billion. To put this in perspective, the current value of the ethanol industry (dominated by the USA, which currently produces about 50 billion litres a year, with Brazil tipped to emerge as a rival in the very near future) is already about $85 billion, so Scotland and the rest of the UK have a long way to go.

"Because of its experience with ethanol, the USA may have a significant advantage," says Kilburn, "but industrial biotechnology will soon be a major part of every economy. If we ask when and where it will start to take off, the answer is now – everywhere."

> **"industrial biotechnology will soon be a major part of every economy"**

Regional solutions

Whether or not Scotland does build a biorefinery in the near future, industrial biotechnology means every country will need regional and also local solutions. For example, Grangemouth is well placed to process municipal waste as well as rural farming and forestry waste, so would make a good location for a biorefinery, but it could also be the base for many other chemical processing facilities. Kilburn also believes that industrial biotechnology sites will be scattered throughout the whole country, much like local quarries in the past, reducing travel costs and processing locally-available materials.

Scotland's key advantage in industrial biotechnology, says Kilburn, is the combination of existing industries such as petrochemicals and pharmaceuticals, the presence of so many major international companies already using industrial biotechnology, such as GlaxoSmithKline, Ingenza and INEOS, its world-class academic research base and its natural resources. The country also has huge potential for marine – both aquaculture and renewable energy. And if Grangemouth could also emerge, after years of decline, as an integrated industrial biotechnology complex, many different companies could feed off each other, as part of an industrial food chain which utilises every last drop of the available materials.

"We have to focus on what we are good at," says Kilburn, "and develop accordingly. We also need to answer several fundamental questions – for example, do we want to create a centre of academic excellence or become an engine of economic growth?" In Kilburn's view, the emphasis for the new Centre should also be on "market pull" not "product push" – developing world-class solutions so that more and more companies knock on the door, rather than developing new solutions and hunting for buyers. Helping to draw up a roadmap to a biorefinery may also be one of its tasks, whilst international partnerships may also emerge – e.g. exchanging knowledge with neighbours such as Norway.

Other parts of the UK have also been put forward as centres for industrial biotechnology – London because of its municipal waste and East Anglia because of its farming – but Scotland has the edge in several areas. "Scotland has a unique formula for success," concludes Kilburn, "and the world-class researchers and industrial partners added to our natural resources (agriculture, forestry and marine) and existing infrastructure are a very strong foundation for the future."

Industrial biotechnology will have a huge impact on countries worldwide and Kilburn also stresses the need for a global perspective. "It will be difficult to build a £1 billion industry by 2025 with home-grown small to medium-sized enterprises (SMEs), important through they are," he explains. "We need to work with major international players such as Lucite, INEOS and GSK."

DR IAN FOTHERINGHAM, PRESIDENT OF INGENZA, AND RHONA ALLISON, LIFE SCIENCES DIRECTOR AT SCOTTISH ENTERPRISE, EXPLORE THE INGENZA PLANT.

The IBioIC has been up and running for less than a year and is still focusing on gathering intelligence and building global links. But Kilburn is convinced that industrial biotechnology has huge potential and will quickly gain momentum in Scotland: "We are surrounded by the products of the petrochemical age (e.g., polymers, coatings and detergents) and our economy is still dominated by fossil-based fuels, but that must change and will change in the near future, as more and more companies adopt bioprocesses as an integral part of their business."

The global economy has depended on fossil-based feedstocks until now, and Kilburn is convinced that the increased use of shale oil and gas will only delay the inevitable move towards biotechnology – in Scotland and everywhere else.

New intellectual territory for energy

OIL & GAS INNOVATION CENTRE (OGIC)

ADMIN HUB: **Heriot-Watt University**

FUNDING: **£10.6 million (initial investment)**

WEBSITE: **www.ogic.co.uk**

"We are setting the agenda for the next chapter in the North Sea," says the chair of the Oil & Gas Innovation Centre (OGIC), Paul de Leeuw. And that new chapter promises to be more challenging and more rewarding for thousands of businesses and academic researchers in Scotland trying to develop innovative solutions for the oil and gas industry in the UK as a whole – and beyond.

The figures are impressive – and the stakes are incredibly high. The North Sea has already produced about 42 billion barrels of oil equivalent (BOE) over the last 40 years, and the industry estimates that there could be as many as 24 billion BOE still in the ground. Even if there are only 12 billion BOE left, they could add up to at least one trillion dollars in revenues at current oil and gas prices, and innovation could make the critical difference – locating new reserves and making production more efficient and economic.

To put this in perspective, de Leeuw points out that investing about £5 million a year through the OGIC is a fraction of the *circa* £20 billion spent by the UK oil and gas industry in 2013 in exploration, development and production. But even a small budget can make a very big difference to universities and companies in Scotland, as well as major operators, if the money invested translates into business results.

The oil and gas industry is a major employer and investor in the UK. It employs over 200,000 people in Scotland alone, and there are over 2,300 companies in the UK oil and gas supply chain, ranging from the large and well-known service providers to small entrepreneurial companies.

PAUL DE LEEUW

Scotland has 12 universities doing research and providing oil and gas-related courses, and according to a recent survey by the OGIC, we now know there are over 450 people directly engaged in research – a capability that the new organisation will rely on to make future breakthroughs.

The technical challenge is daunting, says de Leeuw, who has 25 years' experience in the industry, including senior posts with Shell, Marathon Oil, Amoco, BP, Venture Production and Centrica. Most of the North Sea oil produced until now has been relatively easy to find and extract, but exploration is moving into deeper and more remote waters, where the costs will be much higher and the risks also greater – in technical, financial and environmental terms. According to de Leeuw, the challenge is to improve the exploration success rate to more than 35 per cent, increase the "average oil recovery factor" to more than 50 per cent and increase production efficiency to 80 per cent, at the same time as reducing decommissioning costs – with innovation leading the way.

The new organisation is designed to fill a gap in the innovation life cycle and accelerate delivery of innovative services and products, by making sure that it's in tune with industry needs and helping academic researchers and companies access research and development funds. In some cases, it will also help set up new university spin-outs, in partnership with organisations such as Scottish Enterprise and Highlands & Islands Enterprise.

For de Leeuw, it all starts with access to data, funding and know-how, and making connections between different stakeholders. By finding out what operators need and what their problems are, the OGIC will feed this information back to companies in that particular field and identify the academic partners who are best equipped to help them deliver results – knowing there's already demand for the service or product. This 'matchmaking' function should not only accelerate the development of new market-ready solutions, but also help to nurture the companies' growth and the strength of the sector in general.

At the moment, says de Leeuw, development of new technologies can take as long as 8 –15 years, from initial idea and concept to prototype, testing and commercialisation. There is often a "race to be second," he adds, with operators highly reluctant to be first to experiment with new ideas, because of the high risks and high costs involved in such a tough environment.

In the past, the operators did much more in-house research, but the structure of the industry is changing all the time, and most of the new companies operating in the North Sea now rely more on the smaller players in the supply chain to deliver innovation – and that is exactly where the opportunity lies for the OGIC and its industry partners in Scotland.

The OGIC: How it works

The OGIC will be "a delivery mechanism for the industry, linking industry needs to university resources and know-how." It will focus on three major functions:

1. Sharing the industry's technology needs
2. Early-stage assistance and funding
3. Project funding

The OGIC will interact with more than 2,300 operators and service providers, translating what they need into practical projects, then connecting companies in the supply chain with the right academic researchers, to develop solutions. For early-stage assistance, it will offer match funding for companies of up to £20,000 to fund initial research. In this way, academic researchers will 'double their money' thanks to business involvement, and the companies will – in effect – gain access to world-class researchers at about half the cost. Bigger projects to deliver market-ready commercial solutions will receive up to £250,000 from the OGIC, enabling companies to grow and creating new jobs in the process.

For more information, contact **info@ogic.co.uk**

Profile **Oil & Gas Innovation Centre (OGIC)**

For the oil and gas sector in the UK, the timing of the OGIC is perfect, says de Leeuw. The technical challenges are greater than ever because exploration is heading for more difficult waters, and new technologies are starting to emerge, which promise to deliver innovation in the areas most needed, with universities leading the way in research. Meanwhile, the new Technology Leadership Board is developing industry themes and a culture of collaboration is becoming the norm.

The need to invest more in innovation is also gaining more support from government. "The OGIC will work closely with other funding organisations such as the ITF (Industry Technology Facilitator), Interface, the TSB (Technology Strategy Board) and the UK Research Council to leverage innovation spend," says de Leeuw.

Major themes

According to de Leeuw, the OGIC will initially focus on the following themes:

1. Improving exploration outcomes
2. Well construction, drilling and completions
3. Enhanced recovery
4. Asset integrity and life expansion
5. Shale gas exploitation
6. Subsea
7. Production optimisation
8. Decommissioning

Over the next year, these themes may be further developed by the new Technology Leadership Board, but de Leeuw and his new team are keen to get started, and the first project kicked off in June this year.

The OGIC plans to get 100 projects up and running over the next five years, with half of them involving early-stage assistance, providing funds for new research of up to £20,000, which businesses will match. The other projects will be closer to commercialisation and receive OGIC funds of up to £250,000. Running 20 projects a year may seem ambitious, but de Leeuw points out that this would mean an average of less than two projects per university.

Apart from coming up with new solutions for practical industry problems, these projects should also create about 500 new jobs by 2018. And to underline the practical nature of the OGIC, de Leeuw explains that its location in a business park in Aberdeen is to make sure the OGIC team (8–10 people by the end of this year) is close to "where the action is," rubbing shoulders with potential industry partners, including SMEs and micro-businesses.

Shale oil and gas extraction is another major issue, which is likely to grow in importance over the next few years. To make it work in the UK, the industry needs an efficient supply chain and innovation could have a huge role to play, from planning and site preparation to extraction and eventual decommissioning. There is no question that the UK has significant resources, but there are different challenges ahead in terms of the geology as well as the political issues, so the role of the OGIC will be to monitor the industry and analyse potential future needs, before it initiates any new projects. "All our activities must be demand-led," says de Leeuw. "If there is no demand from industry, then we won't provide any funding for projects."

Decommissioning of oil and gas facilities will also demand increasing attention in years to come, as the offshore platforms reach the end of their economic life. The chief aim is to make the decommissioning process as efficient as possible, not just in terms of time and money, but also in terms of environmental impact. Projects could cost tens of millions of pounds, so any savings will be critical, and innovative ideas could transform the whole approach – maybe from an unrelated industry. Carbon capture and storage may also come into the picture in the future, providing further areas for the application of new technology.

Cross-industry potential

The OGIC is creating a new "ecosystem" of industry partners, and de Leeuw anticipates that collaboration may lead to a lot of cross-fertilisation between different sectors, including partnerships with companies which have never had contact with the energy sector before. For example, Scotland has an active software development industry, which may be able to develop new solutions for visualisation and simulation – not just for training but also to rehearse operations in the kind of difficult and hostile environments often encountered offshore in the UK. If companies in Scotland can produce best-selling games such as *Grand Theft Auto*, why not become world leaders in visualisation for other industries, including oil and gas? Another sphere where future applications may have a big impact is real-time information displays, combining data processing with other solutions such as Augmented Reality (AR), so engineers see layers of 'live' information to diagnose and repair problems.

> **But there's also a fantastic prize to go after, and to get there we need innovation and transformational change**

De Leeuw and his colleagues are already in regular contact with the other innovation centres recently set up in Scotland, including the Industrial Biotechnology Innovation Centre (IBioIC) and the Innovation Centre for Sensors and Imaging Systems (CENSIS). IBioIC could collaborate in numerous projects, because of its strong emphasis on industrial processes, including petrochemical production, whilst CENSIS has a member of staff based in OGIC's Aberdeen office, to explore the possibilities for future joint projects. According to de Leeuw, another key objective is for Innovation Centres to learn from each other; "Cross innovation will be key to success," says de Leeuw, "and that means working closer together and sharing our experience and knowledge."

Intellectual property

Since the OGIC was set up this year, de Leeuw has been impressed by the "very positive feedback" from everyone in the industry when he explains its strategic objectives and how it will work. One concern, however, is the way it handles intellectual property (IP) – who will own it and profit from sales? Oil and gas is a highly competitive business where IP is jealously guarded, but de Leeuw's job is to persuade operators and other companies in the supply chain that they can protect their own interests as the same time as promoting innovation in general, using new solutions to improve how they work and earning income from industry-wide global sales.

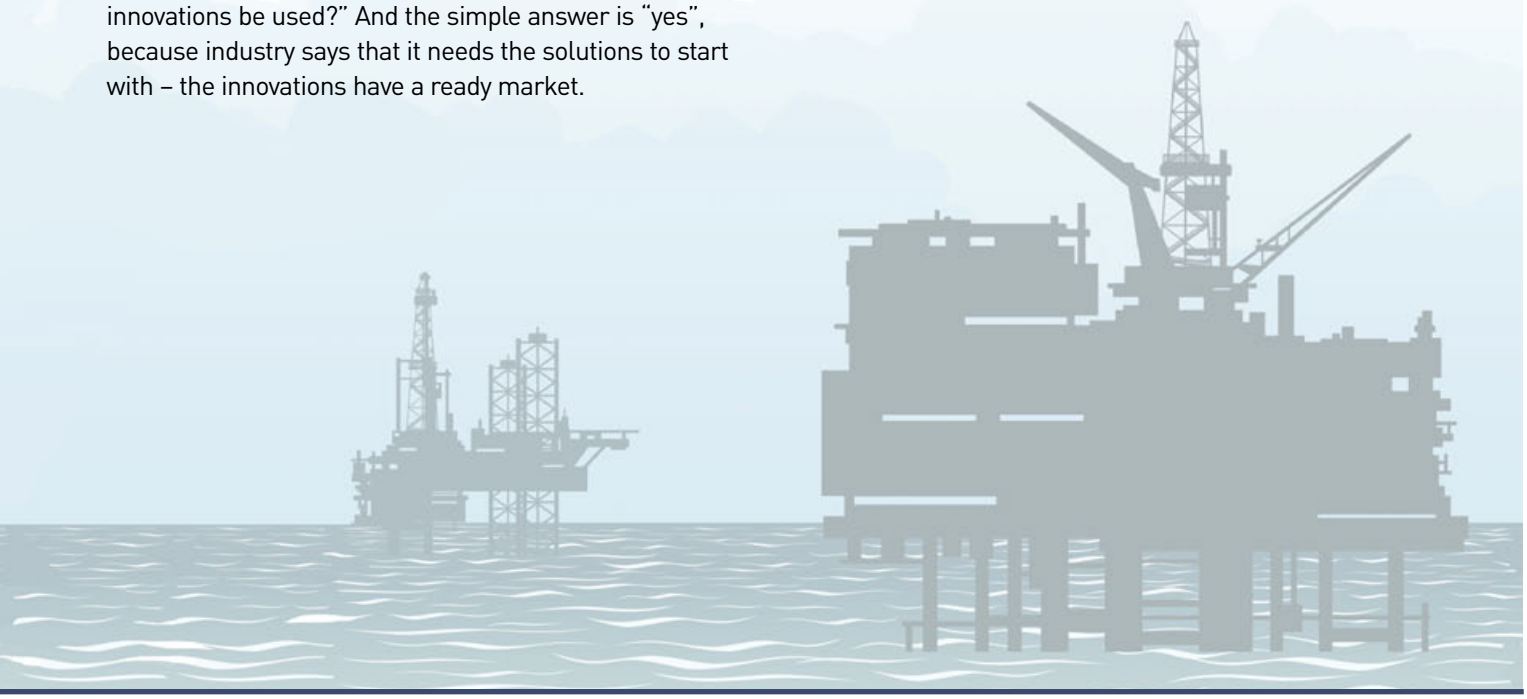
Another question raised by service companies is "will the innovations be used?" And the simple answer is "yes", because industry says that it needs the solutions to start with – the innovations have a ready market.

Big game, big numbers

Maximising the potential of the North Sea reserves will take the oil and gas industry into a different dimension – deeper waters, greater exposure to more extreme weather and harder-to-locate, more inaccessible wells, plus the problem of getting the products to shore, via pipelines and tankers. No one can be sure how much oil and gas is really out there or predict future prices – which makes it much harder to work out any possible return on investment.

The oil and gas industry is key to Scotland's future economic success, so any progress in developing solutions will make a huge difference – no matter how much oil and gas is produced. Looking at the numbers in more detail, de Leeuw explains that there are plans in place already for the first eight billion barrels. To produce the next few billion barrels will be a more difficult technical challenge, he says, but to reach a target of 16–24 billion BOE will require innovation like never before, and that is where the OGIC fits into the picture.

"The stakes are high," de Leeuw says. "We need to maximise recovery and minimise costs, while addressing production decline. But there's also a fantastic prize to go after, and to get there we need innovation and transformational change. The challenge for the OGIC is to be the delivery mechanism for innovation, getting operators, the supply chain and researchers to collaborate, so everyone wins. We know there must be better ways of working and we need innovation to thrive. Our job is to drive the agenda and accelerate the innovation process."



Lateral thinking for fish farms

SCOTTISH AQUACULTURE INNOVATION CENTRE (SAIC)

ADMIN HUB: **University of Stirling**

FUNDING: **£11.1 million (initial investment)**

WEBSITE: **www.scottishaquaculture.com**

"The aquaculture industry has changed a lot over the last 40 years," says the interim Chair of the Scottish Aquaculture Innovation Centre (SAIC), John Webster. "But one thing will never change – we are in the business of producing high-quality protein for human consumption, and we're interested in any innovative solution which will help improve the quality, sustainability and cost-efficiency of the industry."

There are many issues which affect the production of finfish (e.g. salmon) – for example, naturally occurring sea lice, viral pathogens and other diseases, and the availability of feedstuffs – but according to Webster, the major producers know exactly what needs to be done because they face these issues every day in their business. And the challenge for the SAIC is to bring together industry and academic researchers to ensure the focus is on problem-solving, rather than science for science's sake or the race to publish academic papers, and persuade business that investing in research will pay off in the long term, for their individual companies and the industry in Scotland as a whole.

Webster, who is also the technical director of the Scottish Salmon Producers' Organisation, has played a key role in securing the initial round of funding for the SAIC and appointing its CEO, and has been involved in aquaculture since the early days of the industry in Scotland, both as an academic and representing producers. In his view, there has always been a good relationship between academics and business, which has already led to some innovation – for example, the collaboratively funded TSB/industry wrasse project, based at Machrihanish – but there needs to be more emphasis on practical research, money-making services and products and sustainable solutions.

> **when it comes to fish health and protection of the environment in which the fish are farmed, everyone must share solutions and know-how, because everyone shares the same risks**

The organisation will "identify and commission problem-solving research and be responsible for knowledge exchange and training which will help improve the growth, efficiency and profitability of the sector," with the research funded in a 'just in time' manner. The business plan also makes clear that "the success of the SAIC will be measured through the translation of its activities into growth and increased profitability for existing and new aquaculture businesses, the creation of new, high-quality sustainable jobs in all sectors of Scottish aquaculture and a demonstrable positive impact on the Scottish economy."

The structure of the SAIC is also innovative in its own right. With its administrative hub based in Stirling, the organisation will be spread around the country, with possible sites in Dunstaffnage (at the Scottish Association for Marine Science), Scalloway (the North Atlantic Fisheries College) and Machrihanish (the Marine Environmental Research Laboratory) – or wherever the resources are located.

Transformational change

The SAIC brings together business, research and academic partners to promote "transformational change" in the future, but the structure of the industry in Scotland has already changed dramatically over the past few decades. At one time, there were over 100 salmon producers, but now the vast majority of farms are owned by only six or seven companies. These large firms drive the commercial success of the industry and are already investing in research, but there are many SMEs employing thousands of people who would also benefit from greater innovation, and who could also contribute ideas. The challenge is to make sure there is synergy between the different stakeholders, and persuade everyone of the potential for mutual success. Every company is always seeking new ways to sharpen its competitive edge, in international and domestic markets, but there are also opportunities to share new ideas – and earn money in the process.

The ownership of intellectual property (IP) is always an issue for organisations such as the SAIC, but if companies invest in the development of innovative services or products (e.g. a new food for salmon or treatment for sea lice) that are used by their competitors as well as by themselves, they will profit from sales at the same time as sharing the benefits with business rivals – so everyone comes out a winner. And when it comes to fish health and protection of the environment in which the fish are farmed, everyone must share solutions and know-how, because everyone shares the same risks.

Fish facts

Finfish and shellfish production contributes a total of over £1.3 billion per annum to the Scottish economy. Current annual production of salmon is about 160,000 tonnes, worth more than £700 million and generating global retail sales of more than £1 billion. The government target is to increase production by 50 per cent by the year 2020, the equivalent of an additional £350 million in first sale value, worth over £500 million in the shops, and to double production of shellfish over the same period.

Every additional 10,000 tonnes of salmon which reaches the market creates an additional £96 million for the Scottish economy, worth £43 million at the farm gate.

Every new fish farm contributes an average of £10.5 million per annum to the Scottish economy, creating five to six new 'high-quality' permanent jobs, with salaries totalling about £200,000. In addition, the new farms will spend about £2.5 million on equipment and services, and £3 million on feed from Scottish suppliers, producing 2,100 tonnes of gutted weight salmon from every 1,500 tonnes of feed. Total farm gate value is about £9.1 million, for use by Scottish, UK and overseas processors, while retail value is about £11.8 million, including £8.3 million in exports.

In Webster's view, another major challenge for the SAIC is to get the academic community to focus on getting some early results, so SMEs can see a quick return on their investment. "We need credibility and the credentials," says Webster. "And we want the industry to see research as an integral part of their business – to see investment in innovation as something that will generate income."

"The role of innovation centres," he says, "is to get people to understand the nature of working together, rather than argue about who owns the associated IP."

One of the SAIC's priorities will be to convince major industry players and SMEs of the value of investing in novel research and, in crude terms, this means they will have to put their hands in their pockets. Researchers will also have to change their approach, because if they want industry money, they will have to persuade their investors that they see the challenge as industry sees it and understands the problems that industry faces. "The research community will have to think in terms of innovations that solve business problems," says Webster.

Opportunities for everyone

As well as meeting the technical challenge, Webster also thinks the SAIC must reassure the public and the government that the science it helps to support is solving problems at the same time as contributing to Scotland's GDP, "not just improving the status quo but helping to facilitate real innovation." This means there will be tremendous opportunities for SMEs – especially if they have a talent for lateral thinking.

For example, the industry has made a lot of progress in the treatment of sea lice, developing the same kind of management techniques as any other food-producing industry faced with a similar parasite problem. "But maybe there are clever thinkers out there who approach the problem from a totally different perspective," says Webster, "and come up with a new engineering solution, rather than another therapeutic intervention – for example, using filters, ultrasound or lasers, or changing the design of the cages."

Innovations in aquaculture may also come from unrelated industries, says Webster – not just engineering but sensors and imaging systems or industrial biotechnology, both of which are also the themes of two other innovation centres currently being established in Scotland.

Food for thought

One of the areas where innovation is needed is feedstuffs for fish farms. Apart from the need to educate the public on the cost-efficiency and sustainability of salmon farming, addressing outdated perceptions about how much protein it takes to produce fish for human consumption, there is a huge need to develop alternative sources of feed. Salmon can be net producers of protein, producing more than one tonne for every tonne of feedstuff they are given, but the demand for feed is starting to accelerate all over the world as the demand for high-quality protein increases in developing countries such as India and China, turning fish oils into a commodity traded on exchanges.

To replace this scarce, increasingly expensive commodity is therefore at the top of the wish-list for many producers, looking for terrestrial or plant-based alternatives to feed their fish and stimulate marine growth – for example, phytoplankton and the algae or seaweed which are part of the food chain – which in turn can be used to feed fish.

"There are still enough sources of fish oil for salmon," says Webster, "but the supply is much reduced and if the pharmaceutical industry continues to buy up more fish oils (rich in omega three), we will soon need alternative sources, with modern science and technology offering a range of options that will be taken up by food producers across the globe."

> **an opportunity to better link industry needs to high-quality science, and join up the problem-solving skills that exist within the industry with the knowledge and know-how in Scottish academic and research institutions to identify, develop and apply solutions to practical problems**

In addition, attitudes to feed stuffs need to change, whether it is public perception or a marketing issue. For example, when salmon are growing, they use oils for energy as well as depositing some oils in their flesh. But they grow just as well by using plant oils, so using plant oils to fuel growth, then supplementing diets with fish oils that are rich in the important fatty acids towards the end of the growth cycle, is much more cost effective as well as further improving sustainability.

Seaweed cultivation is another theme that may get more attention in the future. As well as being used for fertiliser, it has potential as a food for human consumption and may also have a role to play in integrated multi-trophic aquaculture (IMTA). Although IMTA is gaining increasing attention from many researchers, Webster believes its commercial potential is limited for the time being – as soon as there is any problem in the multi-trophic system, the fish are protected before other species simply because they are worth much more money.

SAIC priorities

During the next five years, the SAIC will focus on "the big hits" first – as it gets up and running, it will need to show signs of progress in the areas which matter most to industry in terms of both bottom-line and universal benefits. The strategic priorities are fish health, breeding and stock improvement, feedstuffs and new engineering solutions, including hatchery technology, and the industry members of the SAIC consortium have identified four Priority Innovation Actions (PIAs) for urgent attention:

- The improvement of sea lice control – a major inhibition on the growth of salmon farming
- Development of alternative feeds for finfish which are sustainable not just in carbon terms but in the optimal utilisation of global resources
- Rapid detection methods for viral pathogens and diseases, drawing on knowledge from all academic fields
- Development of secure health-certified Scottish mollusc spat production systems, to make Scotland competitive across all aquaculture sectors

Other activities will include the development of advanced predictive modelling of the fate and behaviour of substances released from farms during fish production, development of integrated fish health management techniques and strategies, and examining new options for the deterrence of predators.

Educational initiatives

The SAIC will also support new educational initiatives, including funds for MScs in aquaculture. The universities of Stirling, Aberdeen and St Andrews already have successful undergraduate and post-graduate programmes in marine biology and aquaculture, and the SAIC will focus on developing new modules which emphasise the practical aspects of the science, including business management. According to Webster, graduates now spend more time in the field, seeing fish farms in action, and this will be key to the future success of its programmes, including fellowships and industry placements.

Overcoming obstacles

"We know what is stifling growth," says Webster, "and we recognise that businesses have to make money. Our job is to strike the right balance between the need to help the individual companies to sharpen their competitive edge by developing new services and products and the sustainability and profitability of the industry as a whole – for example, there's a 'truce' when it comes to things like fish health because that is a common concern."

The success of the SAIC will be measured in terms of economic impact, and the organisation will seek to be self-sustaining within the next five years by attracting new investment and additional funding, but it's hard to predict what will happen in detail. As Webster explains, there will not be room for "ethereal" research to start with, but some new graduates or SMEs may come up with some brilliant ideas which revolutionise the industry – in other words, expect the unexpected.

According to the SAIC, "the Scottish aquaculture industry has long called for a one-stop shop to help deal with the key obstacles to growth," and it hopes the new facility will create "an opportunity to better link industry needs to high-quality science, and join up the problem-solving skills that exist within the industry with the knowledge and know-how in Scottish academic and research institutions to identify, develop and apply solutions to practical problems."

"There is huge excitement in the industry about the new organisation," says Webster, "and great enthusiasm about what it can deliver. We are absolutely clear about what we are aiming to achieve, and our first task is to get the Innovation Centre into the industry.

Big data is the next big thing for business

THE DATA LAB

ADMIN HUB: **University of Edinburgh**

FUNDING: **£11.3 million (initial investment)**

WEBSITE: **www.thedatalab.com**

Almost every aspect of today's society is influenced by data. Data – and the information locked inside – is now recognised as the definitive source for competitive advantage in every sector of the economy. This recent trend has been headlined as "Big Data," but volume is only one of the defining characteristics of emerging trends in the information age. The velocity, veracity, variability and associated value in data are also important and we are seeing a more accurate term emerge – namely, data science. Simply put, data science helps us to understand data and enables us to unlock the value within.

One of the key elements that gives data science its power, however, is the human dimension. New informatics and analytical methods will ultimately generate new innovation, but perhaps the more spectacular breakthroughs will come from a range of new partnerships across various industry sectors, government departments and academic institutions. And that is why The Data Lab is being established.

Announced in April 2014, this new innovation centre funded by the Scottish Funding Council is dedicated to helping Scotland capitalise on the growing market in analytics and 'big data' technology. The Centre will transform the nature of collaboration between industry, public sector and academic partners, providing new ways of benefiting from the innovation and expertise within Scotland's world-leading university sector. With hubs in Aberdeen, Edinburgh and Glasgow, The Data Lab's primary focus will be on the digital technology, energy, financial services, healthcare and public sector markets, delivering a range of industry-led programmes across its three main themes: collaborative innovation, community building and skills and training

Innovation centres are primarily focused on delivering economic impact, but The Data Lab could also help shape future social, education and welfare policies

"One of the biggest opportunities for The Data Lab is in enabling new partnerships across industry, public sector and academia. Building the right multi-disciplinary team is very important when it comes to tackling data science challenges," says David Richardson, the Chief Operating Officer of The Data Lab. "Our universities have a wealth of world-leading informatics and computer science research and The Data Lab is focused on helping industry realise the value of this. We are industry-led from the start and our activities have been created in consultation with industry and public sector partners."

Before its funding was approved, The Data Lab bid team conducted market research across a range of key industry sectors, to find out how businesses and public sector bodies had previously worked with academia, and how they innovate. It also met with a number of local companies to understand what were perceived to be the big opportunities for Scotland.

The results of these discussions then helped shape the structure of the organisation as well as its budget profile, with a large amount dedicated to funding collaborative projects with universities that "deliver economic and social benefit through the application of data science."

New frontiers

The Centre for Economics and Business Research (CEBR) estimates that the Big Data marketplace could see 58,000 new jobs created within the UK alone, and the cumulative benefits to the economy are estimated to reach £216 billion over the years 2012–17.

Many of the new applications made possible by data science have previously been too costly or too challenging to implement – for example, using social care and fuel poverty analysis to benefit major industries such as utilities or financial services, as well as government policy and planning. Retailers have been using big data for years to analyse customer needs, using information from online transactions and loyalty cards to personalise their relationships with customers, but future innovation will come in the form of joining up people and organisations which may never have collaborated ever before.

Developing new technology solutions will also be a key focus of The Data Lab, but ultimately it will be concerned with solutions which help to improve a company's bottom line and/or lead to better products/services that deliver increased social value.

Innovation centres are primarily focused on delivering economic impact, but The Data Lab could also help shape future social, education and welfare policies. A key element of this will involve using data linkage to bring together disparate data sources, as well as making use of existing information. This allows data to be re-used repeatedly for a range of new applications. For example, using analytics on linked data may reveal a geographic or a demographic cluster where the government needs to intervene or can develop new policies that better serve its citizens.

Big data, big numbers

According to IBM, 90 per cent of the world's total data was created during the last two years, and every day we add 2.5 quintillion (1018) bytes of data to the total.

"Big data" uses the latest computing techniques and the most powerful computers to make sense of this huge explosion of data. But the challenge is not just to crunch all the numbers but also to pull all the data together from disparate systems which may not even talk to each other, at the same time as respecting data privacy and confidentiality, whether it affects the individual, government or corporation. Sometimes, the problem is to know where to look for the data to start with.

The primary aim is to get clean, high-quality data and add it all together for analysis which helps us make better decisions and also detect problems under the surface. This enables companies to improve their efficiency and boost their bottom line, or helps a government deliver better services such as social and healthcare – in all cases, using advanced analytics to get extra value from data.

PHOTO BY GARY DOAK

LEFT TO RIGHT: MALCOLM DOBSON, CHIEF TECHNOLOGY OFFICER OF DC THOMSON, DAVID RICHARDSON, CHIEF OPERATING OFFICER OF THE DATA LAB, AND NEIL LOGAN, CHAIR OF THE DATA LAB AND CHIEF TECHNOLOGY OFFICER OF LOCKHEED MARTIN BTS.

For companies, it may mean they need to develop a new business model or redefine their marketing strategy to address a newly-identified customer segment. Data science may also reveal where the system is failing, or when it is about to fail. By using new high-frequency data sources such as data from smart energy meters, or even personal wearable fitness devices, analytics could allow us to predict something is about to go wrong, enabling preventative measures to be taken.

For applications such as energy consumption, by predicting future supply and demand, utilities can offer new incentives for customers which alter behaviour and avoid them having to build expensive capacity for energy storage into their infrastructure.

What makes data science even more exciting is that "nobody's an expert and to tackle many of these problems requires a multi-disciplinary team with a range of different skillsets," says Richardson. "No one person or institution has all the answers." Data science is a blend of statistics and visualisation with data management and many other disciplines, but no matter what disciplines get involved, and no matter what solutions are developed, data is always at the heart of it all – whether it's production from an oil field or the number of phone calls received by a bank, or the billions of heartbeats recorded by wearable healthcare devices. With the growing use of ever-more-sophisticated sensors in so many aspects of everyday business and ordinary life, there is little doubt that the volume of data will continue to grow, and the need for data science will become even greater than ever.

The big idea

As the innovation centre for data science, The Data Lab was set up to "capitalise on the growing market in analytics and 'big data' technology," and the investment is expected to generate 345 new jobs and add £155 million of value to the Scottish economy. New companies will also emerge in the sector, specialising in data science, as well as new jobs in the more established companies and government departments, plus university researchers. The economic impact will also go far beyond the science itself – for example, boosting oil recovery in the North Sea or saving billions in the healthcare sector.

Neil Logan, Chair of The Data Lab and Chief Technology Officer for Lockheed Martin BTS, says: "The amount of data in the world is estimated to be doubling every two years and many organisations are struggling to cope. The Data Lab will help Scottish industry unlock value from data and enable new opportunities to be developed in collaboration with our world-leading universities. I'm excited at the opportunity of partnering with organisations across a number of sectors, including: digital technology; energy and utilities; financial services; health; and public services. The SFC's investment, together with support from Scottish Enterprise and Highlands and Islands Enterprise, helps ensure that Scotland takes a leading role in this exciting growth market."

> **We want results, short-term and long-term. We want to be the go-to place for data analytics in Scotland...**

Malcolm Dobson, Group Chief Technology Officer, DC Thomson, adds: "The Data Lab offers a fantastic opportunity for businesses such as brightsolid to help bridge the gap between Scotland's world-leading university research in data science and the commercial potential for Scotland to be a leader in this fast-growing global market. I think it is a game-changer."

Professor Aaron Quigley, Director for Knowledge Exchange for the Scottish Informatics and Computer Science Alliance, says: "The data science innovation centre presents us with a vital opportunity to connect growing, data-attuned industries with world-leading academic expertise in all areas of data science. It positions The Data Lab to become a world leader in data science, and the place academia and industry look towards for data science innovation and leadership. Across 14 Universities, we are looking forward to working with industry on breakthrough innovation, by drawing on cutting-edge research to produce new products, jobs, services and insights."

Future plans

The Data Lab will focus on the application of data science and develop new data science tools and technologies required by industry. It aims to deliver 100+ collaborative innovation projects, educating 1,000+ professionals, and organising workshops and high-profile events for academia and industry, in line with its emphasis on collaborative innovation, community building and skills and training, including the funding of new university courses and industry placements. Online learning also features in its plans, providing courses in data science for people interested in continuous professional development (CPD) or wishing to apply new skills to their own business. "We also want to educate business about the opportunities," says Richardson.

"Our primary focus will be on helping industry connect with the talent and expertise within Scottish universities," says Richardson. He also sees The Data Lab as like another start-up, with the big difference that it is funded for five years as soon as it's open for business. Richardson and his team also plan to have academic researchers working side by side with business partners in The Data Lab, developing new applications for projects.

"This is new territory for everyone," Richardson says. "The technology and basic science are out there. What makes it all so innovative is how people come together and develop new solutions that tackle real problems and deliver real value."

Scotland already has several examples of companies leading the way in big data, including Skyscanner (fast emerging as a major global player in the tourism sector), Aridhia (a world leader in bioinformatics) and Blackford Analysis, a spin-out from the University of Edinburgh which develops software solutions for the medical, oil and gas and defence industries, "using cutting edge algorithmic solutions to problems requiring real-time analysis of datasets."

Other areas identified by Richardson are manufacturing, fraud detection, climate change and logistics – all of which could benefit greatly from data analytics. He also anticipates scientists getting involved from areas such as physics, geoscience and mathematics.

"We expect the unexpected," he says. "We will go out and meet people, find out what they want and understand how we can help collaborate to deliver value, but it's impossible to know exactly how The Data Lab will develop over time, as new partnerships form and we learn from each other. But although it is hard to predict exactly what the future may bring, we do know that our job is getting value from data. If there's no value, what is the point? We don't want innovation for innovation's sake. We want results, short-term and long-term. We want to be the go-to place for data analytics in Scotland."

BILL MCBRIDE (IN FRONT), INTERIM CHAIRMAN OF THE CSIC.

A constructive approach to construction

CONSTRUCTION SCOTLAND INNOVATION CENTRE (CSIC)

ADMIN HUB: **Edinburgh Napier University**

FUNDING: **: £7.5 million (initial investment)**

WHO: **Construction Scotland, Scottish Enterprise, Highlands & Islands Enterprise and 11 universities in Scotland**

At a recent presentation in Aberdeen, Bill McBride was asked how the newly-set-up Construction Scotland Innovation Centre (CSIC) was going to spend its £7.5 million "grant" from the Scottish Funding Council (SFC).

"It's not a grant," McBride replied. "It's an investment."

As the Interim Chairman of the CSIC, McBride is keen to ensure that the money is turned into tangible outcomes – not just to give the SFC "value for money" but also to satisfy a traditionally conservative industry which is and always will be hard headed when it comes to results, and a major contributor to Scotland's economy.

The construction sector in Scotland is worth about £8.7 billion a year and employs 130,000 people, but the challenge facing the CSIC is that the industry is highly fragmented – with the top ten contractors accounting for roughly £2.2 billion a year but employing only 6,000 people, and 88 per cent of the contractors employing fewer than ten people. With a total of 31,000 companies involved in the sector, that means the CSIC deals with a very wide spectrum of businesses, with very different needs and ambitions, but McBride is very clear about the need to reach them all.

"It wouldn't be good enough only to engage with the Top Ten contractors," he says. "We also have to deal with thousands of SMEs and micro-businesses, and treat them with equal respect, as well as meeting their individual concerns." In such a fragmented market, he adds, it's also important to identify areas of common concern across the whole sector, and get everyone to buy in to the idea from the start. "It's like intelligent design," McBride continues. "Everyone can learn from one another, and create the kind of synergy we see in oil and gas."

The construction industry is ready for "disruptive innovation", but McBride is also clear about the mission of the organisation – to deliver results and return on investment. "The construction sector is a major employer and has a huge impact on the Scottish economy," he explains. "It is also a great multiplier, generating lots of value added for every pound invested. We need a structured approach and a supportive environment which brings different people together, and our mission is to take the Centre forward to become self-sustaining, generating income and attracting alternative sources of funding."

To be truly successful, he adds, innovation must have an impact throughout the whole sector, ultimately leading to more jobs and profits. In McBride's view, this should lead to a "virtuous cycle" of investment which sees construction companies develop innovative solutions, in partnership with University Business Schools and academic researchers, then, seeing the rewards produced, re-investing some of the profits in further research, to develop the next innovation, leading to a spiral of investment which produces more and more innovation.

What's needed is a culture change, McBride believes, to "transform how we do innovation, and optimise the opportunities created by focusing on innovation, empowering contractors so they will drive development in future."

Lots of people and companies have great ideas, he continues, but they may lack the skill-set to move on from concept to prototype and ultimately commercialisable products which generate profits and jobs. The fragmented structure of the industry and the very nature of construction can make innovation very hard to achieve. Whilst most new products in other sectors (e.g. electronics) can be prototyped in workshops, then tested to destruction and researched for market potential, "construction is in muddy fields" and the prototype is often the building itself. The costs involved, and safety issues, make it very risky to experiment.

"Innovation happens at a very different level, and also crosses many different disciplines," says McBride. "The construction industry is already innovative in specific areas, but it is difficult to drive innovation across the whole sector – especially in recent years when the industry entered recession, and there was a 'race to the bottom' as contractors competed for business. Now, however, the timing is right, and the industry is better placed to see the real value of innovation."

"We need a structured approach and a supportive environment which brings different people together"

The construction industry in Scotland

According to the latest figures from the Office for National Statistics, construction output in Scotland grew by almost £1 billion in 2013, taking total value to £10.7 billion.

The strongest growth was in private commercial activity and infrastructure, including major public-funded projects such as the Queensferry Crossing – the bridge designed to relieve the pressure on the Forth Road Bridge – and the construction of the Commonwealth Games Athletes' Village in Glasgow.

However, figures for output in the house-building sector showed a decline in the value of public sector housing – falling to its lowest level since 2007.

According to the managing director of the Scottish Building Federation, Vaughan Hart, "Recovery in Scotland is being led by government investment in and significant growth in the private commercial sector. But the value of housing output in Scotland actually fell by £141 million in 2013."

This drop in new housing last year is counterbalanced by a recent report which concluded that demand for new homes could fuel the creation of nearly 30,000 extra construction jobs in Scotland over the next five years. The Construction Industry Training Board (CITB) expects the private housing sector to see average annual growth of 4.7 per cent, boosted by major housing projects such as a £100 million eco village in Aberdeen and a £1.5 billion sustainable housing development in the Douglas Valley.

The CITB report added that average annual growth in output for the construction industry over the next five years was expected to be two per cent. And a recent report by the SBF said that seven out of ten firms were currently looking to recruit apprentices, while six out of ten had taken on trainees in the last year.

Researchers welcome opportunity

The University of Aberdeen will be one of the partners in the new Construction Scotland Innovation Centre (CSIC). Its newly-established Centre for Innovative Building Materials and Technologies (CIBMT) brings together specialists in a broad range of disciplines to research and develop new solutions for sustainable construction, including homes, buildings and urban infrastructure development, including research in energy-efficient buildings and innovative, high-performance thermal insulation and ventilation technologies.

CIBMT Director, Dr Mohammed Imbabi, says the CSIC is a fantastic opportunity to bring together a wide range of expertise and align it with real industry problems. "In Aberdeen," he adds, "we have long recognised the need to reduce conventional energy use and carbon emissions in buildings and across the built environment. Our integrated, multi-disciplinary approach to achieving this objective involves addressing a number of issues, from the materials used in their construction or renovation to the effect of the building on its local and global environments, and its impact on people's everyday lives."

Professor Andrea Nolan, Principal of Edinburgh Napier University, said: "The construction sector faces many challenges but also opportunities. The centre will provide a transformational platform for delivering economic and environmental benefits for our future generations."

For example, many researchers have been doing work on "healthy buildings," including studies on the benefits of natural light, which can boost productivity in offices, improve performance in schools and help people in hospitals recover more quickly. "People spend a lot of time in buildings," McBride explains, "and the environment can have a big effect on our performance." The challenge is to get this knowledge out there into projects in the real world. Greener buildings – with a smaller carbon footprint and greater energy efficiency – are another area where innovation has a key role to play, whilst off-site manufacturing can also contribute to project success.

"The more you can fabricate off-site, the better," says McBride.

In addition to the emphasis on new materials and methods of construction, many smaller contractors also want to see more innovative business processes adopted in the industry – for example, new measures to improve their cash flow. These smaller companies are also very often the driving force behind innovation, and the CSIC wants the industry to harness their talents so they have an impact throughout the supply chain.

Sometimes, progress comes from challenging people and organisations. When asked why they do something in a particular way, most companies reply that it is how they've always done things, and "if it's not broken, why fix it?" But even though they may be competent, McBride says, there's usually a better way – as business guru Jim Collins famously said, "good is the enemy of great."

"It's hard to solve a problem with the same old way of thinking that got you in trouble to start with," says McBride. "Sometimes you need to be an *agent provocateur* and sometimes you need a catalyst for change, such as our world-leading Scottish university partners. The CSIC will address the need for deep-rooted structural change and deal with a broad range of issues, but we can't solve every problem overnight and we certainly will not succeed without changing the culture."

BILL MCBRIDE, INTERIM CHAIRMAN OF THE CSIC AND MANAGING DIRECTOR OF THE WESTCROWNS GROUP.

First things first

The first steps for McBride in his interim role are to appoint a board, recruit a CEO and engage with the different stakeholders – including everyone from government and trade federations to micro-businesses and SMEs, major contractors and the 11 universities who will provide the initial research base: Aberdeen, Dundee, Edinburgh, Edinburgh Napier, Glasgow Caledonian, Glasgow School of Art, Heriot-Watt University, the University of the Highlands & Islands, Robert Gordon, Strathclyde and West of Scotland.

For McBride, the priority is to get the right people involved from the start, because "innovation is all about people." The board consists of diverse people with a skills set which reflects every part of the supply chain, including customers, major contractors, entrepreneurial SMEs with a track record in innovation, sub-contractors and academics. The new CEO will need to have good industry experience and ideally be someone who has "been there and done it" in terms of business and innovation.

Later on, the CSIC wants to have a home for the organisation – a one-stop shop for innovative companies – but the first priority is people.

"People are the greatest drivers of innovation," says McBride, "and leadership is needed to exploit this potential."

Within three weeks of his appointment, McBride set up a meeting in Dundee for representatives of industry and academic researchers, and the response has been encouraging. Some universities have well-established departments with a lot of experience working with industry and applying for funds, whilst others bring a fresh approach – and innovative ideas.

Communication with the industry will also be important, via trade federations as well as direct. "The big message is all about innovation, but different interests groups have different interests, and also wonder how they will benefit from the new Centre, so we'll speak to them as individuals," says McBride. "But everyone already recognises the benefits of innovation as an engine of growth which will be good for the economy, jobs and investment – and create a better industry."

Another key part of the mission will be education and training, funding industry placements and doctoral programmes – to create a new generation of "industry champions" immersed in a culture which promotes innovation, as well as a better-skilled workforce prepared for the next stage in the industry's future.

The go-between

The CSIC will be a go-between for customers and industry as well as researchers. Major customers (e.g. the NHS or Scottish Water) want better, greener, more cost-efficient projects, delivered on time within budget, and the CSIC can speak to researchers and their industry partners to find the best ways to achieve this, then bring the different parties together to put new ideas into practice.

Industry reaction

"With construction strongly influencing the quality of the environment in which we all live and work, it is essential that developments taking shape on projects around the country are connected to the academic capability and innovation in our higher education sector, as this will ensure that an innovative culture pervades our industry," said Ed Monaghan, Chair of Construction Scotland.

"This is essential to the future of construction here in Scotland, as we increasingly respond to stringent sustainability agendas and new market opportunities both here and abroad. Collaboration, knowledge exchange and innovation are achievable, but not the norm. The role of the Innovation Centre is to transform that mindset and ensure innovation becomes business-as-usual, creating a sector that is sustainable and one that generates greater economic impact for Scotland."

Profile

Acting as a go-between could make a critical difference in steering the direction of research towards more practical and more commercial projects. Whilst academics may gravitate towards what interests them most, business people focus on profits, and aiming for more innovation could satisfy everyone's needs because it is not just an engine of growth but a stimulus for new academic research.

"In some ways, we are pushing against an open door," says McBride, "because the different stakeholders now recognise the mutual benefits that will come from closer collaboration and innovation – economic growth, more profits and more jobs, and more investment in research."

Future plans

Just as McBride himself intends to steer the CSIC into its next stage, able to run on its own, he hopes that innovation in the industry and real-life projects will create the momentum required to drive more innovation in the future, with the industry pushing ahead on its own and sustaining its own growth. And before he returns to his job as Managing Director of the Westcrowns Group, a company which employs about 400 people and turns over £37 million year, he's determined to get the right people on board.

McBride is passionate about innovation and the future of the industry in Scotland. He understands the importance of changing the industry culture, but also knows the bottom line is where the success of the CSIC will be measured: "We have the biggest opportunity in 25 years to change the industry within a generation. We also have a great under-utilised asset. New products and solutions are important, but we will not succeed unless they are commercialised, and our job is to leverage the current investment to create new jobs and generate new sources of income – not just another new patent. Innovation is essential to future success, but it must be sustainable."

The formula is simple: if research and development leads to successful solutions which provide a good return on investment, then more funds will be ploughed back into future R&D, and other companies will also be inspired by these successes to go down the same road. To make it work in such a results-oriented business will be a challenge, not just for science but also for the art of persuasion.

"We're putting the pieces of the jigsaw together," McBride says. "It would be great to bring 100 projects to market within the next five years, but the challenge will be transformational change in the industry and academic culture, and sustainable growth in construction."

"The role of the Innovation Centre is to transform that mindset and ensure innovation becomes business-as-usual, creating a sector that is sustainable and one that generates greater economic impact for Scotland."

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