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INNOVATION CENTRES: CONNECTING THE FUTURE

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Rising to the challenge

IAN RITCHIE CBE FREng FRSE FBCS CEng

Here in the UK, we have some of the world's top universities. Alongside the US, our leading institutions dominate all the league tables for high-quality research; but unlike the US, our economy doesn't rate particularly well in applying this innovative research and development (R&D) to industrial applications – and in the process creating wider economic benefit.

R&D spend in the Higher Education (HE) sector in Scotland is genuinely world leading; with about 8.5% of the UK population, we competitively win around 13.5% of the UK's research funding. As a result, of all the UK's regions, Scotland ranks first in R&D spend as a proportion of GDP, and fourth in the entire Organisation for Economic Co-operation and Development (OECD). However, when we measure private sector business enterprise R&D (BERD), we rate very poorly indeed: only 0.74% of GDP, ranking Scotland eighth amongst all UK regions and solidly down in the third quartile of all OECD economies. (By comparison, BERD in Israel and Korea runs at more than 3% of GDP.)

So, we are great at innovation, but could do much better at creating business success and economic benefit from this innovation. This conundrum has puzzled governments and economic agencies over the years. Part of the problem is that there are very few innovative corporations with head offices in Scotland capable of taking up research developments and bringing them to market.

Many are aware that in Germany, for many years, the various Fraunhofer institutes have successfully applied new innovation to industrial take-up, and this demonstrates a need for some kind of 'translational' structure between research and its application.

This issue led Scottish Enterprise to develop three Intermediate Technology Institutes (ITIs) in 2003 in the fields of energy, life sciences and creative technology. This initiative was abandoned in 2010 when it became obvious that they had not been able to successfully identify enough technology which was genuinely market ready.

The UK Government asked Dr Hermann Hauser to look into this problem and, in a report published in early 2010, he recommended setting up 'translation institutes' – several of which have now been set up by Innovate UK under the label Catapult Centres.

Here in Scotland, however, we clearly have a more chronic need – even more severe than in the rest of the UK – to address this problem, and that is why the Scottish Funding Council (SFC) has developed policies to try and help.

In 2013, SFC, in conjunction with Scottish Enterprise and Highland and Island Enterprise, encouraged the formation of a new breed of 'Innovation Centres' to support transformational collaboration between universities and businesses. The Centres aim to enhance innovation and entrepreneurship across Scotland's key economic sectors, create jobs and grow the economy. All of these Innovation Centres have backing from industry and draw on all of Scotland's research expertise in the relevant sector – crucially to work on problems and opportunities identified by industry. They arrange secondments, industrial studentships and spaces for collaborative work, and share equipment.

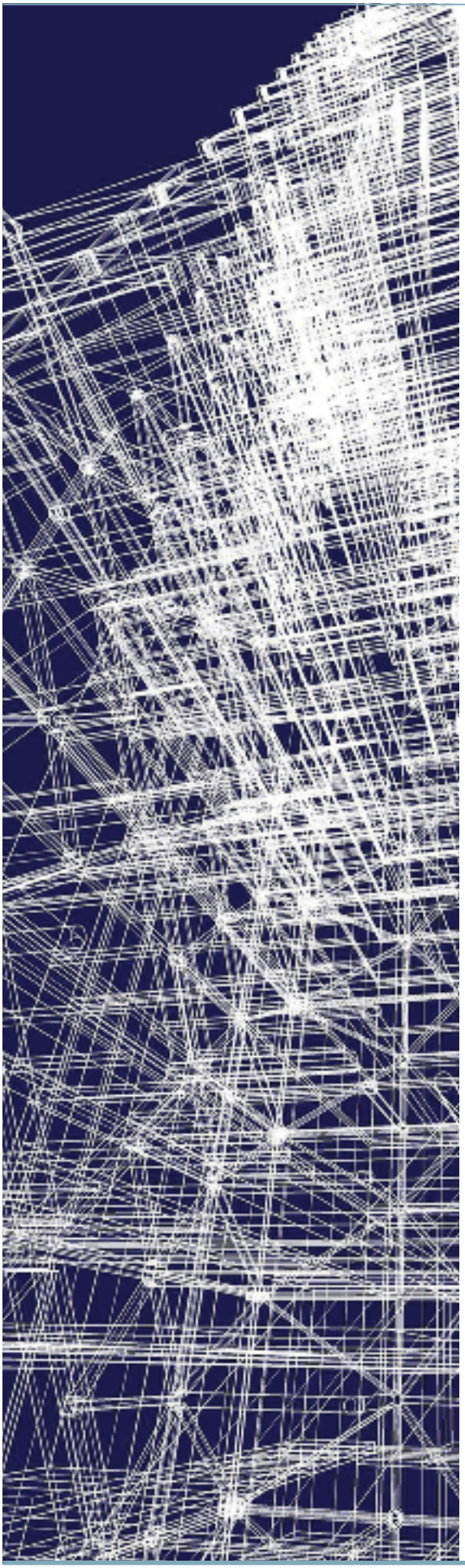
Their declared vision is: "Using the Scottish university infrastructure, human resources and research excellence as a platform for collaborations across the whole of Scotland, Innovation Centres will create sustainable and internationally ambitious open communities of university staff, research institutes, businesses and others to deliver economic growth and wider benefits for Scotland."

The SFC has committed £120 million to the Innovation Centre programme over five years and each Innovation Centre is expected to leverage further investment from industry and other sources of funding.

Now that these Centres have bedded down, it is fascinating to see what progress they have made in the short time since they have been established.

According to the reports in this special issue of *Science Scotland*, it looks good so far, in terms of the number of projects launched and the amount of matched investment now pouring into research. This gives us reason to hope that these new Innovation Centres can rise to the challenge of helping the Scottish economy to compete better in the modern world.

Ian Ritchie CBE FREng FRSE FBCS CEng



Contents

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Innovation Centres: **Connecting the Future**

Setting up a ground-breaking programme of eight Innovation Centres in Scotland, the Scottish Funding Council's concept was for social as well as economic impact. The aim is to create sustainable and internationally ambitious communities of university staff, research institutes and businesses to create future prosperity and wider benefits for Scotland. Backed by a five-year investment of over £120 million, the centres are making rapid progress and are starting to produce some exciting results in terms of projects and collaborations between academic researchers and businesses across different industry sectors...

Focused on industry need

The concept of Innovation Centres burst into life through a dynamic set of conversations between the Scottish Funding Council (SFC), the enterprise agencies and Scottish industry. The talks were focused on a determination that Innovation Centres should be tightly aligned to industry needs – with industry leading the way to the best economic returns and the strongest potential for technological progress.

The idea was to accelerate technological advances by creating new and transformational collaborations between Scotland's world-leading university researchers and business, with industry partners sharing the costs of research activities. This was a radical change in direction for both universities and businesses, backed by the belief that this fusion of intellect, discovery and entrepreneurship could bring about a revolution in how we build future prosperity and social wellbeing in Scotland.

Progress so far

According to Professor Albert Rodger FREng FRSE, Chair of the Scottish Funding Council's Research and Knowledge Exchange Committee, the Innovation Centres have been quick to set themselves up and get on with the business in hand. They have also been quick to build their connections with industry and to initiate projects. Professor Rodger believes every sector is different, but feels patterns are already beginning to emerge as projects cross the boundaries between different Innovation Centres and their respective industries and markets.

Professor Rodger sees the potential for huge benefits to society from Innovation Centres involved in medical and health-related research collaborations: "Scotland has long been a place for medical discovery and continues to be a world leader. Close and constructive partnerships between those at the cutting edge of medicine, science, technology and engineering – whether they be in universities, NHS Scotland or in industry – will be key to Scotland staying ahead of the field."

Innovation Centres

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

The Digital Health & Care Institute (DHI) is intended to have a strong social impact and has already begun to produce results. These include the development of My Little One – technology that makes it possible for parents to keep in touch with their babies while they are in neonatal care (which is the case for more than 10% of babies born in the UK every year). The DHI has collaborated with the Scottish Ambulance Service to explore how digital technology can enhance human interactions. It is also helping to develop a clinical decision support system in partnership with a consortium formed by the University of Dundee, Duodecim Medical Publications and NHS Education for Scotland. The DHI is already talking about medical technology and data to potential partners and clients in other parts of the world, including North America and Asia.

Stratified Medicine Scotland (SMS-IC) is unique in its ability to take advantage of Scotland's integrated patient data system and in its capacity to connect directly into an international network focused on this revolutionary new branch of medical science. It is currently putting forward a case for UK Catapult funding, which will see it become part of a network of world-leading centres designed to transform the UK's capability for innovation in areas such as medicine, energy, satellites and transport.

The uniqueness of the Industrial Biotechnology Innovation Centre (IBioIC) lies in its technical expertise, linking the Industrial Biotechnology community and providing the tools for success. The three came together in the recent opening of the Rapid Bioprocess Prototyping Centre (RBPC) at the University of Strathclyde. This suite of state-of-the-art equipment will allow users to rapidly analyse new microbial strains for a range of bioprocesses. The RBPC will be complemented by the opening of the Flexible Downstream Bioprocessing Centre at Heriot-Watt University later this year. These facilities fill a critical gap in the ability to scale up biotech processes.

CENSIS, the Innovation Centre for Sensor and Imaging Systems has recently announced its new £6 million Mirage Project, a collaboration to produce materials integral to manufacturing a variety of goods that use sensors, ranging from asthma inhalers to infrared cameras.

The project, the first of its kind in Scotland, will see four companies and the research division of Electronics and Nanoscale Engineering at the University of Glasgow working together. Aiming to boost turnover for the businesses by a collective total of £135 million over the next ten years, as well as cut their production costs by up to 50%, the project will give them a critical competitive edge in the global sensors market. The project is expected to deliver £56 million to the Scottish economy over the next decade.

The Scottish Aquaculture Innovation Centre (SAIC) works within a tightly-knit industry where everyone gains from each other's success. The centre has addressed issues such as sea-lice control and pollution. It is also the closest example of what SFC calls a "multi-disciplinary cluster of innovation," engaging other skills from, for example, engineering, where innovation in design and construction can support the work of the aquaculture research community.

As businesses respond to the challenges of the 21st Century, the data they collect – and perhaps sometimes even take for granted – may prove to be one of their greatest assets. Led by the Data Lab Innovation Centre, the race is now on to exploit that asset in ways that give Scottish businesses and companies operating in Scotland a competitive advantage. One way the Data Lab is making experimentation and innovation possible is by analysing the big data held by companies such as ScottishPower, the industrial partner in one of the first projects to get underway at the Data Lab. The project is looking at the application of data for predictive maintenance, where there is the potential for significant economic benefit for both operators and consumers.

PROFESSOR ALBERT RODGER FREng FRSE

About SFC

The Scottish Funding Council (SFC) is helping to make Scotland the best place in the world to educate, to research and to innovate. Investing around £1.5 billion of public money into further and higher education each year, SFC provides the funding that allows Scottish colleges and universities to provide opportunities for over half a million learners. Our support for university research means that every university in Scotland is carrying out world-leading research.

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."

Scotland's Innovation Centres

Stratified Medicine Scotland Innovation Centre (SMS-IC)

CENSIS: Innovation Centre for Sensor and Imaging Systems

Digital Health & Care 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)

The oil and gas industry has gone through a volatile period since the sector's Innovation Centre (OGIC) first opened its doors. According to Professor Rodger, while there is still an important and necessary focus on extracting oil and gas from diminishing North Sea reserves and beyond, "the Innovation Centre needs to work in the context of the economic challenges facing the industry – securing long-term employment and retaining hard-won skills in the face of current job losses facing the sector." The Oil & Gas Innovation Centre also has a role to play in engaging with other industries, such as utilities, where similar skills are employed and exploring where it can adapt existing engineering or IT solutions with innovative results. He believes that, although times may be hard for oil and gas, the industry has the capacity to adapt and emerge even stronger. Therefore, when the predicted recovery comes, the industry needs to be ready. Oil and gas companies and academic researchers are also engaged with a wide range of organisations across the UK and overseas, where they are sharing expertise as well as resources.

Opening for business at a time when confidence in the industry is at a seven-year high, the Construction Scotland Innovation Centre (CSIC) has already been in touch with over 500 companies to explore their needs. CSIC also has strong international potential and is working closely with organisations such as Scottish Enterprise to exploit this to the full. It sees international advantages to many developments in low-carbon building technology, including off-site construction techniques and the development of materials for demanding environments – both areas where Scotland is already strong. Another area of interest is single-skin party wall systems, in which CSIC is a co-investor, together with Glasgow Caledonian University and Edinburgh Napier University, in a partnership with Stewart Milne Homes.

Innovating with Innovation Centres

The Innovation Centres are already beginning to realise what they set out to achieve. Above and beyond that, they are beginning to combine their forces to provide an exciting multi-disciplinary approach to problem solving and product development.

"What is really exciting is the potential for the Innovation Centres to work together on the big industrial and societal challenges facing Scotland", says Professor Rodger. "We are asking, for example, what could happen if we make a "super-link" between, say, innovators in digital health and care and innovators in big data. Therefore, from this year we have introduced the Innovation Centre Challenge Fund, making available a further £1 million for collaboration across Innovation Centres."

This Innovation Centre Challenge Fund will call for action across more than one industry sector, stimulating multiple Centres to draw collaboratively on the expertise of Scotland's world-leading universities and other stakeholders to bring innovative, industry-focused solutions to market to benefit the people and economy of Scotland.

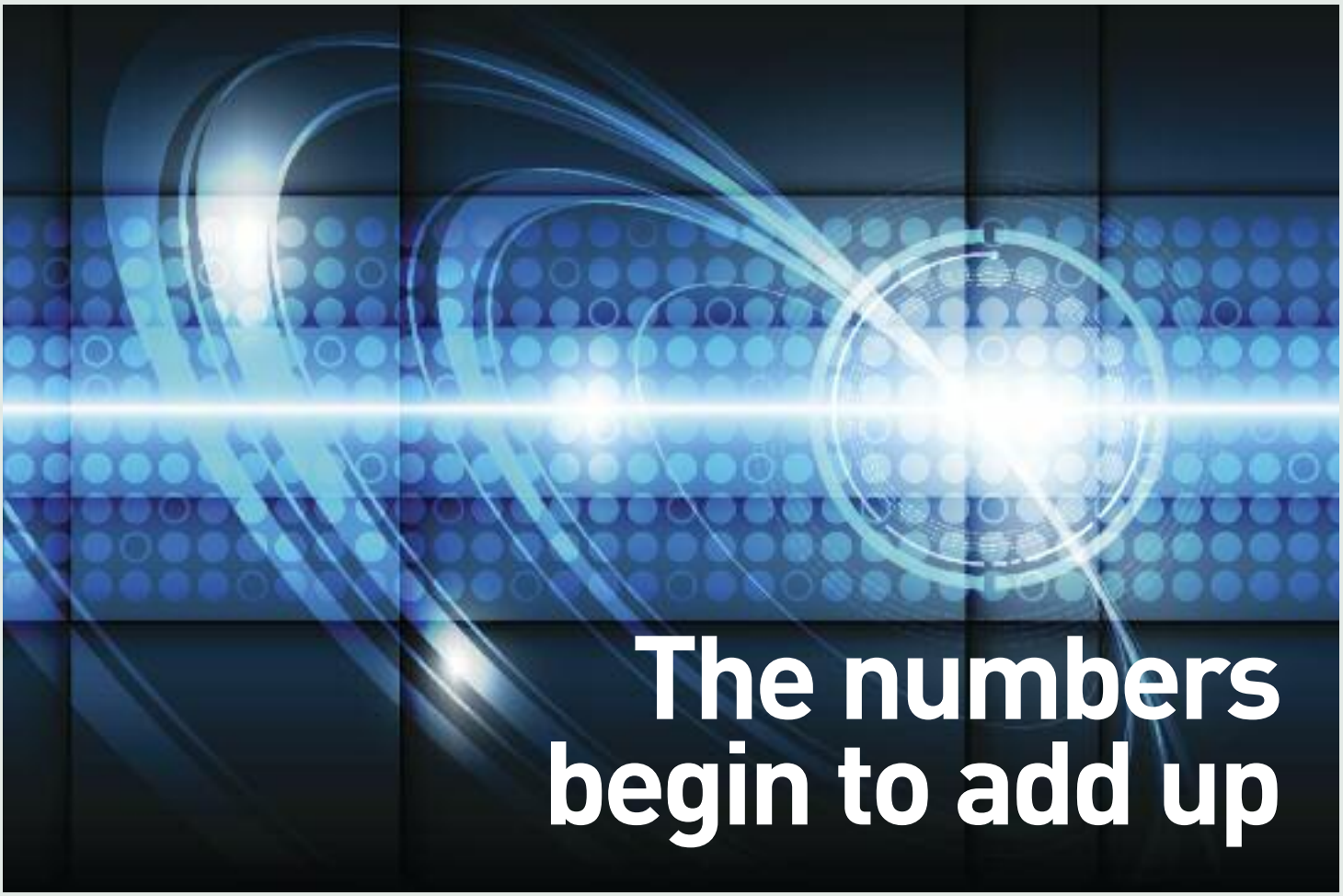
What next?

So which sectors of the Scottish economy could be the next to benefit from similar support?

According to the Scottish Funding Council, continued support for the first eight Innovation Centres, and potentially the creation of new Centres, will happen where innovation can be proven to be critical to economic growth. To assist with the next stage of development, SFC is to commission an independent review evaluating impact and progress so far.

In the meantime, there continues to be a role for the Scottish Funding Council and its partners in continuing to promote the idea of collaboration for innovation to academic researchers, business and the general public. The 2016 Year of Innovation, Architecture and Design is providing a great platform to get across the wider social impact of the Innovation Centres and their part in the Scottish Government's vision for future economic prosperity. SFC also wants to communicate Innovation Centres' potential impact on Scotland's quality of life, including health, transport, food and housing, as well as education and life-long learning.

"It's all about building belief and excitement around Scotland's ability to innovate", says Professor Rodger. "People are aware of what Scotland achieved in the Enlightenment and are really proud of the great innovators of the past such as James Young Simpson, Mary Somerville and James Watt. I'd like them to be equally proud of what we're achieving now and what we are capable of achieving in the future. Innovation Centres are part of that future and the possibilities are limitless."



The numbers begin to add up

WHERE: **Edinburgh, Aberdeen, Glasgow**

FUNDING: **£11.3 million from the Scottish Funding Council**

WEBSITE: **thedatalab.com**

The amount of data being created by users on smartphones, computers and corporate systems is increasing exponentially year after year, but our ability to make sense of this digital explosion is also improving, as data scientists help business and government use information to strategic advantage – to save resources and improve our way of life. And The Data Lab is leading the way in Scotland by taking on new challenges which call for the most innovative use of data science in everything from analysing crop yields to how children travel to school...

Data analytics is not a new science – for example, major retailers have used it for years to study customer behaviour so they can target products and promotions more effectively. The main advantage of data science today is that the hardware and software have improved so much in recent years that analysing vast amounts of data is now much more affordable and practical. "It's worth doing jobs which were simply not worth doing before," says Gillian Docherty, the CEO of The Data Lab.

Unlike data science, however, The Data Lab is something new, and is also adopting a novel approach to the science. One of the eight innovation centres recently set up in Scotland, The Data Lab is driven by industry needs and is also now headed by someone with over 20 years' experience in industry, working for computer giant IBM.

Six months after she left IBM to be part of the new innovation centre, Docherty stresses that The Data Lab only supports projects which themselves are innovative and could not be handled by commercial data science firms."If the project isn't innovative," she explains, "it will not be funded by us."

More power to Aggreko

Glasgow-based Aggreko is a leading provider of modular, mobile power and temperature control solutions to various industries, including events, mining, oil and gas, petrochemical and refining, construction and manufacturing. The company has two business units: Rental Solutions, which operates in developed markets and hires its equipment for customers to operate; and Power Solutions, which supports emerging markets by operating as a power producer – for example, by supporting a country's national grid or providing short-term power for a global sporting event or remote mining operation. In 2015, the company, which employs about 7,300 people globally, supported 55,000 customers and had 10,000 assets in the USA alone. Aggreko designs and manufactures its equipment in Dumbarton and is working with data scientists from the University of Strathclyde, using the latest machine-learning techniques and telemetry technologies, to develop a system able to predict equipment failure based on analysing historical data and comparing it with current symptoms. This technology will help its engineers proactively resolve issues, to help maintain the reliability of equipment and improve customer service.

Global Surface Intelligence

Edinburgh-based Global Surface Intelligence (GSI) has developed a powerful software solution which analyses satellite and other data to predict future conditions on the ground, so clients can make better environmental and business decisions. Working with a team of geoscientists from the University of Edinburgh, the company is studying satellite data, then taking account of the weather, to predict future crop yields – not just to help farmers but also commodity brokers, whose decisions can make or break investors.

GILLIAN DOCHERTY

"We're motoring, and collaborative projects are driving us forward. The concept is becoming reality now..."

The Data Lab has three criteria for projects:

1. It must have some commercial impact in terms of creating new jobs and driving economic value.
2. The Data Lab and its academic partners in Scotland must have the ability to execute the project, attract commercial sponsorship and provide follow-on value.
3. It must be innovative in terms of the science involved or novel in the way it is applied – for example, the technique may have already been used in the airline industry, but not in oil and gas or engineering.

One of the most difficult challenges is how to measure the impact of any given initiative, but Docherty explains that every client is asked about impact right from the start of the project and is expected to provide extra details at various stages thereafter.

The economic contribution of The Data Lab is key to its long-term success. It was set up to help Scotland "capitalise on the growing market in analytics and 'big data' technology," and its initial target was to create about 250 jobs and generate over £100 million in terms of economic value, over the first five years – for example, boosting oil recovery in the North Sea or saving millions in the healthcare sector, as well as other areas including climate change and manufacturing. The 17 projects planned so far are expected to create about 140 jobs and generate economic value of about £35.5 million; but the impact will go far beyond these headline figures – the benefits of optimising data also have a knock-on effect by freeing up more capital from savings in costs and enabling redeployment of resources. Meanwhile, The Data Lab itself has been busy creating new jobs, with staff numbers reaching 20 people this year, based in the Edinburgh headquarters and in hubs in Aberdeen and Glasgow.

"We're motoring," says Docherty, "and collaborative projects are driving us forward. The concept is becoming reality now."

Collaborative innovation

The Data Lab was designed to "transform the nature of collaboration between industry, public sector and academic partners", and collaborative innovation will continue to be central to its mission, working on projects where "the outcome is greater than the sum of the parts." For example, it is working with CENSIS and Alexander Dennis, "the world's leading supplier of double-decker buses," to investigate the wider use of vehicle sensors; to monitor air quality and engine performance, as well as live passenger movements, to reduce pollution and improve traffic management.

Another initiative, working with DHI (the Digital Health & Care Institute) and SMS-IC (the Stratified Medicine Innovation Centre) is designed to improve cancer care, while Docherty is currently in talks with CENSIS and the Scottish Aquaculture Innovation Centre to measure the environmental impact of fish farms; not just to improve productivity and prevent pollution but also to shape future government policy.

Skills and training is another priority, including online learning, summer schools, the funding of new university courses and industry placements for students. The Data Lab is sponsoring 40 students at the University of Stirling, Robert Gordon University and Dundee University. As well as paying their fees, it brings them together at regular workshops with industry partners for training and networking sessions; for example, representatives from Skyscanner and IT recruitment specialists, MBN Solutions, who talked about the opportunities in industry, and Dr Malcolm Fairweather from The Institute of Sport in Stirling, who described the role of data science in elite sports. Docherty also reveals that 60 companies have come forward to ask about employing the first wave of graduates, and the first "Data Talent Scotland" event is also underway, bringing industry partners together with up to 250 MSc students.

There are now 14 MSc degree courses in data science in Scotland, and international demand will increase. A future brain drain would be a nice problem to have, "but we want to make sure we keep all this talent in Scotland," says Docherty.

Community building is also a major activity. For example, The Data Lab recently sponsored eight Scottish companies to go on a Scottish Enterprise/SDI (Scottish Development International) mission to a data science conference in New York (Big Data and Analytics in Finance) and also visited companies including Verrisk Analytics, Dataminr and The Data Incubator. "There are fantastic opportunities for business there," says Docherty, "and three US companies have also shown interest in coming to Scotland to set up data science operations, knowing that we have the talent they need. This also helps put Scotland on the map from a data science perspective."

Community building has also led to a new partnership with Datakind, a network of volunteers who help third-sector organisations take advantage of data science. "Actionable insights" are the key assets of data science, but Datakind believes that "the same algorithms and techniques that companies use to boost profits can be leveraged by mission-driven organisations to improve the world; from battling hunger to advocating for child wellbeing and more." Datakind has already taken part in Data Lab events and the two organisations will launch a new project in 2016 to bring together leading volunteer data scientists and charities to help drive new insights for the charities.

Amiqus

The latest technology start-up from Edinburgh, supported by the RSE Enterprise Fellowship programme, Amiqus, is developing automated legal tools which use open data to help predict the outcome of claims and disputes, so legal issues can be resolved without necessarily going to court. Using natural language processing, the software tracks through case histories and court information to compare against current disputes, so all parties involved can make informed decisions over how to proceed – potentially saving significant money, time and court expenses.

The Data Explosion

Every minute:

- Facebook users share nearly 2.5 million pieces of content.
- Twitter users tweet nearly 300,000 times.
- Instagram users post nearly 220,000 new photos.
- YouTube users upload 72 hours of new video content.
- Apple users download nearly 50,000 apps.
- Email users send over 200 million messages.
- Amazon generates over $80,000 in online sales.

Star Wars

Before the latest *Star Wars* premiere, data scientists Richard Carter and Roman Popat from The Data Lab analysed the names of several hundred characters from the popular films to determine which language is the most likely source of each name.

After collecting over 500 names from Wikipedia, the data scientists used artificial intelligence and natural language processing to analyse the names, breaking them down into a sequence of character strings – e.g. "Luke" decomposes into "l", "u", "k", "e", "lu", "uk", "ke", "luk" and "uke." Using software called textcat (text categorisation), they compared the strings with dozens of languages and worked out the probability of any given name coming from any of the languages.

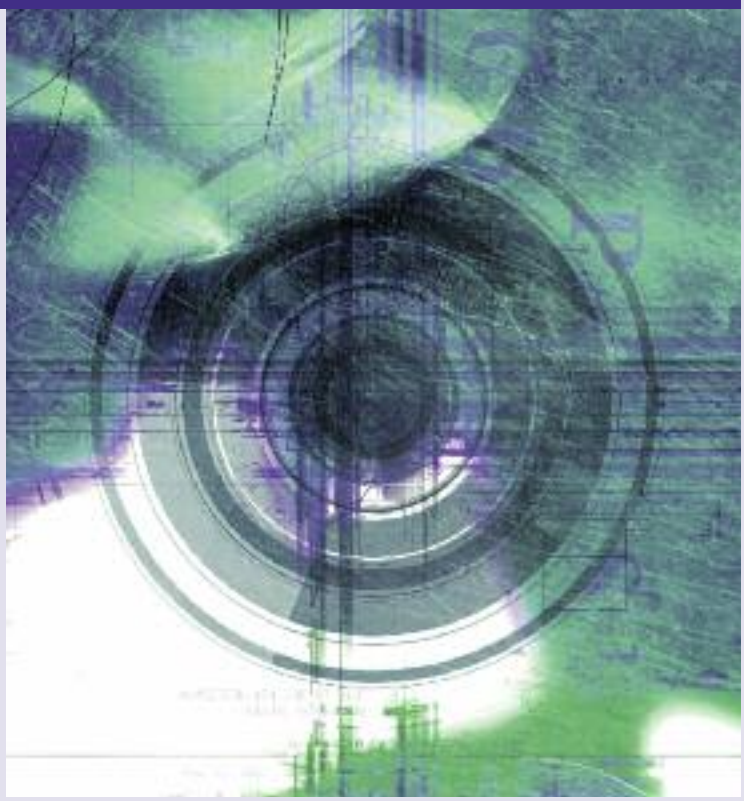
Even though the methods used are highly sophisticated, the data scientists are keen to point out that they did it for fun and that the results are not meant to be taken too seriously.

The research did throw up some interesting conclusions, however – including an apparent connection between the names of Jabba the Hutt and the rest of the Hutt "clan" with Scots.

The Rise of the Scooter

According to Roman Popat of The Data Lab, "every child's journey to school is an adventure of sorts," and one of his recent projects was to analyse how children in Scotland travel to school – and in the process demonstrate how data science can help us to understand trends in social behaviour.

Using data from the "Hands Up Scotland" survey, Popat discovered that children from different types of school tend to use a different mode of transportation. For example, more children in primary and secondary schools walk to school than children who attend independent schools. Most children at Special Educational Need schools arrive by bus or taxi, whereas driving and Park & Stride schemes are more popular in primary and independent schools. The number of children arriving by scooters, skates and bicycles is also increasing, and when Popat drilled into the details, he found that an unusually large proportion of children go to school by roller skates or scooter – in East Lothian and Midlothian, over 10% of children travel by scooter.



Industry-inspired

The key to success for all the innovation centres was to "put industry people in at the core of the organisation," and Docherty certainly fits this description. She spent 22 years with IBM in London and Scotland, returning north in 2005. Her last two years were spent as Software Leader of IBM's Scotland Enterprise Business Unit, after three years as Scotland Territory Leader. Before then, she was a technical and sales specialist, and sales manager for the Systems and Technology Group. Her experience with IBM's "client-facing team" was also a good preparation for her current job, working with clients in both public and private sectors.

At IBM, Docherty also developed her knowledge of data science – her former employer is the world's biggest provider of data analytics solutions. Among the projects handled by her team in Scotland was working with Edinburgh City Council to develop a "visual dashboard" to monitor activities in different departments and provide "a single view of the citizen" to improve services and prevent fraud. And this kind of initiative could soon be launched in every industry in Scotland.

The Data Lab has had ambitious targets from the start, and as the other innovation centres become more established, it will play an increasingly critical role at the centre of various ground-breaking projects – not just crunching numbers, but turning raw data into valuable assets, for government and business organisations in Scotland.

Did you know?

- The Centre for Economics and Business Research (CEBR) estimates that the Big Data marketplace could create 265,000 new jobs within the UK alone, generating economic benefits of over £322 billion between 2015 and 2020.
- The increased use of sensors will lead to an explosion in the volume of data – according to IBM, 2.5 quintillion (1018) bytes of data are added every day.

Aquaculture casts the net wider

WHERE: **University of Stirling**

FUNDING: **£11 million**

WHO: **A consortium of 46 businesses and 16 higher education institutes**

WEBSITE: **scottishaquaculture.com**

The aquaculture industry in Scotland generates over £1.8 billion a year for the Scottish economy and its supply chain contributes about 8,300 jobs, in locations all over the country. It is also a major exporter, second only to whisky in the food and drink sector, sending over £500 million-worth of products overseas. But this success depends on innovation in fish health and welfare, as well as improved productivity combined with more sustainable and cost-effective sourcing of feed, and this is the challenge for the Scottish Aquaculture Innovation Centre (SAIC) as it searches for partners across the university and industry spectrum – and new ideas based on everything from whisky production and treatments for cancer to broad beans and insects...

Scotland has always been known for its premium salmon, but Heather Jones believes the country will also soon be known for world-class aquaculture science and technology; as well as its premium talent and industry know-how.

Since Jones took up her job as CEO of SAIC, the organisation and its members have played a key role in a number of initiatives, including an experimental shellfish hatchery in Shetland, developing new vaccination techniques, and research into lumpfish and wrasse – the "cleaner fish" that help control sea lice. The industry-led board is also proud of the fact that for every single £1 spent by SAIC in its first 12 months of operation, it has attracted £3.60 in industry and academic funding.

HEATHER JONES

> **Physicists and statisticians, engineers, whisky producers and big pharmaceutical companies have all been keen to get involved**

By the end of 2015, SAIC had announced five major projects, worth over £9.1 million, including £2.3 million from SAIC. SAIC has also helped its partner universities win extra funding of £1.6 million from the Scottish Funding Council (SFC) to buy new equipment; for example, three liquid-chromatography-tandem-mass spectrometry systems for analysing vitamins, lipids and proteins. In addition, there are currently 20 new SAIC scholarships (at the Universities of Stirling and Dundee), with 20 more due to be added this year (with plans to add Aberdeen and Heriot-Watt).

SAIC has been busy since starting up in late 2014, but Jones says "most success is led by industry at industry speed," with SAIC smoothing the way and encouraging collaborative partnerships, rather than dictating the agenda to business.

Jones is also pleased that different people and organisations in fields with no previous links with aquaculture have turned their attention to the challenges faced by commercial producers in Scotland, and are beginning to realise the huge potential for exporting their skills and solutions all over the world. Physicists and statisticians, engineers, whisky producers and big pharmaceutical companies have all been keen to get involved, either through funding, research or providing resources. Leading supermarket chains (including Sainsbury's, M&S, Tesco and Waitrose) are also part of the consortium, partly because they have similar interests in "pre-competitive" issues such as fish health and welfare. One way they can help is funding MScs in aquaculture and marine engineering, and research in sustainable feeds, fish genetics and fish health. Feed producers also have a big role to play, including companies in other markets; for example, converting by-products from distilleries (wash is a good source of sugars and carbs) into fish feed, in partnership with drinks giant Diageo. According to Jones, there is also very promising research into broad beans and insects as possible sources of protein for fish, while algae still has huge potential. To support progress on sustainable feeds, SAIC recently launched a call for "expressions of interest" on solutions for alternative feeds for finfish. Another area where SAIC is supporting progress is the use of engineering and automations solutions in aquaculture, with companies that previously worked in oil and gas now turning their attention to fish farms, focusing on cage design, robotics and computerised feeding solutions. "It's a small number of companies compared to other industries," says Jones, "but this helps us keep tightly focused."

Companies such as Gael Force Marine, one of the largest suppliers of marine equipment and chandlery in the UK, have also been enthusiastic supporters of SAIC, because they see the value that will come from innovation in the sector as a whole – including forming partnerships with engineering companies more used to oil rigs than fish farms.

"As well as fish biology and fish farm equipment, we focus on environmental impact," says Jones, citing the example of research into seawater currents. Another example of the scope for attracting new talent and ideas to the aquaculture sector is mathematicians from the Universities of Glasgow and Strathclyde, who are more used to modelling problems in human epidemiology, who are now turning their attention to diseases in fish.

Among the other "pleasant surprises" for Jones have been several firms in the human or veterinary medical sectors who think they may have something to offer aquaculture that hasn't been thought of before. During workshops and meetings, several researchers have come forward to offer ideas, including an ingenious solution developed for testing Ebola in West Africa, called "Lab in a Suitcase." Because this innovative device was originally designed for use in areas remote from any lab, it could possibly be modified for testing fish health on fish farms.

TRAWLING THE WORLD IN SEARCH OF IDEAS...

Cancer researchers have also been talking to SAIC about how they can help in translating drug delivery technology from humans to fish. New syringes ergonomically designed for use with fish are another solution to emerge from the veterinary medical field. "We are taking new ideas from other disciplines and offering them to the people who care for the fish," says Jones, "adapting techniques first developed for humans or cattle and sheep."

"Scientists have studied human health for two millennia," Jones continues, "and animal health for about the last 500 years. The aquaculture industry has only existed for about 50 years, so we still know very little about fish biology compared with the biology of ruminants, for instance."

Attracting new ideas from other areas of science and technology is part of what Jones calls the "Connect and Collaborate" service which SAIC can deliver, bringing in investment and co-funding projects with commercial potential – researchers may be passionate about a particular strand of research, but unless it appeals to commercial producers, it will not be funded. "We ask the industry to tell us what their problems are, rather than funding research for its own sake," says Jones. "For some academic researchers, this is a big change in culture, but they soon see the benefits of what we are trying to do – they are now getting funding they may not have seen in the past. They are also beginning to see the opportunities in Scotland and beyond. In 2015 alone, we launched five projects worth over £9 million, and in our second year we will fund nine new projects. In addition, SAIC has a target to attract UK and EU funding worth £5 million by 2020.

International perspective

Jones, who has a public policy background, working for the Scottish Government in various capacities including three years as the head of Aquaculture, Freshwater Fisheries and Marine Licensing, is also excited about the international potential of the aquaculture industry – not just in terms of exports but economic development. For example, researchers from the Institute of Aquaculture at the University of Stirling are applying their know-how to aquaculture in Malawi, a country where fish protein is vital, but where over-fishing – in Lake Malawi, for instance – could be counter-balanced by farming fish instead.

Aquaculture in Scotland

The aquaculture industry in Scotland involves the farming or culturing of fish, molluscs, crustaceans and seaweed. The major product of the industry is salmon, but it also produces significant quantities of rainbow trout and mussels.

Current annual production of salmon in Scotland is about 160,000 tonnes, generating global retail sales of more than £1 billion and making Scotland the largest producer of salmon in the EU, exporting to over 50 countries.

Innovation in aquaculture could boost industry revenues and sustainability, improve food security and counter threats such as overseas competition and emerging diseases. And that was why the Scottish Aquaculture Innovation Centre (SAIC) was established in 2014, with 26 aquaculture companies and 13 research organisations driving the bid.

Where is innovation most needed?

SAIC focuses on innovative projects and research that tackle urgent industry issues, promote sustainability, or mitigate risks for producers. The current priorities are:

- improved sea lice control;
- alternative sustainable feeds for finfish;
- rapid detection methods for viral pathogens and diseases;
- development of secure health-certified Scottish mollusc spat production systems.

In her new job, Jones has also visited Tasmania to check out a new shellfish hatchery there – a vertically integrated operation that could serve as a model for the new pilot hatchery supported by SAIC at the NAFC Marine Centre set up in Scalloway, Shetland, under industry leadership through the Scottish Shellfish Marketing Group, with support from the University of the Highlands & Islands. The aim of the 30-month trial is to grow mussel spat (baby mussels) and sell them to commercial producers, then scale up the operation over time, as in Tasmania. According to SAIC, it is "a trial to test the commercial viability of a mussel hatchery in Scotland which could lead to higher productivity in the shellfish industry and support rural businesses and jobs." The project will also conduct R&D to support the development of new technologies and processes, to increase the yield of farmed mussels.

Food security is also important to Jones and SAIC, including reducing dependence on imports. Scottish salmon may be a quality product (a good source of Omega-3, Omega-6 and Omega-9 oils) and have a good reputation for welfare, but Scotland and the UK as a whole have to think about long-term domestic supplies and sustainability. Exports are important, but being close to market is a major strategic advantage. Europe imports more than 60 per cent of the fish it consumes, but Scotland is an ideal location for salmon, and could play a big role in plugging the trade gap as well as improving our health.

Future directions

SAIC has already changed many people's perspectives. Businesses have worked together and formed new partnerships with academics. Academics and students have become more aware of the industry's problems, and the opportunities this will create for researchers, including many who have never even dealt with fish before except at mealtimes. "We are brokering communications among a diverse group of people and organisations," says Jones. "We are also reaching out much wider to researchers and business in general, to stimulate new ways of thinking. Engagement with the industry is critical to our success."

Education is another key part of the SAIC strategy, funding scholarships and introducing students to potential employers at workshops and via work placements. "We're creating the next generation of industry leaders and academic researchers who appreciate what each sector can offer the other," says Jones. "We must be forward looking if we want to build a sustainable industry, based on economic, social and environmental benefits." Part of this means the creation of jobs, especially in rural and coastal communities, as well as new career paths that do not exist yet.

In its second year of operations, the work of SAIC will continue, "bringing people together, accelerating change, and drawing in new commercial and research partners, from both inside and outside the aquaculture sector."

The sector may be relatively young, but it is catching up fast, thanks to SAIC's open-minded approach. Adapting new technology developed for treating diseases such as cancer may seem like a clever idea for fish, but the question is how to commercialise any solution. And perhaps in the future, new healthcare solutions developed for fish may be used to help humans.

Building solid partnerships in building

WHERE: **Glasgow**

FUNDING: **£7.5 million initial investment**

WHO: **Scottish Funding Council, Construction Scotland, Scottish Enterprise, Highlands & Islands Enterprise and 13 universities in Scotland**

WEBSITE: **www.cs-ic.org**

The construction sector in Scotland employs over 170,000 people (about 7% of the country's total workforce) and contributes over £10 billion to the national economy (about 10% of the total). In recent years, the industry has been in recession, but there are positive signs of recovery – and the Construction Scotland Innovation Centre (CSIC) is leading the way by encouraging collaboration and innovative responses to industry needs...

The Construction Scotland Innovation Centre (CSIC) has its sights set on a spacious, vacant building across the street from its new offices in Glasgow. And if everything goes according to plan, the construction industry in Scotland will soon have an impressive new facility that could transform the way it goes about its business in future.

"We're setting up a home for industry to explore new technology that either doesn't exist in the construction space or hasn't been mainstreamed yet," says Stephen Good, the Chief Executive of CSIC.

Inside the new facility, due to open later this year, will be new high-tech devices which will seem like science fiction to some of the people who come in to use them – advanced modelling and simulation tools, automated manufacturing and robotics, augmented and Virtual Reality equipment, 3D printers and sophisticated sensor technology. Drone technology will also be part of the mix, with aerial cameras increasingly used for difficult (and sometimes dangerous) jobs such as surveying and facilities management; for example, Historic Environment Scotland uses drones to inspect its buildings for damage, rather than using scaffolding or other more costly methods.

CSIC Projects

Among the projects launched so far is one involving Stewart Milne Group to develop "the UK's first patented prefabricated timber frame party wall system," in partnership with Glasgow Caledonian University and Edinburgh Napier University. In the past, construction of the wall between adjoining properties involved three separate stages, but the new solution cuts this to a single operation, thanks to off-site construction. The CSIC contributed £100,000 to the project and helped to win additional funding of £230,000 from Innovate UK, topped up by Stewart Milne to a total of £800,000. The new system is expected to improve construction by enhancing thermal, fire and acoustic performance. It should also be easier and faster to install, and more cost-effective. And as well as having export potential, the project is expected to create 24 new jobs at Stewart Milne Group.

Working with Transport Scotland, another project aims to build new acoustic barriers for motorways, using shredded rubber tyres inside the barrier. Initial tests have proved the solution will work and the next stage will be to construct a new housing for the recycled tyres.

The Scottish Scenic Routes initiative was a challenge to develop solutions for sites in the Cairngorms National Park (the Devil's Elbow in Glenshee and Tomintoul), "to encourage more people to experience and enjoy the breathtaking landscapes." The winners will receive a prize of £5,000 and a mentoring package from a Cairngorms National Park Authority design team and the CSIC. Winning projects were scheduled for construction by the end of March, 2016. The challenge was not just about aesthetics, but also about how to use innovative materials and building processes in such remote sites.

THE SCOTTISH SCENIC ROUTES INITIATIVE: SUSTAINABILITY HIGH ON AGENDA

One of the buzzwords on everyone's lips will be BIM – building information modelling – systems, and the idea is that everyone who trains at the centre will eventually speak the same digital language, embracing new technologies which promise huge advantages to industry.

Some of the technologies will come from unexpected directions. One of the CSIC's new academic partners, Abertay University in Dundee, is better known for its focus on video games, but it will also have a serious role to play in the new facility, as more and more organisations join forces to improve the whole approach to construction; for example, in design and simulation. CSIC is also working closely with the other Innovation Centres in Scotland, including The Data Lab and CENSIS and, "given the underpinning nature of the construction industry across the breadth of Scotland's economy," has a big contribution to make in other sectors such as healthcare, oil and gas, industrial biotechnology and aquaculture, where innovative construction solutions can also be key to unlocking value through innovation.

"The key to driving innovation in any industry is collaboration," says Good, and the new Centre will provide an opportunity for everyone involved in the sector to meet, including universities and companies not even involved yet in construction. To illustrate this, Good cites the example of the Forestry Commission Scotland, which has launched its own timber development programme as part of a drive to encourage more sustainable use of home-grown timber materials in construction, as well as innovation in design, engineering and processing.

Industry training will be another big part of the Centre's activities. For example, using sensors which analyse motion (climbing ladders or lifting weights), people can be taught health and safety procedures. Other sensors could be embedded in building materials to check for structural damage or monitor air quality. Rapid prototyping will also be possible, using 3D printers and other digital CNC equipment – speeding up design and saving money. Companies will also be able to "explore the latest methods of construction" such as offsite-manufactured and modular homes, and "try before they buy" as new equipment comes on stream. Good also wants to create an environment in which industry feels more at home, takes ownership of the innovation process and has open access to the cutting-edge equipment and expertise in a familiar industry setting.

For Good, it is essential for the industry to drive what goes on at the Centre. "More than 500 businesses in Scotland have already told us their needs," he says, but there are thousands of other firms, ranging in size from a few individuals to large corporations, who could benefit from being more involved, and that is a challenge which Good and his team are determined to meet.

So far so Good

Good believes one of the biggest achievements so far has been building the team of in-house industry experts, with seven people in position already, growing to ten later this year. All of them are specialists in different areas, with complementary experience in construction innovation, economic development and start-up ventures, and they recognise the opportunities created by the CSIC. "They all buy into the vision," says Good, "and love exploring what the construction industry has the potential to do. My greatest personal reward is to see how passionate they are in their new jobs."

Another aspect of the work which gives Good satisfaction is that industry also buys in to the project. "Industry drove the creation of CSIC, so has demonstrated an appetite to see change happen," he says. "It wants to see that change deliver a more innovative, forward looking industry and our job is help de-risk the journey."

Project management is critical to future success, and the team takes a hands-on approach to the "different cultures" that exist in academia and industry. "Economic impact is also critical," he adds, "as well as international reach."

The main "surprise" for Good so far is "how readily industry has embraced innovation and the spirit of collaboration," and come together as partners. "We have some of the best emerging talent working with captains of industry," Good explains. A pool of 60–70 people is also involved in assessment of projects, through CSIC's technical advisory group. "The volunteers are happy to invest their time," says Good, "because they recognise the long-term, mutual benefits for everyone. They want to make a difference."

Getting more women involved in a traditionally male-dominated industry is another major challenge, but Good is optimistic new processes and technologies (including digital) will level the playing field as time goes by, and change outmoded perspectives: "The move from brawn to brain will literally change the face of the industry."

PREFABRICATION FOR THE 21ST CENTURY

> "The move from brawn to brain will literally change the face of the industry"

CSIC Support

Business innovation support

The CSIC helps businesses to collaborate with academia, public sector and other industry partners to seek support and training to allow them to evolve an innovative culture. It also helps businesses adopt or create innovative business models and/or processes that will capture or create new opportunities.

Product innovation support

Helping businesses to develop new construction products, components and solutions which deliver innovation to the supply chain, including prototyping or testing/certification.

Process innovation support

Assisting businesses in developing new manufacturing or assembly systems.

Service innovation support

Helping businesses to access new market opportunities locally, nationally and internationally, by developing innovative marketing models, new ways of engaging with customers or monitoring impact.

Innovation inspiration

Good clearly loves innovation, whether it is prototyping new technology or construction and production techniques, including low-carbon solutions, or applying disruptive business models to traditional sectors. Trained as an architect, he spent just under ten years at Anderson Bell & Christie, working on a variety of housing, education and healthcare projects. Good was always interested in the details, in particular the use of novel building techniques, and joined CCG (Scotland) Ltd in 2007 to develop new methods of timber off-site manufacturing solutions. CCG had used a lot of timber frame solutions in projects but had never manufactured them before; although it did have significant experience in producing its own door and window components, so had a good understanding of manufacturing processes. After visiting various European facilities to investigate how other countries produced offsite timber frames, and investing over £12 million, CCG (which employs over 600 people) set up the new off-site manufacturing (OSM) division to produce the frames in-house, as sustainably as possible, "with trees going in at one end and houses coming out the other," according to Good. One of the major projects where the frames proved a winner was the athletes' village built for the Commonwealth Games in Glasgow in 2014. "CCG wanted to do things differently," says Good, "and develop its own expertise – learning from its work with university researchers."

As well as gaining this experience with academic culture, Good also learned a lot about machinery, and new manufacturing methods, including the use of robotics. Another key advance was end-to-end integration – for example, working with the company's roofing and rendering division and setting up a new venture called the Building Futures Lab, CCG's low-energy sustainability consultancy, as well as partnering with housing associations and architects. And this was an excellent way for Good to prepare for his job at the CSIC.

During this period, Good was asked to join Construction Scotland's Industry Leadership Group as industry lead for the innovation working group that "dealt with all the innovation stuff" and ultimately coordinated an industry steering group that was successful in securing the funding for CSIC.

THE SCOTTISH SCENIC ROUTES INITIATIVE: WORLD-CLASS DESIGN IN REMOTE LOCATIONS

The challenges ahead

"We have to pick our challenges," says Good, and this means new initiatives in key areas including off-site manufacturing, advanced construction, infrastructure, energy and ICT, environment, design and performance. These "project themes" have emerged from industry-led exploratory workshops, involving everyone throughout the supply chain, as well as researchers and policy makers. Some larger companies, such as the Robertson Group, have their own research and development teams, and they join in along with smaller businesses to share ideas and experiences. "We encourage industry to be much more proactive," says Good. "We want them to identify what's needed, take advantage of emerging opportunities and work out detailed objectives, which we then support through the engagement of academic, public sector or other industry partners."

Good also wants to establish an industry "brand," with Scotland known at home and overseas for quality and world-class expertise in different sectors of construction. "We want to develop a toolbox," says Good, "that will help us break into new markets. We also want to educate the market – sometimes, it is a leap of faith to move from traditional on-site techniques to factory-manufactured solutions, for example. And that is why the Innovation Centre is needed."

Culture change is one of the most difficult challenges faced by the CSIC. "Many Scottish companies innovate every day, although often don't recognise it, and only a minority are used to working internationally," says Good. "Collaboration is also common, but they tend to work project to project; so we want to capture that collaborative spirit and scale it for the benefit of the industry as a whole. In design and construction, one solution rarely fits all, but commercial pressures often mean you can't reinvent the wheel every time a new project begins; so for example, mass customisation techniques can be useful in the most bespoke of projects – combining the efficiency benefits of mass production, whilst maintaining the individuality of a customisable solution."

Another challenge is for everyone in the construction supply chain to embrace innovative processes such as BIM, where every aspect of a project is embedded in a system in real time, so that when you change one thing, the knock-on effects are efficiently managed everywhere else. "It needs a huge amount of trust and collaboration," says Good, "but the benefits can be dramatic."

Good also mentions other transformational approaches industry is exploring, such as "post-occupancy evaluation" to improve the designed versus constructed performance of buildings, and flat-pack bricks which could save lives in areas struck by disaster by speeding up erection of shelters – innovative solutions that could soon become standard as the industry continues to evolve.

"Our need is not just to improve the skills of yesterday, but to develop the skills of tomorrow," says Good.

Making economic sense with sensors

WHERE: **Glasgow (Inovo Building)**

FUNDING: **£10 million**

WHO: **Scottish Funding Council, Scottish Enterprise, Highlands & Islands Enterprise, 12 universities in Scotland and 17 founding industry partners**

WEBSITE: **censis.org.uk**

Sensor and imaging systems contribute about £2.6 billion per year to the Scottish economy, in a global market worth over US$600 billion. There is hardly any industry that doesn't make use of these clever devices, and the technology is also becoming embedded in everyday life – not just to measure things but improve productivity and generate profits...

If innovation wasn't full of surprises, it wouldn't be called innovation. And for Ian Reid, the CEO of CENSIS, the Innovation Centre for Sensor and Imaging Systems, the biggest surprise since he came on board two years ago is not just the spectacular advances in technology and the number of projects the centre has launched but the variety of projects and companies getting involved.

In some ways, the variety is easy to explain – sensor and imaging systems are used in such a wide range of industries for all sorts of jobs – but it's hard to predict "what next?" in terms of new applications.

The questions asked by problem owners cover the spectrum. Are the strawberries getting enough to drink? Are the cows in estrus (ready to conceive)? What are the pollution levels in the centre of Glasgow today? What's happening deep in the ocean? How can we improve the efficiency of water pumps? How can we detect the source of methane emissions?

All these questions are part of a normal day's work for the people at CENSIS. "If you can measure it," says Reid, "you have the foundation for a new kind of business." And this is reflected in the range of topics covered by CENSIS, including everything from food processing and defence to civil aviation and precision agriculture.

The first wave of projects suggested the variety to come, including a collaboration between Dunfermline-based Optos and the University of Glasgow to develop new eyecare solutions, and another project to develop a sports medicine device which brought together the University of the West of Scotland with Cumbernauld-based Gas Sensing Solutions. Other projects included adapting a device originally developed to monitor the density of fluids in oil pipes for use in the production of bechamel, custard and hollandaise sauce by Macphie of Glenbervie (in partnership with Heriot-Watt University's MISEC Research Group); the use of hyperspectral imaging (HSI) in the water environment (AECOM and the UK Astronomy Technology Centre); and the development of low-cost magnetic encoders (Renishaw and Heriot-Watt University).

EVEN COWS TAKE PART IN THE LATEST SENSOR INITIATIVES...

To date, there have been about 25 projects, nearly ten of which have now been completed, with timeframes varying from only a month to about 30 months, working with large, small and medium-sized companies, from one end of the supply chain to the other. "We are happy with progress so far," says Reid, "but we want to do more projects; and bigger projects."

Recent initiatives include setting up a wireless video network in Glentress Forest for a sporting event (the Enduro World Series mountain biking competition), providing 'live' images from multiple locations, using pioneering technology developed by The Centre for White Space Communications at the University of Strathclyde. The project was organised in partnership with Scottish Enterprise, Boston Networks, Microsoft and Indigo Vision, and at the end of the event, the network was dismantled – leaving the beauty spot completely untouched.

One of the most unusual projects supported by CENSIS is the development of a new kind of sensor to monitor cows – not just their movements but, through analysing this data, also their health and wellbeing. Farmers claim to be about 60% accurate when it comes to knowing if cows are in estrus, but the new device increases this to over 90% accuracy, which can be critical, because any unnecessary delay in insemination reduces productivity. The digital collar was developed by a spin-out from the University of Strathclyde called 'The Silent Herdsman', which develops predictive analytics software for dairy and beef farmers, to "improve herd performance, business efficiency and animal welfare." The innovative collar sends the data to the farmers via smartphones, and can also be used to monitor how much the cows are chewing – another indication of health. "The 'necklace' was developed using off-the-shelf components such as motion sensors and a small computer," says Siân Williams, Business Development Manager for CENSIS, "but the magic is in the use of tools to analyse the real-time information." According to Williams, the new device also has significant export potential, with India and Latin America major targets.

Pig farmers are not forgotten by CENSIS – another project uses sensors to monitor back fat. At a certain stage of their development, the pigs start to produce more fat than lean meat and this reduces productivity and profitability.

Key Objectives

The CENSIS 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.
2. Be a beacon for economic development and wealth creation by developing a strong innovation ecosystem, combining skills and integrating communities of researchers and innovators across the supply chain.
3. Create economic impact by funding applied research to meet industry needs.
4. Stimulate a more entrepreneurial and innovation-driven culture amongst the research and industrial base.

CENSIS: Major themes

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

IAN REID

> **"We are not experts in every industry, but we do have the core skills and know the right people to speak to, to translate a business problem into a research agenda."**

Economic value

No matter what initiatives are funded, however, the golden rule is economic value, says Reid. "Creating economic value may be a black art in some ways," but the ultimate objective is to change the culture – how universities and business work together, "bridging the gap between concepts and commercial solutions."

The aim is also to encourage Scottish companies to "dip their toes in the water," says Reid, "and explore the possibilities of sensor and imaging systems." CENSIS also helps potential partners access funds from UK sources and beyond. "We are not experts in every industry," Reid says, "but we do have the core skills and know the right people to speak to, to translate a business problem into a research agenda."

Reid also sees the challenges ahead: "We have lots of problem owners and lots of great technology, but our job is to build the supply chain so the partners involved can make money."

More surprises

According to Reid, a lot of the work done by CENSIS also involves "what-ifs" – if a company could measure a particular quantity, could that lead to a useful solution? Even if it does not solve the problem entirely, the company may learn a lot along the way. For example, Scottish Water came to CENSIS seeking to improve the efficiency of its thousands of pumping stations by using data to predict the failure rate and thus reduce planned outages. In the end, the project (working with the University of Strathclyde) did not turn out as expected. Even though it was able to monitor current performance and had accumulated a lot of historical data on previous failures, it turned out to be very hard to predict future failures. But thanks to the project, Scottish Water was able to analyse real-time performance and change the way it operates its network of pumps and thus reduce its power consumption – a major achievement in view of the fact that Scottish Water is Scotland's biggest electricity consumer. The project also underlined how hard it is to predict equipment failures: "You really need to design data collection systems with the end application in mind," Reid explains.

Another big "surprise" for Reid is how much CENSIS teams up with the other Innovation Centres: "Two years ago, if you had showed me a list of the Centres and asked me which ones we would work with, I could not have predicted what has happened." The Data Lab and the Digital Health & Care Institute are natural partners, but CENSIS has been working very closely with the Scottish Aquaculture Innovation Centre, as well as Oil & Gas and Construction, and sees tremendous opportunities with all of them, "opening hearts and minds to the greater efficiencies" sensor and imaging systems can bring, especially in areas such as building management or decommissioning oil rigs.

Environmental monitoring has huge potential for CENSIS, including a pilot study being conducted in Glasgow in conjunction with the Institute for Future Cities at the University of Strathclyde, to monitor particulates, using four or five mobile detectors. "This is an area where Scotland has a lot of potential," says Reid, not just in urban management and the "Smart City" agenda, but also in rural management, including measuring levels of gas emissions from peat bogs.

DOLPHINS LEAD THE WAY BY INSPIRING NEW SENSOR SOLUTIONS

Business Development Director Mark Begbie is taking a very close interest in the mobile air quality project, which he believes will demonstrate the value of the system and its capabilities, with vans on the move taking samples at different locations and modelling data in real time to see pollution levels at a glance. "The benefits could be enormous," says Begbie, "especially for vehicle makers, urban authorities and transport service providers." Begbie also thinks the new technology will soon be integrated into public transport: "Buses can be seen as mobile points of connectivity, not only monitoring air quality and helping buses operate in zero emission mode, but also helping to analyse passenger movements and traffic."

Begbie also highlights a solution now being developed to monitor methane emissions at landfill sites, using special lasers to detect "fugitive emissions," combining this with wind-speed data and "data inversion maths" to model the area in three dimensions and pinpoint the source of the leak. Similar technologies can also be used for security systems, as stand-off detectors for explosive materials such as hydrogen peroxide, or at test sites for shale oil extraction.

Precision agriculture is another hot topic, using data gathered from sensors (e.g., hyperspectral imaging) to optimise land use and yields, with satellites or special drones providing the images. CENSIS will also be involved in a new "Agri-EPI Centre," in partnership with Innovate UK.

The Internet of Things

For CENSIS, the Internet of Things (IoT) will be an area which sees a lot of action in the future, and it was recently selected as one of the four local partners to deliver IoTUK Boost, a series of challenges "to advance the take-up of IoT in the UK and find real solutions to business challenges," focusing on smart cities and the environment, in collaboration with The Data Lab and the University of Edinburgh's Informatics Ventures.

Eighteen companies were invited to attend a two-day workshop and respond to a call for ideas. The workshop helped them mature their ideas and develop business plans, and five were selected to receive mentoring support as they bid to commercialise their product ideas. "This project will put Scotland and CENSIS on the map," says Reid, "as a source of expertise in IoT."

The technology

Sensor and imaging systems (SIS) are becoming increasingly intelligent in terms of how they detect things (changes in heat or light, vibration, density, pressure of gases, etc.) and communicate with other devices. Some sensors produce raw data, some pre-processed information, while others operate in unison across a distributed system. The ultimate challenge is to turn the data into useful information, to improve the design or performance of systems and projects. Applications include environmental safety and security.

Inspired by dolphins

New sensor technology inspired by bottlenose dolphins could help improve subsea detection capabilities, thanks to a new collaborative research project launched by Heriot-Watt University's Ocean Systems Laboratory and underwater systems company, Hydrason Solutions. With support from CENSIS worth £40,000, the researchers will develop an enhanced wideband sonar system using signal processing techniques gleaned from previous research on dolphins.
The new technology will be deployed on underwater vehicles, enabling users to locate underwater objects more accurately, as well as probing their structure and composition, without direct contact – for example, to find blockages in pipelines, check for structural defects, detect explosives or discriminate between man-made objects and wildlife.

Global ambitions

CENSIS recently announced a "ground-breaking new collaborative research and development (R&D) project" which is expected to create more than 40 new highly skilled research and manufacturing jobs and generate more than £50 million for the Scottish economy over the next ten years – winning Scottish companies a significant slice of the fast-growing market for sensor and imaging systems.

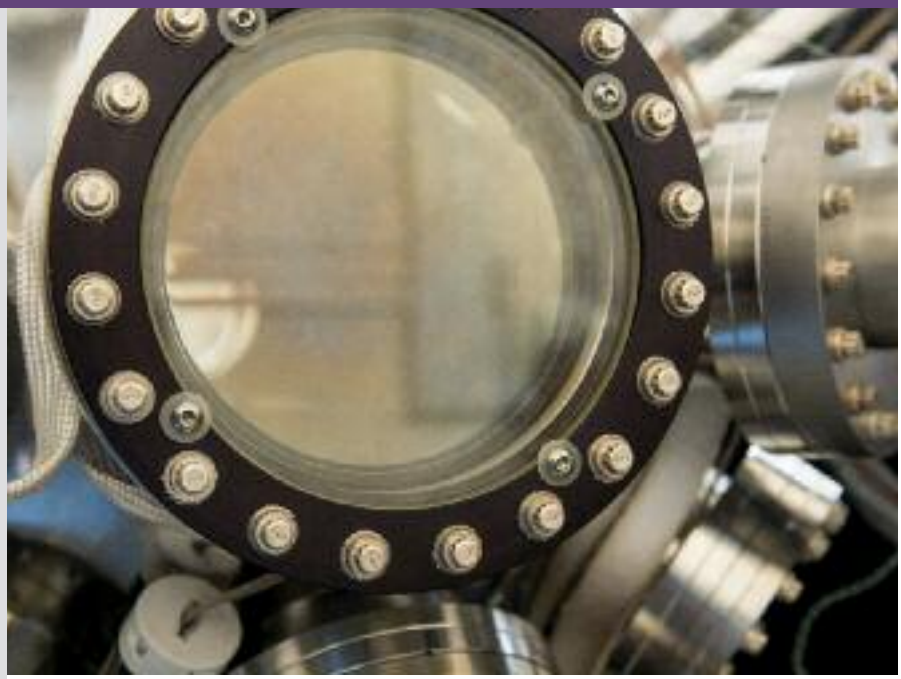
The Mirage Project is the first initiative of its kind backed by Scottish Enterprise and CENSIS, and will bring together several university and business partners, including Cascade Technologies, Compound Semiconductor Technologies Global, Gas Sensing Solutions and Amethyst Research, and the Research Division of Electronics and Nanoscale Engineering at the University of Glasgow.

The project will provide a new platform to develop and manufacture new cutting-edge mid-infrared (mid-IR) sensors for multiple markets, via access to III-V semiconductors, for applications such as environmental monitoring, medical diagnostics, military communications and security systems, and collaborate on making a range of new products that incorporate sensors, from asthma inhalers to infrared cameras.

The collaboration is expected to boost turnover for the businesses by £135 million over the next ten years, and cut production costs by up to 50%, giving them a critical competitive edge in a key segment of the global sensors market, expected to be worth over $150 billion by the year 2020. The participating companies will provide £2.8 million of the funding, matched by £2.6 million from Scottish Enterprise and £241,000 plus capital equipment from CENSIS.

Ian Reid, Chief Executive of CENSIS, said: "This project is a game-changer for collaborative R&D. Not only will it underpin the development of Scotland's sensor and imaging sector, but it will also provide the academic community with access to cutting-edge technology, allowing further innovation and collaboration. The organisations involved will be at the forefront of global trends and in a unique position to access new markets, ultimately creating a globally-competitive supply chain of businesses."

Deputy First Minister John Swinney said: "This project is an excellent example of how collaborative working can support the development of advanced manufacturing technologies, boosting productivity and driving growth. Innovation Centres have a unique role to play in engaging with businesses to identify new solutions and we would like to see more of these types of projects develop in the future."



In tune with this initiative, CENSIS recently opened the Connected Devices Development Centre (CDDC), a new in-house facility to "help SMEs overcome many of the challenges they face in product development and allow them to fast-track the development of IoT products and services," developing product ideas from concept to prototype and commercialisation, with help from technology vendors and academic researchers. The CDDC will also "provide a complete ecosystem of hardware tools, connectivity, cloud storage, data analysis and visualisation and mobile application development." Reid describes the idea as "applying the IoT paradigm to CENSIS."

Reid also says the new facility will help reduce the time and cost of building new products and "de-risk" research, enabling companies to focus on the value add. "Companies can spend a lot of their budget reinventing the wheel," he explains, "but the CDDC helps avoid that by providing access to lots of off-the-shelf components." In one recent case, a company developed a prototype at the CDDC and won a new contract simply by demonstrating what it had built, without further refinement. Several leading vendors are providing the hardware and, according to Reid, they also end up as winners because developers get used to using their equipment and the same industry standards. One vendor also said the company "couldn't be expert in all fields," and took a big interest in "working with the ecosystem" to see its products in action.

In the world of sensor and imaging systems, animal or human behaviour can be treated much the same as the "behaviour" of man-made devices – for example, predicting the failure of a wind turbine based on analysing "vibration events" is not so very different from predicting the heating or lighting requirements of buildings, based on analysing levels of carbon dioxide, or when to inseminate cows, based on their levels of hormones. Sensor and imaging systems are transformative technologies, changing how we live and work as well as helping manage the environment. It is only a matter of time before these intelligent systems are playing an even more critical role in our everyday lives, and organisations such as CENSIS will be making it happen, in partnership with industry and Scotland's research base.

Translating promise into profits

WHERE: **Glasgow (Inovo Building)**

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

WHO: **14 Scottish universities and 46 industry members**

WEBSITE: **ibioic.com**

Industrial biotechnology is not yet part of everyday vocabulary, but it promises to transform our everyday life and become a huge part of the global economy, changing the way we produce many chemicals and pharmaceuticals, fuels and manufacturing materials. It also promises to play a major role in what is called the "circular economy," helping to extract the maximum value from all our resources, including waste, industrial by-products, feedstocks and timber. And the Industrial Biotechnology Innovation Centre (IBioIC) is aiming to put Scotland on the map as a leader in this revolutionary science – and make the Scottish industry a billion-pound business within the next ten years.

Recent advances in science such as genomics and synthetic biology are starting to rewrite the rules of industry, including new techniques for manufacturing and processing, waste management and energy. And Roger Kilburn, the CEO of the Industrial Biotechnology Innovation Centre (IBioIC), thinks that Scotland has the potential to play a major role in this emerging global business, because it has the companies, researchers and resources, as well as the infrastructure needed to support it. Translating that potential into economic impact will not be easy, but the process has already begun.

In many ways, the IBioIC has achieved more than expected since it started operating in early 2014, getting several major projects off the ground and steadily building its membership base (companies pay up to £50,000 per year to join). It has also revised its projections since then, seeing greater opportunities in terms of market growth but also expecting the growth to be slower.

According to Kilburn, Scotland scores highly in many key aspects of industrial biotechnology:

1. availability of feedstocks, raw materials and industrial by-products;
2. a world-class life sciences and pharmaceuticals industry, and world-class research base;
3. a strong petrochemical industry, including large refinery and chemical processing facilities;
4. marine resources (including aquaculture) and a strong renewables sector;
5. a supportive regulatory environment – clear, understandable and ethical;
6. good utilities and infrastructure;
7. a growing specialist skills base.

This combination of natural resources, industrial experience and scientific expertise puts Scotland in an excellent position to be a major force in industrial biotechnology, but Kilburn recognises there are still major challenges lying ahead; which the IBioIC is meeting head-on.

Progress so far

Several industrial biotechnology projects have recently been launched in Scotland, including innovative work by Celtic Renewables and Horizon Proteins (a spin-out from the Heriot-Watt University), using by-products from distilleries to create new biofuels and feedstuffs for fish farms; and Scotland's first biorefinery, set up by CelluComp in Fife, producing new materials for paints and coatings, paper and packaging and personal care products from vegetable waste such as carrots and beets.

One of the biggest successes so far for the IBioIC is a project led by GlycoMar, a biotechnology company based in Oban. In partnership with Norway's MicroA, GlycoMar has set up a new joint venture called Prasinotech to produce high-value polysaccharides from microalgae, for use in skincare cosmetics. This will involve industrial-scale cultivation and processing of the patented polysaccharides, taking advantage of MicroA's photobioreactor technology. Full-scale production is expected to begin within a year.

The project was one of the first to emerge from a competition organised by the IBioIC soon after it was set up in January 2014. It was also completed within 12 months, in collaboration with researchers at the Scottish Association for Marine Science (University of the Highlands and Islands), the University of Edinburgh and the University of Strathclyde, and was jointly funded by the IBioIC, Innovate UK and Innovation Norway.

For Kilburn and his team, the project was a "leap of faith" in many ways, because it is so hard to tell if any project will be a commercial success. Successful candidates usually know from the start which academic researchers they want as their partners, however, and Kilburn explains that the idea is to get the universities to see things from an industry perspective. "Companies ask for nothing that won't create value," he says, and sometimes they are seeking innovation in areas new to researchers. Another key role played by the IBioIC is to help draw up the contract between all the partners, making sure

ROGER KILBURN

the process is open, transparent and fair. Good governance is critical, says Kilburn.

Other highlights include a project by Ingenza to "make biotechnological protein expression more predictable through the proactive management of cellular translation;" and another project, also by Ingenza, to use engineered bacteria "for the scalable biosynthesis of products traditionally made from petrochemical-starting materials." Another global leader, GSK, is using synthetic biology principles to develop a new biochemical route to an important starting material for manufacturing of antibiotics.

Competitive competitions

The competitions run by IBioIC are open to its members and partner universities, inviting them to apply for funding to help projects get closer to commercialisation. According to Kilburn, some smaller companies may have lost out in the first round of some competitions but still have commercial potential, so the IBioIC has set up a new competition for micro-companies (turnover of less than £1 million a year and less than ten employees) – one of three scheduled each year.

After projects are selected, the next stage is to satisfy the technical advisory board, then the commercial advisory board, who assess every project according to a pre-set template (for example – is it new, is there a market, can the product be delivered fast enough?), but there is no guarantee any project will be a success. Initially, the target was to demonstrate commercial benefit within 12 months, but Kilburn says this will be relaxed in the future to enable a greater number of projects to become eligible; although "quick wins" that prove impact early will always be welcome.

> **The 20th Century saw the industrialisation of chemistry, and the 21st Century will see the industrialisation of biology**

Different timescales

The IBioIC deals with a wide range of organisations, from micro-companies to global corporations, but it takes the same approach to every project, large or small. The multinationals may have more demands on their time, and handle much more complex long-term projects, but they are not necessarily better or different in terms of big ideas or attention to detail. The big difference is the financial commitment – it takes a lot of money to build a new plant, designed to operate for several decades.

The industry timescale will always be one of the challenges faced by new projects, no matter how big or how small. The IBioIC tries to steer Scottish companies through what is known as the "valley of death"; after proof of concept, the difficult and expensive stage is to prove that the process will work and scale up to commercial requirements. For example, GlycoMar knew early on that the new microalgae had enormous potential, but did not know if it made economic sense until they had tested the process on a much bigger scale. Kilburn says that the GlycoMar project was started and completed very quickly, but points out that some major industry projects can take many years. His former company, ICI (now Lucite), spent 12 years developing new ways to make Perspex monomer, using chemicals including hydrogen cyanide, and is now exploring the "biological route" to production. It may take two years to develop the basic manufacturing process, says Kilburn, but another eight years to perfect, including the construction of a pilot plant. "Large-scale innovation develops very slowly," he adds, citing the example of the Forestry Commission, which has to think ahead for several decades. Big projects also require more attention to optimisation; extracting as much value as possible by improving every aspect of production.

Economic impact?

Kilburn is a great enthusiast for industrial biotechnology: "The 20th Century saw the industrialisation of chemistry," he says, "and the 21st Century will see the industrialisation of biology." But even though industrial biotechnology may be the next revolution in science and technology, Kilburn is cautious about estimating the economic impact of the industry – or the long-term economic impact of the IBioIC. "We revised our five-year plan," he says, "one year after setting up the centre. We think it represents a bigger opportunity than we first described, in terms of overall activity, but economic impact is still hard to measure. We are focused on activities and outcomes, and believe we are beginning to gather momentum, but our methods have not changed, despite the fact the industry is growing even quicker than expected. It was worth about £230 million last year, compared to earlier predictions of £200 million, so we are well on track to reach £400 million by 2020, and we are targeting £1 billion in another five years."

Kilburn also says that the IBioIC has not spent as much of its budget as planned. "It's a slow-burning fuse," he explains. "Many projects require significant high-risk investments, and this requires caution and long-term perspective."

On the other hand, says Kilburn, the cumulative benefits could be enormous: "Success breeds success – if a project works, it tends to grow and lead to additional projects."

The expanding supply chain

There may not be thousands of companies in Scotland queuing up to get involved in industrial biotechnology, but Kilburn believes there are many companies who should be part of the supply chain but just don't know it yet. Some people may think the sector is part of the chemical space, but agricultural companies, primary food producers, utilities and waste management companies should also be checking out what they can do. For example, several local authorities use waste to generate power and could manufacture higher-value chemicals from the same materials. The paper industry may have declined, but trees still have significant value in many other new applications and could ultimately replace our requirement for fossil fuels to manufacture chemicals.

"If we want to build a £1 billion industry by 2025, we will need big investors," says Kilburn, "but we also need a lot of smaller companies, including micro-companies."

Key Objectives

The IBioIC has 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.

The vision

Supported by Scottish Enterprise (SE) and Highlands & Islands Enterprise (HIE), the new Industrial Biotechnology Innovation Centre was set up to "harness the combined intellectual horsepower of Scotland's higher education institutes and create a single portal for industry." 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."

Culture change

Like so many other innovation sectors, industrial biotechnology calls for a culture change, not just in business or academia but also the general mindset. The chemical companies see the potential of industrial biotechnology, and more and more people are beginning to recognise the value of the circular economy, but everyone will have to be prepared for a long-term commitment; especially because it is so hard to forecast the future. For example, says Kilburn, the original reasons for setting up the petrochemical complex at Grangemouth are no longer valid today. Ninety years ago, West Lothian shale oil was processed at Grangemouth and exported by ship. Later, it became a port for importing oil – until the tankers grew too big to navigate the Forth. Then it became the end of the pipeline from the oil fields in the North Sea. And soon it could become the hub of Scotland's industrial biotechnology sector; and go on for another 90 years in its new incarnation.

"That's the power of the chemical industry," says Kilburn. "The feedstock (e.g. oil) may change, but not the location."

The success of Grangemouth could also have a knock-on effect, as one new development follows another, but Kilburn also believes other sites will be set up all over the country, close to sources of materials such as timber, biomass and waste.

At the same time as promoting the sector in Scotland, Kilburn is aware that the general public will take time to appreciate its value, in economic terms and social impact, as well as in healthcare. "To some extent we operate under the radar," says Kilburn. "As time goes by, industrial biotechnology will be subsumed into the circular economy, as one of the clever technologies making it work."

Future challenges

Although the IBioIC focuses on Scotland, it also has its sights set overseas, and works with Scottish Development International (SDI) to promote the industry here and encourage inward investment. Kilburn strongly believes that Scotland offers an ideal location for industrial biotechnology ventures, but also thinks "we should be better at making that compelling case" to decision makers in other countries. To support this effort, the IBioIC will commission feasibility studies for feedstocks, says Kilburn. "We know they are available in volume and we know what they are," he explains, "but we need to establish how competitive they are."

Fiscal measures such as incentives (e.g., tax breaks) could be a major attraction to inward investment, but Scotland faces the same challenges as other countries in Europe. It is hard to compete with countries outside Europe which offer an 80% guarantee on loans up to $250 million, says Kilburn, "so we need to work harder to optimise investment opportunities."

The big question for multinationals thinking of setting up operations in Scotland is "how much do they want to be here?" says Kilburn. "We have plenty of suitable sites and resources, but this is a highly competitive and global business, so we have to do more."

Another future target is to open the second industrial biotechnology equipment centre at Heriot-Watt, to facilitate the scale-up of processes for biotechnological production. The first equipment centre, based in Strathclyde, is for rapid screening of new microbes; it is easier to generate new bugs than test their effectiveness. The "plug and play" approach enables companies to use the equipment they need, so they can make better use of their funds.

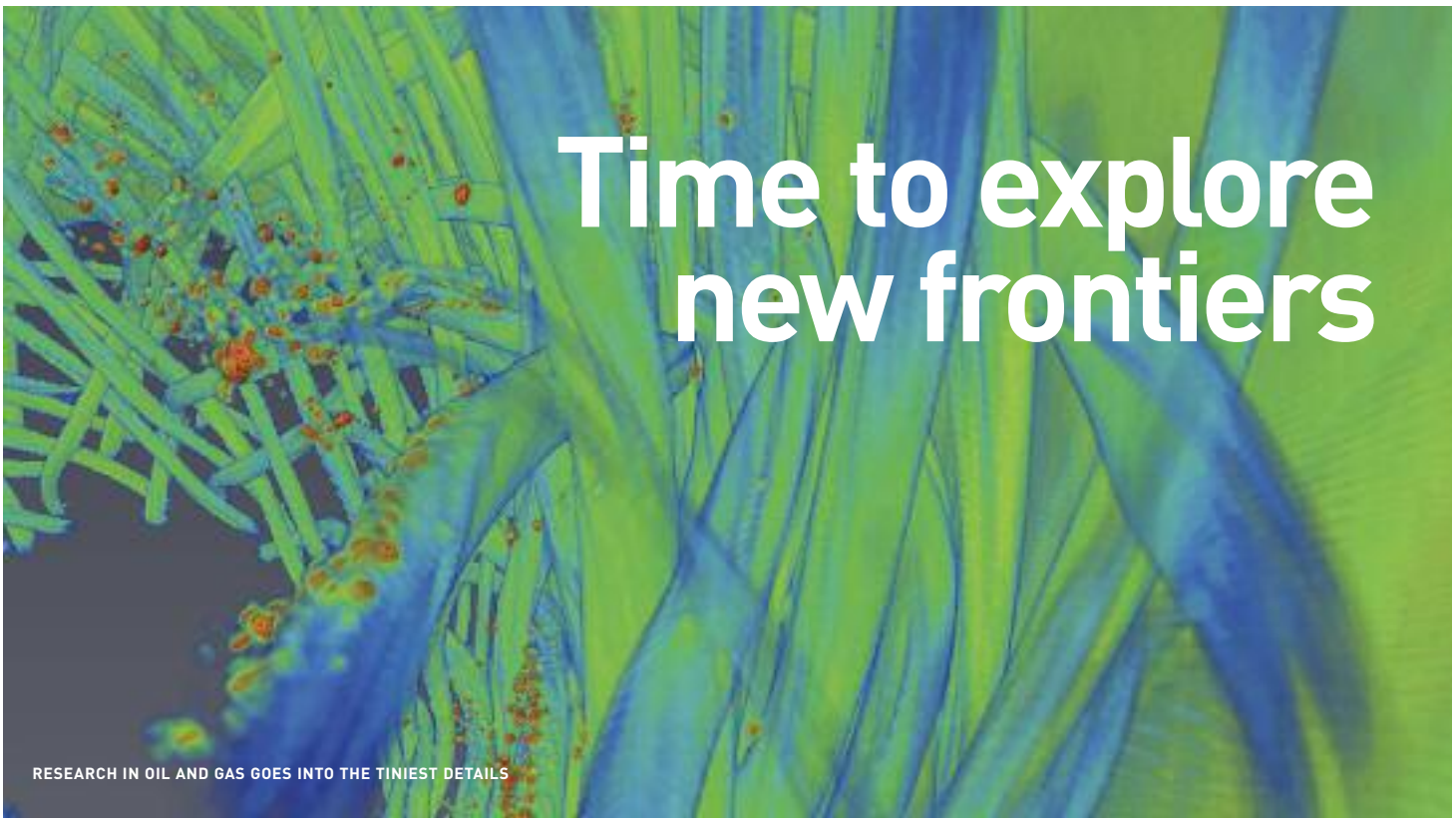
In terms of specific research, Kilburn hopes there will be breakthroughs in studies of lignin, a complex polymer which provides the structure in wood and many plants. It's easy to burn wood, or convert the cellulose to sugars, but to find a high-value use for lignin is the "Holy Grail" of biotechnology.

New skills supply chain

Facilitating innovative projects and promoting the industry at home and abroad will continue to be priorities at the IBioIC, but Kilburn and his team think their biggest contribution so far is to boost education in their specialist subject, including setting up an MSc in Industrial Biotechnology and funding PhDs – a total of 19 over the last two years. An HND programme will start in August. The MSc students must spend three months of their time in an industry placement and, as a result, two-thirds of the first group of 17 graduates had jobs before they had finished their courses, with companies including GSK and Ingenza.

"We need new skills," says Kilburn, "and we set up the Collaborative MSc programme in less than eight months." Some skills required are generic but some are very new; for example, knowing how to design a new bioprocessing plant.

About 90% of all the chemicals we use today are based on petrochemical derivatives, but as industrial biotechnology gathers momentum, these building blocks will be replaced by "fermentation equivalents," according to Kilburn. If Scotland continues to turn out a new generation of industrial biotechnologists, some of those new products could become as celebrated as the country's other fermentation favourite, whisky. And Kilburn would be first to toast that success.



Time to explore new frontiers

RESEARCH IN OIL AND GAS GOES INTO THE TINIEST DETAILS

WHERE: **Aberdeen Innovation Park**

FUNDING: **£10.6 million**

WEBSITE: **ogic.co.uk**

The oil and gas sector has taken a big hit over the last two years, but companies in Scotland continue to pump out a stream of new products and innovative solutions, with the Oil & Gas Innovation Centre (OGIC) in Aberdeen playing an important role by getting businesses together with researchers – not just to help the search for new deposits but explore new ideas...

Since OGIC was officially launched in November 2014, the price of oil has dropped from over $100 per barrel to about $30 per barrel, and the UK oil sector has lost over 15% of its jobs (down from about 440,000 to 370,000). Faced with such a dramatic decline in its fortunes, most other industries would probably panic, but the oil and gas sector is different – the current "crisis" is widely regarded not only as part of an industry cycle but also as a good opportunity for many companies in the supply chain to be more innovative and inventive.

After 30 years in the industry, Ian Phillips, CEO of OGIC, has "seen it all before", but he also sees what's happening under the surface. It may take time for prices to recover, and many fields may now be unproductive or hard to exploit, but the current situation of over-supply may quickly become one of under-supply. "OGIC was conceived and launched before the drop in prices, but people are keener than ever to do innovation," says Phillips.

The recent economic conditions have had an effect on the sector, says Phillips, but this has not stopped innovation – it has simply changed the timescale and the level of funding required. "We expected to launch about 12 projects in our first year," says Phillips, "with a maximum OGIC contribution of about £150,000 per project. We met our target for number of projects, with average funding of about £35,000 per project. Many of these first projects are likely to develop into a further phase, so already we are seeing repeat business. What has impressed me is the number of companies with innovative ideas who are close to commercialisation – in some cases 12 months from market – that we can help by putting them together with researchers, to get over the finishing line." Most projects so far have also involved only one SME and one university partner, with OGIC providing about half of the funds, and the business partner matching this investment.

With 14 projects funded by early 2016 and about 20 more in the pipeline, the level of activity is starting to gather momentum, and some much bigger projects are being discussed. The vast majority of companies that OGIC can help are small and medium-sized companies in the supply chain who are closer to market and want quick returns on investment. The organisation is also in talks with some big corporations, including several companies in Scotland, but results will be slower to come.

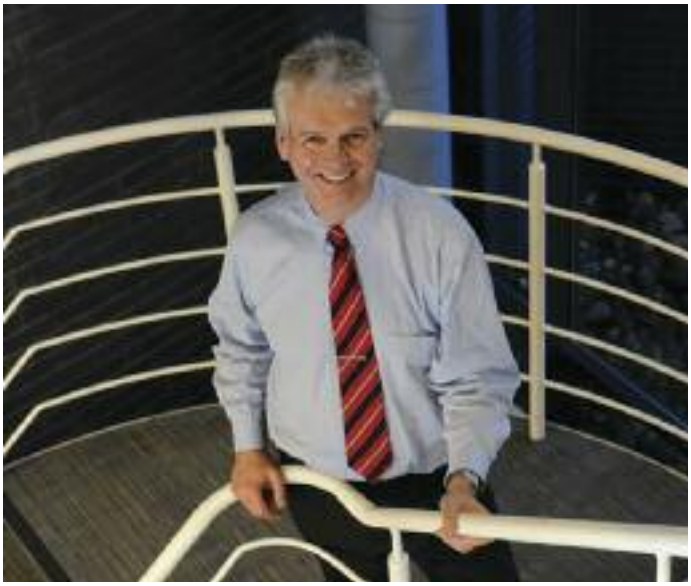
What OGIC has focused on since the beginning is "knocking on doors" – and keeping its door open to Scottish firms, organising workshops and other events. In its first year, more than 100 individual technology businesses approached it for support, and OGIC itself has spoken to 750 companies all over Scotland and beyond. The innovation centre sees itself as "a vital bridge between energy businesses with ideas that address pressing industry needs, and the world-class research capabilities in Scotland's universities," and the list of projects is beginning to prove that the formula works.

The project pipeline

The projects so far have been relatively modest in terms of the funding required, but the long-term gains could be enormous – and the technology involved is cutting edge. For example, US-based company Blueshift approached OGIC with a product originally developed for another industry which it believed could play a major role in oil and gas. Phillips says that many problems faced by oil and gas are "the same problems with different labels" faced by other industries, and Blueshift's AeroZero is an excellent example – a polyimide aerogel "500 times stronger than conventional silica aerogels", designed to improve insulation for deep-sea pipe-in-pipe oil and gas pipelines by reducing installation costs, improving pipeline compression resistance, reducing the amount of steel in pipeline constructions and, consequently, increasing oil and gas flow and assurance.

For the initial project, the Strathclyde researchers set up a multi-disciplinary team of specialists in composites design, composites engineering and materials science to focus on design and carry the project through proof of concept, processing improvements and material modification. Blueshift needed fast results and Strathclyde delivered. "This was Blueshift's first experience working with a Scottish University, and the team demonstrated an exemplary level of technical expertise," said Dr Garret Poe, Executive VP of Blueshift.

Another major project supported by OGIC is a new drive to reduce costs in the North Sea, expected to unlock up to £1 billion in additional revenue through improved production efficiency and cost savings. The Technology Leadership Board (TLB) has identified Asset Integrity as a technology theme, and is specifically looking to target advances in process vessel inspection and managing corrosion under insulation (CUI).



IAN PHILLIPS

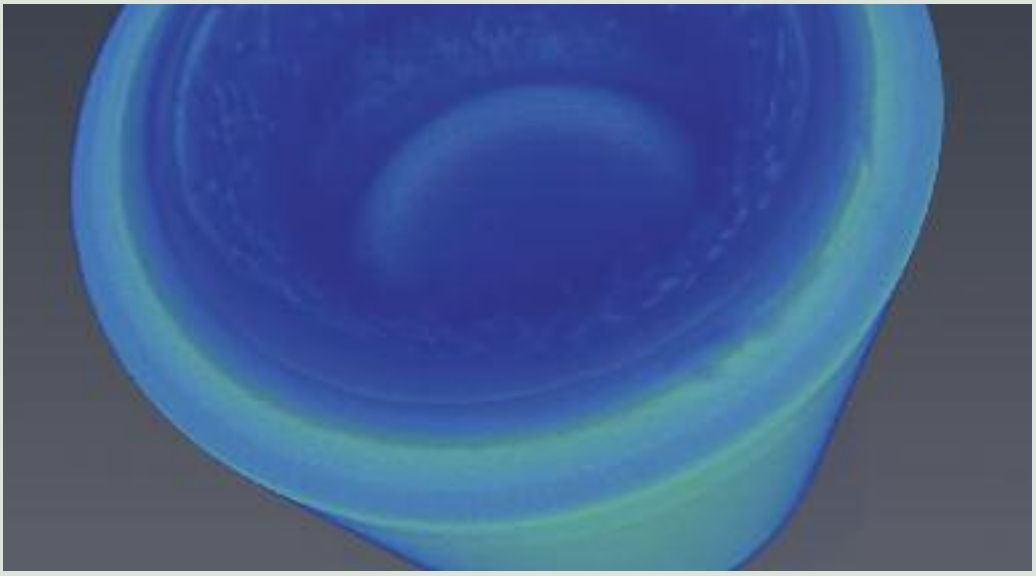
The project involves the TLB working in partnership with its industry champions, Total E&P UK and Amec Foster Wheeler, Oil & Gas UK, Oil & Gas Authority, Oil & Gas Innovation Centre (OGIC) and Industry Technology Facilitator (ITF).

Phase One has mapped out the existing technologies and identified potentially relevant technologies and processes not currently used offshore. In Phase Two, proposals will emerge for carrying out key asset integrity work – using technologies from other industries.

"This project directly responds to the maximising economic recovery agenda for the UKCS (UK Continental Shelf)," says Phillips. "All of those involved are focused on delivering technologies and processes which change the way industry deals with process vessel inspection and CUI, in order to reduce costs and unlock additional revenues that are currently lost through suboptimal activities offshore."

The asset integrity project has huge implications, and even though OGIC is providing expertise and organising workshops rather than direct financial support, the project is more evidence of OGIC's highly focused capabilities.

Another project underlines the multi-disciplinary nature of modern research, with Glasgow University teaming up with Badger Explorer to help develop a solution for reducing the cost of evaluating subsea hydrocarbon deposits. The Badger Explorer technology is a rig-less formation and reservoir evaluation tool which drills down to the target reservoir, compacting and ejecting the drill spoil at the back end of the device using an ultrasonic compactor, using sensors to continuously record data and provide long-term monitoring of the formation. The team in Glasgow will help with testing and further research into a key component within this "game-changing" product, to develop a solution which reduces the risks, costs and complexity compared to conventional drilling rigs.



NEW HOSE DESIGNS TAKE ADVANTAGE OF THE LATEST TECHNOLOGIES

"The fact that the R&D capabilities required for this element of the project are within the University of Glasgow is testament to the enormous oil- and gas-related expertise that we have as a country, which OGIC aims to harness in support of the energy sector's future," says Phillips.

When the project was announced, Professor Margaret Lucas, who leads the ultrasonics group in the School of Engineering at the University of Glasgow, said: "Working with Badger Explorer demonstrates the industrial demand for our skills, taking our high-power ultrasonics research into oil and gas exploration. The group's diverse expertise and research activities extend from ultrasonic surgical devices which could be used for a bone biopsy, to an ultrasonic drill for planetary sample retrieval."

Academic innovation

Phillips hopes that these initial partnerships will evolve into long-term alliances, with the universities providing world-class technical and human resources – and adding scientific credibility to projects. Phillips has observed a subtle change in policy in recent years, with universities increasingly aware they have to focus more on economic impact by recruiting more researchers with experience in industry to attract commercial funding. "Some universities have embraced this need and also changed their structure to accommodate the new business climate," says Phillips, "and the benefits are mutual – many companies need to accelerate projects and get quick returns, and the universities have the resources required." Some of the projects supported by OGIC have involved universities not traditionally associated with oil and gas, and this is a breakthrough which should lead to further advances and get more universities involved.

Materials science, chemistry and chemical engineering are all part of the academic mix, but OGIC will also support a new MSc Oil and Gas Innovation programme in oil and gas innovation to create a new generation of graduates more focused on the specialist needs of the industry, with training in business as well as in science. In the past, most scientists who worked in oil and gas did a "conversion course" (e.g., petroleum engineering) after completing their basic degree, but the new degree will be more business-focused, including time spent studying commercialisation and innovation development.

Future challenges

It's hard to measure economic impact at this stage, but OGIC has already launched several projects which promise substantial returns, and future projects promise to be equally ambitious – and bigger in scope. Some may also lead to new production facilities and create jobs, or at least protect jobs that may have been lost. To develop an original idea into something of real economic value is a difficult journey, but Phillips is confident most of the projects that OGIC is backing will lead to significant sales, both at home and abroad. "Sometimes, a few thousand pounds unlocks millions," says Phillips.

OGIC's main priorities are:

- improving exploration outcomes;
- well construction, drilling and completions;
- enhanced oil recovery;
- asset integrity and life extension;
- shale gas exploitation;
- subsea;
- product optimisation and decommissioning.

How it works

The innovation journey usually begins when businesses approach OGIC with an idea – problem owners needing innovative solutions or developers needing assistance to bring innovations to market – and OGIC sends out a call to researchers for expressions of interest. If they want to be involved and help accelerate the project, the universities describe the researchers available and their track record, and more detailed discussions are held to come up with a concrete proposal. OGIC draws on a panel of about 30 industry experts and selects a maximum of five specialists to assess each proposal: Is it innovative? Does it benefit oil and gas? If the project passes these tests, OGIC writes a contract and the project begins.

First success for OGIC

Hydrasun and the University of Strathclyde have completed the testing of an innovative well intervention solution – the first project approved and funded by OGIC.

Hydrasun is a leading provider of integrated fluid transfer, power and control solutions to the energy, petrochemical, marine and utilities industries, including flexible hoses. The new well intervention hose is designed to maximise the production of oil and gas from subsea wells by keeping the well, and its associated control equipment, clean and free from restrictions or blockages such as hydrates or wax, which can reduce production rates – enabling significant savings over conventional systems.

The work done by the Strathclyde researchers involved destructive and fatigue testing of a number of samples, which provided information on the product's performance capabilities in different simulated operational conditions.

Ernie Lamza, Chief Operating Officer at OGIC, said: "The collaboration between Hydrasun and the University of Strathclyde enabled testing of a new technology to accelerate qualification and open dialogue with potential end users."

"The funding process with OGIC proved to be incredibly quick and responsive and made the whole process very easy," said Ben Coutts, Director of Engineering and Research & Development at Hydrasun.

New rock technology rocks

The University of Aberdeen has taken delivery of new high-pressure/high-temperature rock deformation apparatus from Sanchez Technology in France, thanks to funding from OGIC. The kit can test rock and cement samples under conditions of extreme temperature and stress, replicating conditions deep beneath the sea floor. By providing accurate data on the properties and the behaviour of rocks under such conditions, the equipment can aid exploration and production activity at depths far in excess of current drilling activity.

Dr David Healy of the School of Geosciences at Aberdeen, said: "As operators go deeper and deeper, there are significant technical challenges to overcome as conditions become hotter and more pressurised. This apparatus can make a tangible difference by providing companies with accurate data at depths of up to ten miles, to reduce the risks to operators, and potentially encourage new exploration activity."

Decommissioning will become increasingly important over time as the older oil and gas fields reach the end of their natural lives, with the UK oil and gas industry expecting to spend an estimated £50 billion on dismantling and disposing of equipment and "plugging" the wells. Scottish companies could play a key role in the future, says Phillips, but new solutions have been slow to emerge: "It's hard to scope large decommissioning projects, and we've been struggling to find significant innovation – so far." Clever chemistry and pyrotechnics would help, but the process is still "horribly expensive," according to Phillips, so there will be opportunities in the future.

As well as helping to develop new solutions to plug oil and gas wells, OGIC also sees its role as "plugging a gap in the market," because it has the expertise and industry contacts to help smaller companies leverage funding and identify potential research partners closer to home. Other organisations in Scotland help start-ups, provide general business advice and fund research, but do not always have the specialist knowledge required – some smaller projects may not even be on their radar, even though they have significant potential. For example, a project may only require £20,000 to fund it, but the pay-off could be huge in terms of revenues and jobs, and have "profound implications," says Phillips.

"Oil companies don't simply throw their money at problems," says Phillips. "Innovation is key to addressing these challenges." Sometimes the problem – and the solution – may not even be directly related to the oil and gas sector. For example, one leading oil firm in Scotland told Phillips it spends millions of pounds every year on scaffolding, so if it could reduce these costs by helping to develop a better solution, it would also be willing to fund the research.

In future, long-term projects may require more resources, and larger companies will also get involved; but for now the motto must be "small is beautiful" for OGIC, with an emphasis on innovation closer to commercialisation. "By supporting collaboration between SMEs and academics in Scotland, we can accelerate the delivery of new technologies to market," says Phillips. "Our initial projects demonstrate the logic of this approach and we anticipate that industry as a whole will increasingly look to near-to-market technologies as it seeks to work more efficiently."

OGIC has already worked with several other Innovation Centres in Scotland, including The Data Lab, the Industrial Biotechnology Innovation Centre (IBioIC) and CENSIS (the Innovation Centre for Sensor and Imaging Systems). These three are natural partners for OGIC, but Phillips is also excited about possible collaborations with the Scottish Aquaculture Innovation Centre (SAIC), helping fish farms make the move from busy coastal areas to deeper and more remote waters. Inspecting the cages will be a big challenge, requiring special video technologies and sensors, so expertise from oil and gas will play a major role.

"The idea from the start was to look out for possible partnerships with other Centres," says Phillips, "to kick around ideas and explore new opportunities. But the network is already working much better than most of us ever expected."

To paraphrase Phillips, austerity may be "the mother of invention," with industry budget cuts forcing a radical rethink of how to explore and exploit our reserves. Innovation will certainly get a big boost from this change in approach, with smaller players in the supply chain providing solutions to improve efficiency and reduce costs, but when industry fortunes improve, these innovative companies will be even more in demand. And Phillips and his colleagues at OGIC will be more than happy to help.

Healthcare gets personal

WHERE: **Glasgow (Queen Elizabeth University Hospital)**

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

WEBSITE: **stratmed.co.uk**

The Stratified Medicine Scotland Innovation Centre (SMS-IC) is so new and dealing with such a new science that everyone involved learns something new every day – whether it's the use of innovative technology, an invaluable insight into killer diseases provided by new genetic sequencing data, or how to help persuade the population of Scotland to volunteer for one of the biggest-ever medical experiments in history...

It's the home of "the Scottish disease" and has one of the highest rates of diabetes, cancer and cardiovascular diseases of anywhere else on the planet and, because of this, Scotland also promises to play a major role in the development of more effective treatments for many diseases – with the Stratified Medicine Scotland Innovation Centre (SMS-IC) leading the way, by helping to advance our understanding of the genetic factors involved in disease. Ultimately, this will lead to individual therapies based on our understanding of how our genes help to predict our responses to drugs (pharmacogenomics), and also help us understand the progression of many diseases, in the process, saving lots of money and improving public health. The days of "hit and miss" may soon be over, thanks to better knowledge of the links between genes and disease, and prevention may overtake cure in the race to beat many diseases.

The Chief Executive of SMS-IC, Dr Mark Beggs, is often asked how such a small country can possibly make such a big contribution, but the answer is simple: we may only have 5.3 million people, but their genes can be a window into many diseases, partly thanks to integrated medical records. It is also much easier to work with a single healthcare provider, says Beggs. In most other countries, patient data is spread over multiple organisations, including private healthcare companies, and this makes it difficult to engage with the data at a national level. According to Beggs, people in Scotland seem more predisposed to participate in genetic research because they see the long-term benefits and also trust their records will remain confidential and only be used for progressive research – if new treatments emerge, we will all profit, not just the big pharmaceutical companies. In addition, people in Scotland do not move around very often – annual turnover is roughly 1–2%, compared to about 9% in major cities such as London, and this positive asset really helps when following patient outcomes as part of precision medicine studies.

DR MARK BEGGS

Poor health statistics give researchers plenty to chew on, but there is also growing evidence that people in Scotland are happy to help. For example, SHARE (the Scottish Health Research Register) is a new initiative by NHS Research Scotland to establish a register of people aged sixteen or over willing to allow the coded data in their NHS computer records to be checked to see if they are suitable candidates for future health studies or clinical trials, and give permission for the use of any leftover blood from routine clinical tests to be used for anonymised genetic research.

Led by Professor Colin Palmer in the University of Dundee and launched as a national programme in August 2015, the register (www.registerforshare.org) already includes more than 100,000 names, aiming for a total of 500,000 within the next five years. "The use of 'spare' blood is resourceful, unique and a 'world first', made possible only through close collaboration between the NHS and universities and industry," said Professor Anna Dominiczak, Head of the College of Medical, Veterinary and Life Sciences at the University of Glasgow, when the project was launched.

Beggs also points out how important it is for everyone to register, even if perfectly healthy, because if they develop chronic diseases in the future, the ability to compare stored clinical samples pre- and post-diagnosis is a fantastic resource, and aligning this with their genetic profile could be invaluable in trying to understand the progression of many diseases. "This is an excellent example of Scotland as a biomedical resource," says Beggs.

When Beggs gives presentations to the general public, people often come forward to share their personal experience of healthcare and express their hope that medical science will be able to deliver better outcomes for future generations, by using their personal records. Other countries have had problems convincing their own populations that the research will protect the confidentiality of personal data, but Scotland seems to have escaped this thanks to good communications and the ongoing efforts to build trust with the general public.

The willingness of people to participate in cutting-edge genetic research is not enough on its own to revolutionise healthcare, however. "In Scotland, it is relatively easy to engage with a national patient cohort," says Beggs. "This is a huge advantage for stratified medicine, but we also need, and have access to, the world-class researchers, industrial partners and government backing to make it all work."

Industry backing

As well as four of Scotland's leading universities and health boards (Aberdeen, Edinburgh, Dundee and Glasgow), SMS-IC has the backing of two major industrial partners: Aridhia Informatics and ThermoFisher Scientific.

Aridhia is one of Scotland's most successful high-technology companies, using biomedical informatics and analytics to support the management of chronic diseases, precision medicine and biomedical research. The company's main contribution, says Beggs, is the value of its powerful technology platform, which makes it possible for multiple partners to work together, in different countries, sharing huge amounts of data – what Beggs describes as "distributed collaboration." Ownership of data is clearly defined, and Aridhia's involvement makes sure the data is secure, appropriately governed and professionally managed – making it attractive to commercial users in Scotland and beyond. SMEs, universities and health boards will soon be able to use the sequencing and data management capabilities available at SMS-IC, on a fee-for-service basis, for their own projects.

ThermoFisher Scientific is a US-based world leader in developing tools for genetic research, with revenues of $17 billion and approximately 50,000 employees in 50 countries. Its Enterprise Solutions Group is working very closely with SMS-IC, as well as with similar initiatives in the US and Saudi Arabia (where diabetes is an increasingly worrying problem), providing expertise as well as its next-generation Ion-Torrent sequencing technology, in the quest for future breakthroughs in pharmacogenomics and the understanding of disease.

Instead of partnering with industry right from the start, the SMS-IC could have gone down a completely different route, and embedded itself within a university research lab. In the long run, this might have led to very similar results, but Beggs believes that industry driving the project is a win–win solution for all. The industry partners have guided the SMS-IC through the early technical stages, and provide what Beggs describes as "resident experts" – an invaluable resource in such a new science.

Exponential progress

As Chief Executive of SMS-IC, Beggs heads an organisation which is tapping this industry knowledge at the same time as coordinating cutting-edge projects with the country's academic research base, but like most people in the sector, he is also learning as he goes – even though he's spent more than 25 years in the pharmaceutical and life sciences industry, focusing on early drug discovery. Genetic research has advanced at an incredible rate over the last few decades. Beggs jokes that a molecular biology PhD that used to take three years to sequence a single gene could now be completed in a couple of days, largely thanks to rapid progress in next-generation sequencing capabilities. Not so long ago, to sequence just a single gene would be a big achievement, but the SMS-IC now has eight sequencing platforms that can each sequence all 25,000 genes in the human genome overnight, for less than £2,000, bringing it much closer to the budgets of health boards or drug companies.

Current projects

Since setting up two years ago, the SMS-IC has launched a number of cutting-edge projects, including new research into ovarian and oesophageal cancer, rheumatoid arthritis, irritable bowel disease (IBD) and chronic obstructive pulmonary disease (COPD). In all these projects, ThermoFisher's Ion-Torrent platforms will be used for the genetic sequencing and the high-capacity data centre at SMS-IC will process the data (bio-informatic analysis).

High-grade serious ovarian cancer (HGSOC) is the fifth most common cancer, and the SMS-IC study led by Professor Charlie Gourley at the University of Edinburgh focuses on understanding if we can extend the use of novel anti-cancer drugs to a wider group of HGSOC patients – currently the drugs are only prescribed for patients with genetic mutations in their germline DNA (if the mutation is not present, the drug is ineffective), or about 15% of all patients. The study will try to identify similar mutations in the patients' tumour tissue, and it is hoped that an additional 35% of patients may benefit. The project will involve clinicians from NHS Lothian, NHS Greater Glasgow and NHS Tayside, as well as academic teams from Edinburgh and Glasgow.

Oesophageal cancer (OC) is a highly aggressive form of cancer – following surgery and/or chemotherapy, the median survival rate is only ten months. A recent study found that about 10% of patients responded well to a new treatment called Gefitinib, and there were few side effects. The new biological drug is very expensive, however, for use with all patients, and it's hard to predict which patients will respond. The SMS-IC OC project, led by Professors Zofia Miedzybrodzka and Russell Petty at Aberdeen University and NHS Tayside, is trying to identify a genetic signature for Gefitinib response in tumour samples. If successful, the project will lead to the development of a test for clinicians to predict individual response, and pave the way for further trials of Gefitinib, as well as other new drugs. After sequencing and data analysis, the genetic findings will then be validated using diagnostic quality assays in the University of Aberdeen/NHS Grampian genetics laboratory.

Future MS

Multiple sclerosis (MS) – also known as "the Scottish disease" – is one of the biggest problems faced by neurologists because it is so hard to predict the progression of the disease for any newly-diagnosed patient. The individual may need a wheelchair within a few years, or may be more fortunate with only occasional relapses over many years, and this can be as much of a problem for personal planning as for the prescription of drugs.

As part of the SMS-IC project, being led by Professor Siddharthan Chandran and his team at the Anne Rowling Clinic in Edinburgh (http://future-ms.org/), this nationwide project will recruit newly-diagnosed MS patients from all over Scotland (the target is 500 people) to correlate their genetic data with the progression of the disease over the next three years, combined with clinical examinations and MRI brain imaging.

According to Dr Mark Beggs, the Chief Executive of SMS-IC, genetics is only 30% "to blame" or predictive for the disease. Other factors include lifestyle and geography. By analysing MS patients' DNA and RNA, together with a comprehensive assessment of patients' clinical measures, they hope to develop a predictive toolset that helps neurologists predict which patients relapse and which go into remission. This could be a simple blood test which could greatly benefit patients, and save the NHS a lot of money by giving the expensive drugs to the people who most need them – treatment can cost £1 million per patient lifetime and some drugs can cost more than £50,000 for a six-month course of treatment.

In addition, this kind of project has the potential to offer pharmaceutical companies the ability to test their new drugs more precisely by recruiting well-defined patients into clinical trials. Patients recruited into FutureMS will, at the patients' option, consent to be contacted by their clinicians for involvement in future clinical trials. It is hoped that well-focused clinical trials will result in better outcomes for both patients and the drug industry alike.

SMS-IC IS BASED IN THE NEW QUEEN ELIZABETH UNIVERSITY HOSPITAL IN GLASGOW

There are approximately 400,000 new cases of rheumatoid arthritis (RA) in Europe and the US each year, and the direct cost is £11.6 billion per annum in Europe alone, plus indirect costs of about £14.1 billion. The most common drug used to treat RA is methotrexate (MTX), but 60% of patients either do not respond or show toxic effects, leading to the use of other more expensive biological therapies – and many years of drug escalation accompanied by worsening of the patient's condition. The SMS-IC study, led by Professor Iain McInnes at Glasgow University, focuses on trying to identify a genetic signature in RA patients that can predict which patients will respond to MTX. If successful, it will improve prescription of drugs, and help to identify which patients may benefit more from biological therapy. The project is funded by Pfizer and the Chief Scientist's Office, analysing data from RA patients across Scotland, including 21 RA clinics in ten NHS health boards, plus clinicians from NHS Greater Glasgow and academic teams from Edinburgh and Glasgow.

The IBD/COPD Project is led by Biopta of Glasgow, which has been providing contract research services to the pharmaceutical industry since 2002 and is now a world leader in the use of fresh functional human tissues to better predict drug activity prior to clinical trials. The Project aims to help Biopta undertake early identification of patient variability through a pharmacogenomics strategy. Biopta has observed that *in vitro* responses to known drugs, using human tissue samples collected from patients with IBD or COPD, can vary quite significantly between patients. Currently, there is no explanation for this effect, but it appears similar to the differences in response observed in patients – for example, the recognised variation in effectiveness of bronchodilators prescribed for the treatment of asthma.

The Project (led by Dr David Bunton at Biopta) aims to better understand this behaviour by comparing the responses obtained in *ex vivo* human assay systems with the genotype of tissue donors. It will engage NHS Scotland's bio-repository network and will demonstrate a close coupling of tissue access and functional bioassays in disease-relevant tissues. The objective is "to create a preclinical model to understand the genetic basis for variability to known drugs and to relate genomics to the variation in drug efficacy between patients." This will, for the first time, provide a means to better understand patient stratification at an early stage in drug development.

> **Most of the team were also new to the science involved, but now we're fully functional and generating lots of useful data, taking advantage of our state-of-the-art supercomputer and genetic sequencing tools**

The story so far

As well as getting major projects off the ground, the SMS-IC has also won a string of awards, including a Life Sciences Award from Scottish Enterprise, and a Knowledge Exchange Award from Interface, for helping to position Scotland "as an ideal location to deliver the right treatment to the right patient at the right time through stratified medicine."
In addition, the MsC course in Stratified Medicine launched by the SMS-IC won a Higher Education Award from *The Herald* newspaper for "recruitment and industry engagement."

For Beggs, these are important achievements, but he also believes that the biggest achievement so far is bringing together ten different stakeholders, including four universities, two industry partners and NHS Scotland. "Most of the team were also new to the science involved," says Beggs, "but now we're fully functional and generating lots of useful data, taking advantage of our state-of-the-art supercomputer and genetic sequencing tools."

Recruitment has also been challenging, says Beggs. There is not a long queue of experienced next-generation sequencing technicians ready to fill each position, but the industry partners have played an invaluable role, not just in terms of equipment but also training and advice. The SMS-IC has also been able to recruit many of its staff from SMEs and contract research organisations in Scotland's life sciences sector.

The academic programme is now underway, with several graduates already finding jobs with leading industry players. Beggs also talks about the "academic entrepreneurs" now emerging in Scotland, spotting opportunities at home and abroad for solutions such as medical decision-support tools. There is enormous potential for patentable, global solutions in pharmaceuticals and healthcare, and Beggs believes the SMS-IC can make it easier for companies in Scotland to engage with the world-class research base right on their doorstep, to translate their "nascent ideas" into marketable products.

Beggs wants the SMS-IC to be the "go-to" organisation in Scotland for biomedical research, attracting major industry players to Scotland as well as steering SMEs to international markets. The SMS-IC offers the kind of solution that appeals very strongly to the major players in the biomedical industry. "Large corporations are more interested in working with groupings of institutions at a regional or national scale rather than with a single university," Beggs explains. "To be successful in this field, you need the big numbers of patients to deliver sufficient power to the studies."

The other "big numbers" which motivate Beggs are the increasing sums spent on healthcare, and inefficient use of resources. The NHS now spends £13.6 billion on drugs every year – 9.6% of total budget and almost 1% of GDP. It is also estimated that one third or even a half of most drugs prescribed don't work on subsets of the patients they're prescribed for, and this is an issue because we do not yet have the toolsets to evaluate which patients will and which patients will not respond to a particular drug,

"We need to find better solutions," says Beggs. And the national patient cohort in Scotland could be a big part of the answer, by helping us to understand the progression of many diseases and advance pharmacogenomics – a science which could revolutionise healthcare.

The human face of healthcare

WHERE: **Eurocentral**

FUNDING: **£11 million**

WEBSITE: **dhi-scotland.com**

The challenge will not go away in a hurry – demand for healthcare services will carry on growing as people live longer, and demand for cost efficiencies will make the situation even worse over time. Technology has helped create the "problem" by improving standards of care, and technology will also have to solve it, with a little help from people. For Scotland, and a lot of its researchers and entrepreneurs, the challenge is a major opportunity, however. We could become a gateway to the European market and a centre of innovation in healthcare, and ultimately this could also translate into happier, healthier people – more gain as well as less pain...

According to the DHI website, "global health and care efficiency must improve by over 35% to maintain current standards of care for increasing numbers and requirements. Scotland's health and care budget will need to make equivalent efficiency improvements of £3.5 billion per annum." For Justene Ewing, the CEO of the Digital Health & Care Institute (DHI Scotland) since it was set up in 2013, this is only part of the picture, however. Digital technology will play a major part in "tackling the crisis," and companies in Scotland stand to benefit from this revolution in healthcare by selling their products at home and abroad, creating jobs and generating revenues, but "it's important not to lose sight of the human dimension," says Ewing. The DHI is not just about making money, but also about making advances in healthcare. The global digital health market is expected to exceed $1.5 trillion by 2020, and Scotland could earn a significant slice of that income, but how do you value a longer and healthier life?

When My Little One, the first completed project backed by DHI, was officially launched at the Victoria Hospital in Kirkcaldy in November 2014, Ewing experienced something she'll never forget. The project was a collaboration with IC24, working with parents and NHS Fife to develop a tablet-based system which allows parents to view their new-born babies via Wi-Fi and a camera in the cot. But when Ewing saw it in action for the first time in a real-life situation, she didn't just feel satisfaction at seeing the project completed, but experienced a highly emotional moment. "The parents hadn't seen their twins since they'd been born. But when the father saw them on the screen for the first time, he burst into tears," she explains. "He told us we had no idea what this meant to him and his wife, thanks to this clever device."

MY LITTLE ONE CONNECTS PARENTS WITH THEIR NEWBORN BABIES – VIA TABLET COMPUTERS.

This priceless moment illustrates what Ewing thinks the DHI is really about. The initiative was set up to bring together health, care and third-sector professionals, academics and industry partners to work together, adopting "an agile, demand-driven approach that enables the production and adoption of new products, services and processes grounded in new models of economics and work." The idea was also for Scotland to "seize the digital health opportunity, to scale its health and care services and company capability to meet the demographic challenge and to strategically position Scotland as world leading in the rapidly growing health and care markets worldwide." Societal benefit has always been high up on the agenda since the start, along with economic advantage, but sometimes Ewing thinks it's important for her and her team to remind themselves that people are always the heart of the project.

"On really bad days, when innovation is really hard, uncomfortable and sometimes a lonely place," she explains, "I jump into my car and visit some of our projects, to check up on progress. And when I see the energy and how much it means to the people involved, and think of the impact the project could have in the future, it reminds me why I'm here and refocuses my passion all over again."

Ewing also remembers "an interesting question" that helped her to articulate the DHI mission – and why she and her team love what they're doing. "Someone asked me how I felt about taking some of the hardest challenges in life to create commercial gain for SMEs," she continues, "so I thought for a moment and said if we can help to identify and solve some of these problems (such as isolation and vulnerability), through collaboration between academia, business and healthcare providers, then it must be a good thing – not just for the companies but also for society at large." It's good to "make money for all the right reasons," she adds, and also a "fantastic opportunity" which the DHI aims to translate into concrete results for the people of Scotland.

Surprise, surprise

For Ewing, the biggest surprise since she started her job is that the innovation and healthcare sector in general are not what she expected them to be. There are many different agencies active in healthcare, but in the main they cooperate rather than compete with each other. "The innovation landscape may be packed and very fragmented," she says, "and the public sector is a fierce environment in some ways, but the various organisations tend to overlap rather than duplicate what they are trying to do – for example, when it comes to diabetes, the different interest groups have been working together when required."

DHI objectives

- Improve cost effectiveness of health and social care in Scotland
- Improve health performance and patient experience
- Improve quality of life for the citizens of Scotland
- Build the global reputation of Scotland as a centre of innovation for digital health and care
- Engage with more than 200 companies and establish 210 innovation collaborations
- Release up to 140 new products and services with societal benefits from within Scotland
- Create a Doctoral Training Centre in Digital Health and Care
- Generate educational benefit by investing in PhD, Masters, CPD and skills development courses

JUSTENE EWING

The DHI, says Ewing, is trying to provide the "glue" to integrate these many different organisations and interests in our field. "We need to inspire lots of activity, but we also need to pull the industry together," she adds. "That's why we need a 'Team Scotland' approach, combining the strengths of the private, academic, third and public sectors. Sometimes you have to take risks and sometimes you need to be careful, but you have to get on with it – there's a lot at stake in both economic and health terms."

Sometimes there are also "cultural barriers" to innovation, says Ewing. For example, healthcare professionals can be very protective about the NHS, and often tell the DHI at meetings "what they think we want to hear," rather than talk about really difficult problems. "Understandably, nurses and doctors are proud of their organisations, but they also have to grasp the opportunity to change things for the better, and feel empowered and safe in their roles to do so," she says. And to get people talking, the DHI creates a "safe" environment for open discussion – which hopefully will lead to life-changing innovation in future.

The production line

Since October 2013, the DHI has been involved in over 80 projects – developing everything from animations, videos and augmented reality tools, therapeutic games and electronic people locaters to bereavement apps and social media tools for breastfeeding mothers and eczema sufferers, as well as digital solutions for strokes, diabetes, brain injuries, back pain, dementia, colitis and cancer. Every project has an academic partner, as well as involvement from healthcare professionals and industry partners. The ideas come from every direction and one of the challenges faced by the organisation is how to identify those with the greatest potential, then evaluate the projects with a view to commercialisation. The size of projects varies from the very small to national and international projects which promise to have a huge impact (e.g., Scotland-wide programmes for diabetes and cancer). "Some projects may seem highly targeted and very modest," says Ewing, "involving only one academic and one SME, but all could have enormous long-term impact."

For example, the "Tele-ventilation" project could transform the lives of many patients with chronic lung disorders by making it possible to monitor their condition (breathing and oxygen levels) and also provide ventilation at home – freeing up hospital beds and improving quality of life in the process.

Another project highlighted by Ewing is a mobile ECG (electrocardiogram) solution developed by AliveCor of the USA, now being tested at 20 general practices and five NHS health boards in Scotland. According to Ewing, this innovation could have a huge impact in detection of atrial fibrillation (AF), an irregular heart rhythm which affects many otherwise healthy people over 65 years of age. AF is the most common preventable cause of strokes in Scotland (increasing the risk of a stroke by a factor of five), and can be treated with anticoagulant drugs such as warfarin – as long as it is spotted early on. Using a simple adapter which converts a smartphone into a portable ECG (electrocardiogram) recorder, nurses and doctors can identify patients with AF when they go for annual health checks, simply by taking a fingertip reading for just 30 seconds. An estimated 100,000 people in Scotland have been diagnosed with AF, but as many as 30,000 people may have the condition without even knowing. A successful trial – screening up to 10,000 people in the course of a year – would not only help to save lives and produce better outcomes for patients, says Ewing, but also save a huge amount of money in healthcare (over the last 20 years, admissions into hospitals because of strokes have increased by 60%), as well as in lost earnings. And the device is now available at prices starting from only £75.

More flexible approach

According to Ewing, the original business model drawn up for the DHI four years ago has gradually evolved since the centre began operations, adopting a more flexible approach to proposals and industry demand. For example, eight different organisations with interests in improving diabetes care came forward with project ideas, and instead of selecting just one, the DHI suggested it would work with all eight of them as part of a national programme. This should ultimately lead to progress for all and fits in very neatly with Government targets.

Ewing also believes that NHS Scotland has a "unique selling point" in this arena, trialling innovative nationwide projects by taking advantage of its integrated patient information systems and its world-class research base, as well as its wide variety of geographic, economic and demographic conditions. The Scottish Government already has an extensive innovation and entrepreneurial agenda to support all of this. "It's something we should shout about," says Ewing, "and a great asset."

Another way in which the DHI helps SMEs and public healthcare providers is through "pre-commercial procurement" approval. This means that when an individual health board or NHS Scotland partners with an SME and a research team to develop a novel solution, the buyer does not necessarily have to go through procurement procedures all over again when the new product is delivered to market, saving time and money for the healthcare provider, as well as making sure the SME gets future sales. "The process is designed to be very open and fair, as well as neutral," says Ewing, "in line with our mission to make innovation easier for everyone." Many SMEs have struggled in the past to compete with multinational rivals, but now there is a much more level playing field – and greater opportunities to break into markets which used to be closed.

Foundations for growth

The DHI now has a team of 48 people, including 20 who spend most of their time in the Experience Laboratories (see sidebar on next page for details), focusing on "experiential learning" by testing ideas in conditions as close to real life as possible, as well as on rapid prototyping and development. Another 20 people are described as "project support staff," evaluating opportunities and focusing on business development.

Even though she is proud of her team, Ewing strongly believes that the DHI should take full advantage of existing organisations to develop its projects and identify partners. For example, the DHI works very closely with Interface, which helps connect companies with academic researchers. "Coming from industry, my instinct is to be competitive," she says, "but by collaborating effectively with these other agencies, we avoid replicating what they do. There are lots of people and organisations already involved in this space, and we want to utilise everyone's strengths, so that everyone wins, and mobilise Team Scotland."

Driving innovation

The DHI has developed a three-pronged approach to drive innovation:

1. The Digital Health Exploratory engages a wide range of national and international organisations to develop priorities for action, running activities to stimulate the development of ideas and deliver opportunities.
2. The Experience Laboratories provide a safe environment where users (service users, carers, clinicians, practitioners and third-sector partners), businesses and researchers can collaborate and rapidly prototype in response to health and care challenges. Experience labs provide a creative and innovative environment (replicating real-life practice), using design to carry out rapid cycles of experience trialling of new ideas, including new technology, new services and roles and behaviours (often the biggest barrier to successful innovation implementation) which may become candidates for further research, development and exploitation.
3. The Digital Health Factory helps DHI members progress known solutions much closer to market and deployment. It offers a facilitation and resource platform, including access to expertise and test environments, business mentoring support and facilitation to source funding. The Factory works with industry, health and care partners, third sector and university partners to develop commercialisable solutions to real-life situational challenges that can make a difference in clinical, professional or user-based settings.

NEW TECHNOLOGY IS KEY BUT ONLY PART OF THE SOLUTION...

Building capacity

Ewing says the main aim of the DHI is "creating capacity," rather than expressing it in terms of saving costs or improving efficiency, or even technological advances. For example, if a patient can go home instead of having to be cared for in a hospital or nursing home, that is a great gain for the healthcare provider as well as the patient, because it frees up beds and other resources. Similarly, patients having more say in their treatment, and being able make informed choices are major advances.

"There are hard facts we cannot ignore," Ewing says, "but what price life and what price better quality of life? That is why building capacity matters."

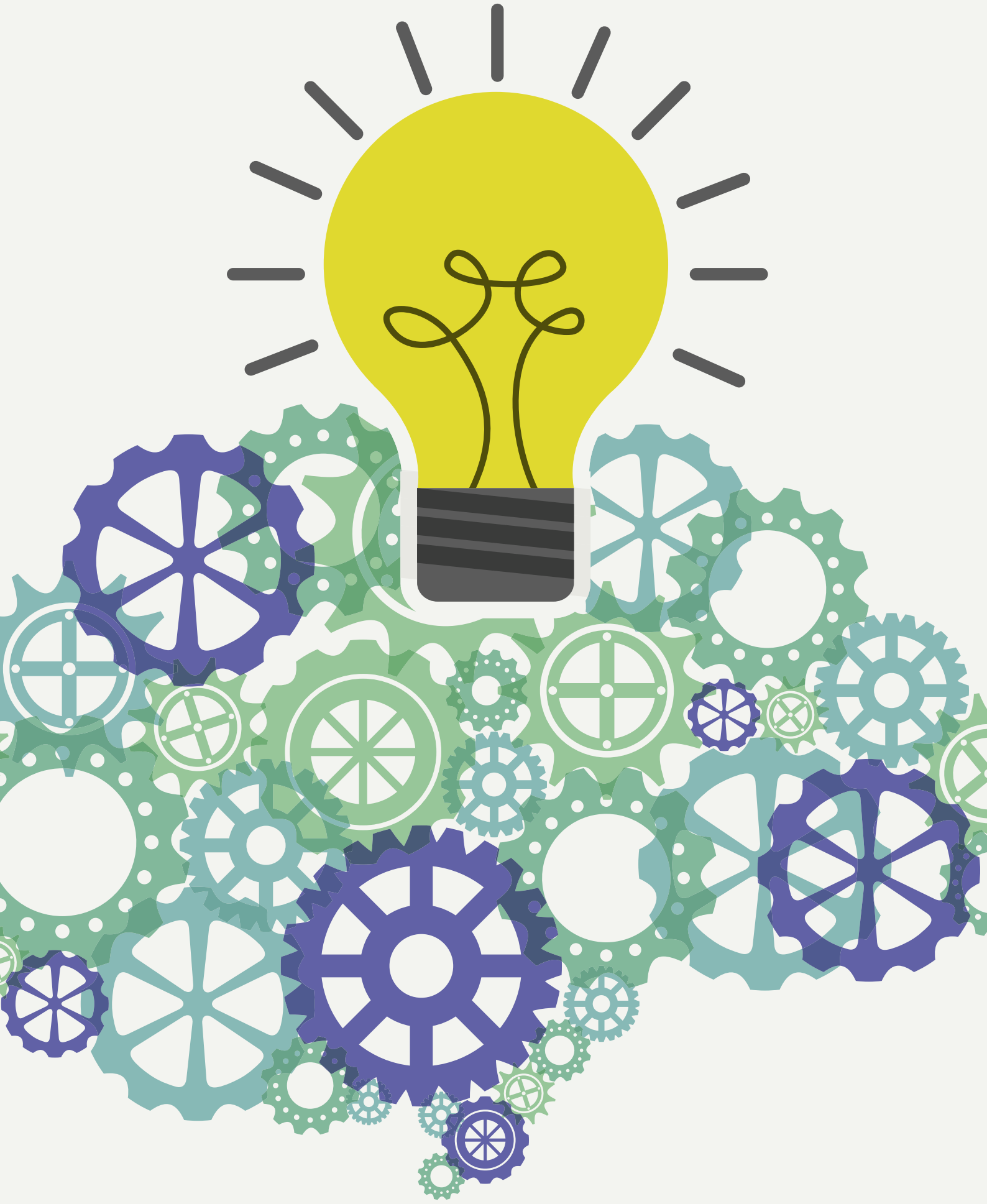
Health education also has a key role to play in the future of healthcare, including making all of us aware that we should also take responsibility for our personal health and make the right choices, based on the right information. Why is it, asks Ewing, that people in Canada spend the last ten years of life in illness, while people in Scotland spend their last 20 years in illness? Predictive analytics, education and empowerment may be the answer.

Moving forward

The DHI is learning fast and moving with the times. It knows that "making innovation easy" is a challenge in more ways than one – the new technology itself is probably the easiest part. When it comes to changing traditional methods of service delivery and introducing new devices, there must be a balanced approach. For example, if you give people new tele-healthcare devices, you have to "take something away" in order to make a real difference, for both patient and healthcare provider.

Ewing also expects that the DHI's next phase will see a reorientation of basic objectives. Digital healthcare technology will continue to radically change through the years – gathering more real-time data from easy-to-wear smart devices, incorporating new and much more powerful predictive analytics. The "Internet of Things" will soon be taken for granted, connecting different systems and devices, including health and fitness apps which soon will seem part of our bodies. More homes will be designed as safe environments for people with special needs, such as dementia sufferers, so they can be more independent and free to 'live life.'

The technology will gather momentum, but policy and attitudes will also need to change. "We have already proved we can collaborate and create cohesion, but in the future we will have to be more focused on the strategic priorities of Government," says Ewing, "including the Education, Digital and Health and Social Care Directorates. We will also need to encourage the development of more open, more connected digital platforms, and have a more international perspective, bringing in more multinational partners to engage and partner with SMEs, at the same time as boosting our exports, and establishing Scotland as *the* International digital health and care gateway to Europe."



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