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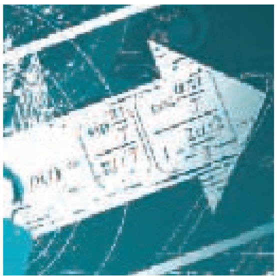
Electronics



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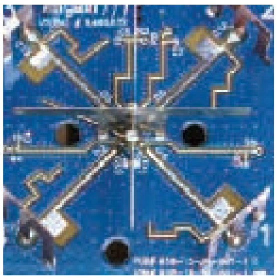
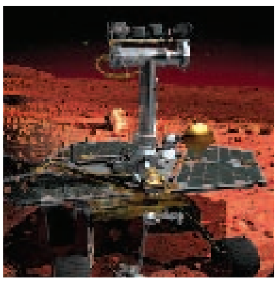


From bricks to smart dust



Intellectual property speculation

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Foreword

Science Scotland: **Electronics**

PROFESSOR PETER GRANT

PROFESSOR DAVID MILNE

Electronics is now an-all pervasive industry with applications in communications, multimedia, transport (automobiles now have 40% electronics content), informatics, etc.

Electronics contributes 2.5% of the UK's total GDP and represents 6% of UK manufacturing.

Electronics in Scotland, as characterised by Silicon Glen, has changed through the years and continues to change rapidly. About 30-40 years ago it was dominated by large companies, foreign multinational manufacturing plants and a few large indigenous companies such as Ferranti and Barr & Stroud.

These companies made major contributions to the Scottish economy and were responsible for training significant numbers of people. This in turn supported growth and development and also provided a steady supply of skilled engineers who moved on to work in other companies.

This era has now passed. Electronics manufacturing has moved to the Asia-Pacific region and competitive pressures have curtailed the training activities of the firms which remain. However, there is now a new wave of engineering activity in Scotland which points to the future.

As you will read in the following articles, the electronics industry in Scotland is now dominated by small- and medium-sized companies (SMEs). These smaller companies are focused on developing and selling the next generation of products but generally do not have enough time to support the overall industry or talk about their impact on the economy to the general public.

Science Scotland attempts to address this issue by describing the Scottish university research in electronics and highlighting its technology transfer into SMEs. One indication of the success of electronics research in Scottish universities is the funding support they win within the UK. The top four Scottish universities currently hold a portfolio of £57 million of EPSRC-funded research awards compared to the top four English universities (selected from a much larger pool) who only hold £44 million of awards. Equally, the commercialisation of electronics technology is being actively pursued in Scotland through a growing number of established and start-up companies.

If one compares the annual generation of new spin-out companies in a major US university such as Stanford, and then scales or normalises this to the smaller research revenue of the Scottish academic research base, then there is no perceptible difference between the commercialisation performance of Scottish and leading US universities.

Electronics in Scotland, as evidenced here, is still a vibrant and dynamic industry, and a significant contributor to the Scottish economy. It also offers exciting career opportunities for recent graduates in engineering, maths and physics to influence the design of future products.

Professor Peter Grant, FRSE, FIET, FIEE, FREng

Professor David Milne, OBE, FRSE, FIET, SMIEEE, FREng

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Editorial Team:

Words: **Peter Barr, barrcomms@btinternet.com**

Design: **Emma Quinn**

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sciencescotland@royalsoced.org.uk

The Royal Society of Edinburgh
22 – 26 George Street
Edinburgh EH2 2PQ

PROFESSOR DAVID CUMMING

Vertically integrated people

Behind the Victorian sandstone façade of the James Watt Building at the University of Glasgow, technicians wearing white hoods, masks and lab coats are advancing the frontiers of science in one of the best-equipped cleanrooms in Europe. But although the ultra-modern Nanofabrication Centre may appear out of place in the old-fashioned campus, it continues a great scientific tradition which James Watt himself would be proud of...

From exploring the outer limits of physics to inventing a capsule which passes through the body to detect signs of cancer is a truly incredible voyage, but for Professor David Cumming it is not just the story of his own career so far but also a reflection of the way modern science is going.

Cumming is the head of the Electronics Design Centre (EDC) at the University of Glasgow, and was persuaded to return to his own alma mater by the opportunity to get involved in nano electronics, taking advantage of his academic background in physics and experience in industry with STMicroelectronics in Bristol.

One of the major attractions in Glasgow is the James Watt Nanofabrication Centre, with its world-class facilities such as electron beam lithography and 750 square metres of cleanroom space, and the EDC's sophisticated test and measurement equipment, including wafer probing up to 325 GHz. But for Cumming, the excitement comes from exploring new frontiers of science and electronic engineering, including bioelectronics.

"In other areas of electronics like defence and computing, we're clear about where we are going," says Cumming, "but biology creates new opportunities to do new things and open up new markets, and the margins are also much greater."

Glasgow has been active in the field of bioelectronics for several decades, and the EDC has moved on from developing simple devices to systems, including sensors on a chip – for applications ranging from security to medicine.

One of the EDC's most promising inventions is the Lab-In-A-Pill, a miniature device developed by Cumming and his colleague Professor Jon Cooper which addresses the need for prevention-oriented devices in healthcare, now being taken to market by a spin-out company called Wireless Biodevices.

According to Cumming, the Lab-In-A-Pill has the potential to greatly reduce deaths from one of the biggest killers today – bowel cancer. Worldwide, there are one million new cases a year and 500,000 deaths, but if diagnosed early, survival rates can be as high as 90 per cent, so any improvement on current technology would be welcome, to replace colonoscopy, which is intrusive, expensive and time-consuming, and faecal blood tests – which are not just unpleasant but also produce false positives half of the time.

Lab-In-A-Pill is a "use once and throw away" wireless device which measures just 2.5cm in length. It is the end result of almost 60 years of research that began with the invention of the transistor. In the early days, the not-quite-so-tiny devices were inserted still attached to a wire, but advances in wireless and video technology, combined with micro sensors and the "system-on-a-chip," have enabled researchers at Glasgow University to make dramatic advances, not just in miniaturisation but also in sensor capabilities, including the detection and measurement of acidity, dissolved oxygen, glucose/fatty acids blood and tumour markers, as well as temperature and pressure – plus a camera.

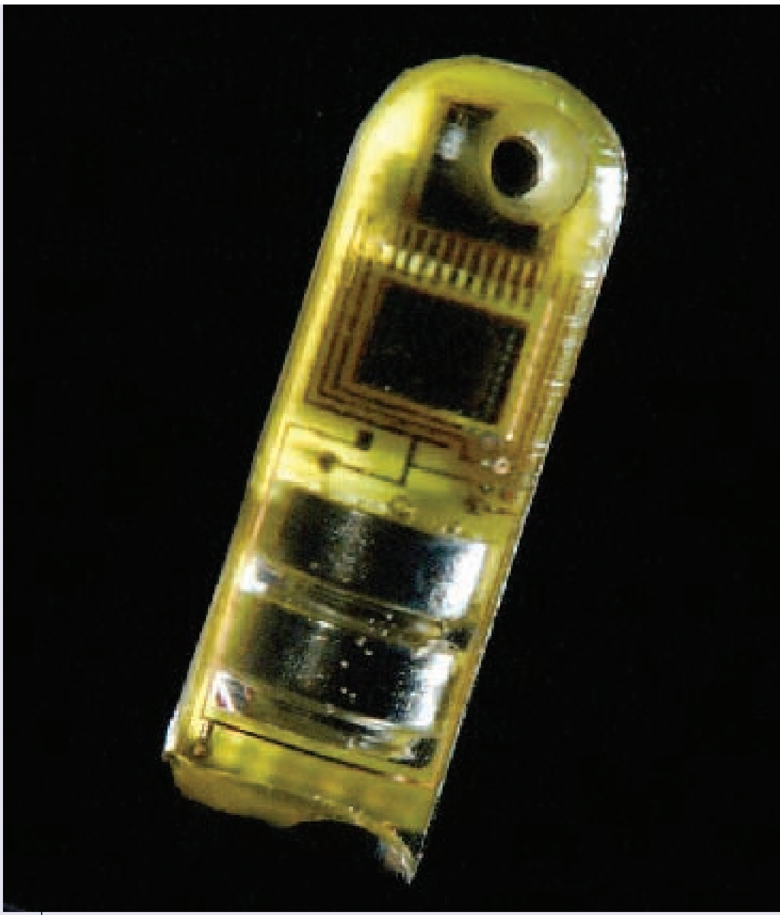
A primary achievement of Cumming's group is to integrate different components on a single IC containing the microcontroller, plus sensors, memory, data encoder and wireless transmitter, just 5mm across. In addition to reducing the size of smart diagnostic devices, and improving the sensitivity of sensors, the major challenges are battery power and wireless transmission. For example, due to the density of organs like the liver, the location of the "pill" in the body has different effects on transmission of radio signals, so Cumming's group created a three-dimensional model of the human body, "slicing and dicing" it into 4.5 million cubes to measure the signal from every location – ultimately to improve reception and therefore the accuracy of diagnosis.

According to Cumming, the developers are confident that as the underlying technologies come down in price, the sky is the limit for sales – potentially hundreds of thousands of pieces a year. The other challenges for this and other similar devices, says Cumming, are to make better use of the "dead space" on the chip and "eliminate interconnect", to make the chips smaller, at the same time as lowering power consumption and improving the sensors themselves.

The EDC has also developed the world's first single-chip pH meter, while another market with enormous potential is "patch clamping" – a technique for studying ion channels in cells, traditionally done with a glass micropipette, where biosensors promise huge advantages. Other breakthroughs include CMOS chips for monitoring the growth of cells, and proton cameras. As well as diagnosis, these and other similar devices will be used in pharmaceutical research – for example, testing new drugs in a "lab on a chip", tissue engineering and cell screening.

One of the major issues in development is how to eliminate "biocidal" materials such as aluminium oxide that kill tissues in contact with the sensors. This is achieved by using a "biocompatible" method called electroless gold plating. Another problem is surface topography – developers discovered that the cells they were trying to monitor would not grow on certain types of surfaces because they are not "bio-friendly."

To solve such problems, Cumming and the EDC work very closely with other departments, and it is this collaboration which he believes makes the big difference in Glasgow, with chemists, physicists and biologists sharing the facilities, in the search for mutual progress.



A WORKING LABORATORY PROTOTYPE OF THE LAB-IN-A-PILL

In Cumming's view, the EDC has strengths in several areas like ultra-fast transistor technologies, bioelectronics and biosensors, nanofabrication, microwave test and measurement facilities, sensors/system on a chip, and optoelectronics for the telecoms industry. It has also been a pioneer for several decades in several technologies like biosensors, but above all, says Cumming, the key to success has been co-operation and what he describes as the "vertical integration" of facilities and people from various branches of science, working side by side with electronics engineers. He himself is primarily an electronics engineer who trained in a physics laboratory, and his department has recruited staff and students including several chemists and biologists, to create a multi-disciplinary atmosphere and promote co-operation.

What makes the EDC different, says Cumming, is also its ability to do fundamental research at the same time as actually making its own prototypes and testing them right on the spot.

"The EDC is where micro meets milli and nano meets micro", says Cumming, "and there's plenty of room in the middle."

Intellectual property speculation

While millions of people all over the world are chatting on their mobile phones, downloading music or watching streaming video on laptop computers, developers at Xilinx in Scotland are quietly working away in the background to make the underlying technology work – thinking up the "logic" which makes very similar chips do very different jobs...

"We provide solutions for many things consumers take for granted or depend on," says Dr Colin Carruthers, Director, Xilinx Scotland. "We also do a lot of things that people aren't even aware of, as they go about their everyday lives."

Sometimes, Xilinx thinks up new ideas which no-one has thought of before, and for which there may not even be a market yet...

As far as the consumer is concerned, what Xilinx develops in Scotland is often invisible – blocks of logic which provide the intelligence for the FPGAs (Field Programmable Gate Arrays) used in many digital products.

The same FPGAs can be put into very different devices, but what makes them different is how they are programmed. According to Carruthers, Xilinx chips are even used in the Mars Rover and particle accelerators to solve the greatest mysteries in science, as well as more common applications such as HDTV, mobile phones, PDAs and wireless basestations.

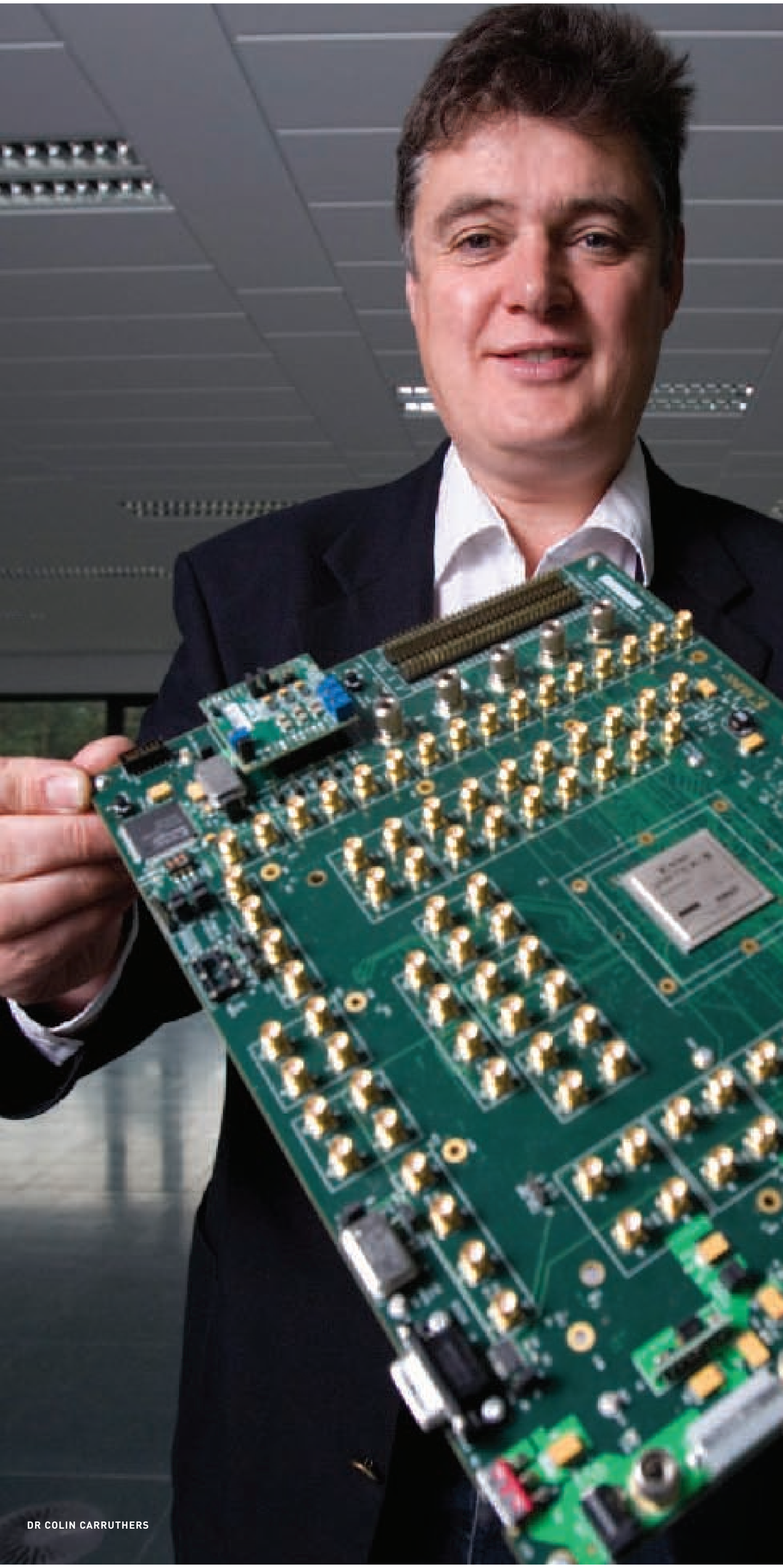
Xilinx customers can change or upgrade (i.e programme) product features and functions "on the fly" – adapting to new standards and reconfiguring the hardware for a specific application. This "on the fly" technology can be achieved even after the product has been installed in the field, allowing upgrades and design flaw repairs following consumer purchase.

Xilinx in Scotland

Xilinx today is the world's largest maker of FPGAs, with just over 50 per cent market share, and its presence in Scotland can be traced back to a company called Algotronix, a spin-out from the University of Edinburgh in 1989 which became a part of Xilinx four years later. Like Xilinx, which was formed in 1984, the small team of developers at Algotronix recognised the potential of FPGAs and developed a numeric co-processor chip which fitted in well with the Xilinx portfolio, plus several other patented devices with commercial potential. Xilinx also recognised the talent at the fledgling Scottish company, and persuaded them to join forces – in the process setting up the company's first overseas development venture, which has since become a major European R&D centre for Xilinx.

As the years went by and FPGA technology continued to evolve, Xilinx in Scotland grew from four to 16 people, focusing on chip design and layout software, as well as board level and development tools. Now more than 40 strong, the Edinburgh-based development team was not only able to take full advantage of the company's international marketing strengths but also its software development skills, documentation and chip verification capabilities – plus what Carruthers calls "cross fertilisation of cultures."

In 1997, Xilinx had four or five radically different FPGA platforms, all performing different tasks but using very similar technology, so the company decided to rationalise to avoid duplication of effort, in the search for a more homogenous architecture. At this time, says Carruthers, using FPGAs for digital signal processing (DSP) was gaining momentum, and this presented Xilinx with tremendous opportunities, especially in the mobile phone market.



DR COLIN CARRUTHERS

What are FPGAs?

When they were invented, Field Programmable Gate Arrays (FPGAs) were regarded as an "off-the-wall concept" that would never take off in the market. Dreamed up by Xilinx co-founder Ross Freeman, the FPGA was a totally new kind of semiconductor which could be customised by individual customers to meet special system requirements, with the help of special software. In the early days, however, the technology required a lot of expensive transistors, so many mainstream companies rejected it because it did not seem to be commercially viable.

Thanks to Moore's Law, which states that the number of transistors you can fit onto an integrated circuit doubles every 18-24 months, enabling dramatic reductions in costs, the Xilinx concept soon became increasingly attractive as a business proposition, and a multi-billion dollar market has emerged, providing smart solutions for a wide range of industries and applications – many of them hardly imagined when the FPGA was conceived.

In simple terms, an FPGA is built around a matrix of configurable logic blocks (CLBs) connected via programmable interconnects. Unlike Application Specific Integrated Circuits (ASICs), which are specially built to carry out specific tasks, the same FPGA can be programmed to do different jobs, using the same infrastructure laid out on the chip. This means that the customer can buy a lot of FPGAs off the shelf and then configure them to carry out particular functions, instead of building an ASIC from scratch. As well as being much more flexible and cost-effective, the FPGA eliminates much of the blood, sweat and tears that go into designing new products.

Xilinx: Major breakthroughs in Scotland

LTE Baseband Reference Design

The next generation of the so-called third generation "3G" wireless standard is called Long-Term Evolution (LTE). This provides a leap in performance over existing standards, and presents significant challenges to deal with higher data throughput rates.

To meet the demands of the new specification, Xilinx Scotland has developed several new or revised DSP LogiCORE(tm) solutions. With such blocks, it is critical not only to verify them as stand-alone blocks, but also to validate them in real systems with real-world data. The Xilinx LTE downlink reference design was developed to provide this validation, as well as providing a reference to customers about how to use the blocks.

The LTE standard is still changing and has not been ratified, making FPGA an ideal implementation platform. The design team decided to implement an LTE reference system design that would provide system level validation of the new LTE LogiCORE IP using real-world data sources such as video streams. Since the main aim of the reference system was to validate new IP LogiCORE solutions, the team wanted to minimise the amount of additional design work for the reference design. They also wanted to minimise the system integration and tool issues and use off-the-shelf boards and IP blocks as much as possible.

The new solution was demonstrated during February 2008 at Mobile World Congress MWC08 in Barcelona, with multiple video channels being transmitted using the LTE encoding and decoding.

By using existing Xilinx IP blocks to maximise IP reuse, and using Xilinx Platform Studio as a single integration framework, design teams can concentrate on the novel parts of the LTE downlink design. This has allowed rapid development and tracking of changes in the LTE specification as it approaches ratification.

In Scotland, the development team focused on cores – blocks of pre-coded functionality, to which the customers can add what Carruthers calls their "secret sauce", taking advantage of the reusability of the components which sit on the FPGA. The cores can even be downloaded free from the web so that customers can try them out before placing an order.

Because they are so flexible, one of the major advantages of FPGAs is that early adopters can get up and running with new electronic devices, like 3G phones, before any standard is set, then reprogram the chip, if required, to conform with the industry standard. And the Xilinx team works side by side with manufacturers to make sure the process goes smoothly, enabling them to ship their products sooner and win new business.

The Xilinx team in Scotland also works very closely with Xilinx headquarters to help in the design of new FPGAs, and because they know the layout of the FPGAs inside-out from the moment they first hit the market, they can quickly exploit the architecture of the new chip design to optimise results for different customers.

Although developers in Edinburgh are pushing the edge of research, Carruthers says they're not engaged in what is sometimes described as "blue sky" thinking but very down to earth and practical solutions for their customers. In fact, their greatest satisfaction comes from solving real-world customer problems, as well as dreaming up original ideas.

When the Xilinx sales team is talking to customers, the Edinburgh team are often called in for discussions, to talk engineer to engineer, in order to come up with new solutions.

For example, says Carruthers, clients sometimes plan to build new products using ASICs (application-specific integrated circuits), but this can be very expensive because it means developing a specialist, one-off solution, rather than "customising" a chip that already exists – saving time as well as money.

In terms of applications, Xilinx solutions are used all over the digital world. For example, it produces cores which enable the FPGAs to be used in mobile phone network base stations, as well as the "satellite" base stations which are now installed in buildings to boost network signals.

Another key market is routers and switches, while Xilinx chips have also been installed in the detectors for the new Large Hadron Collider in Geneva, the world's largest particle accelerator. The automotive, telecom and aerospace industries are also major customers.

Paraphrasing the words of Arthur C. Clarke, Carruthers says that Xilinx technology is "sometimes so advanced it's hard to distinguish from magic", but its success in Scotland is not an illusion.

PROFESSOR STEVE MCLAUGHLIN

Let's get physical

While other researchers are busy developing new applications to squeeze into wireless devices, and add more services onto the network, Steve McLaughlin and his team of engineers are trying to extend the capabilities of the "physical" layer, but that doesn't mean they spend their time with screwdrivers, spanners and soldering irons – it's all about maths...

There are lots of major challenges in digital communications today, like trying to process more data – more quickly – and provide more services over the network, but when you also have to cope with "disruptive technologies," the problems become even harder.

For Professor Steve McLaughlin (Chair of Electronic Communications at the Institute for Signal and Image Processing at the University of Edinburgh), his work in signal processing is all about "pushing the envelope" or extending the boundaries of digital communications systems.

The key is always compromise, McLaughlin says, and as well as reducing the cost per bit, researchers today also have to think about reducing the carbon footprint of networks, in the quest for what is now known as "green radio." When you add disruptive technologies into the mix, the problems multiply, because as soon as you design a new technology, people start doing strange things with it...

"What forces change in the network," says McLaughlin, "is the way people use the services. And disruptive technologies don't only change the network architecture but also the business model."

For example, he explains, when users discovered the joy of texting, the service providers were caught unawares. What started as a stand-by solution for technical problems became a new dimension of the industry which today accounts for about 40 per cent of total network revenues.

Similarly, Google, YouTube, the iPhone and the BBC's iPlayer have all had unexpected effects on the system, changing the nature of traffic and vastly increasing the load.

So, faced with all these different pressures, how do we plan for the future? And how do we measure our progress?

The more things change...

Since the early 1980s, there have been dramatic changes in the industry. At that time, much of the focus was on military systems, while today it is mainly consumer devices. What used to take two years to bring to market can now be delivered in a couple of weeks – much smaller and much more intelligent, and also more data-intensive.

One job McLaughlin remembers in the mid 1980s was the challenge of developing a tactical radio system with a handset weighing less than one kilo, incorporating 18 layers of flexible circuits which today would be a few lines of code in some software, on a programmable semiconductor. "We did not even have any CAD tools," says McLaughlin, "but even though we still deal with the physical layer, today we're more concerned with mathematical problems like interference cancelling algorithms – and that is the smart part."

Despite these huge advances, the "physical" challenges still seem the same – getting wireless devices to process more data (including compressed video) and use up less battery power, while sending and receiving signals faster, at any time in any location. The ultimate aim for McLaughlin is to optimise performance of the physical layer (the fundamental layer in communications systems which processes data for transmission and reception by different devices), and what is called "cross-layer optimisation," balancing the needs of different layers – including applications, network, data link and physical layers.

As well as having to deal with the problems created by progress in other technological dimensions, and the problems created by disruptive technologies, researchers also have to "retro-fit" communications systems, getting the existing network to do things it wasn't designed for – e.g. using the telephone network to provide high-speed broadband.

Often, this means all you can deliver is a "best-effort" service, but it's better than nothing...

The Institute for Signal & Image Processing is involved in several projects for Mobile VCE, including "Delivery Efficiency." Two areas of research have attracted particular interest:

Relay-based solutions for Wireless Communication Systems

Dr Ioannis Krikidis is studying relaying techniques to help develop lower-power wireless communications. This technology uses small wireless terminals to exchange signals between base stations and mobile telephones in cellular communications systems. The relays can be used to increase range and reduce the power consumption and base station costs for cellular operators. Dr Krikidis has developed and analysed several relaying techniques, with an emphasis on improving the data rates and efficiency of relay networks. These techniques will soon be standardised for use in WiMax and third-generation wireless networks and the results of the research will make a major contribution towards this.

A flexible and efficient scheduling scheme for OFDM-based wireless networks

As we move towards packet data communications systems to enable the mobile internet to be delivered to mobile users, the need for flexible scheduling schemes for centralized wireless networks is vital. The new scheduler developed at Edinburgh offers network operators a practical and flexible way to control the operating point of the system, while at the same time utilising the wireless system resources efficiently. The scheduler can be used for both the uplink and downlink directions of the network, and the scheduling decisions are taken at the base station. The scheduler can also be used for OFDM-based systems with Dynamic Sub-carrier Allocation (DSA), as proposed in WiMax. The scheduling policy can achieve close-to-capacity performance over all possible operating points. From a practical perspective, the transmission power is always constant. The user scheduled to transmit or receive is the one with highest weighted channel quality. The different weights given to each user are chosen to achieve a pre-determined channel access ratio. These weighting factors can be either determined in advance or updated in real-time, depending on actual measured channel conditions.

The selection of channel access ratios of users is a degree of freedom given to the network operator, and this helps to achieve service rate requirements, maintain system stability, define suitable fairness criteria between users or differentiate between users based on criteria such as pricing policy.

Maths for engineers

Today, the research group working with McLaughlin focuses on "maths for engineers", and members of his team can write new algorithms and program them onto a chip in a couple of weeks, taking advantage of the latest simulation tools. Among the work being done at the Institute is the development of audio signal processing components for the personalised audio market, and new ways of sampling video signals so they can be reconstructed more easily, improving image quality and maximising use of the available bandwidth. Another project involves reducing the power consumption of base stations by using algorithms to transfer the complexity to the receiver instead of the transmitter. The Institute is also doing ground-breaking work in relaying techniques and scheduling schemes (for more details, see sidebar).

As well as focusing on "maths for engineers", McLaughlin also stresses the practical nature of all this research. "We're not just proving theorems, but doing things," he says. "We need to understand the physical process in order to write maths to solve all the problems. You can't pass 'Go' until you pass the physical layer."

Current problems

Even though there must be lots of compromise in any new concept, if a voice call is delayed in the network by more than 80 milliseconds or there is too much noise on the line, users will reject the new solution, no matter how clever it is. Engineers not only have to ask how much complexity can be built into digital networks but also where to put that complexity.

For example, while other researchers come up with exciting new concepts like "Cognitive Radio," which enables the service providers to dynamically sell their available bandwidth as if it's a commodity, McLaughlin and his colleagues have to deal with major issues like latency and interference, or the system will simply not work. It is all about trade-offs...

McLaughlin is also concerned about the implications of Cognitive Radio (CR) for licensing issues – managing and allocating frequencies. "If CR achieves its full vision," he says, "why do we need to allocate bandwidth?" In addition, McLaughlin continues, agencies like Ofcom have a difficult balancing act, providing clear directions when it comes to regulations, without stifling innovation.

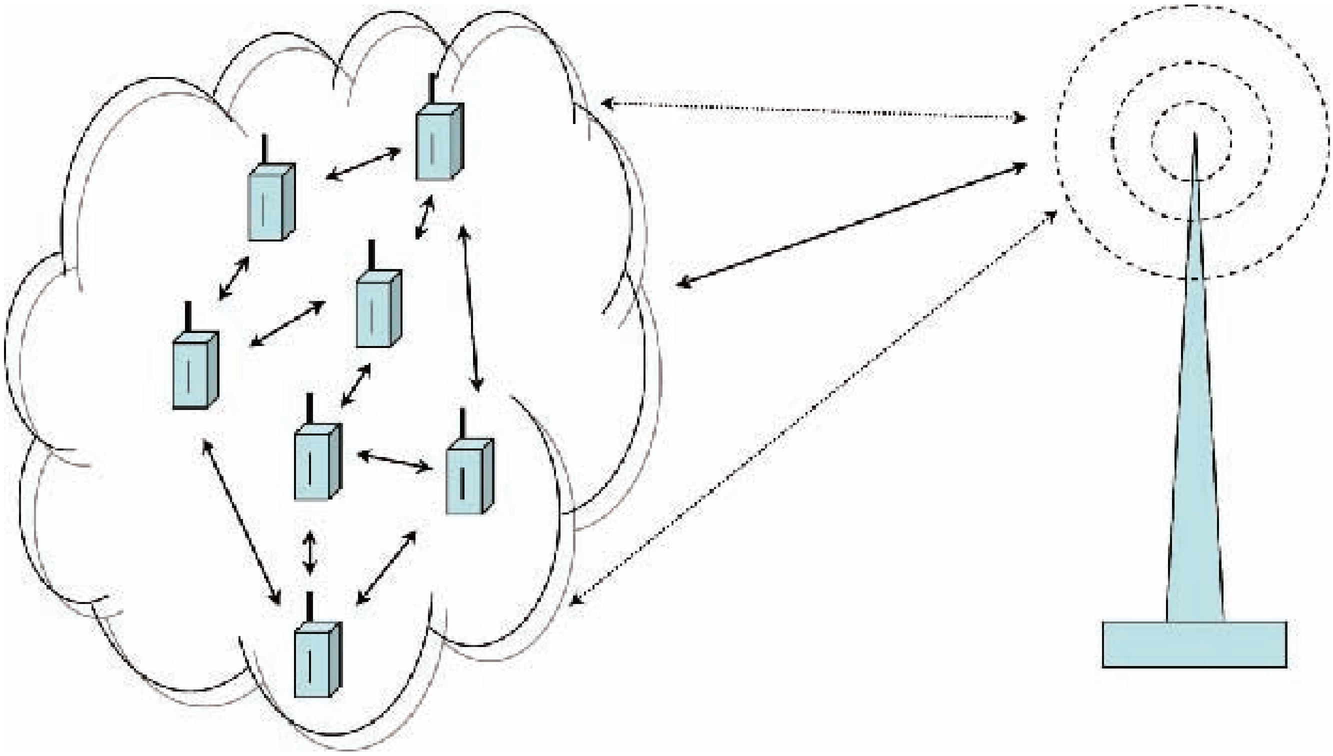


ILLUSTRATION OF USER COOPERATION AND RELAY STRATEGIES IN WIRELESS NETWORKS

Personalisatiation of services delivered by "co-operative radio" also sounds very nice, says McLaughlin, but how do we incentivise users? If subscribers are asked to enable their mobiles to act as mini base stations for other users, bouncing signals from mobile to mobile, then how do we cope with the problems of battery power? Either the phone will shut down in a couple of minutes, or the user will have to pay for the privilege of being part of the co-operative network, helping other users. Ultimately the constraint is the physical layer, and that is where the maths comes in – and also where McLaughlin and his colleagues at the Institute will continue to focus their efforts, as they try to stretch the limits of the possible.

"The electronics industry is always asking how fast new systems will be able to go and how much more data they'll be able to process, but we ask what the real-world limits are, as well as theoretical constraints," says McLaughlin. "We also have to deal with many layers of complexity, right down to the very simplest levels of technology."

Compatible Technology

Like the components in a mobile phone, no-one who's involved in signal processing can work in isolation. The different layers of a digital communication network have to "get on" with each other, and so do the people who work with the separate layers. For example, McLaughlin and his Edinburgh team are involved in the Mobile VCE (Virtual Centre of Excellence) programme, focusing on the physical layer, while their counterparts in Strathclyde focus mainly on the applications layer.

Everyone is asking *what if* questions, but to improve efficiency and reduce power consumption, they also have to ask *how* they will do it. If researchers at Strathclyde come up with something new that places extra demands on the network, Edinburgh have to write new algorithms so the physical layer can cope. If Edinburgh manage to crank extra performance from the physical layer, Strathclyde can think up new ways to exploit the extra capacity.

McLaughlin calls this process "dynamic interaction", and for him and his colleagues, it equally applies to signal processing as human behaviour – and nothing is allowed to interfere.

From bricks to smart dust

Professor John Dunlop and his colleagues at the University of Strathclyde have been working on wireless solutions for several decades, squeezing more and more out of the spectrum as the services and volume of traffic continue to multiply year after year. But even though we laugh about the first generation of cellphones – nicknamed "bricks" because they were so big and heavy – the slimline 3G devices we are using today will look just as bulky, when "smart dust" is sprinkled all over the world...

If wireless telecoms continue to advance at the rate they are going today, telepathy will soon become available for £19.99 a month – or even "Pay-As-You-Think."

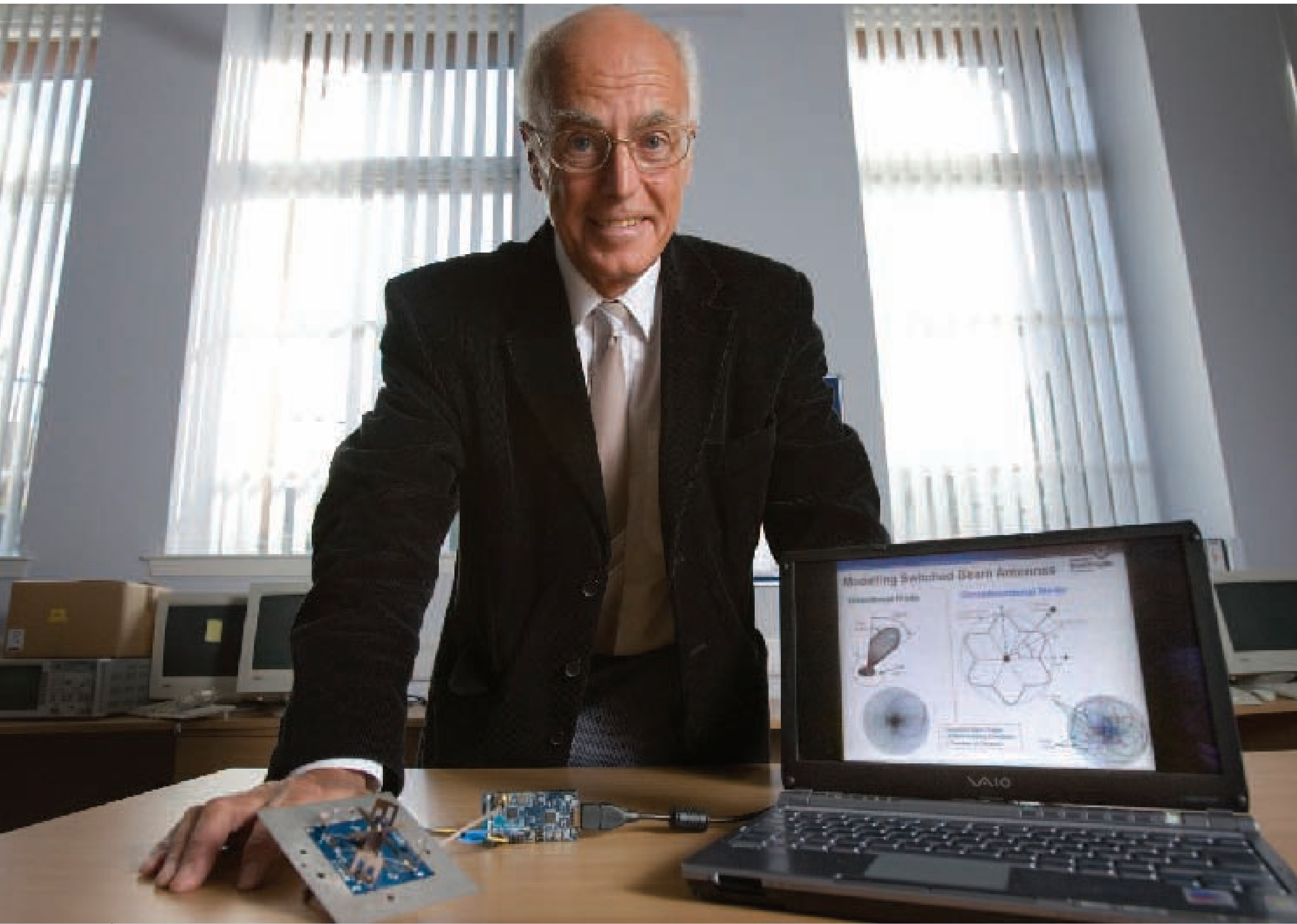
At least, that is the impression you could easily get from Professor John Dunlop, as he talks about the progress we have made since the age of the first mobile handset – the "brick" – and anticipates what is to come in the future.

Science fiction writers would struggle to imagine some of the ideas in the minds of researchers. But for Dunlop and his colleagues, the challenge in the real world is the same today as ever – the available spectrum is finite, and even when analogue TV is switched off, freeing up more bandwidth, demand will soon swallow it up. Service providers will want to introduce more fancy services, and more consumers will demand instant access, everywhere and all the time. Then as soon as developers squeeze some more out of the spectrum, it will soon be consumed once again, and the same old problem will be with us again...

At the University of Strathclyde's Department of Electronic and Electrical Engineering, researchers in the Mobile Communications Group have focused on this basic problem for decades, specialising in several key areas like error correction, in the struggle to accommodate more voice-only signals at the same time as data, and ensure that the signal is steady and clear. The department has also done important work in modelling base stations, helping service providers distribute their network for maximum coverage at minimum cost.

With emerging standards always a critical issue, Dunlop's department was also involved in the "contest" between TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access) – two different ways of using the radio spectrum to allow multiple users to share the same channel. Even though CDMA became the standard for third-generation systems, Strathclyde's work on TDMA produced ideas which helped GSM (the Global System for Communications) to evolve, including a concept called "Link Adaptation", which improves the performance of wireless connections in poor signal conditions.

Link Adaptation helps the network "reach a technical compromise" between number of users and the amount of error protection used to maintain signal quality, and it continues to play a key role in the development of future solutions as well as today's wireless networks. GSM (the second-generation system) is still the most widely used system today and according to Dunlop, Link Adapation can also be used in CDMA and the emerging "fourth-generation" system, OFDMA (Orthogonal Frequency Division Multiple Access).



ADDING SMART ANTENNAS TO WIRELESS SENSORS

The pioneering work which the Department has done through the years in the packetisation of voice also continues to drive its more recent research. For example, in the 1980s, researchers worked out ways of sending voice over Ethernet cables, until then used exclusively for data. In solving many of the problems involved, they further developed their expertise in digital signal processing, and went on to focus on how to prevent bits of voice signals being lost during transmission due to fading – signal restoration and error correction.

For the last six years, Dunlop has focused a lot of his efforts on the Personal Digital Environment or PDE – the "bubble" we all move around in, containing all our digital connections. "From a single handset, users now have a host of devices which collaborate with each other," Dunlop explains. "They move around with us wherever we go, but not always together in physical terms, and this creates a number of problems, including implications for security."

As mobile services become ubiquitous and demand grows for instant access to data from any location, resource management – looking after large numbers of devices, all competing for spectrum – becomes increasingly important to the efficient delivery of services, and this is where Strathclyde has made a number of advances, including in security.

Because it has such a strong background in the mobile arena, Dunlop's Department is also one of the partners in an initiative called Mobile VCE (Virtual Centre of Excellence) which brings together major mobile communications companies and universities in the UK. Started 12 years ago, the Mobile VCE is a collaborative project, funded by the government and industry, which anticipates the future of mobile communications and develops new technologies – and shares the results of research.

Mobile VCE (Virtual Centre of Excellence)

The network for networks

The Mobile VCE (Virtual Centre of Excellence) was set up in 1996 by a group of leading companies and academics, supported by the government, to advance research in mobile and personal communications technology. It currently has about 20 industrial members, including major manufacturers like Alcatel-Lucent, Nokia Siemens Networks, NEC, Samsung and Toshiba, and service providers such as Vodafone, BT and Orange. It has six full academic members, including the University of Edinburgh and the University of Strathclyde.

The main idea behind the partnership is to identify areas where research is needed to enable practical commercial solutions, producing intellectual property which all the industrial members can share, at the same time as strengthening the UK research base. In many cases, the research teams have representatives from several universities.

According to Chief Executive Dr Walter Tuttlebee, the Mobile VCE model will enable companies to access £2.5m-worth of research in 2009, at a cost of £43,500. "This gives them a 'window on the future' and lets them monitor the new technology threats and opportunities which would otherwise fall off the bottom of their budget list in the current economic climate," he added.

Full members also get royalty-free access to resulting patents, recruitment, industry collaboration opportunities, government linkages and elective research – customised initiatives funded jointly by typically 3-6 member companies.

Current projects include:

- Delivery efficiency – optimising wireless resources to enable reductions in cost-per-bit of network connections
- Ubiquitous services – overcoming barriers to the deployment of ubiquitous services in three key domains (user, network and service/content)
- Instant Knowledge – managing the important privacy and security issues for new business services which exploit the power of personal communication devices

In 2009, a new research programme will launch, focusing on three major workstreams - Green Radio, Flexible (self-X) Networks and User Interactions to enable Breakthrough Services.

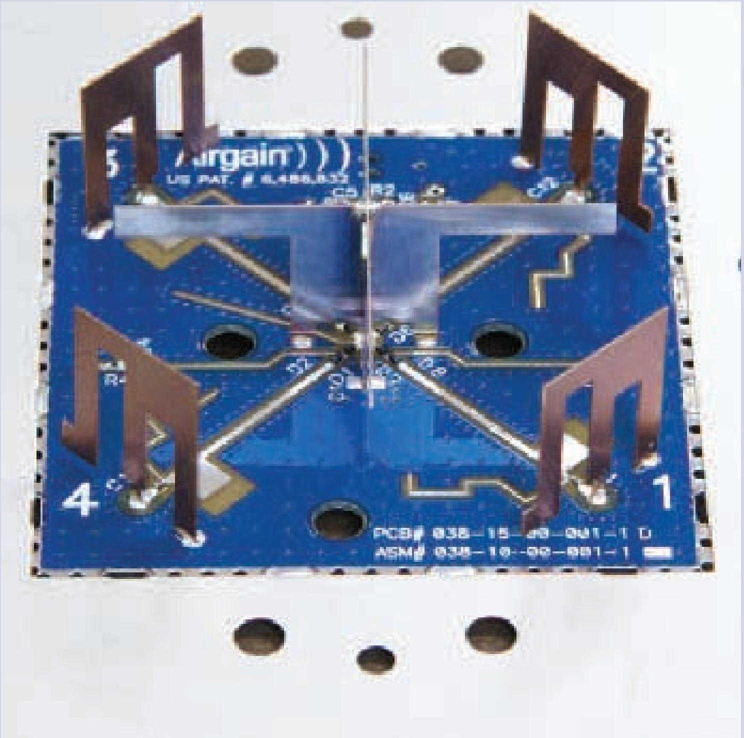
Describing the changes in the organisation over the last 12 years, Dr Tuttlebee said: "Mobile VCE has evolved hugely in that time. It has transformed from a UK-centric research project into a truly global and internationally respected research organisation. It has led many industry missions – to China, Korea, Japan, USA – and has MoUs with leading research institutions in those countries. Its technical focus always has included services and networks, as well as wireless, and this continues. Today's commercial pressures mean that today it is delivering more demonstrations of technology, as well as the more 'traditional' technical reports and patent filings."

Out of this initiative, one of the breakthroughs achieved by Strathclyde is a new kind of concept, patented three years ago, called The Digital Marketplace, which enables subscribers to negotiate prices and quality of service from different service providers, competing with each other for service provision, using special software "agents" which they program with their individual preferences. For example, you may need a lot of bandwidth for data-intensive access during a business trip from Monday to Wednesday, when you are willing to pay for high-quality service, then less sophisticated services from Thursday to Friday, when you're back in the office, and very basic services like voice and texting over the weekend. In every case, the quality requirements are different, and you want the lowest tariff for the particular service you need – except when it comes to more critical work where you can't afford slow speeds, lost signals or errors.

"The business models for consumers and service providers are changing," says Dunlop. As well as creating a new kind of user experience and intensifying competition, The Digital Marketplace will also have an impact on bandwidth and cooperation among different service providers. For example, they may provide coverage for each other in remote areas where some users can't get a signal – saving costs and improving connectivity for everyone concerned.

Following on from this, Dunlop is also concerned with another new concept called Cognitive Radio, which enables users to detect free spectrum and to negotiate with service providers to use their free spectrum or "digital real estate." This allows users to dynamically access available bandwidth. "Several years ago, this wasn't even thought about," says Dunlop, "but now it is becoming a reality."

Similarly, Strathclyde is doing research in Co-operative Radio, which reduces interference and helps users access spectrum by detecting other devices and "piggybacking" signals, so every phone effectively becomes a relaying base station, helping to create ad hoc networks and extending the core network into remote areas.



A SWITCHED BEAM SMART ANTENNA

Strathclyde is also doing research into wireless sensor networks, where the challenges include reducing power consumption and extending battery life – in some cases, sending the sensor to sleep when it isn't required. Another promising technology, being developed at Strathclyde, is the switched beam antenna, so the sensor sends its signal in a particular direction, instead of in every direction, saving power and reducing interference.

Ultimately, this will lead to what is called "smart dust" – tiny sensors which detect and measure things like air pollution, weather conditions and earth tremors, etc. This smart dust will literally be scattered all over the world, and the airwaves will be full of signals, fighting for spectrum. Instead of putting up more and more radio masts, however, Dunlop says the challenge is to make the network smarter by reducing the range of transmissions, using concepts like Co-operative Radio so the signal can bounce from one device to the other.

In an industry where competition becomes more intense all the time, Dunlop and his colleagues at Strathclyde, together with their partners in initiatives like Mobile VCE, are showing that the way ahead will also be increased collaboration, not just between devices but also between different organisations and people.

On track to success

The Mobile Communications Group at Strathclyde has done work for a wide range of industries over the years, including transportation. For example, it had a pioneering role in the transmission of video pictures from trains using the then new GSM development known as high-speed circuit switched data transmission. This work was undertaken for London Underground in the 1990s using a form of compressed video transmission, to relay events occurring on the train to a control room in real time. Radio transmission in underground railway tunnels is a significant problem but it can be achieved using a technology known as the "leaky feeder."

A further development on the public transport theme was undertaken with SNCF, who were considering the next generation of TGVs running at up to 500km/h. The Strathclyde team were part of a consortium which developed a new technique known as "switchover" which allowed multiple users on a train, moving at these high speeds, to enjoy normal cellular communications by rapidly switching a trunked radio link from the train to trackside receivers.

DR MARTIN REEKIE

Analogue conversion

This may be the Digital Age but we live in an analogue world, and Scotland – like most other countries – has a shortage of people with analogue design skills. To address this problem, Dr Martin Reekie of the University of Edinburgh has developed a new teaching tool which turns students on to the wonders of analogue systems...

Dr Martin Reekie says that analogue design is sometimes seen as one of the "Black Arts" of modern technology. Digital systems may grab all the headlines but almost every electronic device needs analogue components in order to function, and designing them requires more flair than algorithmic competence.

What makes analogue technology so challenging, Reekie explains, is that it is not always an exact science – experience or "inspiration" can often play a critical role in design, and that is why it's hard to learn, as well as hard to teach.

In fact, according to Reekie, who runs the analogue design laboratory at the University of Edinburgh, it can take up to seven years of practical experience and further training for the typical graduate to become truly productive in the commercial analogue design environment.

Reekie has spent his career in the analogue and mixed-signal world, and until very recently, feared that we were not producing a new generation of analogue-trained engineers. Too many students were being seduced by the ubiquitous nature of digital technology, and being turned off analogue because they perceived it as being old-fashioned, too complex and full of uncertainties. As a consequence, today's analogue experts are all getting older, and are not being replaced fast enough as they retire.

Industry is crying out for more analogue-trained engineers, says Reekie. Digital solutions may be very good at processing a lot of information very quickly, but the interface with the real world is often analogue. Analogue solutions often consume less power, and as a consequence, mixed-signal systems using both analogue and digital techniques, are becoming increasingly common. Even in systems which appear purely digital, all the very fast signals are essentially analogue, and then we have the EMC and EMI problems, both analogue in nature. When we add RF communications, which are also purely analogue, we see that analogue is posing ever greater challenges to designers and, rather than fading away, it is gaining in importance.

Typically, electronics companies find they need about one analogue designer for every 10 digital designers. However, while we have a lot of digital designers, we don't have many analogue engineers. It's relatively easy to design a device that fits millions of transistors onto a chip, following well-tried and tested procedures, but even though the analogue section may only account for 10 per cent of the chip area, it can take up 90 per cent of the total design time.

One factor that makes analogue different from digital is that analogue design is so varied. Analogue circuits tend not to have one of the big advantages of digital – designs are not so easy to reuse. With digital, you can easily reuse a system designed for another project, but in analogue, even small changes can mean a complete re-design. As a consequence, while digital design automation is absolutely routine, it is much more difficult in analogue systems.

Finally, says Reekie, digital simulations are reliable – if you key in the right data, an accurate answer pops up on the screen. As Reekie puts it, "digital does what it says on the tin." However, when dealing with analogue systems, it is sometimes not even clear what questions to ask the simulator, and when the answers do come, they are only approximate and have to be interpreted.

When learning how to design analogue systems, it's important to learn from mistakes. And according to Reekie, when designing analogue systems it is *very* easy to make mistakes.

ANALOGUE INTEGRATED CIRCUIT DEVELOPED FOR TEACHING AS PART OF THE ASI INITIATIVE

"When things don't work, it's very exciting," says Reekie. In an industrial environment, "exciting'" may mean that the company folds, or the designer is fired, but in the University environment it's educational and fun. When a student tries something different and produces unexpected results, it may be a breakthrough, or it may mean that something bursts into flames, but there's always something to learn.

Reekie says that more analogue "gurus" are needed in industry to develop new products, and in universities to promote the curriculum. And Reekie himself has come up with a novel solution which may address both of these issues at once.

With £100,000 funding from Scottish Enterprise's Analogue Skills Initiative (ASI), plus support from companies such as Wolfson Microelectronics and Analog Devices, Reekie has developed a new integrated circuit (IC) that allows students to design small analogue circuits, make them, and compare the results of computer simulations with practical measurements.

One of the things the new IC demonstrates to students is that with analogue systems, what you get is not necessarily what you expect. When a new design is simulated, it may seem to function perfectly, but when it is actually made, the results can be rather different. This is particularly true if the designer failed to take into account "parasitic components", as they can dramatically change the performance of a circuit.

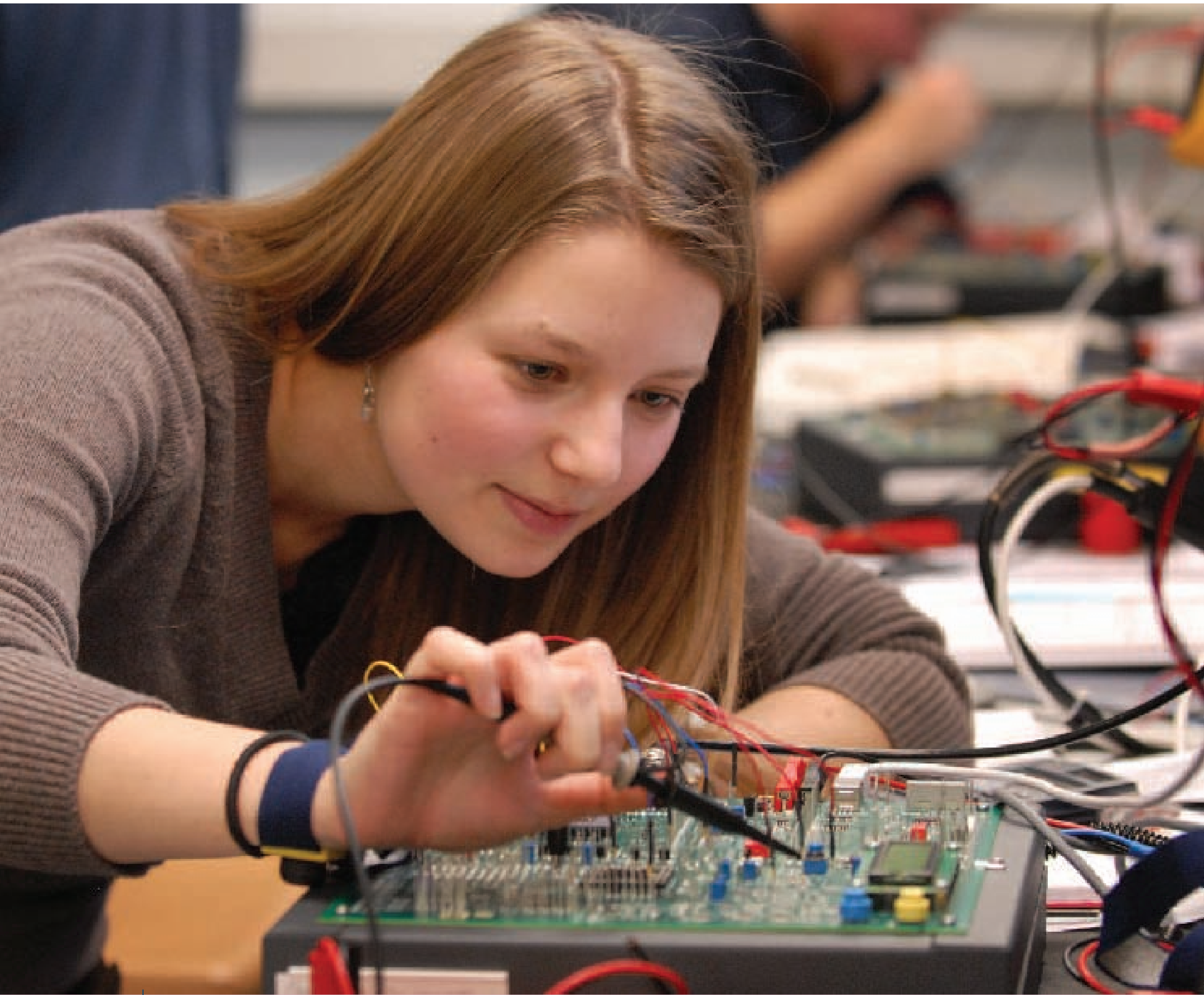
Sometimes, says Reekie, the wrong question is asked at the start. "You simulate the circuit you *think* you have, not the circuit you have," he explains. "Then you can't expect simulation and reality to agree."

The Inside Story

In the past, students used discrete bipolar transistors to learn the ins and outs of analogue design, but most electronic devices today use more fragile MOS (Metal-Oxide-Semiconductor) transistors which don't survive for long in the classroom.

To solve this problem, Dr Reekie developed a new integrated circuit, incorporating several small MOS sub-circuits, plus many individual MOS transistors, all connected to pins on the chip, which is mounted on a PCB (Printed Circuit Board) behind a layer of protection devices. This enables students to work with the MOS transistors and sub-circuits, without breaking them. Scottish Enterprise funding enabled Reekie to produce 70 chips, which Edinburgh students started using in 2006.

The prototype was highly successful, but Reekie has now developed a new PCB for the chip with more advanced new features such as a built-in microcontroller, display screen and signal generator, so students can work on the chip, while at the same time seeing how it interacts with digital circuitry in a fully mixed-signal environment. The new PCB was introduced into the course in September 2008.



STUDENT WORKING IN THE ASI LAB

At the simplest level, Reekie says, "doing is learning" for analogue students. The new IC allows students to build small analogue systems, almost as though they were designing, fabricating and measuring a new IC every time. Over two years, 80 students and six demonstrators – teaching staff and PhD students – have worked with the new IC and Reekie says they're learning all the time how to make better use of its features. In addition, adds Reekie, it is helping to develop students' problem-solving skills, while "removing the fear" from analogue studies.

The new IC converts what used to be a problem into something that actually motivates students, by providing a practical teaching tool that enables students to see their ideas in action, and help them appreciate the gap that often exists between simple theory and practice. When the students see that simulation and reality are different, they know that they can't change reality, so they begin to see the problems associated with analogue simulation. They then adjust their simulation, to make it better model the true situation, and find that simulation and reality begin to correspond. Throughout the whole process, they gain the experience of practical and theoretical work that is so vital to analogue designers.

In most electronic devices, analogue signals are converted to digital data and, over the last few years, students have converted in a similar way. However, if Reekie and his new IC continue to succeed, perhaps the process will reverse and the shortage of analogue design skills will soon be a thing of the past.

The evolution of innovation

If Wireless Innovation does its job well, it will change beyond all recognition in a couple of years. As a focal point for wireless and mobile companies in Scotland, seeking to develop their businesses, the organisation is not just a business advisor but an incubator helping to hatch new ideas and new companies – and a new approach to innovation itself...

ALISDAIR GUNN

Even though the sign says "Wireless Innovation", the name tells a very small part of the story. According to Senior Innovation Manager Alisdair Gunn, "the initiative is not just about new wireless and mobile solutions but also about supporting the growth of a new generation of entrepreneurs and inventors". And what Wireless Innovation is doing for the wireless and mobile sector, Gunn says, is already inspiring similar initiatives in other emerging sectors – for example, Wellness and Health Innovation.

Wireless Innovation itself also has to keep up with industry trends and evolve at the same rapid pace. Established in 2003 by Innovation Centres (Scotland) Ltd, with funding from the Scottish Government's Economic Development Agency, Scottish Enterprise and the European Union, the initiative started with a six-month pilot study, "to identify the range of market failures that were curtailing the growth of companies in this global, high-technology sector."

"From the outset," says Gunn, "we wanted to clearly understand and articulate the specific issues preventing the development of new applications as well as identify the barriers behind the routes to market. Ultimately, this boiled down to starting with a clean sheet and developing a portfolio of focused specialist support for companies."

The emergence of a new industry also required a new business approach. "At an early stage we quickly learnt that many of the emerging companies were struggling to understand what were the important changes taking place in the wireless and mobile markets, and how to translate this impact successfully back into their product and business propositions," says Gunn.

To overcome these issues, Gunn and the newly formed advisory team set out to devise, develop and implement a range of specialised market analysis/intelligence, product development and business development services that were "created from a bottom-up and top-down approach."

Because Wireless Innovation "spoke the same language" as the people they dealt with, more and more companies gradually gained the confidence to access their support services. And according to Gunn, the key to success was creating a team of expert advisors from industry who had years of experience in marketing, product and business development, working with the major global players – in Gunn's case, Hewlett-Packard, Agilent and Philips.

MOBILITY

During the initial pilot stages, Wireless Innovation made over 120 contacts, by holding thought-leadership seminars and other events, and directly engaged with about 30 companies. At the end of the six-month pilot, the new team submitted their findings, which secured further funding from Scottish Enterprise.

But when Gunn is asked now what the sector will look like within a few years, and what types of clients will need the same kind of support, he says: "We are at the cusp of the Digital Wave. Previously, the computer, mobile phone and internet were standalone technologies, but that is no longer the case. They are converging across several vertical markets. The mobile phone is the new handheld computer."

Nobody can say with any certainty what the future will bring, but some trends are clearer than others. "Wireless & Wellness" may be one of the next major trends, for example, but it's hard to know what the new health-care devices will look like or how fast consumers will adopt them, says Gunn. "There will also be much more convergence in areas like broadcasting, advertising and digital media," he adds, "but predicting what will be the next high revenue-generating trend in the wireless and mobile sector can be guesswork for companies. We can help reduce the guesswork with our experience, expertise and market intelligence."

The wireless and mobile market has grown from virtually nothing to around $1 trillion within 20 years, says Gunn, with 4.6 billion subscribers and 1.7 billion handsets a year being shipped by 2011. Eight years ago, the industry was still relatively embryonic, and some ideas which may have seemed obscure at that time are mainstream today. So, faced with this pace of change and highly complex economic conditions, how do you identify the companies and ideas that are most likely to succeed?

Talent spotting may not be an exact science, but Wireless Innovation does have clear criteria. "We look at the individuals," says Gunn, "their experience and vision, and their understanding of what is involved from the beginning to the end of the development and market launch process. We also want to see a roadmap for the new product or application, and ask if the technology has intellectual property potential. Finally, we ask if they are working in a growth market, if they are globally minded, and what kind of contacts and linkages they already have."

Gunn also says that Wireless Innovation sometimes "takes a risk" with certain companies, if their idea is extremely innovative but also seems to have commercial promise.

Wireless Innovation has "engaged" with over 250 companies since it was founded and is actively working with 120 companies. It currently works with about 30-40 companies at a "high-intensity" level, across Scotland. Several of Scotland's wireless and mobile companies also take advantage of the unique level of innovation support and specialist advisory services provided by Wireless Innovation's parent organisation, Innovation Centres (Scotland) Ltd. Formed to transfer expertise to other parts of Scotland, ICS provides support through its business incubators – Hillington Park Innovation Centre (HPIC) near Glasgow and Alba Innovation Centre (AIC) near Livingston.

The services that Wireless Innovation provides to its "clients" include business development, market intelligence and product development support, plus a test and developer facility at HPIC. Above all, ICS is an independent organisation which was set up to stimulate and nurture new businesses, and facilitate emerging business opportunities.

"We advise, not consult," Gunn explains. "We support the companies' executive team. We also focus on providing specialist sectoral support, and access to information. We also help to make introductions, thus creating new business opportunities. Our main aim is to accelerate the business."

According to Gunn, one measure of Wireless Innovation's success is when companies no longer need their advice. Initially, most clients need lots of market intelligence to help differentiate their product offering, but this tends to taper off as time goes by, while the focus on partner development continues to increase.

One of the key strengths of Wireless Innovation has been its ability to develop close working relationships with industry leaders like Qualcomm, Nokia, Orange, Oracle, Siemens, Channel 4, T-Mobile and Microsoft. At the Hillington Park Innovation Centre, companies like Research in Motion, the developers of the Blackberry, have established a presence at the centre – adding to the atmosphere and getting involved in the everyday life of the centre.

Many observers say Scotland is very good at producing inventors, especially in IT and electronics, but not so good at sales and marketing. Gunn also says that Scotland is a leader in "developing new processes, procedures and best practices," but exports too much of its technological talent. Wireless Innovation does not see its primary aim as reversing the digital brain drain, but inevitably that is a topic which always comes up in discussions.

Gunn believes that Scotland would undoubtedly benefit from attracting more "anchor companies" like BBC, HP, Oracle, Agilent, Dell, O2, T-Mobile, RIM or Freescale, who already have an established presence in Scotland. This would bring decision makers and market influence closer to Scotland, and give graduates a structured approach to developing their business and product development skills rather than heading abroad.

But Gunn also recognises that an anchor investor would not be a cure-all, because business models and markets are changing so quickly. For example, he explains, after the fall-out from the dotcom explosion, many large global players changed their approach to research and development, focusing on mainstream products rather than way-out ideas.

Instead of jealously guarding their products at all costs, the large corporations are now more comfortable with "open innovation models," and happy to work with external partners like the young, creative companies now emerging in Scotland. And this is exactly where Wireless Innovation comes into the picture, bringing new partners together, and acting as a trusted advisor with the infrastructure needed to support the young companies. "We are a catalyst, creating a critical mass of companies. This critical mass attracts the Global Players," says Gunn, adding that our home-grown SMEs can play a similar role to the large corporations by retaining our home-grown talent, with a little help from Wireless Innovation.

Do the large corporations cherry-pick all the best ideas and talent? According to Gunn, they now see a greater value in cultivating external partners who have much more freedom to be innovative and "think out of the box." Collaboration is replacing competition as the secret of business success in the emerging digital markets. Acquisitions, partner development programmes and sector-specific venture-capital funds each enable big players to leapfrog their rivals, much faster than doing all R&D in-house.

Wireless Innovation is a gateway to the industry in Scotland, with no commercial stake in the companies it works with – just a passionate interest in the sector's success as a whole. When an overseas company is looking for partners in Scotland, Wireless Innovation is a good place to start, because it "filters" and presents the best talent. "We see a lot of very different companies and get to know which are the ones to watch," says Gunn.

As one of the founders of Wireless Innovation, Gunn can be proud of the organisation's achievements to date, but he is also aware of the challenges lying ahead. He thinks growth will come in areas like Cloud Computing, Energy Conservation, Wellness/Health, Digital Media, Security and the Environment, with wireless solutions becoming increasingly pervasive in every area.

"Existing companies will have to upskill," he says, "and there will be more cross-fertilisation between different sectors." Gunn also believes that Wireless Innovation will have to be as agile as the companies it works with, reinventing itself all the time to meet the challenging conditions of the future.

Fasten your seatbelts

If anyone was drawing up a business plan for an organisation which aimed to become a leading player in the electronics industry, it's unlikely it would take the shape of Steepest Ascent. But the Glasgow-based company is quickly becoming a major influence on digital signal processing and communications, advising major players in the industry and helping shape the future of technology...

LEFT TO RIGHT
GRAHAM FREELAND, BOB STEWART, DANIEL GARCIA-ALIS

Garrey Rice and Daniel Garcia-Alis are flying to Japan tomorrow, and the next day, they will meet a group of engineers from one of Asia's leading mobile phone companies to talk about how to develop the next generation of mobile devices. Two days later, they will fly home to Scotland, and be at their keyboards in Glasgow the following morning, slightly jet-lagged but ready for business. It's all in a normal week's work for Garrey and Daniel, and everyone else at Steepest Ascent – working with big names like Nokia, Qualcomm and Xilinx, in locations all over the world.

For Technical Director Bob Stewart, jet lag was not such a problem on his recent overseas trip. He was lucky – just a quick flight to South Africa for half a day's consultancy, then back home to Glasgow, without readjusting his watch.

Working overseas has become part of the company's normal routine, and the international origins of Steepest Ascent can be traced back to the late 1990s, when Stewart was teaching an industry short course in Los Angeles, and realised that he and other like-minded people had something precious to sell – their knowledge and experience of DSP (digital signal processing). The visiting professor (he had previously worked in Minnesota as well as at USC) was not just rubbing shoulders with some of the industry's leading executives and engineers but showing them what to do.

Back in Glasgow, Stewart also realised that Scotland was losing one of its greatest economic resources. As an academic supervising PhD students year after year at the University of Strathclyde, he could see a large percentage of the engineering talent going to England or overseas to get suitable jobs, so when the opportune moment arrived, he decided to persuade a few top graduates to stay – and become part of Steepest Ascent.

"We had virtually no business experience, no staff, no office and capital assets of zero," says Stewart, "but we did have a couple of very good prospects in the shape of a DSP communication design contract for a company in Minneapolis and the offer to take ownership of some 3G mobile software IP from a partner company, Entegra."

Time for take-off.

Thanks to Stewart's time spent in America and his increasing industry profile, he was able to point colleagues in these blue chip companies towards the newly founded company, and within a few months, two more development contracts were in place, and these formed the basis of Steepest Ascent. In the early years of the millennium, the company's talented team was attracting attention from several potential investors, including a US-based organisation which wanted to establish a base in Europe. Then, in mid-2005, the US partner suddenly announced that "the window of opportunity may have been closed" – the US company itself was being taken over and its Scottish plans were cancelled. It looked like a setback, but rather than being the end of a dream, it was just the beginning...

"There were five engineers in the company in April 2005," says Stewart. "We also had two development contracts, plus the IP (Intellectual Property) from Entegra, so we thought, let's get more work, get our heads down and move this forward."

The name "Steepest Ascent" had been registered the previous year – partly to reflect the mountaineering interests of the company's Chief Software Engineer, Graham Freeland, and a play on words which only electronics engineers would appreciate, based on a well-known algorithm called "Steepest Descent."

Freeland, who had previously worked with Entegra, had a few ideas about developing new simulation libraries – the tools used in the testing and development of new digital communication devices and standards. Add on the determination to succeed and remain independent, and the formula was more or less complete.

"We didn't want to borrow any money," says Stewart. "One of the simplest and best pieces of advice was from Campbell Murray at the Scottish Enterprise High Growth times – you know what's best for your own company."

Apart from its products and services, what also sets the company apart is that it is not a traditional IP "spin-out" from a university, but a start-up underpinned by talent from the University of Strathclyde. "Most people are familiar with the spin-out concept," says Stewart, "but Strathclyde is also encouraging towards start-ups based on critical mass and capability, and even on spin-ins, where new technology companies can find a strong partner in the University."

Steepest Ascent was also wholly funded from the start by its revenues, including a six-figure dollar contract secured within 12 months of its establishment, for the development of next-generation communications systems. In fact, says Stewart, Steepest Ascent has always felt that it would not be of interest to traditional venture capital firms – its assets are primarily its brains, its first-rate engineers and its specialist software, and its ability to win strategic contracts via an extensive list of contacts and customers.

Today, the company has a team of 12 based in Glasgow, including five PhDs, with recent work on digital communications including standards such as 3GPP, cdma2000, 802.11, DVB-T/DVB-H, 802.20, 802.16 and Bluetooth, plus a number of proprietary wireline communication standards. Its products include simulation libraries and software simulation solutions, and the company also provides an automatic VHDL generation solution. About 60 per cent of the company's business currently comes from overseas sales.

In addition, Steepest Ascent has a roadmap to develop further simulation libraries, most specifically for 3G LTE. "With mobile devices," says Freeland, "get ready for another revolution and quite incredible data rates to handheld devices via the enhanced 3G LTE developments." The company has also been involved in the IEEE Mobile Broadband Wireless Access (MBWA) standards group and been a voting member to define the new standard. It is also doing work on embedded software products, although the emphasis is very much on wireless communications solutions.

As well as consultancy and software development, the company holds short courses and on-site consulting events for professional engineers, covering the spectrum of DSP and communications, from theory to practical implementations – one of the strengths of the evolved (rather than planned) marketing model. "We can send in two of our engineers to a company to present, say, on 3G LTE," says Garcia-Alis, one of the managers, "and when the time comes for the company to purchase a new library or get some development work outsourced, they might just remember the two competent guys from Scotland that came by."

Stewart, who is a Professor at the University of Strathclyde's Department of Electronic and Electrical Engineering, describes the company's growth as both cautious and "organic" and expects it to expand at a rate of about 30 per cent per annum, over the next three years, in terms of revenues and people.

In Stewart's other role, as founder and director of DSPscotland, an alliance of companies, research institutes and universities set up to promote the DSP sector at home and abroad, he is keen to see the industry not only grow but get more recognition for what it contributes to the Scottish economy. Steepest Ascent's contribution may not seem dramatic in financial terms but it does provide the kind of intellectual energy and strategic thinking which is needed to drive technology forward in Scotland, as part of a cluster of companies which add up to considerably more than the sum of their parts. It is also a model for the "intelligent enterprise" of the future, living on its wits rather than manufacturing widgets.

Steepest Ascent also believes in "marketing by doing" – instead of the hard sell, it simply gets on with its business. It also gets involved in sponsoring selective events like Femtocells Europe 2008, where its name will be mentioned in the same breath as large corporations like Cisco, Vodaphone, and Huawei – not bad company to keep, for a start-up still a long way from reaching its peak.

Real world interface

Wolfson Microelectronics has been one of Scotland's highest achievers in the electronics industry for more than 20 years. Thanks to its expertise in mixed-signal technologies, it "accidentally" got into the consumer space eight years ago, providing solutions for top-selling products like the iPod and Xbox, but its spectacular success since then has not been any accident...

According to Peter Frith, Wolfson Microelectronics has been "punching above its weight" since it was founded, but today it is fighting in the same ring as some of the industry's giants.

Frith, who is now the Chief Technical Officer, joined Wolfson back in 1985, when it employed just 16 people. But today the Edinburgh-based company employs about 375 people worldwide and has offices in 12 countries, including the US, Japan, China, Taiwan, Korea, Singapore and India, generating revenues of about £117 million last year – 10 times more than 2001.

A major factor in this recent growth is Wolfson's major breakthroughs in consumer electronics, working with large corporations like Microsoft, Apple and Sony to deliver high-performance audio and imaging solutions, with an emphasis on ultra-low power consumption. Its mixed-signal semiconductors can now be found in a wide range of devices such as mobile phones, digital cameras, flat panel TVs, portable navigation systems, Hi-Fis, all-in-one printers and scanners, as well as portable media players and gaming consoles.

Wolfson's surge in business would have been very hard to predict just a few years ago. At the turn of the millennium, the high-tech industry was going through difficult times, but the portable communications market bucked all the trends, and when Apple started designing the iPod and Microsoft was busy with the Xbox, Wolfson was well placed to take full advantage...

How it happened

Right from the start, Wolfson had specialised in mixed signal technologies, avoiding the hot competition in the digital sector – like several other canny companies in Scotland at the time. This meant Wolfson focused on the interface between the real (analogue) world and the digital world, and spent its first 10 years designing custom mixed-signal solutions, in the process building up its expertise in audio, and mixed-signal circuits with low power consumption.

Over time the company started building audio solutions for digital communication devices, including PDAs, and these became increasingly sophisticated (and much more compact) and evolved into solutions for the latest generation of mobile phones.

Sound idea

The WM8350 is an integrated sound and power management solution developed by Wolfson, designed for use in portable media players, navigation devices and VoIP handsets – plus other portable devices powered by single-cell lithium batteries. The new device offers a high-performance audio CODEC for high-quality stereo playback and recording, and is compatible with leading multimedia application processors. It also incorporates low-power audio technology to extend the battery life, plus programmable on-chip amplifiers to enable direct connection of headphones and microphones.

According to Wolfson, the reduced external component count saves about 25 per cent on bill of materials (BOM) costs, while the compact size (7mmx7mm) saves up to 50 per cent on the physical PCB board area. Another benefit is built in "pops and clicks" suppression, which enhances the sound quality and reduces the need for external circuitry.

The WM8350 incorporates six DC-DC converters and four low-dropout regulators to generate programmable supply voltages for different components such as a digital core, I/O and backlight display, in addition to the integrated audio CODEC. This eliminates the need for separate power management ICs and reduces the overall component count.

An on-chip battery charger supports programmable charging modes for single-cell lithium batteries. The charge current, termination voltage and charger time-out are programmable to suit different Li-Ion or Li-Pol batteries. Automatic power supply selection between battery, USB or a wall adaptor enables 'instant on' operation even if the battery is fully discharged. Autonomous battery charging is possible whenever the USB or wall-adaptor supply is connected.

Internal power management functions control the start-up and shut-down sequencing of clocks and supply voltages. This provides protection in the event of undervoltage or extreme temperature conditions. It can also detect deeply discharged or defective batteries and adjust the charger parameters accordingly with a minimum of software involvement.

PETER FRITH

Frith suggests that portable devices typically comprise five separate functional blocks – one each for display, processor, memory, RF (radio frequency) and 'real-world' interfaces (audio, power supplies, battery charging and sensors). It is this last category of 'real-world' interfaces that Wolfson targets with its technologies. The company is 100 per cent fabless, subcontracting manufacture of its semiconductors, so it can concentrate on its "tightly defined core competencies of product definition and design, and its in-house test and measurement facilities."

According to Frith, the challenge today is much the same as years ago – aiming for the smallest geometry and lowest power consumption per function, while building in the smartest, best-performance components – in other words, reducing cost and size at the same time as improving performance, packing in more features and extending the battery life.

Driving trends

In a global market changing every day, Wolfson also tries to keep one step ahead of the industry, driving trends and "defining better solutions" rather than simply following instructions.

For example, says Frith, when a customer has a new product designed to do one task, the Wolfson engineers may see the potential to incorporate other functions – like power management or fitting in an additional speaker driver.

"We always aim to establish a tight engineering relationship with all our customers," says Frith, "and try to find a better way of doing things, not just produce what they initially ask for."

One of Wolfson's biggest initiatives in recent years has been a product strategy called AudioPlus™, broadening the scope of its audio products to focus on what the company describes as "Pure Sound, Smart Power, Enhanced Soundware and True Mics," including high-performance silicon microphones

– or "mics on a chip." One of the latest additions to the AudioPlus™ product strategy is the WM8350 sound and power management solution (see sidebar).

With Pure Sound, the aim is to reproduce audio signals as close to the real thing as possible, eliminating noise and distortion. "Power is a never-ending battle," says Frith. "As soon as the battery life is extended from two hours to eight hours, the product designers immediately add extra features which reduce it back down to two hours." Ultra-low-power-consumption CODECs, integrated power management functions and low-power amplifiers are among the ways that Wolfson addresses the problem.

Wolfson's Enhanced Soundware is built on technology it acquired with the purchase of a company called Sonaptic who developed audio software algorithms. Now Wolfson is combining these algorithms with its mixed-signal technologies to bring exciting new technology such as ambient noise cancellation to mobile handsets.

"First, we established credibility in the audio market," says Frith, "then we defined the devices. Now we have moved on to optimise the feature set, aiming for more inputs and outputs, lower power consumption and smaller size."

For Wolfson, it will always be important to predict where the industry's going, says Frith. This means anticipating and helping to steer new developments in real world interface technologies like sensors, drivers and power supplies, including technologies such as MEMS (microelectromechanical systems or very small micromachines) for microphones, and future applications like accelerometers or ultrasonic sensors.

Some of these ideas seem out of this world to begin with, but now that the company is mixing it with some of the industry's giants and shipping over 300 million silicon chips a year, it is more confident of betting on its future – in the real world.

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