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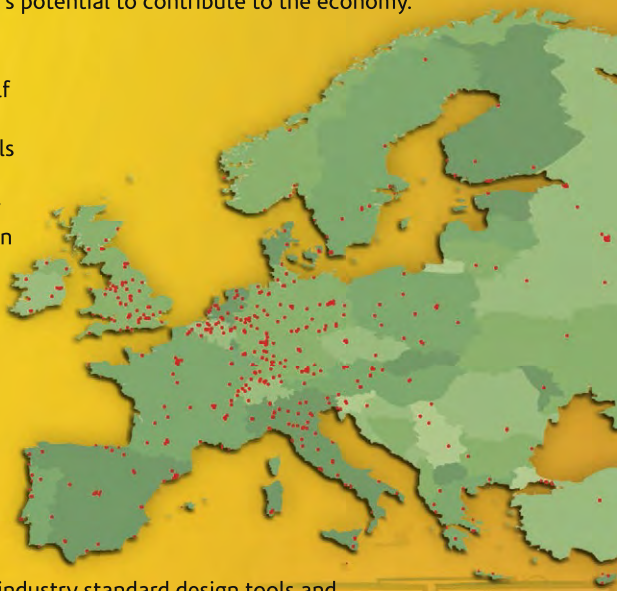
NMI YEARBOOK 2015
NMI YEARBOOK 2015

Training Engineers of the Future

Enabling academic institutes to produce more relevant graduates for industry

The electronics system design sector in the UK and Ireland requires a continuous supply of well-trained graduate and post-graduate students in order to continue to flourish, compete with other regions and fully exploit the sector's potential to contribute to the economy.

The Microelectronics Support Centre at STFC Rutherford Appleton Laboratory has, on behalf of over 650 European academic institutes, negotiated affordable access to the latest tools from many of the world's leading design tool vendors and provides them in a managed way that offers fully integrated multi-vendor design flows for research and student training.



In addition, advanced train-the-trainer courses on a wide range of topics are offered. These courses are run by staff from STFC's Microelectronics Support Centre and are designed to introduce post-graduates, academics and researchers to the best design methodologies and tool practices for electronic system and ASIC design.

By creating a common infrastructure built on industry standard design tools and flows, coupled with advanced training and support, we enable universities to conduct industry relevant research and to train the highly capable engineers which form the lifeblood of the electronic system design industry.

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Science & Technology Facilities Council

Head office: Science and Technology Facilities Council, Polaris House, Swindon, UK.
Establishments at: Rutherford Appleton Laboratory, Oxfordshire; Daresbury Laboratory, Cheshire; UK Astronomy Technology Centre, Edinburgh.

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NTEKlitho have an extensive supply of parts for the full range of Nikon Stepper and Scanners, we have currently manufactured our own illumination optics up to the S204 range with the S205-S207 currently at the testing stage before release. In addition to this we have successfully acted as agents on the purchase and sale of Nikon Equipment through our connections to our broker network worldwide.

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Baroness Neville-Rolfe DBE CMG
Business Minister

MINISTERIAL **FOREWORD**

As Minister for Intellectual Property, I have seen first-hand how electronic systems are at the heart of our economy, underpinning innovation in our manufacturing and services. As part of the Government's commitment to the Industrial Strategy, I am delighted to work with the electronic systems sector and to Co-Chair the Electronic Systems Community (ESCO) Council with Warren East.

MY PREDECESSOR Michael Fallon, now Secretary of State for Defence, wrote last year about how this partnership between industry and Government was a good example of rebalancing the economy through building a dynamic, open and competitive business environment in which our companies can grow and thrive. This complements the investments in innovation made by Government through Innovate UK, and by providing funding directly to support projects through the Regional Growth Fund and Advanced Manufacturing Supply Chain Initiative.

This is in the face of significant challenges. In particular there are concerns about the state of the global economy, which is vital to sectors which export much of their production.

I am convinced that by working together in partnership, Government and industry can identify and address barriers to innovation and growth. The ESCO Council has set ambitious targets for growth by 2020: to increase the sector's economic contribution by 50% (from around £80 billion per year to £120 billion) and to create a further 150,000 highly-skilled jobs in the sector.

In my conversations in the Council, on a recent visit to the sector in Cambridge and elsewhere, I have been struck by how much goodwill there is to meet these targets and address the challenges that the sector faces. Over the past year, the Council has worked to deliver improvements in skills and enabling technologies, recognising that these are long-term challenges which will not be solved at the push of a button. ESCO has also focused on opportunities for growth in key markets from the Internet of Things and the impact of new technology in health and social care, to Industry 4.0 and robotics and autonomous systems.

What has been achieved so far would not have been possible without the efforts of individuals and organisations working in partnership. I am delighted that this includes bodies such as NMI. I am grateful for the support you have given ESCO and for the direct input from a number of NMI's member companies.

However, it is clear that there is more to do. I look forward to continuing to work with ESCO and the wider electronic systems sector in the year ahead to achieve growth and prosperity for all.


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Stan Boland
NMI Chairman

CHAIRMAN'S **STATEMENT**

It has been my privilege to chair NMI during 2014, working with Derek Boyd and the NMI team as we sharpen the mission and drive important initiatives to help make the UK a natural home for the world's most successful technology companies.

AS YOU'LL see in this Year Book, NMI already makes an enormous contribution to our industry. We all signed up as members because we value that contribution but we also know that, by increasing the extent to which we link companies together, we can achieve a lot more and plan to increase our emphasis on that networking.

The UK is – and will remain – a truly innovative and creative place to design, engineer and manufacture deep technology products and services. But figuring out what tomorrow's products and services should be means we all need to continuously learn about new layers of technology, about successful business models, about how to work with others and about choosing specific vertical applications. That isn't an easy task. But NMI's job is to make it a whole lot simpler, thereby ratcheting up your company's – and therefore our nation's – performance several notches. That's our aim.

We know that this can be achieved through market-specific communities (we call them Innovation Networks) as proven by our Automotive Electronic Systems Innovation Network (AESIN). You can expect to see more of these, linking people together on a national scale and proving that one plus one really can equal at least three. We recognise that our core strengths lie in deep technology, starting with semiconductor, embedded software and hardware systems. But what's also becoming increasingly apparent is that deep tech companies can't easily propagate their technologies without a more complete solution being developed and offered to the market. This means that winning deep tech companies now need to know more about the other links in the product chain, like security, cloud computing and application software. So we aim to broaden the reach of NMI to these other vital areas of deep tech. In doing so, we aim to play a full part in helping you build successful enterprises.

For this to happen quickly, we need your active engagement and energy. We can promise the effort will be worth it, so do get involved and enjoy the experience!

Derek Boyd
Chief Executive

CHIEF EXECUTIVE'S **STATEMENT**

Welcome to 2015's NMI Yearbook – a great summary of the work we do at NMI, supported by a fascinating series of articles on contemporary topics within our gloriously diverse industry.

AS I LOOK BACK on 2014, I see it as a year of change. As well as changing the shape of our organisation, our brand to reflect the fact that we're now not just one but a collection of many 'connected communities' and our strapline, we've had significant staff changes for the first time in several years. We've also been working with a new Chairman with new insights, and we see new mission initiatives for NMI.

Right now, NMI's role includes:

- Supporting engineering and manufacturing excellence across a broad range of communities and sharing know-how between different sectors.
- Supporting innovation by bringing industry together in a way that helps organisations more fully understand the challenges faced by customers and creating forums for developing new partnerships and business models.
- Working closely with industry to collate interests and highlight opportunities for R&D investment to Government that are aligned with members' interests.
- Raising awareness of the importance of 'deep tech' in a modern digital economy. "It's more than just apps", to quote Sir Hossein.
- Collaborating with other organisations to develop simpler and more effective industry engagement and representation.

If we cast our minds back several years, we can see how far NMI has come. Benefiting from our members' passionate support and belief, NMI has grown in scope and scale into a body that's now critically important to the future of the UK. I say this because I firmly believe that there's insufficient understanding in the UK of the role and nature of electronic systems and indeed 'deep technology'. Failing to engage with and strategically support electronic systems in the way that many other leading modern economies are doing would be a tragic failure for our nation. Working with others, that's the message NMI carries forward on your behalf.

This presents the NMI team with a challenge. From our very first day, we have engaged with and supported people at all levels in their journeys towards excellence, be it through supervisor development workshops, site assessments, R&D workshops or technical networks. We never intend to lose that grass roots connection with the 'real stuff'. Now that NMI has become the focal point of our industry, however, we're facing increasing demands on our Representation activities and external-facing side of our work, which are too important to fail.

To support both aspects successfully, we need to increase our resources. Mindful as we are of price

"WE HAVE 270 MEMBERS TODAY, BUT WE KNOW OF HUNDREDS MORE WHO WOULD BENEFIT."

Derek Boyd
Chief Executive

sensitivity, that means growing our membership and scale. With greater scale comes added value for our members, since it increases the number of connections within our network, as well as the opportunities to partner and learn, to develop new business, and to collate interests and represent ourselves more effectively. We have 270 members today, but we know of hundreds more who would benefit. Our job is to sell the value of this industry working together and to continue to provide direct support today, while investing in longer-term activities that should result in a brighter future for our industry in the UK tomorrow. With your ongoing support and advocacy, I firmly believe we can achieve this goal and, on behalf of the NMI team, I look forward to working with you on that in 2015 and beyond.

Derek Boyd

ANNUAL REVIEW **OVERVIEW**

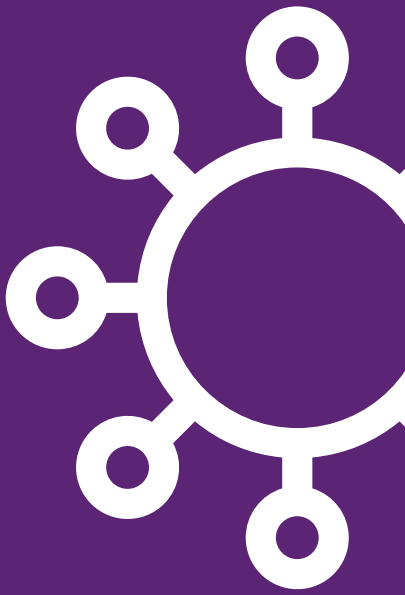
NMI is the champion for the glorious and diverse UK electronics industry.

Our mission is to help make the UK a leading location for electronic systems and related technology businesses.

We lead the agenda, drive key initiatives and provision valuable services for our members.

NMI's work includes:

- Encouraging innovation, communication and collaboration through networking, funding, brokering and signposting activities.
- Representing the electronic systems, micro and nano-electronics sectors to government, policy makers and public funding bodies.
- Supporting skills development, education and training.
- Improving operational efficiency through benchmarking and best practice initiatives.
- Providing an industry specific information flow.



REPRESENTATION

The champion of electronic systems in the UK, NMI gives a common voice to a gloriously diverse industry and communicates its needs effectively to Government, academia and funding bodies.

"WE PROMOTED MEMBERS' INTERESTS FAR AND WIDE, ATTRACTING BRIGHT YOUNG MINDS INTO THE INDUSTRY..."

For that to happen, we knew we would need to open up a more direct channel to Government. So, working with others, we produced the ESCO Report, which included setting up an industry council as one of its key recommendations. One year on we've achieved our goal: the ESCO Council has been formed and industry's engagement with Government is greater than it has ever been. NMI's role in shaping the R&D agenda and the new Electronic Systems Apprenticeship Trailblazer, both of which are covered later, are just the first examples of how we'll now use this channel to good effect. Building on our work with the Migration Advisory Committee (MAC), we also added our voice to a petition to ease recruitment restrictions important for businesses.

Echoing NMI's new strapline, 'Semiconductors to Systems', NMI delivered tangible benefits to members from right across this spectrum, under the guidance of our various advisory boards. As well as completing an unprecedented consultation exercise on the needs of the UK power electronics community that will provide a blueprint for this cluster going forward, we also helped our manufacturing members take full advantage of the new Climate Change Levy (CCL) reporting framework, securing savings of £2.5 million in 2014 alone.

We also promoted members' interests far and wide, attracting bright young minds into the industry, stimulating investment and generating sales.

A showcase for the industry, 2014's Future World Symposium (FWS) featured keynotes from the Government's Lord Younger and European Commission's

Khalil Rouhana. In total, 27 speakers from 23 organisations shared the latest thinking on the Internet of Things (IoT), Connected Home, Autonomous Systems and Connected Intelligence sectors, attracting over 200 attendees. Broadcasting our message to potential customers, NMI helped a growing number of members to attend major international trade shows in Shanghai, Moscow, San Francisco and Grenoble. Further bridging the gap in the supply chain, we ran table top exhibitions at Integral in Minsk and the University of Warwick, and held our first Meet the Supplier event. In November, the major social and networking event of the year for the UK's electronic systems industry, NMI's Annual Summit, Dinner and Awards, provided the perfect forum to celebrate all that's great in our industry. Focusing on Growth and Investment, 2014's Summit highlighted the need for success in 'deep' as well as 'light' tech, to align our collective interests on skills and direct more of the available public funding towards innovation.

Championing the UK's capabilities to a wider audience, we produced a Sunday Telegraph supplement on the future of electronics and our annual NMI Manufacturing Suppliers Directory, listing over 100 specialist companies. 2015's edition promises to be our biggest yet!

Enabling members to keep abreast of the latest developments however and whenever it suits them, not just in print, we started to make increasing use of social media, including LinkedIn, Twitter, Google+, Facebook and YouTube, while refreshing our own website to provide a better user experience and improved platform for getting our message out.

"2014'S SUMMIT HIGHLIGHTED THE NEED FOR SUCCESS IN 'DEEP' AS WELL AS 'LIGHT' TECH..."

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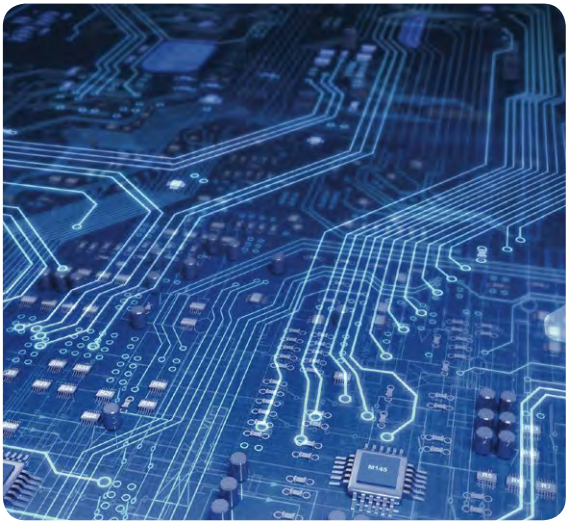
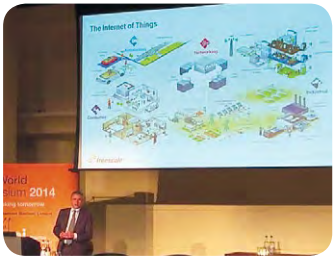
INNOVATION

Innovation is the lifeblood of our industry and NMI is determined to keep it flowing. By running events and networks that cut across disciplines such as embedded software development and technologies such as FPGAs, we drive knowledge exchange, create business development opportunities and facilitate benchmarking.





Electronic systems

Ours may be a remarkably diverse industry, but it's also one that faces common challenges. Addressing those, the Systems & Software Leadership Forum focused on skills needs, ran a model-driven engineering event and agreed changes that will deliver even greater return on investment for participants. Recognising that FPGAs (Field-Programmable Gate Arrays) are one of the dominant platforms for electronic system design, NMI founded the FPGA Peer Network five years ago. In 2014, we strengthened the team with the appointment of industry

"THE 'SELL-OUT' EVENT FEATURED OVER 25 TALKS ON KEY UK INITIATIVES AND FUTURE TECHNOLOGY THEMES..."

expert Doug Amos, who's now expanding this network, and partnered with key eco-system supporters to conduct a major survey of FPGA usage in Britain and Ireland (see page 57). We also ran an expert user event entitled 'FPGA Development – More Productive Lab Time' and established a dedicated LinkedIn group 'of the users, by the users and for the users'. If you haven't yet joined FPGA-Eire-UK, now's the time with plenty of exciting developments up ahead.

Automotive electronics

Now acknowledged by the industry, Automotive Council, ESCO and InnovateUK as the UK's specialist automotive electronics forum, NMI's AESIN (Automotive Electronic Systems Innovation Network) took another giant leap forward in 2014. We ran four project-focused events, an interactive workshop on the industry's functional safety standard ISO-26262, updated stakeholders on AESIN's progress at the Mentor Graphics Automotive Forum and then took a profile-raising stand at CENEX LCV2014, leading up to our flagship two-day UK Automotive Electronic Systems Conference at the University of Warwick. The 'sell-out' event featured over 25 talks on key UK initiatives and future technology themes, including an announcement that AESIN will be leading a research project on the 'Connected Corridor' – the first of hopefully many collaborations catalysed by AESIN. Looking ahead, we've teamed up with Dream Marketing for its 2015 European Automotive Technology Roadshow[1], which offers members the opportunity to exhibit in front of some of the biggest names in the business. Get in touch if you want to be part of it.

Power electronics

We ran another sell-out event, this time on 'Power Conversion for More Electric Transport', revealing the latest developments in automotive, aerospace, rail and marine. There'll be lots more to come in 2015, addressing the needs identified in our UK power electronics survey.

Design excellence and industrialisation networks

During 2014, we ran a series of cutting-edge network events designed to increase know-how and improve performance, reliability, security and features while reducing size, costs and time to market. Themes included 'Multicore – Processors & Programming', 'Accelerating Verification – faster, smarter?' and 'Low-Power AMS/RF Design Challenges'. We also established the Analogue/Mixed/Signal/RF Design Forum to steer future activity, especially around the niche skills required for this specialism. At the other end of the supply chain, we ran events on 'High Performance Packaging' and 'Chip Test Efficiency – a Losing Battle?' Look out for more on these, as well as the Internet of Things (IoT) and Low Cost ASIC/Cost-Effective Chips in 2015. The Fabless Operations Forum met twice and welcomed its inaugural industry chairman, Ian Stacey from DisplayLink. NMI also continued to support the work of the South West Microelectronics Innovation Network (iNET), of which we're a founding partner, in this recognised global node for chip design.

Manufacturing

Our aim is to set the standard for collaborative associations and during 2014 NMI's Lean Manufacturing network delivered more of the practical outcomes – be they in the areas of reduced cost, improved productivity and cycle-time or greater workforce engagement – so valued by its members. As well as organising best practice visits to Foxconn and ABB in the Czech Republic and Siemens and Xaar in the UK, from which one member brought back an idea that's saving his company an average of £6,000 a week, NMI also ran three supervisor development workshops and completed two site assessments, with benefits for all involved. Celebrating these examples of best practice and many more, NMI's annual Manufacturing Excellence Conference took Lean as its theme and featured keynotes from the University of Swansea's Professor Nick Rich[2] and Jason Speedy[3], Head of Manufacturing at Siemens, presentations from the teams personally responsible for achieving successes, break-out workshops and, for the first time, a session on productivity improvement delivered through the medium of theatre (thank you Xaar). Complementing these activities, NMI's tried and tested portfolio of forums and reviews made continuous improvement in all kinds of areas its mission throughout the year. Looking ahead, we're planning a repeat of an earlier energy efficiency event in response to members' requests.

"NMI'S TRIED AND TESTED PORTFOLIO OF FORUMS AND REVIEWS MADE CONTINUOUS IMPROVEMENT..."

References

1 www.aesin.org.uk/events/supplier-roadshow
2 www.tiny.cc/NMIfeaturedvideos
3 www.tiny.cc/NMIfeaturedvideos

RESEARCH AND DEVELOPMENT

NMI has a proven track record of directly helping members to grow their business through R&D. Now that our plans to open up a more direct channel to Government have come to fruition, we're also able to operate at a more strategic level.

During 2014, NMI provided direct one-to-one support and advice to over 100 members, ran R&D workshops on electronics and sensors manufacturing for harsh environments and Horizon 2020, and made over 500 introductions. As a result, we have launched more than 100 R&D collaborations and generated over £100 million of R&D project activity.

On a more strategic note, we took the lead role on technology, working through the ESCO Technology Group set up to identify and overcome the main business

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"NMI IS NOW WELL-POSITIONED TO INFLUENCE THE KEY DECISION MAKERS."

barriers to R&D in the UK. Lack of funding is one of the major ones and, having already spent several years making more of an impact in publicly-funded R&D, NMI is now well-positioned to influence the key decision makers. We therefore made a strong case to Government asking for £120 million investment over five years into the ECSEL European funding scheme, which encourages cutting-edge electronic systems R&D. To put this in context, £120 million from Government would translate into around £0.5 billion of activity. Although our bid did not make it into the Chancellor's December 2014 Autumn Statement we have made significant progress by working with the significant parties and illustrating the potential for future participation. As a result, NMI has now put in place a framework that will enable the electronic systems community, InnovateUK, the Engineering and Physical Sciences Research Council (EPSRC) and Department for Business, Innovation & Skills (BIS) to work together towards common funding goals, be that through ECSEL, Horizon 2020 or other vehicles.

In response to a request from NMI's Microelectronics Design Advisory Board (MDAB), we ran an R&D workshop on design. Involving both industry and academia, this highlighted areas of potential collaboration that could see members partnering with universities and/or other businesses to develop their ideas. The initial event showed promise and we plan to repeat this model in different technology areas, such as carbon electronics or power electronics, as it provides valuable road maps and technology statements that can be used to align industry interests with future funding calls.

SKILLS

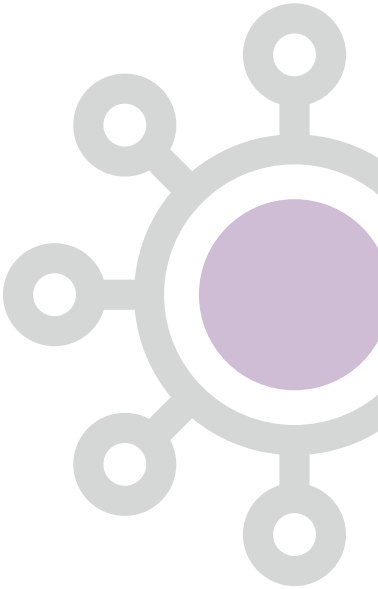
The enormous potential of our electronic systems industry is clear for all to see. But without a constant stream of skilled workers not only will it fail to reach this potential, but the industry's current worth and workforce will be in serious jeopardy. That makes engineering skills a top priority for NMI.

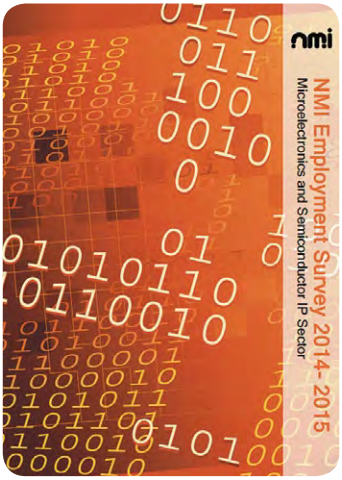
Through our work with the ESCO Skills Group, NMI has been invited to bid for an Electronic Systems Apprenticeship Trailblazer. If successful, this will provide a unique opportunity and incentive to get broad industrial participation into re-defining and developing new industry standards for apprentices up to and including a postgraduate apprenticeship model. Contact us if you'd like to know more.

During 2014, NMI also completed its third annual Employment Survey. Designed to provide participants with an accurate benchmarking tool and to monitor employment trends, the latest findings were particularly encouraging, revealing an increasing demand for engineering talent at all levels. Compared to the 57% of participants who had recruited graduates in the last 12 months, 71% of participants are looking to recruit graduates in the next 12 months, with a further 44% planning salary increases.

The UK Electronics Skills Foundation (UKESF), of which NMI is a founding partner, went from strength to strength. Facilitating employer engagement with schools, the 'Our Electronics Environment' project piloted in 2013 is now an annual event in both Bristol and east England, and will be launching in Scotland in 2015. UKESF's employer-sponsored summer school at the University of Southampton attracted 80 A-level and Scottish Higher students from 77 schools across the UK – twice as many as the inaugural course in 2011. And charting the progress of UKESF's Scholarship Scheme, employers from the electronics industry have so far awarded a total of 174 UKESF scholarships, backed by over £1 million investment.

"71% OF PARTICIPANTS ARE LOOKING TO RECRUIT GRADUATES IN THE NEXT 12 MONTHS..."





The current academic year sees 25 companies involved, offering a total of 65 scholarships.

With the addition of Leeds and Sheffield bringing the number of academic partners to 13 (including 50% of the Russell Group of elite universities) and industry partners AWE, Thales and XMOS bringing the total number of company sponsors to 27 (a threefold increase since 2010), the message is clearly spreading. If we're to remain at the forefront of our industry though, we need more companies to recognise their shared responsibilities to attract and nurture the next generation of talented engineers. Only by acting together now and supporting sector-specific initiatives like UKESF can we ensure that we have the necessary pool of exceptional talent to drive our industry in the future.

Yes, the future for electronic systems looks bright, but only if we have enough bright sparks!

Conclusion

NMI, as you've read, has made major progress in each of the key areas of representation, innovation, R&D and skills over the last 12 months. That is what championing electronic systems in the UK takes! What it also means is that we are now in the strongest position we've ever been to support existing and emerging industry needs, including yours.

If you're not yet a member, we would urge you to consider joining NMI for two very good reasons: it is a great investment in your own organisation's future and the best possible investment you can make in the future of your industry in the UK.

Join NMI today by calling +44 (0)1506 401210 or visiting www.nmi.org.uk/about/join.

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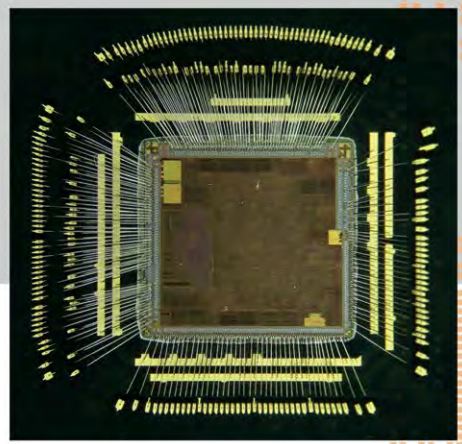

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Simon Segars
Chief executive officer, ARM

LIBERATING **THE INTERNET OF THINGS**

The Silicon Revolution is unlike any other major industrial revolution because you can't easily stare into the heart of the technology and see exactly what makes it work. In essence, the core technology is almost invisible. The goal for us now is to take that cloak of invisibility and spread it, so technology becomes seamless to end users and 'disappears'.

THINK OF cruise control in a car. Most systems require you to interact with the technology to match your speed with the vehicle in front. This is not invisible. Inevitably, this led to new autonomous cruise control systems that use radar or laser technology to detect slowing traffic and match your speed with the vehicle in front. Other advanced systems detect sudden braking and avoid collisions and further systems will ensure your vehicle does not drift out of its lane, alerting you with a steering wheel vibration if you are straying. Wake up!

This is when the technology becomes truly invisible, in how it works and how you interact with it. This is the ultimate goal for us in *Liberating the Internet of Things*.

TECHNOLOGY

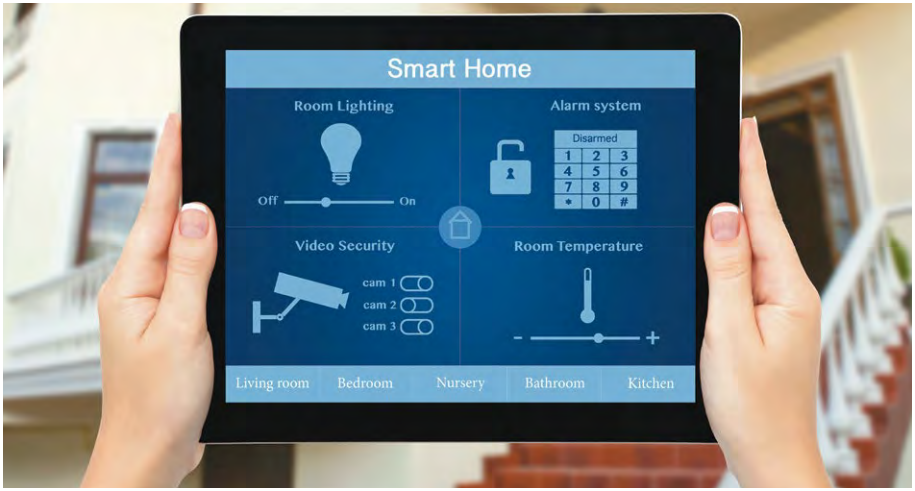
In making the Internet of Things (IoT) a success we need to answer questions that go way beyond the technology. In fact, the technology will be largely tried and tested. We aren't talking about supercomputers, we aren't talking

about superchips. It is the integration of functionalities, infrastructure and data together with the evolution of interfaces and business models that will ultimately unlock the IoT.

We cannot ignore the technology though as there are some fundamental questions to answer at the micro and macro scale. As an example, take a look at how technology is being deployed in the Government-backed smart city scheme in Milton Keynes. The scale of what 'MK' is trying to achieve is impressive. The project connects resources and services via a sensor network so patterns can be analysed. The technology harvests little data from thousands of objects and systems and aggregates it in the cloud as 'big data'. The big data paints a city scale picture around water use, transportation, energy consumption and waste services. Once this data is collected it's possible to come up with efficiency plans, saving emissions, cost and resources. The big data always starts with the 'little data' though and this is where the technology deployed must be as efficient as possible.

"THIS IS WHEN THE TECHNOLOGY BECOMES TRULY INVISIBLE."

You might be talking about waste bins that signal when they are full or a car park that advertises free spaces; the core little data sensors must run on very little power. The reason is simple; you can't wire up objects such as bins to mains electricity so they must rely on long-life batteries or be self-sufficient. This is important as there's no point optimising a waste collection strategy if maintenance staff have to constantly change the bins' power supply. In this case you need chips containing energy-efficient processors such as the ARM Cortex-M0+. It is so energy-efficient it can exist on scavenged power and is so tiny it could easily sit on a human hair.



Connectivity is another area where the technology is mature, with cellular, Bluetooth, Wi-Fi and Zigbee and others. At the cloud end, there is also on-going innovation focused on making data centres more efficient so the predicted explosion in data packets flying around the planet will not bring the system crashing down. ARM is playing a role here, with energy-efficient ARM based server technology from the likes of HP which is well-placed to take on repetitive data processing tasks that will be a key feature of the IoT.

While the technology roadmap is well laid out, there are some things that still need to happen to allow the IoT industry to scale. The most important is making the sensor-to-server path for little data flow properly. The issue is around the many separate standards that exist in the connectivity layer, and also competing software technologies that mean devices cannot communicate in an interoperable way. Whether your boiler can talk to your television probably isn't an issue but your thermostat should be able to communicate with your security system and potentially your lighting system.

Imagine, the security system of your house automatically comes online if the embedded occupancy sensors detect there is no one in. However, you've forgotten to turn off the main lights and the radiators are blazing away.

"THERE ARE STILL SOME THINGS THAT NEED TO HAPPEN TO ALLOW THE IOT INDUSTRY TO SCALE."

It would be great if they were all aligned so the lights would default to an 'away from home' pattern, based on your normal lighting regime. Also the heating system could automatically put itself into an energy saving mode, saving you money. For all of this to happen, you need interoperability between the devices. This communication could happen at the home hub layer or in the cloud but it needs a medium. This is where ARM steps in.

ARM wants to enables markets, just as it did with the mobile market in creating technology standard for processor architecture. This allowed others to innovate around this core technology and this led to a new industry – one that was sustainable, cost and energy-efficient.

We are trying to do the same with the IoT, through our ARM mbed™ IoT Device Platform. The platform consists of an OS for devices, built around open standards which will bring Internet protocols, security and standards-based manageability into one integrated solution. The idea is that the new platform will accelerate the growth of the IoT by enabling innovators to focus on value-add features and differentiation in their products rather than trying to individually solve the underlying technology challenges.

On top of the mbed OS, the platform also offers the mbed Device Server. This is a software solution that provides the required server-side technologies to connect and manage devices in a secure way. It also creates a bridge between the protocols designed for use on IoT devices and the APIs that are used by web developers. This simplifies the integration of IoT devices that provide "little data" into cloud frameworks that deploy "big data" analytics on the aggregated information. Built around open standards, the product can scale to handle the connections and management of billions of devices.

As I write, the platform is barely a month from launch and already companies such as IBM, Salesforce and Ericsson have come on board. This brings me on to my important point about *Liberating the IoT*. Basically, it's a technology that enables business.

THE BUSINESS OF IOT

Amara's Law states: "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run."

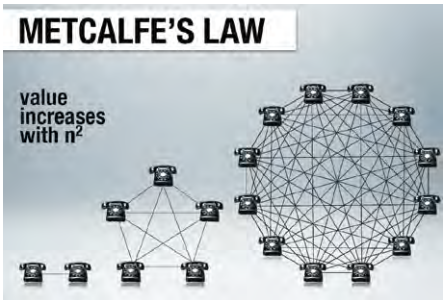
Sometimes there can be huge excitement around a new technology but technologies will not work just because the inventor has created something entirely new with fantastic potential. As Lord Sugar delights in telling his potential Apprentices – you need a business plan!

Look at Kano. This is a new project started by three entrepreneurs in East London. They developed a kit of parts which will enable primary and high school children to build their own computer. They are effectively tapping into the aspiration of parents to ensure their children will be expertly computer-literate. It worked. They asked for $100,000 on Kickstarter and received $1.5 million. The Kano team is already successfully selling the kits and they've had enormous media attention. Once hooked, they can also keep their loyal computer customers by bringing out more advanced kits as they grow older. This is a product with a business plan wrapped neatly around it and it has the potential to scale.

Applying the same thinking to the IoT, we can see that it is hugely important to look beyond the technology and think about the business model.

METCALFE'S LAW

We can start by thinking about another law – Metcalfe's Law. It states: "… the value of a telecommunications network is proportional to the square of the number of connected users of the system (n^2).



Metcalfe's Law was born in the era of telecommunications but is arguably even more relevant to the Internet and the IoT. The key is working out how the whole can be greater than the sum of parts.

Companies such as IBM are expert in coming up with service solutions that take advantage of new technologies. In the case of the IoT they are looking at how all of the billions of packets of little data flowing out of Internet-connected devices can be aggregated and analysed in the cloud. This is a hugely appealing idea. Companies will be able to add intelligence to everyday devices, such as washing machines and dishwashers. The cost will be negligible and on top of the machine a manufacturer could then offer a service allowing the appliance to constantly stream data to the cloud. This little data will be analysed and a maintenance regime produced. It could create a system where a machine would effectively be asking for help from a maintenance engineer before it broke down. You can imagine a world where many goods are offered free of charge and you only pay for the service around it. In fact why imagine it? Radio Rentals have been doing it since 1937.

It's not just the domestic world where this will be relevant. Predictive maintenance is already in operation in the industrial world and Rolls Royce's TotalCare jet engine program is a great example.

We have now looked at the technology and the business model but we now need to think about the other elements that will allow the IoT to scale.

CHALLENGES LEFT TO SOLVE

ARM hosted a debate at London's Science Museum in September this year and the topic was *Liberating the IoT*. I was onstage and I was lucky to be joined by some notable guests: Ed Vaizey, the UK Minister of State for Culture and the Digital Economy; Rory Cellan-Jones, the BBC's technology correspondent;

"YOU CAN IMAGINE A WORLD WHERE MANY GOODS ARE OFFERED FREE OF CHARGE."

Pilgrim Beeart, a successful IoT entrepreneur and founder of 1248 and AlertMe; Clive Selley, Chief Information Officer with BT; and Delphine Rivé, Managing Director with Accenture's UK Communications, Media & Technology practice.

It became clear there were a number of challenges that the panel and audience were focused upon. The most challenging ones were standards, security and privacy.

There is an urgent need to address the standards issue. There will never be one standard for technology governing connectivity for instance but there is room for several catering to different use cases. In device to device communications, we can look at the work being done by the Thread group around mesh networking technology as an example of a standard that is rapidly gaining traction.

Another key area is security as it is imperative to provide end to end confidence that data can be securely and accurately created, stored and transmitted. The industry can confidently handle this challenge and the challenge of creating interoperable standards but the third area is more difficult – privacy.

Privacy is about understanding who has access to the data ie the contract between those seeking to offer a service and those agreeing to take it. My view is that a person should ultimately own their own data and have control over who uses it. The trick will be keeping true to that as services start to build around the

expanding IoT network. It will require service industries to agree codes of conduct, there must be effective policing of that and it must above all lead to contracts with customers that are clear, easy to understand and enforceable.

LIBERATING THE INTERNET OF THINGS

As I have argued, *Liberating the Internet of Things* is going to be complex because we need to make the solutions simple and invisible. Also, we should pay attention to Amara's law and not overestimate what it will deliver in the short term and potentially underestimate what it could deliver if we put the cornerstones in position carefully.

IoT is not a market but it is a trend that cuts across all markets. It's hard to think of any sector where there cannot be a positive impact. This is true for the developed world where we have to make our resources and services stretch further, reduce emissions and cut costs. This is even more the case in the developing world where connectivity can help to improve the quality of life. For example it can lead to a more efficient agricultural industry or a health service better able to cope with a major disease outbreak.

Before these benefits can be realised there are some fundamental issues to tackle. Notably, developing ways of making competing standards for connectivity and data sharing work so we don't end up with a fragmented IoTs; your security system is speaking English and your lighting system is speaking Latin. Security is a prime concern and that must be addressed through the right open standards that make interactions easy and simple and as secure is as practicably possible. Finally privacy, we need to ensure that the potential Wild West of data use doesn't happen as the IoT will only be liberated and scale if it is trusted.

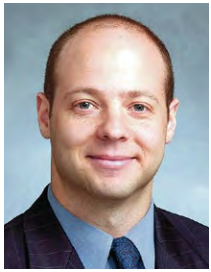
It is possible to solve all of these challenges but the important stakeholders need to ask the right questions and find the solutions that work. Government has a role, but as Ed Vaizey said at the Science Museum forum that role may be to "get out of the way" on some occasions. Ultimately, Liberating the Internet of Things needs a similar approach as was taken with the Internet. It started as a niche technology but was then layered into something with real power and scalability. With the benefit of hindsight we can also avoid some of the issues that affect the Internet today and sculpt an Internet of Things that it is important economically and socially and yet is invisible. As Mark Weiser of the Computer Science Lab once famously said: "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

ABOUT THE AUTHOR

SIMON SEGARS
ARM, CHIEF EXECUTIVE OFFICER:

Simon Segars joined the Board in January 2005 and was appointed Chief Executive Officer on 1 July 2013. His previous roles include President, leading the IP divisions and representing them on the Board, EVP and General Manager of the Processor and Physical IP Divisions and prior to that, EVP, Engineering, EVP, Worldwide Sales and EVP, Business Development. He joined ARM in early 1991 and worked on many of the early ARM CPU products. He led the development of the ARM7™ and ARM9™ Thumb® families. He holds a number of patents in the field of embedded CPU architectures.

David Kleidermacher
Chief Technology Officer, Green Hills Software



DEVELOPING SECURE DEVICES **IN THE INTERNET OF THINGS**

The vast potential of the Internet of Things is threatened by several imposing challenges, and Thing developers bear the burden of meeting many of them:

1. How can designers properly care for the privacy, safety, and security of the information and functions entrusted to their Things?
2. How can a new breed of Thing developers, many with little or no professional embedded software experience, build reliable, efficient, and secure products?
3. How can even the most experienced embedded developers navigate the technical and business maze involved in integrating their Things into the Cloud?

While the challenges are daunting, Thing developers that navigate them successfully will be handsomely rewarded.

ADOPT A ZERO TRUST DATA PRIVACY STRATEGY

One of the fallacies in IoT security is that solutions providers can focus their investment on fortifying the cloud data centre and essentially ignore the security of the Things on the edge. This is dangerous thinking in the cloud era, and is downright folly in the IoT era. Attackers search for the weakest link, and if Things remain weakly protected, they will be targeted. Once a Thing is commandeered, attackers can use the Thing to gain access to the crown jewels in the data centres.

"THIS IS DANGEROUS THINKING IN THE CLOUD ERA, AND IS DOWNRIGHT FOLLY IN THE IOT ERA."

Another aspect of the fallacy is that there is not much worth protecting out on the edge. Things generate a treasure trove of valuable and private information – about our health, our social activities, our location, etc., and present an incredibly valuable target for hackers.

As the IoT grows in complexity, it is not practical for developers to know or control how data will flow across the web and whether the various systems along the way will be worthy of our trust. Thing developers and their customers must adopt a zero-trust strategy, which divorces data protection responsibilities from devices, communications protocols, and cloud services. IoT data privacy is like the content protection problem for digital media. Data owners must

> **"ONE CANNOT BUILD SECURE APPLICATIONS OR THINGS ON TOP OF AN INSECURE OPERATING SYSTEM."**

have the tools required to create flexible policies for authorised sharing, distribution, and access control of data, regardless of how it transits the web. For example, a wearable health care device may encrypt information generated locally with a key that is controlled by the device owner and shared out-of-band only with health-care providers that have a need-to-know.

ADOPT A SECURE PLATFORM ARCHITECTURE

Thing platform security starts with a hardware root of trust, below all software. A hardware root of trust, in its simplest embodiment, is a tamper resistant key storage used, at a minimum, for secure boot of the firmware and associated security-critical components. The boot sequence must utilise hardware-rooted keys to signature check these components before launching them. Subsequently, the hardware root of trust can be used also for remote attestation and for protection of keys used for authentication and encryption. If an attacker attempts to overwrite critical software with malicious code, the attestation process will detect it.

Once securely launched, the executive software (operating system, hypervisor, or TEE) is arguably the most important building block for secure Things. One cannot build secure applications or Things on top of an insecure operating system or hypervisor. Ideally, this software root of trust has the following characteristics:

- **High assurance:** design and implementation certifiable to the most stringent security standards (e.g. Common Criteria EAL 7), including formal proof of security.
- **Scalable:** able to host lightweight, real-time workloads up to full blown Linux operating systems and stacks (and both at the same time).
- **Open:** offering a run-time environment and APIs that follow open standards, fostering interoperability and software reuse.

The platform architecture principles described above give developers a powerful toolbox with which to build secure IoT systems. To demonstrate, let's take a look at the Target Corporation (the second-largest discount retailer in the United States) breach and how it could have been easily prevented. Target (and The Home Depot, the largest home improvement retailer in the United States) PoS terminals were infiltrated by malware, which was able to gain privilege and memory scrape RAM to purloin personal information.

An evolved PoS architecture would use a de-privileged OS and a lightweight security

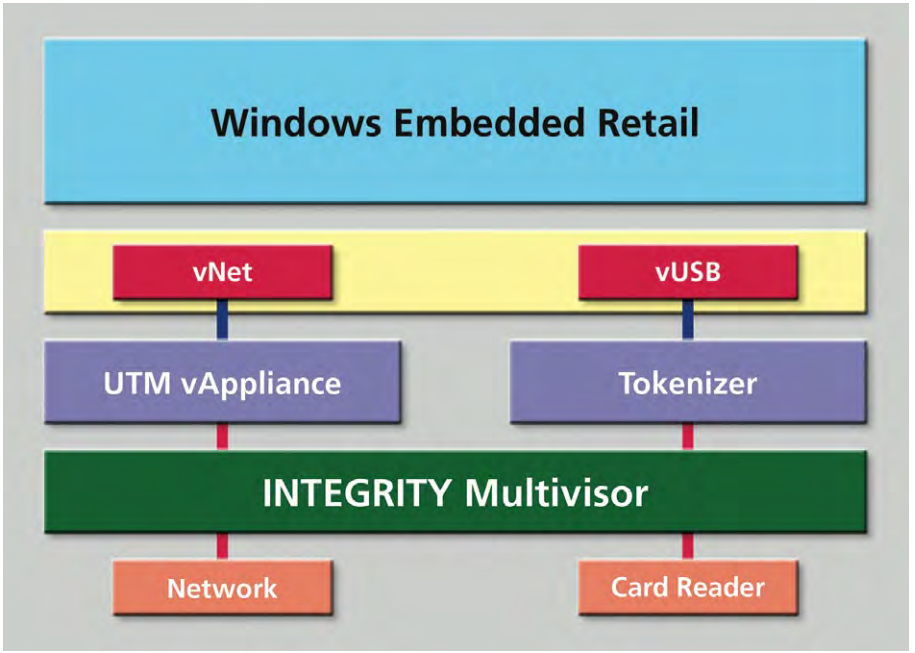


Figure 1: Thingvisor architecture prevents Target breach

critical application, called the tokenizer, to handle the processing of personal information. The tokenizer executes directly on a Thingvisor, a high assurance microkernel-based hypervisor, and manages the physical device used for card swipe. The tokenizer uses a secure connection to a back-end web service for mapping personal records to tokenized records and then issues a virtual card swipe, passing the token, to the point-of-sale OS. While the OS may be infiltrated with malware, it has no personal information to steal.

The overall Thingvisor-based point-of-sale architecture is shown in Figure 1 and has been demonstrated at the NRF Big Show (US National Retail Federation's Annual Convention & EXPO); while Target may have missed out on the concept, it is not too late for Target and other retailers to require such a trustworthy approach of its PoS suppliers going forward.

ADOPT PROFESSIONAL DEVELOPMENT TOOLS

The IoT is attracting an incredibly diverse set of new Thing developers, many of whom have limited professional embedded systems development experience. A typical scenario is to acquire a cheap Arduino, Raspberry Pi, or some other prototyping hardware platform, download some distribution of Linux or one of the mini-kernels (Contiki, TinyOS, RIOT) for a battery-powered design, and start slinging code. Many developers have no clue how to debug

effectively (print statements or LED blinking is state of the art) and follow no rigor in terms of development process for building a reliable product. This approach might work for hobby projects but will fall short when moving to large-scale production or attempting to address markets that demand a higher level of quality and even certification (e.g. ISO 26262 for automotive, IEC 61508 for industrial, government medical device approval, etc.).

When looking for a professional Thing development environment, it is critical to find a solution that is easy to learn and use. Do not underestimate the long-term impact of an optimised development, testing, and maintenance cycle. The same goes for the hardware platform. For example, choosing a microprocessor that provides JTAG debugging and run-time program trace capabilities to help find spurious or complicated bugs faster may provide a huge developer cost and time to market benefit that often goes unappreciated in hardware selections focused on CPU cycles, RAM size, and BOM dollars.

ADOPT LINUX, CAREFULLY

It should come as no surprise that some of the most popular Things, such as the Nest Thermostat and various smartwatches, run Linux. With its open source licensing, widespread availability of developers and applications, Linux has an undeniably important position in the run-time strategy for IoT. However, Linux has problems scaling to lower end designs (footprint, battery life, and performance), real-time limitations, and lacks the safety and security pedigree that one needs in a future-proofed IoT strategy.

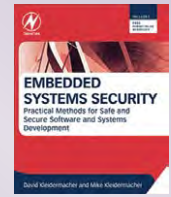
Here again is where the Thingvisor is a win. Thingvisor converts Linux into a IoT-optimised

ABOUT THE AUTHOR

DAVID KLEIDERMACHER
GREEN HILLS SOFTWARE, CHIEF TECHNOLOGY OFFICER:

David Kleidermacher is Chief Technology Officer at Green Hills Software where he is responsible for technology strategy, platform planning, and solutions design. David is a leading authority in systems software and security, including secure operating systems, virtualisation technology, and the application of high robustness security engineering principles to solve computing infrastructure problems. David Kleidermacher earned his bachelor of science in computer science from Cornell University and has been with Green Hills Software since 1991.

David has authored the book "Embedded Systems Security – Practical Methods for Safe and Secure Software and Systems Development".



This book provides:

- A broad understanding of security principles, concerns, and technologies.
- Proven techniques for the efficient development of safe end secure embedded software.
- A study of the system architectures, operating systems and hypervisors, networking, storage, and cryptographic issues that must be considered when designing secure embedded systems.
- Nuggets of practical advice and numerous case studies throughout.

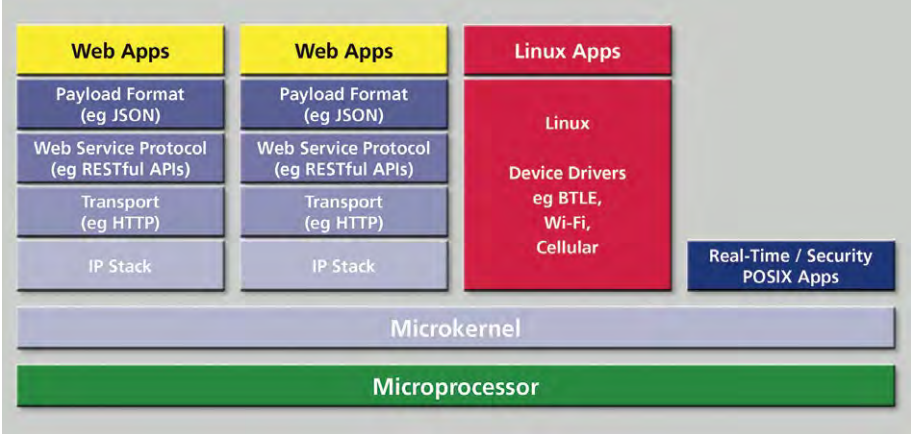


Figure 2: A complete IoT firmware stack

version of Linux, whereby Linux runs atop the software root of trust. For example, in automotive Things, safety-critical software (CAN drivers, rear-view camera, ADAS) may be hosted on the microkernel, leaving Linux to be used for graphics and communications stacks.

ADOPT A WEB-ORIENTED COMMUNICATIONS STRATEGY

Many middleware solutions are staking their claim to be the information exchange backbone of the IoT. Competing consortia, such as AllSeen and Open Interconnect Consortium, and the myriad of protocol choices – MQTT, XMPP, AMQP, COAP, DDS – present a confusing alphabet soup for Thing developers.

Factors to consider include the communications model (pubsub, peer-to-peer, client-server), service discovery model, data representation, overwrite vs. queue, dependence upon reliable transport (TCP), quality of service (QoS) capabilities, and more. A comprehensive discussion of these options is beyond the scope of this article. Ultimately, however, most devices will use the lingua franca of the web, RESTful web services via HTTP and COAP (for constrained wireless devices), because they enable Things to more quickly and seamlessly integrate into the Web.

Figure 2 brings together the entire IoT firmware stack into picture, including the concept of multiple securely partitioned web services components, Linux guest operating systems, and real-time and security-critical components.

We find ourselves in the midst of an exciting time, when the number of objects has recently eclipsed the number of people (PCs, smartphones) on the web. Yet this is just the beginning of a new world in which the Internet will be dominated by smart objects making our lives better and yielding incredible business opportunities for IoT device developers, especially those that approach their craft with an effective, future-proof strategy.

Emma Portman
Test Manager – Group Engineering Software, Renishaw plc

SOFTWARE APPRENTICE SCHEMES: **THE RENISHAW STORY**

Apprentice schemes have existed for many years and in many forms; they can range from simply spending a year with a company who provide specific on the job training, through to more systematic organised schemes which see the apprentice gaining formal qualifications within the chosen field over a 2 to 4 year period. With such a wide choice it can be a daunting task for any young person to make that decision to go down the path of an apprenticeship rather than the traditional route of A-levels and then a Degree.

WHILE RENISHAW has offered a highly successful general Engineering Apprenticeship since 1979 and has run sponsored student schemes since the early 1980's these have concentrated upon mechanical and production engineering, traditional electronics and commercial training.

By contrast, software skills were historically brought into the business as required, through a combination of specialist and graduate recruitment. Though this model worked for a number of years it became increasingly apparent in the 90's and early 'noughties' that we had a significant growing demand for a supply of excellent software engineers, particularly in computer systems engineering, which we would find increasingly difficult to fill by these traditional recruitment methods.

This change has been driven by a number of factors: Changing business demands in which our customers increasingly demand a fully integrated measurement system, rather than just provision of a sensor; a drive to integrate

David Cameron with Renishaw apprentices and graduates

measurement data throughout the process control pipeline and technology advances with high-end micros and FPGA's meaning we can just do so much more in software.

Recognising that need we decided to act and in 2007 set out to create a Software Apprenticeship. Looking around there was little out there to model a scheme on and so we decided to build our own based on the model of our general apprenticeship which combines work with a formal day release study programme,

allowing the apprentice to work towards a professional qualification.

One of the key aspects of the Engineering Apprenticeship is that the apprentice can gain a BSc or MSc in Engineering with the support of Renishaw. The ability to 'earn while you learn' is a very attractive option for young people. According to the Institute for Fiscal Studies the average graduate now comes out of University with in excess of £40,000 of debt for an undergraduate degree. The cost of tuition fees is set to rise and so young people are now starting to look for an alternative way to do their degree. By offering a BSc as part of the Software Apprenticeship it enabled us to attract people who would normally go straight to University. Below are quotes from some of our apprentices which support the change in approach to University that young people are starting to take:

"Getting paid whilst doing a degree and getting excellent on the job training sounded like an opportunity that was too good to miss." *Stewart Coulden-Smith, Software Apprentice*

"Providing the means to gain a degree in a related subject, on the job training and the ability to develop products, were opportunities I couldn't ignore." *Tom Noble, Software Engineer*

"There has been a variety of overlap through embarking on (employment and University) simultaneously, enabling me to pull together elements from each side for a more rounded perspective." *George Withey, Software Engineer*

Our next challenge was to find a University who would be able to support us in providing a degree that covered software engineering and could be undertaken part time on a one day a week release basis. The course also needed to allow the apprentices to gain enough points so that a full BSC Honours degree could be achieved. We already had links with the University of Wales through our Engineering Apprenticeship and they were very happy to accommodate our needs. They provided a BSc(Hons) course in Systems Engineering which covered the interesting mix of software, electronics and mechatronics that is needed to satisfy our business.

In 2013 the University of Wales merged with the University of Glamorgan to become the University of South Wales. With the merger, the Systems Engineering degree became a bespoke Computer Science degree specifically for Renishaw, and this has enabled us to widen our ability to attract apprentices who would have ordinarily chosen to go to University to do this course. Going forward the University are happy to work with us to shape the course further by adding new modules, such as an electronics module and an embedded software module, as the course is run by the Faculty of Computing, Engineering and Science.

Tom Noble former Software Apprentice

The course is also run from the University's Treforest campus and this has provided an opportunity to extend the apprenticeship to a new pool of potential talent based in South Wales. For the past three years Renishaw has run an Open Day at our Miskin site (just outside Cardiff) for all of the local schools, colleges and universities to come and see our engineering processes. This year we were able to include a stand for software as a direct result of the University course moving to the Treforest campus. We currently have a software development team based in Miskin and over the next few years we hope to grow this team with the addition of apprentices.

The software apprenticeship scheme has been running for 6 years and our approach to training the apprentices has changed over those years. In the first few years the apprentices were allocated to teams and they were trained within those teams. While all of the apprentices were happy in their teams and enjoyed the challenges that the work offers, we realised that they needed to have a more rounded view of the company and the different types of software produced. A training scheme was introduced which allows the apprentices to spend time with the different software teams during their first year. This allows them to gain an appreciation of the type of work they will be allocated and to decide which they enjoy the most.

The training has been designed to take the apprentices on a journey. Initially attending our Graduate Induction Programme they learn about the company and the different types of products we produce. They then use this product knowledge to build up their skills on the different types of software used within our products. The journey starts with learning how to build a PC and moves on to application development in C#.net. The apprentices then focus deeper on software design, technical skills, project management, development methodologies, testing, database development, internet development and setting up software projects. They also learn embedded programming using procedural C, and this also introduces the electronics element of software. As a metrology

company we need to use complex algorithms within the software to allow our products to measure accurately. This is also an important part of the apprentices training and they spend a quarter of their training time on this. At the end of their journey the apprentices are asked to setup and create their own project. We've had some very interesting results and one of the projects is now regularly used at career exhibitions and public events to encourage other young people to join our apprenticeship scheme.

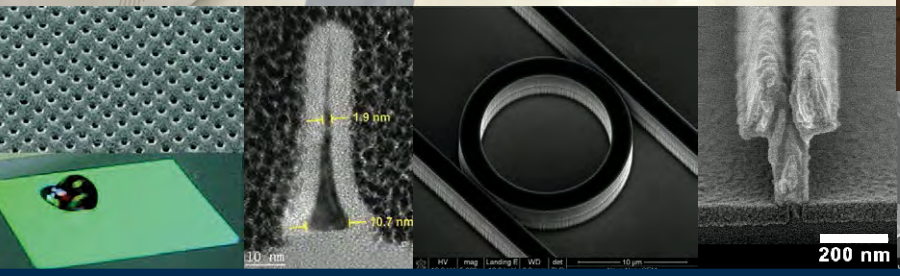
After the first year of intensive training the apprentices then move into teams and they focus on specific types of software. We also encourage them to start to get involved in initiatives happening around the business. This can range from helping to build racing cars as part of the Greenpower competition, to promoting software apprenticeships through

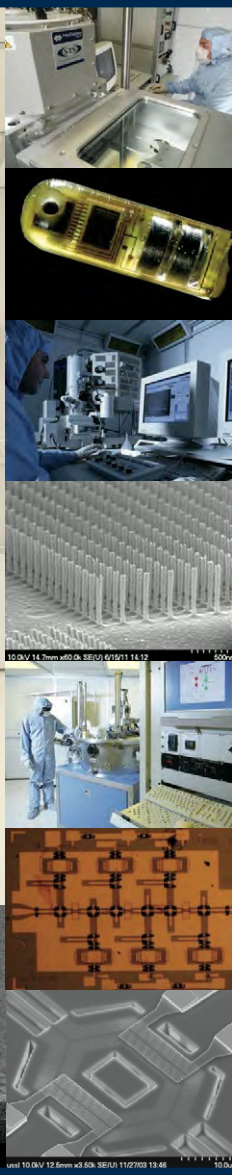
STEM activities. Renishaw also sponsors all of the apprentices to join the BCS (British Computer Society) and this enables the apprentices to keep abreast of the latest technologies, go to lectures and work towards becoming chartered if they so wish. This year we have also introduced an out of hours club called 'Hackspace' where Software, Electrical and Mechanical staff can meet, socialise and

University of Glasgow

James Watt Nanofabrication Centre

- The James Watt Nanofabrication Centre is one of the premiere cleanrooms working with over 288 international companies
- Glasgow has over 35 years experience of developing solutions for science, nanoelectronics, optoelectronics, healthcare, energy harvesting, security & defence, ...
- The 900 m^2 cleanroom is run by 18 dedicated technical staff as a pseudo-industrial operation
- The Centre has sub-5 nm electron beam lithography over 200 mm wafers and low damage process transfer capability
- The Centre presently collaborates with over 90 universities & research institutes from around the world
- Kelvin Nanotechnology provide full commercial access and have delivered services to over 250 international companies
- MSc in Nanoscience & Nanotechnology provides education in the science & technology of present & future micro/nanofabrication http://www.jwnc.gla.ac.uk/NanoMSc.html
- Technology developed in the centre includes 10 nm III-V CMOS, 183 GHz LNAs, 8 nm diameter nanowire MOSFETs, Si nanowire breath sensors, directed stem cell scaffolds, wireless lab-on-a-pill, InSb CO_2 gas sensors, integrated DFB laser systems & many more





Director: Prof Douglas J. Paul
Douglas.Paul@glasgow.ac.uk
Tel: +44 (0)141 330 5219
http://www.jwnc.gla.ac.uk/

Sam Beard former Software Apprentice

collaborate on any ideas they have. All of our apprentices are involved in one or more of these activities and they help to produce well rounded individuals.

On average our software apprenticeship lasts around 3 years. By this point we find that the apprentices are effective team members who can generally work on their own with minimal help. Promotion however is based on skills and expertise and we have had apprentices filing patents in their first or second year of working with us. It is important for both the business and the apprentices that they have a dedicated career path, which moves from apprentice, to software developer, to software engineer and so on. This not only helps to focus the apprentices on the type of career they want but also provides the motivation to keep going in that final year to get their degree, especially as the degree course lasts for 5 years. Despite the length of this day release degree a number of students have chosen to continue their studies to achieve an MSc. Going forward we are particularly interested in the work NMI is involved in to create a graduate apprenticeship scheme as this could be a useful way to extend our apprentice scheme.

ABOUT THE AUTHOR

EMMA PORTMAN
RENISHAW PLC, TEST MANAGER – GROUP ENGINEERING SOFTWARE:

After Graduating from the University of Liverpool, Emma has worked in a number of industry sectors from Utilities to Telecommunications. She has been the Test Manager for Group Software within Renishaw for the past 5 years, a role which sees her coordinating all system test activity across 13 different business units and focusing on a wide range of precision measurement instrumentation products, from traditional machine tool probing software and geospatial laser mapping systems to 3D metal printing systems and neurological planning software. Beyond that Emma also works within the Renishaw Project HUB function which manages the Group Software development process and application lifecycle management (ALM) system, its software toolchain and project management activities. Most recently she has taken over the responsibility for the Apprentice, Graduate and Industrial Placement Schemes for Group Software.

Our software apprenticeship journey has been a unique one which has been at times exciting, and challenging, but always rewarding. Different companies will have different challenges to face. However it's a journey worth undertaking both for the apprentice and the business, when those initial and subsequent apprentices graduate from University, including some with 1st class honours degrees.

Paul Double
EDA Solutions' founder and CEO

ASIC – **THE LOW COST, LOW RISK SOLUTION!**

To look at the many articles on the rising cost of semiconductor device development, you would think only a smattering of well funded start-ups, systems companies or device manufacturers could ever afford to take advantage of the many technical and commercial benefits that Application Specific Integrated Circuits (ASICs) offer. Yet with wide availability of low cost design tools and easy access to flexible, mature IC processes, there has never been a better time to explore the advantages of an ASIC.

BREAKING THE MYTH

Figures such as a $25 million+ just to buy one mask set, and design costs reaching into the $100 millions seem to mark out ASIC design as a rich person's game. But these figures are only for the leading-edge processes that are cost-justified by large system on chip (SoC) devices in high volume consumer products like PCs and Smartphones. For applications like Internet of Things (IoT), where integration levels are lower, and the need to interface with the "real world" mandates the use of analogue circuitry, mature "More than Moore" process technologies are more suitable. Here the costs and risks of using ASIC technology are very different.

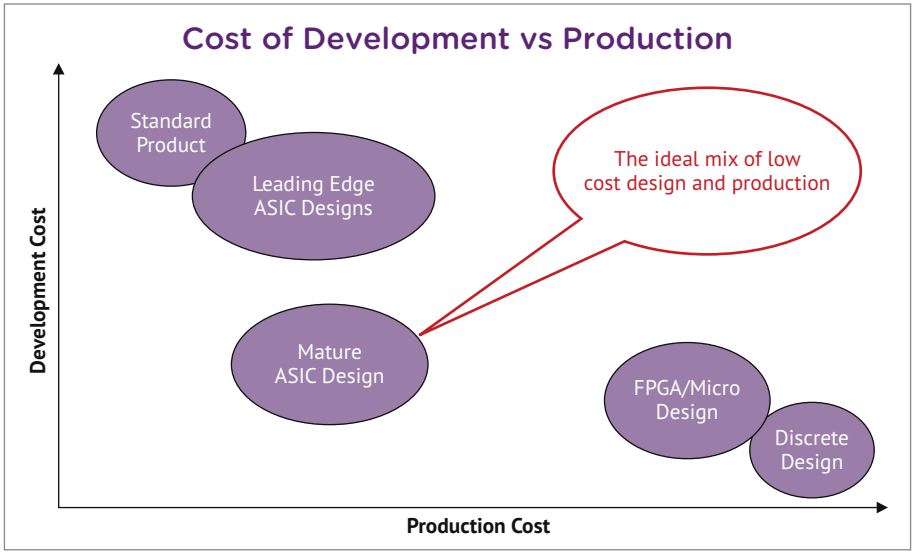
Despite the hype about rising costs, for many projects ASIC design and production has actually become cheaper, to the point that many people who used to believe field-programmable gate arrays or microcontrollers coupled with discrete analogue devices were their only options are finding out that the dedicated ASIC approach is more cost-effective. The key is to choose the appropriate design tools and more importantly process technology, taking advantage of its maturity to deliver the cost savings and to ensure a wide availability of free or low cost IP. The figure opposite shows the relative development and production costs for standard IC products, ASICS and reconfigurable parts like FPGAs.

THE ASIC ADVANTAGE

ASIC has a host of other important benefits beyond low cost of production. ASICs can offer greater performance, lower power, higher voltages, reduced footprint/bill of materials and thus increased reliability. However, perhaps most importantly in this day and age, ASICs offer higher IP security, as an ASIC is far harder to reverse engineer than a microcontroller or FPGA design, where the IP is stored in easy to read memory.

UPSIDE OF PROCESSES MATURITY

The cost of production in the more mature nodes falls over time as the cost of building the fab is depreciated, with the fab owner only



> **"MOST OF THE RISK IN ANALOGUE IC DESIGN LIES IN UNCERTAINTY."**

needing to cover the running costs such as staffing and materials. A technology like the ever popular 0.18um Mixed Signal CMOS node has been around since the late 90s, so all facilities and equipment costs are well and truly written off.

As well as production costs, design costs for those working in the mature process nodes have improved, particularly for those working on mixed-signal flows. Most of the risk in analogue IC design lies in uncertainty. When processes are first rolled out, they offer a moving target to the analogue engineer. Key process parameters may shift dramatically from batch to batch as the foundry engineers tweak settings to improve overall yield. This makes it difficult to model analogue circuits. However, once the process is optimised the foundry can make available accurate libraries that better reflect the behaviour that engineers will see in the real silicon, reducing design risk. These improvements are realised in foundry specific Process Design Kits or PDKs. These are offered by the foundries, and the more they are used the better they become.

WIDE AVAILABILITY OF RE-USABLE IP

Moreover, many foundries offering mature mixed signal processes provide a wide range of pre-characterised IP. The use of such IP blocks is commonplace in the digital world, with world leading UK companies like ARM and

Imagination Technologies offering a wide range of functional blocks such as Microcontrollers, many suited to use in these mixed signal technologies in applications such as Internet of Things. Analogue circuit blocks like comparators, operational amplifiers, band gaps, Analogue to Digital and Digital to Analogue converters greatly reduce design time and risk for the designer.

These older processes also offer support for higher voltage operation, which means they are common choices for mixed-signal designs where analogue accuracy is important, or the need to work in or control higher voltages are required, such as automotive, industrial control or power management applications.

Some foundries can even tailor their foundry processes to meet specific product or application requirements. Plessey in the UK for example has a unique low power process developed specifically for implanted medical devices such as pacemakers, where battery "life" is not just important, it can be a matter of life or death!

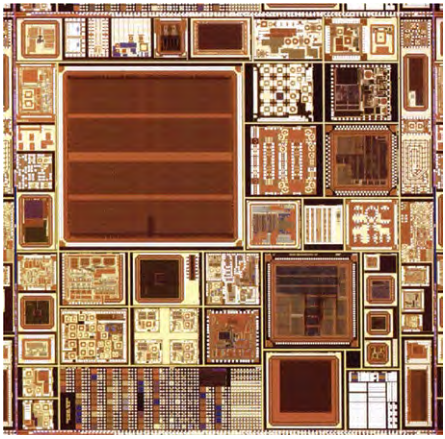


Figure 2

SHARING THE COSTS

Costs and risks in mask and wafer production can be further reduced by using multi-project wafer (MPW) services from organisations such as Europractice. Where small quantities of chips are needed for evaluation/qualification, or small production runs, several designs can be incorporated in a single mask set, as shown in the **Figure 2** (courtesy of MOSIS). Customers typically order 40 devices for evaluation before going to the expense of a dedicated mask set, but up to 1,000 devices of any one design could be produced in a single MPW run. MPW costs are just a fraction of those needed for complete set of dedicated masks and wafers, as customers only pay for the proportion of the wafer that their devices occupy. Most major foundries support multi-project wafer services.

A variation on this theme, offered by X-Fab, to further reduce the cost of production mask sets, is for several process layers to be drawn on the same mask. **Figure 3** shows 4 layers on one mask, cutting mask costs by as much as 70%. This is known as Multi-Layer Mask or MLM.

It's important to remember that neither older processes nor MPW services inhibit leading-edge analogue design. The first single chip Bluetooth transceiver, as shown in **Figure 4**, was developed in the late 90's by a UK start-up using a 0.35um CMOS process. More recently, when another Cambridge start-up was developing a new generation of communications ASICs to exploit the now free to use unlicensed spectrum previously used by analogue TV transmission they turned not to 14nm or even 40nm, but the now mature 90nm process node. The relatively low wafer cost coupled with excellent yield ensured the device offered sufficiently low pricing for the commercially sensitive high volume application, coupled with

"IT'S IMPORTANT TO REMEMBER THAT NEITHER OLDER PROCESSES NOR MPW SERVICES INHIBIT LEADING-EDGE ANALOGUE DESIGN."

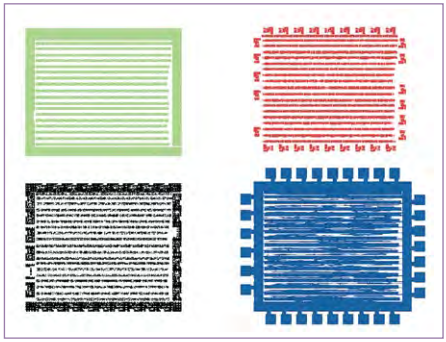


Figure 3

good analogue performance and maturity of process needed to ensure right first time design.

Wide availability of low cost device assembly and test services complete the manufacturing supply chain, ensuring fully functioning packaged, tested chips can be delivered easily and cheaply.

LOW COST DESIGN TOOLS

The use of mature processes brings tool cost down too. There is no need to buy expensive leading-edge design tools intended for advanced nanometre SoC design, as they contain many features that are unnecessary for design in the mature nodes. For example, you need a far more complex and thus expensive design tool to perform simulation, layout or verification of a

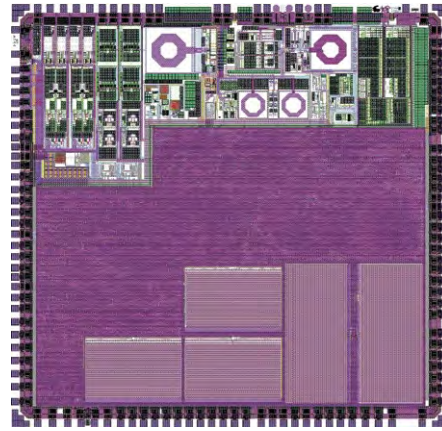


Figure 4

billion gate design in a recently released process node than you do for a relatively simple mixed signal circuit in a mature process, where the gate count may range in the 10's of 1,000's, and most of the analogue circuits are IP blocks provided by the foundry and used many times before.

Low-cost design tools such as Tanner EDA's HiPer Silicon, which was used extensively in both the above examples, have support for HDL digital design, synthesis and place and route together with support for full custom analogue design, allowing engineers to move into mixed-signal chip design on mature processes cost-effectively and easily.

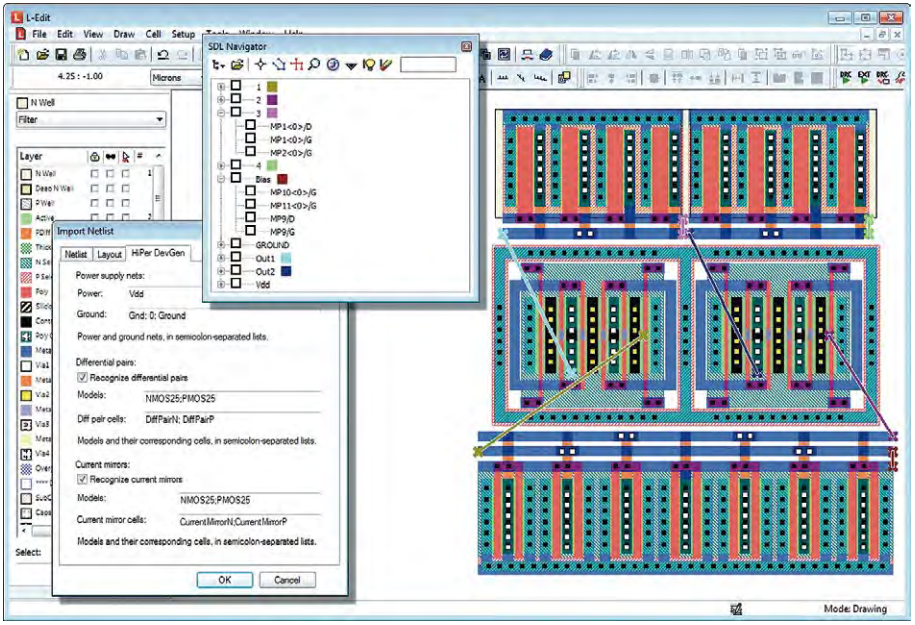


Figure 5

For the analogue side of the design, low-cost or even free-to-use open source tools bring many of the benefits that high-end tools offer without unnecessary features and thus cost. Low-cost tools are often easier to use because they do not put advanced features in the way. However, this does not mean they lack the functionality or capability of the high-end tools for analogue and mixed-signal design. **Figure 5** shows the automated layout of an operational amplifier using Tanner EDA's market leading HiPer DevGen accelerated layout tool.

Another major factor in the choice of design tools is the easy availability of the PDKs needed for accurate and efficient design. This is made easier by the wide adoption in the industry of the emerging Interoperable PDK or iPDK standard. iPDKs are developed by most foundries today, and are designed to work with all the major IC design tools. These iPDKs not only contain the basic process related data like simulation models and process layers, but also complex device generation macros know as Parameterised Cells or P-Cells. It used to be that most tool vendors used proprietary languages for their P-Cells and so foundries had to choose which tool vendors to support. Now, with most tool vendors supporting Python as the language used in their P-Cells foundries can support all the major tool vendors with one PDK.

Low-cost tools have one further saving on their side. Ongoing support costs are a major feature of high-end tools. To deal with the complexities of setting up and maintaining such leading edge system on chip design flows often demands the support of a dedicated CAD department or the involvement of expensive maintenance contracts. If you are working with a smaller

mixed-signal design team, you have to ask yourself whether you need to incur the cost of this type of CAD support, especially when more cost-effective tools are designed to work straight out of the box.

A CASE IN POINT

When long established, yet highlight innovative West Country firm Rotalink needed a way to reduce the size of the control electronics in their miniature electric motors, as in **Figure 6**, they turned to ASIC, as it offered the technological complexity, analog functionality and small form factor dictated by the application. Designed with the Tanner tools, the chip uses tried and tested analog IP blocks provided by foundry partner X-Fab, whose cost effective process allows Rotalink to meet the volume and cost targets mandated by the commercially aggressive industrial control market.
Rotalink Managing Director Melvyn Hazell commented "To remain at the forefront of such a competitive industry requires dedication to continuous technological and commercial advancement, and the use of ASIC helps us achieve both."

Figure 6

ABOUT THE AUTHOR

PAUL DOUBLE
EDA SOLUTIONS' FOUNDER AND CEO:

Paul Double is EDA Solutions' founder and CEO. After gaining a B.Sc. (Hons) in Physics and Electronics at the University of Warwick, Paul started his career in IC Design with Phillips Semiconductors (now NXP), eventually moving into product management. Paul then spent eight years in design consultancy and electronic design automation (EDA) software sales management, first with Rood Technology, then later with Acapella. It was at Acapella that Paul first gained experience with Tanner EDA's IC Design tools. In 2001, Paul founded EDA Solutions to further the interests of Tanner throughout Europe. EDA Solutions is a strong supporter of NMI activities in the UK.

IF YOU THINK YOU KNOW ASIC, THINK AGAIN!

For mature processes, IC design is becoming more accessible thanks to the ready availability of production capacity and lower non-recurrent engineering costs made possible by low-cost tools and lower-priced processes. There is no need to feel that your only options are FPGAs or discrete Micros with board-level analogue circuits. Mature processes allow you to save cost and improve performance by putting the key differentiating elements of your product design into one IC. Custom ICs are no longer the preserve of those companies with deep pockets!

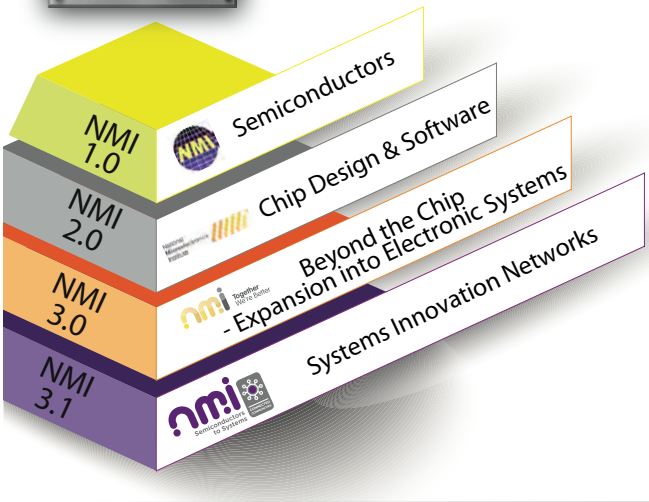
NMI will be running a networking event in 2015 on this topic. Check the NMI events calendar for more details and to register your interest.

NMI is the champion for the UK Electronic Systems industry & Technology sector

Semiconductors to Systems

Established 1996

Commercially operated non-profit organisation funded by members



BUILD CAPABILITY

TECHNOLOGY STRATEGY

- Influence public investment
- £70m+ of public funding secured for the industry
- Assist collaborative funding projects
- £100m+ of R&D project activity generated
- Practical advice for members
- 500+ introductions

INNOVATION

- Networking events across the value chain
- Manufacturing forums
- Technical networks covering design to manufacture
- Benchmarking reports and assessments

EXCELLENCE

FIT TO COMPETE

SEMICONDUCTORS

MANUFACTURING

MAIN ACTIVITIES

Objectives:

- To be the benchmark of collaborative manufacturing associations
- Creating an integrated collaborative improvement system
- Raise performance levels beyond expectations

£2m CCL savings per year

125+ collaborations each year

Developing people through unique access to member sites

LEAN NETWORK

- Continuous Improvement
- LEAN Assessments
- Best Practice Site Visits
- Quality / Cost / Delivery

MANUFACTURING SUPPLIERS

Exploring new market development forums

Tabletop exhibitions within mfg sites

Work with UK Governemnet bodies to organise subsidised shared stands at International Trade Exhibitions

MICROELECTRONICS

NETWORKS

Digital Design & Verification

Analogue / Mixed Signal / RF Design

Design for Manufacture / Test

Quality & Reliability component

IC Packaging Design / Testing

Fabless Operations

NETWORKING EVENTS

20+ Events annually

FREE to NMI Members

Over 1,200 attendees in 2013 from over 500 different organisations

PUBLICATIONS

Electronic Systems Guide

Employment Survey Report

Power Electronics strategy

Yearbook

Supplier Directory

HR Survey Report

Sunday Telegraph / Guardian

INVESTMENT

SKILLS

UKESF an NMI led initiative

£1m+ of investment

170+ scholarships

Shortage occupation list petition for roles crucial to members

Regular employment surveys

REPRESENTATION

R&D tax credits

Trailblazer

ESCO

Immigration policy

ADVOCACY

REALISING OPPORTUNITIES

CONNECTED COMMUNITIES

STRONGER TOGETHER

TO SYSTEMS

ELECTRONIC SYSTEMS

SUPPORTED ACTIVITIES

Power-efficient, Reliable, **Many-core** Embedded systems

PRiME EPSRC

SW Microelectronics iNet

iNets South West Microelectronics

European Regional Development Fund Investing in your future

Leading to **418** Jobs, **254** Products and **47** Collaborations

£2.08m ERDF > £12.1m GVA

AUTOMOTIVE

AESIN DRIVING PROGRESS

Automotive Electronic Systems Innovation Network (AESIN) - an NMI led initiative

POWER ELECTRONICS

POWER ELECTRONICSUK

PowerelectronicsUK is an industry-led collaborative initiative led by NMI

NMI's Power Electronics Network was established in 2004

SYSTEMS & SOFTWARE

Embedded Focus

Application Support

Development / Engineering Technologies

System Complexity

Skills Competence

FPGA PRACTIONERS NETWORK

Launched in 2012

2014 survey shows FPGA "essential" design capability

Driven by FPGA frontrunners forum

CONFERENCES

Future World Symposium

Manufacturing Excellence

UK Automotive Electronics

Electronic Systems Technology Industry Summit

ANNUAL AWARDS DINNER

Annual celebration

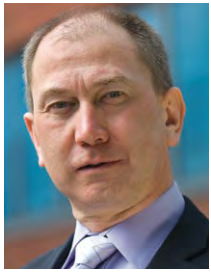
400+ professionals black tie dinner

Awards conducive to sustainable future

INVEST IN YOUR FUTURE & JOIN US - ***www.nmi.org.uk***

Doug Amos
NMI FPGA Network Director

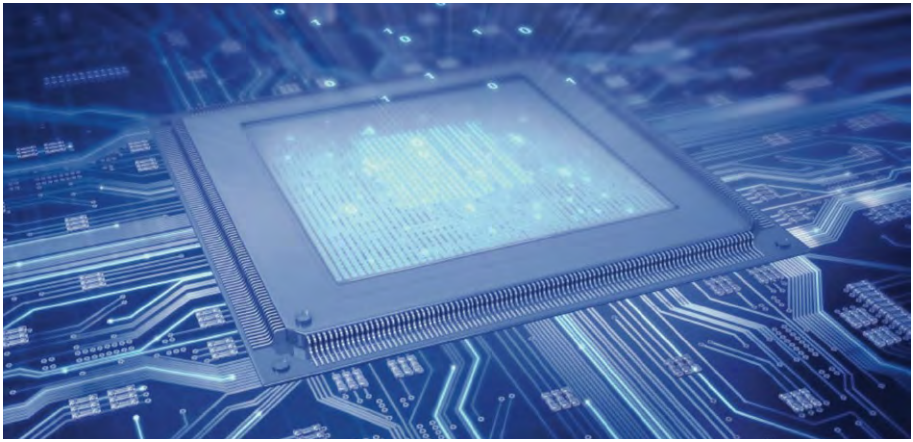
FPGA:
THE FRONTRUNNERS



NMI founded its FPGA Network over 5 years ago and has since organised networking events related to their use. The technology platform of FPGAs is undeniably important and the strong feedback we receive from delegates at these popular events is always encouraging. Yet events are only the beginning; supported by feedback from members and the results of a recent survey, NMI is now expanding its FPGA Peer Network activities to reach more users. The ultimate aim is to make a significant impact in overcoming the continuing challenges in across the region.

LAST YEAR we invited Doug Amos, an electronics industry veteran, to take the FPGA network to the next stage of development for the faithful and growing community. One of the first activities that Doug has undertaken is to conduct a detailed survey of usage within Britain and Ireland to gain better insights into the nature of modern FPGA design and the common challenges that are faced.

By October Doug had pulled a plan together with a number of leading players and the 2014 FPGA Usage Survey was carried out in conjunction with New Electronics and supported by Altera, Aldec, FirstEDA, Mentor Graphics, Silica, Synopsys, Xilinx and Xmos. Participants were asked a series of questions about their usage, design methods, challenges and future expectations.



What did we find out and how will we use that knowledge to support the FPGA community here? Doug picks up the narrative.

FPGA TECHNOLOGY IS "ESSENTIAL" TO THE SUCCESS OF TODAY'S PRODUCTS

The extent to which programmable logic is used in today's products is not surprising in itself however, the degree to which the success of those products rely on FPGA capabilities is quite remarkable. In our survey 81% of respondents told us that their FPGA capability is "essential" to their product's success.

Ok, capability is essential – got that – but what problems are we facing that challenge our capabilities?

CONTINUING CHALLENGES FOR FPGA DESIGN

In the 30+ year history of "programmable logic", every year has seen new devices, new adaptations of the design methodology, and new IP, resulting in FPGA technology being applied to an ever-wider range of applications.

At the leading edge of FPGA design, the techniques and expertise employed can be every bit as challenging and sophisticated as those used in integrated circuit design.

Yet FPGA design is only possible because users have effectively out-sourced silicon layout and other microelectronic decisions to the device manufacturers and tool suppliers. This means that FPGA designers do not expect to be exposed to cell-level decisions and this must not change. We must be able to continue to work at an abstracted level from the silicon and depend upon the tools to make trade-offs

"81% TOLD US THAT THEIR FPGA CAPABILITY IS "ESSENTIAL" TO THEIR PRODUCT'S SUCCESS."

automatically, effectively and without error. FPGA eco-system players have devoted many years of R&D effort and inter-dependent partnership in order to provide devices and tools which are mutually aware of their constraints and this continues; right to the very deepest silicon nodes.

Despite all this collaborative effort, the local engineering community tells us that there are still significant challenges in completing designs to schedule, and those challenges were highlighted in the survey.

SPECIFIC FPGA USAGE IN BRITAIN AND IRELAND

In the survey, 53% of respondents cite timing analysis and closure as being amongst their top three challenges – this was closely followed by RTL verification at 49%. Clearly these challenges are an opportunity for enhanced tools and/or methodology and equally they provide a focus for future NMI technical workshops.

Another strong indication from the survey is that hard or soft CPU cores are used

extensively – embedded in 62% of all FPGA designs. With this increasing use of CPUs, FPGA design now incorporates the wider realm of software and system-level design, which is yet another significant focus for NMI. System-level design includes algorithmic modelling, high-level synthesis, model-based design, software-hardware co-design and virtual prototyping. The frontrunners in FPGA design are often to be found working in these emerging areas but 61% of survey respondents are still solely using the standard high level design languages, i.e. VHDL, Verilog, SystemVerilog or a mix thereof.

Some of the survey's findings reflect universal issues, but others may be particularly significant to our region and not necessarily the focus of the world-wide industry. For example, a surprising 26% of respondents are working to some safety integrity level certification such as DO-254, IEC61508 or ISO-26262. Further analysis is expected to show this is somewhat higher than other global regions .

FPGA FRONTRUNNERS SHINE A GUIDING LIGHT

Obtaining a more accurate profile of the local FPGA usage and challenges will help direct activity of the NMI FPGA Peer Network. This is achieved not only via the survey but also in continuing discussions with users online and face-to-face. We are also seeking more overt direction from the leading users and, at time of writing, we are assembling what we call the FPGA Frontrunners Forum; an invitation-only group comprising leading FPGA users from NMI member companies.

The FPGA Frontrunners Forum will have expertise and be highly experienced in at least one significant FPGA application space; from remote sensing, to communications, to SoC prototyping, and many more. We will meet regularly, virtually or in person, to explain and learn of the others, sharing methods and needs, quickly building a core body of knowledge to help drive the FPGA Peer Network. We expect to recognise common challenges and design trends, which we will partner with key players in the FPGA eco-system in order to provide regional support, training and user development.

DO WE HAVE THE SKILLS AND TRAINING WE NEED?

I have room for one last important data point from the survey: on the subject of training and skills. The survey tells us that 50% of users are expected by their employers to keep their own knowledge and skills up to date, yet less than 22% of teams made time to train existing staff accordingly. We also learned from 19% of respondents that FPGA skills were hired in and a significant 9% resorted to bringing in external

"50% OF USERS ARE EXPECTED BY THEIR EMPLOYERS TO KEEP THEIR OWN KNOWLEDGE AND SKILLS UP TO DATE."

FPGA consultants to help complete a recent project. Anecdotally, many users (but not all) tell us that finding new staff with the necessary level of design skills is problematic. Is this an emerging skills gap? Having previously noted how "essential" FPGA is to product success, it may be that NMI has a role in brokering increased knowledge-sharing to address skills gaps and we will look to the FPGA Frontrunners Forum for more detailed guidance.

BEYOND FPGA?

There is much more to FPGA than ever-larger "plates of gates" fabricated at ever-decreasing silicon nodes. Offshoots and specialism in minority or emerging markets are driving a technical diaspora of FPGA ideas into other programmable devices, including 3PLD, CSSP, FPAA, and PSoC; and if you don't know all those acronyms then I think I've made my point.

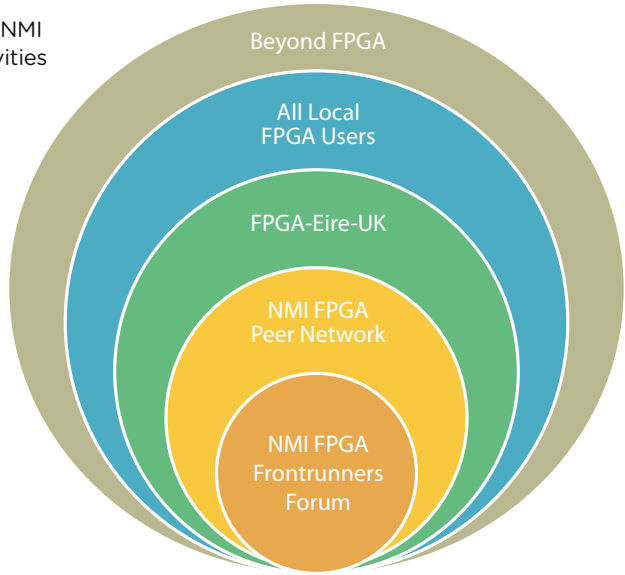
In addition, the application spaces currently dominated by FPGA may be invaded by other programmable devices, including xCORE technology from Xmos right here in the UK. As FPGA usage in our region changes, the NMI Peer Network promises to adapt and even pre-empt that change.

WHERE WILL WE BE THIS TIME NEXT YEAR?

Our approach is to have multiple layers of engagement, both for NMI members and beyond, as summarised in Figure 1.

- Explore beyond bounds of recognised FPGA Usage.
- Stimulate online discussions via FPGA-Eire-UK and other forums.
- Establish an increasingly potent FPGA Frontrunners Forum.

Figure 1:
Expanding NMI FPGA Activities



- Run a more active and interconnected FPGA Peer Network, driven "by the users, for the users".
- Amplify the voice of NMI FPGA users within the worldwide FPGA industry.

If the current growing momentum is successful we will have had a significant effect by the time you read the next NMI yearbook.

HOW CAN YOU JOIN IN?

Keep up to date with the NMI FPGA Peer Network by registering for our bulletins, or ask to join our new LinkedIn group, FPGA-Eire-UK, which is open to NMI members and non-members alike (and monitored to keep it spam-free). If you feel that you have something to offer the group then we definitely want to hear from you – contact doug.amos@nmi.org.uk.

Stay programmable in 2015!

ABOUT THE AUTHOR

DOUG AMOS

NMI FPGA NETWORK DIRECTOR:

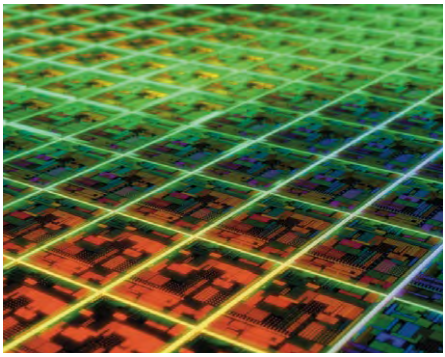
Among other things, Doug Amos is Director of the FPGA Network within NMI. Doug has carved out a living from programmable logic and FPGA for over 30 years, holding technical positions with Altera, Synplicity and Synopsys. He was also a freelance consultant designer and "PIP-Pilot" back when LUTs were still a pretty neat idea. In all that time, the one constant has been the rapid change within the industry, and despite its maturity, FPGA still takes a lot of keeping up with, and that will keep Doug busy for some years to come.

doug.amos@nmi.org.uk

John Moor
VP, Marketing, NMI

THIS NATION OF INNOVATORS: **THE HERE AND NOW OF UK CHIP DESIGN**

Some say that pessimism is one of Britain's greatest exports. That the Great British reserve, over-cautiousness, and a tendency to 'hide a light under a bushel,' stands in the way of much deserved national and global recognition.



EVEN IF THIS was only half true, it's a reasoning perhaps that explains why some on our islands remain seemingly oblivious to the fantastic innovations and undeniable world standing of our chip design industry.

I know we're immensely proud of the sector, but we'd like more people outside of it to be as well. NMI spoke to a selection of some of our stars in industry, about the here-and-now-of-things, their key innovations and major achievements.

As one of the prime catalysts for the landmark ESCO report of 2013, NMI is taking great strides towards raising the profile of our semiconductor industry at the highest levels of government and public life.

More than 18 months in and the nascent ESCO council is pursuing ambitious long-term goals for the UK electronics industry. They're inspirational. Grow it by 55%, to £120 billion, create 150,000 more highly skilled jobs – all this by 2020.

Included though on the more immediate agendas of our emerging chip design firms right now are that dearth of funding, the shortage of the right skills and finding that perfect business model to maximise profit.

We know such macro-economic issues will never be fixed overnight, and in an unstable 'post-crisis economy', our smaller, less well known chip design companies aren't standing still and waiting for long term fixes to kick-in and solve such challenges. They're acting now, they're winning and they're in good company.

ARM ('the world's leading semiconductor IP supplier'), Imagination Technologies ('global leader in multimedia, processor and communication technologies') and CSR

"AS A NATION OF INNOVATORS, I'M SURE MOST WOULD AGREE THAT TO COME FIRST, YOU HAVE TO DO SOMETHING REALLY EXTRAORDINARY."

('world-leading provider of enhanced silicon, software and services for consumer electronics') are bold proof-positive of what can be achieved by UK chip design companies on the world stage.

The ultimate in knowledge-based semiconductor and IP technology brands, recognised throughout the planet. They provide the cutting-edge innovation enabling the world's most iconic and desirable consumer products that we buy into and rely on – smart phones, tablets, DAB radio, sat nav – the list is long.

Such companies continue to blaze one fantastic trail for generations of UK chip design companies to aspire to and follow, and they are. Today. They're all around us.

NMI has been chewing the fat with a number of them. Some well-established, others all-new, and, as the mighty Will.i.am would put it, we felt it was time to '…shout, and let it all out…'

BREAKING DOWN BARRIERS

Short range, point-to-point and mesh-network radio protocols, like Bluetooth and Zigbee are really great – aren't they? Yes, sometimes, not always. Let's face it, with a transmit power a tenth that of WiFi, they're never going to be reliably 'room-to-room' let alone 'whole-of-house'. NMI spoke about it with Bruno Johnson, CEO of Cascoda.

It's a problem that he put to his CTO to fix, and at time of interview, his company was on the cusp of doing just that: "We simply can't shout louder to solve the problem, we can only listen harder. Hence what we need is a radio receiver with much improved receive sensitivity – that's what we've developed," says Johnson.

I'm struck by the fact that after more than three decades is it? Cascoda is effectively introducing only the third type of demodulator architecture in the world. Now that's positive disruptive technology, real innovation – it's a big deal right?

"As a nation of innovators, I'm sure most would agree that to come first, you have to do something really extraordinary, develop something with a high 'patentability' factor" Johnson says. "In this case, arriving at a demodulator that can work with existing radio protocol standards, massively extending their range, without any power penalty whatsoever, is a fair game-changer, yes."

It doesn't take a huge stretch of the imagination to start to realise the implications of what Cascoda has done. By enabling true whole-house energy management control, their technology will

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ultimately succeed in cutting fossil fuel energy consumption and reducing CO_2 emissions.

"Well it's more than just improving the efficiency of the lighting, the heating and the aircon," says Johnson. "It's also about a reduction in build costs, reducing wire routing and proper integration of PIR based alarm systems with energy management systems. The implications are endless."

It's notable too that the Cascoda architecture's low power credentials walk hand-in-hand with the development of higher performance, longer life Lithium cells. The result being far more deterministic and reliable battery replacement cycles in the building management systems of the future.

DISPLAYING TRUE PROWESS

An industry leader in graphics over USB technology, DisplayLink's chips are used by OEMs throughout the world to link displays to embedded applications. Its products are in docking stations, graphics adapters and monitors. NMI asked Chairman and CEO, Graham O'Keeffe about the secrets of the company's success.

"Solving a very real problem in a unique fashion is vital. Businesses that fail are often trying to address too many market segments simultaneously. Those that win focus on a specific market segment and solve a problem better than anyone else. They arrive at a self sustaining position faster," says O'Keeffe.

I'm thinking about the 'societal drivers', and it's clear that the move away from desktop PCs with graphics cards and a growing trend in offices towards 'byod' (bring your own device) will have helped DisplayLink immensely. So too the use of multiple screens to help boost productivity. Not to mention the power saving aspect. I'm wondering though what's next?

O'Keeffe says, "The popular retina displays in truth really aren't very high definition and there's a big move towards ultra high density 4k displays and tablets. Twice the pixel density, twice the resolution. I promise you that using a beautiful 4k screen for the first time is a real wow moment! The demand is real and it's here today."

"Our SoC solutions can produce an output resolution of 3840 x 2160 and allow OEMs to offer full support for 4k ultra high definition monitors and displays. So for end users wanting say a 4k solution for their conference room, for digital signage or to enable Mac or PC laptops to support the latest 4k monitors, we have the answer," says O'Keeffe.

But the laptop market isn't growing I'm thinking. I'm told it's stopped growing. Is there a greater demand to come? Where's it going to come from?

"So yes, it's true that the laptop market is stagnating, the figures suggest 200 million units a year. Smart phones of course are a different matter, at 800 million units a year they represent a huge opportunity," says O'Keeffe.

"Just think. It's said that some 90% of many jobs can be done by using a smart phone.
Their multi-core nature makes them not far off an enterprise workstation – plug them into a keyboard, a mouse and a high definition monitor of course and away you go…"

"Fundamentally I believe that the UK remains a strong mercantile nation, we understand emerging markets and in the last 10 or 15 years our ability to produce some great electronics start-ups is clear evidence of our ability to give

> **"THE MOVE TO SMALLER PROCESS NODES HAS BEEN A MUCH DEBATED CONCERN FOR PROBABLY MORE THAN A DECADE."**

it a go, whatever the challenges and whatever the economic climate," says O'Keeffe.

LIFTING THE LID

The move to smaller process nodes has been a much debated concern for probably more than a decade. After 28nm (and far beyond) what's the best way of tackling variability? We might never be able to design out all of its negative effects, but is there a pragmatic and realistic approach IC designers can take to combat the problem?

Experts in high-performance analog IP and advanced chip design, Moortec Semiconductor has taken on the challenge. Its unique embedded process, voltage and temperature (PVT) monitoring IP is enabling SoC performances to be optimised and IC design flows to be enhanced. NMI spoke to the company's CEO, Steve Crosher.

"You could say that we've lifted the lid on the true operating conditions within advanced 28nm and FinFET devices. With greater gate densities, and higher clock speeds, come big challenges in power density and real thermal issues. By integrating accurate PVT monitoring on chip, problems are alleviated and resolved," says Crosher.

He continues, "It's all about helping our customers get the best out of their devices, by optimising performance for real circuit conditions – on a per chip, or per die basis. You've got a large digital design, a processor, running at a rate of knots year after year, the risk of early failure needs avoiding."

It occurs to me that Moortec is surely playing in a much-privileged space. A UK-based SME operating at the bleeding edge of the finest technology nodes on the planet. Cool stuff, but how come?

"So no, it's not something that's happened over night. We've been focused on developing PVT monitoring IP for more than a few years, and have been lucky enough to work with some Tier 1 lead customers with real vision, a real will to tackle the heat and power problems of sub 40nm CMOS," says Crosher.

"This has given us great opportunities to access the advanced node processes at the world's major foundries, and develop PVT monitoring IP which is market-leading and patentable too – for the levels of accuracy we can achieve, circuit novelty, and techniques employed."

Crosher's enthusiasm and drive is palpable. I'm wondering though how he's going to stay ahead of the game, what's next? Is his position that defensible? Is Moortec really that unique?

"Well, we are the only IP vendor specialising in the area of PVT monitoring. Are we unique? I'd rather say that it's the UK that's unique. We're a country that's full of innovative companies, a place that's still a hotbed for start-ups, where

great designers are solving the problems others can't," says Crosher.

"In terms of what's next, for us, like any other company it comes down to the strength of the road map and the team's desire for innovation. On ours, it's about even higher accuracy PVT monitoring; scattered PVT monitoring – with smaller circuits in higher numbers, on-chip energy optimisation sub-systems and global device monitoring for better device analytics, in-production and in-the-field. Exciting stuff."

PUSHING THE ENVELOPE

Also living amongst us is Nujira, the world's leader in 'envelope tracking' (ET) technology. ET dynamically modulates the power feeding the RF power amplifier stage in smart phone and other portable wireless devices. So what?

Dumb question! Simple answer: ET reduces the energy consumption of mobiles, extending battery life, reducing heat dissipation, and improving coverage – helping to shrink the size and weight of our favourite handhelds. NMI spoke to Jeremy Hendy, Nujira's VP of Marketing.

"We've succeeded because we were working on ET technology years before it became an absolute necessity, our design was innovative, we harnessed a mature process and solved a problem that has now become very, very real. We were ahead of the curve, the first to commercialise," says Hendy.

"The hike in data rates moving from 2G to 3G, from 3G to 4G was crying out for an agile, dynamic RF amp power supply. Our greatest achievement was convincing the handset industry that ET was the way forward, the best way, both technically and commercially to solve their power consumption problem. We made it happen. This year there'll be 125 million smart phones shipped with ET inside. And 4G, in all its different flavours, is a real catalyst right now and we're in the thick of it."

Patents have played an important role in establishing and securing Nujira's market leading position and the company's ethos of innovation. At time of interview, the company had 240 patents protecting its ET IP.
I'm thinking the design team must be big?

"The size of our design team is actually quite small, though recruitment can still be a challenge from time to time. If you compare the half million employed in silicon valley with the 10 thousand employed in Cambridge, there's no real surprise. There's plenty of digital know how out there but less analog and RF, so 'growing your own' has been important for us and we've had good success," says Hendy.

"Some say that the excitement's returned to the UK electronics sector, I'd say it never left. It's never gone away. Britons inherently like to do things first, we remain a highly creative nation. We're innovators and create smart things. Engineering is a core strength. Long may it continue."

HEALTHY OUTLOOK

An ageing population, a shortage of nursing staff, a health service under pressure – a time for technology to wade in and help alleviate a few shortfalls. NMI spoke to Alison Burdett, Director of Technology at Toumaz Group and discovered that healthcare can only get better.

Toumaz' Sensium Healthcare Division developed the world's first ultra low power wireless platform for patient monitoring. In partnership

with its Frontier Silicon Division, it produced a complete end-to-end silicon and software solution enabling OEMs to create products that improve patient health monitoring, both in the hospital and in the home.

"Monitoring a patient's vital signs has always been a time consuming and labour intense task and something generally only carried out once every four to eight hours. SensiumVitals®' wearable patches monitor heart-rate, respiration and temperature every two minutes and communicates the data via a bridge to the nursing station or a web-enabled mobile device."

OK, so earlier detection of patient deterioration, meaning earlier interventions, shorter hospital stays and lower treatment costs – the economic and clinical benefits are obvious… so why has it taken so long for a company to 'grasp the nettle' I ask.

Burdett says, "We were pitching wireless patient monitoring when we founded back in 2001, it just wasn't high enough on investors' radars, the appetite for funding wasn't there. As a design services company with a skill-set firmly in low power wireless we never stopped believing. We were stubborn, we knew we were right."

"Years of steadily building low power sensor interfaces and great wireless IP, a public listing, a merger with Frontier Silicon and we've now got two divisions sharing core skills and technologies in wireless comms and RF. We now have the world's first radio chip that does the job," says Burdett.

Have worldwide communication standards and bandwidth restrictions been able to keep pace I wonder? The company is also regarded as a world leader in chips, modules and software for digital radios. Is DAB take-up happening quickly enough too?"

"It has taken time and a lot of work yes, but there is now an IEEE global standard for wireless healthcare [IEEE 802.15.1NB1] which fully supports the ideal of 'MBANs' or medical body area networks, and RF bands dedicated to wireless medical devices. Of course DAB is a hugely exciting area for us as well," says Burdett.

"UK leadership in DAB again clearly demonstrates the nation's spirit of innovation and appetite for intellectual problem solving. Nobody knows DAB better than us.
Cultural diversity, ethnic diversity, a mix of all different approaches – this only breeds better, more creative thinking. Other countries of the world are now following the UK's lead in DAB."

"Nordic countries are committed to complete digital switch over in the medium term, there are new DAB services in Germany, The Netherlands and France, with other EU countries considering plans. The USA already has its own 'HD radio' in the automotive sector and India has begun transmitter rollout. It's a really exciting time."

NOT THE FINAL WORD

So the next time someone asks you about the UK electronic design sector, whether to work in it, to invest in it, what kind of stuff it does, just how good it really is, please point them to NMI. Yes, there are always plenty of challenges (and we're all working hard to resolve them), but we've a really positive story to share today, it tells of world-leading innovation and we're proud.

Mick Conlon
UK Operations Manager, Diodes-Zetex Semiconductors

GOT KNOCKED DOWN? **GET UP AGAIN!**

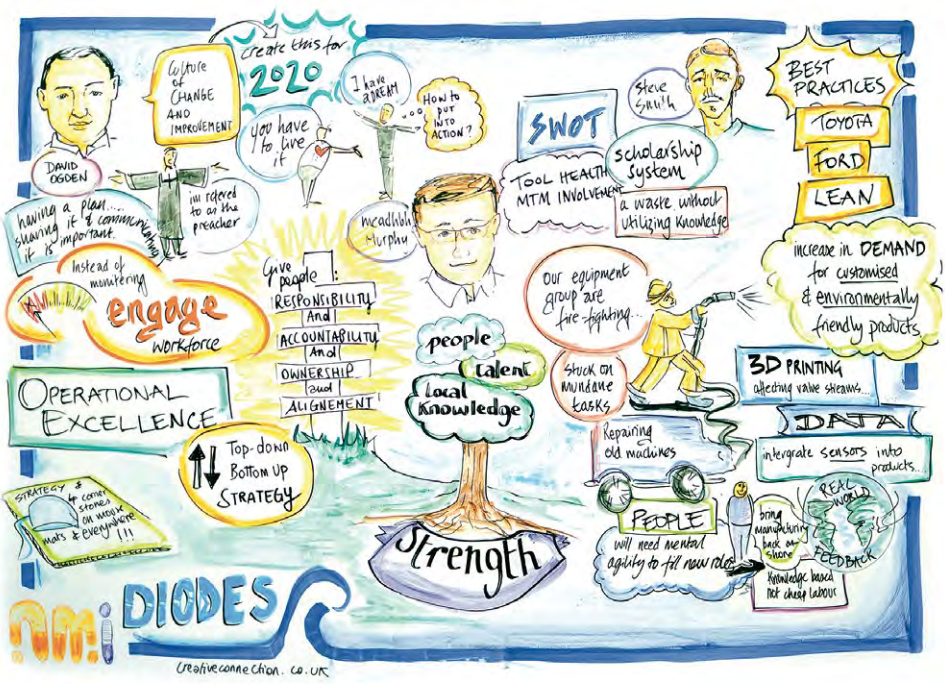
Like many wafer fabs in the UK, the Oldham Diodes Inc site has seen it's fair amount of change over the years; different ownership, different strategies, demand highs and demand lows. Some fabs have stumbled and fallen; and some have stumbled, got up, brushed themselves down and dragged themselves back into viability and now almost enjoy rude health. Oldham Diodes Inc. sits in the latter category.

STRANGELY ENOUGH to some people it is the sites that weren't cutting edge, that weren't risky, that didn't have a portfolio that changed every two years, that have survived. They were (relatively) stable. They knew what they did well and did it. Mostly Discretes it seems, but that's no bad thing.

We have been making semiconductor devices in Oldham for over 50 years. A lot of our basic processes haven't changed in the 25 plus years that I've been in the industry but the efficiency and capability with which they run has been revolutionised. Hence relatively mature technologies have been able to keep pace and be commercially viable in these days of ultra mobile computing and communications.

The challenges that we face making semiconductors in the UK reflect the movement from mass to niche manufacturing. A smaller manufacturing base means a steadily reducing support infrastructure so it becomes harder to find the right company to support what can be a very mature toolset. The NMI helps enormously with this, bringing a common network and voice to both equipment vendors and finished wafer manufacturers. On many occasions we have had great help from other fabs or vendors when we have had to source a part or a material to keep the production line flowing. Often this can be

"NMI HELPS BRING A COMMON NETWORK AND VOICE TO BOTH EQUIPMENT VENDORS AND FINISHED WAFER MANUFACTURERS."



at an engineer to engineer level, the informality often creating far greater bonds of mutual support than rigid business deals could ever do.

The smaller manufacturing base also means a smaller pool of skilled people. But in our own case this has only invigorated the push to get more apprentices and graduates into the business. I know that many fabs in the UK have grown their engineering groups from their own production staff and we at Diodes are no different. A good proportion of our technicians were once operators on the production line, who with the companies help have gained HNC's and HND's and are now adding value daily, performing maintenance and repair tasks.

The smaller group of highly knowledgeable equipment engineers also forces you to look deeply in to how you utilise them and this inevitably takes you down the path of TPM – taking the less technical maintenance tasks away from engineers and handing them over to the shop floor, allowing engineers to add more value with project and difficult problem solving tasks. This is something that we at Diodes need to push forward with in the coming years as the skills shortage becomes more acute.

Cost is always going to be a challenge manufacturing in the UK and the way that we have tackled this in Oldham is with efficient growth. As we expand our capacity, our fixed cost is diluted and with our efficiency pushes, the variable costs are reduced. In this way we have managed to reduce our unit costs to 1/4 of what they were pre 2008. Many efficiencies have come from the systems we have created

to take the burden of administration, reporting and scheduling away from all groups, giving them more time to "add value" by improving uptime, increasing yield or shortening cycle times. But creating these systems is not easy, as you usually have a budget that is very lean, timescales that can't be stretched and a project team that is relatively thin on the ground. But the alternative is to have an expensive non-bespoke system that only covers about a quarter of what your original scope was, with every tweak costing you valuable profit margin.

The biggest challenge that faces us and most fabs in the UK is increasing our global influence in our own organisations and in our market sectors. As the manufacturing base diminished, so did the influence that UK manufacturing had. But we can reverse that trend and put ourselves in a position to influence company strategy by showing that we have better quality, better cycle time, better planning systems and better customer service than our non-UK sister organisations.

This inevitably flows back to the behaviours of the people in your organisation. The common mode of operation of factories that have been through the mill for the past few decades is to not put your head above the parapet and hope that Corporate won't actually notice you're there and leave you alone – until you have proven your worth and improved, this may be the best option, but unfortunately, you may also get forgotten, wilt and die. So instead, we take every opportunity to get our people "Out there" – taking best manufacturing practice to China, showing sister factories the quality standards you need to achieve a good VDA 6 score, highlighting that one skilled planner is worth far more than 7 emailing chasing clerks and sharing methodologies that show you don't have to race your competitors to the bottom of the price barrel.

Differentiation can show itself in many ways, not just in the products that you make.

So if you hit a set back, as the song says, pick yourself up, dust yourself off and start all over again.

ABOUT THE AUTHOR

MICK CONLON
DIODES-ZETEX SEMICONDUCTORS, UK OPERATIONS MANAGER:

Mick Conlon is the UK Operations Manager for Diodes-Zetex Semiconductors based in Oldham in the northwest of England. Having been in the semiconductor industry for over 25 years and working with the NMI Production Forum for a good part of that period, Mick has seen and felt the benefits of the co-operation and benchmarking done within the whole NMI manufacturing group.

Professor Anthony O'Neill
Siemens Professor at Newcastle University

EFUTURES – **ELECTRONICS NETWORK**

Electronics is at a critical point where the need for concerted action at discipline boundaries has never been greater, or for that matter, more exciting. Currently, there exist many barriers between industry and universities which prevent integrated and co-ordinated research. In many cases, individuals don't know where to go to find the 'right' partners or else have technical challenges which could be met by researchers in the UK if only both parties could meet. The overarching aim of the eFutures network is to seek engagement across the wider electronics community with the intention of forming new collaborations both within academic communities and with industry partners.

The eFutures network, funded by the Engineering and Physical Sciences Research Council (EPSRC) was first established in 2010. It has played a valuable role maximising the impact of UK electronics research and has over 370 members from across 55 institutions. The network has received ~ £1 million funding to date, with eFuturesXD being allocated £600,000. eFuturesXD is a offers funding to academics for collaborative research across discipline boundaries, examples of successfully funded projects include:

*S. Moore: "**A toolchain for running NeuroML/LENS models on the Bluehive**" and T. Constandinou: "**Next Generation neural probes for large-scale recording in the living brain**".*

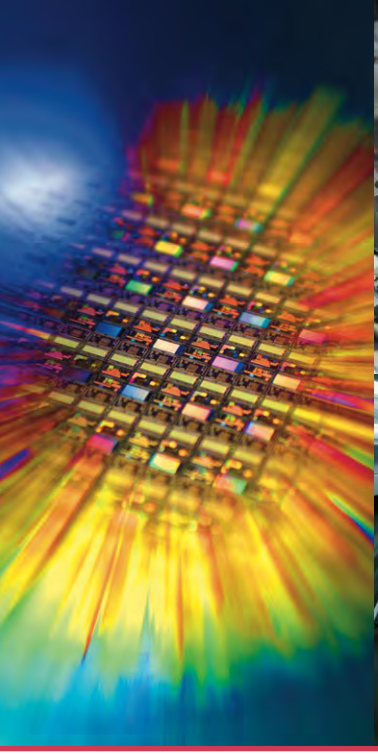
Moving forward, the eFutures network wants to build on its success and leverage benefit from the experience to build and consolidate the electronics communities. We have committed to delivering on 5 key objectives over a 4 year period:

i) Build Bridges
Introduce groups of individuals who share technical expertise and interest who would otherwise not be engaged (Building Bridges to Building Brains – Computer Scientists working collaboratively with Neuroscientists)

ii) Supporting Early Careers
Maintain the flow and career development of talented young researchers to enable them to become potential future leaders.

iii) Working with Industry
Build stronger links between industry and academia through various networking events and seek improved strategic alignment between the two communities.

iv) Working with New Academic Communities
Identify opportunities for to engage with established academic communities where there is a strong overlap in terms of expertise e.g. energy harvesting, power electronics

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v) Consolidate eFutures
Continually review and improve the eFutures network, increase membership, develop the website in order to meet customer needs and initiate various networking events/seminars.

MAJOR RESEARCH PROJECTS

To illustrate and share with you the current vibrant electronics research environment, we will showcase three EPSRC funded projects with potential for future exploitation within the UK.

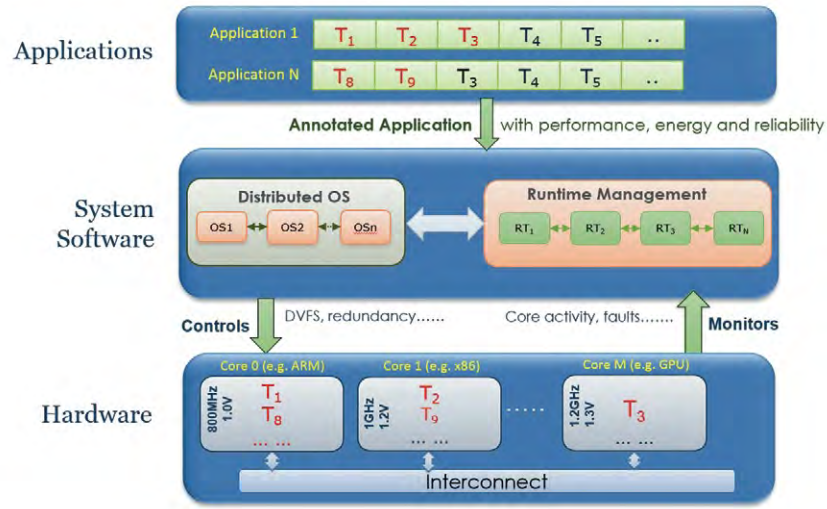
1) PRiME (Power-efficient, Reliable, Many-core Embedded systems)

This 5-year research project aims to enable future embedded computing devices, where today's mobile and embedded devices, such as the smartphone, will see massive performance increases enabled through many-core computing. The now ubiquitous smartphone will take a revolutionary jump – combining the high performance capabilities of supercomputers with the low energy and cost constraints of a mobile platform, e.g. requiring the battery to last for at least a day. This will give everyone a supercomputer in their hand, encouraging innovative and powerful new applications.

PRiME's goal is not to speculate or invent these applications. Nor is it to design the 100+ core processors that are envisaged within the next decade. Instead, it focuses on addressing two fundamental bottlenecks that will stop an embedded many-core vision from ever being realised: energy and reliability.

PRiME is tackling these twin challenges through the development of novel hardware and software technologies. The researchers are taking a cross-layer (hardware, system-software and application) approach, and are considering the interplay between energy, reliability and performance.

Diagram 1: PRiME cross-layer approach to energy efficiency and hardware reliability in many-core systems



> "THE TEAM HAVE ALREADY DEVELOPED NEW SOFTWARE RUN-TIME TECHNIQUES WHICH SAVE CONSIDERABLE ENERGY."

The team have already developed new software run-time techniques which save considerable energy and increase the lifetime reliability of the device with minimal impact on performance and these have been demonstrated on embedded systems that are available today (demonstration videos are available on the project website).

The project brings together researchers from four UK Universities (Southampton, Imperial College, Manchester and Newcastle), five companies (Altera, ARM, Freescale, Imagination Technologies, and Microsoft Research), along with representatives from NMI and KTN.

"A key component of PRiME is the close connection and interplay between world-leading research and the involvement of industry to identify and translate technology outcomes from this programme to commercial exploitation quickly and efficiently," says PRiME director, Professor Bashir Al-Hashimi from the University of Southampton.

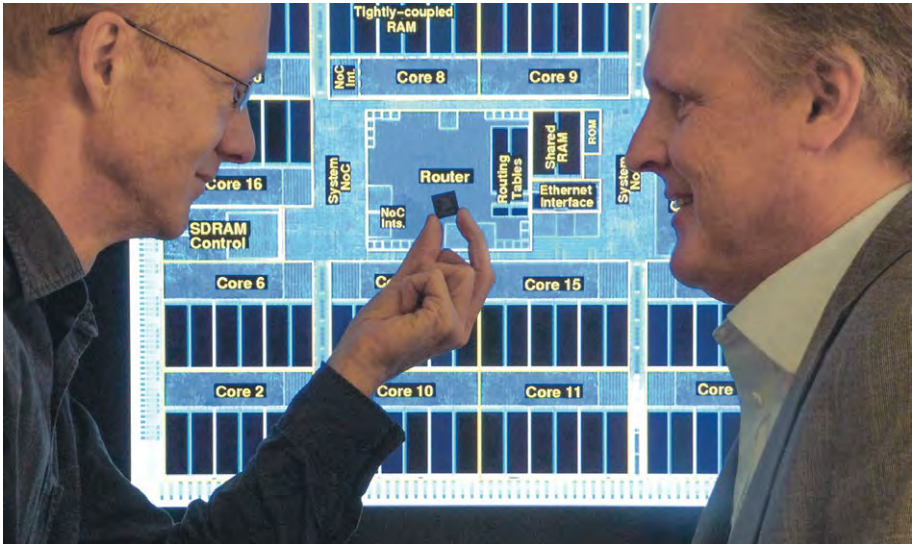
The researchers are currently working to identify and specify the application domains that they are going to target for their research demonstrators. Industrial involvement, including but not limited to PRiME's industrial partners, is essential in this to ensure that the research outputs are relevant, available and ultimately exploitable by UK PLC.

For further information, refer to the PRiME project website.

2) SpiNNaker (Spiking Neural Network Architecture)

The SpiNNaker machine is a massively-parallel computer for brain-modelling applications. It has been developed by the University of Manchester in collaboration with the Universities of Southampton, Cambridge and Sheffield, and with ARM Ltd as an industry partner providing silicon IP. The machine has been designed from the silicon upwards, and will ultimately incorporate a million ARM processors and 7Tbytes of memory, and it will be capable of modelling networks of a scale of 1% of the human brain. It will be available to the wider European neuroscience community through the EU ICT Flagship Human Brain Project, and has led to follow-on research funding from EPSRC and the European Research Council, as well as industry funding under Samsung's GRO programme. SpiNNaker systems are already in use by several research groups around the world, and interest in the platform continues to grow.

Although primarily designed as a computing platform to help unlock the secrets of information processing in biological brains, the SpiNNaker platform is also attracting interest from wider communities whose applications may be suited to the unusual architecture of the machine. Possible application domains include 'Big Data' analysis using appropriate machine learning techniques, real-time robot control, Bayesian network analysis and more – any area



Steve Temple (holding SpiNNaker chip) and Steve Furber in front of SpiNNaker chip plot

where the machine's real-time event-driven programming model is well-suited, and where the problem can be refined into a very large set of small interacting processes.

The Human Brain Project has, as its goal, the development of computational models of the brain that will enable new approaches to the treatment of mental disease. Mental disease costs developed economies more than cancer, heart disease and diabetes put together, as well as causing huge distress to the individuals affected and their families and friends, so addressing this 'Grand Challenge' has huge potential to benefit the economy and wider society.

Applications of the emerging knowledge will also contribute to the development of advanced technologies such as driverless cars and robotic systems, where the application of biologically-inspired vision systems hold great promise.

At present there is considerable interest in these areas from overseas companies (e.g. IBM, Qualcomm and Samsung), but it would be really good to see UK industry getting involved here too. Cognitive systems are set to transform the future of computing; UK industry needs to be involved, and SpiNNaker is one of the most advanced, flexible platforms for advancing understanding of this new area.

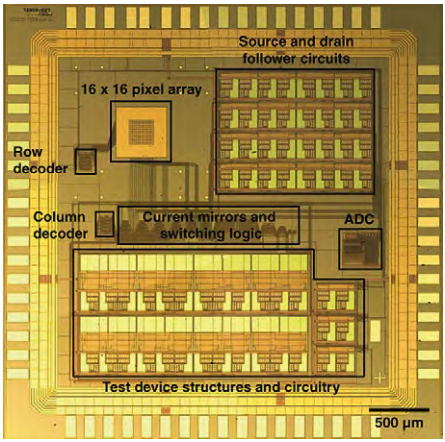
For further information refer to the SpiNNaker project website.

3. Multicorder

Microelectronics has been at the forefront of computer and communications technologies for several decades. The same technology has now become dominant in digital imaging. Surprisingly this is not a traditional ICT product, but rather, a sensor technology. In 2010 microelectronics further extended its reach with the launch of the Ion Torrent next generation

sequencing system. Ion Torrent uniquely used ion sensitive field effect transistors in their millions on a single CMOS chip. It is now clear that microelectronics is a disruptive universal technology that is capable of changing the face of many different markets and applications.
In an EPSRC Programme Grant that is led by Professor David Cumming at the University of Glasgow, research is underway to create the Multicorder. The aim is to integrate many sensor types and variations on to foundry CMOS technology with as little recourse to post-processing as possible. Applications for the technology are numerous – from advanced imaging technologies, to chemical sensors targeted at hospital associated infection.
The collaborators in the project are Professors Lee Cronin and Mike Barrett who are also at Glasgow University and Professor Calum McNeil of Newcastle University. Industrial partners who are contributing to the project include Texas Instrument and Selex ES.

For further information refer to the Mutlicorder project website.



A CMOS proton camera using ion sensitive field effect transistors for use in biological sciences.

There is a wealth of exciting and leading edge electronics research being carried out throughout the UK, much of which will become ripe for exploitation in the near future. As we emerge from the recession and the future economic outlook looks more promising, there is a need for greater integration of facilities, expertise and skills as never before. Working with NMI, eFutures creates the best conduit between business and academia and we invite industry partners to collaborate with our programmes. This will allow a greater pull-through of innovative ideas from university to commercial exploitation.

For more information about eFutures, or if you wish to join the network, please visit the eFutures website or for specific enquiries email us at efutures@ncl.ac.uk.

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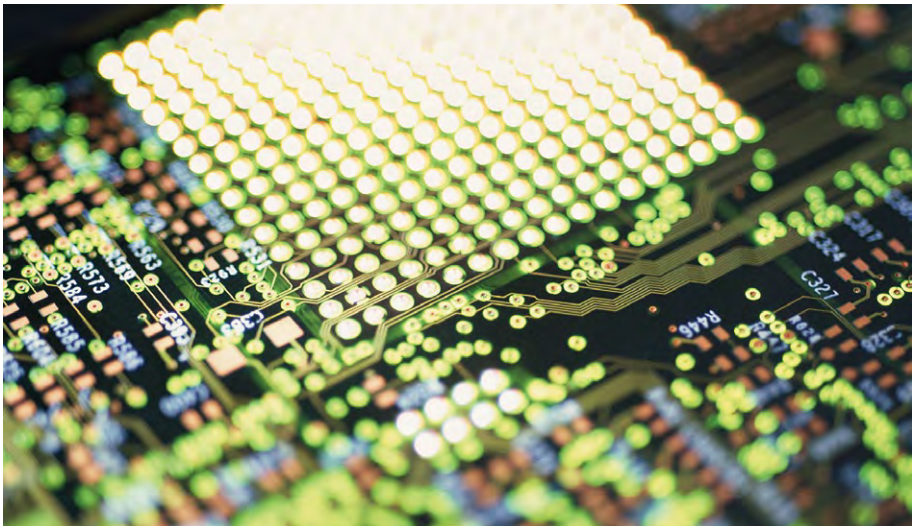
SIEMENS PROFESSOR AT NEWCASTLE UNIVERSITY:

Professor Anthony O'Neill is Siemens Professor at Newcastle University, having joined in 1986 from Plessey Research (Caswell) Ltd. In 1994 he was Visiting Scientist at MIT and pioneered their work on strained Si MOSFETs. In 2002 he became a Royal Society Industry Fellow with Atmel Corp and worked with them to implement strained silicon in a UK commercial process. He was visiting professor at EPFL (Switzerland) in 2009. He took a leading role in establishing an earlier network of UK universities engaged in silicon technology research (Si Futures) and is a director of NMI and the PI for the EPSRC electronics network eFutures.

Peter Connock
Board Chairman, memsstar Limited

CATALYSING CAPABILITY – **A EUROPEAN VALUE CHAIN PERSPECTIVE**

It's quite a shock to realise that it is so long ago that I first became involved with the semiconductor industry in the late 70's at Edwards High Vacuum. It was around then we discovered that, for some unaccountable reason, certain customers were destroying our pumps in 24 hours or less – and I was supposed to find out why and fix it. Almost 40 years later the problems are different but the industry still faces wide-ranging challenges – both in relation to technology and business development.



AFTER SOME formative years in vacuum engineering I moved into product marketing – with responsibility for the, then rapidly developing, semiconductor equipment industry. At that time the challenges were around making things work at all – and we began to learn that co-operation along the value chain was going to be important if the problems of the day, and more importantly the future, were to be solved. However, it is very easy to say that open cooperation is an essential part of a business relationship and quite another thing to implement it effectively – especially in a very rapidly changing and pressured environment.

"INDUSTRY HAS TO HELP ITSELF THROUGH ITS OWN LONG TERM STRATEGIC PLANNING."

The tricky balance between customer, supplier and vendor was very visible during my 20 years at Applied Materials and it remains challenging to convert the traditional, and often adversarial, business relationships to constructive partnerships. However, in the 80's and 90's the concept of the Joint Development Programme (JDP) really developed and several significant advances were made on this basis – think STM/Philips and IBM technology alliances let alone individual programmes between members of the semiconductor value chain.

In Europe, the research community has been, and is, one of the world leaders in joint research – catalysed by the European Commission JESSI programme and FP7. This remains a core European strength and is alive and well in the latest iteration of funding support – Horizon 2020 and all the related and other national and pan-European funding and support programmes.

But it remains hard, especially for SME's, to build the contacts necessary for even relatively small local funding programmes and to allocate the necessary resources to support all the related "red tape". Add to that the very necessary needs for SME's to operate with tight cash flow and to turn developments into revenue in short cycle times – and it is easy to understand why many decide not to bother with complex funding opportunities or long term partnership programmes.

And yet our industry today, other than for truly exceptional "breakthrough" moments more than ever requires some sort of cooperation – often leading to in depth business relationships or even mergers and acquisitions. At minimum all smaller companies require financing of some sort and must have the capabilities to represent themselves professionally to the financial services industry. But, perhaps even more importantly, it is not possible to exist in "isolation" in the semiconductor/ nanoelectronics market where everything is increasingly interconnected and business development requires an extensive network.

We all know that Europe, if it is to break out of the general trend of decline in the vital area of micro/nanoelectronics, must pool it's resources more and must re-establish/strengthen it manufacturing base. This has finally been recognised in National and EU circles and some steps are being made to try and reverse these long-term trends through H2020 funding and many other national initiatives. But industry also has to help itself through its own long term strategic planning and participation in cooperative industrial/development groupings designed to maximise capability in the sector.

But where will the new technology ideas and industry employment be generated – primarily in SME's. So while we must protect and develop our large industry leaders we must equally focus on the smaller companies – and bring

them into the electronics ecosystem in Europe. The opportunities are vast as the "Internet of Everything" develops – but we must help everyone get involved if we are going to fully capitalise on the immense innovative capability that is evident across Europe.

This is precisely where national and pan European organisations like NMI come in. Initially by helping small and large companies (and academia) to form links and subsequently by providing targeted support services – matched to the specific needs of its members – organisations like NMI can help foster relationships that build the future.

These relationships come in multiple shapes and forms; from straightforward sales engagements to consortium building for major projects – and everything in between.

For many years now the NMI Supplier Group has endeavoured to bring together the disparate parts of the electronics value chain. This has occurred through simple networking and more practical activities such as "industry" days or trade events. This is essential work that must be continued and extended in to as many fields as possible.

Why? Because the traditional boundaries that used to exist in the electronics food chain are becoming increasingly diffuse. No longer do "things" simply move up the value chain – the "top" and "bottom" are much more integrated and all parts actually need to know more about what is happening across the chain. This is even more critical as cycle times decrease – by the way another reason that manufacturing needs to be re-established in Europe.

Horizon 2020 puts SME's at the heart of it's funding activity – but doesn't really know how to engage with SME's. The big projects that are now being funded envisage pilot lines building real products for commercial exploitation – in a very wide range of advanced application fields. How can SME's realistically engage in projects encompassing multiple countries across Europe and huge budgets – let alone huge administration?

Our task, through NMI and other organisations such as AENEAS (on which I am the Chairman of the SME "chapter") is to make sure that the talent and capability of UK SME's are given the chance to grow and develop by taking advantage of these new business development opportunities. AENEAS is a non-profit industrial association continuing the activities of the former ENIAC European Technology Platform and representing the Nanoelectronics R&D partners in the ECSEL Joint Undertaking. AENEAS is open to all European key players in Nanoelectronics, such as large industry, Small and Medium Enterprises, research institutes, academia, and associations. Other similar organisations across Europe seek to foster electronics development in a wide range of applications.

This leads to another problem, the diversity of support resources and funding programmes presents SME's, especially the smaller ones, with a bewildering array of "opportunities", all requiring investigation and, if engaged with, fairly significant levels of administration. Not a set of criteria that SME's really appreciate!!

Finally, SME's face many operating challenges within the supply chains in which they are involved that they may have difficulty in addressing without support. These may include IP issues, legal challenges and other obstacles that are considered collective problems by the NMI member community. NMI should therefore

be in a position to help address those collective concerns and support activities that smaller companies may find difficult as a standalone entity. An example of this are the "Supplier Days" that have been established to promote relationships along the value chain.

So, some 40 years on in my career, what are the issues and what do we need to do to ensure that Europe, and especially the UK, must do to keep us in advanced microelectronics? Not only must we avoid being left behind but also find a way to reassert our position in this vital market that is not only strategically important but will also continue to grow dramatically. We have world-class research, innovative SME's and a core of large companies with leading positions in their fields but we have lost leadership in key areas and our manufacturing capacity is too small.

I think it is essential to think in terms of value chains and cooperation across those chains rather than individual activities within the chain. Only through this will we find ways of retaining as much as possible innovation, profitability and jobs in Europe. To do this, all the talent present in Academia, SME's and Large Industry must find ways of working together to common key "application" goals which can be used to establish leadership in key sectors.

NMI can catalyse this process – both within the UK and as a representative and supporter in wider Europe. It must recognise key value chains for the UK and encourage dialogue and cooperation and provide support services to its members within those chains that help them through all the activities that are required to help them develop. It must also act as a representative for the UK across Europe and the world to help ensure UK companies can take full advantage of cooperation, funding and business development opportunities.

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PETER CONNOCK
MEMSSTAR LIMITED, BOARD CHAIRMAN:

Peter Connock has been working in the semiconductor industry for over 35 years with positions in development, customer service, marketing and management at Edwards, Applied Materials and memsstar. His current role, Board Chairman at memsstar, has involved both operational and strategic activities in the global MEMS market and European secondary equipment industry. memsstar is a European semiconductor equipment remanufacturer and services provider and serves the global MEMS marketplace, offering etch and deposition expertise, experience, proprietary and remanufactured systems and know-how.

Peter has complemented his operational activities by establishing a long-term relationship with SEMI – serving on SEMICON, ISS and now the SEA committees for many years.

Peter is closely involved in the ENIAC and ECSEL EU funding programme for technology with special responsibility, as part of the AENEAS industrial association, for encouraging SME involvement in EU funded projects.

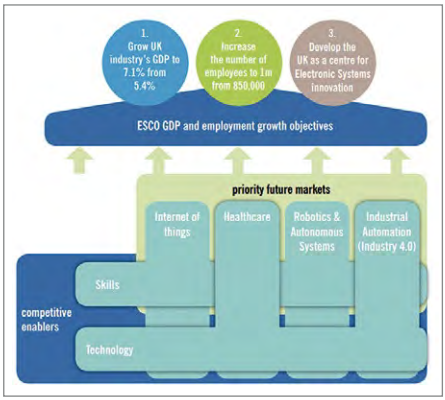
Sarah Macken MSc, BSc (Hons)
Chief Executive of ESCO

UK ELECTRONIC SYSTEMS, **GOING FOR GROWTH**

Electronic Systems is one of the UK's fastest and most responsive engineering sectors. At ESCO (Electronic Systems COmmunity) our job is to work with NMI and other stakeholder bodies to take the voice of this successful industry right into the heart of policy making in Westminster.

THROUGH THE Electronic Systems Council, jointly chaired by Warren East and Baroness Lucy Neville Rolfe, the industry and Government work together to drive forward a programme that has the aim of growing the footprint of the electronic systems industry in the UK.

Baroness Neville-Rolfe became the new co-chair of ESCO in September succeeding the Rt Hon Michael Fallon MP and she has hit the ground running by visiting a series of electronic systems companies. She has already got her first Council meeting under her belt and held a number of bilateral meetings with ESCO representatives. She is pleased to be working with such a strong British success story.



The ESCO Council itself is made up of industry representatives from Altran, ARM, Emerson, Imagination Technologies, Motorola Solutions, Plastic Logic, Siemens, three Trade Associations (NMI, GAMBICA and techUK) and Innovate UK, who have all contributed their time and energy to developing and progressing a joint agenda over the last year. We are enormously grateful to NMI and other Trade Association partners who fund and give generously of their time to support and advance ESCO's agenda.

The ESCO report: a blueprint for economic growth, published in 2013 identified the size and scale of the industry at £80 billion, with 850,000 employees throughout the UK. But the ESCO Council wants the sector to continue to grow through taking up leadership roles in new markets. This means being able to spot areas where the UK has real potential to grow new areas like the Internet of Things, Industry 4.0 and Robotics and Autonomous Systems.

Over the last year this has led to the Prime Minister acknowledging the importance of the

Internet of Things (IoT) as an emerging market in which the UK can play a leadership role. And ESCO has built on this recognition by contributing ideas to the Government's Chief Scientific Adviser Sir Mark Walport in this area, we have also encouraged Ofcom to explore which parts of spectrum can be made available for IoT.

Ensuring that the industry has access to a highly competitive skilled workforce is a major priority for the ESCO Council. The UK Electronics Skills Foundation (UKESF) is continually promoted to Government as an industry success story and has provided 174 students since 2010 with scholarships that have supported them through their course and linked them up to a future employer.

The Government is keen to expand its Trailblazer apprenticeship programme further and is asking companies to design their own standards so that training courses meet real business needs.

For Electronic Systems, we have brought together a group of company representatives who will design apprenticeship standards across the industry. This will include roles like Embedded Software and Hardware Engineering but there are many more standards that will need to be developed. This group will design training programmes for apprenticeships and others and will consult widely with industry to make sure they can be applied by companies right across the UK.

The standards will be reviewed and signed off by BIS and once this happens, companies will be able to apply for funding of up to £28,000 to take on new apprentices.

ESCO would like to see the electronic systems trailblazer develop a full set of standards for our sector starting at Level 2 (the equivalent of GCSE) and going right through to Level 7 (equivalent to Masters degree equivalent).

The Electronic Systems trailblazer has met just once, so there is still an opportunity to get involved and shape the standards that could be used to train your future employees. Please contact Derek at NMI if you would like to find out more or get involved.

ESCO is also keen to highlight new markets and open up new opportunities to companies in areas they may not have considered getting involved in before.

Through bringing industry together ESCO was able to launch the first UK Industry 4.0 demonstrator, based at the Manufacturing Technology Centre earlier this year. The Industry 4.0 demonstrator is the culmination of work by the Industrial Automation workstream and provides a practical platform for UK companies to advance new technology that will win business supplying future factories and process plants.

Over the coming months we will be pressing the case for an Industry 4.0 Living Laboratory and changes to the Capital Allowances regime so that companies having a real test bed for electronic systems technology and there are incentives in the tax regime for manufacturers to invest in new plant and machinery.

Intelligent mobility and reshaping the future of our transport infrastructure also offers significant opportunities for UK electronic systems. Work is underway in NMI's Automotive Electronic Systems Innovation Network (AESIN) to advance a demonstrator that provides an opportunity for UK companies to test how electronic systems interact with transport infrastructure exploring the technology required to develop driverless

cars in the UK. ESCO has helped link AESIN up with the Automotive Council, which has helped to move this project forward. Discussions are also underway with the Advanced Propulsion Centre to look at areas of common industry interest, which we hope will open up further opportunities to UK electronic systems companies.

Barriers to the uptake of technology in the health service are also being identified and work is underway to explore with a cross section of stakeholders from clinicians, NHS England and a continuing cross Government dialogue on how those barriers can be overcome. The uptake of technology in the NHS could both improve productivity in the health service and deliver a better patient experience.

The Technology working group has been active this year in identifying opportunities where UK industry is missing out on European funding sources. The €5 billion ECSEL fund (Electronic Components and Systems for European Leadership) is one such fund, where UK participation is far behind EU competitor nations such as France, Germany and the Netherlands. UK companies can only access funding from this source with match funding available from the member state. ESCO is working with Innovate UK and Government though BIS to increase the UK contribution to ECSEL so that UK companies can apply for funding on a par with competitor nations.

Through working with other Industry Council's like Aerospace, we have also been successful in shaping funding applications where electronic systems have an important role to play, for example the bid for continuing work on the ASTRAEA programme on Autonomous aircraft.

We aim to continue this work with other industry Councils to highlight the opportunities that can be gained from working with the UK electronic systems industry and hope this will open up new business opportunities for our sector. The UK electronic systems supply-chain is so diverse that there are real opportunities to be gained from working with other sectors which may not be aware of the potential within our community.

It has been a busy year and looking ahead we are keen to deliver more for the electronic systems industry. We do rely on the support and contributions of trade associations and individual companies.

We are continually grateful for the efforts that people in the sector make, and would welcome wider involvement from people across the sector.

Anyone interested in contributing to any of ESCO's activities, or to find out more, please contact Derek Boyd at NMI to discuss further.

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CHIEF EXECUTIVE OF ESCO:

Sarah Macken, MSc, BSc (Hons) is the Chief Executive of ESCO, the Electronic Systems Council. This builds on her time working for the aerospace and defence industry. Sarah also works as a consultant helping engineering and technology companies into new markets in the UK and Europe and she previously represented 100,000 small businesses at the British Chambers of Commerce.

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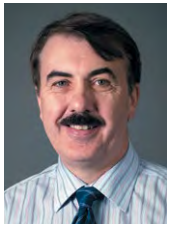

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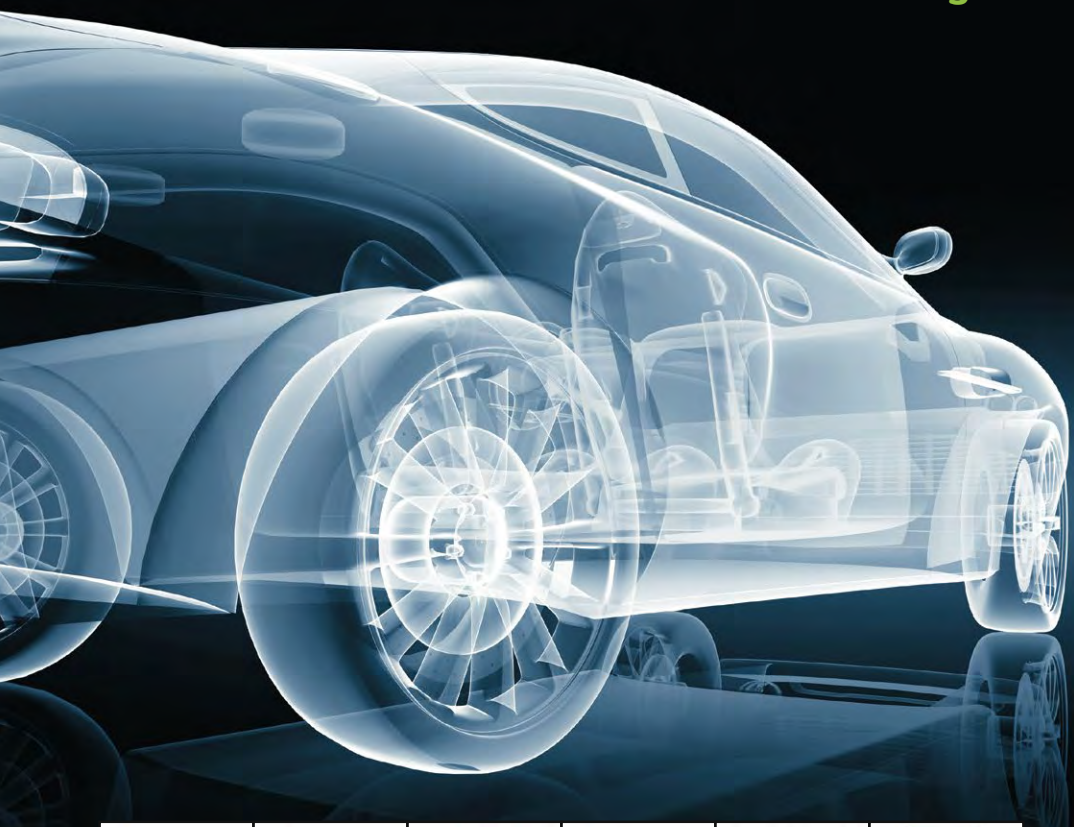

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