Together
We're Better

NMI YEARBOOK 2014

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 required 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.

MicroelectronicsCentre@stfc.ac.uk

Science & Technology Facilities Council

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Establishments at: Rutherford Appleton Laboratory, Oxfordshire; UK Astronomy Technology Centre, Edinburgh; Daresbury Laboratory, Cheshire; Chilbolton Observatory, Hampshire; Isaac Newton Group, La Palma; Joint Astronomy Centre, Hawaii.
www.stfc.ac.uk

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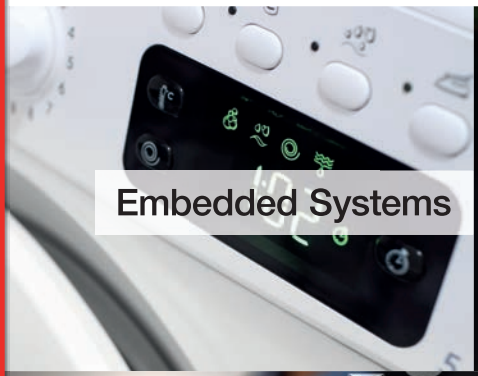

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Michael Fallon
Business Minister

MINISTERIAL FOREWORD

Although not always visible, electronic systems underpin many of the world's economic activities, from control systems for automobiles to sensor technologies for assisted living, and our reliance on electronics will only grow further. The Government is committed to supporting the UK industry which has the opportunity to develop its strong position to become a world leader.

2013 WAS A YEAR OF SIGNIFICANT DEVELOPMENTS IN ELECTRONICS. These include the launch of the 'Electronic Systems: Challenges and Opportunities' report, published in June and the formation of the Electronic Systems Council (ESCO). This forum of senior leaders from the sector, working in partnership with Government, will share experience, best practice and resources in order to address common issues. ESCO's vision is to grow the UK electronics industry to £120 billion (up 55%) and create an additional 150,000 highly-skilled jobs by 2020.

This new partnership is a strong example of the Government's drive to rebalance the economy through providing a dynamic, open and competitive business environment. This has been demonstrated by the work of the Technology Strategy Board and the Regional Growth Fund competitions. In addition, we have ring-fenced support for science, we are promoting exports – particularly in emerging markets – and we are creating one of the most competitive business tax regimes in the G8.

To succeed we need to make the most of our competitive advantages and sustain them. In collaboration with industry, we have published Industrial Strategies in eleven other key areas, many of which provide growth opportunities for electronics. These Strategies set out our long-term vision, providing the certainty and confidence that companies need to invest and grow. Tackling economic weakness and instability will lead to improved opportunities, better jobs and economic prosperity for the UK.

A key aspect in our approach is a commitment to invest in technologies. Based on the recommendations of the science community, research councils and the Technology Strategy Board, we have prioritised eight great technologies with the potential to propel the UK towards significant future growth. These are: big data, space, robotics & autonomous systems, synthetic biology, regenerative medicine, agri-science, advanced materials and energy. These are considered important areas of scientific advance with

Together
We're Better

Industry Summit

November 2014, London

A regular feature in the industry calendar, NMI's **Industry Summit** brings leaders together to receive an Industry briefing and debate the issues with key figures shaping and influencing policy.

See www.nmi.org.uk for details

identifiable commercial opportunities, in which Britain has existing, distinctive capability.

The Government is taking action to address the specific challenges presented by the ESCO Report. As just one example regarding skills, we have been supporting Nesta, Mozilla and Nominet Trust's joint initiative 'Make Things Do Stuff' (MTDS), which offers opportunities for young people to develop their digital-making skills. Having offered over 100,000 offline and online experiences, MTDS has enabled students to shift from being consumers of digital technologies, to making and building their own.

We have shown that we are serious about stabilising the UK economy and encouraging investment and growth. The electronics sector provides superb opportunities for the future, and I look forward to working in partnership with ESCO and others in the sector to address the challenges to long term success identified in the ESCO Report.

WE ARE SERIOUS ABOUT STABILISING THE UK ECONOMY

Michael Fallon
Business Minister

Stan Boland
NMI Chairman

CHAIRMAN'S STATEMENT

I'm delighted to introduce NMI's Annual Review and to do so as Chairman for the first time.

THE STAFF AT NMI, led by Derek Boyd, do an incredible job. NMI is providing support on a very broad range of highly valuable disciplines and it's delivering that support across a wide range of our industry segments, providing the glue and networking to make it truly effective for its members. For this to be achieved by a relatively small team is a reflection not just of their clear commitment to provide the very best tools and frameworks for our industry, but also of the catalytic power NMI is having through encouraging and promoting NMI members to engage with each other for common purpose. Being a member at Icera, and now more recently at Neul, I've already had some experience of this but as I begin to work with the team at NMI and attend some of its events, including this year's Summit, I'm really getting to understand the value being delivered.

I'm joining the NMI Board at an incredibly exciting time. The Board has already shown tremendous foresight at the need to engage more strongly with Government and build even closer links to the specific systems domains (meaning software as well as electronics): two areas I believe are absolutely critical as we take the industry in the UK forward in a post-crisis world. The team has made great strides at that and the publication of the ESCO Report and formation of the ESCO Council,

I'M JOINING THE NMI BOARD AT AN INCREDIBLY EXCITING TIME

Stan Boland
NMI Chairman

co-Chaired by Warren East and Michael Fallon (Minister of State for Business, Innovation & Skills), gives us a great platform upon which to build.

Being in the thick of building a venture-backed technology start-up like Neul whilst chairing NMI will have its upsides and one downside – time will be a constant challenge! Nevertheless, I'm hoping to personally support NMI in three ways:

- Helping develop the business model to ensure the broad range of key programmes can be confidently financed and resourced.
- Helping develop the strategy to work alongside the ESCO agenda and, in particular, to engage the development community in the systems domains.
- Helping to raise the profile of NMI and make sure its value is recognised and used successfully for the benefit of its members.

I look forward to getting my teeth into these goals, working with my fellow Board members and the NMI management team.

Finally, I'd like to thank David Wollen who preceded me as Chair. Under his stewardship, the team has clearly done great things over the years and the organisation has gone from strength to strength. I'm honoured to be taking over from him and I look forward to working with the rest of the Board, and indeed the wider industry, in helping NMI develop our industry through driving meaningful and powerful programmes for the future.

Dr Derek Boyd
Chief Executive

CHIEF EXECUTIVE'S STATEMENT

Now that we've put the Summit and Annual Dinner behind us, it gives me a chance to reflect on the things NMI is doing as an organisation; to examine how we're supporting our members and the industry as a whole.

My philosophy at NMI has always been based on my career in semiconductor and electronics manufacturing; everything we do should lead to tangible benefit, be purposeful and be aimed at achieving 'something'.

THOSE 'SOMETHINGS' now cover a broad variety of topics, some short-term, some long-term, and that's very much the nature of our work. Through building a strong ecosystem, with connections up, down and across the supply chain, together with a functional interface to the external environment and practical steps and measures, we can make a real difference to your future business performance and the business environment in which we all operate.

Holding this as a personal philosophy is fine but it's the implementation that counts. This of course is dependent on the performance of the whole team, so I'm delighted that the same philosophy is one we all share at NMI and come back to from time to time. As we're all from the industry, helping our industry prosper in the long term through tangible measures is something we all care passionately about.

For me, the Summit perfectly summed up what we're trying to do. It was great to receive recognition from Warren East, former CEO of ARM and now Chairman of the ESCO Council, for the leading role NMI has played in bringing the industry and stakeholders together to produce the ESCO Report, which forms the basis for more significant Government engagement and clearer industry strategy than ever before.

However, it was the 'Hear it from our members' section that spoke volumes. We heard Andy Birnie of Freescale talk about our Automotive Electronic Systems Innovation Network (AESIN); a unique platform that brings together the supply chain from chip to OEM. With such a great platform for tangible benefits and thought leadership now in place, 2014 will be the year we take that forward into significant action. We heard from Stuart Jobbins on the ever-growing importance of embedded software and we're excited to be launching the Software Leaders Group; a new collaborative peer group forum. We heard Steve Smith of BAE Systems talk about the importance of

being part of a network of manufacturing organisations who benefit from each other by sharing challenges and learning as part of the Lean Manufacturing journey. We heard Helen Finch of Infineon talk about the benefits of engaging in R&D funding and the role NMI plays in supporting that. Last but not least, we heard from Adam Malpass, UKESF Scholar of the Year 2012 and Young Engineer of the Year 2013, who talked about the benefits UKESF had provided him in developing his career. If we can encourage more young people like Adam to join our industry, we will be in great shape in the future. The Summit provided only a snapshot of NMI's activities, but served as a powerful and uplifting reminder of the difference that real commitment and participation can make.

The Summit also marked the stepping down of our previous Chairman, David Wollen, and the election of our new Chair, Stan Boland. David was our first Chairman from the start-up community and his views on investing for future growth were influential in us becoming the organisation we are today. Over the past three years he's worked closely with me and I feel everyone connected with NMI owes David a big 'thank you' for the time, energy and commitment he has invested since taking over as Chair.

Reflecting the development of our 'Influencing Government' and 'Connecting the Innovation System' activities, we are also delighted to add Stephen Pattison, VP of Government Affairs at ARM, and Brooke Hoskins, Director of Strategy & Government Relations at Raytheon Systems, as important additions to the Board.

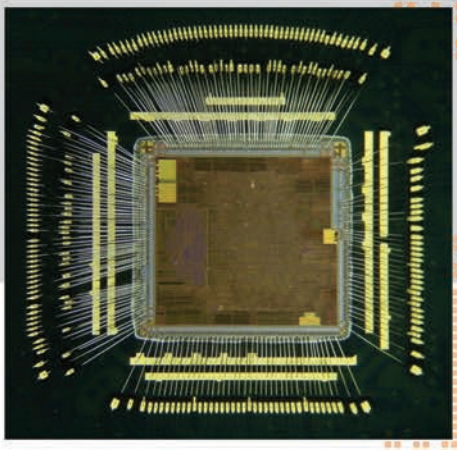
I'd like to welcome the new Board members and our new Chair. Stan is one of the UK's leading entrepreneurs and joins us at an exciting stage in our evolution when we have arguably the biggest and best opportunity yet to make a difference for our members and the industry as a whole. I feel that with a few additional resources, we can push forward and deliver like never before. With his history of raising investment behind exciting propositions, Stan seems like the perfect person to help us shape our strategy.

One obvious missing ingredient that would help drive things forward is co-investment between industry and government, especially with promising and far-reaching activities such as AESIN, which would benefit from the boot-strapping that additional resource could provide. Whilst seed-funding and industrial co-investment are clearly part of Government policy, it seems incredible that this does not extend into the area of building innovation networks and has the effect of starving organisations like NMI of the potential for co-investment to develop sustainable, powerful and long-term industrial collaboration. This is surely something that public policy makers need to review in the near future as it's now a recognised and observable weakness in UK strategy.

In closing, I'd like to thank all of our members for your support this year. We're proud of what we're achieving but we know there's still a long way to go. With the growing army of organisations uniting with NMI in the common cause of driving our industry forward, I feel sure we'll continue to go from strength to strength and personally look forward to being at the very heart of that.

ASE GROUP

Copper Wire



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ANNUAL REVIEW OVERVIEW

NMI is the trade association representing the UK electronic systems, microelectronics and semiconductor communities.

Our objective is to aid the continued development of a sustainable and world-leading industry in the UK by building a strong network and acting as a catalyst and facilitator for commercial and technological development.

A not-for-profit organisation funded by its members, NMI is the home for a membership that spans the supply chain and includes electronic systems design and manufacturing companies, integrated device manufacturers, fabless semiconductor manufacturers, semiconductor foundries, semiconductor suppliers, electronic design services, Intellectual Property providers, research and academic institutions, national and regional government agencies.

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.

REPRESENTING THE INDUSTRY

Together We're Better – NMI's strapline says it all. Ours is a remarkably diverse and fragmented industry, but by giving it a common voice and communicating its needs effectively, be it to Government, academia or funding bodies, we can all move forward as one.

NMI NOW REPRESENTS A BROADER SECTION OF INDUSTRY THAN EVER BEFORE. Originally established to benefit a small number of fabs, NMI's remit has expanded over the years in response to members' requests and technological progress, so that today we represent the electronic systems community in the UK – an industry worth approximately £78 billion a year and employing over 850,000 people.

With that role comes responsibilities. Born out of a desire to encourage the Government to take our industry seriously and understand the role that technology plays in the modern economy, NMI was entrusted with leading on the ESCO Report, a strategic blueprint for the future development of the sector.

Launched in June and produced in collaboration with a number of other trade associations and stakeholders, this unprecedented report into the challenges and opportunities facing the electronic systems community draws on the findings of five workstream reports covering:

- Economic footprint of the UK electronic systems community.

- Research, development and Intellectual Property (IP) creation.
- Innovation climate.
- Manufacturing.
- Skills – supply, demand, provision and gaps.

You can read the full report, its findings and recommendations at www.esco.org.uk, after which we would ask you to lend your support to help deliver its ambitious goals.

A major achievement though this may be, not to mention validation that NMI is tackling all of the key priorities for the industry, the ESCO Report is a catalyst for further action rather than an end in itself. So it's encouraging to see that several of its recommendations are already being implemented. Co-chaired by Warren East (ex-CEO of ARM) and Michael Fallon, Minister of State at the Department of Business, Innovation & Skills, the ESCO Council that will turn words into action has now been established and held its first meeting in October 2013.

Similarly advanced though on a smaller scale, the PowerelectronicsUK Forum represents a cluster that's vital to the UK economy and its international competitiveness. Officially launched in April by David Willetts MP, Minister for Universities and Science, as a direct result of the National Strategy for Power Electronics, also driven by NMI, the PowerelectronicsUK Forum is now the 'go to' place for all things power electronics-related. If you haven't yet connected with its dedicated LinkedIn group, now's the time.

Exciting and important as these groundbreaking initiatives are, NMI remains fully committed to its ongoing activities and original membership base. Last year's Annual Review reported that NMI had fought to safeguard and extend the Climate Change Levy (CCL), which supports industry in its efforts to reduce greenhouse gas emissions through increased energy efficiency. This year we've successfully negotiated new targets and implemented new agreements for members, securing an additional £1 million in savings a year.

THE ESCO REPORT IS A CATALYST FOR FURTHER ACTION RATHER THAN AN END IN ITSELF

Overseeing all these activities and providing future direction at a strategic level is the Microelectronics Design Advisory Board (MDAB). High on its agenda is university engagement, partly to ensure that future generations of graduates are suitably equipped for industry and partly to influence and access the research agenda.

Strengthened by several new appointments, the influential MDAB successfully lobbied the Government's Migration Advisory Committee to add key roles that our industry is currently crying out for to the shortage occupation lists until such time as we have the necessary homegrown talent, another of the ESCO Report's recommendations.

The Manufacturing Steering Group (MSG) meanwhile continues to shape NMI's future offering, first by identifying members' shared priorities, be it cycle time, obsolescence, Lean or workforce engagement, and then how best to tackle them.

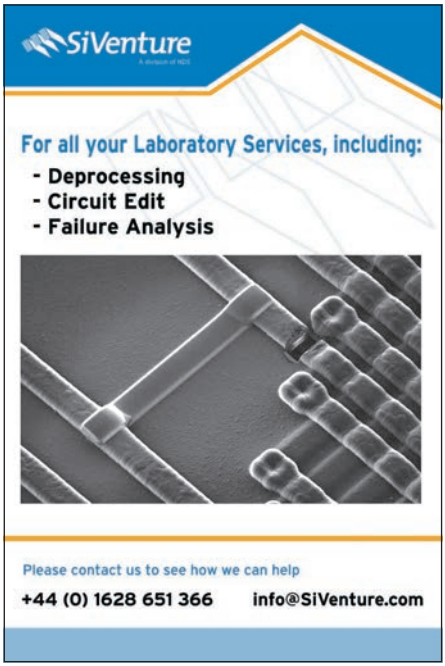
ADVERTISEMENT

SiVenture – A MICRO-ELECTRONICS SUCCESS STORY

The SiVenture laboratory, located in Maidenhead, Berkshire, contains all the necessary equipment to support chip deprocessing, circuit edit and failure analysis, including full chemical facilities, reactive ion etching, focused ion beam and scanning electron microscope.
In addition there are probing facilities to test the results of FIB edits.

Working for a variety of clients, SiVenture provides a high quality, quick turn round, service designed to help clients minimise down time, and maximise yield and throughput.

SiVenture prides itself on its long experience with circuit analysis and edit, and on its ability to be available as and when necessary for its clients.



PROMOTION

Impressive though they undoubtedly are, the UK's world-class capabilities will never reach their full potential if they also remain the country's best kept secret. NMI publicises the industry's value to society and the economy far and wide in order to benefit our many members, be it through encouraging the next generation of talented engineers, attracting further investment or simply generating sales.

THIS YEAR WE ADDED ANOTHER STRING TO OUR BOW with the launch of a new conference, which it's planned will become a regular in the industry calendar. Exploring the technical challenges facing engineers involved in the design of electronic systems to solve societal challenges and provide economic benefits, our first Electronic Systems Technology (EStech) conference featured rousing sessions from Sir Richard Noble on the Bloodhound project and Dr Ivo Bolsens, CTO of Xilinx, amongst others.

Complementing our flagship Future World Symposium (FWS), EStech and FWS will now run in alternate years, with FWS2014 already looming large on the horizon. Scheduled for 29 and 30 April 2014 at Twickenham, FWS2014 will bring you the latest business opportunities, challenges and solutions in the realms of the Internet of Things (IoT), Connected Home and much more, with a Keynote from Khalil Rouhana, director for Components & Systems in DG Connect. This promises to be another leading-edge event, so if you haven't blocked out the days in your diary yet, don't leave it too late. You'll read more about our other events later, but suffice to say that NMI's Automotive Electronic Systems, iPower3 and Manufacturing Excellence conferences all proved highly productive.

Sometimes the communications challenge is more about getting the message out to an audience rather than inviting them to come to you. Following previous years' successes, NMI is once again producing a supplement with the support of several members. Due for publication in the Sunday Telegraph in January, the latest supplement showcases the UK's outstanding capability in electronic systems while also highlighting the rewarding opportunities for bright young minds.

NMI'S ANNUAL SUMMIT, DINNER AND AWARDS PROVIDE ONE FURTHER OPPORTUNITY TO CELEBRATE ALL THAT'S BEST IN OUR INDUSTRY

At a more targeted level, NMI puts members directly in touch with and in front of potential customers, be they in the domestic market or far flung China and Russia where leading brands require the UK's expertise to power their smartphones, set-top boxes and games consoles.

This year, with the help of UKTI (UK Trade & Investment) and SDI (Scottish Development International), we made it possible for members to attend major international trade shows in Shanghai, Moscow and Dresden, assisting with everything from business culture briefings and arranging visas to bi-lingual promotional material and translators on our shared stands.

Closer to home, NMI opens the doors of some of the biggest names in the industry that usually remain closed. April's tabletop exhibition at Seagate in Springtown, for example, introduced members to this global giant in the world of disc drives, while September's event at the University of Warwick coincided with our Manufacturing Excellence conference, bringing suppliers and customers face-to-face.

Whether it's gaining members access to lucrative international markets or big names right here in the UK, NMI facilitates what might otherwise seem impossible, especially for SMEs. If you haven't yet made the most of these opportunities and would like to explore the undoubted potential, contact Mark Hodgetts.

One member benefit that all suppliers enjoy is inclusion in the NMI Manufacturing Suppliers Directory. Listing around 100 specialist companies, all of whom play a vital part in maintaining a healthy and competitive infrastructure in the UK, the 2014 edition will be circulated to all our equipment engineering, purchasing and facilities engineering contacts. It will also be available to download from our website from January.

NMI's Annual Summit, Dinner and Awards provide one further opportunity to celebrate all that's best in our industry. A complete list of this year's winners is included on pages 32-35. You'll be surprised at the calibre, or maybe not if we're doing our job of promoting the industry properly.

CONNECTING AND COLLABORATING

NMI employs a variety of tools and techniques, developed over the years, to help members connect with the innovation system and keep up to date with important developments.

THESE RANGE FROM thought leadership/peer forums providing a broad overview to innovation networks themed around particular clusters, operational excellence geared towards helping industry optimise its performance and technical networks, focusing in on the fine detail.

Once again, electronic systems, automotive electronics and power electronics have all been hives of activity.

ELECTRONIC SYSTEMS

NMI said it would broaden its offering in the systems space and it has done just that, increasing the number of networks and launching an entirely new conference. Providing direction and ensuring that our activities are tailored to members' needs, the Systems & Software Leaders Forum established in December 2012 has almost doubled in size. With the key challenges facing the industry now agreed, members can look forward to concerted action on competency frameworks, addressing the growing skills gap and model-based systems engineering (MBSE). Prior to that, the Forum has already led to a course on multicore programming, run by Intel exclusively for members.

Our inaugural EStech conference has already been mentioned, but in addition NMI ran two

FPGA (Field-Programmable Gate Arrays) expert user events, one on Verification Methodologies and the other on Embedded Processors, as well as conducting a survey on the verification challenges facing the community. Demonstrating the continued expansion, we ran a market sector-focused event on medical electronics, entitled Solving the Challenges of eHealth Solutions. We've also welcomed Aero Engine Controls, Roke Manor Research and Siemens (Traffic Solutions) as members, proof positive that NMI has fully embraced the electronic systems community.

AUTOMOTIVE ELECTRONICS

Launched with the support of many of the UK's largest car manufacturers and supply chain partners in response to the increasing use of electronics in cars and the associated challenges, the Automotive Electronic Systems Innovation Network (AESIN) is going from strength to strength. In March we ran a workshop on Working with ISO-26262, the functional safety standard at the top of the automotive electronics agenda, followed by a two-day conference at Warwick University, featuring keynotes from Visteon and Jaguar Land Rover, not to mention the latest Lotus and Land Rover high performance electric vehicles. Industry experts are talking about a "once in a generation opportunity" for the UK's automotive sector, so if you haven't engaged with AESIN yet, but would like to, see the dedicated website (www.aesin.org.uk) or come along to scheduled events such as the Functional Safety (ISO-26262) workshop planned for March 2014.

POWER ELECTRONICS

Already a core competence of UK industry and R&D activity, power electronics has made giant strides this year, with NMI's ongoing support. April saw the launch of a dedicated steering board, the PowerelectronicsUK Forum, while towards the end of the year, the sector's key players came together for NMI's iPower3, a two-day conference at the University of Warwick, entitled Building a Smart Power Future and covering Smart Energy, Smart Power for Automotive, Transport and Aerospace, and Smart Consumer/Smart Home among other topics. NMI also ran two network events, one on Power Electronics – Transforming the Management of Energy Networks, which coincided with the opening of the new Power Electronics Centre at the University of Nottingham and attracted the likes of Chiltern Power, Scottish & Southern Energy and GE Energy, and the other on Power Electronics for the Smart Home at Newcastle University.

DESIGN EXCELLENCE AND INDUSTRIALISATION NETWORKS

NMI runs the most comprehensive range of sector networks spanning the entire value chain, from front end chip and software/system design through 'foundry link' to manufacture.

Providing an opportunity for knowledge exchange, business development and collaboration, these either focus on the

GLOBAL STEPPER & SCANNER PRODUCTS AND SOLUTIONS

NTEKlitho was formed in Jan 2013 as a third party alternative to servicing all aspects of Nikon Stepper and Scanner Systems. Our highly qualified team of engineers with a combined experience over 80 years ensure first class customer service.

Customer needs are at the heart of our organisation.

NTEKlitho is headquartered in Scotland, UK with facilities in the USA and the Netherlands. We provide service and support worldwide on the full range of Nikon systems G6-S307 and also the Nikon SF systems. With our state of the art cleanroom facility in the Netherlands which fully facilitised and our highly experienced team of engineers NTEKlitho has the capability of assessing, refurbishing and testing customer tools offsite.

With it's extensive customer base throughout the world and it's close relationship with brokers in the USA , Asia and Europe we have fast became the number one alternative to the OEM for customers looking to reduce their costs in this ever challenging economic environment. Completing mass projects on decommissioning, refurbishment and installations with pre agreed logistics and pricing.

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.

In addition to the Nikon service that NTEKlitho provide, we have also partnered with IDL Semiconductor who have offices in San Diego, Singapore and Nijmegen to support the needs of customers on all their Cymer 5000, 6000, 7000/ ALA lasers, they also have an extensive supply of parts for their Cymer systems, IDL can also support Gigaphoton on service.

SUMMARY OF CAPABILITIES

Sales and support

G-line	G6, G7 and G8
I - line	I7, i8, i9, i10, i11, 4425i, i12, i14, SF100, SF110, SF120, SF130 and SF140
DUV steppers	EX12 and EX14
DUV scanners	S202, S203, S204, S205, S206, S207, S305, S306, S307

Illumination and Lens capabilities

Full optics refurbishment G6-i14E Inclination.
Lens optimisation including Distortion, Astigmatism, Curvature, Coma shift, Coma magnification.
Refurbished BMU illuminators.

Lasers

Cymer sales and service.
Gigaphoton to Cymer laser change.

Parts

Please enquire for all your parts requirements, availability and pricing available on request.

Training

Nikon training is available at various levels and can be tailored to individual customer requirements.

For further information on all our products and services please contact **solutions@nteklitho.com**

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NTEKlitho USA
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Cheyenne
WY 82001

capabilities required to deliver innovative products, such as design verification and fabless operations, or specific technical competencies, such as how the UK's mixed signal and RF capabilities enable global mobile communications.

During 2013 we ran cutting-edge events on Embedded Software Security, exploring the different ways to safeguard systems, and Energy-Efficient Systems & Software, which brought the two ends of the design community together to solve a common problem (both delivered under the Embedded Software banner). Other activities within the design space included events on IP – Designing for Integration & Reuse (Chip-Level Design & Verification), which tackled the challenge of designing IP that's not only easy to integrate and 100% reusable but also delivered in an acceptable timeframe, and High Speed Data – Conversion & Acquisition (Analogue/ Mixed Signal & RF), featuring a session from Rutherford Appleton Laboratory.

These were complemented by events highlighting the latest developments in Managing the Ever-Increasing Risk of Electrostatic Discharge Damage, a key factor as the scale of IC transistor gates shrinks year on year, and Design for Reliability – From Chip to System (Quality & Reliability), both of which bridged the gap between chip and system companies. Cost-Effective Thermo Design, run in conjunction with the Cambridge Innovation and Knowledge Centre (CIKC), introduced the latest innovations in IC packaging, while December's Design for Manufacture event took Test as its theme.

The Fabless Operations Forum, which provides senior operational management with a vehicle to discuss common issues such as supply chain management, quality and audit systems, test development planning and regulatory action with their peers and to collaborate to make them more competitive, also met twice during the year, at CSR and Nvidia.

MANUFACTURING

The challenges may remain broadly the same, but NMI continues to explore new and innovative ways of optimising quality, cost and delivery, while maintaining its tried and tested regular forums and reviews.

One year in, NMI's new Lean Manufacturing network has taken its 'Seeing is Believing' approach to a whole new level with the introduction of site assessments and supervisor development workshops.

Site assessments involve a team of Production Managers spending two days on the shop floor, scrutinising how everything is done and talking to everyone who is involved in the operation. The main output is a detailed report for the host site, highlighting existing strengths and the opportunities for further improvement, but it's not just the host site that benefits. The site assessment team too reaps rewards, taking observed good practice back to their own workplace and gaining valuable personal development too.

NMI's supervisor development workshops take a similarly practical approach, with groups of six spending two days on site tackling a range of real challenges at a host site. All of the supervisors who have so far participated have returned to their facilities brimming with ideas for continuous improvement and the motivation to implement them. Both our site assessments and supervisor development workshops are free to members, so get in touch if you'd like to be involved.

Another first for 2013, which we're also keen to repeat in the future, was April's international utilities conference. Co-hosted at Seagate, this provided an excellent platform to share knowledge and best practice on utilities and saving energy, by far the biggest cost for all our members operating a cleanroom. We hope to replicate this energy efficiency success in one form or another next year.

Already a regular fixture in the industry calendar, our fourth Manufacturing Excellence conference took Workforce Engagement as its theme and featured an impressive line up of speakers, including Professor Nick Rich from the University of Swansea and Stephen McKenna, Director Engineering & Quality Assurance at Foxconn in the Czech Republic, alongside several teams of hands-on operators, technicians and engineers presenting and sharing their own successes in manufacturing practice. For more on Workforce Engagement, read our article *Manufacturing in action* on page 107.

Throughout the year, NMI's portfolio of regular forums and reviews continued to deliver tangible benefits where it counts, in day-to-day operations. These include the Equipment Engineering Forum, Purchase Managers Review, Utilities and Energy Conservation Best Practice Forums, Industrial Group, Health & Safety, Facilities, Human Resources and Production, together with a new working group formed specifically to look at cycle time and scheduling systems/inventory management.

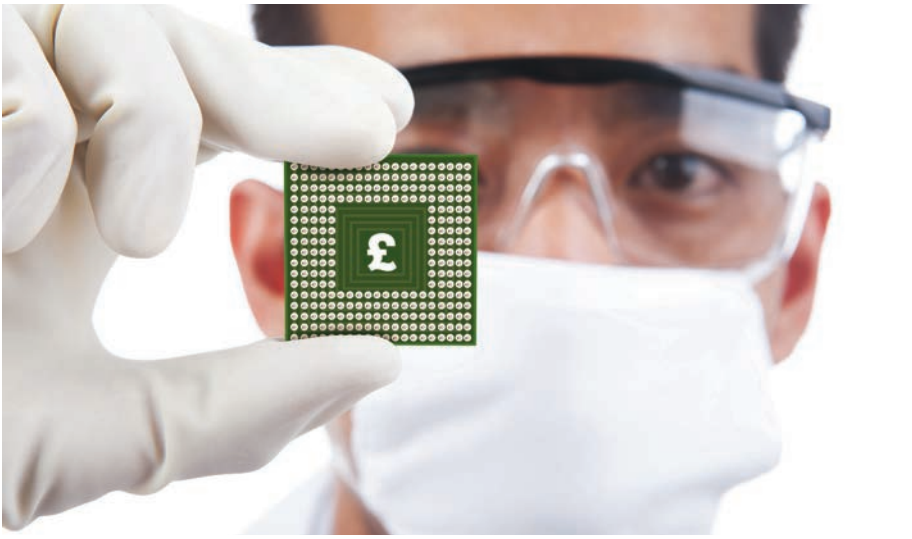
FURTHER COLLABORATION

You could be forgiven for thinking that would be enough for a small team such as ours, but in NMI's desire to always provide the very best service for its members we have also:

- Continued to support and provide management for the South West Microelectronics Innovation Network (iNET), one of the few regional initiatives to have its funding extended for a further two years beyond its original remit.
- Worked with the Electronics, Sensors & Photonics Knowledge Transfer Network to deliver a series of networking events across a range of Embedded System topics.
- Worked with UKTI and our members to highlight the UK's expertise in audio to an inward delegation from China.

RESEARCH AND DEVELOPMENT

Ours is an industry that's always looking forward, so NMI does everything in its power to support and stimulate both the skills pipeline and world-leading R&D activity.



NMI'S DEDICATED R&D RESOURCE has once again acted as a launch pad for a host of promising collaborations and technological advances, be it through providing members with bespoke one-to-one support and assistance through the funding maze, networking with the community to enable effective collaborative R&D or influencing and informing fundholders on your behalf to better align the needs of the community with funding calls and competitions.

Raising awareness of the many potential opportunities, NMI ran well-attended R&D workshops on Artemis and Harsh Environment Electronics, together with a series of six joint events with the Knowledge Transfer Network (KTN) on funding schemes relevant to SMEs, for example.

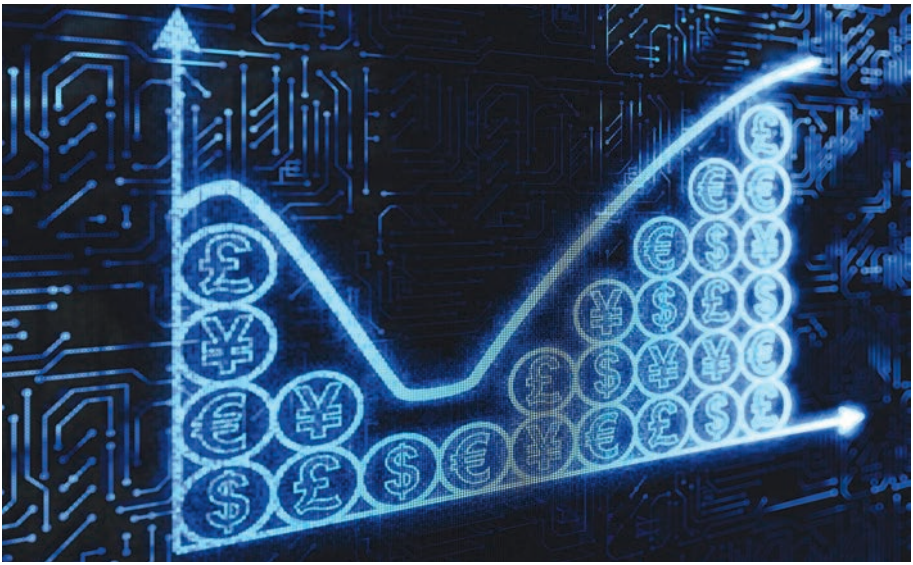
Alerted to the possibilities, the next step is to encourage and support members' involvement in the various funding schemes and 2013 proved to be another fruitful year. In total, NMI members received over £10 million of R&D grants through competitions such as Eurostars, the Regional Growth Fund, SMART, Eniac and Artemis. For more on this, read our article *Benefits and challenges of EU R&D engagement* on page 67.

2013 PROVED TO BE ANOTHER FRUITFUL YEAR

NMI has a particularly strong track record in power electronics and we once again added to our tally in 2013, working closely with the Technology Strategy Board (TSB) who invested more than £20 million of funding in various power electronics-related calls. This brings the total of new R&D funding secured by NMI for the cluster to around £40 million over the last two years, with many NMI members among the beneficiaries. Paving the way for future success, NMI is also creating a unique cross-sector technology roadmap for power electronics that will identify key and disruptive technologies which can be exploited by UK industry, guiding research and investment decisions.

Strong advocates of collaborative R&D as we are, NMI has also lent its support to two pioneering research programmes. Jointly run by the universities of Glasgow and Edinburgh with industrial partners IBM and Wolfson, the first, StatDes, is breaking new ground in process implementation at advanced process nodes. The second, PRiME, which stands for Power-efficient, Reliable, Many-core Embedded systems, pools the talents of no fewer than four UK universities, five companies and seven international visiting experts.

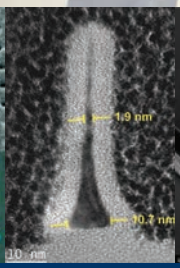
NMI is looking forward to seeing how both programmes develop over the coming year, as well as to offering members more support in the European funding arena with Horizon 2020 bringing a further €70 billion of funding over the next seven years into view.

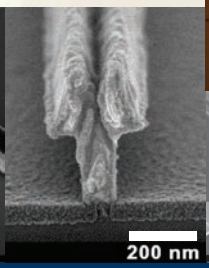


University of Glasgow

James Watt Nanofabrication Centre

- The James Watt Nanofabrication Centre is one of the premiere cleanrooms working with over 250 international companies
- Glasgow has over 35 years experience of developing solutions for science, nanoelectronics, optoelectronics, healthcare, energy harvesting, security & defence, ...
- The 750 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
- The Centre holds many world records including the smallest electron beam lithography patterned devices of 2.5 nm, the smallest layer-to-layer alignment (0.46 nm rms), the highest performance III-V HEMT and the smallest diamond transistor





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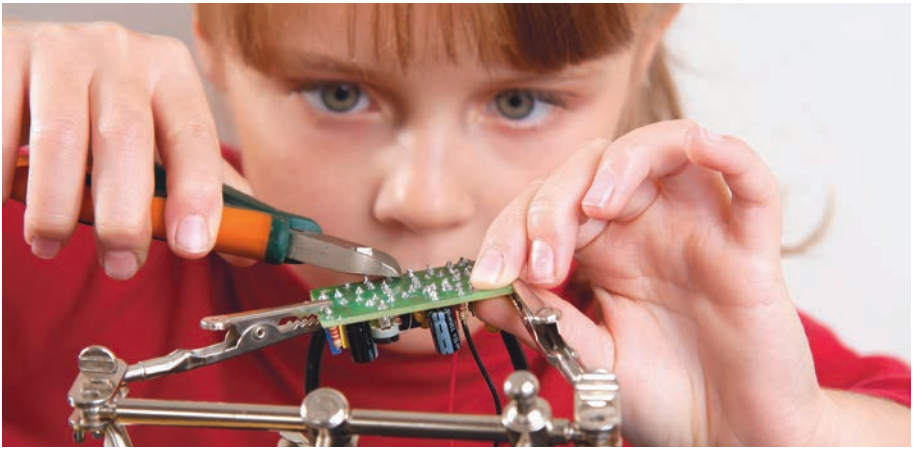
Tel: +44 (0)141 330 5219
http://www.jwnc.gla.ac.uk/

FUTURE SKILLS

In a world of complexity, there is one thing we can say for certain: without engineering skills we have no capability and without capability we have no business. That's why NMI places engineering skills at the top of our priority list. The primary, but not exclusive focus, is on the UK Electronics Skills Foundation (UKESF), of which NMI is a founding partner, and which we established in 2010 in response to the marked decline in UK applicants for electronics degrees.



THIS TREND, as the ESCO Report has since reiterated, threatens the performance and long-term prospects of our industry. Aimed at increasing the number of talented graduates entering our industry, UKESF tackles this challenge in three ways:

1. A schools programme aimed at sparking interest among 12-14 year olds in the world of electronic systems.
2. UKESF Summer Schools seeking to increase the number of talented young people taking electrical and electronic engineering degrees.
3. A Scholarship Programme that connects employers and undergraduates, providing valuable work placements and exposure to employers and the required skill sets to 'hit the ground running' on finding employment after graduation.

The earlier you can inspire young minds the better, so last year UKESF piloted a 10-week project for 12-14 year olds from across the South West, in partnership with EDT (Engineering Development Trust). Designed to stimulate interest in and raise awareness of electronic engineering as an exciting subject and rewarding career path, 'Our Electronics Environment' was a huge hit with all concerned

and is now available as a ready-made project for any company to run with schools as part of the Go4SET portfolio. In the meantime, another pilot is starting in the East of England in January 2014.

Aimed at a slightly older age group of A-level and Scottish Higher students, UKESF's four-day Summer School uses a combination of design competitions, lectures and lab sessions to inspire potential electronics undergraduates. Held at Imperial College London, 2013's course attracted 60 students from across the UK, up 50% on the previous year, and featured topics including biology-inspired machines, mobile robots and a design challenge using the Raspberry Pi, itself a great example of British engineering innovation and the subject of NMI's Raspberry Pi give-away, which saw 50 kits awarded to a range of organisations including several schools during 2013.

If our industry is to continue developing world-leading technology we need the very best people, which is where the UKESF scholarship scheme and Summer Skills Workshop both come in. Targeted at the brightest electronic engineering undergraduates, 2013's workshop featured several inspirational speakers who shared their visions for the industry, as well as seminars on project management, business ethics, negotiation and emotional intelligence, encouraging these top-flight students to develop themselves as rounded people and recognise that while technical skills are important, there are other skills that matter in the workplace too.

With more students than even before participating in the various programmes, around 180 scholarships already awarded, three more universities joining UKESF's academic ranks and both Jaguar Land Rover and Broadcom Foundation adding their weight to the list of sponsors, UKESF is clearly heading in the right direction. To reach even more young people though and secure our industry's future, we need more employers to participate in this truly unique programme, as you can read in *The electronics industry must reach out to future recruits* on page 59. UKESF was awarded charitable status in 2013, so there are now even more ways to help, with the website (www.ukesf.org) being your first point of contact.

NMI's activities are not limited to future skills though. We now conduct an annual employment survey which provides a salary and job benchmarking tool, while also gauging opinion on likely employment trends. We intend to develop the content and range of participation in this survey and look forward to working with you on this in 2014.

CONCLUSION

You may be surprised by the sheer breadth of NMI's activities, but with a community as diverse as ours a one-size-fits-all approach was never going to work. That's not to say there isn't a common thread running through everything we do. All of NMI's programmes, projects and initiatives, be they in the field of skills, innovation, R&D, the business environment, promotion or representation, are designed to ensure our industry is fit to compete on the global stage, fit to lead and fit to win.

As the pages of this Annual Review demonstrate, it has been a remarkably productive 12 months! But with your support we can do even more next year. If you're already a member, thank you for your continued backing. If you aren't yet but would like to enjoy the many benefits you've just been reading about, look into joining NMI today.

ANNUAL AWARD WINNERS 2013

SPONSORED BY:

AESIN
ALSTOM
ARM
ASE GROUP
cadence
CommsMasters
The Leadership Communication Experts
compugraphics
photomask solutions
icgroup
ichor systems
International IOR Rectifier
nmi Together We're Better
Raytheon
Lam RESEARCH
MASER ENGINEERING
Science & Technology Facilities Council
SYNOPSYS
Accelerating Innovation

THE CONTRIBUTION TO INDUSTRY AWARD

Winner: Jamie Urquhart
Award Sponsored by: NMI

THE COMPANY OF THE YEAR AWARD

Winner: McLaren Electronic Systems
Award Sponsored by: IC Group
Photo: Derek Boyd (NMI), Charles Hawkins (McLaren), David Earle (McLaren), Tim Strafford (McLaren), Mark Booker (McLaren), Neil Dickins (IC Group) and Quentin Willson

THE YOUNG ENGINEER OF THE YEAR AWARD

Winner: Adam Malpass
Award Sponsored by: ARM
Photo: Derek Boyd (NMI), Adam Malpass (Dialog) and Kirsty Gill (ARM)

THE SEMI360 AWARD

Winner: Lime Microsystems
Award Sponsored by: Cadence
Photo: Derek Boyd (NMI), Nick Stables (Lime Microsystems) and Janet Collyer (Cadence)

THE INNOVATION AWARD

Winner: Coveritas
Award Sponsored by: ASE Group
Photo: Derek Boyd (NMI), Sean Redmond (Coveritas), Bradford Factor (ASE) and Patricia MacLeod (ASE)

THE COLLABORATIVE R&D ACHIEVEMENT AWARD

Winner: Infineon
Award Sponsored by: STFC
Photo: Derek Boyd (NMI), Helen Finch (Infineon) and John McLean (STFC)

THE TRAINING AND DEVELOPMENT AWARD

Winner: Dialog Semiconductor
Award Sponsored by: Comms Masters
Photo: Derek Boyd (NMI), Rebecca Fradley-Stokes (Dialog Semiconductor) and Heather Campbell (Commsmasters)

THE LOW POWER DESIGN INNOVATION AWARD

Winner: Cam Semi
Award Sponsored by: Synopsys
Photo: Derek Boyd (NMI), Mark Muegge (Cambridge Semiconductor), David Baillie (Cambridge Semiconductor) and Gabriel Lezmi (Synopsys)

THE MANUFACTURING SUPPLIER OF THE YEAR AWARD

Winner: memsstar®
Award Sponsored by: International Rectifier
Photo: Derek Boyd (NMI), Bruce Dickson (memsstar®), Alan Lambie (International Rectifier) and David Gold (International Rectifier)

Together
We're Better

Gala Dinner

November 2014, London

The Gala Dinner has successively grown in recent years and 2013 was over-subscribed and our biggest ever. We plan to make 2014 even better, as this is the event in the UK Electronic Systems calendar **not to miss.**

See www.nmi.org.uk for details

THE PRODUCT EXCELLENCE AWARD

Winner: Frontier Silicon
Award Sponsored by: Maser Engineering
Photo: Derek Boyd (NMI), on behalf of Frontier Silicon – Alison Burdett (Toumaz) and Mike Warren (Toumaz) and Kees Revenberg (Maser Engineering)

THE MANUFACTURING SITE OF THE YEAR AWARD

Winner: XAAR
Award Sponsored by: Ichor Systems and Lam Research
Photo: Derek Boyd (NMI), Ted Wiggins (Xaar), Paula Crofts (Xaar), Paul Smith (Xaar), Owen Tangey (Ichor Systems) and Neil Hendry (Lam Research)

THE INNOVATION IN POWER ELECTRONICS AWARD

Winner: Anvil Semiconductors
Award Sponsored by: Alstom
Photo: Derek Boyd (NMI), Jill Shaw (Anvil Semiconductors) and Colin Davidson (Alstom)

THE ENVIRONMENTAL MANAGEMENT AWARD

Winner: Seagate
Award Sponsored by: Compugraphics
Photo: Derek Boyd (NMI), Mark Moroney (Seagate) and Brian Young (Compugraphics)

THE UNIVERSITY DEPARTMENT OF THE YEAR AWARD

Winner: Heriot Watt University
Award Sponsored by: Raytheon
Photo: Derek Boyd (NMI), Keith Brown (Heriot Watt) and Brooke Hoskins (Raytheon)

THE AUTOMOTIVE ELECTRONICS INNOVATION AWARD

Winner: Freescale
Award Sponsored by: Aesin
Photo: Mark Robson (Freescale), Andrew Robertson (Freescale) and David Battersby (Jaguar Land Rover)

Sir Hossein Yassaie
CEO, Imagination Technologies

WHAT THE FUTURE NEEDS

The most common question I get from industry and financial analysts is: what's next? Although I believe technology has real potential to change our lives for the better, the future of the semiconductor and electronics industry should not (and in fact will increasingly not) be just about how or if we can abide by Moore's Law with every new process node.

WHENEVER DESIGNING new technologies, it is always important to remember that these processors end up in final products which consumers should want to buy and find their lives enriched by.

The consumer market enables everyone in the supply chain to thrive and this growth can only be sustained through ensuring the best possible user experiences and original, exciting product offerings that make a real difference to consumers. Therefore I always try to encourage and help our silicon partners to be increasingly aware of what consumers want and need and focus their engineering towards fulfilling those needs.

THE NEXT REVOLUTION IN MOBILE COMPUTING

If I can summarise what I have learned in my career so far in one phrase, it would be that spurring innovation is all about looking for discontinuities and spotting trends across multiple markets. This involves a deep understanding of what drives markets and how technology must be designed to address that.

Mobile is perhaps the best example of this; when the first smartphones were launched, even industry insiders were wondering whether there was any future for these devices in the context of portable electronics. Since then, smartphones have become everyone's main

GROWTH CAN ONLY BE SUSTAINED THROUGH ENSURING THE BEST POSSIBLE USER EXPERIENCES AND ORIGINAL, EXCITING PRODUCT OFFERINGS

computing device – I'm pleased to say due in part to the powerful but low-power graphics technologies that Imagination has pioneered.

By integrating our GPU and hardware video engines on the application processor, semiconductor companies were able to offer better multimedia experiences and capabilities for developers to exploit.

It created a snowball effect where more and more software companies became interested in investing in mobile; this in turn generated the pull for consumers who were enchanted by the new range of applications that could run on their devices; finally, silicon vendors started accelerating their development cycles to keep up with the demand for higher performance and increasing functionality.

Going forward, everything will need to be smart, so most devices will need a CPU with low power credentials for the next wave of wearable devices. I was very pleased to bring MIPS, one of the most efficient architectures that exist on this planet, into the Imagination family where we can drive forward a compelling next generation CPU. Our expectation and aspiration is that MIPS will grow from its current strong base in networking and the digital home and become a major player in new markets, with the energy we can put behind it. We are already seeing the first steps of this happening: a new, compelling roadmap has been released, numerous customers are licensing the current generation of processors and the first wearable products are appearing in the market.

Another inflexion point in silicon IP is complete hardware integration. For years, including the Wi-Fi and Bluetooth components on the system-on-chip has been a hot topic among integration and design engineers. This all sounded familiar to Imagination who had to overcome similar problems when it initiated something unheard of some time ago: integrating the graphics and video processing units on the same chip together with the CPU. We were pioneers in this area, as our PowerVR graphics IP cores were one of the first solutions to be included in modern mobile SoC platforms.

Now, by incorporating our Ensigma RPU into the SoC we believe system designers will create the next generation of smart TVs, set-top boxes, in-car communication systems or mobile phones and tablets by enabling a combination of world TV, world radio and complete connectivity (Wi-Fi, Bluetooth and more) in all of the above. It's taken some time but this technology has enabled the digital radio market, is empowering connected entertainment devices and early in the New Year will be part of another exciting platform that we're looking forward to being able to talk about at Future World 2014.

ENGINEERING THE FUTURE

Building a successful IP business is a complex and involved task so you have to be prepared to plan and execute roadmaps for the short, medium and long haul. You need to hire the best people in the field and ensure they have everything they need to develop world class technology. Ultimately, new technology can only be created by engineers with the right set of skills, motivation, and respect for the craft.

We understand the value of investing in technology for society. Our IP enables better communication between social groups and delivers the solution companies need to build better platforms for a range of applications from entertainment to e-health, using energy and resource wisely.

What still puzzles me is the lack of really big technology brands, like Amazon, Microsoft and Google from Britain. The UK was once famous for the host of great technology companies it had, but most have either disappeared or have been sold to larger corporations. This puts us in a dangerous position and leaves room for a fundamental question that I've asked multiple times in public forums: do we want the UK to be a nation of tens of millions of consumers or creators who have scale and make a difference on the global scene?

I believe there is still great opportunity and potential for local companies to be successful on a global stage if we do the right things and have the right policies implemented. Everywhere I look, there are British visionaries designing cutting-edge products for top companies worldwide, but we don't have globally-recognisable companies or brands.

A perfect example of this is digital radio; a few years ago, the pace of innovation in DAB was lacklustre. Therefore, the only way to boost interest from consumers for digital radios was to create a leader in the market that had exciting and innovative products – this is how Pure was born. Pure is now a market leader in the UK and worldwide and the underlying processor technologies it uses is included in a vast majority of all digital radios sold. Built in the UK, the brand is now worldwide, including the USA where it has several thousand retailers stocking its wireless audio products.

EVERYWHERE I LOOK, THERE ARE BRITISH VISIONARIES DESIGNING CUTTING-EDGE PRODUCTS FOR TOP COMPANIES WORLDWIDE

Two out of the top three silicon IP companies are UK-based and the rest of the UK tech sector should capitalise on the innovative solutions that are designed here. We should have an ecosystem of fabless semiconductor companies, design houses and global OEM brands that can take advantage of all these IP technologies. In order to build this, we need to look at other regions and understand their models. Companies like Samsung, LG, Sony

ABOUT THE AUTHOR

Sir Hossein Yassaie
PhD, Chief Executive Officer:
After attaining his PhD, Hossein was a research fellow at the University of Birmingham. Prior to joining Imagination Technologies in February 1992, he was with STMicroelectronics and Inmos for eight years, where he set up and managed the DSP and digital video developments. Ultimately he became responsible for the system divisions, including research and development, manufacturing and marketing. Hossein joined Imagination Technologies in 1992 as CTO, joined the Board in 1995, and became CEO in 1998. He was knighted in the 2013 New Years Honours List for services to technology and innovation. (from www.imgtec.com/corporate/investors/boardofdirectors.asp)

did not appear by accident. They started from small beginnings too but they had a long range plan for global success. Given the strength of the UK economy in a global context dominated by influencers from the US or Asia, I feel much more could and should be done to leverage the tremendous intellectual prowess we have here and that has been recognised by every leading semiconductor and OEM manufacturer world-wide.

Even though we have plenty of successful software and hardware companies in tech hubs in the UK, we are still missing two essential pieces in the supply chain puzzle: semiconductor companies and OEM with scale and brand, both of which can make a significant contribution to the future of the UK. The usual pattern with UK start-ups is a meteoric rise followed by either a sudden cut in funding or a rushed sell to a larger company. With the right guidance and support, government organisations such as the Technology Strategy Board could deliver amazing results in enabling a modest number of these start-ups to continue building momentum and eventually establish themselves as technology leaders.

The main problem however lies in the absence of capital. Without a clear strategy and support in funding, most companies will eventually collapse; this needs rectifying urgently. One ideal place to start investing in is the national health system. The NHS has been in dire need of modernisation for it to cope with an ageing population that demands more and more services from GPs and specialists alike. Therefore we should support strategic initiative involving several companies to develop and introduce advanced technologies for e-health and well-being monitoring. If this is done on a long-term and strategic basis it will result in the emergence and creation of more UK businesses that would not only help the NHS to become the best and the most effective healthcare provider in the world but such companies will also have a real chance to become major exporters of proven technologies and solutions for next generation healthcare. The same models can and should be used in other key areas beyond the NHS, including in energy, automation and education to encourage growth of existing and creation of new business in UK focused on areas of importance to the nation.

Furthermore, we need to make sure that these companies are sufficiently well staffed. By focusing on students at an early age and initiating partnerships like UKESF, we ensure they will be the creators of technology and leaders of future companies – and that they have the confidence and capabilities to do it. As one of the fastest growing electronic engineering employers in the UK, Imagination has a strong focus on enabling and enhancing the education of a local engineering community, starting with sixth-form schools and universities. Our UK undergraduate programme is an excellent vehicle for us to engage and excite students when they are making crucial career choices, nurture the UK's best engineering talent, and ultimately strengthen the UK electronics industry.

Overall, we strongly believe we need to ensure that we have a technology and industrial strategy that takes the current environment, industry trends, and our expertise and skill sets into account – and actively steers the UK towards a strong and vital position for the future and on a long-term basis. I am confident there are many who are ready to help so we will continue doing our part. But all these efforts need to be part of a larger strategy – and we need this happening yesterday.

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Warren East

ESCO TODAY AND THE WAY FORWARD

IS THE ELECTRONIC SYSTEMS COMMUNITY ON ITS WAY TO BECOMING A RECOGNISED INDUSTRIAL SECTOR IN THE UK?

"Imagine a world without Electronic Systems" so began the introduction to the ESCO report published on June 27th 2013. This was the culmination of almost 2 years of effort spearheaded by NMI and other trade associations active in the area of Electronic Systems.

It is the intention though of the ESCO council that the publication of the report marked not the end, but the end of the beginning. At the time of writing we are optimistic that the ambitious goals set out in the ESCO report will be seen to be within reach over the next 5 to 8 years.

GENESIS

It has long been recognised in numerous reports that the Electronic Systems sector in the UK, within which most of NMI's member companies are found, is a hugely fragmented and diverse arena. There are a handful of trade associations and compared with other more traditional sectors in the UK all efforts at joining-up have seemed to yield sub-critical results over recent years. The UKEA (UK Electronics Alliance) was trying to achieve this but progress was really not forthcoming and the supporting companies began to focus more on other priorities. The opportunity was apparent however; if industry could be more joined-up, especially in communications with UK government, greater growth and more jobs would follow. At the start of the ESCO process this was largely conjecture and gut feel, what was needed to open eyes and later minds and corporate cheque books would be data. And of equal importance, could we get some Government commitment to listen?

The good news was that in Mark Prisk, the Minister of State for Business, Innovation and Skills at the time, we found someone open to the messages we were given and NMI's CEO, Derek Boyd, was invited to work with other

THE ELECTRONIC SYSTEMS SECTOR IN THE UK IS A HUGELY FRAGMENTED AND DIVERSE ARENA

stakeholders to bring forward an Industrial Strategy for UK Electronic Systems.

With something tangible to aim at Jamie Urquhart, ex-ARM, was persuaded to chair a small group of willing executives from some of the UK's leading companies. With senior staff at BIS providing invaluable support, Intellect and Gambica joined with NMI to put in some vital funding, and UKEA and other Stakeholders all contributed to the development of the report and supporting workstream reports.

LAUNCH

After a great deal of collaborative effort the report was launched on June 27th, in London just off Westminster square. We had a fantastic turnout, and Sir Hossein Yassie (CEO of Imagination Technologies), made use of his recent knighthood to secure the participation of Ed Vazey (Minister for Culture, Communications and Creative Industries).

In the process of generating the report we established the vital information that we intuitively knew but could not substantiate: We are a productive community generating almost 6% of UK GDP with only 3% of the population and we have global leaders here in the UK. The work done in producing the report showed that there is potential to grow the absolute GDP and number of jobs connected with Electronic Systems by 50% and 20% respectively by 2020.

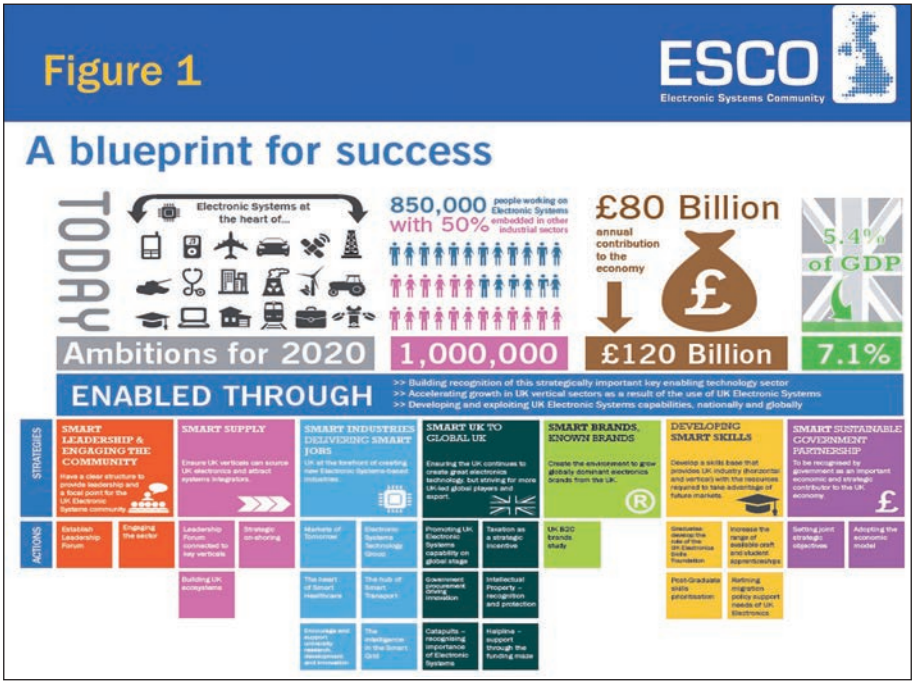

Figure 1: ESCO Blueprint

CURRENT STATUS

The success of the report launch and the enthusiasm that it generated has continued with a number of notable developments:

- The ESCO acronym has momentum in itself and has been reused, now standing for "Electronic Systems COmmunity".
- The steering team has become the leadership team and is now a formally recognised "Council".
- The working group has joined forces with the executive from the UK Electronics Alliance (UKEA) and become the ESCO executive.

The ESCO Council is being co-chaired with me by Michael Fallon, Minister for Business and Innovation. This in itself is a significant step forwards in terms of engagement and we have now established a clear mechanism to partner with Government as part of our original objectives.

Figure 2: Vision for Leadership

Our first meeting held in late October 2013 with ministerial involvement was very successful and produced tangible actions supporting the vision shown in Figure 2. Action plans are also being developed, and members of the leadership team are actively marketing the activity.

We have identified ten primary areas of strength or significant potential for Electronic Systems in the UK and mapped these to the key areas of

Figure 3

ESCO
Electronic Systems Community

UK Industrial Strategies

Top 10 Key Technologies	Auto	Aero	Off-Shore Wind	Oil & Gas	Civil Nuclear	Information Economy	Life Sciences	Construction	Agri	Professional & Business Services	Education
Electronic Materials (Graphene, nanotech, III-V's, batteries)	☑☑☑	☑☑☑	☑☑	☑☑☑	☑☑	☑☑☑					
Plastic and Printed Electronics	☑	☑				☑☑☑	☑☑☑				☑
Sensors	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑	☑☑☑		
Optics & Photonics	☑☑☑	☑☑☑		☑☑☑	☑☑☑	☑☑☑	☑☑☑		☑☑		
Microprocessors & Embedded Software	☑☑☑	☑☑☑	☑	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑		
Communications	☑☑☑	☑☑☑	☑	☑☑☑	☑☑	☑☑☑		☑	☑		
Graphics, Video and cameras	☑☑☑	☑☑☑	☑	☑☑	☑☑☑	☑☑☑	☑☑	☑	☑		
Industrial Automation	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑	☑☑☑	☑☑	☑☑		
Robotics & Autonomous Systems	☑☑☑	☑☑☑		☑☑☑	☑☑☑			☑	☑☑		
Power Electronics & Power Management	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑	☑☑☑		☑☑☑	☑		

☑ Relevant ☑☑ Important ☑☑☑ Vital

Figure 3: UK Industrial Strategies

Figure 4

ESCO
Electronic Systems Community

Societal Challenges as defined by Horizon2020

Top 10 Key Technologies	Health, demographic change and well-being	Food security & sustainable agriculture	Secure, clean and efficient energy	Smart, green and integrated transport	Climate action & resource efficiency	Secure Societies - protecting freedom & security	Building Advanced Manufacturing Capability
Electronic Materials (Graphene, nanotech, III-V's, batteries)	☑		☑☑☑	☑☑☑	☑☑☑		☑☑☑
Plastic and Printed Electronics	☑☑☑	☑☑☑		☑☑	☑☑☑		☑☑☑
Sensors	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑☑	☑☑☑	☑☑☑
Optics & Photonics	☑	☑	☑☑	☑☑☑		☑☑☑	☑☑☑
Microprocessors & Embedded Software	☑☑	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑☑☑	☑☑☑
Communications	☑☑☑	☑	☑☑	☑☑☑	☑☑☑	☑☑☑	☑☑☑
Graphics, Video and cameras	☑☑☑	☑		☑		☑☑	☑☑☑
Industrial Automation	☑	☑☑☑	☑☑☑	☑☑	☑☑☑	☑	☑☑☑
Robotics & Autonomous Systems	☑☑	☑☑	☑☑	☑☑☑	☑☑	☑	☑☑☑
Power Electronics & Power Management		☑	☑☑☑	☑☑☑	☑☑☑		☑☑☑

☑ Relevant ☑☑ Important ☑☑☑ Vital

Figure 4: Horizon 2020 Societal Challenges

the UK defined Industrial Strategies (Figure 3) and to the six big societal challenges identified by Horizon 2020 (Figure 4) with the important addition of Advanced Manufacturing Capability.

LOOKING FORWARD

As I write, over the coming months we plan to have bi-monthly meetings of the council to monitor progress and appoint a CEO to help drive the programme. In July 2014 we will publish an annual report reviewing progress for the first 12 months – just as a company produces a report to account to its shareholders. We hope this will become an annual "Industry Summit" where we genuinely come together to report on and discuss the progress we are making.

Throughout 2014 and into 2015 I expect the ambitious goals we set out in the report will be tested. Are they optimistic? Realistic? Or, perhaps, even pessimistic? Can we achieve even more? A lot will depend on how effectively we can harness the efforts of the community itself. The thousands of companies represented by the trade associations like NMI will only contribute if they can see a path to economic benefit. The companies and organisations directly involved in the ESCO Council today will need to continue their support, but we need the assistance and breadth of others to realise the potential we have here. The ESCO initiative was led by the Trade Associations and other stakeholders with NMI front and central.
The best way for you to add your support is first of all to ensure you are a Trade Association member and to consult with your association on how best to get involved.

THE AMBITIOUS GOALS WE SET OUT IN THE REPORT WILL BE TESTED

IN CLOSING

Terms such as "re-shoring" are rattling around the business community at large at present. Whilst it seems unlikely that a state of the art semiconductor facility will be showing up in the UK soon, Electronic Systems are breathing new life into manufacturing across multiple sectors, and the Internet of Things is now a phrase to be found in the general press and heard on Radio 4. The potential for connected intelligence to address some of the big societal questions is beginning to be recognised in government. At last in the UK the excitement has returned to this industry – our community.

THE POTENTIAL FOR CONNECTED INTELLIGENCE TO ADDRESS SOME OF THE BIG SOCIETAL QUESTIONS IS BEGINNING TO BE RECOGNISED IN GOVERNMENT

ESCO COUNCIL MEMBERS

Warren East – Co-Chairman
Michael Fallon – Co-Chairman
(Minister of State for Business & Innovation)
Juergen Maier – Siemens UK
Indro Mukerjee – Plastic Logic
Stephen Pattison – ARM
Keith Williams – Altran Intelligent Systems
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Peter Brooks – Electronics Yorkshire and ESCO Executive
Ian Osborne – Intellect
Graeme Philp – GAMBICA

KEEPING UP TO DATE

To obtain a copy of The ESCO Report, to keep-up with the latest news or to register for updates, see www.esco.org.uk

ABOUT THE AUTHOR

Warren East served as the CEO of ARM from 2001 to 2013 having joined them in 1994 to set up ARM's consulting business. In October 2000 he was appointed to the Board as Chief Operating Officer and in October 2001 was appointed Chief Executive Officer. Before joining ARM he was with Texas Instruments. He is a chartered engineer, Fellow of the Institution of Engineering and Technology, Fellow of the Royal Academy of Engineering and a Companion of the Chartered Management Institute. He has an honorary doctorate from Cranfield University and has several non-executive director appointments including BT, Dyson, Micron Technology and Rolls Royce.

Warren was appointed Commander of the Order of the British Empire (CBE) in the 2014 New Year Honours for services to the technology industry.

HAVE UK SEMICONDUCTOR STARTUPS HAD THEIR CHIPS?

The UK has long been valued for its technological know-how, creativity and innovation in the semiconductor arena. The startup has been a vehicle of choice for many to capitalise on this innovation. But has the fabless semiconductor startup run its course in the UK? Has investment dried up now that stellar exits are a thing of the past and chips are too expensive to build and qualify? There are some who have direct experience of this space who would respond with an unqualified "yes".

THIS ARTICLE IS an attempt to provide a view from the trenches of undertaking semiconductor startups in a changing landscape, touching on the drivers for enterprise and the agents of change and new models that might emerge that talk directly to exploiting "knowledge-capital".

UK STARTUP LANDSCAPE

Startups are very much in vogue. Outside the chip industry they're abuzz. A glance at Dragon's Den, Tech City/Silicon Roundabout and events such as Futurefest are testament to this. With reference to technology startups, Tech City News boasted *"Outside of London, there are far fewer real hotspots for new business creation. The top postcode outside of London, WA1 (Warrington), accounted for 1,510 – only a tenth of the number of new businesses as Tech City."*

This statement is revealing, partly in that the nature of these startups are "tech" only in that they need a computing platform for their deployment, and partly in that it fails to recognise Bristol, Cambridge, Oxford, Silicon Glen and others for the depth of technological know-how, innovation and capacity to build sustainable high-value global businesses. The UK semiconductor startup scene seems a world away from all this, and invisible to those who promote Tech City as the hub of UK technology – a view clearly held by the British Venture Capital Association[1].

Tech City's supposed progenitor, Silicon Valley, grew in a large home market, driven by industry innovators with an aggressive business mindset and an acute attention to marketing; this was coupled with substantial state investment and a national economy of scale that made it easier to grow a business than in the UK. Most businesses sprang out of other business as they grew. Over time a rich infrastructure was cultivated providing ties between networks of seasoned entrepreneurs, investors, advisors and academia.

Technology markets are now all global. So are all the supply chains that feed them. This offers an even bigger economy of

scale, and successful high-tech startups are emerging worldwide.

One key question is where future UK semiconductor startups will come from. Another is what the nature of the startup will be. The 2011 World Economic Forum Global Entrepreneurship report[2] cited 7 sources of new ventures, all variously industry entrepreneurs seeding new enterprise. It did not cite institutional R&D being a key source of commercial startup. This may need to change.

UK government is invigorating its efforts to cultivate and exploit the "knowledge-economy", to recognise and develop deep technology value that is generated in the UK. In 2011, UK non-business investment in R&D was £10 billion, funding higher education, research councils, defence-related R&D and other sponsorship. The Technology Strategy Board (TSB) has a budget of £440 million for "transforming ideas into new products and services to generate economic growth." This includes seven specific fields have been identified as high value to the economy to be promoted through Catapult Centres. It also includes grants, knowledge transfer, research initiatives and other innovation support. The pressure to extract value from all that R&D is significant.

Other initiatives are more local. Organisations such as Imperial Innovations and UMIP seek to propel university research into the commercial arena, and have a focus on select institutions. Regional networks such as SETsquared and Cambridge Wireless deliver local context and infrastructure for innovation and communication. No doubt there is room for a national initiative too.

Where companies do emerge successfully from academic R&D into seed stage, they usually bring on-board industry expertise, undergo a substantial change in direction in the process as they redirect the technology at a reachable commercial target. In the process these companies have successfully leapt a gap. And it is quite a substantial one.

ONE KEY QUESTION IS WHERE FUTURE UK SEMICONDUCTOR STARTUPS WILL COME FROM

This was central to the themes of reports by Sainsbury[3] (2007), Dyson[4] (2010), and Hauser[5] (2010), all of which explored of the knowledge-economy and its development in the UK. The "gap" between R&D, enterprise and global markets is still there. What is new is a high-level recognition that this gap exists, with attendant questions about how to deal with it.

For the chip industry, the recently-published ESCO report is an articulate response to those questions, raising the profile of the UK semiconductor industry to a high-level audience that appears to be listening. It aims to highlight the UK's contribution to semiconductor systems worldwide, promote its strength in innovation, in manufacturing, in skills development and create a blueprint for the UK semiconductor industry in the context of broader government initiatives. This raised awareness could help

provide a much-needed following wind for new British chip startups.

Of course this still depends on commercial drivers, availability of funding and suitable business models.

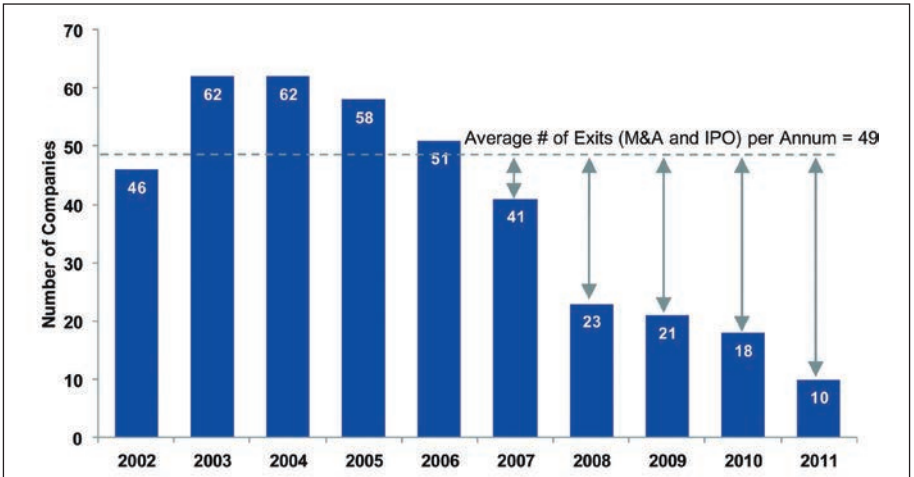
NEW DRIVERS FOR ENTERPRISE

Throughout the global economic downturn, M&A has been a steady growth strategy for industry majors to maintain an "edge", but appetite is sharpened even more so now we are emerging from it, and many leading semiconductor businesses are known to be actively on the acquisition trail. It is also known that the principal driver for M&A today is not revenue/supply chains/customers, rather it is know-how that can deliver strategic advantage to the acquirer's existing portfolio. This usually means smart people with a well-proven and well-directed technology rather than a rich P&L.

Right now it would seem there are some particular drivers that err in favour of startups in the West.

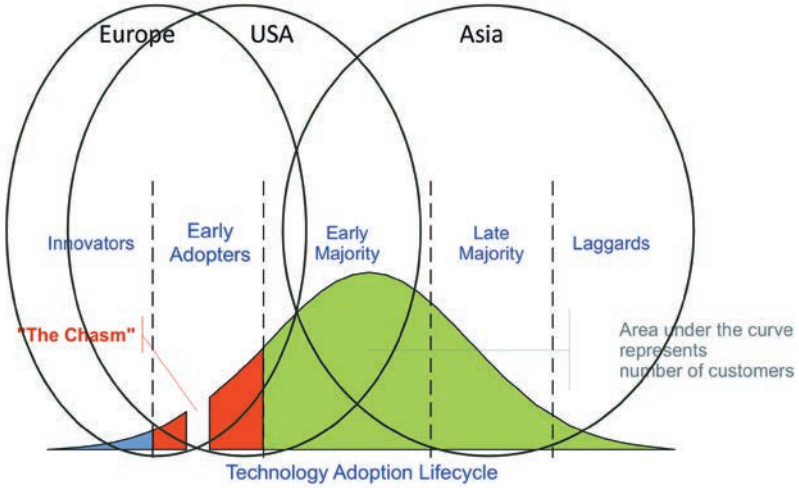
Imbalance of supply and demand: As Figure 1 shows, exits for investors in startups (increasingly through M&A of late) have been relatively steady at around 45 per annum. However, the number of businesses receiving early stage venture capital has plummeted. The resulting imbalance between supply and demand is greatly in favour of any technology startup seeking partnerships and potential M&A – a great opportunity for new "knowledge" enterprise.

Appetite for innovation: The West is intellectually rich. Manufacturing and fulfilment has increasingly headed East and consolidated around global efficiencies of scale. Figure 2 reflects this difference in emphasis. In addition to classic startup models, this is a great time to be building new enterprise exploiting



Sources: VentureSource, GSA, Pagemill Partners

Figure 1: Number of exits for startups vs initial venture funding deals



Source: Infinitedge LLC

Figure 2: Technology adoption emphasis worldwide

specialist know-how and intellectual property. Business models that address this, and which are discussed later, supplement more traditional enterprise and are very much in keeping with the UK's knowledge-economy initiatives.

THIS IS A GREAT TIME TO BE BUILDING NEW ENTERPRISE EXPLOITING SPECIALIST KNOW-HOW AND INTELLECTUAL PROPERTY

Market tsunami: The Internet of Things (IoT) is an attempt to articulate an anticipated vast assembly of new devices and new technologies, with 50 billion things connected to other things by 2020 – all delivering new features, products, and commercial opportunities. This has already spawned startups (Neul, Blu Wireless) acquisitions (Sensinode, Teridian, Icera) and delivered new business strategies (ARM). IoT should be rich pickings for the knowledge-economy, and conveniently is a handle that government can grab hold of. Our industry should make sure it does.

CHANGING INVESTMENT ARENA

Semiconductor startup funding models are increasingly strained. The classic VC investment model sought a 10x return on investment over 5 years, and studies have shown that the average return for

Summary by Exit Type	Number of Companies	Venture Investment		Exit Value	
		$	% of Total	$	Multiple (x)
($USD, millions)					
IPO Exits	30	$2,114.8	12%	$7,447.5	3.52x
M&A Exits	362	$13,645.9	75%	$15,081.9	1.11x
Bankruptcy Filing / Out of Business	95	$2,446.9	13%	$237.5	0.10x
Total	**487**	**$18,207.5**	**100%**	**$22,766.9**	**1.25x**

Source: Pagemill Partners

Table 1: Returns on Investment in the last decade for semiconductor startups

semiconductor companies exiting over the last decade has been a healthy 1.2x as shown in Table 1. Sadly two malign factors conspire to break this model:

(1) exit values are nowhere near the hundreds of millions of dollars of the 90's and noughties, the last-decade average being $46 million according to Pagemill Partners.

(2) costs of building semiconductors are exponentially rising (with a few specialist analog exceptions) and are virtually prohibitive. A chip startup in 2000 could get to market producing qualified silicon product with $5 million-$20 million. Today it is not uncommon for a company to need $40 million-$100 million. A chip mask-set alone can cost millions.

On top of this, there is a funding problem. While there are early stage institutional investors who – laudably – still seed and fund startups, the VC community has recently shown reduced appetite for sizeable A- and B-Series investments. There is a black hole of funding just at the point that a company is able to start demonstrating its value. Figure 1 starkly illustrates this. Part of the reason is the lack of availability of debt capital from banks to mature businesses, which opens up a very attractive lower-risk home for equity investments. Until the banks fully re-embrace lending again, it is hard to see appetite amongst VC's for the riskier targets. This is a simplification of reality, of course, but there is a widely acknowledged dearth of investment that is needed to cultivate growth enterprise.

This state of affairs favours the IP-based or "chipless" business model, where a business can address a key subset of an end product, scale down costs and offer a compelling investment proposition – much as the fabless model did at the end of the last century.

FUNDING AND EXPLOITING THE CHIPLESS MODEL

Investment bankers Infinitedge assess that enterprise value expressed as a multiple of revenue for specialist wireless chip startups might touch 3x, and for analog/mixed-signal companies 2.1x, but that similar figures for Semiconductor IP may be 6.1x or more. They also assess that market indices for IP vastly outperforms those for more traditional semiconductor-related businesses (see Figure 3), fuelled by the explosive growth in handheld devices and associated chipsets.

This promises a compelling ROI model for business founders, and one that is well suited to the knowledge-economy.

By definition, chipless is lean. So the model may have renewed appeal to traditional

Source: Infinitedge LLC

Figure 3: Custom market growth indices for semiconductor industry sectors

investors, such as angel networks, regional investors, venture capital and others. Of course the very nature of the model presumes that such a company's deliverables will have direct appeal to a third party. This makes it highly suited to corporate venturing.

Corporate venturing goes beyond arms-length strategic investment by VC arms of a large corporate. A chipless company with a well-positioned technology can attract investment from corporate product divisions as a low-cost R&D initiative. Such investments might buy equity and might form the start of a spin-in where (once de-risked, the R&D is re-absorbed at a premium) or might be in the form of purchase of rights over IP. The key thing is involvement of strategic investment early on. Infinitedge and Silicon Ventures both champion such models.

An interesting supplement (even alternative) is crowd funding, and this is now being adopted by the semiconductor industry. Adapteva and

CORPORATE VENTURING GOES BEYOND ARMS-LENGTH STRATEGIC INVESTMENT BY VC ARMS OF A LARGE CORPORATE

Micropower Global in the US and Red Pitaya in Slovenia have all launched KickStarter campaigns, Adapteva successfully raising $810 thousand for a product development. Crowd funding has the added benefit of raising the profile of the semiconductor industry via social media. Not a bad thing – right now the UK semiconductor industry's massive contribution to the iPhone is a well-kept secret!

A lean chipless company can survive much longer on a smaller investment. It does not need to invest in costly overheads, and can focus on that all-important metric: time-to-money. Given that "time" is less expensive, this means good ROI. Time can be spent building customer relationships, honing know-how, identifying the best market focus for a technology – exactly what a university spin-out tends to seek.

THE UK SEMICONDUCTOR STARTUP IS DEAD – LONG LIVE THE UK SEMICONDUCTOR STARTUP

So where next? It is clear that classic models for startups are under strain and may even be broken. However that is not the same as saying the industry is broken. Supply and demand for innovation is tilting in favour of startups. New models for business and for investment are starting to emerge, and these models are set to mature and become more prominent.

Chipless businesses with an IP focus are all about harnessing the value of knowledge. With experienced entrepreneurs on board – and the UK has many – these can be affordable commercial vehicles for innovation. They can deliver return to founders and investors, and present to a rich selection of external R&D for potential M&A customers. Alternatively they can be developed into strong global organisations in their own right, as demonstrated by ARM and Imagination Technologies.

The knowledge-based startup model has lots of precedent in the UK. To some it represents a historic failure to fully develop a UK semiconductor industry, but it may be a link to future opportunity if – as some attest – true future value is in ideas rather than physical products. The term applies to any fabless semiconductor company that chooses to extract value from its product development through know-how and industry relationships rather than volume production through foundry. Arguably the likes of Element 14, Microcosm, Alphamosaic, Nanotech, Jennic, IRT, Gigle and Icera all meet this criterion, even if that was not the original intent. Given the track record of these companies, it is true to say that the UK is rich in experience of exploiting the model, and new companies such as Blu Wireless are setting up with that express intent.

The internet (and associated social and professional media networks) is starting to provide new open models of investment, harnessing popular awareness and recognition of innovation. In addition, strategic investment such as corporate venturing provides for huge scope for "open innovation" where R&D risk and cost are spread; out of this, acquirers can survey and mine seams of maturing innovation. Both of these can help mitigate the risk burden felt by wary institutional investors today.

In our diverse industry, such models might just provide an alternative framework to re-energise startups, that at once suits established corporate interests, provides incentive for founders and aligns with national government initiatives to harvest its own extensive investment in R&D.

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A 1985 BSc Hons graduate of the University of Edinburgh, Ian started professional life at Philips Research, is author of 17 technical publications – two winning institutional awards, and 8 patents on analog IC and systems design. He has a keen interest in technology enterprise. For fun he flies microlights. **ian@ieee.org**
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Henry has over 28 years experience in business, R&D and operational management roles – bringing to market innovative high volume consumer products on aggressive technology nodes.

Henry started his career in memory design at Mitsubishi Semiconductor's Japanese R&D site and on return to the UK spent 4 years managing its applications support team in the UK sales office. He joined INMOS (later acquired by STMicroelectronics) as manager of the process NPI team, and after bringing multiple SoC designs to high volume production in product engineering and design management roles, he was appointed as STM's DVD & MediaCenter business unit director. When he left STMicroelectronics in May 2011 he was the technical marketing director of the Connected Home division.

Henry holds a degree in engineering from Cambridge University.

Dr Gordon Mizner
CEO Engineering Development Trust (EDT)

THE ELECTRONICS INDUSTRY MUST REACH OUT TO FUTURE RECRUITS

Urgent action is needed by companies if UK manufacturing, including the electronics sector, is to avoid a critical shortage of skilled labour in coming years. While the development of skills is certainly an area for education structure, policy and curriculum it has also been recognised by NMI that companies must engage with education to avert the problem and NMI has taken the lead in developing through UKESF a number of key initiatives supported by leading educational charity EDT.

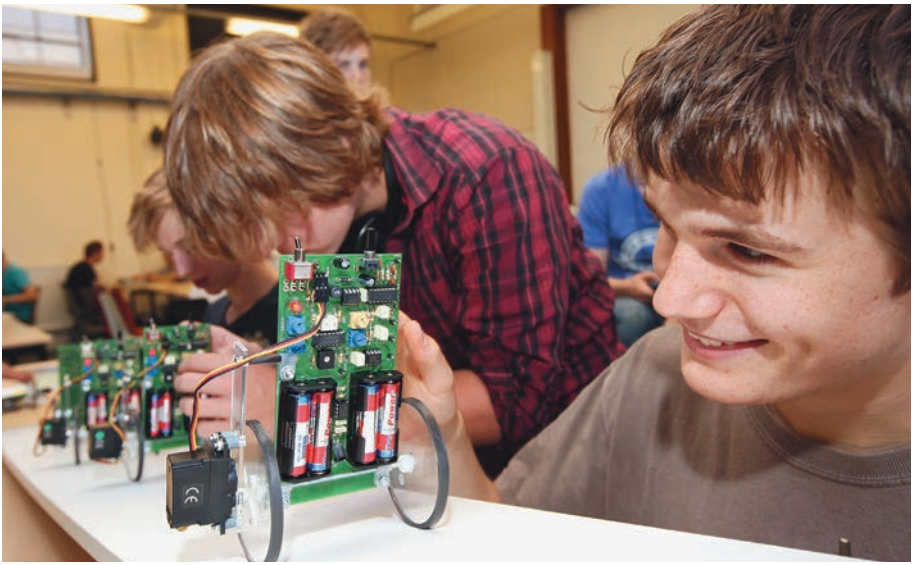
It is only by tackling some of the key issues of information and perceptions at school level that students will be attracted into the industries which will need them at all levels in coming years.

THE PROBLEM

After years of focusing on services, and in particular financial services, for economic growth the UK growth agenda is once again focused on manufacturing as an engine for development. While the UK has lost much manufacturing capacity over the years, it remains a significant global player, and importantly remains highly innovative, hosting many of the world's leading companies and operating at the high value end of the manufacturing spectrum.

However, just as the sector sees the opportunity for expansion, a significant problem has been developing which threatens to stunt the growth that is possible. There is a current and growing skills shortage, particularly focused towards science, technology, engineering and maths (STEM) disciplines and this shortage is accentuated by demographic issues at both ends of the spectrum. Many manufacturing companies have an employee age profile which sees a bulge in numbers nearing retirement in the next decade. At the same time there is a decline in the number of 18 year olds which will bottom out and start to rise again in around 8 years but at the present the numbers are in decline. This means that at the very time retiring staff need replacing the raw material for that replacement is in short supply, and this is even before any required growth in numbers is considered.

Various studies have underlined this need. In September 2012 the Royal Academy of Engineering Jobs and Growth Report showed that demand for STEM graduates and technicians outstrips supply. The Academy estimates that there will be 1.28 million new science, engineering and technology graduates and technicians needed by 2020. Similarly a 2013 Social Market Foundation report puts the



current shortfall of STEM graduates at an alarming 40,000 per year.

WHY AREN'T STUDENTS LINING UP FOR MANUFACTURING CAREERS?

So the demand is high, why is supply not responding?

There are various issues that companies must take a role in tackling. The first issue is one of perception. Science, engineering and technology all have popular stereotypes that damage aspirations to join these sectors. Scientists are mad, wear glasses and have wild hair. Engineers work in garages and have dirty hands and faces. Technologists are geeks with no social skills. All these adverse images lead to children aspiring to careers which are perceived as more attractive and which have positive images in the popular media; sportsperson, news presenter, media industry, actor, entertainer, lawyer, doctor etc.

SCIENCE, ENGINEERING AND TECHNOLOGY ALL HAVE POPULAR STEREOTYPES THAT DAMAGE ASPIRATIONS TO JOIN THESE SECTORS

Another issue is disengagement between communities and local industry. Very often within the communities in which many manufacturing industries operate there is a lack of awareness amongst young people and their families of the local companies,

the available job opportunities and of the routes to attain these. Most companies need to recruit from their locality as job mobility can be poor. This is certainly true for non-graduate jobs but also, to an extent, for graduates in their first jobs. In order to raise aspirations for careers in these local industries, awareness and employability skills need to be developed through contact between industry and schools and the wider community.

Finally, manufacturing industry is still failing to attract new talent from groups and backgrounds which have previously been under represented. A clear example is girls which still have only a 7% representation within the engineering population. There are variations by specific disciplines with girls more attracted by the subjects that are perceived as "making a better world" such as biomedical engineering. Perhaps this offers some insight into how we need to address the opportunities for girls in the traditional disciplines such as mechanical, electrical, electronics, not to mention ICT where the shortage of girls is chronic and getting worse.

HOW TACKLING THESE ISSUES CAN COMBAT THE SKILLS SHORTAGE

The issues outlined above can be tackled to a significant extent by building links between schools and local industry. Evidence from the Education and Employers Taskforce and others indicates that supplemental activities such as visits, access to role models and real-world project work, mentored by engineers and scientists, can make a significant difference to the young person's aspirations and help them make more informed decisions.

EDT, an independent education charity, is the UK's leading expert in building such links and has been working with UKESF for the past three years to make inroads towards changing attitudes among children at school.

EDT runs six main schemes tackling different age groups and providing different experience options for students and companies to engage with. All the programmes focus on four main areas:

- Skills development – equipping young people with skills that are valued by business and the confidence to achieve in STEM and flourish in a range of STEM careers.
- Careers awareness – enabling young people to understand sector opportunities and make informed decisions about STEM learning and work pathways to which they can aspire.
- Curriculum impact – delivering experiences, projects and placements that provide context and relevance to STEM learning.
- Teacher CPD – involving teachers in programme design and delivery to improve their awareness and application of project learning back to the classroom.

Every year EDT provides taster activities, projects and placements which connect industry, education and young people. EDT raises aspirations and provides informed choice for over 25,000 11-21 year olds. Programmes run by EDT range from half day visits to local industry with a format linked to curriculum needs, to 6 month project work linked with a local company for sixth form students with mentoring provided by the company. A key element to most of the programmes is to provide project work that allows secondary school students to see the application of STEM subjects to real problems and issues. Research indicates that pupils at primary school are enthused by science and making things with their hands. However, for many, by the time they get to secondary school they lose this enthusiasm, often because there is no context or understanding of why they are studying the science and maths subjects and how they apply to life. The extra-curricular STEM projects that EDT provides enable enthusiasm to be reignited by seeing the application of science and maths in a real world environment under the guidance of role models working in local industry.

THE PARTNERSHIP BETWEEN EDT AND UKESF

The Engineering Development Trust (EDT) has been working in partnership with NMI through the UKESF to promote electronic engineering to young people. The partnership began 3 years ago and has focused on two projects – an annual Headstart UKESF Electronics university summer school for 17 year olds and an electronics Go4SET school project for 14 year olds.

A KEY ELEMENT IS TO PROVIDE PROJECT WORK THAT ALLOWS SECONDARY SCHOOL STUDENTS TO SEE THE APPLICATION OF STEM SUBJECTS TO REAL PROBLEMS AND ISSUES

The Headstart programme allows those in year 12 (S5 in Scotland) to spend up to a week at a UK university prior to making their UCAS application. The young people can make well informed important degree and university choices based on real experience because they:

- Participate in practical problem solving activities.
- Attend lectures and seminars.
- Visit local companies.
- Experience life as an undergraduate.
- Meet academics, post graduates and young professionals.

UKESF Electronics Headstart courses have so far taken place at Bristol and Cardiff universities as well as Imperial College and are planned at Southampton and Edinburgh. Evaluation demonstrates the impact of the Headstart courses on these students' careers with some 86% eventually giving engineering or science based roles as their first job destination.

The Go4Set activity is aimed to catch students earlier in their school careers, linking teams of six Year 8/9 (S2 in Scotland) students with companies to offer a 10 week STEM investigation. The UKESF Go4SET projects are themed around "Our Electronics Environment" with students exploring the development of electronic/electrical devices of the past, interviewing staff about their use of electronics and finally designing and building a device (or model) that will help a member of the school staff with a particular problem.

This is an innovative and ambitious project for pupils of mixed abilities, from widely different backgrounds and with little previous experience of electronics. However, with the support of mentors from industry the teams produce some excellent ideas and projects which invariably impress the industry assessors to whom they present at end of project celebration events.

The UKESF Go4SET programme has been trialled with ten teams in Bristol linked with mentors from ST Microelectronics, Dialog Semiconductors, Imagination Technologies, Semtech, Horstmann Controls, RS Components/ University Bristol, RWE nPower and Intel Corporation. 54% of the students have been girls. The successful pilot will now be developed across the UK.

WIDER AND STRONGER

As yet the numbers which have been engaged in these pilots remain small and there is a need for rapid acceleration in the efforts to engage students with electronics and other manufacturing careers. There is a need for companies large and small to engage with the process of ensuring the skills of their future workforce by a wider and stronger network of business/education links. Undoubtedly there is a cost in doing this, the direct costs of administrating the programmes and the indirect costs of the engagement of staff in mentoring and presenting to students, albeit that many companies view the latter as an investment in the development of their own people. However, what no electronics or manufacturing company can afford is to be sitting on its hands while its potential future workforce wanders off to pursue subject studies which will leave them unsuitable for employment in local industry.

EDT and UKESF welcome approaches from companies to explore how they can engage in this work. There is considerable flexibility in the options that are available and programmes can be moulded to fit with most company's interests and needs. Doing nothing is not a viable option for the future of UK industry.

ABOUT THE AUTHOR

Dr Gordon Mizner, CEO Engineering Development Trust (EDT):
Gordon studied Aeronautical Engineering at London University. He spent nearly 30 years working for the Royal Dutch Shell group of companies in a variety of functions including research, product management relating to renewable and conventional fuels and lubricants, and latterly general management in the UK, South Africa, Indian Ocean and Africa. Returning to London in 2002 he became Vice President – Commercial Fuels & Bitumen in Shell International Petroleum Co.

In September 2005 Gordon joined the EDT as Chief Executive.

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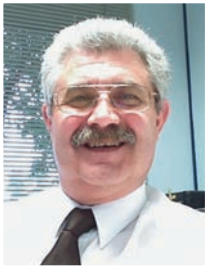
Steve East
STMicroelectronics

BENEFITS AND CHALLENGES OF EU R&D ENGAGEMENT



As part of our support for R&D activities within the NMI community, we help provide companies with the know-how to make business decisions on participating in publicly-funded R&D programmes. There are a broad range of Regional, UK and European programmes and funds available, but there can be a tendency, by companies unfamiliar with these schemes, to 'chase the money' rather than think about the strategic business reasons for participation. The decision to participate can boil down to two questions: (1) Does the project align with my company's strategic business goals? and (2) Does the project align with what the funding agency wants to see? Answer those two questions honestly, and you will have a better chance of success.

FUNDING VARIES BY INSTITUTION AND RANGES FROM 100% FOR ACADEMICS THROUGH TO 60% (OR MORE) FOR SMES AND 50% FOR LARGER ENTERPRISES

SOME OF THE biggest and most ambitious projects are developed through the European Commission Framework Programmes. FP7 was a 7-year €50 billion programme that has just finished, but its 7-year €70 billion successor Horizon 2020 (H2020) is just beginning. Several NMI members have successfully participated in Framework, often because the critical mass and market reach possible at the European level is more appropriate in the Electronics Systems space. To give you an idea of what it is like to participate, we have asked Steve East from ST Microelectronics to share his experiences.

I have held various roles within STMicroelectronics since 1985 and I moved to Edinburgh, where the company has an established R&D centre for its Imaging Division, in 2003. Four years earlier ST had acquired a highly successful University of Edinburgh start up, called VLSI Vision, a small company specialising in CMOS imaging technology. This was an exciting period of evolution for ST's imaging division. The race to provide the best miniature camera solutions for the exploding mobile phone market was on and STMicroelectronics was well placed to become an established leader in the field. Today ST's imaging division is a successful key player in this highly competitive volume market. Notably, though, the technologies ST has developed for mobile imaging provide good platforms for further developments aimed at broadening our addressable markets in other fields of photonics.

However, we don't always know what tomorrow's products will be. We know that yesterday's RTD provides the enablers we need for today's products, we know that today's RTD will provide the enablers we need for tomorrow's products and we know that without exploitable results from today's RTD we might struggle to have advanced products tomorrow. So we know that an RTD strategy is key to long term sustainability in a highly competitive global scenario but how do we mitigate the risks? One position is to put the main internal focus onto comparatively low risk RTD that we know is needed for our core products. Given that not all the RTD we'd like to do can be carried out internally, we can engage in higher risk innovation collaboratively, sharing the risks (and, of course, the benefits) with partners in a mutually acceptable arrangement.

This is precisely where engaging in funded collaborations can provide the answer. It provides access to skills and competences we may not have. It provides access to resources ensuring critical mass is reached. It provides expertise in applications which are outside of

today's core business, overlapping our strengths with customer strengths. It stimulates the propagation of know-how through collaborative knowledge building, sharing and acquisition and increases creativity and innovative ideas. These all combine with the funding itself to mitigate risk while increasing the chances of a positive impact on our bottom line through the creation of exploitable results. ST was interested in the field of single photon detection, a popular area of research in Europe, but with most of our resources committed to mobile imaging applications how would we adequately resource such work? An EU funded collaborative approach seemed to provide the answer, but could we make it work for us? We decided to try.

A number of research grants have become available to EU member states (and some other countries which have opted to join the European Research Area) under the European Framework Programme for Research and Technical Development. Future grants will be awarded under a programme called Horizon 2020, which has some differences but essentially serves the same purpose. The objective of these grants is to help fund RTD collaborations within the ERA, securing Europe's global competitiveness for the future. These grants essentially enable high risk innovation projects that might otherwise not happen by helping to mitigate risk for commercial companies and supporting academic institution involvement. The amount of funding varies by institution and ranges from 100% for academics through to 60% (or more) for SMEs and 50% for larger enterprises.
The funding purpose is to support worthwhile projects, bringing together consortium partners with different skills and attributes to achieve a common goal. This was very interesting for ST because, in return for providing access to our CIS foundry process, expertise in both the appropriate areas of technology research and the applications of interest would be contributed by other consortium members.

We had no previous experience of engaging in Framework Programmes so we asked Scotland Europa, an organisation which promotes the engagement of Scottish institutions across Europe, to help us get started. The first thing Scotland Europa did was to put us in touch with training organisations. Anyone with any knowledge of how the European Commission works will not be surprised to hear that the processes to be followed in building consortia, submitting project proposals, dealing with funding rules, negotiations and periodic reporting are all subject to fairly rigid rules and procedures. The training was invaluable in getting us on the right track from the outset. Normally the next step would have been for us to write a brief description of the project we wanted to undertake and then actively seek partners across Europe. This is something Scotland Europa or networking organisations can help with, whether it is promoting directly through co-operation profiling bulletins or through specific partnering events.

In this case, however, we were approached by parties who had heard of our interest in few-photon detection research and who had already identified an appropriate FP6 FET (Future and Emerging Technologies) Open call. After an initial investigation which revealed that this was a serious potential partner with a good track record we opened a dialogue to discuss the project outline and the way forward.
There were a number of things to establish. We had to be sure that the proposed consortium members were complementary, each having their own area of research expertise which would contribute to the project results. We had to be sure that all partners had a genuine interest and motivation to deliver and

WE HAD TO BE SURE THAT ALL PARTNERS HAD A GENUINE INTEREST AND MOTIVATION TO DELIVER AND THAT THERE WERE NO PARTNERS WHO WERE ENGAGING PURELY FOR FINANCIAL REASONS

that there were no partners who were engaging purely for financial reasons (this happens and spells disaster). Importantly for ST we also needed to be sure that there was complete alignment and understanding between all partners on the business model for exploiting the results. This is key for any consortium, it is pointless to develop IP only to find that it cannot be ultimately commercially exploited to due to unrealistic access conditions. Finally all partners were happy to move forward, so we began to write our proposal.

The proposal writing task itself should not be underestimated, but often is. The proposal needs to clearly show a description of the work and the reasons for doing it, comparing expected results with the current state of the art. The commission do provide templates which help with the document's construction, but in addition to the project work it is very important to address all of the relevant points highlighted in the funding call itself and in the commission's SRA (strategic research agenda). To this end the authors and editors must be familiar with both documents. The proposal will be assessed by a number of experts against a list of criteria provided by the commission. All of the proposals submitted in the same call will be assessed and then arranged in a list ranked by score, so it is important to score highly in each assessment criteria category. The amount of funding requested by each project is known, so when the accumulative total of the ranked projects exceeds the total available a line is drawn. Projects above the line are invited to negotiate a grant agreement. There are two pieces of significant advice I would give when writing a proposal. The first would be to employ an experienced project manager, with a track record, who knows how to manage the partitioning of the work and can ensure the quality of the proposal. The second would be to get a second opinion from a consultant or similar who can proof read the proposal and execute a dummy assessment. Such consultants can be recommended by regional development agencies such as Scotland Europa or by trade associations such as the NMI.

Our first point of engagement in 2002 started a line of collaborative projects within Framework that has helped to progress our RTD activities and our business direction. A brief summary of our projects is:

MEGAFRAME: A STREP (a relatively small collaborative project in Framework terms) which was approved under an FP6 Future Emerging Technologies call and was launched in June 2006, running until April 2010. It was a 5-partner project (all carefully chosen) that received a €1.85 million grant to develop a million frame per second photon counting camera. Initial progress was slow because it took time to establish a sound consortium

agreement – it is never too early to work on that. Once the project was up and running, we produced three generations of working silicon, starting from a 32x32 array, eventually producing images from a 160x128 proof of concept chip. Two patents were also filed as a result of the project.

An important aspect of a successful RTD projects is that results can either spawn specific product directly, or develop ideas that can be exploited in aspects and features of next generation products. In MEGAFRAME, the project results contributed towards the next generation product design of the 'FlightSense' family, the first product of which was announced at the 2013 Mobile World Congress in Barcelona. Aspects and applications developed as a result of the project include a proximity detector that uses photon Time-Of-Flight technology and power management for mobile phones where we can shut down functions that are not needed when a phone is 'at ear'.

SPADNET: Building on this success, we used the core consortium of MEGAFRAME minus one (a 'publishing-only' partner) to act as the core of a 9-member STREP proposal into Call 5 of FP7. The new consortium included a commercial partner in the application domain, which helps ensure good business impact from the project. SPADNET entails developing a scalable network of SPAD-based sensors for SiPM applications. The project also involves the development of a proof-of-concept demonstrator module for Positive Emission Tomography. The SPADNET proposal received maximum marks (15/15!) which in part reflects the good reputation of the consortium in being able to deliver through the success of MEGAFRAME.

So what are the other main leanings we have gained from the experience of these projects? Firstly, participation solely for financial reasons does not work and should be avoided at all costs.

From a business perspective, it was through always being very focussed that the work we carried out in the project aligned with what we wanted to do as a business. The discipline of writing a good and realistic proposal benefitted us as much as it did help get a good score: Priorities, challenges, outcomes and expected impact were worked out in detail. By taking sound advice from the likes of the Commission, the National Contact Point, we tailored a good proposal and developed stakeholder relationships that helped as the project was being delivered. We could develop good market exploitation potential through market intelligence, developing a demonstrator and building a strong 'well oiled' consortium that was focused on business goals rather than publications.

Looking ahead, Horizon 2020 holds opportunity for us as we seek to develop new products and plans. I would recommend that other companies in the Electronics Systems

PARTICIPATION SOLELY FOR FINANCIAL REASONS DOES NOT WORK AND SHOULD BE AVOIDED AT ALL COSTS

space consider this as a potential R&D route but with some very strong words of caution:

Be realistic; don't do it for the money – do it for the business benefit; carefully choose which opportunity to apply for and use resources such as the NCP and NMI to help you do it – the options are many; carefully select your partners involving those and only those that will help the project achieve its goals; get a good project manager, work hard at partnering and plan your budget and resources for the project carefully.

Tangible business benefit and growth is the prize.

ABOUT THE AUTHOR

Steve East, STMicroelectronics: Steve East began his career with STMicroelectronics in 1985 when he was recruited as part of a task force to launch a new ASIC design centre for the company. After a spell working for ST in Grenoble, Steve moved to the Imaging Division's Edinburgh site in 2003. Since 2005 Steve has been managing future and emerging technology development programs with an academic and collaborative focus.

Prof Jon Holt
Atego Systems

ADOPTING MODEL-BASED SYSTEMS ENGINEERING – I KNOW AN OLD LADY

INTRODUCTION TO MODEL-BASED SYSTEMS ENGINEERING (MBSE)

The world of engineering faces increasing challenges as the systems that we produce become ever more complex and sophisticated. It is no longer good enough to think of the engineering of a system as a collection of disciplines, each of which delivers their individual system components that are then integrated. As the system becomes more complex so the need for increased joined-up thinking increases as these traditional engineering silos become so closely related as to become, in some cases, indistinct. Consider a modern day system, such as a car, aeroplane or medical system and think about the impact of, for example, software on each. Can any of these systems function without its associated software? Can the software be seen as a separate component of the system that can be integrated after all other systems have been developed?

AS THE NEED FOR a more comprehensive approach to developing such complex systems increases, so the case for 'systems engineering' becomes more relevant. Systems engineering is a multi-disciplinary and cross-industry approach to delivering successful systems.

In order to understand and communicate different views of the system to relevant stakeholders, then powerful strategies are required to identify and manage the complexity. One such approach involves the use of modelling the systems. In model-based systems engineering (MBSE) the model lies at the heart of the definition, deployment and execution of this approach.

In order to sell MBSE into an organisation it is crucial that the benefits of such an approach can be clearly defined. However, depending on the stakeholder within the organisation, these

SYSTEMS ENGINEERING IS A MULTI-DISCIPLINARY AND CROSS-INDUSTRY APPROACH TO DELIVERING SUCCESSFUL SYSTEMS

benefits will differ. Also, implementing MBSE in a real organisation is far easier said than done and requires the successful realisation of people, process and tools.

BENEFITS OF MBSE

A key part of any MBSE endeavour is to consider the system from different points of view or, to put it another way, to consider different contexts. The idea is that the system will potentially look different depending on the context from which it is viewed, whether we are considering the requirements, analysis, design, or indeed, any other aspect of the system. In fact, when considering the benefits of adopting MBSE they must also be looked at from a number of these points of view, or contexts. One way to identify these contexts is to identify a number of stakeholders. We define a stakeholder here as the role of any person, organisation or thing that has an interest in our system. In this instance, our system may be thought of as the adoption of MBSE in an organisation.

Figure 1 shows that a 'Stakeholder' must realise one or more 'Benefit' from the system. A number of different types of Stakeholder (represented by the triangle symbol) are shown, each of which will, potentially, realise a number of different benefits from the adoption of MBSE. The benefits for each of these stakeholders will now be discussed, using the example of a car:

- The 'User' of a car will be the driver and passengers. Benefits for the User will include improved reliability, increased availability of the car, improved safety and security. It should be noted that the Users may actually be unaware of such benefits as nobody notices the absence of faults (resulting from the benefits), but everyone remembers when things go wrong!
- The 'Operator' of the car will be the maintainers, repairers, etc. The benefits here will be mainly concerned with improved understanding through better documentation, traceability, etc and more lucid procedures for the maintenance and repair of the car.
- The 'System Sponsor' will be whoever spends money on the car. The main benefits here will be better, more usable features that represent value for money of the car.
- The 'Standard' will represent all the appropriate standards, legislation, etc that

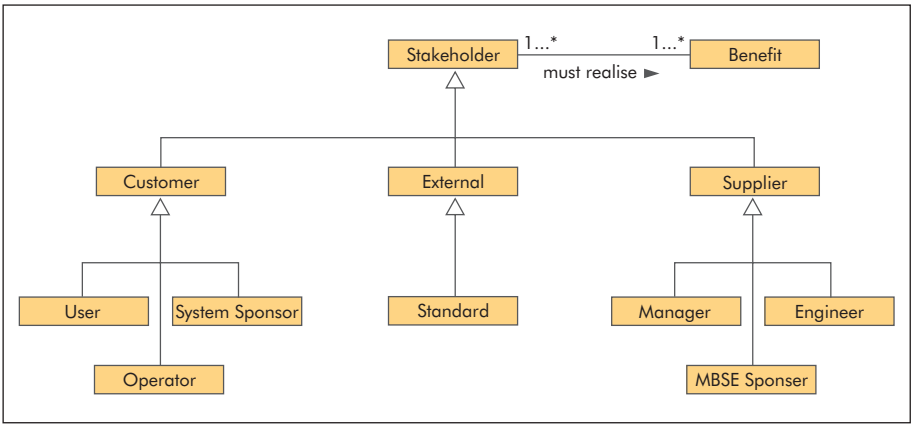


Figure 1: Typical organisational stakeholder roles

applies to the car. The adoption of MBSE will result in being able to demonstrate better compliance with all relevant standards.

- The 'Manager' will be whoever is responsible for developing the car. The main benefits here will be being able to deliver the project on time and within budget and to improve the project delivery in terms of saving time, resource and hence money.
- The 'Engineer' stakeholder represents the role of the people who develop the car. The benefits here will include improving consistency of information (requirements, specifications, design, etc), improved automation (for testing, model checking, artefact generation, etc) and, hence improved tool interoperability. All of these will improve the general approach and make it more efficient.
- Finally, the 'MBSE Sponsor' represents the role of the person or organisation who invests in MBSE in the first place. The main benefit here is to increase the value of the business by increasing quality of the system and hence sales. These will all combine to provide a return on investment (ROI) for the investment on MBSE.

The overall benefit of MBSE is the aggregate of each of the stakeholder-based benefits discussed here and so it is important that the relationships between these benefits can be identified and analysed – this can be achieved by modelling. For example, to demonstrate ROI for the MBSE Sponsor, then it will be necessary to realise the benefits of the Manager and the Engineer. Therefore, when trying to sell or justify MBSE, it is essential to identify the stakeholder and, therefore, the context of whoever you are trying to sell it to in order to make the best business case. A different approach in terms of management tactics and delivery solutions may be required for each stakeholder, and this must be borne in mind when making the sales pitch for MBSE.

THERE ARE THREE BASIC ASPECTS THAT MUST BE CONSIDERED FOR MBSE TO BE SUCCESSFULLY REALISED – PEOPLE, PROCESS AND TOOLS

REALISING MBSE – I KNOW AN OLD LADY

One of the main themes presented in this article for the successful implementation of MBSE is undoubtedly the need to know 'why'. Unfortunately, too many attempts at MBSE either fail or deliver no benefits (fail) as the original needs were not known in the first place. In order to know whether one has achieved what one has set out to achieve, it is essential to understand these needs and the benefits discussed above are a good start point for this exercise. Once these needs are understood, there are three basic aspects that must be considered for MBSE to be successfully realised – people, process and tools.

Figure 2 shows the three essential aspects for realising MBSE successfully:

- The 'Person', by which we mean competent people with the right skills for their roles.
- The 'Process' by which refers to the basic approach that is followed, such as methodology, process, framework, etc.

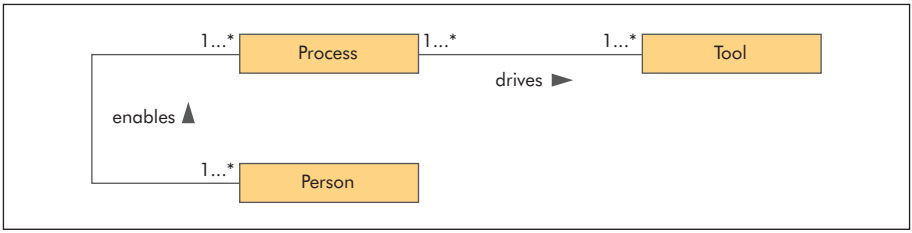


Figure 2: Three essential aspects for realising MBSE successfully

- The 'Tool' by which we mean notations, software-based modelling tools, etc.

By not understanding why and just blundering ahead blindly, the risk of failure increases greatly and no amount of MBSE will save you if the basic need is not understood. A good example of this is the use of the Systems Modelling Language (SysML) that is an excellent technique for visualising different aspects of a system. However, the SysML is just a tool, has no inherent process and requires competent people to apply it effectively – realising only one or two of people, process or tools will undoubtedly lead to failure.

This is somewhat akin to the children's poem 'I know and old lady'.

'I know an old lady who swallowed a fly'. MBSE can be an excellent way to deliver successful systems but is essential to have the right people, process and tools in place to achieve this. However, in order for the people, processes and tools to be put into place, it is essential to understand the 'why'. This is rather like the old lady from the old nursery rhyme who swallowed a fly.

'I don't know why she swallowed a fly'. Why did the old lady swallow a fly? What was she trying to achieve? Unfortunately, we never find out. The old lady goes further and further through an ever-increasing array of solutions to a problem that is never defined. By not understanding why she swallowed the fly in the first place, all subsequent actions are doomed to failure. When we want to understand the 'why', we need to consider a few points, for example: why do you want MBSE, what will it be used for, and who will be using it? It is essential that the 'why' of MBSE is considered and by this we really mean carrying out a proper needs capture and analysis exercise, rather than just generating a wish-list. When engineering any type of system, the first step is always to get a good idea of exactly what the needs are for that system. Implementing MBSE should be treated like implementing any other system. Bear in mind that there will be many stakeholder roles interested in MBSE and each of them, potentially, has a different point of view on what benefits they want to realise from the MBSE activities and how they can be used. These different points of view will result in conflicts, common interest and overlapping needs, all of which must be resolved. It is essential that all pertinent stakeholder roles are identified and that an understanding of the 'why' for each stakeholder is arrived at.

Bearing this in mind, 'I know an old lady who swallowed a spider (that wriggled and jiggled about inside her)'. When confronted with a fly in the stomach, the temptation is to look for tried and tested approaches to fly removal, such as

JUST BECAUSE A PARTICULAR APPROACH TO MBSE WORKS FOR ONE ORGANISATION DOES NOT NECESSARILY MEAN THAT IT WILL WORK FOR ANOTHER

spiders, but is this suitable? When implementing MBSE, the temptation is to look for best-practice approaches that people have followed before and that have a number of success stories associated with them. Indeed, there are many best practice models such as standards, architecture frameworks, modelling notations, processes, methodologies, etc that are readily available. However, each of these must be tailored for any business and their suitability assessed. Just because a particular approach to MBSE works for one organisation does not necessarily mean that it will work for another – only when the context is the same will this be the case, therefore the needs for MBSE must be considered in an appropriate context before they can be assessed.

'I know an old lady who swallowed a bird/cat/dog'. Spiders in the stomach bring their own problems. There may be a clearly-understood and logical progression of eating slightly larger animals to solve the problem, but does the old lady actually understand the nature of her problem or, for that matter, her own physiology? Alongside the 'why' of MBSE, it is essential to be able to relate this to the system being developed. Key to this understanding is having a common understanding of the key terms and concepts that relate to the domain for which the architecture is being developed. Before we can realise people, process and tools, we need to talk a common language both in terms of the spoken language (such as SysML when modelling) and the domain-specific language (such as a domain-specific ontology that identifies and defines concepts and terms associated with a particular area).

'I know an old lady who swallowed a goat/cow'. Goats are renowned for eating anything – but would a goat eat a dog? Cows are herbivores, so the eating of goats is simply not consistent with a cow's normal behaviour. By focussing too much on identifying larger and larger mammals, is the old lady losing sight of her goals and losing touch with reality?

The visual manifestation of MBSE is through describing a number of views that make up the model. Views are actually very easy to generate, but there must be a reason why the views are needed. It is all too easy to generate a set of random views that are not contributing to meeting the underlying needs. Also, all these views must be consistent with one another or the result is a set of pictures rather than a true model.

'I know an old lady who swallowed a horse – She's dead of course!'.

CONCLUSIONS

There are a few key points that emerge from the discussion in this article:

- Understanding why – understand the fundamental needs for MBSE from different points of view by considering contexts. This applies when considering any aspect of the system, whether it is requirements or design, implementation or benefits. The first section of this article gave a good start point for considering the 'why' of MBSE.
- Speak a common language – understanding the terms and concepts is essential both in terms of the spoken language and the domain-specific language.
- A model consists of a number of Views. Each view must have a purpose – do you understand which of the needs that they are satisfying? Also, all views must be consistent – they must form part of a model and not be just a set of pictures.

People, process and tools are essential for realising MBSE, but bear in mind that each of these may bring its own problems. Simply applying more, or bigger, people, process and tools at a problem (fly, spider, bird, cat, dog, goat, cow and horse) is not the best approach.

It is all too easy to get this wrong and to end up with a house full of dead bodies, hay and horse dung.

ABOUT THE AUTHOR

Professor Jon Holt, Global Head of Systems Engineering for Atego: Professor Jon Holt is an internationally-published and recognised expert in the field of system engineering. His main area of interest is the application of systems modelling to all aspects of system engineering.

Jon is currently the Global Head of Systems Engineering for Atego and his areas of expertise include: UML and SysML for system engineering, process modelling, standards compliance, requirements engineering, life cycle modelling, enterprise architectures, architectural frameworks and competency assessment.

Jon has authored nine books covering the application of UML and SysML to systems engineering, process modelling, enterprise architectures and competency assessment.

Jon is a Professor of Systems Engineering at the UK Defence Academy, where he is involved with teaching and research and is also a Fellow of both the IET and the BCS and is a Chartered Engineer and Chartered IT Professional. He was recently elected as the Technical Director of INCOSE UK.

SIMPLY APPLYING MORE, OR BIGGER, PEOPLE, PROCESS AND TOOLS AT A PROBLEM IS NOT THE BEST APPROACH

THE CONNECTED CAR

The phrase "Connected Car" now means many things to many people; everything from live GPS/Telematics, streaming video across the internet, hands-free mobile telephone, to eCall, remote diagnostics and vehicle-to-vehicle (V2V) communications for collision avoidance for example – the number of connections and applications of those connections is endless.

THERE ARE MANY trials and demos around the world of various aspects across the Connected Car spectrum and some are more realistic than others. The myriad of connections and formats will slow down adoption and the rollout of the associated standards. The applications that are leading the way are the legislated ones using an established network (like eCall on GSM) and the ones where the business model is very clear (like multimedia applications – Ford Sync, GM OnStar, etc). The ones that are slowest to emerge into production vehicles will be the safety related ones, since there is the need for a valid, sustainable business model – who pays for the infrastructure and ongoing service?

The UK automotive industry is in a strong and exciting position to lead in all of the Electronic Systems required to enable these technologies and the AESIN[1] network launched in 2012 has created a home for the Electronic Systems community in the UK to work together in a common goal aligned with the UK Automotive Council strategy and related UK bodies.

FOOT NOTE (1) AESIN

The Automotive Electronic Systems Innovation Network (AESIN) [1] is a UK initiative focused on the accelerated and advanced delivery of Electronic Systems into the car and infrastructure. This requires new thinking and new forms of collaboration. AESIN was launched in 2012 by industry and NMI, the UK's electronic systems trade association. AESIN participants come from across the supply chain: from materials research to OEMs. They include: Jaguar Land Rover, McLaren Electronic Systems, Visteon, Plextek Consulting, Freescale Semiconductor, Mentor Graphics and Renesas Electronics Europe.

THE UK AUTOMOTIVE INDUSTRY IS IN A STRONG AND EXCITING POSITION

The automotive industry is in the midst of a revolution.

The market winners will be the automotive companies that engage in open innovation practices, developing new partnerships in a technology fuelled eco-system enabled by intelligent systems and connectivity.

AESIN (Automotive Electronic Systems Innovation Network) is at the heart of it – come join us:

www.aesin.org.uk

Lotus Evora 414

Jaguar Hybrid XJe

CONNECTING IT ALL UP

There are many definitions and applications of the Connected Car and these can be broken down and examined in more fundamental detail outlined in Figure 1.

When reviewing the list, two things become clear:

- The variation of bandwidth, latency & trust levels means that no single network protocol can cover all applications. 3G can cover most, except the safety related driver assist systems.
- Covering the whole list means the Car OEM needs to have a controlling interest in the Connected Car communication, beyond the simple public multimedia/eCall type applications that are available via smartphones. Given recent security alerts, they need to control access to the car network, and hence need to keep ownership of the overall communication path.

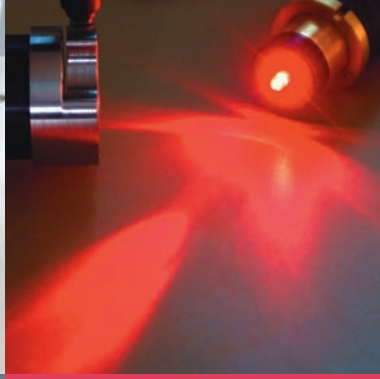
CONNECTED VEHICLE TECHNOLOGY HAS THE POTENTIAL TO ADDRESS 81% OF ALL UNIMPAIRED DRIVER-RELATED CRASHES

This end-to-end ownership by the car OEM opens up creative new business propositions with associated revenue stream, e.g. remote diagnostics for preventative maintenance, lower cost warranty programs, lower cost Insurance bundled at point-of-sale, pay-as-you-go horsepower, green driver rebate schemes etc.

Example Use Case	Benefits	Usage[1]	Bandwidth	Trust Level
Remote diagnostics connection	Driver, OEM	24/7 or "At home"	Medium	High
ECU software upgrade	OEM	"At home"	High	Highest
Electric vehicle battery status	Driver	24/7	Low	High
Driving style (for variable insurance premium rates)	Driver, society	24/7 or "At home"	Medium	High
Road usage fee/tolls	Driver	24/7	Medium	High
Entertainment download	Passenger	27/7 or "At home"	High	Basic internet security
Traffic information and map update	Driver	24/7	Medium	Basic internet security
Driver assist systems (collision avoidance)	Driver, society	24/7	Medium	High (but with<10ms guaranteed latency

Note 1: "24/7" means always on, realtime connection; "At home" means connected to home Wifi network when parking

Figure 1: Connected Car application parameters *(Courtesy of Freescale)*



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The safety use case for the Connected Car is a special example. "Connected vehicle technology has the potential to address 81% of all unimpaired driver-related crashes," according to Peter Appel, head of US DOT's Research and Innovative Technology Administration (RITA).

Vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) communication requires low latency (<10ms), low range (1km) and high security. Two-way Dedicated Short Range Communication (DRSC) has been designed to meet these requirements for V2V and V2I. Spectrum has been allocated to this at 5.9GHz, with the communications standard defined – Wireless Access in Vehicular Environments (WAVE) or IEEE802.11p.

There are several use cases behind DSRC – V2V communication to avoid a collision with an unsighted vehicle, V2I or V2V communication of local traffic conditions, e.g. a previous accident round the corner and the so-called "Bluewave", warning drivers of approaching emergency vehicles. With the limited range of DSRC you can imagine that the vehicles themselves act as a carrier, setting up ad-hoc mesh networks e.g. re-transmitting warning about an accident on the north bound motorway, as cars continue to travel south freely.

However, the big question with DSRC is "who will pay?" When the beneficiary is society, from reduced accidents, injuries and fatalities, it is difficult to generate a business model. The solution may lie in incentives from health or auto insurance companies, but will probably need legislative mandate, and government investment in infrastructure, to ensure this becomes a widespread reality. That investment will not be insignificant when you consider the range of DSRC (1km) and the amount of road in the UK (>400,000km), so clearly a targeted and phased approach will be necessary covering accident black spots and busy intersections first.
In addition, when looking at the average age of the vehicles in the UK (7.6 years) [2], we need to ask how long it will be until we have enough vehicles that can connect to V2V networks to start having an impact on the accident rates? Investing in that option on your new vehicle will take a leap of faith, or some government mandate, or perhaps some other financial incentive.

SECURITY AND INFRASTRUCTURE

It is arguable that all the technologies needed to implement Vehicle-to-everything communications (V2X) and such massive new levels of connectivity between people, their vehicles and the infrastructure around them,

WHEN THE BENEFICIARY IS SOCIETY, FROM REDUCED ACCIDENTS, INJURIES AND FATALITIES, IT IS DIFFICULT TO GENERATE A BUSINESS MODEL

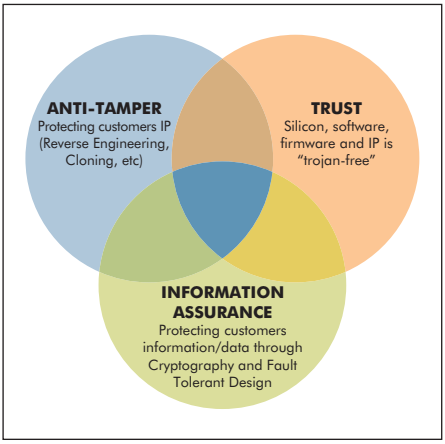

Figure 2: Primary Information Security Functions *(courtesy of Plextek Consulting)*

already exist. However, there are some fundamental challenges, already well understood by other industries, which the automotive sector must overcome, if delivering such extensive connectivity and interaction is ever to become commercial reality.

Firstly no-one, be it users, governing bodies or the insurance industry underwriting the risks, will be prepared to allow the use of these systems and networks unless they can be sure that personal data and physical safety are secured by rugged secure communications frameworks and standards. How sure can a driver be that the emergency data his car is stopping for in a hurry is guaranteed (by an industry standard) to be coming from the car in front and not a road-side hacker? Worse still maybe, what are the insurance liabilities when 'communication between multiple trucks in an automated convoy' is either broken or compromised? Does the Industry need to address all these issues and consider every possible 'corner case' before such systems will become acceptable?

With this thinking in mind it's clear that data security, standards and liabilities will be fundamental to any progress and only then will the next critical factor come into play – business cases.

Even given that a secure V2X network infrastructure exists, no individual or group of companies or organisations are likely to invest in rolling out new technologies and services without first identifying compelling business models to support them. These may be commercially driven business cases or government funded/directed initiatives. So for every element of the V2X M2M rollout, secure architectures as referred to in Figure 2 are needed. But who will provide the infrastructure? Even once the industry has defined the standards, who will invest in a complete new infrastructure to support V2X communications? Will any group take this on, or are the costs and risk so high that it will fall to the incumbent service provider infrastructure (e.g. the current cellular operators) to extend its capabilities to support it?

HOW SURE CAN A DRIVER BE THAT THE EMERGENCY DATA HIS CAR IS STOPPING FOR IN A HURRY IS GUARANTEED

As interest and expectations explode for these services and features, it's up to the industry to drive the solutions and it is a hugely timely opportunity for bodies such as NMI AESIN to take a leading role in pushing these forward to bring all the interested parties together.

CONCLUSION

There are many use cases proposed for the fully connected car, ranging from enhanced safety via collision avoidance to an improved driver/passenger experience by offering full internet connectivity for the on-board infotainment system. These multiple use cases have different requirements in terms of bandwidth, latency & security, so it is difficult to see how one single protocol can be the solution. While this presents many technical challenges, perhaps a bigger challenge is a commercial one – the question of "who pays?" for the service (and infrastructure) to achieve the enhanced safety. Finding a lasting solution will need collaboration between new and unnatural partners across the various parts of the vehicle supply chain, and beyond.

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Andrew Ashby, Plextek Consulting: Graduated in Electronic Engineering, Andrew Ashby has spent over 20 years in blue chip major semiconductor manufacturers in Field Applications, Account Management, Global Sales and Business Development roles. Since then he has held the sales director role in a Cambridge based technology start-up company and now heads up strategic accounts and new business development activities in the automotive sector for Cambridge based Plextek Consulting. In this role Andrew is responsible for bringing together innovators, T1s and OEMs, to deliver both innovative solutions and established methods and capabilities from other industry sectors, into the automotive supply chain.

Martin Green
Visteon

SAFE AND INFORMED – THE FUTURE OF DRIVER INFORMATION

As we look towards the automotive market in 2020, we can identify several key market drivers that will have significant impact on driver information systems. Drivers are being presented with ever-increasing levels of information which presents car makers with the challenge of providing an informed but safe environment for the driver.

This article discusses some of these market drivers and challenges.

The impact of Consumer electronics devices on Driver Information Systems can be readily observed in the adoption of display technology in the automotive environment.

THE IMPACT OF CONSUMER ELECTRONIC DEVICES (PHONE AND TABLETS) ON DRIVER INFORMATION

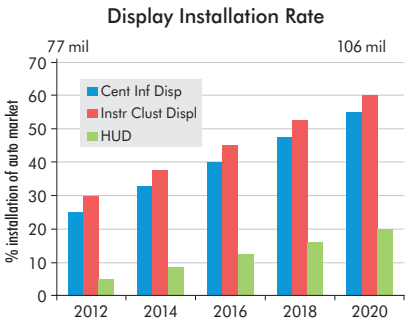
The smartphone industry subconsciously shapes the consumer's expectations for display quality, graphics, user-friendly interfaces and their desire for 24x7 connectivity.

The automotive display market is only a very small proportion of the global display market which include TVs, tablets, laptops and smartphones but must be designed to meet the automotive industry's stringent safety and performance requirements. Automotive displays must be able to operate in temperatures between – 40 degree to +80-degree Celsius – conditions never experienced by any consumer device – which adds significant cost and technology complexity to the adoption of new display technology into the vehicle.

Display technology trends

The increasing need to display unpredictable content, both brought and beamed in to the car, has resulted in a steady growth in the use of Thin Film Technology (TFT) displays as shown in **Figure 1** which can show reconfigurable graphics. TFTs are now replacing the traditional segmented and dot matrix display technology which are limited in the range and quality of graphics supported. The growth in the use of reconfigurable TFT displays has occurred mostly in the centre console for navigation, comfort and media information and in the instrument cluster to manage the flow of information presented to the driver and to enable information to be accessed on demand.

The size and resolution of these displays broadly follows (but still lags) the trend in consumer electronics due to the cost of making them compliant with the stringent automotive requirements.



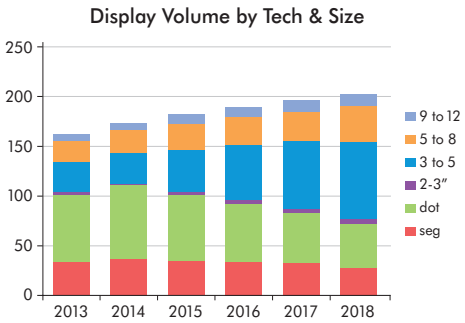


Figure 1: Display forecast *(courtesy of Visteon)*

Looking to the future trend of Display installation as shown in **Figure 1** we expect to see:

- By 2020 > 60% of Instrument clusters will have a reconfigurable TFT display.
- By 2020 > 55% of vehicles will have a centre information display.
- By 2020 – Head-Up Display installation rate is estimated to reach 20%.

In addition to display technology, the consumer experience of smart mobile devices requires Automotive manufacturers to consider the Human Machine Interface technology that provides user satisfaction while maintaining safety.

HMI (Human Machine Interfaces)

The smartphone and well known tablet brands have made consumers critically aware of the quality of HMI and the importance of intuitive and user-friendly device interfaces. Likewise, vehicle manufactures, such as BMW- iDrive, Audi MMI, Ford MyTouch, are also increasingly considering the vehicle HMI and its features part of the "brand image", suggesting that the driving experience is enhanced through their particular HMI solution.

Traditionally, automotive product quality was focussed around the clarity of the displayed graphics in terms of readability and visibility, the ergonomics on the reach zones and physical interface characteristics such as the size, feel and sounds of switches and buttons. However, consumer demand for user friendly interfaces means that the HMI logic behind the interface is equally important; getting any one of these elements, or the interaction between them, wrong can have an adverse impact on the consumer's user experience and the perceived quality of the vehicle.

CONSUMER DEMAND FOR USER FRIENDLY INTERFACES MEANS THAT THE HMI LOGIC BEHIND THE INTERFACE IS EQUALLY IMPORTANT

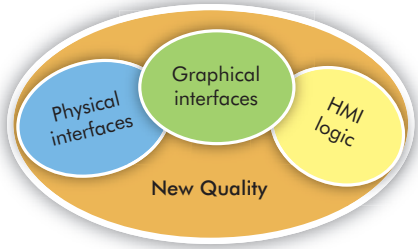


Figure 2: "New Quality" including HMI logic *(courtesy of Visteon)*

Visteon's consumer research demonstrated that delays between the user touching the display and the graphics responding; repetitive illogical menu structures or poor interaction flow is perceived as poor quality.

Today and in the future, the consumer's new perception of a high quality interface combines a careful optimisation of the physical, graphical and logic interfaces as shown in **Figure 2**. However as content, feature and the need to integrate smartphone and off-board connectivity evolves, automotive HMI development becomes increasingly complex.

IMPACT OF ADAS (ADVANCED DRIVER ASSISTANCE SYSTEMS)

European NCAP collision prevention rating systems and insurance company incentives for Emergency Braking Systems (EBS), have been key factors behind the growing adoption of Advanced Driver Assistance Systems (ADAS). Camera based ADAS solutions have appeared to be more cost effective due to their ability to support more than one function, e.g. forward facing stereo cameras enabling EBS, park assist and object detection. The adoption of more camera based solutions has increased the amount of visual based content that needs to be passed to the driver at the appropriate time to avoid increasing driver information workload.

The growth in ADAS systems is also enabling the possibility of low speed, autonomous driving. Low speed autonomous driving may allow the driver to multitask whilst stuck in traffic but requires the HMI to be multimodal. When the car is in autonomous driving mode the driver could be answering emails, reading careful aggregated websites or chatting on social networks. However, the HMI must quickly revert back to a more traditional automotive HMI as soon as the driver has to take control of the vehicle.

INFORMATION OVERLOAD REQUIRES NEW APPROACHES

As the information and feature content increases, it has to be accessed and seamlessly integrated into the HMI framework. Recent estimates indicate that a driver's eye workload is reaching a point where incremental content inevitably will cause driver workload issues. When travelling at 100km/h it takes approximately 0.8 seconds for the driver to look down at an instrument cluster or navigation system. In the 0.8 seconds the eyes have to move down, re-focus on something closer in the field of view and the brain has to assimilate the information before the eyes move back up to re-focus on the road ahead. At 100km/hr, the car will have travelled 22m during this time.

The growth in the use of head up displays (HUD) shown in **Figure 3** or head down combiner solutions can reduce some of this time delay as it reduces the time it takes for the eye to move and re-focus. Visteon, like many vehicle manufacturers, already have traditional HUD solutions and are now looking towards next generation wide angle windscreen head

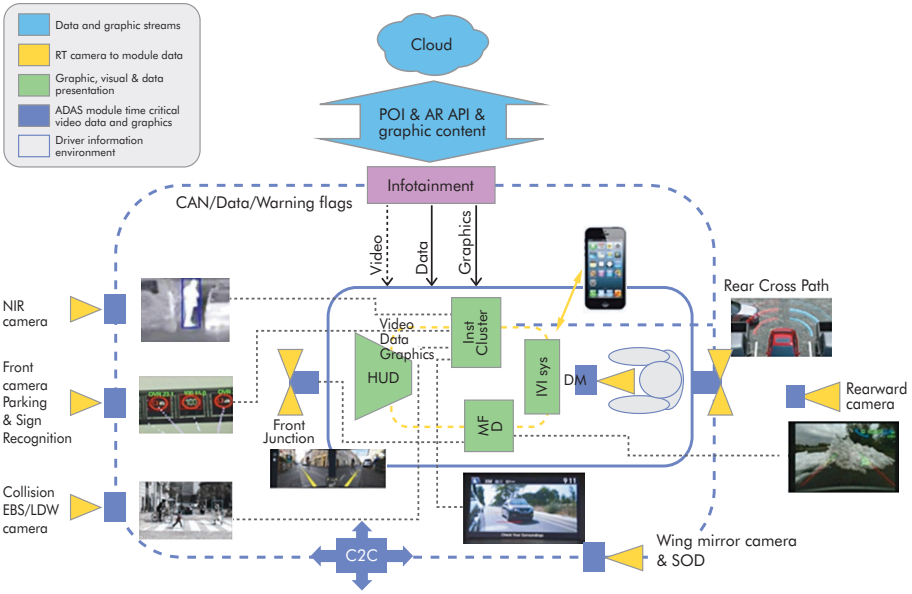


Figure 3: High level driver information content *(courtesy of Visteon)*

up display solutions as a potential game changer in driver information HMI systems.

These systems could radically change HMI approaches in the automotive environment because a larger proportion of the immediate information would be presented in front of the driver (vehicle speed, warnings, navigation arrows) and as a result we could see instrument clusters becoming secondary and supplemental to the HUD interface and traditional navigation displays interfaces only used for destination entry as the navigation information would appear in the widescreen HUD as an augmented overlay.

HUD and Wide screen HUD do not automatically enable the presentation of more information to the driver as information overload will detract from the benefits it brings as shown in **Figure 4**. The automotive industry will have to focus on **what** gets shown, **how**, **where** and **when**.

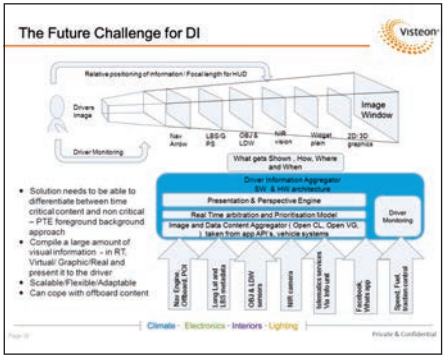


Figure 4: Future challenges for presenting Driver Information *(courtesy of Visteon)*

CAN A "DRIVER WORKLOAD MANAGER" SOLVE THE PROBLEM OF DRIVER OVERLOAD?

Several vehicle manufactures are developing workload/cognitive management systems as shown in **Figure 5** and these features are integrated into their driver information platforms.

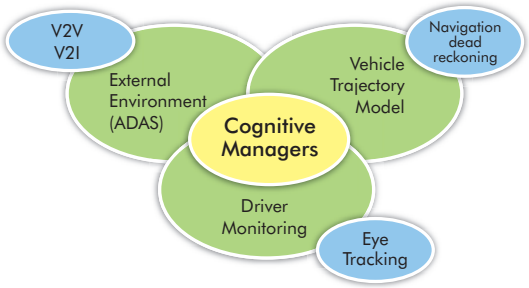
The purpose of the workload/cognitive manager is to make an assessment of the external environment, ascertain the trajectory of the car and the activity of the driver. Based on these aspects, the workload or cognitive manager determines if the information should or should not be shown to the driver.

High volume adoption of cognitive managers/ workload systems is still a long way off as consumers may still prefer to be in control of what they should do, where and when. The issue that each individual's cognitive ability varies due to tiredness, health or emotional influence still remains. This variability in the range of cognitive ability also presents vehicle manufacturers with another challenge in identifying the exact point to warn the driver as some may find it insightful and helpful whilst others annoying and redundant.

Visteon is integrating driver monitoring solutions into driver information platforms and HMI solutions. Using Infra Red (IR) cameras and sources, the position of the eye can be tracked and the direction of the eye gaze can be predicted.

This helps us to understand if the driver is already looking at a potential hazard ahead and may not need an additional warning. Alternatively, if the driver is in not looking at the hazard we can employ methods to attract their attention. There is on-going research being carried out by the University of Glasgow in this field, investigating the most appropriate methods to re-assert a drivers attention whilst also conveying a level of urgency.[1]

The use of eye tracking and monitoring can also be used to assess the level of attentiveness of the driver and whether or not they are drowsy by monitoring the number of blinks and eye movements.



1st Generation used simple inputs (accelerator presses, steering yaw rate, basic vehicle trajectory model).

2nd Generation builds upon 1st generation ADAS features adding more advanced vehicle trajectory models and can hold or reject information such as phone calls or messages.

3rd Generation will assimilate ADAS information with vehicle trajectory models and real time driver monitoring to determine the safe level of communiation to the driver – HMI can adapt to present more or less function and content.

Figure 5: Driver monitoring solutions *(courtesy of Visteon)*

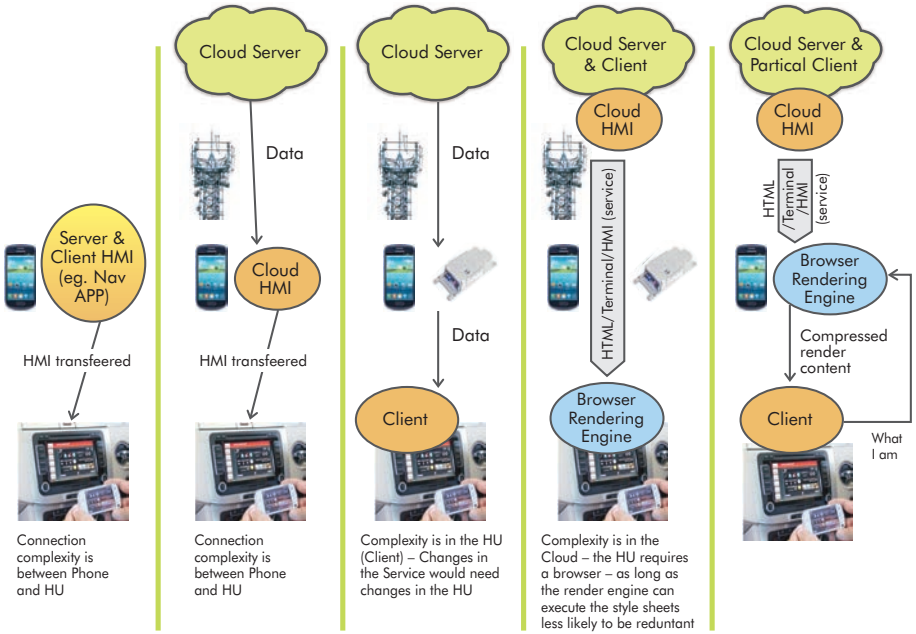


Figure 6: HMI in car *(courtesy of Visteon)*

WHERE IS THE HMI IN CAR – IN THE SMARTPHONE OR IN THE CLOUD?

Embedded, brought in and beamed in content presents new challenges for the vehicle manufacturer. Not only do they have to define the HMI and content for each model level, they also have to take into account where the HMI content is coming from and the resulting client server structure as shown in **Figure 6**.

Ideally the vehicle manufacturer would like to design the HMI architecture once and re-use across the vehicle platforms, independent of the delivery channel. However, to do this several application interfaces have to be used to bridge the gaps between the cloud content and the actual displaying interface used in the car.

New software and HMI tool chains are being developed that allow the HMI to be delivered through different channels and also re-used across platforms. As an example, it may be possible to send the same HMI content directly to the car if it has an embedded connectivity solution; or via the car owners smart phone to the car, if they don't have an embedded connectivity solution. Achieving this level of HMI commonality reduces cost, implementation time and extends the time before the hardware on the car becomes obsolete.

Many vehicle manufactures are now considering hybrid HMI architectures where the car has a base level of embedded functions which is augmented by content and features accessed via the cloud. The utopian goal would be to have the client in the car as a relatively simple

terminal and the intelligence in the cloud as this would allow the HMI, features and content to be updated as necessary. This, however, may be a complex task as it depends on car connectivity.

CONCLUSION

Consumer electronics is having a major impact on shaping the future of driver information systems. As the driver becomes bombarded with information, the quest for driver safety (ADAS) will impact the interface technology (HMI) adopted in car. New technology and approaches such as HUDs, Cognitive Managers and HMI commonality are being developed in readiness for driver information challenges ahead. These enabling products must be designed to deliver on key requirements:

- Differentiate between time critical and non-time critical content.
- Compile a large amount of visual information in real time.
- Decide when and where it is presented.
- Solutions that are scalable/flexible/adaptable.
- Integrate off-board HMI and Smartphone content.

As a member of NMI, Visteon is able to share their future driver information vision with suppliers, partners and customer within the electronics industry and from this stimulate interest in creating solutions to address the challenges ahead.

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As advanced planning manager for Visteon's Electronics product group, Martin Green is responsible for analysing global technology trends to identify and bring to market the next generation of electronics technologies. Starting his 22 year-long automotive career as a graduate design and manufacturing engineer with the Echlin group, Martin joined Ford Motor Company in 1994 to establish an automotive pump design group and managed engineering teams across Europe. He subsequently progressed into advanced systems engineering at Visteon Corporation, running global projects with a focus on hybrid and fuel economy technologies.

Prior to this current role, Martin was the sales and marketing manager for Visteon's powertrain division and product marketing manager for Visteon's electronics product group.

Martin Green is a graduate in engineering from Portsmouth University and obtained a MBA from the Henley Management College.

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UK EMBEDDED SYSTEMS FUTURE: COLLABORATION FOR GROWTH

A CHANGE IS NEEDED

Embedded Systems are pervasive. So much so that we often don't recognise their existence in what are now 'everyday' products, from low-cost toys to high-value, high-integrity, security-critical or safety-critical systems.

AS THE UNDERLYING SILICON becomes more capable, so we (as consumers) demand more features from our product, never to return to our simpler beginnings.

Customers expect to see cheaper, faster time-to-market, more reliable products, defining more connected and more context-aware systems. These require significant interaction between independently designed systems, yet we increasingly rely on them. For systems of systems the complexity risk problem is more acute, as the breadth of the interfaces and causal interaction is a significant multiplier, both in proving that it does what is expected, but more significantly that it doesn't do anything unexpected!

Most companies have already adopted a significant amount of software control in their products in the quest for improved performance, optimisation, or even the ability to configure the product in a manner that requires little manufacturing change, for different applications.

For many companies, including those whose brand is synonymous with mechanical reliability, the use of software systems offers both an advantage and a potential risk. As companies strive for a larger market, usually with higher-

FOR MANY COMPANIES THE USE OF SOFTWARE SYSTEMS OFFERS BOTH AN ADVANTAGE AND A POTENTIAL RISK

level system integration responsibilities, the 'composition' risk exponentially increases.

An increase in system complexity, in almost every aspect of electronic product, is a certainty, so a break-through in embedded system development for future applications would be a significant competitive advantage.

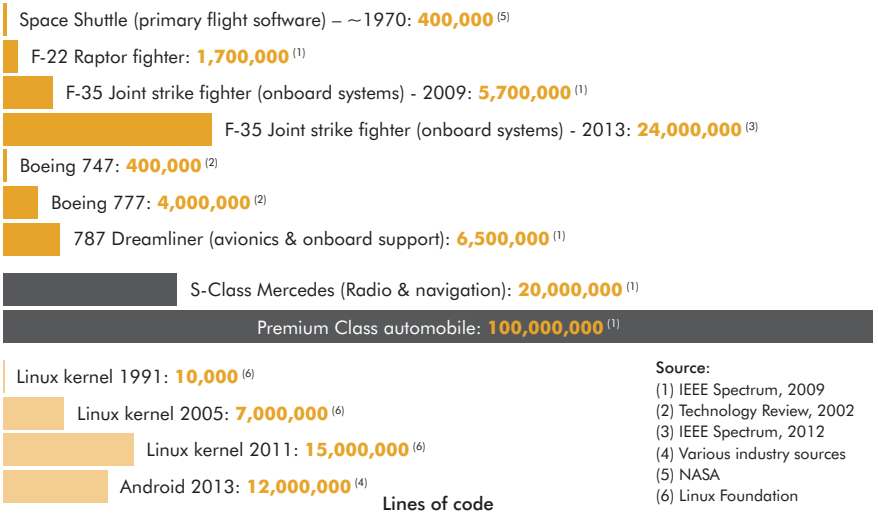
SYSTEM GROWTH IS OUTPACING US

The systems we describe in software today are untenable (in development timescale, cost or risk) in other implementation solutions. That complexity is increasing as both the electronic platform capability increases and our consumers' expectations increase. The industry's engineering processes are currently discontinuous and not developing at sufficient pace to accommodate this complexity growth and as a consequence are already stifling output.

Software engineering has an unenviable reputation for delivery, is hard to risk- and project-manage, and appears to be difficult, or expensive, to quality control in most industries. This is exacerbated in the toughest software engineering environment of all (i.e. hard-real-time embedded systems) that we routinely adopt to deliver safe, secure, robust and reliable operation in our everyday machines.

As an industry, we need to develop new processes that can provide seamless product lifecycle management from concept, through its engineering, to delivery. The hard-pressed engineers of today have little time to develop such ideas and current academic learning still propagates engineering disciplines and methods that are at best 10 years behind the industry best-practice. The availability of 'industry-ready' graduates is poor and they frequently find the challenge of embedded

THE EVER INCREASING COMPLEXITY OF EMBEDDED SOFTWARE CODE BEING DEVELOPED



systems engineering unattractive and the rewards insufficient compensation.

This puzzle is not unique and a number of industries have potential fragments of the solution, yet are fearful of sharing this knowledge lest it should disadvantage them. Collaboration amongst non-competitive industry segments could potentially see significant improvements in productivity, innovation, robustness, security and safety in the resultant products.

WHY IS COMPLEXITY AND RISK SIGNIFICANT WITH SOFTWARE SYSTEMS?

Our history of engineering shows us that when one engineering technique is no longer capable of delivering the capability, we evolve new techniques. This pattern is also true for most of the products with which we are familiar.

Simple mechanical products adopted electrical actuation to achieve some flexibility, then transformed into electronic control for better precision, and then into software control for even greater flexibility and optimisation.
We have to accept therefore, that the systems we generate in software today are of such complexity they are no longer tenable (recurring or non-recurring cost, timescale, adaptability) in other implementation technologies.

If we add to this mix, and use, our "physical product" programme management techniques, especially those related to 'visible' progress, we have a cultural mismatch which drives inappropriate behaviours e.g. early production engineering. As many of our embedded systems reside within, and choreograph, the physical (usually mechanical) solution, they are frequently managed with this mentality.

Worse still, the flexible nature of software means that the embedded system is often the 'accommodating' "glue" that can be used to resolve any shortfalls in system interfaces, performance, product integrity or other design inadequacy (such as destructive or detrimental areas of operation).

COLLABORATION WOULD ENABLE A STEP-CHANGE

An industrial collaborative body could seek to engage with competitors, non-competing partners, or with academia to research and develop ideas that are scalable and focussed on industry's key problems in embedded systems such as software estimation, management, seamless development, and test regimes that deliver appropriate confidence in an engineered embedded system product.

Such a collaborative body could make the research affordable, accessible by large corporations as well as small and medium enterprises and could position the UK at a significant advantage.

As new paradigms, methods and tools get identified within this collaboration, there are opportunities for tool-vendor collaborations, spin-out companies and the opportunity to teach a new generation of engineers the methods and development processes that will enhance the industries they join, whilst improving their early career prospects, in what is already a skill-short technical industry.

Some large corporations already appear to be recognising the significance in future embedded systems, building large software and embedded systems centres of excellence local to the significant academic institutions that traditionally create graduate engineers.

The UK needs to leverage its international reputation in Embedded Systems, Computer Science and the Electronics industry to secure a leading position through collaboration between

industries and with academia to achieve a step-change in its industrial capability.

COMMON CHALLENGES

Most businesses would recognise the challenges of developing products that contain embedded software systems; managing software projects; managing a supply chain of software developers, or of managing their own team of developers.

In developing embedded real-time products those businesses also share the same processing platform concerns with regards non-deterministic impact of cache, yet the necessity for performance; the criticality of real-time debug for on-chip cores and peripherals, yet the lack of access and connectivity with BGA packages; the need to ensure on-target verification, yet the late availability of target hardware.

Statistically, as a whole, nationally, and even internationally, we are not good at developing software (embedded or application) when success is measured by content, delivery to schedule and cost. Currently very little information is shared across industries, as each sees themselves as domain specialists, and very little information is shared within an industry for fear of losing competitive advantage.

The reality is that embedded systems skills are highly portable, as they are reasonably abstract in nature. A device driver specialist in one industry is likely to be able to work with an unknown platform and device set; a programmer of a block-structured language can easily adapt to the syntax of a new language, or at even lower levels to the instruction set and execution behaviour of a particular microcontroller core, memory and peripheral.

THE IMPORTANCE OF A WELL-DEFINED SYSTEM

Our ability to transform a perfect specification into a suitably predictable implementation is unfortunately significantly compromised by our ability to specify such a system. By far the dominant driver in most embedded system costs are an inadequate specification. At a detailed level, these specifications errors take much longer to be discovered and the rework cycle is much longer, making the programme overrun both in time and cost.

The systems engineer's transformation of a problem into viable component solutions is heavily dependent on his experience of the component domains capabilities, an accurate assessment of the attributes necessary to be specified and controlled, and trade-study experiments of suitable fidelity to appropriately inform him.

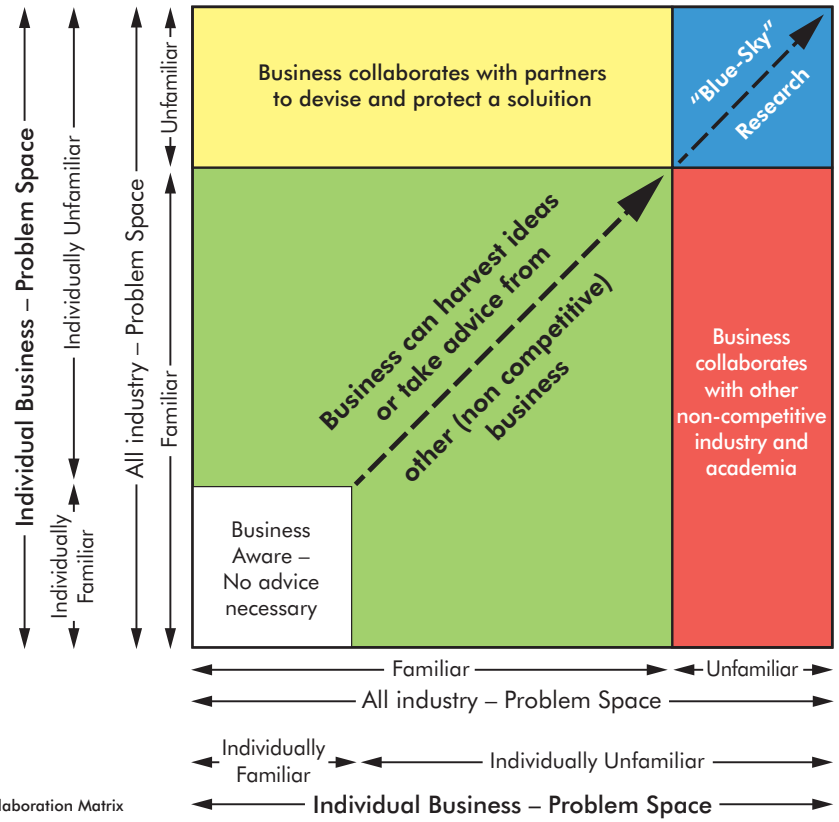
This domain is least understood in modern engineering companies, often leading to premature commitment to costly production engineering and expensive rework or compromise. The majority of this problem stems from a culture of wanting to 'see progress', which in embedded systems are manifestly non-physical, is intrinsically difficult to convey with any useful measure.
(c.f. Mechanical engineering where a prototype component, geometrically to scale, but absent all key attributes of material properties would be 'seen' as evidence of significant progress.)

Within a well-specified system, error rates in software are largely a consequence of the development process. Current methods of mitigation by process improvement are not keeping pace with the increase in complexity and so are unlikely to be sustainable.
The inevitable outcome of this, then, is that future systems will contain more errors (which will be observed as reduced quality or more failures of the system) unless a step change is made.

As cost pressures (for both recurring 'unit' cost and non-recurring 'development' cost) along with miniaturisation efforts that affect size, weight, power consumption, thermal management become more significant, the ability to optimise the holistic solution because of its multi-faceted relationships, becomes untenable.

The once favoured green-field design, that had a solo engineer responsible for the partitioning of the system solution, whether for purity of purpose (Maximum cohesion, Minimum coupling); for ease of engineering development within the supply chain or organisation; for maximising variant product capability at point of 'configuration and manufacture', or as mitigation for future extensibility, may be insufficient as a design principle.

We can reasonably expect more of our future systems to replace components of a system, expected to enhance the performance of the whole, extend the opportunities for the future, but preserving its inter-operability with the remaining legacy components, more as a



Collaboration Matrix

continuing enterprise change. Modelling from System level, and embellishing as it migrates to solution, in the various implementation domains, is, as yet, a goal rather than a reality. These systems will need to be able to offer interfaces that respond to the service requests they receive, rather than be design-time defined, yet still be safe and secure; robust to both failure and malicious attack. Current mechanisms tend to be unwieldy, add significantly to either complexity or overheads and tend to degrade system performance, worsen development cost (in the short term) and prove difficult to predictably validate behaviour for future (un-described) scenarios.

SHARED KNOWLEDGE

These challenges are common across all industries, as are many of the solutions. Like at the outset of a peer-to-peer file share, we are placed with a number of players holding elements of the solution, while no one player holds all the pieces. We however lack a mechanism where the players feel they are able to trade their knowledge for fear of either disadvantaging themselves, or exposing the state of their business.

An engagement model shows the problem and solution space where through collaboration a single business can expand its knowledge through potential knowledge of other businesses in the industry.

In trading those positions the component suppliers (for example the silicon designers and silicon manufacturers) would be able to aggregate the requirements, prioritise the common demands and enable significant complexity of future generations, by potentially building in mechanism that support the embedded systems developers (e.g. better random failure detection, memory and register integrity checks, execution time measurements, debug capabilities).

In trading those positions, software project management could develop objective tools for measuring progress and maturity; for managing risk; for validating architectural strategies, at early concept and design stages.

In trading those positions, people skills could be raised to a higher common standard through skills frameworks, competence assessment and business needs that are objectively measured; learning solutions provided through respected academic partners or 3rd party training solution providers; the potential for 'body-swaps' could be developed between businesses to help develop the abstract skills necessary for good systems engineering, through experience of different products, markets or customers.

CULTURE CHANGE: THE BIGGEST CHALLENGE

Whilst accepting that this means a culture change, not just at a technical level, but at the deep-seated root of management fear of diversion, exposure, migration of experts, and even salary wars, we also have to accept that there will never be a 'better time'. The economic challenges of today mean that we load all teams heavily and can ill-afford any distractions. The strategic gain of potential productivity improvement always loses out to the immediacy of being short-handed on the current project.

Cultural change is hard, often with the slowest rate of change, especially where there are diverse customer 'custom and practice', geographically differentiated cultural norms, and exacerbated in an industry renowned for introverts as the dominant personality type.

However, this industry segment and its associated market, is not going to shrink and our failure to share experiences and solutions will inevitably lead to us losing a potential market position of national importance.

BRINGING THE INDUSTRY TOGETHER

A number of these common challenges can be solved through a members club that enables shared information borne of experience; the formation of non-competitive alliances to solve common problems; to collaborate as cost-sharing research partners with academic institutions; to raise the standards that enable members to be more successful (e.g. content, delivery, cost). A number of contractual alliance models already exist within the scope of specific industries.

It is inevitable that industry will require support in solving problems. As collaborative efforts, the cost and accessibility of academic thinking becomes tenable even for Small and Medium Enterprises. Unlike some physical sciences, Embedded Systems Engineering requires rather less capital investment. It is difficult to identify a single academic establishment that appears to fulfil all the needs so a 'nomadic' style of engagement, moving the problem to various specialist establishments, may be necessary.

For all of the participating industries, key to academic or business partnership will be return on investment and protection of its own interests. Not only must this deliver solutions that deal with current day shortfalls, but clearly must involve solutions that will scale with the expected increase in complexity with a suitably less proportionate investment in the solution and its use.

NMI has already initiated this collaboration by running a "Software Peer Forum" and is expanding this into the "System and Software Leaders' Forum". To maximise value, this forum needs better representation from the range of industries, company sizes and business markets that make up the Embedded Systems world; Leaders who are able to both offer insight and discussion, based on experience, and take away ideas for their business application; Systems Engineering and Software Engineering experts to improve communication and collaborative value.

ABOUT THE AUTHOR

Stuart Jobbins, MSc CEng FIET MIEEE, Chief Executive, Sofintsys Ltd:
Stuart is an independent consultant with over 33 years professional experience in software system development with an academic history and continuous professional career in electronics programme, project, business and technical management in embedded systems. His wide career has seen him cover industrial, defence, communications, automotive, aerospace, marine and nuclear backgrounds.

Stuart is a Fellow and Professional Registration Advisor for the IET, a Chartered Engineer, a Member of the IEEE, a Visiting Professor in Computer Science and Embedded Systems and sits on a number of national and international Academic and Industrial Advisory Boards. He is passionate about engineering, especially systems with extensive software engineering, its professional development and education, and enthusing youngsters into engineering as a career through his work as a STEM Ambassador.

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Mark Warren
Perforce Software

CONTINUOUS DELIVERY – A SUPPLY CHAIN LESSON FROM THE SOFTWARE INDUSTRY

Relentless innovation is a fact of life for this industry: every step of every process to bring products to market is under constant pressure to yield ever more than before, in a shorter time, whilst maintaining – and ideally improving – quality. The product lifecycle process now has long "value chains" that each contribute a small part to a larger, more complex end-product, across software, design, engineering, QA, release, marketing and sales teams.

DUBBED CONTINUOUS DELIVERY, a new set of best practices are emerging to keep these value chains intact and to address the need to get more innovative products out faster but without compromising quality. This article introduces the concept of Continuous Delivery and describes how it can work in a highly innovative engineering and manufacturing environment, as part of creating a resilient value chain.

CONTINUOUS DELIVERY DEFINED

Continuous Delivery (CD), which has its roots in the software development business, can be summarised as the time taken between requirement definition and delivering business value by iterating frequently to introduce changes. In the software market, CD is helping organisations tackle two extremes: the need to satisfy demanding customers and roll out new products to market quickly, versus the reality that systems are increasingly complex, with more 'moving parts' that need to be orchestrated.

CD is a logical extension to the already popular approach of Continuous Integration (CI) which itself is an evolution of practices first adopted as part of the agile movement and methodologies (such as *Scrum* or *Kanban* releases are broken into short "sprints" with planning and retrospective review phases planned in to ensure that working systems could be released at any point). CI is concerned with the automation of the build and, to some degree, testing processes so that errors in source code can be identified and remediated as early in the development process as possible.

CD takes this to the next level and asks the user or team once the code is building cleanly and passing tests: how quickly can that package be deployed into production? Importantly, if this is to happen rapidly, how can you ensure the quality of such rapid releases and if necessary back them out? How can you show adherence to compliancy policies?

In hardware environments, this can seem like an impossible goal. Surely hardware

FEEDBACK CAN ALSO POSITIVELY INFLUENCE FUTURE PLANNING, ENSURING THAT THE NEXT ITERATION IS ADAPTED IN LINE WITH LESSONS LEARNED SO FAR

can't be continually re-built and released into an assembly line as frequently as that? Prototypes can be expensive and time-consuming to build. Setting up production lines in a fabrication plant is not something that companies want to do too often.

However, as early adopters in engineering and manufacturing companies are demonstrating, CD does apply to this world. For example, where systems are largely variations of firmware or applications on a generic hardware platform (let's take a smartphone as an example), then the challenge is about how the right variant of the software gets installed at the right point in the production line. Another opportunity might be to focus on the stages of the development process through to integration type testing which might be handled in a simulator. In that case the costs of rebuilding platforms is reduced considerably.

BEST PRACTICE

There are several keys to successful Continuous Delivery, but this paper focuses on three: Automation, Feedback and Versioning.

Automation

While manual intervention is always required somewhere down the line, automation does prevent errors and also, enables optimisation. For instance, can some component not be compiled every time? Can testing being automated? If something goes wrong, how easy is it to revert to a previously working environment? How do you measure performance of each stage of a manual process? Automation is also critical for compliancy, because it provides an 'audit trail' of what happened when, where and actioned by whom.

Feedback

In the Continuous Delivery context, "feedback" is any information about the performance of the system: Is it passing its tests? Is it delivering the performance, functionality or value that the customer requires? Is the development team delivering the required functionality at a pace that will see schedules achieved? Testing is an important component here: while not everything may need to be tested (in fact, the extra load and time of doing so may be inadvisable), all important subsets should be, to verify core functionality or validate regressions have not been introduced. Some automation systems put extreme loads on the version management engine so having one that can scale for such usage is critical. Feedback can also positively influence future planning, ensuring that the next iteration is adapted in line with lessons learned so far.

Versioning

A version management system provides the definitive 'single point of truth' of all assets (code, documents, planning documents, images, test data, diagrams) and is essential to CI and CD. Without that knowledge, they have no solid foundation. Plus, the automation itself should be maintained within the chosen version management system, which as previously mentioned, also acts as a compliancy record.

While some organisations have historically evolved or inherited multiple version management systems, there is an increasing trend towards standardising on one system, especially since the current generation of version management systems are designed to operate over geographically distributed environments. A common version management system ensures visibility of changes and easier collaboration. For example, if conflicting changes are flagged during check-in, either by the version management system or CI build & test, then the version management system should help resolve the conflicts with complete change history. In this industry, choose a version management system that is designed to contain all assets (not just computer code), is usable by anyone (not every contributor is a software engineer, although they are the focus audience for some versioning tools); and scalable to support large projects and teams if required. Some systems perform admirably in a tiny team, less so when hundreds or thousands of users dealing with terabytes of content.

A COMMON VERSION MANAGEMENT SYSTEM ENSURES VISIBILITY OF CHANGES AND EASIER COLLABORATION

CONCLUSION

Time to market has never been a more critical element of the supply chain, while ensuring quality for the customer and profitability for the manufacturer. Continuous Delivery automates the process of supporting all the checks and changes that are vital from development to testing and production, as quickly and reliably as possible. With an understanding of CD best practices, with the support of the right version management system, CD could have a positive impact on the management of this industry's increasingly challenging supply chains.

ABOUT THE AUTHOR

Mark Warren, Marketing Director, Europe, for Perforce Software: Mark has over 25 years' experience as a consumer and vendor of enterprise development and configuration management products. Worldwide, the version management and code collaboration portfolio from Perforce Software is used by thousands of customers including AMD, CSR, National Instruments, NVIDIA and Panasonic. Perforce Software helps companies in this market sector to support various aspects of embedded design, from components-based design through to rapid-prototyping.
www.perforce.com

Ted Wiggans
Operations Director

MANUFACTURING IN ACTION

Traditionally NMI's manufacturing group has concentrated its efforts supporting the semiconductor sites but in recent times we have found significant benefits by including other companies within the electronics systems space into the group.

DESPITE THE DIFFERENCES in products and technology each site effectively has the same challenge when coping with staff and with the demands of quality, cost and delivery. NMI's Lean Network has been an excellent forum to help those involved to explore and solve some of those challenges. We invited Xaar to tell us their story of how they met market opportunity with manufacturing excellence. Xaar is the world-leading independent supplier of industrial inkjet print heads and offers a wide product range which provides their customers with the flexibility and choice in the revolutionary market of digital printing.

Ted Wiggans, having worked with NMI over many years, first with Zetex (now Diodes) in Oldham and subsequently with Camsemi in Cambridge, takes us on the Xaar journey.

XAAR PLC:

Xaar was formed from a spin out of Cambridge Consultants in the 1990's to exploit and commercialise a new inkjet technology. The original model was to license its technology to companies but it become clear that this approach had limitations so in 1997 Xaar took the brave decision to move into the world of manufacturing. One of the key steps in this journey was the purchase of a site in Stockholm, at that time owned by IBM, and resulting in a business with a turnover of £43 million in 2005. At this point Xaar also

NMI'S LEAN NETWORK HAS BEEN AN EXCELLENT FORUM TO HELP THOSE INVOLVED TO EXPLORE AND SOLVE SOME OF THOSE CHALLENGES

purchased a state-of-the art site in Huntingdon. This had the added advantage that R&D and Manufacturing groups could work side by side, while being close to the company headquarters in Cambridge.

The Huntingdon site has since expanded rapidly with more and more of the 65,000 sq ft being facilitated for volume manufacturing of their latest products.

Demand for the company's products has also continued to exceed all expectations since that time; one of the key sectors being the European ceramic tile manufacturing which has seen businesses completely transformed due to this unique technology. A major advantage to digital printing is that it is non-contact hence breakages are eliminated. Also, print runs can be as short as a single tile bringing inventories under strict control. Ceramic tile images are now as realistic as natural stone, or wood, or whatever material you wish imitate!

HIGH DEMAND AND FACTORY EXPANSIONS – THAT IS WHEN THE FUN AND GAMES REALLY BEGAN!

Although one part of our story involves the building of cleanrooms and equipping them with purpose built equipment, the other part of the story is about building a workforce – management, supervision, engineers and operators – virtually from scratch.

IT'S ALL ABOUT THE PEOPLE

My philosophy has been formed through bitter experience over more than 30 years in high tech manufacturing: any fool can buy a factory and the equipment to fill it – all that takes is money. The thing that makes the difference is the quality of the people who work in the factory and the systems, techniques and processes that they put in place to build the product.

The challenge for Xaar was to build a workforce capable of implementing those systems, techniques and processes against a background of massive demand.

By the beginning of 2011 the Huntingdon plant was under severe pressure to improve quality, to reduce H&S issues and to reduce costs whilst simultaneously increasing output and the size of the workforce. Morale in the plant was low as targets were continually being missed, and new starters were having an adverse impact on overall performance. And the factory looked like a building site to boot!

Something dramatic had to be done and it had to be done quickly. The traditional method of management shouting louder and demanding more for less was quickly rejected and a diametrically opposed path was taken: engage the entire workforce and build a culture that embraces improvement, is prepared to learn from others and is flexible enough to cope with the unexpected (both good and bad). For many of our (newly formed) management team this was a step into the unknown, but it was the step that we took.

And that is the point where NMI came in. I have worked with the NMI over many years so I am not embarrassed to admit that my reasons for Xaar joining were entirely selfish. We were recruiting people from a variety of industries and backgrounds, some with no industrial experience at all. To develop all of our systems and procedures in house, learning what would work and what wouldn't the hard way, would be very time consuming.

NMI GROUPS

Through the NMI network groups we could rapidly access examples of best practice developed in real manufacturing environments. We could then blend this learning with our own in house developed initiatives to increase the velocity of the improvement programmes. And that is exactly what we did.

We quickly placed our people into the NMI network groups, with supervisor visits to other NMI member companies, and visits by other NMI members to the Huntingdon plant. We joined the H&S group, the Facilities group, and latterly the Operations group.

And all of that helped to fuel the engine of improvement that we had already created. The realisation that other companies have seen the same issues, have developed ways of tackling the issues and in many cases resolved the issues, really helped our people. Seeing things done in a better way, or a quicker way, or a cheaper way stimulates improvements in all areas. It has also been a real motivator for our people when they have received positive comments and suggestions from employees of other NMI member companies.

WE HAVE BUILT AN ORGANISATION THAT HAS AN APPETITE FOR IMPROVEMENT

Through taking on board the learnings from those groups and adding them to our own experiences we have managed to keep the Xaar manufacturing powering forward. We were able to successfully increase the Huntingdon capacity by over eight times and with continued demand for our products, further expansion investments have followed.

SEEING IS BELIEVING

The Huntingdon headcount is now over 450 people and the Swedish headcount is over 100. Staff turnover is extremely low, attendance levels extremely high, H&S performance is excellent, and morale is first class. In fact, the enthusiasm of the workforce is infectious.

Our people were enthusiastic presenters at the NMI Manufacturing Excellence Conference in October 2013, and brought back even more ideas to share with their workmates. And more visits to the plants of NMI members are being organised.

The financial performance of the company speaks for itself: turnover is up, GM is up, profits are up. In fact company turnover, which doubled in the three years between 2009 and 2012, will have increased by over 50% in 2013. This performance has not gone unnoticed by investors, and Xaar has now joined the ranks of the FTSE250.

WHAT OF THE FUTURE?

The potential market for printed products is enormous both with traditional products and with a host of new technologies. However, doing things the old fashioned way does not facilitate a fast enough response to modern economic requirements – such as rapid design alterations or on-demand production. Xaar has already played a key role in changing the graphics and ceramic industries, and our products are making significant gains in the label and décor markets.

You can also rest assured that, as I write, Xaar people are working on new and exciting ways to change the world of print from analogue to digital.

Despite all of that we are acutely aware that we are not perfect. As an organisation we know that we still have a long way to go before we can truly say that we are making the most of our people. However, what we can say is that we have built an organisation that has an appetite for improvement, a willingness to learn and a level of enthusiasm that others would kill to achieve.

ABOUT THE AUTHOR

Ted Wiggans,
Operations Director, Xaar:
Ted joined Xaar in January 2011, aged 57, with over 30 years' experience in high technology operations. Immediately prior to joining Xaar he was Chief Operating Officer at Cambridge Semiconductor Ltd (CamSemi). Before joining CamSemi in 2006, he was Operations Director at Zetex Semiconductors with overall responsibility for its multi-site, multi-national manufacturing activities and a global team of 500. In addition, he has held senior-level manufacturing, engineering and quality roles with Motorola and Philips. He is a Chartered Engineer and a member of the Manufacturing Industries Division Board of the IMechE.

Claire Mackay
Technical Sales Manager, eXception EMS

CAPABILITY ON OUR DOORSTEP: PARTNERING YIELDS GREAT BENEFITS

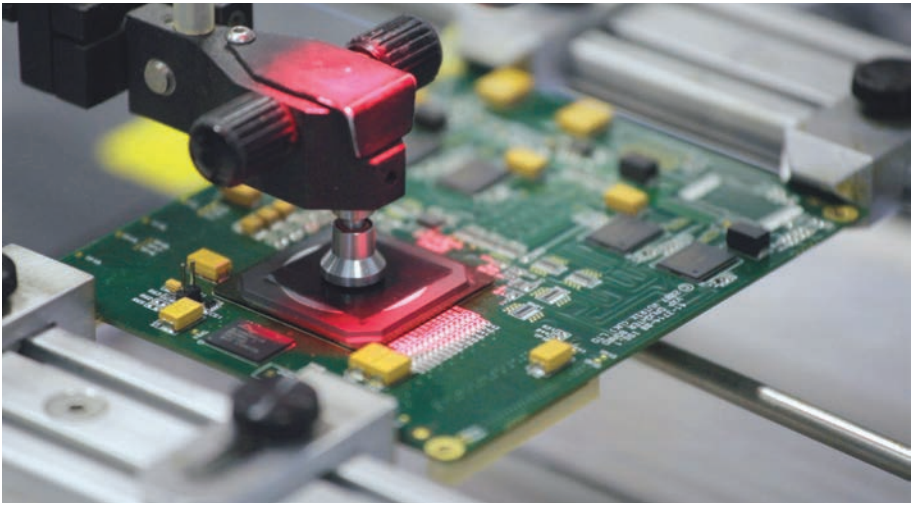
TAKING A FRESH LOOK AT UK CEMS (CONTRACT ELECTRONICS MANUFACTURERS)

Despite the recent economic downturn, the UK continues to invest in design and development with OEM's recruiting across the engineering base. OEM's have had to look inwards on their own strategy's to determine how best to increase market share and shorten TTM (time to market) against fierce global competition. This has traditionally led to an upward trend in outsourcing of electronics production to competent and skilled manufacturing assemblers often in lower cost, offshore regions. However, the UK CEM scene is alive and prospering with the latest reports confirming over two hundred CEM's operating here. Ranging from the specialised twenty-staff facilities to larger scale tier 1 – global footprint operations. These support multiple sectors and customers often needing expert and more responsive service.

IN THE PCB SECTOR, space constraints in ever smaller intelligent devices, such as smartphone and tablets, are making the production of demo or reference boards ever tougher. CEM's are continually being pressured to deliver on time and within budget to their semiconductor clients who constantly push the boundaries with design and technology. They're also dealing with the consequence of smaller and smaller components that need a multitude of new assembly equipment and skills to ensure reliable performance across all market sectors.

Here in the UK, not only have we understood the need for investment in automating processes to alleviate those previously seen cost pressures that led to offshoring, but we are ideally placed to engage in closer relationships with our customers. Local supply provides an opportunity to help deliver technology roadmaps by ensuring the necessary equipment and processes are in place, trialled for product build and are available within the timescales required. As an example, semiconductor technology is renowned for its fast innovation so understanding the technology direction over the short and long term allows the CEM to investigate then invest in the latest technology ensuring continued support for product development. From this, the CEM can then provide the customer with manufacturing guidance for next generation design requirements.

Speed is frequently of the essence. In such a fast-paced and highly competitive environment being first to market with new products, versions



and updates is critical, which means deadlines can be extremely tight. As is often the case, the design phase of a new project absorbs the lion's share of the allotted time for product development. This in turn puts pressure on the supporting CEM to deliver quickly with reduced lead times. This is where local CEM suppliers with world class capability can excel.

The relationship between the customer and CEM is also becoming critical – gaining insight into the very early stages of product development is giving the CEM insights that will have a bearing on their own technology direction. With the sector so pressured by time to market, technological innovation and price, there has never been a more important time for CEMs to adapt, get close to their customers and work collaboratively to ensure quality and price meet the needs of the customer. A change of mind set and approach is also required to gain maximum benefits from local supply. A CEM is often seen as a 'supplier'; however those that engage more closely often build longer-term relationships allowing co-investment to support future roadmaps. This partner approach is winning through – working directly with client teams in early stages of development from design through to product creation. This partnering approach is becoming ever-more critical as it gives CEMs the ability to improve product development cycles substantially. Taking a partnership approach means there is an

TRENDS IN RECENT YEARS TO OFFSHORE ELECTRONICS PRODUCTION SHOULD NOT GO UNCHALLENGED

immediate technical contact within both the customer and the CEM, which allows for technical engagement at the very beginning of a project – crucial to delivering on expectations further into product development.

A key benefit of this more 'entwined' approach is designing out manufacturing cost and removing unnecessary process steps.
For example, client PCB designers are conversing with CEM manufacturing engineers before final review of a new design, which allows the manufacturing engineers to review the data and provide detailed feedback and support by way of DFA (design for assembly) or DFM (design for manufacture) to enable design changes to be made for ease of manufacturing and to invite cost down. Clients are fully supported with advance material procurement, accelerated engineering and assembly without any compromise on quality. Hey presto every program managers dream!

In summary, trends in recent years to offshore electronics production should not go unchallenged. There are many UK CEMs who have adapted their services to provide local and international clients valuable services and commercial advantage. So let's reconsider our strategies when choosing a CEM partner, revisit the true costs and the additional benefits that exceed simple price considerations, after all what is the true price of doing business based on cost alone?

Mark Sumnall
Sales Director for Busch (UK) Limited

MEETING THE EFFICIENCY AND MAINTENANCE CHALLENGE

Despite reports of the UK economy being 'on the up' conditions continue to be challenging for many responsible for the running of any type of manufacturing process, and medium/high vacuum technology used in the microelectronics industry is no exception. Here Mark Sumnall of Busch (UK) Limited looks at the key trends and challenges ahead.

FOR 2014, keeping costs to a minimum is likely to remain at the top of the agenda for many and clever management of energy efficiency and maintenance can play a key role in keeping within tight budgets.

Energy efficiency will undoubtedly have a major part to play this year as it has two key areas of impact for the user; firstly, equipment that is operating correctly will ensure production levels are optimised and secondly, when it is running efficiently, less energy is used and in turn, utility bills will be kept to a minimum.

Service and maintenance is another major area of importance. With production managers under pressure to save costs, a good way of shaving a few pounds off the budget may appear to be to increase the time between periods of maintenance, but inevitably this will prove to be a false economy. Equipment that is well maintained will undoubtedly give better and more efficient performance, again leading to lower energy bills. Costly downtime can be avoided with regular and correct servicing. More importantly, using approved spare parts will ensure performance and warranties are not compromised. While it might be tempting to install that slightly cheaper counterfeit part, it may not last as long and could cause loss of production time and potentially damage the pumping system.

EQUIPMENT THAT IS WELL MAINTAINED WILL GIVE BETTER AND MORE EFFICIENT PERFORMANCE, AGAIN LEADING TO LOWER ENERGY BILLS

PURCHASING NEW EQUIPMENT MAY NOT APPEAR TO BE THE BEST IDEA FOR THOSE TRYING TO MANAGE THEIR BUDGETS, BUT INVESTING IN THE LATEST TECHNOLOGIES CAN MAKE A SIGNIFICANT IMPACT ON IMPROVING OPERATIONAL PERFORMANCE AND EFFICIENCY

Purchasing new equipment may not appear to be the best idea for those trying to manage their budgets, but investing in the latest technologies can make a significant impact on improving operational performance and efficiency. In particular, when using vacuum as part of a microelectronics process, installing newer, more energy efficient vacuum products and systems will make a difference in the majority of cases.

An example would be the latest scroll vacuum pumps that are hermetically sealed and completely dry running and are used in many specialist applications including the handling of noble gases, helium leak detectors, laboratories and R&D, analytical devices, mass spectrometers and electron microscopes as typical areas of use. In the seminconductor industry, they are widely used for the evacuation of load locks and transfer chambers.

As times continue to be challenging, possibly the best advice is to work with the equipment manufacturers and experienced, qualified service providers. They have extensive knowledge and expertise along with a wide range of different services such as decontamination, remanufacture and consultancy, and can provide advice and support to help customers meet their needs and requirements.

ABOUT THE AUTHOR

Mark Sumnall, Sales Director for Busch (UK) Limited:
With 57 companies operating in 39 countries and more than 2,600 employees, Busch is the global market leader for vacuum and overpressure pumps for a wide range of applications, including food, pharmaceuticals, oil and gas, woodworking, printing and packaging, and offers a comprehensive product portfolio. As a pioneer in vacuum packaging, in 2013 Busch marked its 50 anniversary by celebrating half a century of continuous quality, innovation and service to become the premier supplier of vacuum and overpressure equipment.

INMOS AND THE TRANSPUTER: 30 YEARS ON

It is 30 years since the Transputer was officially launched, the first samples emerging from the Inmos headquarters in Bristol in 1984. The technology has inspired generations of engineers and seen many innovative developments across the UK in the following three decades. Despite its chequered history, the story of Inmos contributes strongly to the high tech cluster now present in Bristol & Bath and beyond.

INMOS WAS FOUNDED in Bristol in 1978 by Iann Barron, then a Cambridge-based computer consultant, Richard Petritz and Paul Schroeder, two US semiconductor industry veterans. It was strongly backed by the UK government with the intent of forming a national champion in the emerging industry of semiconductors. Petriz had worked at Texas Instruments in the US and had moved to become a venture capitalist, while Schroeder was a memory design specialist.

The aim was to develop a new generation of microprocessors to take on Motorola and Intel, making incremental improvements in all areas of processor design and, critically, putting the memory on the same chip. The choice of Bristol was the result of political in-fighting at the time, as the North-West and Scotland were politically more acceptable. However, Barron needed the site to be near Heathrow for the regular flights to the US side of the operation, and so Bristol was the compromise.

This was an ambitious challenge. Led by David May and Robert Milne, the transputer design team had to develop not only the architecture and design of the new device, but also develop a suite of software tools to facilitate the design

and develop a workstation to run them on. At the same time the new processor architecture with multiple cores, embedded memory and serial communications links meant more software innovation was needed as well. A new concurrent programming language, Occam, was developed as the native language for programming the transputer.

THE AIM WAS TO DEVELOP A NEW GENERATION OF MICROPROCESSORS TO TAKE ON MOTOROLA AND INTEL

IN 1982, CONSTRUCTION OF A WAFER FABRICATION PLANT IN NEWPORT, SOUTH WALES WAS COMPLETED

"Inmos was a pretty extraordinary project really," said May, who is now professor of computer science at the University of Bristol. "Most of the community was using 8bit devices programmed in assembly language, and we came along with 32bit device with a high level language. It was the first processor built specifically to support parallel processing and in many respects it is still leading edge," he said. "The efficiency of the integration of the processing with the communications is still leading."

The last component of the challenge was to produce a factory to make the chips. In 1982, construction of a wafer fabrication plant in Newport, South Wales was completed.
The process technology development was led by Peter Cavill, who came from Marconi and Jonathan Edwards from Plessey. The company also established a US subsidiary in Colorado. The company needed memory expertise for its product plans and the first actual products that Inmos shipped were memory chips, designed and made in Colorado.

An initial funding round of £25 million had come from the government's National Enterprise Board, but this was almost immediately at odds with the policies of the new government under Margaret Thatcher that came to power in 1979. This situation led to delays in funding the next round of £25 million as the National Enterprise Board was merged into the British Technology Group. As the government pursued its policies of privatisation, buyers were sought for the Inmos shares.

However, as the company faced into challenges in all areas of design, manufacturing and commercialisation, conflict and tension between those groups, and also between the UK and US operations all took their toll on the business. With limited support from government, a sale was inevitable.

In July 1984, a week after a failed bid for British Aerospace, Thorn EMI made a £124.1 million bid for the government's 76% interest in the company – the remaining 24% was held by the Inmos founders and employees. This was raised to £192 million by August and the deal was finalised in September, all prior to the first actual microprocessor being sold.

The first transputers to be sold, the T212 and T414, went into production in 1985, although the second test chip that had been developed had, in fact, been sold to IBM for use as a video controller in the PS/2 computer.

However, after the Thorn deal, there was no additional funding for the company. Profitability had not been attained and, inevitably, redundancies followed with some whole teams being laid off. In these events however, can be traced the genesis of the current cluster beyond Inmos.

The first 'spin off' from the company was Meiko in 1985, with 6 engineers building parallel supercomputers based around the transputer with the first production system, based on the

T414, being launched in 1986. Along the way Meiko developed an innovative interconnection technique. However, Meiko themselves ran into financial difficulties in the mid 1990s and formed a joint venture with Alenia Spazio of Italy called Quadrics Supercomputers. Quadrics remains as an embedded computer division within Alenia Aerospatiale, part of the Finmeccanica group.

The hardware team from Quadrics went on to set up Gnodal in Bristol in 2008 to take the Ethernet transputer interconnection technology it had been developing in a new direction leading to Gnodal being recently acquired by Cray Inc.

Another company, Division, spun off in 1985 to develop virtual reality software and hardware. Set up by a team of four that included Ray McConnell, the company used parallel processing to become the 'world's first public virtual reality company'. Division was acquired by US company Parametric Technologies in 1999 for $46 million and the technology is still used to build virtual worlds.

McConnell went on to found PixelFusion in 1997, which developed a massively parallel processing engine for high performance computing, but struggled to find a market niche. It changed its name to ClearSpeed in 2001 and shifted to providing chips and accelerator cards that plugged into PCs and servers for high performance computing, including scientific and financial systems. Despite deals with IBM and AMD, and selling a supercomputer cluster to the University of Bristol, the company suffered in the collapse of the banking system in 2008 and laid off the majority of the workforce although it continues to sell its array processors.

McConnell has since gone on to found Blu Wireless, developing 60GHz wireless technology for high data rate applications such as linking Blu Ray players to HDTVs without wires and wireless backhaul for 4G LTE mobile phone networks.

Inmos, now owned by Thorn EMI, was still struggling. The end came in 1989 when Inmos was sold to SGS-Thomson, the franco-italian semiconductor company. The charismatic managing director of SGS-Thomson, Pasquale Pistorio, was very enthusiastic about the transputer and wanted to revive it. The T9000 programme was started in 1990 as the next generation high performance transputer but long delays meant the market overtook the technology and the chip never made it into full production, despite a launch in April 1991.

Another spinoff was Motion Media Technology in 1993, set up by a team of eight engineers from Inmos who were made redundant. The company developed video communication networking and a videophone and had a long list of blue chip clients. The company merged with the Scotty group, and in 2005 the intellectual property was bought by AuPix, which was set up by two former directors of Motion Media. A spin-off from Motion Media was EsGem, who were developing a technology for tracking issues in networked products.

By December 1994, Inmos was fully assimilated into the now renamed STMicroelectronics, and the use of the Inmos brand name was discontinued, but the legacy of the transputer continued. The Chameleon multimedia processor was developed by a team including David May – now head of the computer science department at Bristol University and a founder of XMOS Semiconductor – and Simon Knowles – who went on to co-found Element14 (sold to Broadcom) and Icera (sold to NVIDIA), but the Chameleon too never made it to production.

However, the transputer continued to evolve. The most successful incarnation was the ST20, a re-engineered transputer derivative that was incorporated into system-on-chip devices for set top boxes. This, eventually, became one of the highest volume microprocessors in the world with over a billion units being shipped.

STMicroelectronics continued to be a strong influence in the South West, employing several hundred staff at the Inmos site in Bristol working on digital TV hardware and software, hard disk drive software and consumer chips. This particular branch of the story will shortly end as ST has announced the closure of the Bristol site in 2014.

The spirit of the transputer lives on across Bristol & Bath with the city being one of the world leaders in multicore technology, boasting a number of leading CPU development teams and highly complex software development and support companies. This came in part from the graduates who made up the Inmos team. "The youthfulness of the staff meant we were trying to re-invent computing and that's what made it possible to get such experienced people all across the industry," said May. "That was part of the culture," he said. "I'm still amazed that we managed to develop a design system from scratch and used it to develop a state of the art product.

Perhaps the best example of this spirit is at XMOS, where chips with multiple cores and flexible, deterministic interconnect cost just a few dollars. The first devices were launched in 2008 and now with 8, 16 and 32bit cores, and an ARM core, the xCORE chips are challenging the established economics of the micro controller market.

"There was another opportunity that is often missed as the transputer was also seeking to be a system component" he said. "You needed a higher level of abstraction from transistors and gates to assemble systems so the idea was to use a computer as the component. As it happens there were problems with that as it was a state of the art chip so it was an expensive component at the time and it couldn't be made in the quantities needed to build an electronic system. Now it would be feasible to do that and the XMOS core is an example of that."

"If you did the transputer now, it would be probably too small to make – you could put around 4,000 on a single 10mm^2 chip in a 20 or 30nm process, so you really could use it as a system component nowadays," he said. "Back then we were too far ahead of what the economics of process technology could deliver."

The legacy of Inmos provides the region with a key strength in high performance computing systems. Picochip, while not a direct spinoff from Inmos, used key expertise in massively parallel processing networks on silicon, the tools to build such devices and the software to program them and is now part of Mindspeed. Startups such as Somnium and Zenotech are developing the next generation of software for managing multicore systems in the cloud.

As the cluster has developed, so other companies have moved into the area to tap into the skills base and talent pool. Imagination Technologies is a key player in multicore systems, starting with the graphics and video controllers and adding wireless, communications and central processors, and this is a largely a result of Inmos-alumni Sir Hossein Yassaie, its chief executive. In 2011, Imagination chose Bristol as the location for its latest PowerVR Design Centre.

With multinationals such as Nvidia, CSR, Broadcom, HP and others, the cluster continues to grow in both size and breadth. Support organisations such as the Microelectronics iNet have been formed to foster growth and innovation. Long standing networks such as Silicon South West continue to facilitate knowledge share and communications.

The multicore technology – both hardware and software – that was developed at Inmos continues to be used in one way or another in many different applications today. The skills that were developed and delivered have created a generation of highly innovative, experienced engineers that compete on the world stage. The original spirit of entrepreneurship continues to manifest itself in start-ups, mergers and acquisitions. Whilst Inmos itself had a roller-coaster ride, it seeded a wonderfully rich and diverse cluster in Bristol & Bath that continues to thrive.

ABOUT THE AUTHORS

Rick Chapman:

Rick has nearly 30 years of experience working in high tech industries, predominantly Semiconductors and Software. After 5 years with Marconi, Rick joined STMicroelectronics in 1990. Over nearly 12 years, he held a variety of international positions, including Semicustom R&D Director and Business Development Director – Microprocessors.

Since 2001, Rick has worked with several start-ups. He was a founding executive of SuperH Inc., an intellectual property licensing company and, as VP of Business Development, he delivered revenue growth from zero to $7 million in two years. After a spell as CTO of Cobault Ltd, a CRM software company, he joined Spiral Gateway Ltd, a semiconductor start-up designing an innovative reconfigurable microprocessor architecture. As CTO of Reveal2me Ltd, he helped bring a disruptive content delivery platform for smart phones to market.

He is currently Director of the Microelectronics iNet and works with other organisations in Bristol & Bath supporting the high tech cluster.

Don't get him talking about cricket.

Nick Flaherty:

Nick is a Bristol-based freelance technology writer, analyst and consultant who has covered the semiconductor and electronics markets for nearly 25 years.

He is the Embedded Editor for EETimes Europe and writes for a wide range of technical trade publications around the world, including SW Innovation News, covering the technology developments in the region. He has worked for Electronics Times, Electronic Engineering and Electronics Weekly, edited MicroTechnology Europe and Electronic Product Design and started Automotive Electronics, as well as writing for many multinational semiconductor companies.

He is also a member of the West of England High Tech Sector Group and heavily involved with the silicon and technology cluster in the SouthWest as the former editorial director of Silicon SouthWest, and is CTO of his own electronics startup, enchantd ltd.

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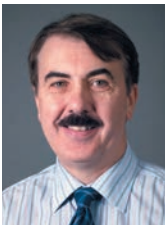

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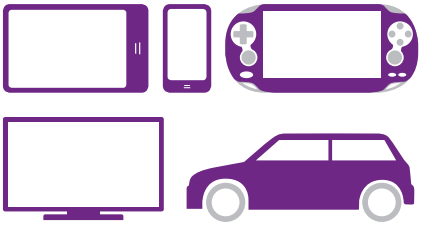

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