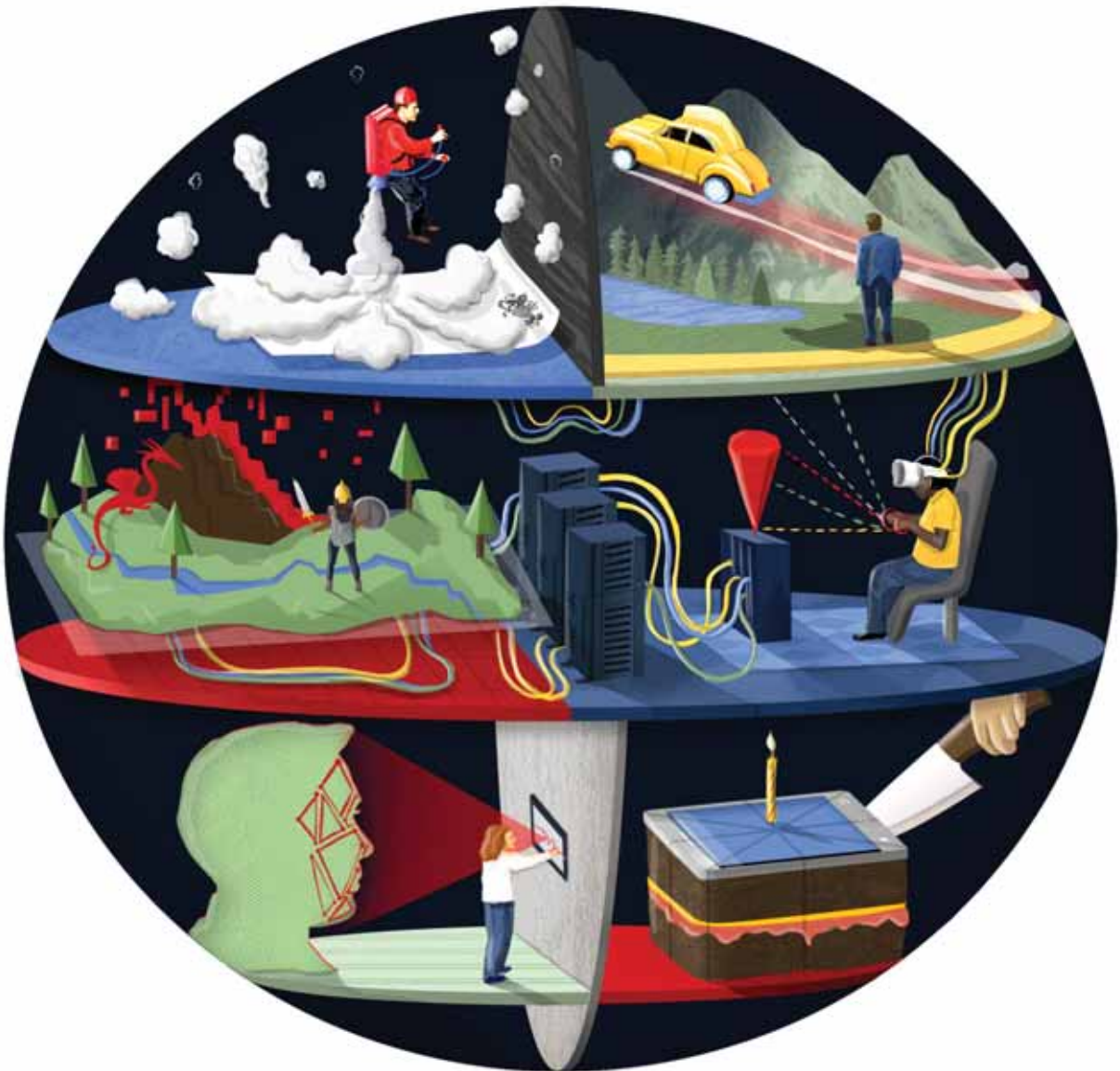# Spotlight

## EMERGING TECHNOLOGIES: BUILDING BETTER WORLDS

Matt Warman MP / Martha Lane Fox / Herman Narula

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# What technology isn't telling us

One of the most compelling experiments in electronics took place in the mid 1990s, when Dr Adrian Thompson of the University of Sussex decided that rather than try to redesign a microchip, he would see if he could create a microchip that would try to redesign itself. Instead of programming the chip to do a set task (in this case, distinguishing between two audio tones) Thompson gave it 50 completely random chunks of unprogrammed ones and zeroes, and asked his computer to see if they were any use to the chip. They weren't, but the computer ranked them anyway, "killed" the least effective chunks, and swapped pieces of code from the most effective chunks to create new ones. In doing so he mimicked, very simply, the rules that govern biological evolution – the most effective persist and are replicated.

Within 250 generations, Dr Thompson's random code had become noticeably less random. Within 1,000 generations, the code-chunks all showed some ability to recognise a sound. A few thousand generations later, a piece of code emerged that was perfectly suited to the job it had been given, despite the fact that Dr Thompson had not written any part of it. It was unlike any piece of code humans had ever written. Untroubled by the mathematical logic of conventional electronics, it used the physical quirks of the circuitry itself to compute in a way that was both bizarre and highly efficient. It took Thompson some time to figure out how it worked at all.

Two decades later, technology is developing around us in ways that look increasingly like evolution. Artificial intelligence, in particular, is a field in which researchers are often unable to say exactly how a programme solved the problem it was given. It may be that we will all, one day, live in Dr Thompson's experiment, and share a world with technology that no-one invents or even understands. It may also still be possible to decide if that world is a utopia or a dystopia.

# Leading the world into the next industrial revolution



**Conservative MP and former technology journalist Matt Warman explains how the UK can be at the forefront of technological disruption**

Technology means the world of work is changing – this new, much-talked-about industrial revolution will shape the coming generation of workers' lives. It may be full of unimagined jobs, robots and drones, or it may be full of artificial intelligence and a truly ubiquitous internet. Whatever turns out to be the case, it will be better for the UK to be at the forefront of this new world order than at the back. Better that we capitalise on our huge geographical, technological, academic and business advantages to become the revolutionaries, rather than have this revolution done to us.

With that in mind, the biggest opportunity this government can seize is to align a new industrial strategy with the Chancellor's stated ambition to invest in research and development with unprecedented vigour. Done right it will take full advantage of Britain's uniquely appealing position between Silicon Valley, Europe and beyond. And done responsibly it will protect the rights of workers as the global economy evolves to adapt to the internet age, as

well as making sure that global cooperation means taxes are collected wherever they are due.

At the most basic level of any technology strategy, however, is of course infrastructure. Those new companies, from Uber to every microbusiness that relies on eBay, are nothing if they and their prospective customers do not have instant access to the web at a speed that fosters innovation.

So universal broadband is a transformative commitment that should be welcomed. It will build on the existing roll-out of superfast broadband that has delivered coverage to British people at an unprecedented rate in Europe, and our more recent plans for increasing full-fibre coverage and development of 5G – the technologies that will ensure we have digital networks that are fit for the future. New technologies, from a host of providers, will mean that 5G is as important as fibre in providing a key part of the technological infrastructure we will need in the future, and the government's conscious bid to

# We should not pretend that all new thinking is progress

promote a mixed economy in which communities help themselves wherever possible is to be welcomed. The devil will be in the detail, but it always is.

In itself, the Universal Service Obligation is an excellent thing, but it is also a foundation for the future. Of course, the 10Mbps starting point is 10Mbps more than those whom it will benefit most are getting at the moment, but it is not a speed that any government would wish to set in stone. I have spoken myself in Parliament of "digital inflation" requiring regular analysis of what the right figure should be for the USOs of the future, and asked that they also consider latency and upload speed as much as they consider download speeds. In short, that means that for some, solutions such as satellite connections may have a part to play, but nobody should pretend that these expensive workarounds will be sufficient for even a small part of the mass market.

On top of this infrastructure bedrock, businesses will increasingly rely on new technologies to increase their productivity, which is why forward-thinking approaches to the regulation of driverless cars, drones and AI will be crucial. When I was first elected in 2015, I was surprised to discover the government already had a driverless cars unit at the Department for Transport, but it is just one indication of the long-term groundwork required for these truly transformative ideas to become reality. Likewise, with Gatwick Airport recently seeing a runway closed due to drone activity, it is important to acknowledge that when new and old technologies meet, there is a host of issues to sort out. More drone deliveries might mean less freight transported in other ways, but government's responsibility is to smooth the transition process as much as it possibly can; there is a balance between backing the Luddites and pretending that all new thinking is progress. But we should bear in mind that all previous industrial revolutions, disconcerting though

the short-term may have been, have created jobs, and improved human health and wellbeing. There are jobs today, some of them fairly new, that in the years to come will be as niche as chimney sweeps and coopers. We are only now working out what those jobs are.

The internet, too, is giving life to human behaviour that is both good and bad: the huge amounts of money raised for charities and individuals, from the Icebucket Challenge to the victims of terrorist attacks, are new and unprecedented. But there is also unprecedented levels of abuse, radicalisation and extremism that technology and technology companies cannot simply dismiss as too difficult.

It was not that long ago that images of child abuse were dismissed as too numerous and too diverse to be detected automatically; today, doing so is routine. Likewise, no responsible company would seek to provide a safe space online for terrorists. Government and business must co-operate to address these unique challenges because doing so is in all our interests.

I'm optimistic about robotics and artificial intelligence providing some of the solutions both to those deadly serious challenges and also to the challenges of ageing, unhealthy jobs and unhealthy lifestyles. The government's commitment to the research and the infrastructure that underpins all of that will be most effective when it is seen in the context of the challenges facing the whole public sector, and where collaboration between diverse areas of government and business is encouraged at every turn.

As Britain prepares to leave the EU, we will have opportunities to write our own regulations in a way that we've not been able to for more than 40 years. That position on the world stage is unique, and seizing it will require the balancing of a host of competing interests. But the prize at the end is a world-leading position for our businesses and our citizens that nobody should doubt.

# Could the games industry remake government?

**Will Dunn meets Herman Narula and Rob Whitehead, co-founders of the billion-dollar startup Improbable, to find out why virtual worlds are technology's next big earthquake**

We stand on the wooden deck of a ship, staring out at a sea of clouds. A school of flying manta-ray creatures drifts past. In the distance, islands hang in the sky.

"That isn't background," says Herman Narula, gesturing to the distant horizon in the video game, *Worlds Adrift*, which we're looking at. "Those rocks in the distance are places you can go to. You can go to all of these places - there is no painted background."

This, says Narula, is the fundamental difference between this new game and every other video game ever made. Every game made prior to *Worlds Adrift* offered "the illusion of a world; this is an *actual* world."

This is what makes Improbable, the London-based startup company founded by Narula five years ago from his parents' house while he was still at university,

now worth over a billion dollars: it offers the means to make actual worlds.

**The million-player game**
The technology developed by Narula, his co-founder Rob Whitehead and his team at Improbable has been widely misrepresented in the rush to explain why a small startup was able to secure second-round funding of $502m, without handing over control of the company. The BBC, the *Guardian* and others have described Improbable as a 'virtual reality' company, but this is simplistic and misleading. Improbable's product is not a game or a headset, but an operating system. In the same way that Microsoft makes Windows and software developers write games and applications that run on Windows, Improbable makes a platform called SpatialOS, upon which new kinds of

**Immersive digital worlds could soon replace social networks**

games are being built. The difference is that each installation of Windows – or any other operating system, such as the iOS software that runs on every iPhone – runs on a single computer. SpatialOS runs on thousands of computers, all at the same time. Improbable's technology is distributed computing, and Narula believes it will be even more influential in our future than the Windows PC or the iPhone have been in our past.

People describe Improbable as a virtual reality company because this is what SpatialOS enables people to make. By bringing together thousands of machines into a distributed supercomputer, it provides software developers with the means to create huge virtual worlds that can be inhabited by many thousands of people at the same time.

The first industry that Improbable aims to transform is the gaming

# Improbable secured $502m in funding, and kept control of the company

industry, the biggest and fastest-growing of the entertainment media. The biggest event in online gaming so far took place in a game called *Eve Online.* Over 21 hours on a Monday in 2014, a conflict over a space station escalated into an all-or-nothing showdown between the game's warring factions. At its peak, more than 2,500 players joined a single map. The game had to run ten times slower than usual to accommodate the number of players present. For SpatialOS, this number of simultaneous interactions would represent a normal day in a small virtual world. Despite the large number of players currently enjoying the early preview of *Worlds Adrift* – Narula says there are "thousands" – the developers are currently limiting the size of the world they're playing in, to give them any chance of bumping into one another.

"When you play *World of Warcraft,*" explains Narula, "you're not really in a single world. You're in thousands of copies of the same world, and those copies are all static. They never change, nothing you do in the world ever creates a lasting impact. So the kind of engagement you can have involves going through a linear story, like in a single-player game, but you have other people around that can help you with it." Worlds Adrift, on the other hand, "is a single world the size of Wales, with millions of simulated entities inside it. And every action any player takes in the world permanently impacts the world in a way that then creates effects that other people encounter."

"It has cartographers," adds Rob Whitehead.

There is a cadence to the way Improbable's two co-founders talk. Narula's speech is very fast but also very detailed and composed, as if he is reading as quickly as possible from an internal textbook. Whitehead says less, dropping in observations that Narula quickly elaborates upon, but in speaking to either there is the same sense of chatty yet formidable intelligence. At one point in our conversation Whitehead makes a comment about the Mandelbrot set,

and from his expression it is clear that he assumes everyone in the room knows what he is talking about.

"Yeah, cartographers," continues Narula. "There are people on the internet, flying around this world with compasses and wind speed, to try to create maps of how big this world is."

Narula is eager to stress that this is not an incremental development in games programming. He describes the difference as "binary"; "you're either running on one server or on a massive distributed cluster. If you're running on a massive distributed cluster, thousands of new things are possible. The endgame for this company, what we're trying to build and to make happen, is literally to create new realities."

It is at this point that Narula's mountainous ambitions loom into view. He talks about upscaling "from thousands of machines to millions of machines, to datacentres that are located near population centres, to the point where we can have low-latency, massive interactions that are happening with millions of people."

If the idea of a million people playing a game at once sounds unlikely, consider that this would amount to 0.05 per cent of Facebook's current membership.

### New nations

On 27 June, Facebook announced that its membership has now exceeded two billion people. If Facebook was a country it would be by far the most populous nation on Earth, with a population more than six times that of the United States (assuming every account is a real person). In 2015, Facebook claimed it had indirectly created 4.5 million jobs worldwide.

For people who work in traditional industries, the idea that a computer game could hold its own internal economy and create large numbers of jobs may sound flimsy. For Rob Whitehead, it's as normal as a paper round. Before he went to Cambridge, Whitehead "built virtual goods - weapons, gadgets, that kind of thing" in Second Life, the online virtual world that has been running since 2003.

"That was my job. I went into uni with a couple of tens of thousands of dollars' worth of virtual money, made from this virtual thing. Of course from my side, I saw it as just content creation, but people within that world derived real meaning and had real experiences because of the things I made."

Narula says most of the value now applied to goods is no more or less real than the things Whitehead built in Second Life. Design, scarcity, social value and skill dictate whether a piece of leather becomes a £1,000 handbag or a £3.99 windscreen cleaner. "So much of what we already do in the industries in which we create value is constructing realities on top of the base value of whatever it is you're dealing with." A game with millions of players would have, Narula says, "its own massive, internally consistent economy".

With millions – or hundreds of millions, or billions – of people joining a virtual world, the current thinking about what constitutes a video game would be left a very long way in the past. In fact, says Narula, "That stops being a game, and it starts being a country."

If the games industry can produce new worlds of this size, the effects will be felt far beyond the community of players and PCs. "This is a fundamental thing," says Narula, "equivalent to AI in terms of its potential importance to society. This comes under the category of those enabling technologies, industrial processes that no-one thinks of, but that happen to enable really important things that happen in the world. Distributed computing, and in particular this type of distributed computing, is that important, that fundamental – and that hard. It requires you to rethink the foundations of how applications are written."

If Narula is right, it will require people to rethink more than just programming. The simulations that can be created in the hive-mind of Improbable's distributed supercomputer are so complex that they may offer the chance to rethink how cities and transport systems and economic markets are run, and how governments create and justify



policy. It may be the most disruptive technology in government since the ballot box.

### The what-if machine

For policymakers the most important aspect of Improbable's work is not the transformation of the $100bn gaming industry but the disruption of how policy is written and tested. "One of the most important uses of virtual worlds," Narula explains, "is answering questions about the real world – a world of complex adaptive systems, which can probably not be understood unless we can recreate their behaviour at very large scale. The weather is a complex adaptive system, and the way we predict the weather is through massive-scale simulation. The same is true of so much of what we do.

"Most public policy is built on shaky assumptions on top of these complex adaptive systems, and being able to properly model these systems is going to

**Improbable's virtual Cambridge predicts how the city and its population will react in different scenarios**

make a big difference. Virtual worlds will become our collective "what-if" machine, before we try things in the real world."

Improbable is already using its technology in this way, with surprising results. One of the first projects was a simulation of the city of Cambridge and everyone in it: "the population, the transport network, the sewage network, the mobile phone network, electricity, gas, water, and also the spread of panic in certain situations. One of the things we found that was quite counter-intuitive was that in some situations, when something bad happens, damage can be limited by actually turning off communication, because it prevented panic spreading, which prevented traffic building up. That was startling. The idea that making people communicate less is going to help people in a disaster isn't something we're proposing as a policy, but these counterintuitive behaviours

look to be interesting."

In the planning of infrastructure, rational but counterintuitive arguments can often lose to more easily grasped assumptions. "The classic challenge," says Narula, "is that a lot of the obvious thinking - building a road to reduce congestion, for example - turns out not to be true when you look at the real behaviour of these systems." Infrastructure simulation could provide a cheaper, more effective way to

## "It stops being a game, and it starts being a country"

determine the efficacy of contentious projects such as HS2 and allow for better planning of everything from telecoms networks to healthcare spending.

What Narula and Whitehead assume, of course, is that people will listen to reason. Brexit's predicted impact on the economy, for example, actually became part of the anti-intellectual rhetoric of the Leave campaign. No prediction about the future of the country can be made apolitically, and it is more likely that virtualisation will be used more by businesses to pitch their case for policy changes than a newly enlightened government.

What is certain is that if Narula and Whitehead succeed in providing the means to create new worlds for millions of people and to change the way governments and businesses plan for the future, their platform will become, like Windows and iOS and Facebook, a very powerful force in the world. Mark Zuckerberg once thought of himself as mere platform provider, outside politics, but recent events have forced him to confront the very real influence his company wields. Do the Improbable founders have a simulation for that?

"There are maybe six Olympian businesses on this planet," Narula agrees, "and the fact is that no-one can argue that they don't have a special and unassailable status of almost undisruptable, hegemonic control over certain aspects of life. I don't know if that's a situation that can continue without some form of rethink.

"Nobody wants to see another group of tech people get rich in a non-socially conscious way. We like to think that what we're doing here will actually improve people's lives in tangible and direct ways. That's one of the reasons that public policy and government work were really fundamental in the early stages of the company. We didn't go there because we thought it was where the most revenue was – we felt it was a way for us to understand what real problems we can impact."

"But," he adds, "video games are cool, too."

# Instead of trying to see the future, start making it

**Dr Calie Pistorius**, **chief executive of DeltaHedron, says that companies must stay abreast of the latest technologies in order to remain competitive**

Anticipating an actionable future enables a proactive shaping of the future, rather than merely reacting to a world predetermined by others. The fate and fortunes of companies, irrespective of the business they are in, are closely linked to the technologies on which they rely to conduct their business.

It is the dynamics of technological change, whether incrementally or disruptive, in products, processes and services, which drive innovation and progress. Emerging technologies present great opportunities, but also strategic business risks and threats to companies' and industries' products, operations, supply chains, logistics, business and manufacturing processes. The strategic business risk here is as much about failing to exploit the opportunities as it is about the threat of an adverse event.

Technologies are continuously being improved, leading to "better, faster and cheaper". At the same time "last year's hot model" becomes obsolete. Some technologies evolve at a gentle and incremental pace, whereas others change rapidly. From time to time the technological, business and societal landscapes are disrupted by radical innovations, often coming from unexpected and different industries to the one in which they impact.

The disruptions typically result from the interaction of a combination of emerging technologies blending with innovations from other fields, be it finance, fashion or fitness. Many emerging technologies are IT-based, including big data and analytics.

However, the disruption can just as easily come from new materials, drones, robotics, 3D printing, virtual and augmented reality, biometrics or the Internet of Things.

Technological innovations spawn new opportunities, jobs and careers, business models, companies and industries; new ways of doing things and new sources of prosperity. When a new technological order is established, expect the industry hierarchy to change. New companies, in fact new types of companies, become the new industry leaders, often those that had no position in the old technology. The "wave of creative destruction" tends to destroy the established structure, triggering the demise of old technologies, labour markets, jobs and skills and eventually also companies and industries based on the old and obsolete technologies.

There are many examples of those who have created successful new futures underpinned by new technologies. Similarly, there are many who have perished whilst fumbling the future, who have been in denial and steadfastly clung to the obsolete, ignored the precursor indicators signalled by emerging technologies or deployed ineffective innovation strategies to deal with them. It not unusual to find that their organisational cultures just could not embrace the technological change, often causing the transition to a new technology to, if it made, to be bungled.

Anticipating what can happen in the future is one thing, knowing what to do about it is quite another. As is the case with all business risks, the process of technological innovation and the associated opportunities and strategic business risks – especially those presented by emerging technologies – should be managed, and managed within the context of an innovation strategy which is an integral part of the corporate strategy. Vigilant and continuous tracking of emerging technologies and assessing their impact are essential elements of this process.
**For more information, visit: www.deltahedron.co.uk**

**Martha Lane Fox** talks to Augusta Riddy about Doteveryone, and how the UK can foster responsible innovation

# The fight for the UK's tech soul



"**S**orry, I'm just choking on a broad bean." Its 5.45pm and Martha Lane Fox is eating her lunch. As an entrepreneur, digital activist, mother of twins, and CEO of Doteveryone, it's surprising she has time to eat at all.

Doteveryone, in her words, is "a think tank fighting for a fairer internet … the notion of a digital society as much as a digital economy". Its journey began in 2015 when Lane Fox delivered the Dimbleby lecture, laying out her vision for an independent "institution to think about the internet in a different way" and to push for as inclusionary digital progress as possible in the UK, so that "no one is left behind". They work in three areas: "digital leadership, digital understanding and digital society".

A key focus of the think tank is trying to close the "gap of experience between what is happening in technology" and what is happening in different spheres of societal leadership. Before setting up Doteveryone, Lane Fox was 'UK Digital Champion' under David Cameron, encouraging people to get online and improving public services through digital access. Did her experience of policymakers cause some concern, leading to the start of Doteveryone? "Sort of … I think one of the most challenging issues that we face is that people making big decisions for us have, not through any fault of their own, not had the opportunity to immerse themselves in the digital world".

The think tank, as part of their digital leadership drive, set up an MP mentor programme, "we got a cohort of MPs and matched them with a mentor and helped them to learn a bit more about the digital world" in an environment where they felt comfortable to ask questions and admit if they didn't know something. They

offer similar services to other public service leaders; Lane Fox admits that even she gets "completely confused and lost so how must it be if your main job is worrying about a hospital".

In her Dimbleby lecture, Lane Fox opened with an anecdote from her time as founder of the now hugely successful site lastminute.com, when she was 25 years old. She and her then-business partner Brent Hoberman were raising

# "We don't have women making the big decisions"

money for the project, and a potential investor only had one question at the end of the pitch: "What happens if you get pregnant?". She is passionate about getting women into tech, and walks the line with her own organisation: the leadership of Doteveryone is 85 per cent female and both their CTO and CEO are women. "We've just got an amazing group of kick-ass women who are talking about technology". For Lane Fox, the underrepresentation of women in tech is nothing short of a disaster, "it's one of the most pressing issues to face the sector: that we don't have women in leadership roles and we don't have women making the big, important, complex decisions".

Sexism in the technology sector, although ongoing, has received more attention in recent months with revelations of sexual harassment in high-profile Silicon Valley firms like Uber. Lane Fox, although concerned about

these incidents, believes it isn't a problem specifically with tech culture, but rather the industry mirroring discrimination taking place almost everywhere, "you've got to be careful to not lump all these things together. There's clearly something going on at Uber which is not true in a huge number of other good tech businesses ... I think it [sexism] is pretty prevalent across lots of different bits of the world".

That an industry which is less than 20 years old is following suit is the real tragedy. Recalling when she first became involved in the sector, the sense of optimism and the assuredness that this time it would be different makes her disappointment all the more acute, "I am horrified that we have replicated the old hierarchy in an industry that didn't exist".

Sexual inequality isn't the only thing that Lane Fox is fighting, "we still have a crisis in this country of numbers of people who can't afford or don't know how to use the internet". She is almost evangelical about the power of digital skills to make a material difference to someone's quality of life, "if you watched my lecture you'll know what an insane belief I have that digital skills don't change the world, but they can sure as hell help you get a job". Meanwhile, a high number of jobs in the tech sector are waiting to be filled, "and if we don't fill them then we won't have such a vibrant economy".

But surely technology also has the immense power to take jobs away? "I feel like there's more emphasis than I can remember in the last 5 years on the nature of work, how the workforce is going to change and the annihilation ... that's going to happen to some industries". Is basic income the answer? She's not sure, but it is a question that needs to be addressed by policymakers now. "We've got to start testing and working through lots of different creative scenarios".

The morality of increasing digitisation is something that Doteveryone focuses on, and the need to apply values to this unruly realm is an idea that has

# "It's not too late to be ethical about the internet"



preoccupied Lane Fox for some time: "It's not too late to be ethical about the internet". As a think tank they have been analysing the example of fairtrade, "the fairtrade group started off with hippies and bananas and now loads of people don't want to buy products unless they know where they came from and I think there's model there for the internet".

The underlying concern is that as a country, we need to be moving much more quickly in order to be prepared for this new reality which is already upon us, "we're living in a world where the internet is the organising principle and we're not organised around it". Lane Fox believes that regulation will be applied, but it's happening too slowly, "We will look back on this time and think 'wow it took us a long time to work out what to do!'. I'm sure it will happen but I couldn't posit a guess where from and how right now". This concern goes beyond Westminster, "it's not just about Government. Fairtrade didn't come from Government so there's stuff you can do through movements and campaigning that can shift behaviour".

As for the international order, she predicts that some of the big companies will need to be broken up, "there is a danger that they have become so much more important than country

governments that it gives them a displaced sense of what is in their control and power. These are all dangerous dynamics". She is adamant that the people who work for these companies are, on the whole, decent; "I don't believe they get up in the morning to be unethical. I don't think that at all". The answer isn't to stifle their innovation, but to catch up.

What is Doteveryone most excited about right now? "We love the internet! My idea was not an attempt to make it feel less of an exciting place but an attempt to make it feel more of an exciting place, but for more people". Clearly, her sense of awe has not diminished since that pitch when she was 25, "I was talking to someone from DeepMind earlier and some of the stuff they're working on ... it's terrifying and extraordinary in equal measure, but it's still exciting". Her focus now, and the focus of Doteveryone, is to make that excitement universal, "half the world is still not using the internet and there is a hugely important divide between people who have it and those who don't ... the extraordinary empowerment that comes when you can give someone access; that to me is as exciting as the latest, whizziest bit of technology".

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# Why "big data" is the next big thing

**The UK's manufacturing industry is on the brink of a digital revolution, writes Dr David Bott, principal fellow of Warwick Manufacturing Group, University of Warwick**

Manufacturing is an important part of how we judge progress in our civilisation. From the first transformation of found stones into cutting tools about 2.5 million years ago, to the use of production line processes in the last century, humanity has used the latest ideas and technologies to address its problems and achieve its goals. You can debate how many industrial "revolutions" we have seen but from that early use of fracture mechanics to the latest application of digital technologies, our desire to turn raw materials into increasingly sophisticated artefacts, and make money in the process, has never been in doubt.

The use of digital technologies is interesting in that they could be viewed as transforming raw data into usable information in a process analogous to the physical transformation we are familiar with in manufacturing. The ability to collect a wide variety of data from distributed sensors, to analyse it alone and in combination, to store and easily retrieve both the base data and information and knowledge it can be turned into, allows any part of the manufacturing cycle to be improved or replaced.

It was first applied to individual machines in the factory decades ago, then used to link those machines to improve both efficiency and quality. About this time, the link between designing on a computer and making with a computer-controlled machine was made. The internet allowed data transfer between organisations, and this coordinating process was applied up and down supply chains to drive overall efficiency. This allowed producers to share information of products and delivery within the business chain, and that capability was applied more widely – to the customer; an application which has seen its most accessible manifestation in the logistics area.

What this digitalisation also gives us is the drive towards an understanding of the underlying business processes – and allows us to think whether it could be organised differently, from sourcing materials and components, to interaction with customers. But there are pitfalls. The analysis of large data sets to discover patterns of behaviour and apply them to increase effectiveness and efficiency is different from the old algorithm-based approach. You do not need to understand the underlying science to use a pattern. But if you have not captured all the relevant data, the pattern may lead to changes in the wrong direction – you will often hear people talk about the difference between causation and correlation in this respect. It is important, therefore, to find a way to tie back insight gained from this approach to a fundamental understanding of what you are doing.

The other challenge to overcome is the security of your digital systems. We are sadly getting used to digitally controlled systems either breaking because people don't use them properly, or being deliberately broken by people for their own advantage. Any system with as many sensors and low level controllers as is required to manage a whole manufacturing process is prone to these problems and must be fully safeguarded. But there is little doubt that digital manufacturing is partly here already. The only question is how long it will take individual companies and what route through the forest of opportunities and acronyms they will take.

*After 26 years with BP, Courtaulds and ICI, spent in both their corporate centres and business units, David Bott began a love affair with start-ups ten years ago. He was diverted into spending seven years setting up and directing the Technology Strategy Board, since rebranded as Innovate UK).* **To find out more about digital manufacturing and the work of WMG, please visit: www.wmg.warwick.ac.uk**

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# Collaborative innovation: the new R&D

**Jonathan Blair**, managing partner at law firm Bond Dickinson, explains how the pursuit of innovation is bringing the Davids and Goliaths of the business world together like never before

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They say two heads are better than one, and this is as true in business as any other environment. Large companies can find it a challenge to innovate because, while they are keen to take advantage of advances in technology, they are held back by their size. Smaller businesses, meanwhile, can be less risk-averse and unencumbered by structural process, but they can lack the capital and leverage to take their ideas to the next level. By combining the strengths of both, the potential of firms both big and small can be unlocked.

In my experience, collaborative innovation takes place when you have a big business that sees the need to change and future-proof itself, but recognises also that it isn't nimble enough to do so. A small or medium sized business (SME) that displays innovation and fast progression can then replace what the large firm is lacking. Collaborative deals come in three forms: acquisitions, minority stake investments, both of which form the vast majority of transactions, and formal joint ventures. Acquisitions involve one company purchasing another, wholly incorporating the strengths of the SME into the larger organisation. In a minority stake investment, the larger organisation buys 50 per cent or less of the SME. This is a good option when the talent that founded and grew the SME are part of its value, and need to be retained. In a

## Businesses have invested £102bn in collaboration

formal joint venture, the two companies create a new corporate entity without the larger needing to buy any part of the SME.

Over the last four years, big businesses have invested £102bn in UK-based SMEs in this way, through 5,447 deals. This signifies a huge departure from standard-practice investment in research and development (R&D), and a growing trend. It is now estimated that corporates spend 65 per cent more on collaborative deals with SMEs than they do on R&D.

Why has this shift taken place? Traditional R&D is done in-house, on the back of a budgeting exercise that is time-consuming and involves a lot of bureaucracy. This is unfortunately typical of large businesses and the structures that hamper them. If a business wishes to pursue a collaborative deal with an attractive SME, some set-up time and cost is involved at the outset, but most of that

paperwork is cut out. The SME can be left largely in whatever shape or form in which it was found, and the investor company can decide to what extent it would like to become involved.

While collaborative innovation may sound futuristic, it is in fact particularly well suited to traditional businesses that have not historically taken advantage of innovation. The financial sector currently leads the way, with a third of all deals between big businesses and SMEs being collaborative. In the past four years, £31bn has been invested in this type of collaboration by the financial sector. There are historical reasons for this, most notably the fact that the industry was ripe for the application of technology to a very old and traditional sector. Two years ago, people hadn't heard of the word fintech, and financial services companies were forced to make dramatic changes. They have done so at astonishing speed.

The financial sector favours minority

stake investment, which makes up 75 per cent of the deals that take place. The trailblazers of the fintech revolution have almost all been small to medium-sized businesses, so it is no wonder that big banks and other financial institutions have sought them out. Research by Bond Dickinson demonstrates that for financial services and the insurance sector, collaborative innovation has allowed companies to adapt effectively to digital disruption. It has enabled them to engage with exciting startups, creating links that benefit both partners. Instead of turning their backs on the young companies changing the sector fundamentally, large financial institutions have further shored up their futures by embracing and incorporating disruptive elements into their own business models.

The second most collaborative sector is the manufacturing industry. In contrast to the financial sector, 83 per

# Growth is only going to be driven by innovation

cent of deals are mergers and acquisitions. Manufacturing has more of a history of pressure to innovate, and did not need to make so great a leap to become collaborative.

When companies seek a collaborative deal, the David in the scenario will need to approach it with caution and awareness to avoid being gobbled up. As the smaller partner in this process, and therefore the one carrying less clout, it is crucial that the SME in question is clear about what they wish to gain from the collaboration.

An SME's unique selling point is that they are nimble, creative and free from laborious process and procedure. They must recognise the value they hold, and that their agility could be at risk if they are not careful to preserve their independence. Large companies naturally want to keep an eye on the money they have invested, but that can lead to imposing the same bureaucracy on the SME that they sought to rise above in the first place. This is a particular risk for acquisitions, in which companies can find that by trying to incorporate SMEs into their structure, they lose the fluidity and ingenuity that originally made the SME an attractive investment.

To ensure that both parties get the best out of these asymmetric deals, we recommend that a few key principles are adhered to – the five secrets of collaboration. I want to highlight two in particular: culture and motivation. It is a challenge that all businesses face as they grow and become more successful: how should the culture of the firm be preserved? For an SME to thrive in a collaborative deal and for the investor to get the best returns, it is necessary to create a culture of independence, and establish early on an ethos that encourages innovative thinking and practice.

Motivation becomes crucial when the two companies have come together in their chosen arrangement. Without the financial pressure to pursue exciting business ideas, the SME may become slow-moving and stale. In minority stake investments, cultural incentives are most effective, whereas in acquisitions, money is likely to be a more significant motivator. Whatever their principle motivation, it is important that SMEs make their priorities visible before going into collaborative deals, to avoid disappointment down the line.

Unsurprisingly, collaborative innovation has taken a hit in the wake of the vote to leave the EU. We had seen a steady increase in collaborative deals but post-referendum there has been a drop of 28 per cent. Big businesses are pausing for thought, and it is critical that continuity is restored in the wake of a disruptive general election and a destabilising result. The decrease in collaborative deals should concern policymakers. It is a clear indication of economic strain, and therefore an increased risk to SME investment. Growth in any sector, in any country, is only going to be driven by investment and innovation. It is my opinion that nobody ever grew a business by cutting costs. In the UK we have a strong heritage of innovative trading and of growing beyond our borders. With stability restored, I am confident the collaborative innovation trend can bounce back.

Bond Dickinson is a high-performing law firm based in the UK with excellent access to Germany, France, wider Europe and the US. Our top-standard lawyers and strong international links mean we are at the forefront of collaborative innovation, working with such firms as AIG and Atom Bank.

We assist clients at every stage of the collaborative process, from initial advice and consultation to legal execution. Bringing together Davids and Goliaths in this way to foster exciting new pathways is something that Bond Dickinson is proud to facilitate. Greater cooperation can only be a good thing, exploiting the resources of businesses large and small to create a more innovative business climate overall.

# The ID card you didn't know you had

**Law enforcers and businesses can now routinely identify you, at a distance and without your knowledge, using a data source you can't change: your face.**

Oscar Williams **looks into the implications of this growing technology**

Just over a year ago, the *Guardian* published a story headlined: "Face recognition app taking Russia by storm may bring end to public anonymity." If it sounds like clickbait, it isn't. The story featured FindFace, a Russian dating app that lets users identify people with 70 per cent reliability, simply by capturing a photograph of a crowd.

At present, FindFace is limited to users of a Russian social media site - but facial recognition is hardly confined to Russia. Police, retailers and social media firms in the UK are increasingly using the technology to identify members of the public without, some critics say, adequate scrutiny.

The issue came under the spotlight in April when it was revealed that South Wales police force was set to deploy facial recognition to monitor football fans who were in Cardiff for the Champion's League final. Faces were scanned and cross-referenced against 500,000 custody images stored by local police forces.

It's not the first time facial recognition has assisted with policing at major events. Over the last two years, the technology has also been deployed at Download Festival and Notting Hill Carnival. British forces are considered to be at the forefront of the field internationally.

Luciano Floridi, professor of philosophy and ethics of information at the University of Oxford, says the application is still in its infancy, but advancing rapidly: "The hype is on the capacity of this technology to identify people through facial recognition without knowing what you're looking for, automatisation throughout," says Floridi. "The hype is still slightly unjustified to be honest. But the hope [is] that one day, we may just be a step away [from automating the process]. It's difficult to tell, because technology is developing so quickly that, and I'm serious about this, it could really be around the corner."

One of the most pressing ethical issues, Floridi suggests, is not whether the police should be using the

## "How can we be sure this is not dragnet surveillance?"

that is recorded does not end up on a permanent searchable database?" She adds that the technology is developing rapidly and the police are demonstrating a real appetite for using it: "We need an urgent public debate about the use of such intrusive surveillance."

South Wales police force did not respond to a request for interview, but shared public videos in which officers discuss how the technology works. Assistant chief constable Richard Lewis said the facial recognition had already helped the force to catch a man who was wanted on recall to prison.

A report published by the Royal Society and British Academy last month found that the UK's current framework for data management is failing to keep pace with technological progress. The institutes called for the government to establish a new, independent body to oversee the management of data by the public and private sector. Floridi, who was part of the working group that wrote the report, said the organisation could assist law enforcement agencies. "It would be for that body to advise the police for an ethical treatment of the deployment and use of facial recognition. It would go a little bit beyond the strictly legal context that would ensure compliance."

The independent body could also help retailers to deploy the technology with greater transparency. In 2015, a survey of 150 retail executives from IT service firms Computer Services Corporation found that a quarter of shops used the technology, a figure that rose to 59 per cent for fashion retailers. But despite the proliferation of facial recognition, shoppers remain largely unaware of when they are within its gaze.

Duncan Mann, chief operating officer at retail analysis firm Hoxton Analytics, told the BBC in March that the technology is popular among shops that want to compete with online retailers: "Online retailers gather all kinds of information about shoppers, and physical stores also want to understand how people behave in a shop."

So how might it work? Maja Pantic,

technology, but what happens to the thousands of newly collected images after the event: "If the police were to say: 'The data would be destroyed after 24 hours. We just check them. We're not interested in finding you. We're interested in finding these five people, who we are worried might be carrying a bomb into the stadium.' Okay, well I can live with that. It's the boundless, endless repurposing of data that worries everyone. In short, we are entering into the unknown. It's like saying - trust me, I'm going to use the data forever, but I'm not going to misuse them. That's a bit of a blank cheque."

It's a concern shared by Millie Graham Wood, legal officer at Privacy International, who says the technology goes much further than CCTV: "We are talking about sophisticated tracking technology; that might be cross-referencing our faces with custody records and other datasets, to build up a detailed profile of you. How can we be confident that this is not dragnet surveillance, where every single face

# Shops may be able to link faces to email addresses

a professor of affective and behavioural computing at Imperial College London and a world leader in facial recognition research, says that shops may be able to link a face to a name and email address when a customer makes a purchase in store and signs up for a loyalty scheme. If the shopper then returns and CCTV is able to identify them, the retailer could send a follow up email if they leave without making a purchase.

Under the EU's General Data Protection Regulation, which comes into force next year, the analysis of facial images for the purposes of identification is explicitly defined as biometric data, alongside fingerprints and iris scans, and must be treated accordingly. A spokesperson for the Information Commissioner's Office said: "Any organisation must make sure that any images are only used for a specific purpose and that people are aware they may be recorded and that appropriate measures are in place to keep the recorded images secure."

At Imperial, Pantic is working on FACER2VM, the largest UK project in the field of biometrics. Her work could revolutionise how facial recognition is deployed: "My group is working on a very specific topic and that is recognising people through facial expression. It means that even if you have a very, very sophisticated mask, the kind Hollywood produces for actors to look like another person, we would be able to recognise people by the dynamics of their faces for as long as we observe them. This is for the highly secure systems, where you really want to exclude the possibility of having an intruder, such as for pilots or the FBI. [...] We are working very closely with the Home Office." Nevertheless, she says that the technology should only be used for the initial identification, rather than in a court of law, because accuracy can't be guaranteed.

Despite recent breakthroughs in her own team, Pantic is concerned about facial recognition research being conducted behind closed doors in Silicon Valley. Artificial intelligence or machine learning, the process that underpins facial recognition, improves as it analyses new data. As such, Google and Facebook have a major advantage over academics in the form of their vast image banks. The disparity is widened, Pantic says, by the brain drain from academia to universities and the ability for big firms to easily buy startups: "This is very scary. It could mean complete innovation concentration in a very few companies."

A Facebook spokesperson pointed to the firm's Facebook Artificial Intelligence Researchers (FAIR) initiative, which they said "actively engages with the research community through publications, open source software, participation in technical conferences and workshops, and collaborations with colleagues in academia". The spokesperson added that the firm complies with EU data protection law. Google did not respond to a request for comment in time for publication.

The opportunities and risks associated with artificial intelligence may finally be gaining traction across Westminster and Whitehall. At the end of June, the House of Lords appointed an ad hoc committee to consider issues related to the economic, ethical and social implications of the technology. Floridi says he's optimistic that the proposal for an independent body to monitor data will be welcomed by government: "I would be very surprised if it was not well received and I expect things to move in that direction in a year or two."

But he's more cautious about the government's approach to surveillance, in which facial recognition is likely to play an increasing role. Floridi concludes that in the wake of recent terrorist attacks, the issue has been "politicised and for the wrong reasons": "This is coming top down. It's an instinctive reaction; more risks, more monitoring, which is just not what we need. We don't need a bigger surveillance state. We need more social acceptability and preferability for the solutions we need to have. You can't just impose it because you say so. That's the major opportunity [the government] is missing."

# Virtual reality and the modern customer journey

**ZeroLight associate marketing director** Joseph Artgole **explains the value of deploying virtual reality in the automotive retail process**

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Immersive technologies have been opening new avenues to consumer engagement in a number of markets. The automotive industry, in particular, is seeing such technologies transform the point of sale, changing how consumers interact with high-value products. International brands have already deployed virtual reality experiences at different stages of the customer journey, differentiating their proposition to enhance engagement amongst their target audience.

Toyota utilised virtual reality as part of a high-impact digital campaign for the Toyota C-HR prior to production. As a mobile solution, the Toyota C-HR VR experience was set up in high footfall areas across Europe, allowing potential customers to explore and sit inside the vehicle, on the real seat, without the car present. Audi harnesses VR at the point of sale, delivering their entire product catalogue with all options and upgrades for their customers to explore. Alongside the portfolio, customers are immersed in unique environments in which they can create their desired vehicle to scale, including the moon. Such practices are exclusive to the medium, allowing for signature features that provide a truly memorable experience. Italian hypercar manufacturer Pagani use the medium post-sale, allowing customers of their Huayra range the chance to interact with and explore their potential product to scale before production. The value of digitisation is significant as their vehicles are hand-built to specification; no car is the same and the possibilities are endless.

Whilst these three case studies alone highlight the unique benefits of deploying immersive technologies within the retail space, recent research has uncovered the customers' perspective on the medium – 82 per cent of 1,000 respondents polled across the five largest European economies indicated an interest to see, explore and configure a car to their preference using VR/AR technology prior to purchase, and 65 per cent said they would be more likely to visit a dealership if they knew it had an immersive technology experience in place. Half said they would be more likely to explore more of the dealer's range of cars, whilst 40 per cent said they would experiment with optional extras. Such figures emphasise the value of the medium at the point of sale, especially when the biggest pressures dealers face within the modern marketplace are declining visits and upsell potential. Going beyond the dealership, 78 per cent of respondents agreed that the technology would give them a greater connection with a brand. An experience that's well executed can effectively drive positive attitude formation, encouraging advocate behaviour and word-of-mouth promotion. Indeed, 29 per cent of the sample confirmed that they would be likely to tell a friend about a potential VR/AR experience.

A successful immersive commercial experience allows the customer to naturally formulate an opinion. This means they have to perceive the product with absolute clarity and be able to react intuitively within the digital space. Accordingly, 48 per cent of the sample confirmed that visual quality and interactivity are the most important features within an immersive experience. For the automotive industry, combining these values with an experience around configuration holds significant value. Of those surveyed, 90 per cent stated they expect to be able to configure their vehicle prior to purchase, making personalisation a requirement for modern dealers. By taking one of the most significant processes in the purchase journey and delivering it through immersive mediums, you can create a compelling, unique and consumer-centric engagement tool.

**Martin Docherty-Hughes MP** is the SNP's first ever spokesperson for the industries of the future. Here, he explains why his party created the new position and what he intends to do with it



# Technology must serve the people, not vice versa



We are often told we are living at the start of a new industrial revolution, an age in which our world will change beyond compare. For many that has already happened, and in reality it is Europe and North America that seem to be the developing, rather than developed, nations of this new age.

That is a crude assumption, even for an unseasoned politician like myself. In reality, that is the non-digital reality nation states are wrestling with in the concept of industries of the future, their application and impact. Governments across the globe are playing catch-up with states such as Singapore, Estonia and Rwanda, where it is recognised that necessity is the mother of invention.

These three independent nation states share a not dissimilar history in which economic, physical and political trauma have played a significant role defining their recent histories and the challenge of

overcoming them; Singapore bound to a reality of no natural resources, Estonia starting from scratch in the post-Soviet age and Rwanda rising from the ashes of genocide. Each challenged in the very concept of what it means to be a sovereign nation state in a post-colonial and post-communist age. While their starting points differ, all three began with a recognition that to exist, they must give their nations' peoples a rationale to stay, a rationale to believe that the state's vision of the future is one which improves living standards, life expectancy and opportunity.

The ability to start from scratch has enabled these small nation states to lead the way in advancing technology at every level of society, from voting to paying taxes, to giving small business the opportunity to emerge and grow in the most challenging environments. It is a national endeavour.

# Governments across the globe are catching up

Elsewhere in the world, we are not starting from scratch. We are the inheritors of an industrial structure founded at the dawn of the 16th century, emerging from the printing press to the industrial landscape of Dickens. It is an infrastructure on which old scientific advances were well matched. An infrastructure that enabled the hierarchy of business and inhibited democratic participation and equality, an age which required revolution to enable basic change. It is an age of colonial and communist dominion over the drivers of industry and thought. It is an age for the few.

It is one which I am well acquainted with; my father, now nearing his 83rd birthday, is a coppersmith, a trade learned in the greatest shipyard of the 20th century – John Brown of Clydebank. The shipyard no longer exists and the town has changed beyond belief. Technological advancement placed us at a profound disadvantage at a time of great change. While shipyards in South Korea and Norway embraced new and innovative approaches to ship construction, the UK was quickly left behind.

Having been given a new portfolio as spokesperson for industries of the future, a portfolio that covers a profound range of uses from the morality of AI to how robotics can assist in the perennial issue of an ageing population, I am conscious that the SNP must seek to engage in the debate as well as championing practical investment in the infrastructure of the future. In doing so, we will rise to the challenge of building a nation state that is more equal, more able to offer its people improved living standards, improved life expectancy and freedom in ways our parents and grandparents could never imagine.

This is a scientific endeavour that

# The digital age should be one of equality



**The Falkirk Boat Lift connects Scotland's canals, but also its engineering past and its technological future**

must be measured not only by wealth creation but by prosperity and equality across class and geography as its main purpose. The more equal a society is, the more secure it is.

While still a devolved political state, Scotland will face many limitations and challenges in delivering infrastructure for industries of the future. No doubt many will countenance the quick fix of retrofitting, which we must caution against. Retrofitting the digital age on top of the industrial age will allow a range of difficulties to emerge; it will maintain and embed monopolies in both the public and private sectors, critically in the financial sector and in the arena of democratic participation, burdening small- and medium-sized businesses as well as local communities with structures that limit innovation and opportunities to deliver greater equality.

Scotland is already looking beyond the physical boundaries to independent nations such as Finland, Estonia and Iceland to inform a range of policy fields, none more critical than skills. And yet we all need to look at the economic model that will deliver this change, and one

country stands out in its philosophical and practical approach as well its ability to challenge industries of the future and to enable innovation in science through one of the most traditional concepts in our societies – community.

We must reflect on the Mittlestadt of Germany as a model which enables stability and growth, not at the expense of communities, but with them at its heart. Wealth creation alone, without stability for communities, must be rejected. The social wealth and social capital of communities, as well as their resilience, are a far better measure of the effectiveness of government policy. There is now an opportunity for the industries of the future to be at the heart of equality, dignity and liberty.

Technology and the House of Commons do not go together. Nevertheless, it is my intention to speak out in this bastion of the past on the profound challenges we and our children will confront in the not-too-distant future.

If I have a hope of what the digital age will be, it is an age in which equality and dignity are the drivers of industry and thought. It must be an age for all.

# Businesses must evolve alongside technology

**For the emerging technologies of the fourth industrial revolution to be useful, more advanced business models are also needed, says Forcam's**

Andrew Steele

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**FORCAM**
*we speak machine*

Factory economics traditionally focused on the guy on the shop floor. Manpower was the only thing that could be accurately recorded - how many people walked into the factory on a Monday morning, and what the output was on a Friday - and the rest was a very complex system that very few people understood. The man on the shop floor was far from the most significant cost, but it was always that way, because that was the part of the cost that people could control and easily understand. Instead, they should have been looking at what their equipment was doing.

Because there are so many variables, people were unable to do that – until now. With the data we're collecting and the analytics we can run on it, we're helping to develop tools that can analyse the vibration characteristics of a machine as it makes a run of 100,000 parts. We can now look more at the future state of that equipment, to predict how it can be maintained and to make better decisions about how it could be used. These concepts are not new, but the ability to actually carry them out is, and the changes they bring are profound. We're seeing fundamental changes in the way people run their businesses. People are finding better economic models for running their factories, with profound knock-on effects in management and culture across businesses.

This is something businesses need to consider seriously as they adopt new technology – the new economic models required by the new things they're using.

Servitisation – offering things as a ongoing service rather than a single transaction – is a good example. Recently we've been talking to companies about an "Uber for manufacturing" model, in which they would pre-qualified to make certain parts, and they would be able to advertise when they have free capacity, and to change their pricing to spot rates.

Some industries are already well set up to move to this way of working. In autosport, for example, the price of a part isn't so much of a concern – it's whether you get it by Friday. People pay for speed, flexibility and skill. With the right technology, more traditional sectors could follow. In aviation, for example, companies currently invest in the knowledge that they're going to be making a specific part for five years. But that might only take up 70 per cent of their factory; there might be another 30 per cent that is more flexible.

Understanding and regulation will be necessary to making this kind of change successful. Businesses need the knowledge that informs how you do business in this new way, and there must be membership criteria for companies offering services.

With better communication and use of data, economic models in which people can fill spare capacity or pay a premium where there's a shortage in the market are becoming inevitable. There will be models where people pay for higher skill, higher technology options, and opportunities for smaller, more flexible manufacturing, closer to markets. It will no longer be viable to have something shipped for eight weeks or sitting around for months before it can be delivered, if you can deliver it in a week from a flexible, high-end facility that doesn't just make one thing, which can adapt quickly and has a very skilled workforce.

I think we're seeing the end of huge, centralised monster companies, in which people don't dare make their own decisions. Most of the new technology we work with at Forcam is about getting the right information to the right people, and making decisions at the right level. Some bigger primes still see technology as a centralising force, but I don't. I see it as giving the little guy the power to stay a step ahead.

# Is our connected future really secure?

**Duncan White**, **patent attorney at Marks & Clerk, explains why we need to get "smart" about the Internet of Things**

Imagine you are the proud owner of a WiFi kettle. Assuming you have the technical ability to connect it to your other devices, you can wake up to a freshly boiled kettle, allowing you to enjoy your first cup of tea three minutes earlier than those with the "dumb" (as opposed to "smart") alternative. This is just the tip of the Internet of Things (IoT) iceberg.

As the name suggests, IoT relates to the connection of a device or physical object (including living things) to the internet, for the purposes of information gathering and analysis. Generally there will be an "edge node", or endpoint, which may be the thing itself, such as a device comprising a sensor, say a smart thermostat, or air quality sensor, or a sensor attached to the thing of interest. This could be a location monitor on a cow for instance. In order to attach the edge node to the internet there must be some form of wireless communication.

Consequently, IoT is a merging of technologies – the endpoint hardware (usually sensors), telecommunications (especially wireless protocols), and data aggregation and analysis (so-called "big data"). Furthermore, IoT applications are not restricted to a particular sector, and range from retail to agriculture (not just cows), to smart cities and autonomous vehicles.

The prediction of 50 billion connected devices by 2020 is popular but outdated. While industrial applications have progressed significantly – contributing to Industry 4.0 – IoT is still struggling to take off in domestic settings. Certain attempts at connecting consumer devices have generated bad publicity, ranging from incredulity to outrage over privacy and security vulnerabilities – the hacking of baby monitors for example.

There is still plenty of hope for our connected future, however. The technical challenges preventing widespread adoption of IoT in the home – energy efficiency and effective wireless communication – have now mostly been overcome. In contrast to the unclear value propositions of early applications, we are seeing more IoT innovators focusing on solving real-world problems.

The most pressing challenge is now security – the more complex a system, the greater the potential benefits to individuals and society, but also the greater the security risks. Take the example of a house fitted with a WiFi-enabled lighting system. The resident will have a hitherto unseen level of control over their domestic ambience, while a successful hacker might be able to disturb their sleep by flashing the bedroom lights. Now consider tens of millions of the same system, installed across a country – big data may help energy providers predict demand, whereas hackers may be able to attack the grid by causing a surge in demand (or create a botnet for DDoS attacks, such as Mirai).

Elsewhere, cybersecurity is an issue of international significance, particularly in light of the recent WannaCry ransomware attack. The potential for IoT to create vulnerabilities to key sectors of national and global infrastructure makes the issue a top priority for those in the IoT community. For those developing smart devices and the systems that connect them, security is becoming an obsession, and they are filing more patents for encryption and authentication methods, which can only be encouraging for the future of IoT. However, many players pushing their own solutions to the security problem and it remains to be seen which if any solution will gain acceptance and become a de facto standard.

**For expert advice on safeguarding innovation, visit: www.marks-clerk.com**

# Opening up the black box

**In order to make effective technology and innovation policy, says Dr Carlos López-Gómez, head of the Institute for Manufacturing's Policy Links team, we need to know more about how innovation really happens in modern industries**

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New technologies and applications are emerging at unprecedented speed. If the UK is going to benefit from the research coming out of our world-class science and engineering base, our innovation policy needs to be grounded in an understanding of the technologies themselves, and the manufacturing systems in which they are to be deployed.

Consider some of the new technologies that are attracting attention from governments right now – bio- and nano-manufacturing, robotics and AI, advanced materials and 3D printing. Turning research into economic impact is not a straightforward task, and it is hard to establish a clear sense of policy direction. Research in these new areas is typically spread across a wide range of disciplines, and it's not only subject expertise that needs to be brought together. In order to bring these technologies to a commercial scale, 'scale-up' risks and challenges need to be addressed all along the value chain.

Add to this the fact that an increasing number of countries are becoming serious players in global manufacturing. The result is lack of clarity as to who the winners, and losers, in the industries of the future will be – and the role policies should play in determining this balance.

**From research to real economic impact**

How can this complexity be navigated? The answer is to open up the "black box" of technologies, manufacturing systems and sectors – to prevent the people making policy decisions from doing so in the dark.

Trying to establish solid foundations for developing innovation policy was the driving force behind the establishment of the Centre for Science, Technology and Innovation Policy (CSTI) at the University of Cambridge's Institute for Manufacturing (IfM). CSTI was set up as research unit in 2012 with funding from the Gatsby Charitable Foundation.

From the outset, CSTI was clear on the need to harness the expertise of economists and management researchers together with scientists and engineers to provide research-based but practical evidence which is of real value to policy makers and programme managers.

The IfM is in many ways the ideal home for such an endeavour. It locates policy research within a broader research community that is actively engaged in understanding the whole spectrum of manufacturing activity, from new production technologies and processes, through product design, technology and innovation management to global supply chains and new service-oriented and sustainable business models.

This means our policy research is surrounded by – and highly attuned to – the practical manufacturability, scale-up, operational and management challenges faced by emerging technologies.

In 2016, the Gatsby Foundation provided further funding to establish Policy Links as CSTI's not-for-profit knowledge transfer unit. Policy Links helps governments develop more effective industrial innovation policies. The team talks to policy officials and researchers from around the world to understand how other government departments and agencies work. This has allowed us to form a uniquely international network of collaborators from which our clients benefit.

Policy Links provides advice on technology and innovation policy design, and offers training for government departments and agencies – helping to lift the lid on the industrial innovation "black box".

**For more information, visit www.ifm.eng.cam.ac.uk/policy-links**

# Six things politicians have said about technology

## "I stand here as an avowed ignoramus on many of these amazing technologies"

**Baron King of Bridgewater**
*House of Lords*

In other circumstances the 83-year-old peer's admission might have been charming. He was, however, speaking at the second reading of the Investigatory Powers Bill – perhaps the most important piece of legislation to our digital privacy and security ever passed – so it would have been worth brushing up.

## "The best people ... who understand the necessary hashtags to stop this stuff"

**Amber Rudd**
*The Andrew Marr Show*

Speaking in the aftermath of the Westminster terror attack, the Home Secretary later clarified that she had been referring to hashes, which are used to map data. Rudd has not, however, altered her controversial stance in favour of breaking end-to-end encryption.

## "Man is still the most extraordinary computer of all"

**John F Kennedy**
*Speech to NASA*

Kennedy gave this speech in 1963, while awarding the Distinguished Service Medal to the pioneering astronaut L. Gordon Cooper. Cooper had recently brought a malfunctioning Mercury space capsule safely back to Earth by hand, using only his wristwatch and calculations he made in the condensation on the window, while the cockpit filled with carbon dioxide and the temperature climbed past 38°C. "Extraordinary" is faint praise.

# "Clearly, the Chinese would like to abolish the internet"

### Nigel Farage
*Infowars*

At a Leave campaign event in the US Farage spoke to the far-right conspiracy theory website Infowars.com, which notoriously claimed that the Sandy Hook school massacre was staged by the government to push through gun control laws. In the interview Farage also affirmed that "Brexit would not have happened without the internet", which is almost certainly true, and begs the question of whether abolishing the internet is a completely bad idea.

# "Ed Balls"

### Ed Balls
*Twitter*

Now closing in on 100,000 retweets, this most succinct and tautological of political tweets sums up better than any essay the dull narcissism of social media's mindless, endless, meaningless popularity contest. By accidentally tweeting his own name – Balls was trying to search for an article about himself whilst shopping in Asda – the then-shadow chancellor encapsulated in eight characters everything that happens on social media. "It's a joke that anyone with a Twitter account can get involved with," enthused the *Telegraph* recently, while on the sixth anniversary of Ed Balls day the *Express* asked "do you remember THAT tweet?"



# "We have to see Bill Gates.. about closing that internet up in some way"

### Donald Trump
*Campaign rally, South Carolina*

Seemingly unaware that Bill Gates is not the president of the internet, Trump lambasted the worldwide communications network in 2015 for producing children who wanted to be, as he put it, "masterminds". He continued that people "are fed up with incompetence, they are fed up with stupid leaders". It would take another year for the appalling irony of that statement to sink in.

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