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Addressing the complex issues facing society

Gavin Costigan



Gavin Costigan became the Chief Executive of the Foundation for Science and Technology in February 2019. From 2010 to 2019 he worked at the University of Southampton, his last role being Director of Public Policy, responsible for increasing the policy impact of research at the University. He also established, and was the inaugural chair of, the Universities Policy Engagement Network (UPEN). Prior to this, he was a civil servant in central Government for nearly 17 years, in what is now the Department for Business, Enterprise & Industrial Strategy (BEIS), as well as in the Foreign & Commonwealth Office. His roles included leading the network of science attachés in UK embassies, managing the Large Facilities Capital Fund within the Science Budget, and reviewing the governance of Research Council Institutes.

I have always believed that complicated things really are complicated. This does not mean that they are not possible or should be put on the 'too difficult' pile – but they are complex. Some, like climate change, need to be tackled for our continued survival while others have major implications for the way we live our lives. That is why I have an aversion to statements that include phrases like: "It's really very simple." The most important and challenging problems facing society are not simple and not easy – simple and easy have been done already.

While we may appreciate the complexities of the environments in which we work, I cannot be the only one who has fallen into the trap of making false assumptions about how simple and easy it should be for someone else to deliver something. One reason why systems are complicated is that they usually require inputs, solutions and trade-offs from a range of different parts, each one of which has, in turn, its own complexity.

So how can an organisation like the Foundation for Science and Technology support the complicated process of responding effectively to the challenges that we face? The Foundation provides a neutral platform for Government, Parliament, industry and the research community to discuss key issues which have science, technology and innovation elements. Its involvement will not 'solve' these problems (although it may help demonstrate that they are more complicated than first thought) but it does provide a place to explore that complexity.

Some of the challenges we will debate in the coming years are already clear and are likely to be recurring themes:

- climate change, its prevention and mitigation, as well as the technologies available to do so;
- the Government's Industrial Strategy and the various challenges it contains;
- Brexit and its impact on the industrial and research communities;

- the way technology is changing medicine and healthcare;
- data science, artificial intelligence and the internet of things.

We will also look at different sectors of the economy and specific technologies – often linked to reports by Government or Parliament – and explore how realistic suggested approaches might be. Events, as yet unknown, will also shape the programme.

Our traditional way of bringing people together to explore these complex issues has been via larger evening discussions and smaller, daytime round-table meetings. Event reports are posted on our website and published in the Journal you are reading. Yet if our aim is to provide a platform to explore complex problems from different perspectives, we need to engage a diverse range of views and use a variety of means to achieve this. So in the coming year, we will be exploring new ways of providing that neutral platform for debate – as well as continuing the successful established formats. Initiatives will include:

Getting out of London: the Foundation will seek to bring more people into discussions on key topics by holding meetings in different venues across the UK. London will still be a central location for our meetings, but we will actively partner with others to hold events elsewhere as well.

Communications: a website redesign, use of social media and filming speakers at events will draw more people to the debates we are having, allowing further discussion online. A new podcast will look at issues at the boundary of Parliament, Government, industry and the research community.

Flexible formats: evening meetings work well for some participants but not others, particularly those with caring responsibilities and those who need to travel further to get home. So we will mix-and-match our events to increase the range of people taking part.

Early and mid-career participants: the Foundation for Science and Technology has a long tradition of securing senior-level participation, both as speakers and attendees. However, this can miss crucial input from early- and mid-career professionals from industry, academia and the civil service. We will create new mechanisms to secure participation from this group, including piloting a new Future Leaders programme of activities, and allowing their voices to be heard as speakers and panellists.

Diversity: we will widen the diversity of our speakers and will never have an event with an all-male panel.

FST Journal is another area where we aim to make changes and improvements, with online versions of articles linking to audio or video files, or slide presentations. I would welcome your views on that, and on all the ideas above – please do drop me an email.

We will widen the diversity of our speakers and will never have an event with an all-male panel.

The complex challenges faced by society need input from people in Government and in Parliament, from industry and from the research community. That is where the Foundation for Science and Technology has impact: bringing that diverse group of people together to focus on that which is complicated. It has been doing this successfully for over 40 years, the past 18 of which have been under the guidance of my predecessor Dr Dougal Goodman, who retired in February. He leaves an enormous legacy and I hope that I can build on that in the months and years ahead. □

Gavin Costigan

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UPDATE

UK legislates to achieve zero-emissions by 2050

Prime Minister Theresa May has introduced an amendment to the Climate Change Act which will make the UK the first G7 country to legislate to reach net zero emissions by 2050. The change was introduced via a Statutory Instrument which was laid in Parliament on 12 June and does not require a vote. No10 has also dismissed the claim made by Chancellor Philip Hammond that achieving such a target could cost the UK economy £1 trillion and result in public spending cuts.

The Committee on Climate Change (CCC) issued a report in May saying that the UK can end its contribution to global warming within 30 years by setting an ambitious new target to reduce its greenhouse gas emissions to zero. Achieving a 'net-zero' target by the middle of the century is in line with the UK's commitment under the Paris Agreement says the Committee.

However, while the CCC rejected the use of international carbon credits in achieving the target, the Government will allow it.

The CCC report found that the foundations are in place throughout the UK and the policies required to deliver key pillars of a net-zero economy are already active or in development. These



The costs of the transition to a net-zero economy are manageable but must be fairly distributed.

include: a supply of low-carbon electricity, efficient buildings and low-carbon heating, electric vehicles, developing carbon capture and storage technology and low-carbon hydrogen, stopping biodegradable waste going to landfill. However, these policies must be urgently strengthened – current policy is not enough even for existing targets.

Policies will have to ramp up significantly for a 'net-zero' emissions target to be credible, given that most sectors of the economy will need to cut their emissions to zero by 2050. The Committee's conclusion that the UK can achieve a net-zero GHG target by 2050 and at acceptable cost is entirely contingent on the introduction without delay of clear, stable and well-designed policies across the emitting sectors of the economy.

The overall costs of the transition to a net-zero economy are manageable but they must be fairly distributed. Rapid cost reductions in essential technologies such as offshore wind and batteries for electric vehicles mean that a net-zero greenhouse gas target can be met at an annual cost of up to 1-2% of GDP to 2050.

There are a range of benefits from the transition to a zero-carbon economy, says the Committee. These include benefits to people's health from better air quality, less noise thanks to quieter vehicles, more active travel thanks to increased rates of cycling and walking, healthier diets, and increased recreational benefits from changes to land use.

● See feature on pages 5-13

www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming

IPBES report warns of ‘unprecedented’ threat to biological diversity

Nature is declining globally at rates unprecedented in human history — and the rate of species extinctions is accelerating, with grave impacts on people around the world now likely, warns a report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) published in Paris at the beginning of May.

“The overwhelming evidence of the Global Assessment, from a wide range of different fields of knowledge, presents an ominous picture,” said IPBES Chair, Sir Robert Watson. “The health of ecosystems on which we and all other species depend is deteriorating more rapidly

than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide.

“The Report also tells us that it is not too late to make a difference, but only if we start now at every level from local to global,” he said. “Through ‘transformative change’, nature can still be conserved, restored and used sustainably – this is also key to meeting most other global goals. By transformative change, we mean a fundamental, system-wide reorganization across technological, economic and social factors, including paradigms, goals and values.”

“The member States of IPBES Plena-

ry have now acknowledged that, by its very nature, transformative change can expect opposition from those with interests vested in the status quo, but also that such opposition can be overcome for the broader public good,” Watson said.

Compiled by 145 expert authors from 50 countries over the past three years, with inputs from another 310 contributing authors, the report assesses changes over the past five decades, providing a comprehensive picture of the relationship between economic development pathways and their impacts on nature. It also offers a range of possible scenarios for the coming decades.

www.ipbes.net

Antarctic ice shelf melting 10 times faster than average

A section of the world’s largest ice shelf in Antarctica – around the size of Spain – is melting 10 times faster than average and warm ocean currents beneath it are to blame. A team from the National Institute of Water and Atmospheric Research (NIWA) in New Zealand, University of Cambridge and British Antarctic Survey, studied the north-western corner of the Ross Ice Shelf to build up a record of how it is melting, and the key processes driving it.

The findings are significant because the stability of ice shelves is generally thought to be related to their exposure to warm deep ocean water. However, the study shows that surface ocean heat also plays a crucial role.

Although the interactions between ice and ocean occurring hundreds of metres below the surface of ice shelves seem remote, they have a direct impact on long-term sea level. Floating ice shelves stabilise the ice sheet, and loss of the major ice shelves would lead to accelerating ice flow and sea level rise of several metres or more. Currently the largest ice shelves are melting slowly; but smaller ice shelves that float in seawater just 3 °C above freezing point are melting 100-200 times faster, showing the impact that warm ocean water can have.

www.bas.ac.uk

Delivering world-class research/innovation

UK Research and Innovation (UKRI) has published a series of Delivery Plans, outlining how the organisation will work with its partners to ensure that world-leading research and innovation continues to flourish in the UK. The plans highlight the areas of focus and key activities of UKRI’s nine constituent councils as well as a number of cross-cutting themes.

UKRI Chief Executive, Professor Sir Mark Walport (pictured), noted: “The delivery plans are the blueprints for UKRI’s ambition to deliver the future of research and innovation. They outline how we will address the major global and societal challenges of our time, catalyse collaboration and contribute to meeting the Government’s ambitious target of 2.4% GDP spend.”

He added: “UKRI has had a strong first year – the Future Leaders Fellowships programme, the Strength in Places Fund and the Industrial Strategy Challenge Fund are all examples of the difference we can make working together as one organisation.”

The Delivery Plans have been developed with input from across UKRI’s research and innovation communities and build upon the Strategic Prospectus, published in May 2018, which outlined UKRI’s vision, mission and values.

Delivery plans have been published by the nine constituent councils with,



Sir Mark Walport: a blueprint for UKRI’s ambition to deliver the future of research

in addition, a plan covering cross-UKRI initiatives. This details the six themes that guide the organisation’s approach to delivering the 2.4% target:

- **Business environment:** delivering economic, social and cultural impact
- **Places:** supporting growth across the UK
- **Ideas:** building partnerships and addressing challenges
- **People:** creating the skills and environment required for research and innovation to thrive
- **Infrastructure:** enabling access to, and investing in, world-leading research and innovation infrastructure
- **International:** fostering global partnerships and tackling global challenges.

www.ukri.org/about-us/delivery-plans

CLIMATE CHANGE

The 2015 Paris Agreement set out a global response to the challenge of climate change. But can the goals set then be achieved? This question was debated at a meeting of the Foundation for Science and Technology on 16 January 2019.

Delivering the goals of the Paris Agreement

Nick Bridge

SUMMARY

- Tackling climate change offers huge potential benefits to society
- A steep downward trajectory in emissions is needed to reach zero by mid-century
- New alignments and coalitions must be made in order to take the process forward in 2020
- The economics of low-carbon technologies are changing radically
- Delivering the Paris Agreement goals is everyone's business.

The Paris Agreement sets the target global temperature increase as well below 2 °C and ideally 1.5 °C while the 2018 report from the International Panel on Climate Change (IPCC) is pushing us towards 1.5 °C.

In Figure 1 (p6), the black line shows the current position, already at 1 °C of warming. The IPCC's work showed that 2 °C is a pretty frightening place to be. One statistic that I have found has resonated around the world in my travels is that at 1.5 °C we could perhaps save 20-30% of the world's coral. At 2 °C, some 99% is gone. That difference also came out very powerfully in the IPCC study yet the world is currently on course for 3 °C – or even 4 °C.

Modelling shows how comprehensive the impacts are across the world in very different but profoundly interconnected ways. There are different models but it should be remembered that in a 4 °C world, some parts of the planet will experience over 10 °C of change.

Some people who are not convinced by the science ask: 'What if this is a hoax and we create a better world for nothing?'. Yet just listing the actions needed to tackle this issue shows extraordinary benefits to society, for example: the preservation of our biodiversity, air quality, sustainability and green jobs (green jobs are growing in some places at 10 times the rate of other jobs).

The UK, for example, has huge economic opportunities from low carbon technologies.

As global population increases, so resource use goes up together with economic activity. By 2020, emissions of CO₂ will be between 40 and 50 billion tonnes per year. From that peak, the world has to dramatically reduce emissions: by 2030, pretty much every dollar and cent of investment globally has to go into sustainable finance. Innovation is essential.

The big technological challenges have to be solved and shown to work at a commercial scale. These have to deliver a really savage downward trajectory to get close to a net-zero emissions position around the middle of the century. In addition, there must be a huge amount of forest growth and other ways of taking carbon out of the ecosystem.

While all this is technically achievable, the dramatic nature of the required reductions is very striking. It would be catastrophic, though, if the world did not meet this particular challenge.

Take a UK example of just what can be done. Coal has progressively been taken out of the economy until that historic day nearly two years ago when we had zero coal in electricity generation for the first time since 1882. As another example of success, the offshore wind story is one where regulatory policy, business innovation and scientific collaboration have led to a situation where the UK is the biggest offshore energy producer in the world. The unit cost is less than new gas or nuclear and hugely less than coal.

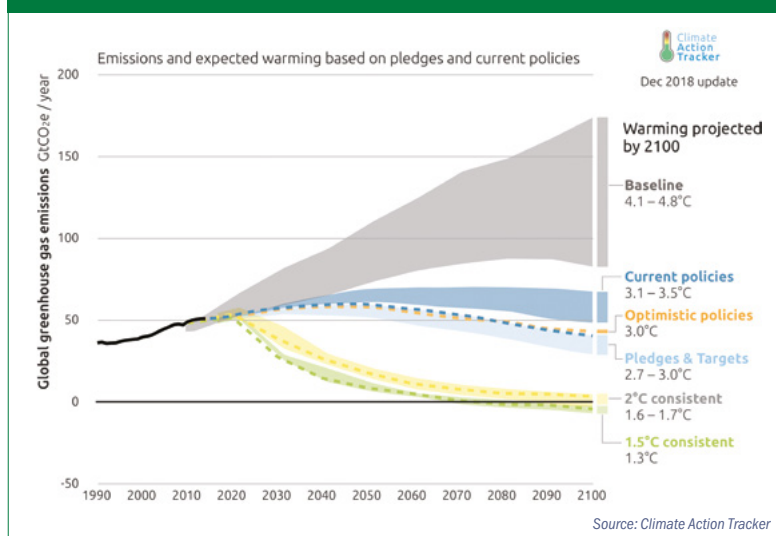
As the UK Climate Change Committee has noted, though, the current clean energy strategy only gets us around 60% of the way to meeting our carbon budgets in 10 years' time. The carbon budgets provide long-term certainty about what we need to do – and when – in order to reach our carbon reduction targets. It is very clear in the UK case, that even if energy were on a reasonable track, when it comes to transport, buildings, cooling, agriculture, land use and industrial processes, we have huge steps to take. I believe the tech-



Nick Bridge was appointed Special Representative for Climate Change by the Foreign Secretary in May 2017. He was Permanent Representative of the United Kingdom to the OECD from 2011 to 2016. Previously, he served as Chief Economist at the Foreign and Commonwealth Office and Head of the Global Economy Department. He spent over a decade in diplomatic postings to China, Japan and the United States.

Technological changes have to deliver a really savage downward trajectory to get close to a net-zero emissions position around the middle of the century.

Figure 1. 2100 warming predictions



(Above) the scale of the challenge. (Right) the UK is a world leader in offshore energy production.



Andy Dingley

nologies we need to achieve the targets exist, but not yet at scale.

So that is the picture in the UK. Yet even though the UK has one of the best climate action strategies in the world, we are struggling to meet the agreed carbon reduction targets.

The Industrial Strategy has a clean, green underpinning ethos and a set of grand challenges. Zero-emissions technologies were an area where the UK has been taking leadership over the past year. Powering Past Coal was an alliance we established with Canada, which was seen as the political high-point of the international gathering at COP 23. We have also been working with the green finance community to develop a set of recommendations that the Government will respond to with a Green Finance Strategy.

The international perspective

Looking back to 2015 and the Paris Agreement, there were a number of political alignments that made that agreement possible. The USA and China came together a year before and concluded a crucial deal after many bilateral meetings. India was supportive. There was great leadership from the European Union and especially from the UK. There was a great deal of influence exerted by the small island states or large ocean states. Africa was behind the process.

We had a grouping in 2015 that could get the Paris Agreement done – they agreed to decarbonise the world by the middle of the century or thereabouts. At the last COP, the rules of the road to implement the Paris Agreement were finalised.

However, five years on from Paris, at COP 26, countries have to come to the table, report on what they have done and commit to go further. So 2020 will be a really big year. It will also be the

year when the Sustainable Development Goals are reviewed and the Convention on Biodiversity is due to be finalised in Beijing.

There are enormously positive developments in China and India. India pledged 160GW of clean energy (double the UK capacity) in four years. That figure has been revised upward to 225GW and the programme is on track. So India has made remarkable headway in wind and also in solar. China, meanwhile, is leading the world on wind and solar. Europe remains focussed and ambitious. The Small Island States have held numerous meetings particularly with the Pacific Islands. Mexico and Columbia are remaining engaged.

But there are always other factors that come into play. There are substantial levels of investment in coal taking place around the world, funded by China's Belt and Road Initiative, which are not compatible with these goals.

Even with the coalition that had been built ahead of Paris, the deal only just got over the line. Look at the political situation now. While there are some remarkable initiatives happening in the USA at state level and in research institutions, at federal level the story is quite different. In Brazil, support is failing and there is a hardening of the Russian position.

Overall, none of China, India, Indonesia or South Africa has taken the potential leadership role of a major emerging market. Across Africa in general, there is currently a lack of focus on this issue, despite the enormous opportunities from integration across the continent, together with the attendant benefits of resilience and economic development. Japan is very under-ambitious so far and Korea is preoccupied with difficult issues around nuclear.

At present, then, we do not have the coalitions we need. The coming months will be critical in seeking to build these alignments. On a positive note, what has changed recently is the pricing.

To deliver on the Paris Agreement will cost a great deal of money. Yet today, we have crossed a threshold. The economics are changing in a fundamental way. Clean energy is virtually always as profitable as conventional carbon-based methods of generation. That message still has to be communicated across society, though, and the clean and green route will involve disruption and change in an extraordinarily narrow period of time.

As an example of the need for rapid change, consider oil and gas sector investments in low-carbon as a proportion of total capital over an eight-year period. While some businesses such as BP, Shell

and Repsol are focussing on these technologies, others – particularly Russian, Chinese, Italian, Brazilian and Indian companies – are still putting their money into traditional fossil investments, with implications for the next 40 or 50 years.

Delivering on the Paris Agreement is possible, but it is an extraordinary challenge over a very short time and it will require system-wide change. Stepping back and recognising exactly what is involved will be vital. And this is everyone's business. The issue has shifted decisively from being an environmental problem to a mainstream economic and political challenge for our era. It will not be solved by simply talking about climate change but will involve discussions about health, air quality, quality of life, liveable cities, biodiversity protection, species protection and clean water. □

Beyond the current climate process

Qi Ye

SUMMARY

- It is unlikely that the Paris Agreement goals can be delivered
- Emissions are on the rise again
- National governments have made promises they have been unable to deliver
- The UNFCCC process has not delivered
- Climate governance must be rethought if it is to deliver the required results.

I believe that it is quite unlikely that the goal of the Paris Agreement, specifically on keeping global temperature rises below 2°C, can be delivered. First, the Nationally Determined Contributions (NDCs) which each country submitted were not sufficiently focussed on the overall target. Implementation so far has been totally inadequate and the conditions to achieve it have not been present.

There is now a consensus that in order to limit global warming to below 2°C, global emissions need to peak by 2020 (which is almost upon us), they need to decline by about 25% by 2030 (which is less than 12 years away) and we have to reach net zero emissions around 2070. This is a daunting challenge.

A year ago, there was a sense of optimism. Global carbon emissions had levelled off since 2014. In China, there had been a very rapid growth in emissions since the start of the century. In 2014, though, President Xi and President Obama got together and announced that China would reach peak emissions at around 2030.

Yet, the past five years have been the warmest since records began. Atmospheric CO₂ is at a record high and still increasing at an alarming rate – roughly 3ppm per year. Global greenhouse gas emissions in 2018 grew 2.7% – that is on top of 1.6% in 2017. In fact, emissions in 2018 were at an all-time high. That is the challenge we face.

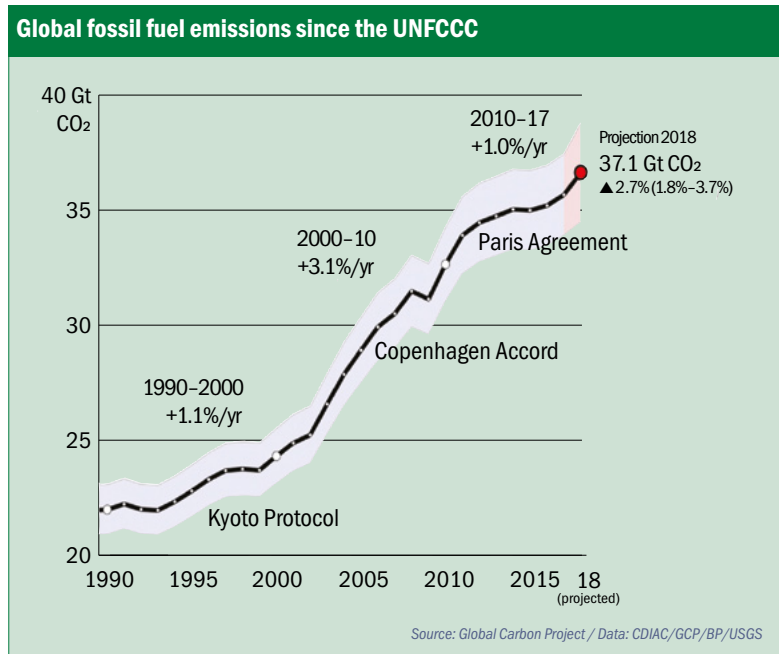
An emissions gap report of 2018 indicates that emissions will not peak by 2030 – remember that the condition to achieve 2°C is to peak by 2020!

Counting all unconditional NDCs under the Paris Agreement, the gap by 2030 is 15 billion tonnes, while adding in all the conditional NDCs still leaves 13 billion tonnes. So it is a very big gap and achieving 1.5°C would mean bridging an even bigger gap.

The NDCs are inadequate because those that were pledged and confirmed under the Paris Agreement only take us to about 3°C of warming. So the Paris Agreement said we want to be at 2°C but current commitments only achieve 3°C: there is a very big gap.



Professor Qi Ye, a leading expert on China's environmental policy, is Director of the Institute for Public Policy in the Hong Kong University of Science and Technology. He was formerly a senior fellow and director of the Brookings-Tsinghua Center for Public Policy (BTC) in Beijing. He also serves as the Cheung Kong Professor of Environmental Policy and Management at Tsinghua University's School of Public Policy and Management. Prior to joining the BTC, he was director for the Climate Policy Initiative in Beijing and director of the Climate Policy Institute at Tsinghua University.



An emissions gap report of 2018 indicates that emissions will not peak by 2030 – while the condition to achieve 2 °C is to peak by 2020.

Around the world

China's emissions were projected to grow in 2018 by 4.7%. That is a significant jump after a few years of levelling off.

The rate in the USA had been decreasing over the past decade, but last year increased to 2.5%. The EU in general has been decreasing at a very high rate, but last year fell back. India has seen a jump of 6.3%. The emissions gap is not closing: it is actually larger than previously estimated so there is an even bigger challenge in front of us.

G20 countries collectively represent 78% of the world's emissions and, collectively, they are not yet on a track to meet their commitments under the Agreement. A few are on track but the majority are not. Note that 'on track' does not necessarily mean these countries are doing a great job – it may mean they did not set ambitious NDCs! For most countries there is a huge gap between the policy needed and the policy enacted.

The political reality in different countries is not helping either. In the USA the withdrawal from the Paris Agreement itself is a problem as the administration is now removing as many as 78 environmental protection rules; so the Environment Protection Agency (EPA) will have a very hard time achieving their original goals. The government is now loosening emissions standards for coal. Climate change issues are becoming very polarised in the USA.

Japan also has problems delivering on its goals.

Technological innovation and deployment have played the biggest role in bringing down emissions and in reducing energy and carbon intensities.

China

China has done a very good job in staying on track to meet the commitment under the Paris Agreement. Under the earlier Copenhagen Accord, it promised to cut energy intensity by 40-45%. By 2018, China had achieved 46%.

Yet in other areas progress has not been so good. The carbon market is one. It was highly anticipated and expected to have major impact. Yet a year after the deadline for the start, the national carbon market is still not quite there. There are seven pilot projects but unfortunately the price of carbon is too low at around €10. The scheme is not working well enough to bring down emissions.

China's success in bringing down energy intensity has much to do with policies to tackle the domestic air pollution problem. As a matter of fact, just by addressing air pollution, China could deliver its Paris Agreement commitment. However, the economic slowdown of recent years, and consequent economic pressure, has weakened climate action. For instance, the target for reducing PM 2.5 concentrations is 3% in 2020. The previous year's target was 15%. Coal consumption has also rebounded for three consecutive years.

International politics, especially USA/China relations, are damaging the climate community in China and internationally. In 2014, the joint presidential announcement played a very positive role in setting a foundation for the Paris Agreement. Now the two countries are fighting against each other on this issue.

The incentives for solar, wind and other clean energy technologies in China are being removed and the National Development and Reform Commission (NDRC) is planning a subsidy-free clean energy sector by 2020.

Since 2009, China has played a leading role in clean energy development globally: around 30% of total investment came from China, but this has started to decline over the past year.

Resistance

Some of the proposed 'good ideas' to achieve the Paris goals now face political resistance. The 'gilets jaunes' movement in Paris has spilled over into other European countries. The people in Paris are in essence protesting against the Paris Agreement itself.

One of the ideas behind the Paris Agreement was for countries to learn from each other, but in fact national governments are making promises that they are unable to honour. Governments feel they must be seen to lead on climate change. They make promises to the voters but then it is really hard to keep them because of the high cost



Decarbonisation is actually happening in most countries at an amazing rate. Technology and investment are behind this.

– and also because of pressure from other well-organised groups.

There is no system for international governance to erase these basic political facts. How to address this problem? ‘Seeking truth from facts’ is a well-known Chinese saying. The fact is that these pledges are voluntary and not legally-binding. Implementation faces many challenges and this UN-led, top-down process is not really working as well as we would like to believe.

Certain aspects have been working well since the conclusion of the UN Framework Convention on Climate Change (UNFCCC). Many domestic policies and actions are really working well. There are many examples in China and in the UK.

Technological innovation and deployment have probably played the biggest role in bringing down emissions and in reducing energy and carbon intensities. Consensus on climate change science, decoupling of economies from fossil fuels and the engagement of the younger generation have all played important roles.

Decarbonisation is actually happening in most countries at an amazing rate. In fact, it has accelerated. Technology and investment are behind this.

Yet other aspects do not work so well. For example, targets are set but not achieved. Finance for international development under the UNFCCC is not available, to put it simply. Technology transfer has not taken place as envisaged under the UNFCCC process. The carbon market has not been very successful and has not met expectations, be it in the EU, China or California.

We need to rethink climate governance if it is to be more effective in the future. So far, governments have had to deliver this process, but there are other important players such as the business world. There are also the NGOs, the people who are passionate about this subject.

The UN is taking care of too many details of this process and it is not very good at this. Nearly 200 parties dealing with technicalities is not a good idea. This top-down process really needs to be redesigned. The UN and governments should play a much lesser role.

The models that we use need to be revisited. They play a very important role, but make a lot of assumptions about capability, politics, the political economy. Those assumptions may – or may not – be very realistic.

We need to reinforce technological change and transfer right now, because the current isolationism is not delivering. We need to reshape our cultures and economies to significantly reduce our commercial consumerism and in reality we need to rebuild our civilisation.

We face a much bigger challenge than just fixing technical problems. In China, this concept is being promoted under the title of ‘Eco-Civilisation’ or ‘Ecological Civilisation’. We must all work together to assure our common future. Let’s make it happen. □

Technological innovation and deployment have played the biggest role in bringing down emissions and in reducing energy and carbon intensities.

Moving the process forward

Bryony Worthington



Baroness Bryony Worthington is the Executive Director of the Environmental Defense Fund Europe. Appointed a life peer in 2011, she is a leading expert on climate change policy and carbon trading. She served as Shadow Minister for Energy and Climate Change in the House of Lords, leading on two Energy Bills for the Shadow team. In 2006, she helped launch a Friends of the Earth campaign for a new legal climate framework, which led to her selection as a lead author on the UK's Climate Change Act.

The Environmental Defense Fund is a US-based charity which has been in existence since the 1960s. Three years ago, it established a permanent office in Europe and appointed me as Executive Director.

One important question is whether the Paris Agreement that was concluded in 2015 can make it through the current turbulent political times. The phrase 'the age of bewilderment' has been applied to today's politics. Nobody knows what is going on and it is not just in Westminster.

President Trump cast doubt on the Agreement's survival by announcing he would pull out – but note the timing. He made the statement one day after the deadline for pulling out before the next US election. That, I think, is down to some clever planning by smart people in the White House.

But as a symbol it is certainly damaging and confers legitimacy on a cadre of people with extreme views. A claim by the president of the USA that climate change is a hoax gives licence to people who would not otherwise have spoken out.

Yet, by the very act of pulling out, he has confirmed in many people's minds that the Agreement is something worth having. This has galvanised other countries to ratify in record time, even states like Nicaragua who said at the start they were not interested in participating.

Taking this seriously

The fact that this is a UN initiative conveys the message that we are finally, as a world, trying to take this seriously. And that will have an effect on business decisions – it creates a sense that to be on the right side of history you should be moving into a more positive, sustainable business and life model.

I saw this first-hand when I was working at an energy company and the Climate Change Act had just been passed. They were considering a big capital investment but it was marginal. The costs of doing it or not doing it were not clear. However, in a presentation to the board, I saw the Climate Change Act cited as a reason to go for the cleaner option. When you have a narrative that is compelling and a legal framework that is widely understood, it can have a 'nudge' effect, which is important.

Let a country decide what it is going to do and it will come forward with business-as-usual, minus a little bit.

SUMMARY

- The US decision to pull out of the Paris Agreement has, paradoxically, stimulated other countries to commit to the process
- The agreement presents the challenge clearly as one of controlling sources and managing sinks
- Current commitments by signatories will not achieve a 1.5 °C limit on global warming
- The global shipping and aviation sectors offer positive examples of how the process might be taken forward
- The rapid falls in technology costs offer opportunities for individuals and organisations to take action.

I believe that, by and large, the consensus around Paris will continue and it will progress, despite the current turbulence.

Will Paris deliver?

Will the Paris Agreement deliver on its goals? Well, it faces many challenges.

It does however present the problem as a fairly clear equation to solve: anthropogenic sources of greenhouse gases must be balanced by anthropogenic sinks to reach zero sometime before 2100. That is a first acknowledgement that this is about controlling man-made sources and enhancing man-made sinks. It subtly changes the way the UN views the matter, because for too long it has been seen rather ideologically as 'just about renewables and efficiency'. Now that is a fantastic goal but utterly impractical and insufficient in the timescales we are talking about. As many technologies as possible must be directed at this problem if there is to be any chance of negotiating those amazingly steep transition curves. Ruling out any approaches at this stage is absolutely crazy.

The UN must embrace a plurality of solutions and the Paris equation is the first written indication that they are accepting the scale of the challenge – and that it is an issue about both sources and sinks.

In terms of ambition, the bottom-up approach was always going to be tricky. Let a country decide what it is going to do and it will come forward with business-as-usual, minus a little bit. The EU is a classic case. A 40% reduction by 2030 sounds good but it is already on target to achieve well over

30% by the end of this decade. That leaves another decade to deliver just 1% per year. That is nowhere near the ambition needed from Europe as the leading industrialised bloc in this challenge.

So everyone has opted for a very safe offer and as a result, the world is heading towards over 3°C of warming, not 1.5°C. I suspect the negotiators knew this and so they built in some important features. There is the continuing dialogue to get countries to agree a process for increasing that ambition as well as the five-yearly review which will take effect in 2020 (that is just around the corner!). There are details hidden within the legalese that would allow countries to collaborate and create shared ambition – indeed, trading of ambition is within the possibilities. Clubs of countries could come together to take the process further with mutually-beneficial investment programmes.

That is the good news. However, as someone remarked: “The problem with Paris is it is the wrong people talking about the wrong issues in the wrong place.” There is certainly an element of that: bring together the world’s Environment Ministers and there is likely to be a certain type of dialogue and a certain type of outcome.

Without the participation of the world’s Treasury Ministers, Finance Ministers, Energy Ministers and Transport Ministers, progress will not be very fast. The likelihood is that governments will sign up to something internationally, go home and hit a domestic brick wall because the economics are not favourable.

Other global sectors

There are two vital global sectors not covered by the Paris agreement: aviation and shipping. Now between them, they account for 4-5% of global emissions which is significant – each sector is responsible for annual emissions comparable with Germany’s. Interestingly, their rules of governance were created in the 1950s when pooling of sovereignty was driven by commerce: common rules were needed to enable money to flow and business to be done.

So those two old parts of the UN have the capacity to write global rules that are applied to everyone. The concept of common but differentiated responsibilities does not really apply if a level playing field is required. A ship can be flagged in one place but trade between different ports across the globe. It is a much more realistic view of today’s world: one that is interconnected and international.

These sectors have been criticised for not taking environmental issues seriously. Recently, though, they have started to take action. The shipping industry signed an agreement 10 years ago to

As someone remarked: “The problem with Paris is it is the wrong people talking about the wrong issues in the wrong place.”

remove sulphur from fuels and that is now kicking in. In 2018, a climate change reduction target of a 50% cut by mid-century was agreed.

I think this is interesting because there are a large number of engineers and technical finance people taking practical decisions about investing in vessels that have to have zero-emissions by 2030. Now, 2019 is a crucial year – policies are coming forward to be discussed by member states and will be signed into law sometime early next decade. I would hope, because shipping has to be very practical, that governments will find the policies and the will to make that happen.

This is an example of multilateralism in a world where multilateralism seems to be generally out of favour at the moment.

Aviation

Aviation, despite its shaky start, has created a common metric and a common way of thinking about emissions that applies to nearly everyone in the sector. It has at the moment a more voluntary approach and is focussed on offsetting and carbon markets rather than on technological investment. However, it provides another example of a global sector coming forward and devising rules that will drive the process forward. The challenge is to stimulate similar discussions in other global sectors, like steel for example.

New tools

In the Environmental Defense Fund, we talk about ‘the fourth wave of environmentalism’. This refers to the way citizens, people, NGOs, are able to do extraordinary things due to the reducing costs of technology. As a modestly-sized NGO, we have still found the funds to launch our own satellite and we will be monitoring methane emissions at a global level. As a consequence, we are finding the oil and gas industry are much more receptive to our calls because they know that once that satellite goes live they will not be able to hide.

Technology costs matter, not just in terms of CO₂ abatement, but also because they enable us access to the data and the knowledge we need in order to solve this problem. □

The oil and gas industry are much more receptive to our calls because they know that once that satellite goes live they will not be able to hide.

Taking practical steps



Emma Howard Boyd, Chair of the Environment Agency, joined the panel after the formal presentations.

The Environment Agency is the UK's environmental regulator, but also has responsibility for flood and coastal risk management. It is at the forefront of tackling the physical risks of climate change.

The World Economic Forum's January report confirmed that three out of the top five risks to humanity link to climate risk. However, we should not just be looking through a 'risk lens' but also at the opportunity of building resilience as we look to create a prosperous future. The Industrial Strategy and the Clean Growth Programme must reflect a clean and resilient investment strategy. What is the point of investing in energy efficiency measures that are then washed away in a flood or melted in a heatwave?

Last October, I was invited to be the UK's representative on the newly-established Global Commission on Adaptation. The way different groups, including business leaders and investors, are collaborating on this agenda gives me huge optimism.

As Chair of the Investment Committee of the Environment Agency Pension Fund, I helped set up an initiative with the Church of England's National Investment Bodies two years ago. Between us we have something like £15 billion of

assets under management. We then built a partnership with LSE Grantham Institute which involved FTSE Russell as well as other bodies.

As we headed into the 2018 COP, the partnership had \$9 trillion of assets under management supporting this initiative. This also supports a further initiative called 'Climate Action 100+' in which investors with a value of \$31 trillion of assets under management are engaging with high-carbon industries. We are creating tools to understand the transition of our portfolios for a low carbon economy.

Collaborative relationships

We need to work within the existing frameworks because they are the best we have at the moment. At the same time, we all need to explore collaborative relationships that lead to action, and the important word is 'action' because this is a race we have to win. Different countries or business leaders may push the agenda forward at different times, but we all have to work together.

While it is understandable to be daunted by some of the statistics and deadlines in the IPCC report, I personally am optimistic about the partnerships that we can build on climate change. □

The third goal of the Agreement



Professor Nick Robins, Professor in Practice for Sustainable Finance at Grantham Research Institute on Climate Change and the Environment, London School of Economics and Politics also joined the panel.

There are actually three goals in the Paris Agreement. Goal number one on emissions attracts the most attention. Goal 2 is about resilience and adaptation. Goal 3 – which is truly transformational – aims to make financial flows consistent with the first two.

We must align the financial system (worth \$386 trillion) with the Paris Agreement. The good news is that \$32 trillion of investor assets are already committed to this path. Central banks like the Bank of England and the People's Bank of China are leading initiatives in this area. There is the Green Bond market which doubled in value between 2016 and 2017.

A social contract is needed in order to achieve this transition. The message from COP24 at Katowice in the coal region of Poland was: 'We need a just transition.' The *gilets jaunes* in France are also an example of people reacting to energy-related change.

We need to demonstrate that this is a very

good news story in terms of avoiding catastrophe as well as creating green jobs and producing health benefits. As part of this, we need to focus on ensuring that 'no-one is left behind'. Climate action has to be set in the broader context of sustainable development.

In helping to achieve all three goals – emissions, resilience and finance – the financial sector has an important part to play. Investors can give confidence to policy-makers and they can help improve corporate governance (Shell has recently tightened its climate targets in response to shareholder engagement). They can also reallocate their capital towards assets that will deliver the Paris goals. Remember, this money is not located in some distant financial system, it is ours – personal savings, ISAs, pension funds.

Economic pressure and market turbulence clearly impact on progress. Indeed, recent market turbulence has already dented green finance. We need to remember that the global financial crisis

of 2008 almost killed the preferred climate change tool of choice – carbon markets. It has taken almost 10 years for this market to re-establish itself. It is vital that economic pressures, market turbulence and related issues like protectionism do not throw climate measures off course. Instead, policymakers and investors need to be

ready to ‘do whatever it takes’ to keep finance flowing towards the transition.

Finally, we need to find ways to really connect with citizen savers so that every pension fund member, every ISA owner in this country, knows whether their fund is aligned to the Paris Agreement. □

It is vital that economic pressures, market turbulence and related issues like protectionism do not throw climate measures off course.

The debate

The discussion that followed the formal presentations covered a wide range of issues, including: progress in the UK; shipping; the forthcoming G20 meeting; and behavioural change.

Progress is frustratingly slow for reasons linked with politics, including the short time horizons of many politicians, and the fact that large incumbent companies have a century of profiting from fossil fuels. £200 billion a year needs to be spent on climate-related investment to achieve the necessary change.

The current UK statutory targets will not be met without more detailed policies on domestic heating, housing, land-use and transport. Although there are shortcomings, the UK has a stronger legislative base to promote effective action on climate change than most countries. If the UK leaves the EU, would it be able to act effectively on climate change when so much of its effort has been bound up in European initiatives?

Action on shipping

The International Maritime Organisation has started to take action on shipping. In some countries nuclear power could play a major role in reducing emissions. In Japan, for example, a 20% reduction in emissions should be possible from nuclear power, once its nuclear reactors have been restarted.

The UK does not generate electricity from coal, but 40% of Germany’s electricity still comes from that source. In the UK, investment in renewables has become more economic.

The decision of the Japanese Prime Minister to put climate change at the centre of the country’s G20 Presidency in June was welcomed. The G20 accounts for 80% of the world’s GDP. It is easier to invest in climate change in periods of economic growth, and so establishing a positive cycle for economic growth and environmental protection will be challenging at the G20.

The energy of young people like 15 year-old Greta Thunberg of Sweden has made a big impact. Some young people are making choices about foods based on their carbon footprint, and even in

primary schools there is awareness of carbon miles in lunch boxes. Although the planting of trees is accepted as a way to sequester carbon dioxide, there were differing views about which species had the most beneficial impact overall.

Carbon capture and storage (CCS) could contribute to decarbonisation. Spending on transport infrastructure is substantial, so this needs to be clean and resilient. Most insurance policies do not cover climate impacts and large sections of California are already uninsurable against fire risk.

Changes in individual behaviour could be significant. Media programmes by celebrities like Sir David Attenborough stimulate a great deal of interest among the public. The Royal Academy of Engineering had developed a sustainability rating system for infrastructure. UK car production is making important advances, with The Transport Systems Catapult aiming for 50% of car production to be all-electric by 2030. □

FURTHER INFORMATION

The Paris Agreement on climate change <https://unfoundation.org/blog/post/paris-climate-agreement-101-no-jargon-just-facts>

IPCC Special Report on the impacts from a 1.5 degree centigrade increase in temperature above pre-industrial levels www.ipcc.ch/sr15

COP24 Conference in Katowice, Poland www.cop24.katowice.eu

World Economic Forum <https://toplink.weforum.org/knowledge/insight/a1Gb0000000LHVfEAO/explore/summary>

The Climate Change Committee independent assessment of the UK clean growth strategy www.theccc.org.uk/publication/independent-assessment-uks-clean-growth-strategy-ambition-action

Local authority carbon leadership initiative www.uk100.org

PANDEMICS

How well prepared is the UK for a flu pandemic on the scale of the 1918-19 event which killed many millions of people worldwide? The question was discussed at a meeting held at the Royal Society on 5 December 2018.

Preparing for a flu pandemic

Christopher Whitty



Professor Chris Whitty CB FMedSci is Chief Scientific Adviser at the Department of Health and Social Care (DHSC). He has overall responsibility for the Department's research and development, including the National Institute for Health Research (NIHR) and life science strategy. He is currently Professor of Public and International Health at the London School of Hygiene & Tropical Medicine and an NHS Consultant Physician in acute medicine and infectious diseases at University College London Hospitals. He is also Gresham Professor of Physic. He will become Chief Medical Officer for England in October 2019.

Pandemic influenza is at the top of the UK National Risk Register as the biggest predictable major risk.

It is now 100 years since the great 1918-19 flu pandemic in which between 50 and 100 million people died. Government has to plan for, and then respond to, large numbers of infectious epidemics of varying severity; this was the worst in modern times, although not the worst possible.

Epidemics occur every year. In 2018, there were 6-12 epidemics of significant proportions, ranging from the outbreak of cholera in Yemen through to a small outbreak of monkey pox in West Africa. A flu pandemic is on a scale quite unlike almost all of the others; the only exception in the past 100 years being HIV.

In planning for an infectious epidemic there are a number of factors to consider. Speed of spread is very important and influences the type of response. Clearly mortality, or virulence, is also key. Geographical limits may come into play: a vector-borne disease transmitted by mosquitoes will only occur where those insects live. This factor is not relevant in flu which can go anywhere that humans live.

Available public health counter-measures to prevent, and medical counter-measures to cure, infection are clearly crucial. And then there are other aspects like workforce protection and societal impact.

Pandemic influenza is at the top of the UK National Risk Register as the biggest predictable major risk. There are several reasons for this: it is an airborne disease which means that many of the counter-measures that can be used in other environments are not effective: with vector-borne diseases mosquito control is an option; for touch diseases like Ebola people can be isolated; and in the case of a water-borne disease action can be taken to make water safe. But with an airborne disease, the range of public health counter-measures is substantially reduced.

The spread of a flu pandemic is likely to be very rapid. A high proportion of the population will be affected and potentially all at the same time. That is very important for planning purposes.

The last pandemic in the UK in 2009-10 was of low mortality and virulence, but they can be much worse. The UK has to plan for a 'reasonable

SUMMARY

- The onset of influenza pandemics can happen at great speed
- Anyone can be infected with flu but the very young and the elderly are usually most impacted
- The first wave of a pandemic is not necessarily the worst
- Vaccines typically take at least four months to develop from the time of identification of the virus
- The biggest problem, other than infection, is fear and misinformation.

worst case scenario' and the main risk, for a variety of reasons, is influenza A. That is not to say that influenzas B, C and D are not important, but in terms of a pandemic, A is the major risk.

The onset of influenza pandemics can happen with phenomenal speed because the spread rate is so rapid. Figure 1 shows the mortality rate, by month, in the USA, comparing 1918 with the previous year. It devastated society over the period of just a few weeks.

The risk in today's world

It is often reported in the media that flu pandemics are even more of a risk today because of our interconnectedness. In terms of transport that may be true but it does not hold in other respects. A much more integrated transport network means that wherever it comes from, we will get it, possibly within 24 hours of first reports. Yet, better nutrition, better housing, better heating, as well as more copious water for people to wash their hands and the availability of antibiotics reduces the likely severity compared to 1918-19.

A population pyramid of the UK from 1918 looks similar to that of the Central African Republic today. In fact, the mortality rate in a good year, prior to the war, was worse than most African countries today. The 1918 pandemic hit a society which was much poorer, much younger and much less well-prepared in some ways than if it were to be hit today. Only the higher proportion

of older people works to our disadvantage.

All flu pandemics can move quickly and the 2009-10 flu pandemic was no exception. It spread both within countries and around the world at phenomenal speed. Trying to slow it down by measures like airport screening is completely pointless. In the UK, this relatively limited pandemic resulted in large numbers of people going to their GPs. In reality, many had upper respiratory tract infections, many others will not have had flu, while still others would be what is derogatorily and rather unfairly termed 'worried well'. In that pandemic, officially there were 457 deaths. There was a vaccine but not until well after the peak: the likely onset of normal, seasonal flu can be predicted but pandemics occur without warning – they may happen completely out of season – so the usual type of planning for flu simply will not suffice.

Transmission and mortality

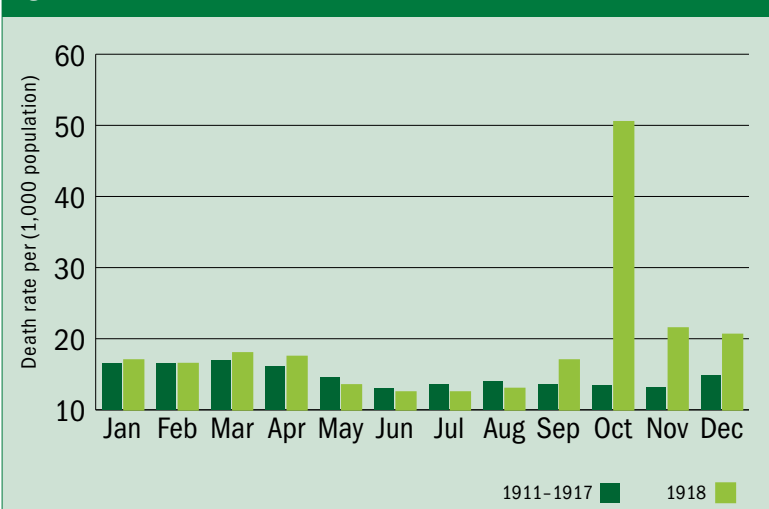
Many people have the mistaken belief that the more virulent the disease, the less transmissible it is. Unfortunately, this is not true. For flu, there seems to be little evidence of any correlation between virulence and transmissibility in the historical record.

Within the last 100 years, the 2009 H1N1 outbreak had a 0.3% mortality. The number of cases was somewhere between 10 and 200 million worldwide. The flu pandemic of 1918 had a 3% mortality – i.e. 10 times that amount – transmitted at roughly the same rate. Many of the animal flus, before they jump to humans, can have much higher mortality rates. So, in the most recent, H7N9 avian flu had a mortality of 30%, i.e. ten times higher than the flu pandemic of 1918. While it is likely that the mortality virulence would go down to some degree in the case of a transfer to humans, in my view 3% mortality should not be seen as the worst that would be possible.

The societal impact of any infection – and this is certainly true for flu – will depend on who is affected and may become a huge problem for particular groups in society. So for example, HIV was initially, in western countries, a particular problem for gay men and intravenous drug users. It was a heterosexual epidemic in Southern Africa. There are many diseases – Ebola, Lassa and Marburg being good examples – where a very high proportion of the people who die will be healthcare workers because they come into contact early, at a point where an epidemic has not been recognised.

Anyone can be infected with flu. And while anyone in a pandemic can be killed, as with all infections, children and the elderly will bear the brunt of mortality. That is true for virtually every

Figure 1. Death rate from H1N1 flu 1918



infection. With a seasonal flu, there is usually a very low mortality in younger people: in the flu pandemic of 1918, though, there was a significant spike in mortality in people of young working age, also young parents (Figure 2). This is different from a normal seasonal pattern and would lead to a very different societal impact.

It is often assumed that the first wave of a flu pandemic will be the worst, but that is not necessarily true. In the 1918 pandemic, the second wave was much more severe. While that would give more time to develop a vaccine, it is not always the case: the first wave will still in some cases be the worst and – on a reasonable worst case scenario – that has to be the assumption.

Vaccination

Ever since the time of Edward Jenner, policy makers have assumed that vaccines are the solution to all problems. In fact, for very many infections a vaccine is not the right answer. The search for an HIV vaccine has been going on for a very long time, with no obvious success. In most years, though, there is a reasonably effective vaccine for flu.

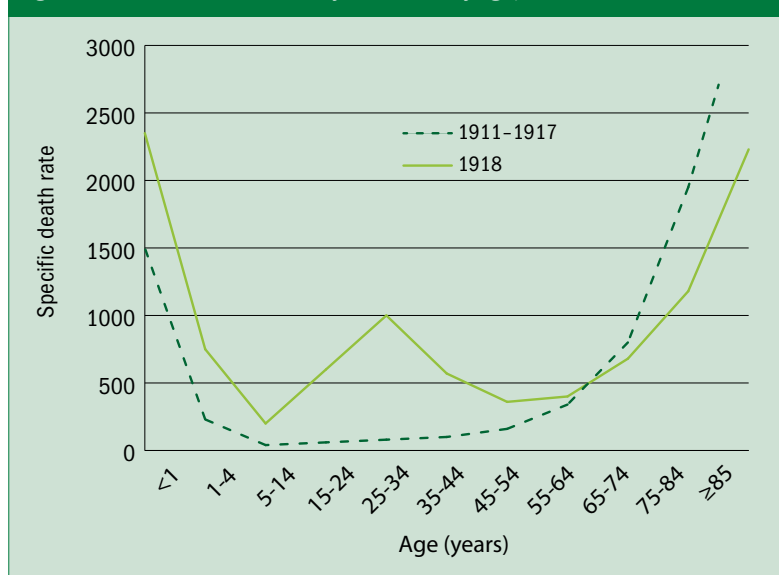
Between the point that the virus is first characterised and the point when the vaccine is available, the minimum planning time should be four months. Given the speed of movement of flu, the majority of the damage may have occurred before the first vaccine actually hits the clinics and schools.

There is much discussion of the possibility of a pandemic vaccine which will protect people through the whole year. The search has been ongoing for a very long time: a lot of money and a great deal of science has gone into this search, so far without success. The challenge is not scientifically impossible but has proved extraordinarily difficult.

Figure 1. Death rate from H1N1 flu per thousand head of population, USA, 1918.

The search for a pandemic vaccine which will protect people through the whole year has been ongoing for a very long time. The challenge is not scientifically impossible but has proved extraordinarily difficult.

Figure 2. Influenza and mortality in the USA by age, 1918



(Above) **Figure 2. Influenza and mortality in the USA by age, 1918. Deaths per 100,000 people. (Above right) Influenza research at the Centers for Disease Control and Prevention in Atlanta, US**

One recent advance is a move from the old-fashioned egg-based system (the current method) to a cell-based production system. While this does not produce better vaccines, they can be made more quickly.

Anti-viral approaches

There is a surprising amount of controversy about the role of anti-viral drugs. There are several drugs which are used against flu, the most well-known being Oseltamivir and Zanamivir. If taken early they probably reduce severity, at least in a significant number of people, and they may reduce the duration of symptoms by a day or two. The benefits are modest and the treatments only reduce symptoms – they do not stop the disease.

We cannot know how efficacious these drugs will be during a pandemic, because by definition we do not yet know this virus. And flu has proved extremely capable at evolving resistance to drugs: a single point mutation may make a drug essentially useless. There could be a switch from a highly-sensitive strain to a highly-resistant one in a very short space of time.

Banking on a drug-led response is therefore not a safe planning assumption, although they are potentially very useful in certain circumstances and we need to hold stockpiles.

Secondary causes of mortality

Perhaps more important – but much less known – is that probably the majority of deaths in the 1918 flu pandemic were due to secondary bacterial pneumonia. Many antibiotics can potentially work in this situation: of course, antibiotics were not available in 1918. Although they will be available, there would be global demand for them in



James Gathany/CDC

the case of a pandemic with supplies being run down with great speed.

Supportive treatment for people with severe flu is substantially better than in 1918. However, there are very few Intensive Care Unit beds and they would be overwhelmed so quickly in a pandemic that they would, for practical purposes, be useless.

Above all, basic nursing care remains vital – and you do not need to be a nurse to do it. That remains constant and is no different from 1918.

Planning

Our job is to think about the science elements of any practical problem. A number of initiatives can be taken to respond to the threat of a pandemic better. These include mathematical modelling to give reasonable forecasts of how fast the flu will move and how many people are likely to die.

A very good virus identification network is already in operation, indicating which viruses are circulating. However, the speed of onset, from the first cases to the peak, will be incredibly quick, so any advantage that confers should not be exaggerated.

Pre-planning is essential. This includes deciding which parts of the health system would be ‘switched off’, and in what sequence, in order to keep the overall system running, faced with a huge increase in demand.

Vaccine production can be optimised but the current lead-time is still four months. Antivirals and antibiotics can be stockpiled.

The biggest problem, other than the infection, is fear and misinformation which causes people to behave in a way which appears rational to them but is, in reality, ineffective or even from a societal point of view damaging. □

Examining the impacts on society

Andrew Coburn

SUMMARY

- Pandemics affect the whole global economy, not just healthcare provision
- National strategies tend to fall into two categories: those with pharmaceutical-led responses and those based on non-pharmaceutical strategies
- A number of factors are increasing the risk of a global pandemic
- There are also countervailing initiatives to reduce risk
- The current reliance on vaccine development carries its own risks.

The arguments for better preparedness for pandemics are as much about economics as they are about healthcare or humanitarian considerations. The Centre for Risk Studies examined a number of scenarios for present-day pandemics. They are slightly less virulent than the worst-case-scenario presented for the National Risk Assessment, but our focus was on their overall impact on society and economics – and whether that constitutes a reasonable case for broader intervention and preparedness.

Each year the Centre publishes a 'Pandemic Risk Register' of threats to the global economy. We monitor where pandemic sits relative to terrorism and financial crises as well as other risks such as cyber threats. We try, essentially, to quantify how much risk there is.

We have also been advising our research sponsors on how we could be better prepared through the partnership between public and private sectors.

The Centre has published a study on a hypothetical pandemic scenario, to try and understand the impact on economic activity¹. Our estimate (see Table 1) was between \$7 trillion and \$23 trillion damage to the global economy from a moderate virulence outbreak of an influenza virus. We looked at the levels of absenteeism that might be expected in businesses, somewhere between 17-25% for two or three weeks. Now, a business can tolerate up to about 9% of absentee-

ism. At 17% or more, the business effectively has to close down. So a pandemic would cause massive economic disruption around the world.

Let us take one hypothetical example which shows the issues around the availability of vaccines.

In this case, the pandemic takes around nine months to circumnavigate the globe. For a global business trying to manage absenteeism in its Chinese operation, having just had to deal with a similar situation in the US market, this becomes extremely disruptive. Businesses are investing large sums of money and time into risk management and exploring how they could partner with government to help with these problems.

Health services

Table 2 shows the likely impacts on the health services. Hospitalisation demand would be about 16 times current capacity in terms of spare beds that are normally available. This 'hospital surge capacity' is critical. With intensive care, the situation is almost impossible – demand is two orders of magnitude larger than spare capacity and so on.

There are now 160 countries that have filed their 'Pandemic Preparedness Plan' with the World Health Organisation (WHO). These fall into two broad classes. There is the 'gold class' based on a pharmaceutical response and then there are those of the poorer countries with lower GDP per capita who have to rely on non-pharmaceutical strategies.

So, while a pandemic is a common, shared problem, there is a big divide in the response. One country may have stock-piled Tamiflu to treat its population but there are plenty more people coming in from other infected countries who do not have the same healthcare resources.

The assumption is that a vaccine arrives six months after the pandemic starts, a second wave is prevented and everything returns to normal. What happens, though, if the vaccine is delayed? What happens if the infection is too virulent even for the vaccine production to meet demand or, indeed, that there is some sort of problem with the vaccine? Well, then the death toll could rise by a third. To give some indication of the impact, the private healthcare systems in the USA bear about \$120 billion of loss in these kinds of outcomes.



Dr Andrew Coburn is Chief Scientist at the Cambridge Centre for Risk Studies, Judge Business School, University of Cambridge. His recent work has included a focus on cyber risk, financial crises, and threats with the potential to disrupt the global economy, such as pandemic risks and geopolitical events. Andrew was a member of the Blackett Review Panel convened in 2010 to address how the UK government can use risk analysis techniques to avoid strategic shock and he was a member of the Scientific Pandemic Influenza Advisory Committee Modelling group (SPI-M).

Table 1. Consequences of hypothetical pandemic scenario

	Scenario	Poor response	Vaccine delay	Poor response and vaccine delay
Global death toll projections	19 million	22 million	24 million	25 million
Global loss of GDP	\$7 trillion	\$10 trillion	\$14 trillion	\$23 trillion
Proportion of world annual GDP	12%	18%	25%	40%
Duration of global recession	6 months	9 months	9 months	12-24 months
Life insurance payouts	\$99 billion	\$113 billion	\$119 billion	\$121 billion
Healthcare insurance payouts	\$93 billion	\$122 billion	\$128 billion	\$144 billion

A pandemic would cause massive economic disruption around the world.

Table 2. Healthcare demand can swamp capacity

	USA	UK
Physician consultation demand	PHCP consultations	GP consultations
Normal consultations per week	19,623,240	4,672,200
Pandemic consultations in peak week	15,871,380	3,778,900
Pandemic demand as proportion of capacity	81%	81%
Hospitalisation demand		
Total number of hospital beds	944,277	136,486
Normal occupancy level	68%	86%
Pandemic hospital bed demand	1,800,000	312,000
Pandemic demand as multiple of spare capacity	5.9	16.3
Intensive care demand		
Total intensive care beds	67,357	3,770
Normal occupancy level	80%	85%
Pandemic intensive care bed demand	350,000	58,000
Pandemic demand as multiple of spare capacity	25.9	102.6

Increasing and decreasing risk trends

What are the trends that are increasing pandemic risk? Well, top of my list is 'gain-of-function' research. People are actively trying to make viruses more virulent in order to thoroughly understand their mechanisms, but I believe this is under-policed.

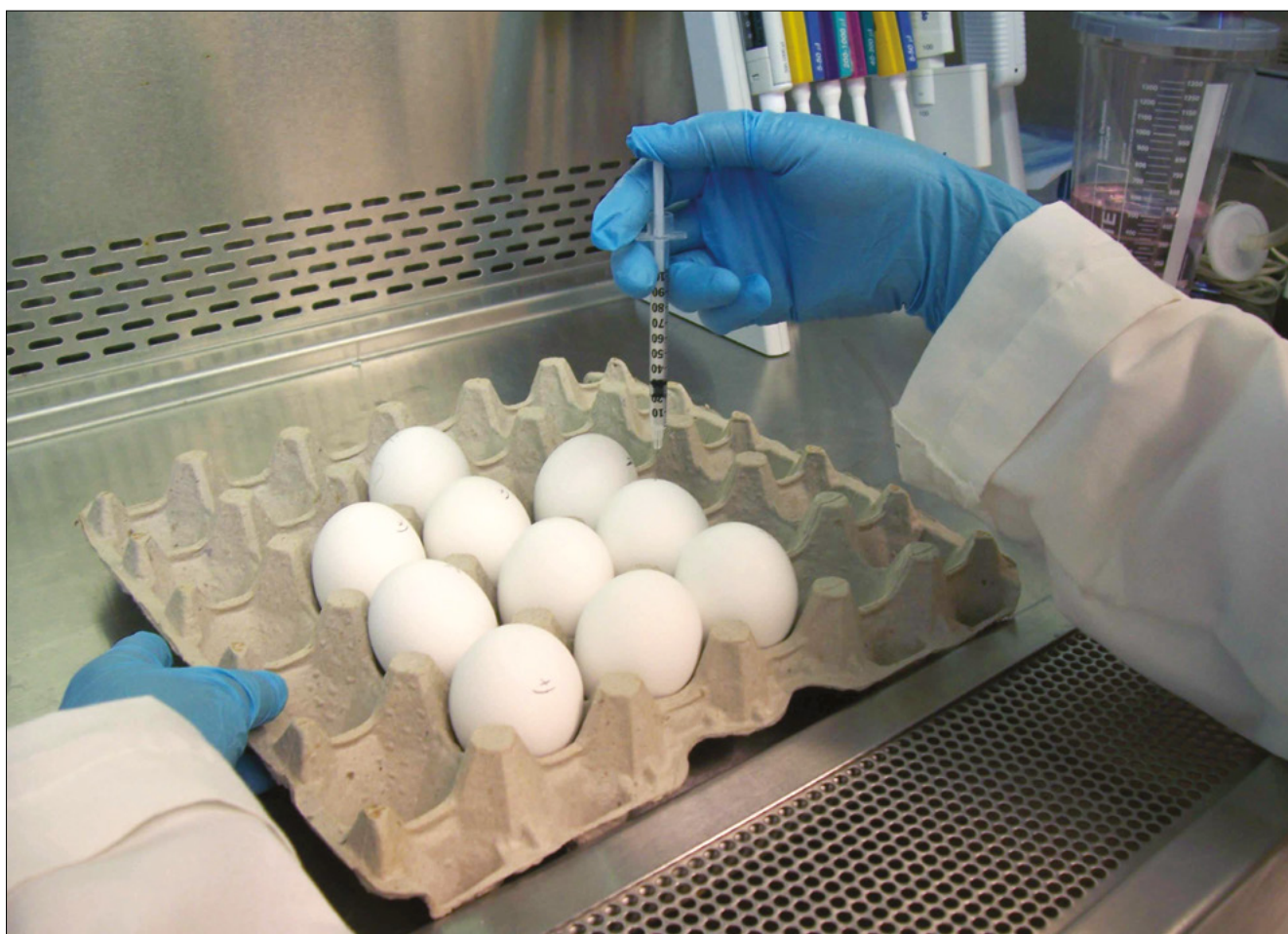
We have tried to quantify the effect of antimicrobial resistance (AMR) on a future pandemic scenario. Assuming specific failure levels for our standard antibiotics gives significant increases in the death toll.

There are growing populations of livestock which, in emerging economies particularly, are becoming zoonotic reservoirs for future new strains of disease. In addition, WHO statistics

show an improving efficiency of healthcare provision: this has the effect of reducing surge capacity.

Pharmaceutical companies are less motivated to carry out vaccine research – their business models do not really support vaccine development activities. Increased international travel allows quicker and larger rates of infection.

However, there are also developments that are decreasing the risk of pandemics. The current technology for vaccines is pretty old-fashioned and relies on large numbers of eggs. Switching to a cell-culture manufacturing technique speeds things up significantly. There is now the possibility of universal influenza vaccines. Healthcare expenditure in the global economy is also steadily increasing.



U.S. Food and Drug Administration

In terms of emerging infectious disease, a really good vaccine for Ebola has just been finalised and there are other vaccines on the way for some of the worst haemorrhagic fevers: those are at the top end of our spectrum of concern.

There is some great work going on in disease surveillance and emerging economies have much better networks of detection, reporting and monitoring.

The 1918 pandemic was certainly the worst that we have been able to measure and understand. There are hints in the literature of others in history, but medical science records do not exist for these. The deaths from secondary bacterial infections in 1918 are largely treatable with antibiotics today.

What next?

What might nature throw at us next? Nature has in the past created new types of pathogens that combine in different ways, so we actually need to be prepared for a combination of any of the known diseases. Haemorrhagic viruses with high infection rates would be a real nightmare scenario.

Historically, there has been a global pandemic – something that crosses international boundaries that is new which we do not have the toolkit for – every 13 years. About two-thirds of those are

influenza. It is one of the most adaptive and changing diseases. Preparing for a pandemic is not solely a UK problem, it is actually a global problem. It is just not possible to close the border – the spread will happen too fast.

Surge capacity and healthcare provision are quite key, as well as stockpiling drugs for known threats including influenza. Much of our strategy is very dependent on vaccines, which we have outsourced to the private sector. However, the business model is poor in rewards, so that needs to change radically.

We need a game-plan for anything that could be thrown at us while focussing on the more likely infections. □

Old-school vaccine technology: A US Food and Drug Administration laboratory worker injects an influenza virus into an egg, where it will grow before being harvested.

¹ Ruffle SJ, Bowman G, Caccioli F, Coburn AW, Kelly S, Leslie B, Ralph D (2014) *Stress Test Scenario: São Paulo Virus Pandemic*. Cambridge Risk Framework series. Centre for Risk Studies, University of Cambridge. Available from the publications section at www.jbs.cam.ac.uk

What might nature throw at us next? Haemorrhagic viruses with high infection rates would be a real nightmare scenario.

The digital component



Professor Rachel McKendry, Director, i-sense and Professor of Biomedical Nanotechnology at University College London joined the panel after the main presentations.

Public Health England (PHE) is rightly acknowledged as one of the most advanced public health systems in the world, particularly in the area of influenza surveillance. We have excellent modelling work and there have been tremendous advances in vaccines since the 1918 pandemic.

However, how digitally prepared for a pandemic are we? One of the biggest challenges during a pandemic will be communication and the need to counteract any misinformation online. How much is being done to prevent rumours appearing online? Are we using Facebook and social media to counter-

act misinformation for example linked to vaccines?

There are emerging new technologies for early disease detection, enabling researchers to study the transmission and impact of a pandemic. Today, nearly everyone has a smart phone. Companies are being encouraged to share their data with Public Health England and with hospitals for pandemic flu preparedness. Our i-sense researchers at UCL have been exploring the use of search data and working very closely with PHE on this. With algorithms based on machine learning, we believe we can give an earlier indication of flu by up to a week. These advances are already being used in national flu surveillance by PHE, but much more could be done through more data-sharing between public health institutions and researchers.

A&E services are likely to be completely overwhelmed in a pandemic. We need to look at supporting people at home to avoid overcrowding clinics and here digital technologies could play a role. Development and piloting of these methods should be carried out in times of seasonal flu: implementing them in a pandemic would be – at best – challenging. Our knowledge and our toolkit to respond to these challenges must evolve as fast as the virus. □



New apps can help with early disease detection

FURTHER INFORMATION

UK Influenza Preparedness Strategy 2011

www.gov.uk/government/publications/responding-to-a-uk-flu-pandemic

São Paulo Virus Pandemic Scenario Cambridge Centre for Risk Studies, Cambridge Risk Framework University of Cambridge, Judge Business School

www.jbs.cam.ac.uk/fileadmin/user_upload/research/centres/risk/downloads/crs-sao-paulo-virus-pandemic.pdf

The National Risk Register of Civil Emergencies 2017

www.gov.uk/government/publications/national-risk-register-of-civil-emergencies-2017-edition

Annual Report of the Chief Medical Officer 2017 Health Impacts of All Pollution – what do we know?

www.gov.uk/government/publications/chief-medical-officer-annual-report-2017-health-impacts-of-all-pollution-what-do-we-know

Operating framework for managing the response to pandemic flu

www.england.nhs.uk/wp-content/uploads/2013/12/framework-pandemic-flu.pdf

Influenza Pandemic Brief, April 2016

www.england.nhs.uk/wp-content/uploads/2016/04/pandemic-influenza-brief-apr16.pdf

NHS Board paper on Influenza Pandemic preparedness

www.england.nhs.uk/wp-content/uploads/2017/03/board-paper-300317-item-10.pdf

The debate

Published alongside the Government's Risk Assessment are 10 simple, practical measures that would make a huge difference if every household acted on them. The advice was there. Social media could be more pro-active and sophisticated, as a way to support positive communications to the public about the threat, to build confidence in the counter-measures that were planned and to promote precautions the public could take themselves.

These tools could also be used to counter misinformation on the web, which poses an increasingly significant threat. Spurious evidence and arguments against vaccines are, for example, being deployed with great sophistication. Scientists have a responsibility to engage in equally sophisticated counter-arguments and in finding new ways to communicate positive, evidence-based public health information and advice.

The NHS website (www.nhs.uk) is widely used. Could an NHS app be developed, giving advice on pandemic risk, preparedness and countermeasures? However, pandemics vary in impact. In a mild pandemic it would be important, for example, not to induce behaviour changes which might have an unnecessary adverse impact on the economy. Internet service providers should be asked or required to take down misinformation on social media. Fake news needs to be called out and countered systematically with evidence and the truth.

There needs to be renewed investment in vaccine development – and in particular the search for a universal flu vaccine. Basic science is still needed alongside developmental research. It is necessarily a long-term game. The sea changes in treatment for Hepatitis C and HIV emphasise the need to keep at the issue – and to take an optimistic view. Nevertheless new, more visionary approaches may be required.

Viruses as well as counter-measures will continue to adapt and evolve. It is crucial to watch for developments in the animal sector. Zoonotic strains are vital indicators; and both researchers and surveillance teams monitor strains circulating in the animal world and in the fowl and bird population in particular.

Antibiotic supply

Ensuring a supply of antibiotics for secondary infections will be a key success factor in preparing for and responding to a flu pandemic. The NHS needs to be supported in preparing for the longer term impact of an epidemic, with a particular

emphasis on primary care. There is a strong argument for investing in new technologies to tackle seasonal flu, which can then also support the response to a pandemic.

The management of death raises wider issues than just logistical and ethical challenges. The death toll in a pandemic would have a huge cultural impact. The deaths of a large number of young people could have a devastating impact – although there was interesting evidence from the Ebola outbreak that the population had adjusted surprisingly quickly.

Current developments in global and national politics undoubtedly make this a difficult time in which to pursue a multilateral agenda. But better international institutions and structures to tackle the issue of pandemics at a supra-national level could do much to enhance global resilience. □

The discussion that followed the formal presentations covered issues such as: fake news on social media; an NHS app; vaccine development; and the role of antibiotics.



John Keith/National Cancer Institute

Research is continuing for a universal flu vaccine.

The National Risk Register of Civil Emergencies

Alongside emergency services and local authorities, the Government has an important role to play in identifying, assessing, preparing for and dealing with emergencies, from flooding and severe storms to industrial accidents or terrorist attacks.

The Government produces the National Risk Register of Civil Emergencies¹ (NRR) every two years in order to give information to the public about these risks, alongside advice and guidance on how to prepare for them.

The NRR is based on information from the National Risk Assessment, which is a classified assessment of risks that could happen in the UK over the next five years. Both documents help the Government and local authorities to inform, plan and prepare.

These risks are written in the form of scenarios or events, such as a severe storm or a disease outbreak. The seriousness of any risk depends on two things: (a) how likely it is to occur; and (b) the expected impacts were it to happen. Government considers both of these factors when assessing a risk scenario. Some of the most important risks are set out in Figure 1.

Infectious diseases

The emergence of new infectious diseases is unpredictable but evidence indicates it may become more frequent. This may be linked to a number of factors such as: climate change; the increase in world travel; greater movement and displacement of people resulting from war; the global transport of food and intensive food production methods; humans encroaching on the habitat of wild animals; and better detection systems that spot new diseases. No country is immune to an infectious disease from another part of the world. In light of evidence from recent emerging infectious diseases such as Ebola and Zika, the likelihood of this risk has increased since the

previous 2015 edition of the NRR.

Human diseases take a variety of forms, some of which have the potential to cause a civil emergency due to the number of people they might affect in a short space of time. One such risk is an influenza ('flu') pandemic. Flu pandemics are natural events that happen when a unique flu virus evolves in such a way that few people (if any) are immune to it.

There are important differences between 'ordinary' seasonal flu of the kind that happens in winter, and pandemic flu. In a pandemic, the new virus will spread quickly and cause more serious illness in a large proportion of the

Animal diseases are partly a threat because of the potential for some diseases to spread from animals to humans and cause illness or fatalities.

population, due to the lack of immunity. There is a high probability of a flu pandemic occurring, but it is impossible to predict when, or exactly what it would be like.

Emerging infectious diseases could also cause large numbers of people to fall ill. These are diseases which have recently been recognised or where cases have increased over the last 20 years in a specific place or among a specific population (e.g. the Zika virus). The likelihood of an emerging infectious disease spreading within the UK is assessed to be lower than that of a flu pandemic.

Ways of catching these diseases can include:

- respiratory (airborne from one infected person to another);
- vector-borne (spread to humans via a third-party species, e.g. a mosquito);

- blood-borne (spread between humans via exposure to infected blood or blood products);
- food-borne (spread by contaminated food/water).

It is difficult to forecast the spread and impact of a new flu strain or disease until it starts circulating. However, for pandemic flu, consequences may include up to 50% of the UK population experiencing symptoms, potentially leading to between 20,000 and 750,000 fatalities and high levels of absence from work. In addition, there is likely to be:

- disruption to essential services, particularly health and education;
- economic disruption, including disruption to business and tourism.

The most recent pandemic flu outbreak was an H1N1 strain (swine flu) in 2009 which caused at least 18,500 deaths worldwide. In 1918, another variant of the same H1N1 strain (Spanish flu) killed over 50 million people globally. However, other flu strains exist with pandemic potential, such as H5N1 (avian or bird flu). This strain caused several hundred human deaths in South East Asia in 1996.

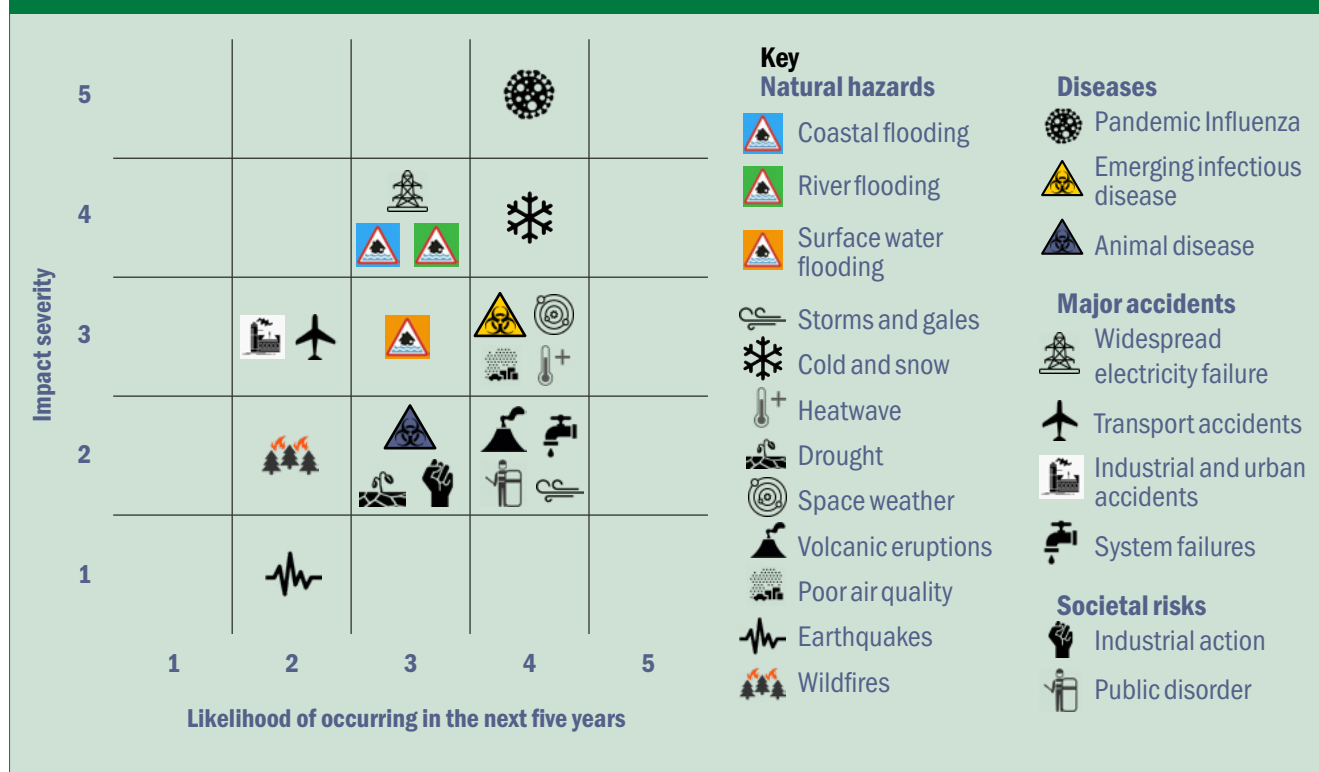
Over the past 25 years more than 30 new (or newly recognised) emerging infectious diseases have been identified around the world, such as Ebola, Zika and Middle East Respiratory Syndrome. The latter emerged recently in 2012 and poses a global health threat.

Animal diseases

Animal diseases threaten the UK for two main reasons: firstly, because of the potential for some diseases to spread from animals to humans and cause illness or fatalities; and secondly, because they affect the animals on which the country relies for food, trade, or to maintain the ecosystem.

'Zoonotic diseases', which spread

Figure 1. Hazards, diseases, accidents and societal risks



from animals to humans, include avian influenza spread by migratory birds, movements of live poultry, poultry meat or contaminated vehicles/materials. Some strains can cause diseases in humans. West Nile virus is spread by mosquitoes and via birds as intermediate hosts. It can cause encephalitis or meningitis in people (inflammations of the brain/brain lining and spinal cord) although 80% of those infected show no symptoms at all. It has never reached the UK. Rabies is spread by bites/scratches from infected animals. It infects the nervous system and is usually fatal once clinical signs appear. Rabies is present at very low levels in some UK bat populations, but the risk to humans is very low.

Animal diseases which cannot spread to humans are termed 'non-zoonotic' and include foot-and-mouth and swine fever. These harm the UK by affecting animals (particularly livestock) that agriculture or ecosystems rely on.

Government action

The UK Government response to these risks takes a number of forms, including pre-event planning, coordination and international collaboration.

The UK Influenza Pandemic Pre-

paredness Strategy covers strategic planning, response and scientific evidence. Contingency plans exist for many emerging infectious diseases. The World Health Organisation (WHO) collates global influenza preparedness plans.

Government Departments, Devolved Administrations, public health agencies and devolved NHS branches share plans and information.

The UK Government collaborates with others to undertake work on prevention, detection and research. WHO has an influenza programme which provides member states with strategic guidance, technical support and coordina-

In 1918, a variant of the H1N1 strain (Spanish flu) killed over 50 million people globally. However, other flu strains exist with pandemic potential, such as H5N1 (avian or bird flu). This strain caused several hundred human deaths in South East Asia in 1996.

tion of activities.

Should an outbreak of disease occur, the Government response strategy involves:

- detection – specialist epidemiology and microbiology capabilities exist within the UK to identify, characterise and respond to infectious diseases;
- antivirals – the Government stockpiles enough antiviral medicines to help treat people showing symptoms during a flu pandemic. Antivirals can help treat flu symptoms but are not a cure;
- vaccines – vaccines will be developed as soon as possible once new flu strains are identified. This will take at least four to six months after a pandemic begins;
- personal protective equipment – emergency responders have personal protective equipment for severe pandemics and infectious diseases. There are also protocols in place for infection control both before and during an incident. □

¹ www.gov.uk/government/publications/national-risk-register-of-civil-emergencies-2017-edition

TECHNOLOGY AND THE LAW

On 20 June 2018, the Sir Brian Neill Memorial Debate considered the opportunities to be gained from greater use of digital technology in the legal system – a topic that had been close to Sir Brian’s heart.

Employing technology to improve the delivery of justice

Geoffrey Vos



The Rt Hon Sir Geoffrey Vos is Chancellor of the High Court of England and Wales. He holds responsibility for the conduct of business in the Business and Property Courts. Prior to this role, he was appointed a Lord Justice of Appeal in 2013 and acted as President of the European Network of Councils for the Judiciary from June 2014 to June 2016. He was the Chairman of the Chancery Bar Association from 1999 to 2001 and of the Bar Council in 2007.

Any transaction on the block chain is, by definition, borderless which creates risks as well as opportunities.

The challenge of how the adoption of new technology can improve the efficiency of the justice system is one of huge importance. If a few taps on a mobile phone can obtain virtually anything within a day or so, it is surely not reasonable to expect to wait years for a just outcome to a simple dispute.

A massive court and tribunal reform project is already underway that will bring the biggest investment to the court service for decades. An online solutions court is already undergoing full-scale testing for divorce and for small money claims. This will allow claims to be started and mediated online, with physical hearings being reserved for cases that cannot otherwise be resolved.

Since April 2017, online filing of all documents has been compulsory in business and property courts. Orders are produced electronically and some hearings employ digital case management systems. In a recent, very large Court of Appeal case (it lasted two weeks and 15 counsel appeared) each judge had three screens showing the documents referred to, their own notes and any document the judge individually wanted to review. There was also simultaneous transcription of the proceedings. I was one of those judges and conducted the whole case, including writing parts of the judgment, without using any paper at all.

The international context

The UK faces competition from business courts across the world that are keen to attract commercial dispute resolution and arbitration. There are existing international commercial courts in Singapore, Dubai, Abu Dhabi and Qatar and new ones being set up in Brussels, Amsterdam, Paris, Frankfurt and Dublin, to name but a few. Most will be English language-based and will apply a common law approach.

UK advantage

There are more FinTech, LawTech and RegTech start-ups in the UK than in the whole of the rest of Europe, but Paris, Berlin and Amsterdam are catching up fast. There is a great deal of EU

SUMMARY

- English law and UK dispute resolution are well-placed to provide the legal foundation for international business and property contracts involving new digital technologies
- A careful evaluation is needed as to when physical courtroom settings are appropriate – and when a digital process could be more effective
- Issues of fact could often be decided online in advance of a courtroom hearing
- If court hearings were no longer to be the norm, ways must be found of ensuring appropriate public access to the digital judicial process
- The use of technology must not exclude the vulnerable or the less wealthy.

investment and a diversity of ideas as to how artificial intelligence can be deployed to support lawyers and other professionals.

Distributed ledger technology (DLT) has far greater reach than many imagine. It is capable of use in relation to smart contracts of course, financial transactions generally and in an almost unlimited number of other areas such as land and intellectual property registers, utility billing, telecoms and transactions in almost any field.

There are said to be some three trillion Financial Services transactions globally each year and it is forecast that within five years most will be DLT-based smart contracts. Any transaction on the block chain is, by definition, borderless which creates risks as well as opportunities.

English law and UK dispute resolution are well-placed to provide the legal foundation for many of these contracts because in the UK the Prudential Regulation Authority and the Financial Conduct Authority have adopted a very sensible ‘wait and see’ approach to regulation. If history is anything to go by, the EU’s approach to regulating FinTech is likely to be more interventionist than the UK’s and our common law system is well-placed to

respond to digital innovation in order to provide legal certainty in this brave new world.

Accelerating take-up

So that is the background. How can the adoption of new technology be accelerated to improve the efficiency of the justice system? My expertise lies in the area of business law, where judges, arbitrators and lawyers are learning the benefits of working digitally. The justice system will be more relevant and effective if it provides a digital service to clients and court users who have long since reduced their reliance on paper.

There needs to be a very careful evaluation of when physical hearings with a judge, the parties, their lawyers and witnesses are really needed – and when technology offers a more efficient option.

Lawyers and judges will need training, not to become computer code experts, but to understand how disputes arise from transactions on the blockchain for example. Basic legal training remains largely the same as when I started reading law at university nearly 45 years ago!

Surely the objective should be to provide a truly digital business justice system, delivering speedy and dependable outcomes for hard-pressed commercial parties at a proportionate cost. It seems obvious to me that claims in such a system must be started and conducted online.

There is no reason why participants could not log on within a time window, make submissions online and respond to questions by the judge online. In this way, everyone's voice can be heard without spending large sums flying witnesses into London or elsewhere from far away. Some of the biggest global law firms already ban staff from international travel, requiring them instead to conduct overseas business meetings by Skype, Facetime or Telepresence: a Telepresence meeting is almost identical to a physical meeting.

A combination of these mechanisms can be applied to dispute resolution. In the case of, say, an application for a freezing order to prevent a defendant from putting assets out of reach, the claim is already lodged online in the business and property courts. The relief could also be granted online. The judge could consider the material filed online, ask questions, receive the answers and make the appropriate order. The record would show what the court had been told and once the defendant was informed of the order they could apply to set aside the injunction by exactly the same process. Even cases involving multiple parties and witnesses could be resolved wholly or partially in a similar way.

Preliminary issues could be resolved by online questions and answers and a judicial determina-

tion without costly court attendances by lawyers and parties – even evidence could be given in writing, online or remotely by Skype.

In some cases, time in the physical courtroom is crucial, but there are many cases where parts of the trial process are simply costly and unnecessary. Why, for example, are written submissions reiterated orally before and after oral evidence?

In many cases there are only a handful of substantive, factual disputes and even those are often born of misunderstanding or mistrust rather than substantive disagreement as to what actually occurred. A good proportion of the factual disputes are quite irrelevant to the outcome and could be avoided altogether if considered in greater detail at an earlier stage. If judges were more engaged online, asking questions, directing evidence, resolving cases stage by stage, they could probably resolve the majority of even lengthy trials by an iterative, online process.

The legal system is too hidebound by procedural rules and long-established practices. Courtroom hearings could be made more efficient and business-like if the judge were up to speed with the issues and the progress already made online. That would bring into better focus the issues still dividing the parties.

Ensuring access

I would add two important concerns regarding online justice. Simultaneous transcription services and the case management systems that allow for paperless trials and appeals are expensive and at the moment are paid for by the parties. It is important to ensure that digital processes are available to business litigants in the smallest as well as the biggest cases.

The core principles of our justice system must also be respected – the most obvious being open justice and access to justice. If court hearings were no longer the norm, ways would have to be found of ensuring appropriate public access to the digital judicial process. Under no circumstances can justice be delivered behind closed doors.

Moreover, while access to justice is generally enhanced by smart procedures, the use of technology must not exclude the vulnerable or the less wealthy. All that said, I think our business and property courts are doing well in terms of operational efficiency and providing state-of-the-art litigation processes. We need to continue to think imaginatively about our civil procedures in the context of both Brexit and the digital revolution.

The UK is well-placed to deliver justice in a world-leading way, but to do that we will need to invest in reform and be ready to take the opportunities offered by LawTech. □

In some cases, time in the physical courtroom is crucial, but there are many cases where parts of the trial process are simply costly and unnecessary.

If court hearings were no longer the norm, ways would have to be found of ensuring appropriate public access to the digital judicial process.

Adopting new technology for a modern justice system

Susan Acland-Hood



Susan Acland-Hood is Chief Executive, HM Courts and Tribunals Service. She was previously Director of Enterprise and Growth at HM Treasury, responsible for policies on productivity, growth, business, infrastructure, exports, competition and markets, and for energy and transport spending. She has also worked extensively on home affairs and justice policy, both at Number 10 and in the Home Office. She has also had senior roles in the London Borough of Tower Hamlets, and in the Social Exclusion Unit.

One project allows individuals to enter a plea for a minor offence online. People are slightly more likely to respond online than to a letter.

Much of the work of the Courts and Tribunal Service reflects the fact that, although the principles which underpin our justice systems are enduring, our processes do not need to be as old as our principles.

The justice system exists to defend our fundamental rights and freedoms. It empowers us to do all the things we do in life. It allows us to enforce our rights against anyone, but in practice it still empowers big, strong and capable actors more than smaller, weaker and less-informed ones.

Change is not just about replacing analogue processes with digital ones, but needs to ensure there is no unnecessary complexity in the system and that it is accessible. It is concerned with putting power into the hands of those who use the system and enabling them to navigate it much more readily. That matters because when people with a good case do not come to the law, they suffer themselves but so too does society because it becomes less risky to rip-off the ordinary citizen.

We often refer to the need to design for 2050 and not 2018. We do not have a crystal ball that shows us what the legal system will look like at that date, but whatever is built must be capable of change, iteration and development.

Our £1 billion programme is ambitious but it needs to be. We are aiming to take elements of systems in use elsewhere in the world but in a way that gives extra benefit by bringing them together into one place. This will be built in small, sharable, agile parts, so that it can be adjusted in response to feedback but also, by building small and testing with real people, the final result is better.

Crime

The starting point is to determine the processes we want to see in a criminal system and how these can be underpinned with good quality technology. One already completed project allows individuals to enter a plea for a minor offence online. This adds a new route to a system in which a letter is sent: people are slightly more likely to respond online than to a letter. The new method is relatively quick and easy to use. There has been a good take-up and some good user feedback.

The online pleas are brought together into 'automated track case management'. A single adjudica-

SUMMARY

- Reform of the justice system is about putting power into the hands of users
- Best practice from around the world is being combined to transform the English justice system
- Whatever is built must be capable of change, iteration and development
- One beauty of a digital system is that it can quickly highlight where further adjustments need to be made
- Our work is rigorously tested with real users.

tor, sitting alone, determines these very low-level cases – typically speeding offences or failure to buy a ticket on the underground. The first use of this has been on Transport for London cases and we put about 350 TfL cases through this system a week. The magistrate, sitting with a legal adviser, looks at all the evidence in the case. They are able to see the plea that someone has made or see what has been sent to the person. They then make a decision which is kept as part of the system of record.

We have the beginnings of a 'common platform'. This brings together the police, the Crown Prosecution Service (CPS) and the Courts Service in a single, end-to-end system which removes the need for people to transfer records between different networks, whether on paper or by re-keying.

Trials, on a small scale, are underway in Liverpool. The police send in material and the CPS then decides whether or not to charge a suspect. The evidence uploaded by the police appears on the CPS screens. The defence can access the initial details of the prosecution case much earlier than at present because as soon as the decision to prosecute is made, this is in turn made available to them. The same system is used to bring material into the Crown Court case. It is used to allocate hearing time and then the Crown Court Clerk can log everything that happens during the hearing. This is also integrated with our recording system.

Families

Submissions using the existing, 15-page paper divorce form had a rejection rate of about 40%, so

about 4-in-10 applications were sent back because people had completed them incorrectly.

In designing the new online system, the emphasis was on making sure the questions were simple to answer and we tested that with real people in July 2017. The error rate had reduced to 8% by September. One beauty of a digital system, of course, is that it can highlight where people are going wrong and indicate where further adjustments need to be made. The error rate was down to 5% by Christmas.

Some of the remaining errors seem to be connected with printing and posting the form and a marriage certificate. So just after Christmas 2017 a new service, enabling people to take a picture of their marriage certificate on their phone and upload it, was introduced. There was an immediate 90% success rate and that is increasing all the time. The overall error rate is now below 1%.

It is available to any individuals who want to get divorced in England and Wales (a lawyer's version is in development). This is a really good illustration of how to make something cheaper for everyone, but also better at the same time.

Something very similar is being developed for probate. Once again we have had extremely positive user feedback for the beta version, some that has been genuinely quite moving.

A project is planned on public family law which will allow us to take information digitally from local authorities. It will also permit the production of orders during the hearing so that people can see them at the time. This approach will be extended to adoption and private family law.

Civil

Available to everyone is an online system that allows small money claims to be made online and also allows defendants to respond. The rate of defence of claims is higher than under the old system and we are looking to see whether there are larger numbers of claims for small amounts. That would support the theory that there may well be people who have good claims but do not bring them to court, particularly for small amounts, because they fear that the process will be too complex and it will not be worth it.

This method encourages people to resolve disputes before going through the system: it offers mediation and other means to resolve disputes out of court, so a respondent can make an offer without admitting liability and the parties can negotiate a resolution.

Tribunals

Starting with social security and child support tribunals, people can now submit their appeals

online. They are getting quicker answers from the Department for Work and Pensions (DWP) and this tool allows them to track their appeal. The use of SMS messaging is a really important method of communicating with large numbers of people, because the vast majority of people – even those who do not have or use email – have an SMS-enabled phone and know how to use it.

One area that is still at an early stage is a process that will allow judges to ask questions of people online in order to resolve cases without necessarily requiring a physical hearing. In the field of social security and child support, it is recognised that asking people to come to a physical hearing is difficult and challenging for many. This method will also allow individuals to submit their answers by audio recording or by video. It is not necessary to be able to write a stream of continuous text in order to tell the tribunal what it wants to know.

Over the coming months, there will be testing of full video hearings: in the tax tribunal, for example, people are already being invited to have their cases heard by video. We have had no difficulty in finding people who want to have their case dealt with in this way. A judge has been sitting in one of the tribunal buildings in London, the appellant has been at home using their own equipment and the HMRC presenting officer has been in the Belfast office.

In developing solutions for different parts of the justice system, we are very mindful of the common components which need to exist across the whole infrastructure as well as bespoke parts that need to be in particular places only. The intention is to bring those together over time into an online court system.

Evaluating our efforts

We are very serious about evaluation. Our work is rigorously tested with real users, something I believe is crucial to success. We are also developing plans for programme-wide evaluation with the Ministry of Justice, as well as a dedicated strand of work on management information and data.

We believe that our approach can create opportunities way beyond the walls of HM Courts and Tribunals Service. So we are looking at ways to allow others to design bits of LawTech that can then interface with us. There are things the state does well, but there will be other things where an app developer designs something that is far better for particular, specific uses. If those apps can link seamlessly into our system and allow people to feed cases in, then a whole new world starts to open up. □

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Upgrading the justice system

Richard Susskind



Professor Richard Susskind OBE FRSE is President of the Society for Computers and Law, Chair of the Advisory Board of the Oxford Internet Institute, and Strategy & Technology Adviser to the Lord Chief Justice of England and Wales. He chaired the Online Dispute Resolution Advisory Group of the Civil Justice Council whose proposals on online courts have been adopted as judicial and Government policy. He is a Fellow of the Royal Society of Edinburgh and of the British Computer Society. An Honorary Bencher at Gray's Inn, he was awarded an OBE in 2000.

I first addressed the Foundation for Science and Technology on the topic of technology in the courts in 1991. I was Chairman of the Society for Computers and Law and Sir Brian Neill was President. Some 20 years later, the modernisation of the court system and the widespread introduction of technology is the subject of a joint initiative by the Government and the judiciary. We have a combination of great people in HM Courts and Tribunals Service, a very supportive judiciary and funding from The Treasury. Our stars are currently aligned.

Three factors in particular will bring greater change in the coming 20 years than has been seen in the past two centuries in the way lawyers work.

The first is the 'more for less' challenge – how to reduce the cost of legal services. This is an issue for everyone, from major organisations with legal teams of more than 1,000 people down to the individual citizen.

Second, there are now new providers coming into the marketplace. In England, the legal system has been liberalised to the extent it is now possible for non-lawyers to participate in delivering legal services. Some of these new entrants, such as the 'Big 4' accounting firms, are of a different order of magnitude from conventional legal businesses and are looking seriously at how to deliver legal services.

Third, of course, is technology.

The process of change

The legal world is going through three phases of change. The first, which I think ended in about 2016, was that of denial. Denial by people who felt that somehow the legal world was immune from any change. Very few senior individuals believe this any more.

We are going through a second phase just now, which I reckon will last until the early 2020s, where the solution to the 'more for less' challenge is to use lower-cost labour, for example, by outsourcing, offshoring and using paralegals – taking the cost out, not with technology but by using people who cost less.

SUMMARY

- The next 20 years will see greater change in the English justice system than the previous two centuries
- The current system of dispute resolution is too costly and too slow
- Online courts are not intended to be a full replacement for the physical courtroom
- Online solutions are designed to be affordable, quick, intelligible and proportionate
- The goal is to increase access to justice and in so doing promote the rule of law.

A third phase, the 'disruptive phase' will happen as a variety of technologies (some of which are already bubbling up) replace some of the ways that legal service is delivered.

The advance of technology

In 1996, just over 20 years ago, I wrote a book entitled *The Future of Law*. In it I suggested that the dominant way that lawyers and clients would communicate in the future would be by email. The Law Society of England and Wales claimed at the time that I was bringing the legal profession into disrepute by saying email would be used between lawyers and clients! So much has already changed but there is still a long way to go.

The underpinning technologies are growing at an exponential, explosive rate. Our systems are becoming increasingly capable. It is hard to pick up the *Financial Times* or *The Economist*, or indeed any daily paper, and not read a story about a new app, breakthrough, or technological development. Our systems are becoming increasingly pervasive and I do not just mean our handhelds and our tablets, but other developments like the Internet of Things.

In 2005, a good memory card might have offered 128MB of storage: fast-forward less than 10 years to 2014 and that figure was 128GB – a thousand-fold increase in less than 10 years. That explosive growth is happening not just in memory cards, but in processing power, in hard disk capacity, in the number of internet users, number of websites, bandwidth and so on. This is underpinning an increasing capability of our systems, particularly in the areas of machine

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learning and big data. In that context, in the most document-intensive and information-intensive sector of all – the legal world – can we honestly imagine that we are somehow immune from change? That seems to me entirely improbable.

A service or a place?

The fundamental question seems to me to be whether we really need physically to assemble on all occasions to resolve our differences? Is ‘court’ a service or a place?

There are clear problems with the justice system in its current form. When I was invited by the Civil Justice Council in 2014 to look into the possibility of online dispute resolution, our group identified very quickly that for low-value claims in particular, the current system is too costly and too slow, it is unintelligible for non-lawyers and it is too combative – it somehow feels out of step in a modern digital society.

A quotation from Sir Brian Neill comes to mind: “You do not need a Rolls Royce to haul a water cart.” I just think it is such a wonderful image and very appropriate in this context. Lord Dyson also put it very well when he said: “Any system that has a 2,000-page user guide has a problem.” He was referring to the Civil Justice system and the Civil Procedure Rules.

Online courts are not a complete alternative to the courtroom. For suitable cases (and not all cases are suitable), they offer a state-provided dispute resolution service where parties do not need to congregate physically. Judges can receive evidence and arguments electronically and they can communicate the decisions electronically.

This is new approach and will need to be supported by a highly-simplified set of procedures and rules. It is not a case of grafting the technology onto the old system, but of re-thinking the rules and simplifying them so that the whole process is far more focussed on the genuine needs of the users. The aim, therefore, is for a system that is affordable, quick, intelligible and proportionate – in short, greater access to justice at lower cost.

In practice

There are significant challenges to overcome. Judges without courtrooms. Justice without lawyers. Naturally some in the legal establishment are apprehensive about this. Yet there are many examples of this working well. Every year on eBay there are 60 million disputes among traders. Almost none of them is sorted out by courts and lawyers; they are resolved by online dispute resolution.

Take the Financial Ombudsmen Service: in 2014 it dealt with around half a million disputes between citizens and financial institutions. Some

90% were resolved with a combination of mediation and conciliation. Of the remaining 10%, only 20 of the hearings were actually face-to-face engagements.

Allen & Overy and Deloitte have developed a system, publicly reported, to help investment banks comply with new developments in derivatives regulations, internationally. This is one of the best case studies of legal technology we have ever had. It generated fees of tens of millions of dollars and has transformed the way major investment banks actually comply with the new regulations.

In litigation, a 2011 article confirmed that where there is a huge body of documents to review in a case, online systems can out-perform junior lawyers and paralegals. These reviews use established technologies.

A 19-year-old developed a ‘Robot Lawyer’. It provides a guide on how legitimately to challenge – and so avoid paying – parking tickets.

In Uganda, a very impressive young man has brought together a team to help people who have no access to justice but do have mobile phones. The team uses this technology to deliver legal help and guidance, explaining to people what their entitlements are and helping them enforce those entitlements.

Lex Machina is a system developed by Stanford University. One claim made for it is that it can predict the outcome of patent disputes much more accurately than any human lawyer. The interesting thing is that the system knows nothing about the law. But it does have information on up to 200,000 patent cases – who the judge was, which courtroom it was in, which law firm was involved, which lawyer was involved, the name of the litigant, the subject matter, the value of the claim. With enough objective data about cases, it can make a more accurate statistical prediction of the outcome of a case than by using the legal method. Now that is really challenging.

New systems and approaches

One central question every client will ask is ‘what are our chances of winning?’ That is not a straightforward legal question, but a request for probability. If it is demonstrable that new technologies can deliver a more accurate response than the legal method, then the market will opt for that. We are living in very interesting times where systems are out-performing human experts.

What does this mean for legal education? The question is really: ‘What are we training young lawyers to become?’ My worry is that they are being trained to become 20th century lawyers. In many law schools the subject is still

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If it is demonstrable that new technologies can deliver a more accurate response than the legal method, then the market will opt for that. We are living in very interesting times where systems are out-performing human experts.

At the end of a talk I gave in China last year, six individuals came up to me and told me about their doctorates in AI and Law. I do not know of anyone who is doing a doctorate in AI and Law in England.

taught as it was in the 1970s, both what is taught and how it is taught.

What does a 21st century lawyer look like? They may not look like the lawyers that we were taught to be in law school in the 1970s. The important thing is they will deliver the outcome the client wants, i.e. solutions to their problems. I visit the USA regularly and there are now around 20 institutes or centres in law schools that are looking at the future of legal services, examining the impact of legal technology and committing serious numbers of staff and investment.

There are some similar initiatives in Scotland and Wales, but England is lamentably behind. It is ironic: English law firms are ahead in LegalTech, but the law schools are behind.

At the end of a talk I gave in China last year, six individuals came up to me. They told me about

their doctorates in AI and Law. I do not know of anyone who is doing a doctorate in AI and Law in England. If we really take legal technology seriously, we have to create within our law schools an environment in which young students are exposed to the possibilities of the future.

Any profession runs the risk of becoming preoccupied with its traditional working methods and processes rather than the outcomes that are expected of it. In fact, in the end people do not really want courts and lawyers – they want the outcomes that courts and lawyers bring. The challenge is to upgrade our justice system, harness the power of existing and emerging technologies, and so modernise our legal profession, court system and law schools.

Fundamentally, the goal is to increase access to justice and in so doing promote the rule of law. □

The debate

In the debate following the formal presentations, issues such as confidentiality, the use of machine learning, equity and mercy, and the balance of priorities were raised.

Early adopters of online systems in medicine had difficulties convincing patients that these systems could maintain confidentiality. The legal profession may encounter similar issues. This may be more of a problem for older generations than younger ones.

Digital systems are at risk of being hacked, not only by tech-savvy litigants but also by some foreign powers. The Ministry of Justice needs to use next-generation monitoring technology. Of course, much of the justice system is intended to be transparent and publicly available. However, when IT systems were introduced for sensitive cases in social work, some social workers were found to be browsing case files with which they had no involvement, an issue that could occur in legal circles too.

Could machine learning reduce the number of lawyers needed, or would the skills sets required for

lawyers in the future be different? One shortcoming of artificial intelligence is that it may not provide reasons for judgements; convincing participants that their case had been handled reasonably may require a human judge setting out reasons. AI might therefore be used more extensively in commercial rather than family proceedings. Machine learning relies on surveying past judgements and it may not therefore initiate innovation in case law.

The prospect that digitisation may lead to quicker resolution will be welcomed in insurance, where justice and positive outcomes for individuals would be much assisted by a more rapid process. In smaller civil claims the introduction of online settlement could make resolution much more readily available.

The delivery of justice may involve a technically correct solution which tempers equity with mercy, and this may be beyond machines. In larger civil cases, the involvement of the judge in determining the relative strength of argument of expert witnesses will remain important. Recent greater awareness of unconscious bias needs to be taken seriously.

Although some disabled people, such as the deaf, may prefer online processes, personal judicial input will be required for sentencing decisions which involve discretion, as well as in family cases involving children.

The goal of the criminal courts is to protect the rights of society, whereas the civil courts are principally concerned with achieving fairness for the parties in a dispute. In both, the right balance has to be struck between speed, cost and justice. □

FURTHER INFORMATION

Sir Brian Neill - A Tribute Richard Susskind, the SCL President, offers his tribute to the Rt Hon Sir Brian Neill PC, a former President of SCL
www.scl.org/articles/10149-sir-brian-neill-a-tribute

Ministry of Justice and HM Courts & Tribunals Service: New legislation will modernise the courts
www.gov.uk/government/news/new-legislation-will-modernise-the-courts

The Judicial System of England and Wales: a visitor's guide www.judiciary.uk/wp-content/uploads/2016/05/international-visitors-guide-12.pdf

RESEARCH AND DEVELOPMENT

On 18 July 2018, more than 30 experts drawn from academia, business and government gathered at The British Academy to discuss how to nurture international research and development partnerships in a post-Brexit world. Representatives of NASA and the US National Science Foundation were among those participating.

Looking to the future

Sir Norman Lamb, Chair of the House of Commons Select Committee on Science and Technology, referred to a 2016 Royal Society Fact-sheet, which recorded that more than 50% of research outputs were the result of international collaboration, the most frequent partner countries being the USA (12%), Germany (7%), France (4%) and Italy (4%).

The March 2018 Science and Technology Committee report *Brexit, Science and Innovation*¹ had a number of insights into the challenges facing the UK. First, there are the effects on all areas of research due to the continued uncertainty. Although there is cross-party support for continued research collaboration and inclusion in EU Research Programmes, this could not be achieved regardless of price. Second, the UK must maintain regulatory alignment with the EU. Third, it is critical that visas and permits are available at all levels, enabling the workers the UK needs to come here, together with their families and dependents.

Immigration debate

This latter point is the topic of a further Committee report, *An Immigration System that works for Science and Innovation*². The report highlights the need for a system that facilitates short and long term stays in the UK, enables further travel outside the UK for research purposes and features an efficient, streamlined and low-cost application process for employers and employees.

Dr Douglas Terrier, NASA Acting Chief Technologist, reflected on the success of the US space programme. From starting as a 'space race' it had evolved into an international space collaboration culminating in the building of the International Space Station and visits to all planets of the solar system.

He argued that the challenging envi-



More than 90% of infant foods contain supplements developed originally for astronauts.

ronment of spaceflight pushes the limits of all our sciences and technologies, even unexpected ones. For instance, more than 90% of infant foods contain supplements developed originally for astronauts in microgravity environments.

The focus of future space programmes is collaboration and indeed the recent White House Space Policy Directive #1 calls for NASA to "lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities".

He noted the increasingly successful commercialisation of low Earth orbit, with companies like Blue Origin, Space-X, Bigelow and Virgin Galactic starting independent space operations in the very near future. While major sci-

ence programmes like the James Webb Telescope and potential missions to Europa or Enceladus will continue to provide new science, the public may feel the impacts of the space programme first through developments in technologies like in-situ manufacturing and 3D printing, advanced propulsion and power and quantum computing. Potentially the most impactful is Artificial Intelligence which promises to revolutionise almost every aspect of business and culture.

Dr Terrier concluded by noting that all these technological developments will change our lives and jobs (as they have done in the past), but that what we have learned from the past 60 years of the space programme is that there is no static model that will ensure success. However, for those who adapt and collaborate, the opportunities are boundless. □

¹ www.publications.parliament.uk/pa/cm201719/cmselect/cmsctech/705/705.pdf

² <https://publications.parliament.uk/pa/cm201719/cmselect/cmsctech/1061/1061.pdf>

CIVIL SOCIETY

The Foundation's annual luncheon for Learned and Professional Societies was held on 28 September 2018 at the Honourable Society of Gray's Inn in London.

A vision for the next decade

Addressing the audience, Ben Harrison MBE, Policy Manager at the Office of Civil Society, DCMS, spoke about the Government's Civil Society Strategy. He noted that the country faces a number of long-term societal challenges. These include a growing and ageing population which is putting new demands on the NHS and social care services. There are major environmental challenges which must be addressed for the sake of future generations. The housing shortage needs new and bold solutions. The pace of change of technology is disrupting and changing the way we work, consume media, communicate and do business in the UK.

Societal challenge

Government alone cannot respond to all the challenges or seize all the opportunities. Big societal challenges are being tackled through solutions that bring together public services, private sector businesses, and communities in collaborative effort. That is what the *Civil Society Strategy*¹, published in August 2018, is focussed upon. It should be viewed as a companion to the Industrial Strategy. It is based around support for thriving communities which require trust, connectedness and goodwill to flourish. Greater local control, through services which were co-designed with local communities, is important. In addition, younger people need to be better involved in local decisions.

The power of place

The Government wants to encourage a more collaborative place-based approach. By working with public service providers and the private sector, as well as individuals and communities, in particular places, policy can be developed that is both more sensitive and appropriate. It will then achieve better social and economic outcomes and result in better places for people to live and work in.



Long-term societal challenges include a growing and ageing population, major environmental challenges, housing shortage and disruptive technological change

Rather than have public servants working in silos accountable only to Whitehall, this alternative approach encourages people to work together with local communities in order to collaboratively design services and pool budgets. Key to successful place-based work is the empowerment of local people to take their part in the decisions that affect them. This means, for example, devolving more power to community groups and parish councils, and including them in service delivery and local decision-making.

The future Shared Prosperity Fund will help tackle inequalities between communities and raise productivity, through the adoption of an inclusive growth model. New models of finance will play an increasingly important role including crowdfunding for public infrastructure, boosting social impact investment and developing new models of investment in local communities, funded by money from dormant accounts.

The social sector should have more effective involvement in the policy process, with the digital revolution providing the means to connect more effectively.

The strengthening of safeguarding practices in charities can help to grow public trust in the sector.

The business community has a role in mainstreaming the delivery of social value across the private sector, tackling financial exclusion and supporting initiatives such as the responsible business Leadership Group.

The public sector

The Strategy proposes that the public sector develop more collaborative commissioning, involving local groups in order to engage all the community.

Learned and Professional Societies have a key role in promoting education and debate about how to increase trust and confidence in decision making; and they constitute a major source of expertise and knowledge. They should continue to take the time to engage with Government, including on more effective ways to engage youth in these issues. □

¹ www.gov.uk/government/publications/civil-society-strategy-building-a-future-that-works-for-everyone

MAJOR SUPPORTERS IN 2018/2019

A

Airbus
Arts and Humanities Research Council
Association for Innovation, Research and
Technology Organisations (AIRTO)
AstraZeneca
AXA XL

B

BAE Systems
Babcock International Group
Biochemical Society
Biotechnology and Biological Sciences
Research Council
BP International Ltd
BPE Solicitors LLP
BRE Group
British Academy
British Geological Society
Brunel University London
BSI Group

C

Canterbury Christ Church University
Chartered Association of Building
Engineers
Chartered Institute of Credit Management
Chartered Institute of Linguists
Chartered Institute of Plumbing and
Heating Engineering
Comino Foundation
Cranfield University

D

Defence Science and Technology
Laboratory
Department for Environment, Food and
Rural Affairs
Department of Health and Social Care

E

Economic and Social Research Council
EEF (Make UK)
EIB Institute
Elsevier b.v.
Engineering and Physical Sciences
Research Council
ERA Foundation

G

Genomics England
GO Science

H

Heads of University Centres of Biomedical
Science (HUCBMS)
Health and Safety Executive
High Value Manufacturing Catapult

I

IBM (UK) Limited
Imperial College London
Innovate UK

Institute of Biomedical Science
Institute of Food Science and Technology
Institute of Materials, Minerals & Mining
Institute of Mathematics and its
Applications
Institute of Measurement and Control
Institute of Physics
Institute of Quarrying
Institution of Chemical Engineers
Institution of Engineering and Technology

J

JISC
Johnson Matthey Plc
JSPS

K

King's College London
Kingston Smith
Knowledge Transfer Network Limited

L

Lloyds of London
London Mathematical Society
Luminance Technologies Ltd

M

McLaren Technology Group Ltd
Medical Research Council
Met Office

N

National Physical Laboratory
Natural Environment Research Council
Natural History Museum
Network Rail
Nottingham Trent University
Nutrition Society

O

Open University

P

Palaeontological Association
Parliamentary and Scientific Committee
Peter Jost Charitable Foundation
Publishers Licensing Society

Q

Queen's University Belfast

R

Recruitment and Employment
Confederation
Research England
Rolls-Royce
Royal Entomological Society
Royal Geographical Society (with the IBG)
Royal Society of Biology
Royal Society of Chemistry
Royal Society of Medicine

S

Science and Technology Facilities Council
Shell International Limited
Society for Applied Microbiology
Society for Editors and Proofreaders
Society of Maritime Industries
Society of Operations Engineers
Sovcomflot (UK) Ltd
SPTS Technologies Ltd
STEM Learning

T

The Academy of Medical Sciences
The Alan Turing Institute
The Foundation for Professionals in
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The Haskel Family Foundation
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The Medical Schools Council
The Royal Academy of Engineering
The Royal Commission for the Exhibition of
1851
The Royal Society
The Wellcome Trust

U

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