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Managing the benefits and risks of Artificial Intelligence

In January, The Foundation for Science and Technology gathered together a roundtable of expert voices from across academia and parliament to discuss Artificial Intelligence, particularly generative AI and how it might be regulated.

Organised in collaboration with the All Party Parliamentary Group on the OECD, the roundtable saw a selection of thought leaders including Professor Helen Margetts OBE, Lord Tim Clement-Jones and Professor Sana Khareghani come together on the issue of Artificial Intelligence and global governance. The meeting was set up to coincide with the visit of the Deputy Secretary General of the OECD, Ulrik Knudsen, to London. Attendees took a deep dive into how to harness AI's capabilities and its substantial risks, such as misinformation. Further discussion included regulatory choices, standardisation, speed, lingo and fairness, and where the UK fits into the emerging global picture. A full report of this roundtable event is available on **www.foundation.org.uk**.

Foundation Future Leaders of 2024

The Foundation was delighted to welcome a new cohort of Foundation Future Leaders, which include early and mid-career professionals across defence, animal science, space, government departments and policy leaders.

With a wide range of experience, the 2024 cohort will be building their knowledge and networking within the science policy arena, learning from senior figures across government, universities and industry, and undertaking expeditions including a trip to UK Parliament, the Harwell Science and Innovation Campus near Oxford and the Snowdonia Space Port, later this year.

Keith Lawrey retires

In April, the Foundation said a fond farewell to its long-standing, and much respected Learned and Professional Societies Liaison Officer, Master Keith Lawrey, in a retirement celebration at The Honourable Society of Gray's Inn.

The room was full of associates from across various societies and organisations who came to celebrate and listen to a flow of speeches and accolades about Keith's tireless commitment to his work.

Keith has handed the baton to our new L&P Societies Officer, Lori Frecker, who comes to us from a background of senior diversity and inclusion roles at the Royal Society, Judicial Appointments Commission and the Law Society.

No-one left behind in the journey to Net Zero

In February, the Foundation worked with the Institute for Community Studies and the British Academy to bring together experts from across national and local government, the research community and charity to discuss what is needed to ensure that no individuals or communities are left behind in the transition to Net Zero. In a roundtable discussion, participants explored the challenges of making greener choices easier and cheaper, the role of communities and local partners, and what decisions are needed at a national level.

The roundtable was prompted by an FST event in November 2023 which explored progress on net zero transition in UK policy, science and innovation. This event revealed a gap in person-centred research, policy and strategy to build a just transition to net zero. In 2019, an independent review proposed that a public participation strategy was essential to the successful adoption of low carbon measures by UK communities. However no such strategy exists as yet. This roundtable asked how we can bring household and community policy together with net zero policy, technology, innovation and investment. Lord David Willetts chaired the event in his role as Chair of the FST and the chair of the APPG on net zero. Attendees included chief scientific advisers and senior policymakers from three government departments. Emily Morrison, Director of Sustainability and Just Transition at The Young Foundation, presented an overview of new research funded by the Nuffield Foundation looking at Our Journey to Net Zero in the round. A report of this session is available on the Foundation's website in the events section. **www.gov.uk/government/publications/civil-nuclear-roadmap-to-2050**

Podcasts: the Foundation's hidden gem

The Foundation's podcast has regularly been called its 'hidden gem' and continues to welcome a wide variety of expert guests across the science and policy sphere. New episodes include conversations with Professor Dr Jack Stilgoe, professor in science and technology studies at University College London, on driverless vehicles; Sleep therapist Dr Katharina Lederle on the science of sleep, and Dr Geoffrey Neale, Royal Academy of Engineering Research Fellow, about his work with composite materials within the aerospace and automotive industry, and how they can help us move towards the UK's net-zero goals. We also have a range of episodes on Artificial Intelligence and a special selection from senior figures in the world of science advice in Rwanda. You can listen to any episode on demand by visiting the podcast page on **www.foundation.org.uk/podcasts**.

GUEST EDITORIAL

At a time when war and unrest grows across the world, there is also a degree of ambivalence around UK defence spending. Is it time for UK defence to step up and take more of a priority?

Strong armed forces are a deterrent and still crucial

Alan West

The predictions of Francis Fukuyama in his book *The End of History and the Last Man* were wrong when he said that, with the end of the Cold War and collapse of the Soviet-Union, liberal democracy would be the final form of government for all nations.

Some experts predicted that 'state-on-state' warfare was a thing of the past. Notwithstanding this, our nation maintained its strategic deterrent and the principle of Continuous at Sea Deterrence (CASD). In the late 1990s and 2000s our nation embarked on a series of counter-terrorist wars (or operations) that were by choice and not essential.

The invasion of Afghanistan in October 2001 may have been necessary post 9/11, but having savaged Al-Qaeda and forced the remnants into the Pakistan Fata, allied forces should have withdrawn and left the Afghans to it. Instead we lost focus and it all ended in the ignominious panicked withdrawal in August 2021. The invasion of Iraq in March 2003 was unnecessary and a mistake.

Warped defence spending

When our forces withdrew in May 2011 the country was in a mess. Prolonged anti-terrorist campaigns in central Asia are not the UK military's forte. And it had warped defence spending. However, the Treasury were delighted, as fighting terrorists demands far less military expenditure than fighting with a peer nation in state-on-state conflict. Defence expenditure was cut dramatically, particularly in the Coalition's 2010 defence review.

The UK is an Island and the maritime is vital for its wealth and security. Terrorists can have only limited impact in the maritime environment so inevitably the diminished defence spending became army- and air force-centric for more than a decade. This was despite the fact that SDR 1998 had stressed the importance of the maritime to our nation and included an intention to build two new large aircraft carriers as an essential part of our maritime capability. Ship numbers were cut and areas of expertise such as anti-submarine warfare neglected. All maritime patrol aircraft were then removed from our inventory.

Events of recent years have shown what an error it was to think the world and mankind had changed. The Balkan war of the 1990's should have been a warning. It was a warning ignored by most European members of NATO and the EU, who have taken the aspiration for a peace dividend to greater lengths than the UK. Defence spending has been steadily reduced and these reductions continued even after Putin's annexation of Crimea. Continental NATO forces are in no sense ready for war. The US found this difficult to accept as they were effectively bankrolling European security. Unsurprisingly Putin drew the conclusion that Europe would avoid war at any cost. That is partly why we are in today's parlous situation.

Initially, we all thought we could do business with Putin, but he has become progressively more hard-line leading Russia to occupy Crimea in 2014 and invade Ukraine in February 2022. He is leading what is effectively a rogue state and threatening European and world peace.

China is strengthening its financial grip on nations involved in its 'Belt and Road' initiative, threatening navigation in the South China Sea and menacing Taiwan.

War rages in Sudan. The invasion of Gaza by Israel has raised the spectre of war with Iran and in the Southern Red Sea the Houthis are attacking global shipping. Suddenly we are confronted with the possibility of war breaking out between NATO and Russia. And UK joining an alliance in war against Iran.

In July 2016 Parliament approved the replacement of the Vanguard class SSBN with Dreadnoughts and new nuclear warheads – a hugely expensive undertaking that was at the limit of our industrial, scientific and engineering capability. So in military spending terms we are faced with the perfect storm.

Since the end of the Cold War, defence spending has been progressively cut from 4.8% of GDP to 2.3% of GDP, and service manpower from 300,000 to 150,000.

Alan William John West, Baron West of Spithead, GCB, DSC, PC a retired admiral of the Royal Navy and formerly (from June 2007 to May 2010), a Labour Parliamentary Under-Secretary of State at the British Home Office with responsibility for security and a security advisor to Prime Minister Gordon Brown. Prior to his ministerial appointment, he was First Sea Lord and Chief of the Naval Staff from 2002 to 2006.

Events of recent years have shown what an error it was to think the world and mankind had changed. Defence spending has been steadily reduced and these reductions continued even after Putin's annexation of Crimea.

It takes time to deliver most aspects of defence capability. One cannot just turn on a tap. And yet the world situation demands capability now.

It takes time to deliver most aspects of defence capability. One cannot just turn on a tap and expect it. Some areas such as cyber, small drones, Artificial Intelligence, engineering biology; future telecommunications semiconductors, and quantum technologies can be turned around quickly – but most hardware and platforms have long production timescales. And yet the world situation demands capability now.

The Government has at long last woken up to the need for an increase in defence spending with an intent to go up to 2.5% of GDP by 2030. A good first step but too little too late.

The Govenment has however added an extra £500m to the £2.5bn annually to support Ukraine and identified boats, armoured vehicles, long range missiles and ammunition to be supplied from our armed forces. This is a good thing because if Putin is not stopped on Ukrainian soil we may have to stop him on NATO soil.

However, war stocks were one of the areas that was run down when Ministry of Defence (MoD) planners took the risk that Fukuyama was right. Wars against terrorists do not demand vast stockpiles of ammunition and weaponry, but against a peer adversary they do. We have been slow in rectifying this shortfall. For example, when we start giving away ammunition stocks we should ensure the firms involved have built into their structure the capacity to replace those stocks at speed. The government should fund manufacturers to have shadow factories ready to be opened up when a national emergency arises.

There is also real doubt as to whether we have sufficient qualified personnel to train the Ukrainians and our own armed forces should they need to expand. Defence firms will need more highly skilled workers. Do we have sufficient? I doubt it.

The Nuclear arena

This has become particularly apparent in the nuclear arena where there are insufficient scientists and engineers to deliver the new warhead programme. The AUKUS agreement (a trilateral defence partnership between Australia, the UK and the US which was announced in September 2021) is important and good news for the UK but demands work on a new stream of SSNs (nuclear-powered general-purpose attack submarines). This comes at a time when Barrow is still trying to deliver the last Astute class submarines and the new Dreadnought class.

What is clear is that new technology seldom sidelines the old but rather enhances it. So money is not saved but more needed.

This nuclear programme of work should be seen as a national endeavour. The UK shipbuilding enterprise requires a strong order book to be able to invest for the long term and improve its competitiveness. It needs a rolling programme and a more strategic approach facilitating access to finance. SMEs have a real problem unless there is a drumbeat of orders which we should commit to, even if some of the spend is years away.

The cry from the Treasury and others is that there are huge inefficiencies in MoD spending and that by resolving these no extra funding will be required. This is simplistic nonsense. Year on year so-called efficiency savings have resulted in weaker, less capable forces.

Long-term thinking

A long-term view is required. For example, the carriers had £1.5 billion added to their cost because the Treasury demanded a straight funding line from the MoD, which they achieved by stopping work on them for two years. Equally, we are now desperately trying to get enough frigates into our Navy because we took too long ordering them. There is also a debate to be had about sovereign capability and national resilience. We need to maintain certain skills and production capability so that we are not in the thrall of an outside player at a time of national emergency. For example nuclear submarines, satellites, crypto, steel, sonars and so the list goes on. Some have already been compromised.

One wonders whether the MoD considers wider employment, industrial and economic factors in its value-for-money assessments of where to procure defence systems. And indeed whether the Treasury factors in the contribution of Defence to UK prosperity in procurement decisions.

A number of new lessons have been learnt from the war in Ukraine and old lessons relearned. What is clear is that new technology seldom sidelines the old but rather enhances it. So money is not saved but more is needed. The use of drones at scale has been an eye-opener but has not removed the need for artillery and armour. The efficiency of new anti-aircraft and anti-missile systems has to be factored in, but the efficacy of multi-million pound missiles shooting down cheap drones will have to be addressed.

Strong armed forces are a crucial deterrent and therefore prevent war. They also have utility in a number of other ways, particularly in terms of national resilience, and should be properly funded. In the final analysis they are there to fight and win against the King's enemies. □

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CONTEXT

Governments and regulators across the globe are considering the rapid changes being brought about by artificial intelligence. There are huge potential benefits, but also significant potential harms. The EU AI Act is the new European regulatory framework in the EU, with the USA and other major economies discussing similar issues, and with much discussion at the UN and OECD. In the UK, some aspects of AI are included in the new online safety bill, and the UK was also the host in November 2023 of the first global AI Safety Summit.

On Wednesday 28th February, The Foundation for Science and Technology held an event to explore the different challenges of regulating AI and how different jurisdictions approach that challenge. Speakers included: Stephen Almond, Executive Director for Regulatory Risk at the Information Commissioner's Office; Professor Sana Khareghani, Professor of AI Practice at Kings College London; Dr Cosmina Dorobantu, Co-Director and Policy Fellow for the Public Policy Programme at The Alan Turing Institute, Professor Dame Wendy Hall DBE FRS FREng, Regius Professor of Computer Science at the University of Southampton; and John Gibson, Chief Commercial Officer at Faculty AI.

A video recording, audio and presentation slides are available on the FST website: **www.foundation.org.uk/Events/2024/Can-Artificial-Intelligence-be-regulated-and-if-so**

AI can be regulated: this is how

Stephen Almond

SUMMARY

- AI is built on data, and the questions of how to regulate AI are not new
- Like all complex problems, the answer is not simple, but it is close to what the government has set out
- Regulators must have a common set of approaches that joins them up
- Data protection law is just one piece of the puzzle.

Can Artificial Intelligence (AI) be regulated? As the regulator of course I would say yes, but apparently the motto of the Royal Society, where we are speaking tonight, is *Nullius in Verba*, or 'do not take anybody's word for it'.

So, I will not ask you to just take my word that AI can be regulated. Instead, I thought that the best way of illustrating why I believe that AI can be regulated is to talk through what it's like to regulate AI right now.

At the Information Commissioner's Office (ICO), we sit at the heart of AI regulation. AI is built on data, much of it personal data, and so, despite all of the media hype over the last year, the questions of how to regulate AI are not new for us. We have a fair bit of experience in how to regulate it and how to get things right.

The world of data protection law is principles-based and sets out a range of things that we should be thinking about when we're processing personal data. These are the same principles that you'll see in the government's white paper for how AI should be regulated.

You'll hear the government talk about questions of fairness and bias or safety and security. Or about accountability and redress or transparency and explainability. These are all core features of how data protection law already governs AI.

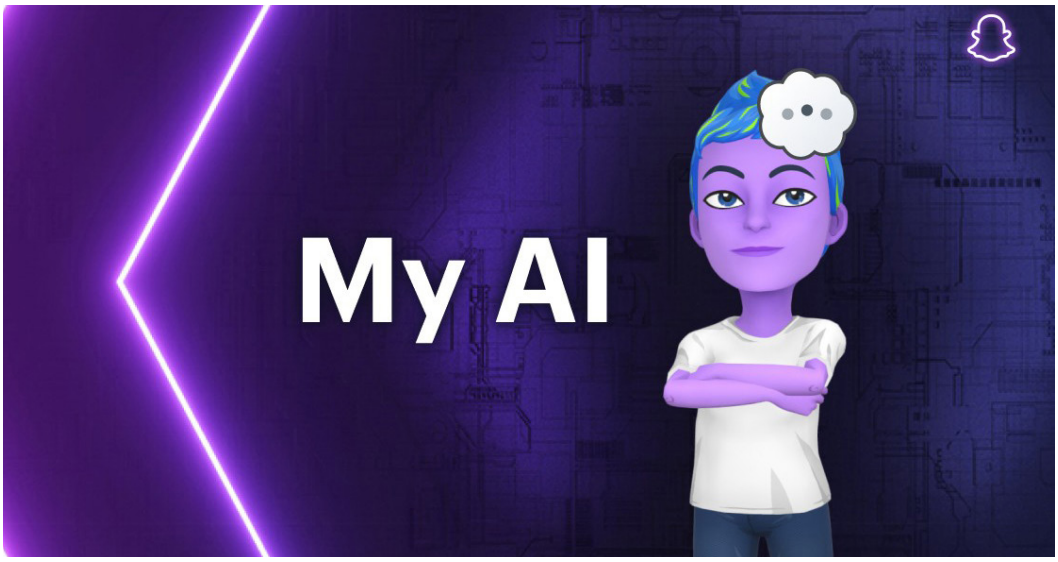
I'm not here to try and persuade you that data protection law is the answer to how to regulate AI. It is very much just one part of this particular puzzle. We are seeing AI be used everywhere from entertainment to financial services to medicine. As a general purpose technology which is applied in lots of different contexts, it needs to be brought into conformance with what our expectations are for those activities, particularly the ones that are currently carried out by humans.

Regulatory framework

Like all complex problems, the answer to the question of how to regulate AI is not simple, but I do believe it is close to what the government has already set out. It needs to rely on a framework of existing domain specific regulators and have a common set of approaches across those regulators. It needs to ensure that we as regulators are joined up, that we're not creating conflicting issues between us, and that there are no major gaps.

So, what is it like to be a regulator in the age of AI? Just over a year ago, I was with my horizon scanning teams who were putting out their annual report on the biggest technology trends that were going to be important for data protection in 2023. They said, "we think that we should put forward generative AI" and I said "no, the issues

Stephen Almond is Executive Director for Regulatory Risk at the Information Commissioners Office (ICO). He leads the ICO's teams charged with engineering information rights into the fabric of new ideas, technologies and business models as part of a dynamic digital economy, including through the Digital Regulation Cooperation Forum. Prior to joining the ICO, Stephen led a World Economic Forum initiative to promote the adoption of a more agile, innovation-enabling approach to regulation with governments and tech firms worldwide.



The ICO had concerns about potential privacy risks arising from the 'My AI' chatbot that had been rolled out in Snapchat.

there are not new". This might seem absurd after the year we've had, but I – mostly – stand by my position that, just as AI is not new, the problems and the challenges of how to govern generative AI are largely not new either.

In many respects, generative AI is simply another form of AI for us to respond to with our existing principles-based toolkit. We already have very comprehensive guidance on how organisations developing or deploying AI should be building in those core principles I mentioned earlier.

As winter turned to spring, we were quick to set out key guidance to the market on the sorts of things that we thought people should be taking note of, including our top tips for developers and deployers of generative AI.

Innovation Advice

In the summer, we followed this up with the launch of our Innovation Advice service, enabling organisations to get fast, frank feedback on their novel ideas. As you can bet, the first questions were all about generative AI.

At the same time as supporting innovators before they brought new ideas to market, we had to take the step of issuing warnings to firms that were not taking their existing regulatory responsibilities very seriously.

We advised that we would be knocking on doors, particularly on those organisations developing the most powerful models that sit at the very top of the food chain, and looking at their data protection impact assessments.

Come autumn, we announced that we had issued Snap, Inc. with a preliminary enforcement notice in respect of their 'My AI' chatbot that had been rolled out in Snapchat. We had concerns that the privacy risks surrounding this service that was being used by children had not been adequately identified and mitigated; we are now receiving representations from Snap, Inc. before a final decision is made.

Over the course of the last year, we have learned more about the unanswered questions that remain surrounding data protection law and generative AI, such as in what circumstances webscraping may be lawful. We're determined to provide clarity to organisations, and at the start of 2024 we commenced a consultation series seeking to address these questions.

In tandem, we're going to continue to join up with others. Building on our consultation series, we're working with the Competition and Markets Authority to prepare a joint statement on how we are going to regulate foundation models together.

Through the Digital Regulation Cooperation Forum, we are developing a joint offering with other digital regulators to support innovators looking to bring new ideas to market that straddle our regulatory remits. Our new DRCF AI and Digital Hub will provide rapid response support to innovators who have questions around how the law applies.

We are going to continue to respond at pace to developments in the market. Just like at the start of last year, where my teams were saying to me, "we really need to lean into this generative AI trend", my teams are now saying to me, "we need now need to really lean into personalised large language models".

It is in this way that we will successfully regulate AI: by being responsive to the pace of technology, by setting principles rather than detailed rules, by engaging with the market to provide regulatory certainty, by taking action where we find serious noncompliance and by doing so in concert with our fellow AI regulators. □

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How the UK set out to regulate AI

Sana Khareghani

SUMMARY

- Adoption of AI technologies can only happen with clear and appropriate regulation in place
- The UK government wanted to work hand in hand with existing regulators to try to figure out the right approach
- Regulation needs to be a coordinated effort
- The Digital Regulation Coordination Forum and the core principles were set up and designed to try and ensure that AI is used safely, is transparent and technically secure
- The Alan Turing Institute has worked alongside standards agencies and the UK Government to create the AI standards hub
- There are still many areas that the Government needs help with regarding AI and there is room for more expertise on the matter.

When the UK government was setting out to regulate AI, I was the head of the Office for AI and during that time, we came up with the outline framework for the AI regulation white paper. We realised that we needed to spend a lot of time with the regulator's themselves as well as other experts in the ecosystem. We have an incredibly rich regulatory landscape here in the UK, and the regulators are experts in their area. The Information Commissioners Office (ICO) for example, has been leading the way on thinking about data, the fuel for AI and there are many other regulators who are looking at the applications of AI and how these applications manifest within their sectors (e.g. the Medicines and Healthcare products Regulatory Agency, MHRA). It became apparent that there are several challenges when looking to regulate AI, including a lack of clarity on remit, consistency and approach, to name a few.

Defining UK regulation of AI

I think it is important to put some context around the 'pro-innovation framework'. We cannot have adoption of AI technologies without appropriate regulation in place. There will be no innovation in companies if we do not have clear guidelines, because nobody wants to take the risk of being the one who made a change without the regulator on their side. We saw examples of this with the finance sector where the government had to create financial sandboxes to encourage innovation.

When we were preparing the bones of the white paper, we had to ask how do we put the right guardrails in place to allow innovation and adoption of AI technologies to happen? Our conversations with regulators and the broader ecosystem of advisors led us to a context-specific approach i.e. where applications land within a specific sector. The approach also had to be risk-based (similar to the EU AI Act), coherent (simple, clear and predictable), and proportionate and adaptable. So rather than coming in hard with rules and regulations, the UK government wanted to work hand in hand with the regulators to try and figure out the right way to approach these questions. Lastly, regulation needed to be a coordinated effort for two main reasons: first, so that understanding where something ends and where something else begins is clear and, second, that regulators can help each other along the journey.

With this in mind, the Digital Regulation Coordination Forum and the core principles were created. These principles were designed to try and ensure that AI is used safely, is technically secure and does what it says on the tin, that it's transparent and explainable. It also considers fairness and responsibility as well as routes to redress and contestability. None of this approach was done in a vacuum. This was done hand in hand in consultation with the ICO and many other regulators and organisations that helped create the AI regulation white paper.

The broader ecosystem outside of the AI regulation landscape includes organisations such as the Alan Turing Institute, which have worked alongside our standards agencies as well as the UK Government to create the AI standards hub. We also have the AI assurance roadmap which is part of the arsenal to help assure organisations are adhering to the guardrails.

I was no longer in the government when the AI Regulation white paper was published. The government's response to the white paper is available and shares the number of responses that were

Sana Khareghani is Professor of Practice in AI at King's College London and AI Policy lead for Responsible AI UK, a £31Mn grant focused on seeding and connecting the international eco-system for responsible AI research and innovation.

AI regulation is a big monolithic thing. We need to start somewhere – it does not matter where.

received as well as next steps that the government is taking forward including funding into the regulatory ecosystem.

Just before the publishing of the white paper response the government also hosted the first ever AI Safety Summit in Bletchley Park, with focus on safety and security of AI systems.

AI regulation is a big monolithic thing. We need to start somewhere. The UK has started on the application side, the EU is using a different approach, and the US is looking at the whole thing. There is plenty of work to be done across this, it does not matter where we start, I suspect the answer will be somewhere in the middle. ☐

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EU and UK approaches to AI regulation: a world apart?

Cosmina Dorobantu

Dr Cosmina Dorobantu is the Co-Director and Co-Founder of the Public Policy Programme at The Alan Turing Institute, the UK's national institute for data science and artificial intelligence. With a team of 55+ full-time academics, the Programme is one of the largest research programmes in the world focusing on AI for the public sector.

SUMMARY

- The EU AI Act classifies AI systems according to risk.
- The Act is 'rules-based' which means it relies on rules that establish obligations for providers and users depending on an AI system's level of risk.
- Despite clear differences between the EU and UK's approaches to AI regulation, there are points of overlap and intersection.
- AI governance and regulation is an area that is in desperate need of international cooperation, as AI development and advancement are global issues.

Over the past few years, some of the brightest minds in the world have been thinking about how to regulate artificial intelligence (AI). This is a tremendously exciting time to be alive because we are at a point at which we are starting to see the results of their efforts.

We are at the very beginning of the journey to regulate AI, where several national and multinational initiatives are starting to make an impact in the real world. At home, we have had the publication of the UK Government's response to the 'A pro-innovation approach to AI regulation' consultation – a policy paper presented to Parliament by Michelle Donelan, Secretary of State for Science, Innovation and Technology. And in the EU, the European Parliament passed the EU AI Act, which is the world's first comprehensive AI law. Today, I want to take you on a journey through the continent and tell you a little bit about the EU AI Act and the points of intersection with the UK approach.

How does the EU AI Act work?

The EU AI Act, which is a 450-plus page document, classifies AI systems according to risk. We have 'minimal-risk' AI systems, which the EU claims are the majority of AI applications currently available in the Single Market. These include AI-enabled video games and spam filters, and the EU AI Act stipulates that they are free to function as they are. We also have 'limited-risk' AI systems, an example of which are chatbots (though not Chat GPT and others like it, which fall under the generative AI guidance). 'Limited-risk' AI systems are subject to light transparency obligations under the Act, such as developers and deployers ensuring that end users are aware that they are interacting with AI. Then we have 'high-risk' AI systems, and the vast majority of text in the EU AI Act is about them. There is a lot of detail on how a system might be classified as 'high-risk.' When an AI system is classified as 'high-risk,' the AI system's providers have a fairly long list of obligations, including establishing a risk management system and a quality management system. Finally, there are 'unacceptable-risk' AI systems, such as social scoring systems, which are prohibited from the Union altogether.

You might hear some buzzwords that describe the European approach to AI regulation. One of them is 'rules-based,' which simply means that the EU AI Act relies on new rules which create obligations for providers and users depending on an AI system's level of risk. Another term is 'statutory,' because the Act introduces new legislation and heavy penalties. Non-compliance with the EU AI Act will lead to fines ranging from €7.5 million or 1.5% of global turnover, to €35 million or 7% of global turnover, depending on the infringement and the size of the company. For a

company like Google or Microsoft, 7% of global turnover can be in the billions. Finally, you might also hear the EU approach to AI regulation described as being 'horizontal.' Horizontal legislation means that the Act applies across all the AI systems placed or used within the EU, regardless of the sector in which they are used.

How does the UK's approach differ?

When the EU and the UK started to work on their approaches to AI regulation, they seemed to be taking two diametrically opposed views. Rather than opt for a 'rules-based approach', like the EU, the UK decided to take a 'principles-based approach' which has five core principles underpinning it. These are (1) safety, security and robustness; (2) appropriate transparency and explainability; (3) fairness; (4) accountability and governance; and (5) contestability and redress. Unlike the EU, the UK did not introduce any new legislation and did not put the five principles on a statutory footing. Finally, the UK went for what we call a 'vertical approach' to AI regulation, relying on the expertise of existing regulators and their deep sectoral knowledge to tailor the implementation of the principles to the specific context where the AI system is used.

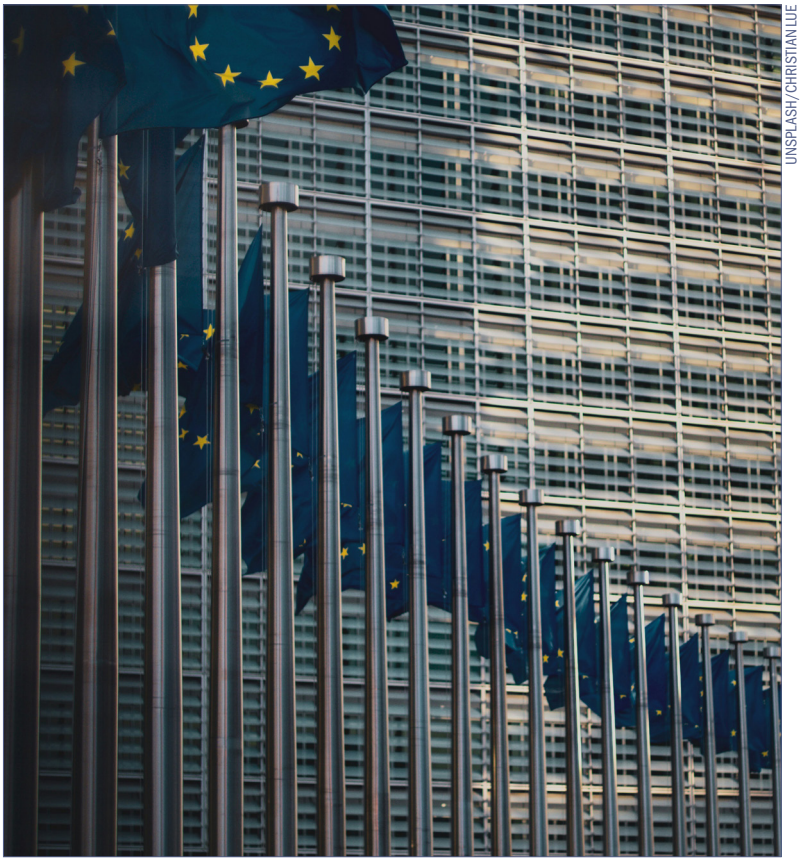
Common ground

Now, I want to challenge the notion that the two approaches are diametrically opposed because, however different they seem, there are points of overlap and intersection and, as time passes, we do see them slowly converging towards a healthy middle.

What are the points of commonality? If you look at the rules-based and the principles-based approaches, there is a common denominator between them, which is that both approaches are risk-based. The level of risk provides the sliding scale that determines the extent to which the rules or the principles apply.

Regarding new laws, it is true that at the time of writing, the EU is bringing in new legislation and the UK is not. However, the UK's Government is signaling that legislation might follow. In 'A pro-innovation approach to AI regulation', the UK Government's stance is that it "will not put these principles on a statutory footing initially." The word 'initially' is a clear signal that legislation may follow within the UK, as well.

Something that we knew from the very beginning is that a horizontal approach to AI regulation misses out on the sectoral nuances of AI design, development, and deployment, while a vertical approach misses out on the coordination mechanisms that a centralised approach brings. Despite going for a horizontal approach, the EU did concede to the addition of some sector-specific guidance in the EU AI Act, while the UK, despite going for a vertical approach, is building a centralised function to ensure regulatory coherence and to create mechanisms for regulatory coordination and oversight.



UNSPLASH/CHRISTIAN LUE

Unlike the EU, the UK did not introduce any new legislation and did not put the five principles on a statutory footing.

The other large point of commonality between the EU and the UK's approaches to AI regulation is standards. I think this matters an awful lot, because the successful practice of both approaches relies heavily on AI standards.

Regardless of what your views are of the UK, the EU, and what their relationship should be, AI governance and regulation is an area that is in desperate need of international cooperation. AI development and advancement are global issues. If countries follow their own path when it comes to AI governance and regulation, not only will this lead to a fragmented and inefficient market, but it will also fail to prevent current and future harms linked to AI innovation. I believe that the world should – and can – come together to address these challenges. ❐

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Regardless of your views about the relationship of the UK to the EU, AI governance and regulation is in desperate need of international cooperation.

The good and the bad actors of AI and how we manage them

John Gibson

John Gibson is the Chief Commercial Officer at Faculty, Europe's leading applied AI company. Prior to joining Faculty seven years ago, John spent over a decade working in government, most recently in the Prime Minister's Policy Unit where he led work to support the growth of the UK tech sector. He also held roles as Director of Government Innovation at Nesta and as a Director at Fingleton Associates, where he designed the Open API Standard for Banking. He sits on the Board of Innovate UK.

SUMMARY

- We should think of AI as an incredibly important technology that we do (at this time) have total control over, not an outside threat like climate change or inflation
- AI can deliver gigantic improvements in productivity. However, the same technology can also enhance the bad actor's ability to do the thing they want it to do
- In any scenario where the probability of Artificial General Intelligence (AGI) is greater than zero, that's something that needs to be taken very seriously and treated differently
- We therefore need to distinguish between 'narrow' models, which regulators should seek to accelerate safely, and General ones, which require more caution
- A question that deserves more attention is how do we build the technologies and the tools that allow us to interrogate, understand and control increasingly powerful models?

Without good regulation, less innovation and business activity happens. But it's really important that the debate around how we regulate AI adopts the right posture towards the subject.

We should not think of AI as an external threat that we have only limited control over; something we want to mitigate and manage like inflation or climate change. Instead we should take it as an incredibly important technology that we do (at least as we stand) have total control over. If we get things right, AI could help solve a lot of societal problems and create a lot of good changes for wellbeing and productivity at a scale and at a speed that we're not used to. We should start with that premise, and that regulators see their role in this as being one to accelerate the adoption of the technology and ensure a soft landing into society and that it delivers the goods that it can deliver, without creating the sort of harms that can happen if it's not well-managed.

Distinguishing narrow and general models

There a bit of nuance to my point. I think the best way to unpack it is to visualise it.

Using the graph on the right (Figure 1), the y axis is the capability of a system, and the x axis is how general it is. You can see a chess computer, it's extremely good at one thing, but it only does one thing. Then you take a human. Most humans are probably not as good as chess computers at chess, but they're very general machines that can do very many things at once. So I've drawn a rough red line on the top right region of that graph. The regulatory debate should be about defining the space and then figuring out what we can do to accelerate the stuff that happens on the left hand side of the red line, while also being pretty cautious about the things that might happen on the right hand side of the line.

Narrow models and good actors

Let's take narrow models. Narrow models are those AI systems which do specific things. There's broadly speaking two scenarios that have different consequences for how I think these models should be regulated. You've got narrow models used by good actors and narrow models used by bad actors. In the case of narrow models by good actors, what we're talking about here is organisations up and down the country using AI to make their business run better in some way. What we need to make sure here is that there are not unintended consequences to the good faith actions that people are taking. In many ways, this is the simplest area to consider from a regulatory perspective which also has the objective to speed up implementation. This is where the vertical approach has been adopted in the UK focusing on the existing regulators. This is a series of potential harms that we know about already. There are just new ways of creating those harms that need to be carefully managed as you adopt the new technology.

The one caveat to my position on narrow models and good actors is in autonomous weapons. This deserves a category on its own. There was an awful lot of debate around this for a very long time and in Ukraine, it's happening in front of our eyes. We have Sakar drones that may or may not be acting autonomously in the field and

delivering explosive payloads to people in the field without humans in the loop. It feels like that's a Rubicon crossed, and it does not feel like that's getting the sort of debate it needs. It's a scary technology, not least because of the risk of terrorists and others who want to do harm out of the battlefield, and in cities and so on.

Narrow models and bad actors

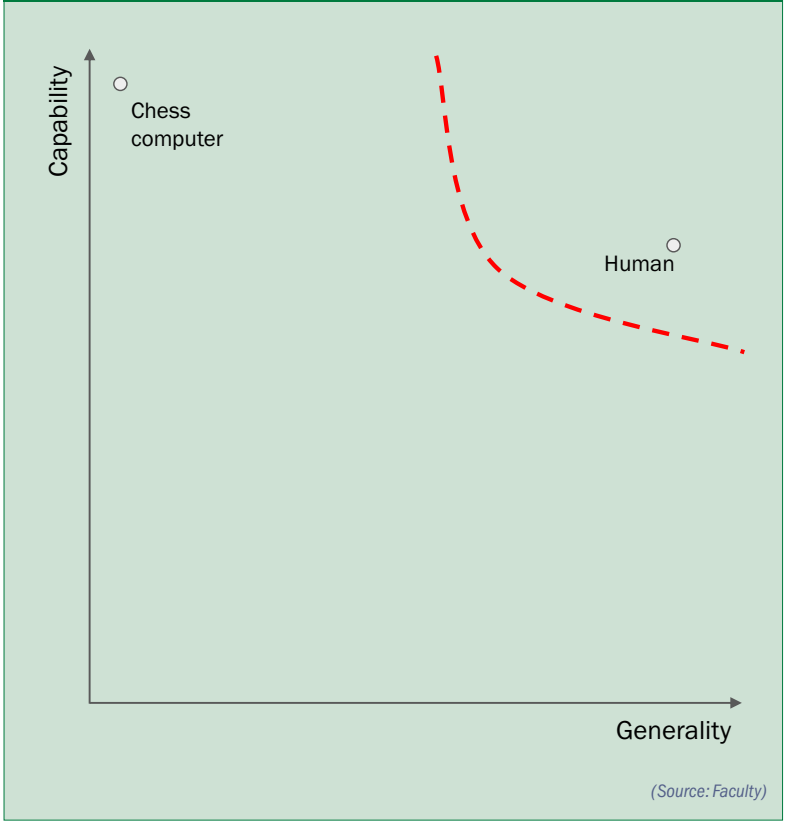
This leads to my second point on narrower models and bad actors. There are more novel issues here that require more thought and I'm not sure that vertical regulation is the right approach here. We are starting to get an emerging picture of some of these risks such as with deep fakes, automated cyber-attacks and misinformation at scale. I think there is a more general position on this which is missing in the regulatory landscape at the moment.

What generative AI can do generally is deliver gigantic improvements in productivity. For many roles across the labour market, for a doctor, web developer, graphic designer we're seeing studies that say it's more efficient to do your job if you use this technology. However, in principle, the same technology can also enhance the bad actor's ability to do the thing they want it to do.

The mechanisms that are in place to prevent harm today are basically the safety training of the models that are out there in the world. At the moment, models are created by feeding them information from the internet, and teaching them to understand language. You then have something that is very, very powerful. It will answer any question you ask it without regard to any criterion of morality. A safety training layer is then applied on top of that. So if you start to ask it bad things like, I want to go and shoot at my school, how do I kill the most number of people without getting caught? It will not give you an answer. Generative AI models are delivered into the world this way to help prevent them from causing harm. However, inside the servers of open AI, somewhere, there is a copy of every version of the pre-safety training model. It exists and if you ask that model to do terrible things, it will tell you how to do it, and it'll tell you how to do it much better.

These large models have leaked from large research labs in the past. There's a model called llama. It's one of the biggest open source models out there now that was originally leaked from Facebook, but crucially after it was safety trained. If a pre-safety trained model like that leaks and makes it onto the dark web, then there's no reason why all of the criminals in the world cannot access it and increase in their productivity. The world does not need that and I think is an area which is currently a void in the regulations. The EU Act with its horizontal approach starts to address issues like this but they have reserved the powers to demand security standards for how you store those models only for those models they classify as 'systemtic'. In my view, they need to drop the threshold for these requirements to include some less powerful models.

Figure 1. Distinguishing between narrow and general models of intelligence



(Source: Faculty)

The regulatory debate should be about defining the space where human capability lies and excercising caution about what happens there in terms of AI.

General models

When we think about general models, in any scenario where the probability of Artificial General Intelligence (AGI) is greater than zero, that's something that needs to be taken very seriously and treated differently. Interestingly, the EU has drawn a line that looks a bit like my graph, in the act. It covers models that are about as sophisticated as Chat GPT. They define things according to how much computation was used in training. The regulatory regime placed around it is then proportionate to that kind of model. However, I think there is a gap between the capabilities of those models, and the capabilities of models to come, especially those that start to approach anything that looks like AGI. In a world where we do create AGI, it's almost certainly the most consequential technology we've ever invented as a species, and it has the potential to have very profound consequences for us that no one can really understand. There are other technologies like precursors to

We fundamentally do not understand how some models work, or how to control them. As they get more powerful, that becomes problematic.

biological nuclear weapons, where access is heavily restricted. I think that's the kind of thing you could start to see happening with AGI.

AI Assurance

AI assurance is under-explored in the regulatory world. One of the big problems we have with the technology that sits at the top of my graph is that we fundamentally do not understand how these models work, or how to control them. As they get more powerful, that becomes problematic. There is an emerging field of research referred to as AI safety which I think is very important. How do we build the technologies and the tools that allow us to interrogate, understand and control these models? There's a gap in the regulatory space for mandating that the people who are building deep foundation models, are investing their time and resources into this research and in proportion to the amount of money they spend on building the underlying technology. That would help them work according to government standards and make sure that we have the technological means to stay in control. □

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A global voice on AI

Wendy Hall

Dame Wendy Hall, DBE, FRS, FREng is Regius Professor of Computer Science, Associate Vice President (International Engagement) and is Director of the Web Science Institute at the University of Southampton. She became a Dame Commander of the British Empire in the 2009 UK New Year's Honours list and is a Fellow of the Royal Society, the Royal Academy of Engineering and the ACM.

I started out on my AI policy journey doing a review of Artificial Intelligence for the UK Government in 2017 and last year I was appointed to the United Nations High-Level Advisory Body on Artificial Intelligence (AIAB). I should stress that this has a year's commission to produce a report for the UN's Summit for the Future in September, and their global technology compact.

The UN and AI

I often sit in rooms where we're talking about how AI can benefit the UK, the US, Europe, China and the tech companies, but we do not talk about what it means for the rest of the world. The world that is not represented here, the world that has not been included in these debates. The UN is very serious about how it can help govern, convene and coordinate AI at a global level, for the benefit of everybody. That's what I like about it. I've been part of the development of the internet for a long time, and we did not get that right with respect to governance and regulation. It works across the world but so many people are excluded from it and bad things have happened in the name of openness. We must not repeat this history for AI. We must learn from those lessons and move on. So that's part of my passion piece here.

The UN AIAB interim report is currently out for consultation and by the summer we should have the final version. It will not answer all the questions, but will suggest forward-looking approaches that come from the bottom up (i.e. a citizen-centric approach), as well as top down. The UN Secretary General's key focus regarding the report, which will be discussed at the Summit for the Future in September, is how AI can help support the UN's Sustainable Development Goals.

The wonderful thing about the report for me is that it is truly global. For example, I co-chair the governance working group with Professor Yi Zeng from the Chinese Academy of Sciences. AI is just like climate change in that you cannot talk about it without having all the whole world engaged in the debate. The AIAB has an incredibly diverse selection of experts, including 50% women and representatives from many countries in the Global South. There are lots of different perspectives, lots of opportunities to network and I'm learning so much from them.

SUMMARY

- We need to talk about what AI means for the world outside of the global powers' technology companies
- The UN has produced an interim report. Its work around AI is focused on how it can benefit everybody
- We must learn from the past and the lack of initial guard rails around the internet
- The upcoming UN report discusses the types of organisations that could be set up to govern AI at a global level and looks at their responsible actions
- Overall governance is about coordinating principles, and convening and coordinating international cooperation and standards which will permeate through all of the work being done across nation states.

SHUTTERSTOCK/ ALEXANDROS MICHAILIDIS

A key focus for the UN is how AI can help support the UN's Sustainable Development Goals.

The writing of the interim report started the week before the UK AI Safety Summit. I was one of the very few people who actually got a ticket to that event. What I noticed when I arrived was that there were so few senior academics there from the UK or any other country for that matter, which was very strange. I did not understand what had to be so secretive on a day that had nothing to do with secrets, and why so many experts were excluded. However many of the UN AIAB members were present all of whom had been nominated by their home countries. So it was actually a very diverse Summit in many ways and it was great to see the leading government representatives from the UK, US and China on the stage together to open the day. There were a lot of 'behind closed doors' conversations as you would expect, but also some discussions in working groups about more socio-technical issues which were very useful.

Anyone interested in what the UN AIAB has to say on AI should read our draft report. It includes discussion about governance, regulation and standards from many different aspects, but all interrelated. We also look at what sort of role the UN might play in global AI governance. The report discusses the types of organisations that could be set up to govern AI at a global level, and what their responsibilities might be.

The regulation of AI will happen in nation states. Global governance is more about coordinating principles, convening and coordinating international cooperation and standards which will permeate throughout all of the work being done. This must be agreed globally in order to work. ☐

DOI: 10.53289/ZVMW4245

FURTHER INFORMATION

Implementing the UK's AI Regulatory Principles:
https://assets.publishing.service.gov.uk/media/65c0b6bd63a23d0013c821a0/implementing_the_uk_ai_regulatory_principles_guidance_for_regulators.pdf

Consultation response to the Government white paper on AI regulation
https://www.gov.uk/government/consultations/ai-regulation-a-pro-innovation-approach-policy-proposals/outcome/a-pro-innovation-approach-to-ai-regulation-government-response#:~:text=In%20the%20AI%20regulation%20white,support%20regulator%20coordination%20and%20clarity

Artificial Intelligence in schools
https://educationhub.blog.gov.uk/2023/12/06/artificial-intelligence-in-schools-everything-you-need-to-know/

Data poisoning and the creative sector
https://theconversation.com/data-poisoning-how-artists-are-sabotaging-ai-to-take-revenge-on-image-generators-219335

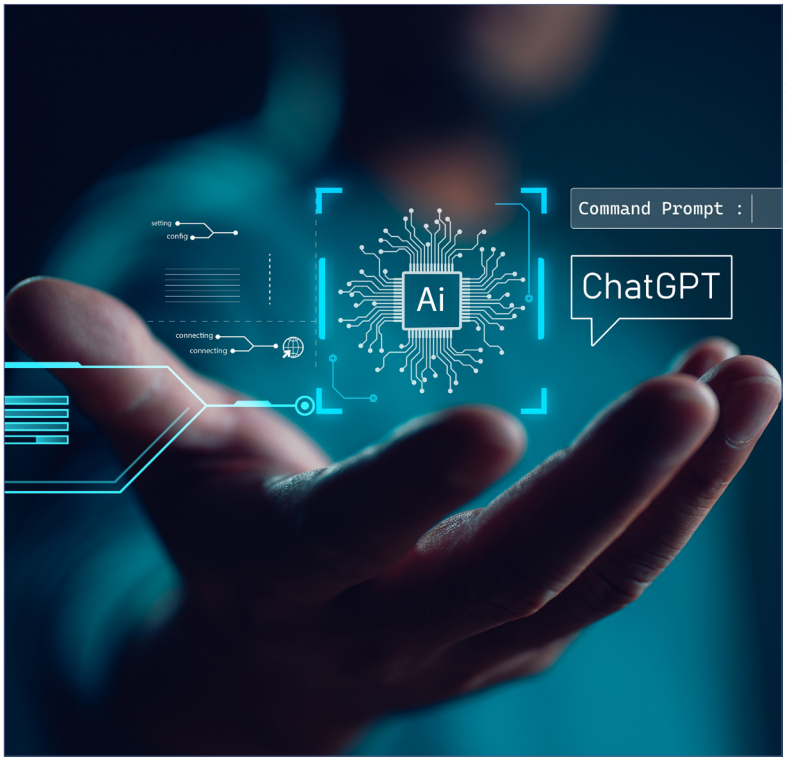
The debate

After the presentations, the speakers joined a panel to answer questions from the audience on a variety of topics, including: cross-border challenges, public attitudes, bias in AI models and protecting children.

The UK AI safety agenda has gone down a rabbit hole. This was the statement which opened the debate. Research into AI is incredibly important but it feels like the UK Government has focused exclusively on this, while neglecting other important aspects. We must look at a variety of levers to manage the different risks that new AI technology could pose.

Should we reframe regulation before elections and also determine the personality of an AI model? We should follow the engineering philosophy that we know so well and design responsibility in from the outset, rather than applying safety features later on.

UK regulation might not stop individuals going elsewhere, to a country acting in a more fast and loose regulatory fashion. These are technologies that do not act within borders. They require interoperable rules and regulations that states sign up to. This is where the UN come in. This is a challenge that is bigger than any individual country and one that needs us all to come together.



SHUTTERSTOCK/ SOMYUZU

Public consultation

We need to talk to the public more about their views on AI and this is important in terms of how Artificial Intelligence will affect democracy. Who decides on fairness? It is incredibly important that the answer to that is democratically elected governments and the regulators enforcing that. Otherwise, there is a risk that fairness will be decided by the tech companies that build the models. AI software can embody a world model which comes through data or safety training. Standards need to be clearly defined according to the way that we (as a democracy) choose and those who build and design models must be held accountable.

Small steps are important. There are practical things we can do now before answering philosophical questions about more advanced technology – such as making legislation for deep fakes.

Our ability to implement systems to govern the way that AI models make decisions can be very precise around controlling and monitoring bias, so this may paint a more positive future. We can use technology to lay some bias bare but there are still reservation on the ability to correct bias in models. We are not there yet.

In the absence of the right regulatory landscape, some people are using data poisoning (the deliberate and malicious contamination of data to compromise the performance of AI and ML systems) to protect themselves. For example, entire companies have been created to 'poison' the IP of creative artist's online assets so that their work cannot be reproduced.

Do we wait to see what unintended consequences come out of the use of AI in education and by young people? One panelist named this area the 'wild west' but warned that schools should take control and put in the right principles and guidelines now about how these technologies should be used by their students and teachers (they are probably already being used). Things should be embraced, but handled with care. Children are early adopters and proficient users of these technologies but they do not understand the risk of AI and are often left behind in decision-making. Concern around AI use in research and its impacts on peer review was shared across several panelists. Some optimism on the benefits of AI on the education system followed. ❐

Children are early adopters and proficient users of technologies, but they do not understand the risk of AI and are often left behind in decision-making.

CONTEXT

It's a time of change for the UK fusion programme. The JET (Joint European Torus) facility in Culham came to an end in December 2023, after 40 years at the cutting edge of global fusion research. The Euratom partners are focussing on the International Thermonuclear Experimental Reactor (ITER) in southern France. Meanwhile, the UK decided not to rejoin Euratom at the same time that it rejoined Horizon Europe, in September 2023. On the commercial side, the UK is producing a number of small, high-tech fusion technology companies looking to work with fusion research facilities globally, and the UK Atomic Energy Authority has announced plans for STEP (Spherical Tokomak for Energy Production), a prototype fusion power plant to be built in Nottinghamshire.

On Wednesday 27th March, The Foundation for Science and Technology held an evening discussion to look at where these changes leave UK fusion, how we can ensure that we maintain our position in global fusion activities, and what the UK's key priorities are for the coming years. Speakers included John Staples, New Nuclear Strategy & Fusion Energy Director at the Department for Energy Security & Net Zero, Professor Sir Ian Chapman, Chief Executive for the UK Atomic Energy Authority, Dr Kate Lancaster of the School of Physics, Engineering and Technology, at the University of York and Francesca Ferrazza, Head of Magnetic Fusion Initiatives at Eni.

A video recording, presentation slides and speaker audio from the event are available on the FST website at: **www.foundation.org.uk/Events/2024/The-UK-Fusion-Programme**

UK is ahead of the curve when it comes to Nuclear Fusion

Report of the presentation by John Staples

SUMMARY

- Fusion could play a crucial role in energy security and decarbonisation
- Fusion has potentially abundant resources, is carbon free, is energy dense and has few waste issues
- The UK has a fantastic record in fusion and a strong institutional set up. We need to hold on to that and grow it
- A new fusion strategy was published in autumn 2023 with strong objectives demonstrating commercial viability and moving towards a private sector in fusion
- It's a difficult mission but fusion is an international endeavour.

Fusion is incredibly hard. Mr Staples opened his talk by asking the question, why do we do it? Global energy demand is rising and he explained that the International Energy Agency (IEA) has said that it will rise by 75% over the next 30 years. There's a global need for energy security and decarbonisation and a massive technological challenge to deliver both of these. Fusion could play a crucial role in moving towards these goals.

Five key benefits of fusion

In a list of benefits, Mr Staples began by pointing to the abundant resource potential of fusion. One of its key ingredients is deuterium which is found in seawater, and tritium which can be bred within a facility. This means that there is a fuel cycle built in. Secondly, it's carbon free and provides base-load firm power, so it can counter the intermittency of renewables. It's incredibly energy dense, has much shorter live waste, and far fewer waste issues than then fission. There are also fewer radioactive waste byproducts. Some of the components can become radioactive in the process, but as a policy and technical challenge, the waste issue is far less than it is in fission.

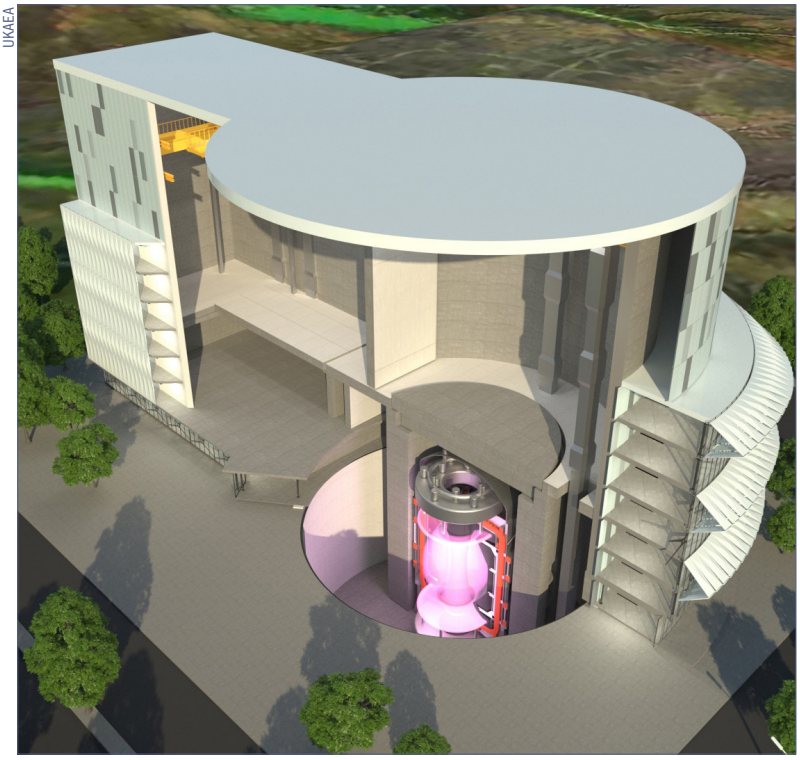
What's happening in the UK?

During his talk, Mr Staples noted that "the UK has a fantastic record in fusion and one that we should be proud of". The UK has been working on fusion research and development since the middle of the 20th century and we have an "exceptionally strong" institutional set-up.

He noted that the UK recently hosted a Japanese delegation who were struck by the strength of UK fusion institutions such as the Culham Centre for Fusion Energy, the biggest fusion organisation in the world, the UK Energy Authority and the Joint European Tourist Facility. He said that we

John Staples is a director in the Department for Energy Security and Net Zero. He leads the teams responsible for policy on fusion energy and advanced nuclear technology. His previous role was Director of Net Zero Strategy within the department. Prior to that he worked in HM Treasury for over a decade, in a variety of roles, but mainly focused on infrastructure.

UKAEA



STEP is a publicly funded major infrastructure programme that aims to demonstrate a commercial pathway to fusion.

also have a growing private sector with impressive emerging companies such as Tokamak Energy and First Light Fusion coming out of the UK.

Exploring some of the UK's policy around fusion, My Staples pointed to an updated fusion strategy published in the autumn 2023, with two key objectives. The first one is to build a world-leading fusion industry that would support different technologies, be capable of exports and capable of establishing world leading companies in the UK. The second – a key anchor in the strategy – is developing a prototype fusion power plant to deliver energy, and prove commercially viable. Ultimately, this is about demonstrating commercial viability and getting to a world where we have a proper private sector in fusion. He was confident that from a UK perspective, there are scientific gains and economic opportunities to be made, if we play things right.

Elements of strategy

To dig into elements of the strategy, he asked the audience to first look at STEP (Spherical Tokamak for Energy Production), which is the prototype future fusion plant project. He explained that £240m had already been committed, and a site at West Burton has been acquired which is at the location of an old coal plant. "It makes a great story", he said, observing that they have taken an area that has a long energy history but is fading, and now has an opportunity to revive as a public-private collaboration using fusion.

Mr Staples also pointed to 'Fusion Futures', which is a new project that has £650m committed to it. He said that his team are spending this on facilities, skills and R&D, with the aim of growing the sector overall. The plan includes £200m for a new facility focused on tritium breeding. As this is one of the key scientific engineering challenges, he said that this will be a major focus.

Regulation and planning

During a trip to Washington DC in the USA for several fusion conferences, he said that regulation came up as a key enabler for the growth required in the sector. He said that "the UK is ahead of the game. We passed legislation in the autumn which is important because it established that fusion will be regulated differently from fission, reflecting its different risk profiles".

Instead of going through the Office of Nuclear Regulation, fusion projects will go through the Environment Agency and the Health and Safety Commission and Health and Safety Executive. Mr Staples believes that that is significant with positive feedback from industry. The next phase he explained, in terms of policy framework, will be to consult on a national policy statement. Like other key infrastructure sectors, this will ensure fusion is given consideration and priority within the planning system.

International collaboration

"Fusion is an international endeavour, this is a big mission". Mr Staples said that there are two aspects of this that are significant. The first is deepening a bilateral relationship. He explained that we have already entered into a strategic partnership with the US and there are many areas where we can work very closely with the US including skills, facilities and R&D. He also noted that the UK has entered into a relationship with Canada and is in close touch with Germany, Japan and Korea too.

The second aspect is multilateral relationships, which will be a priority over the next few years. He explained that the UK is working through the International Atomic Energy Association (IAEA) as the industry grows to ensure that the multilateral level approach is enabling rather than hindering growth.

To conclude, Mr Staples said: "the UK has quite a precious thing here in this potentially transformative technology of enormous economic value. We have great strengths and, in many ways, a strategic advantage over other countries. It's very important that we maintain and hold on to that and grow it. It's about taking us forward into the next stage and growing fusion into a proper industry as the technology develops." □

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How the UK is making strides in fusion

Ian Chapman

SUMMARY

- After breaking world records with NIF, we have confidence in our predictions moving ahead to big experiments, like ITER
- ITER produces a very significant net power gain and really demonstrates that fusion can be done on a commercial scale
- The UK has a unique competence in fusion that you cannot find anywhere else
- Thousands of companies are now involved in fusion
- The next phase in the UK is the development of a prototype powerplant called STEP.

Fusion is not necessarily always mañana, mañana, forever away.

In 2022, the National Ignition Facility (NIF) in the US announced that they had achieved real fusion power with a net thermal gain; so you get more thermal power out than you put in. That's a huge step for fusion. We also have the Joint European Torus (JET) that we host here in the UK. This is the largest fusion facility in the world, where we have successfully broken our own world record a number of times over the last three years, setting a final world record of 69 megajoules over about five seconds.

The important part of those experiments was that they overlaid exactly what we predicted would happen. That means that we have confidence in our predictions as we move ahead, to big experiments, like ITER.

ITER is the largest scientific collaboration ever undertaken by humanity. It's a huge project in every sense, in footprint, price, timescale, geopolitical complexity and, in my view, impact. If ITER works and produces a very significant net power gain, where we'll put 50 megawatts of thermal power in and produce 500 megawatts of fusion power outwards, that would really demonstrate that fusion can be done on a commercial scale.

ITER is now largely built and many of its components are ridiculously complicated. At the start of the project, we did not have supply chains for the components, we did not really think they could be built, but they now exist. There have been so many world firsts involved in that project which have led to a whole new industry and we are delighted to see big energy companies and engineering firms getting involved in ITER throughout.

Whilst it is a global project, UK companies have been heavily involved. £650m worth of contracts have come into the UK supply chain and UK companies lead the construction management as agent and as architect engineer.

There has been a complete change in the fusion landscape and we are now doing things at power-plant scale. We are beginning to have the industrial competence to do that but we are no longer in ITER. We are no longer in the Euratom research and training programme and JET ceased operation at the end of last year, so it's a time of much change.

Where the UK stands out

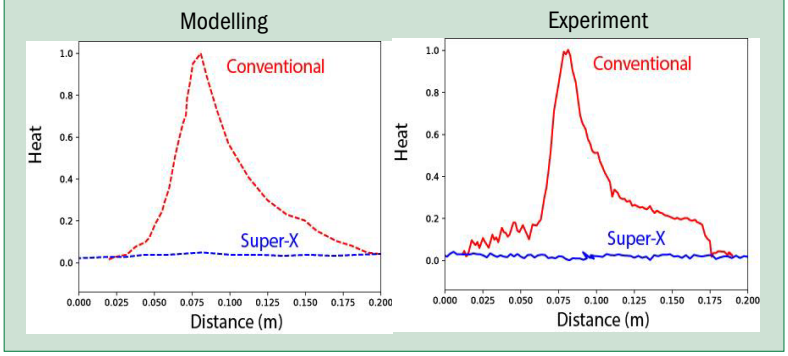
However, we are very lucky that the UK genuinely has a unique competence in fusion that you cannot find anywhere else, and that's multifaceted: It starts with our national lab – the UK Atomic Energy Authority (UKAEA) which is the largest fusion organisation in the world. A lot of that competence is born from JET, but we are also the first to build a spherical tokamak and we think spherical tokamaks have a huge potential for minimising cost and maximising commercial viability of fusion power plants.

We have also developed competence in all the enabling technologies that you need for fusion – be that the materials which have to withstand the unfavourable environment of the most intense neutron source on the planet and huge heat gradients; or how you manufacture and test and qualify those materials; how you maintain the inside of the machine, which is a place you cannot send people so you have to do it robotically, or how you fuel the facility. We also have to make our own tritium. Tritium has a very short half-life and there's no natural tritium left so you have to make it. Understanding how you store, process and fuel machines with tritium is key.

Stitching all of that together needs complex and advanced computing. We do all of those things in the UK and that enables us to do the

Ian Chapman is the chief executive of the United Kingdom Atomic Energy Authority (UKAEA). He has progressed through a number of positions in the UK fusion programme, including Head of Tokamak Science in 2014 and Fusion Programme Manager in 2015. In October 2016 he became UKAEA's Chief Executive Officer, succeeding Sir Steven Cowley.He has published over 110 journal papers and given 30 invited lead-author presentations at international conferences. In 2015, he became a visiting professor at Durham University.

Figure 1. Reducing peak heat flux



Extracting heat from a magnetically confined fusion powerplant (e.g. Spherical Tokomak): modelling vs reality.

foundational things too. For example, we have really grown our supply base, we have invested heavily in skills and will continue to do so with government support. We're really thinking about technology transfer into fusion from other adjacent industries, and also out of fusion. We are also developing the competence to build power plants. At the same time, we are investing in industry programmes which develop small and medium sized enterprises; new technology, and innovation in the sector. Startups such as First Light Fusion and Tokamak Energy are being born in the UK which is really good to see.

Fusion really is all over the country. UKAEA as the national lab now has four sites, we have university partners in 35 different universities and we now have 4000 companies working in fusion.

The spherical tokamak

One of the big hindrances to the spherical tokamak is trying to make the power plant as compact as possible. If you look at ITER, a third of the money goes into very large buildings. Another third goes on huge magnets with the largest cryogenics plant in the world to cool those magnets. So if you can use smaller more geometrically efficient magnets and put them in a much smaller building, you can strip out billions in cost.

After building the first spherical tokamak in the 1990s, we showed it was far more efficient than alternative ways of approaching fusion. However, the condition for fusion is that the fuel has to be 100 million degrees or it will not fuse. If you take that sort of heat source and put it into a much smaller volume, the chances of melting the walls of your box are obviously a lot higher. So the rest of the world never really invested in spherical tokamaks, because they said you'd never be able to cope with the heat. We agreed that if we could not find a way of extracting the heat, it could be a dead end so we built a machine called MAST Upgrade, which was the first public project to win the Royal Academy of Engineering major projects prize.

If you look at the figure to the left (Figure 1), the red line is the conventional way of extracting heat from any magnetically confined fusion power plant. We said we think we can do it like the blue line here. So reduce the peak heat flux which gets to the wall by a factor of 10.

I do not think everybody in the community thought we would achieve that but when we turned on our facility in 2021, but the second graph shows our first results. That really gave us confidence to move ahead with the spherical tokamak for energy production. Frankly, the UK is not big enough in the energy market to compete through volume. We will never have a product which becomes cheapest by building lots of units in the UK. We have to have a product which is innovative and therefore becomes cheaper than our competitors, and that's what we think the spherical tokamak offers.

Now in the concept design phase, we recently passed legislation and have found a site for development of a prototype powerplant called STEP. The main construction will likely happen over the 2030s and we are aiming to complete the build by around 2040. Based on all of the components needed to make this happen, this is simultaneously a depressingly long and audaciously fast timescale. The site chosen after a two-year process with 15 nominations was, until March last year, a coal power station operated by EDF. It has a train line, a direct connection to a national grid, no new pylons, and an extraction licence of water from the Trent. It has millions of people living in the local environs less than an hour away and it has a population around it who have been involved in power generation their whole lives and want new power projects. This is the only fusion power plant project that actually has a site and is getting on with preparing that site. We are setting up a public private partnership in a slightly different way to many other countries in the world by both investing in innovation in SMEs, and at the same time working together with large companies on powerplant programmes. We have an industry programme, which is about stimulating innovation and working with SMEs. But we also have a national endeavour, which is about building a prototype power plant.

The first thing that we will do once we've set up this new company – UK Industrial Fusion Solutions – is to contract an engineering partner and a construction partner, which will be with us on

The condition for fusion is that the fuel has to be 100 million degrees. The chances of melting the walls of your box are obviously a lot higher.

that 20-year journey to build a prototype. Our aspiration is that having done that, they then have the competence to build more power stations. This is a huge export potential for the UK – not just having a design of a power plant, but enabling the whole supply chain in the critical technologies which are required for fusion.

The last ingredient is people. We're working very hard on training the next generation of people, and the Government has invested heavily in apprentice training centres. Today, we have 460 learners for 35 different organisations and we want to do the same at at graduate level, PhD level and postdoc level with a £55m investment from the government to do that.

Not only has the UK seen some really big advances in the last couple of years, broken the world record for fusion power many times and set up new facilities across all of the enabling technologies needed for fusion, we are seeing collaboration with industry on the scale of thousands of companies now involved in fusion. We hope that continues to increase, notably as we now procure partners to move forward with the STEP programme with us. □

We're working very hard on training the next generation of people, and the government have invested heavily in apprentice training centres.

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How fusion works and where the UK sits in the picture

Kate Lancaster

SUMMARY

- You need extremely high temperature, a density of particles and an eye on time to make fusion work
- Inertial Confinement Fusion (ICF) is a system where fuel is compressed to a very high density at 10 hertz, until it self-ignites
- The National Ignition Facility in California achieved ignition for the first time on 5th December 2022
- The UK has long been a world leader in the science behind ICF. The recently formed UK Inertial Fusion Consortium has produced a roadmap.

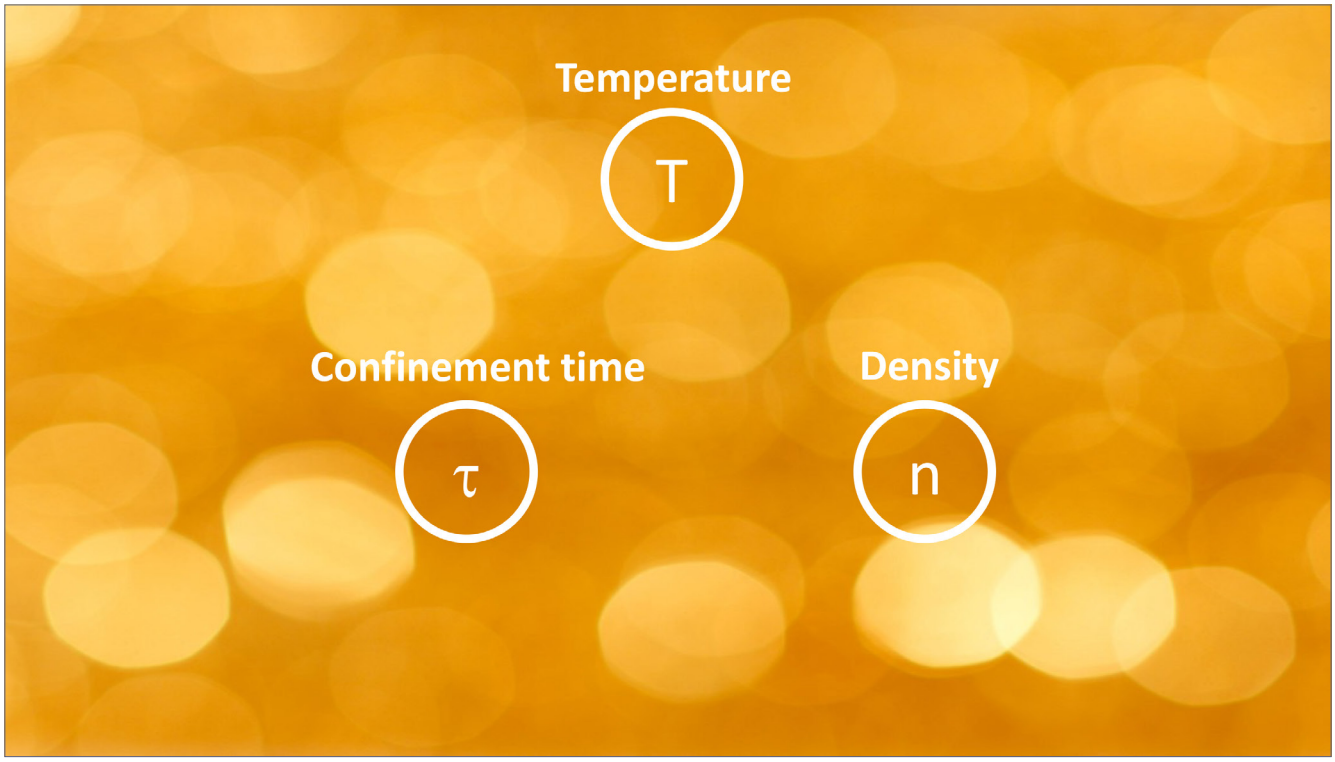
I want to talk about the science behind fusion and will start off by presenting the three knobs that we can twiddle to get fusion to work. So temperature is a non-negotiable, it needs to be hot. We then need to look at the density of the particles in the system, and the time in which you can confine those together to produce net energy. Imagine a system that has a moderate density of particles which you can keep together for a long period of time, or a very dense system of particles, which you keep together for a short period of time, but one that does that over and over again. It just so happens that the two main approaches to fusion fall into those categories.

You may have heard about magnetically confined plasmas, which generally are a moderate density of particles kept together for a long time. On the other side of things, there is a system where fuel is compressed to a very high density until it self-ignites. This is like a diesel engine, but for nuclear fusion. If you do that at 10 hertz, you get Inertial Confinement Fusion, where you're confining the fuel by its own inertia. This can be done with photons and it does not matter if it's lasers in the optical or it's X-rays from a hohlraum. You irradiate your ball bearing-size pellet of deuterium and tritium and heat up the outer layer, so that it expands very violently in a process called ablation. It's a similar process that happens to your cornea during eye laser treatment, but much more violent!

Newtonian physics

If you've got something ablating outwards very violently, by Newton's third law, the rest has to collapse inwards. Materials are compressed to about 1000 times solid density. Eventually this piston action will cause the temperature in the centre to become very high, so that you get what we call a hot spot. At this point, fusion occurs, alpha particles are produced there, things heat up further and more alpha particles are produced again. The result is a kind of fusion burn wave propagating through the full system. This hap-

Dr Kate Lancaster is a senior lecturer based at the York Plasma Institute, part of the School of Physics, Engineering and Technology at the University of York. She received her PhD in 2005 from Imperial College whilst based in Central Laser Facility at the Rutherford Appleton Laboratory. A post-doctoral position was followed by a permanent research position at the Central Laser Facility, before coming to the York Plasma Institute in 2012. Her research expertise is in ultra-intense laser-plasma interactions and advanced inertial fusion schemes. She specifically is interested in the role energetic electrons play in laser plasma interactions.



Fusion relies on three separate factors: temperature (T); the density of the particles in the system (n); and the time these can be confined together to produce net energy (τ). Fusion systems can have a moderate density of particles which can be kept together for a long period of time, or a very dense system of particles, kept together for a short period of time.

pens in a fraction of a second so you have to do that multiple times a second for something like a power station. That is what ICF is.

There is a massive facility built at the Lawrence Livermore National Laboratory in the Bay Area of California called the National Ignition Facility (NIF). The clue is in the name. It was designed to work with Ignition, but although it is Ignition defined as the energy obtained from fusion is larger than the laser energy entering the system, it is not yet net energy, or energy "on the grid".

It is the largest laser system in the world, and frankly, as far as I'm concerned, the most beautiful laser system in the world. It's incredible. They filled it with over 50 different diagnostics. Anyone who's ever done any kind of experiment knows that getting 50 instruments to work simultaneously is a miracle. They did not get ignition to begin with, and there were lots of problems in terms of their predictive capability and so forth, but after an incredibly beautiful, careful set of experimental and theoretical work, they managed to achieve it, which is incredibly exciting. I started this game in 2001, at an advanced inertial fusion scheme. So this is what I've been waiting for my whole career. They achieved this for the first time on 5th December 2022. They put in two and a bit megajoules of laser energy and got three and a bit out, which is a fantastic achievement.

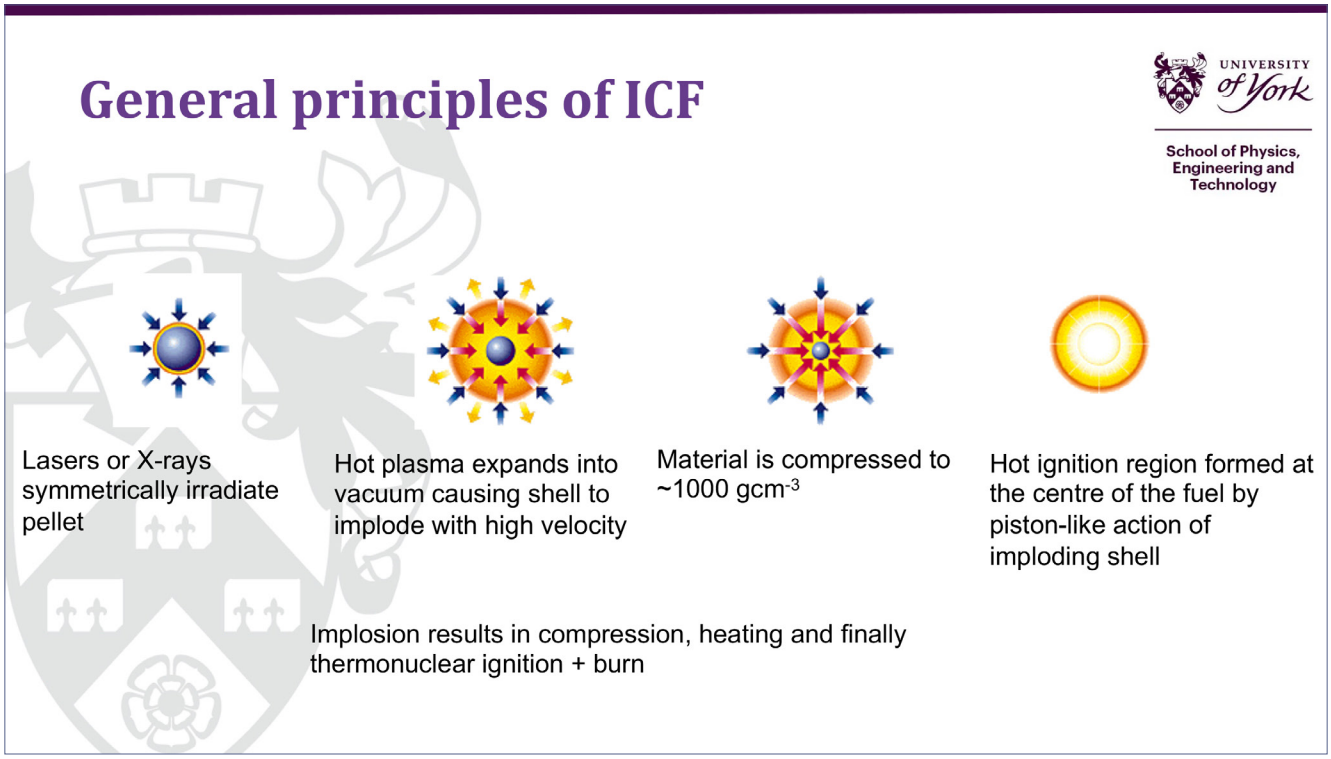
Although Ignition has been achieved (the energy obtained from fusion is larger than the laser energy entering the system), this is not yet net energy.

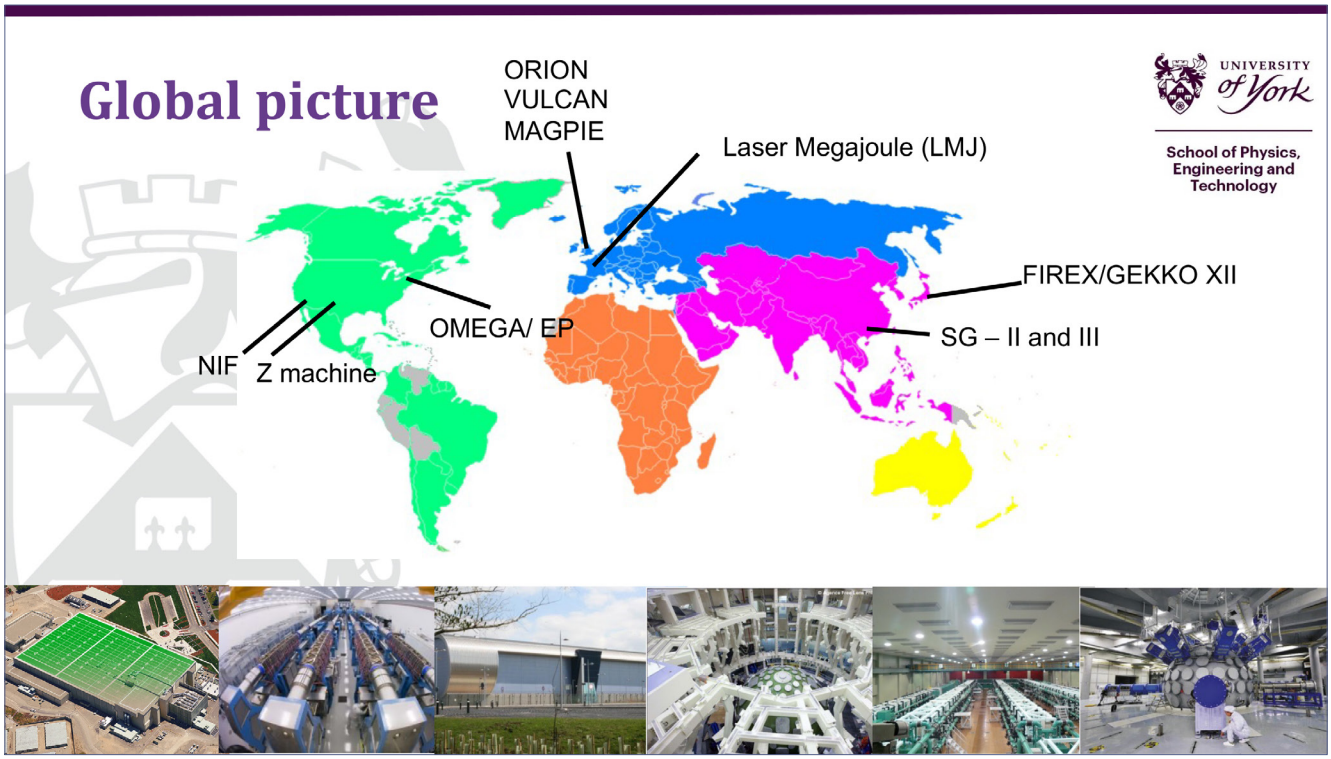
To put this into context, there's about a megajoule of energy in a four-bar KitKat. I'm pretty sure you've never eaten a four-bar KitKat in 10 nanoseconds – though I know we've all given it a good go. That's the sheer power of this system and demonstration of this is robust. It's not just a one off. I hear on the underground grapevine, that we're now at around six megajoules of energy, which is very exciting.

On the global stage, the NIF is the only show in town that's capable of getting ignition, but there are lots of supporting facilities. There are lots of high rep-rate, low -energy systems, which we do our bread and butter in. But (pictured, bottom right) these are the ones that have been largely involved in inertial fusion energy.

We have a very well established, decades old community in the fusion space. It's a relatively modest sized community; six or seven universities and some national labs, the Atomic Weapons Establishment (AWE) and First Light Fusion involved in these spaces.

We've been world leaders for a long time in the science. We've got high-intensity lasers with Vulcan, Gemini and Orion. We are also world-leading in targetry, capability, theory and computational





modelling in the high-energy density space. We definitely punch above our weight. There are also lots of scientists from the UK. Many who trained at Imperial College ended up at Lawrence Livermore and have been deeply involved in the NIF programme with the ignition discovery.

One of the things that our relatively modest community has done to try and give ourselves a bigger collective voice, is form the UK Inertial Fusion Consortium. It consists of about 90 members from the UK's Central Laser Facility (CLF) and was established to try and foster a more joined-up approach to foster collaboration and coordination, and to try and get a bit more of a collective voice for our community in the UK. Out of this, we have created a UK fusion roadmap, looking at the period from 2021 to 2035.

The roadmap focuses on a number of different areas, including the hardcore research side of things, funding, how to increase the funding going into the IP landscape, and facilities and technology. We have some of the best lasers in

Top: the process of Inertial Confinement Fusion; Bottom: the NIF is the only facility that is capable of getting ignition, but there are many other supporting facilities.

the world and some of the best technology so we are also looking at the UK strategy at large.

But how do we grow the UK community? How do we grow equitably? Every decision must be made with a view to making our community more diverse, and more equitable. We have a deep relationship with UK AEA so it's really important to be joined up in the training of people who are entering the fusion space, and there's loads of overlap between the IFE (intertial fusion energy) community and the MCF (magnetically confined fusion) community. If you are interested in this roadmap or the consortium, see the links to the right. □

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NIF ignition
www.nature.com/articles/d41586-023-04045-8
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.132.065102
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High Gain ICF schemes
https://royalsocietypublishing.org/doi/10.1098/rsta.2020.0028
https://royalsocietypublishing.org/toc/rsta/2021/379/2189

UK Inertial Fusion Consortium
www.inertial-fusion.co.uk

Fusion will be here sooner than expected

Francesca Ferrazza

Francesca Ferrazza is Head of the Magnetic Fusion Initiatives unit at Eni S.p.A., Italy's Energy company, in charge of supporting the development of fusion technology and projects. She has a background in semiconductor physics and over thirty years of experience in applied research and R&D management, in particular in the areas of Renewable Energy sources, Environmental and Remediation technologies, biofuels and storage. During the period 2009-2018 her responsibilities were on the company's Renewable and Environmental R&D portfolio, and between 2018-2022 she took the responsibility of the Company's R&D Centre for Decarbonization and Environment, leading 120+ researchers and many laboratories in Northern Italy.

Eni is a global energy company based in Italy. Eni works in more than 60 countries, including in the UK where the company has been since 1964. Today, our activities in the UK span across the entire energy value chain – from the traditional sector to carbon capture and storage, to offshore wind and fusion energy.

Why fusion?

We saw fusion technology coming a few years ago and started investing when we saw that things were maturing. We wanted to time it right to get fusion onto the decarbonisation path.

We have been involved in a decarbonisation path for several years with targets to reach net-zero emissions by 2050. Decarbonisation can only be achieved through a variety of technologies that are applied depending on the situation. Our flexible approach favours the use of all options according to their maturity and effectiveness in reducing emissions. In the UK for example, we already have a mix of energy sources including a renewable energy company working on offshore wind through our affiliate company Plenitude. Eni is also a leading operator in Carbon Capture Storage (CCS) projects in the UK, leading to the development of two CCS Clusters: HyNet North West and the Bacton Thames Net Zero project. We see a mix. Renewables and biofuels are already here.

Fusion is a very interesting source of energy, it gives a great amount of power with high energy density, it is a baseload, and it complements renewables. Back in 2018, we invested in a fusion company startup; Commonwealth Fusion Systems, a spinoff from the Massachusetts Institute of Technology (MIT) in the US. We saw the need for private investment in fusion, an important additional boosting point to what had been largely a government-based set of international programmes.

Being an energy company means that we want to use that energy and want to deal with power stations delivering energy to the grid, while making sure that this it is done in a proper way. We are

SUMMARY

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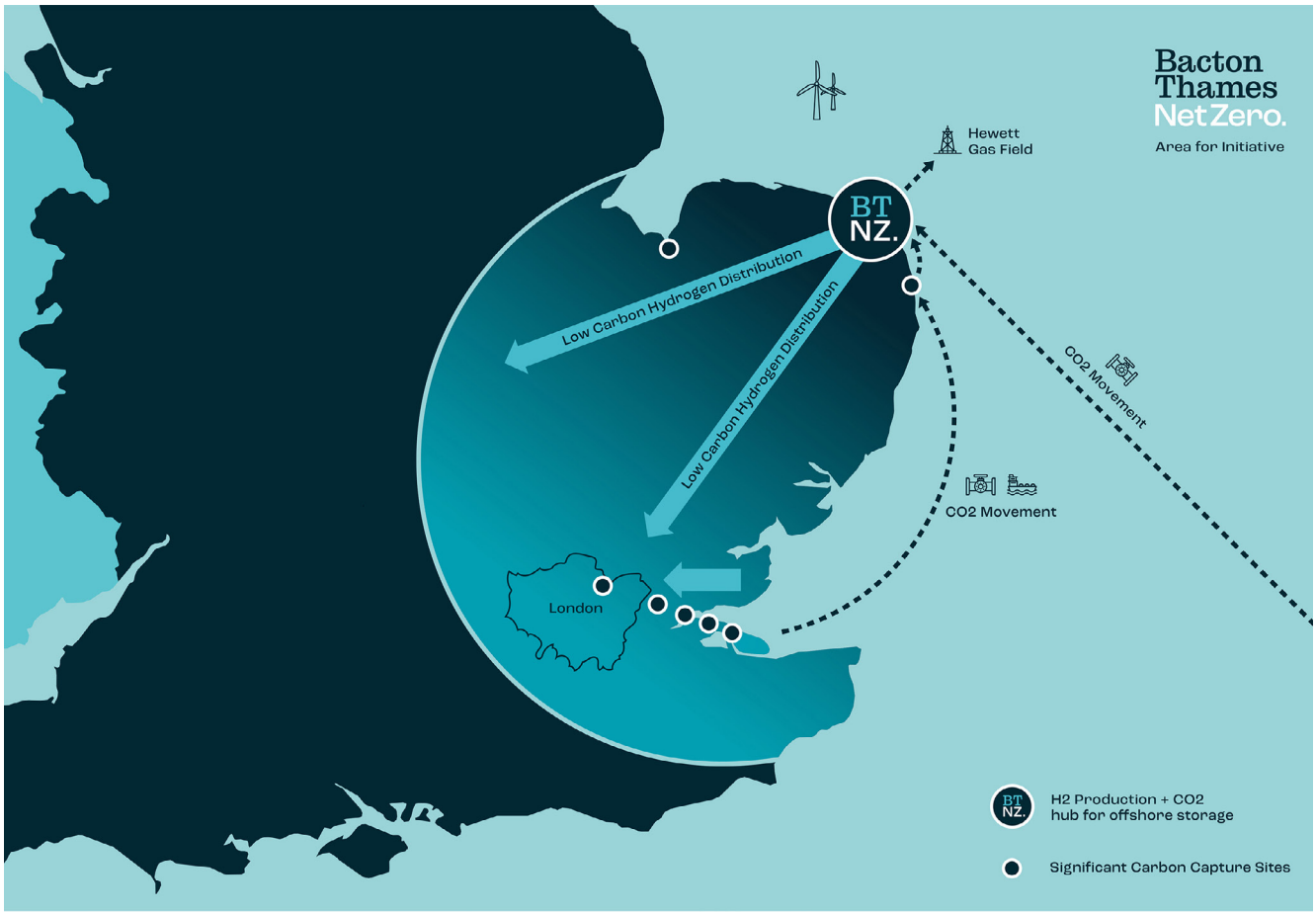

Bacton Thames Net Zero (BTNZ) is an initiative that aims to substantially decarbonise power and industrial processes in the Bacton and Thames regions.

used to complex projects in difficult parts of the world and fusion is the challenge we wanted.

In the pathway towards technology commercialization, of course there are a lot of unknowns, so we are engaging with the best in class research centres, universities, institutions, agencies and supply chains to deliver the results we need; especially going to the fuel cycle (for instance), which has never been tested at an industrial level. It is also a challenge to get the energy to commercial power stations and power plant stage. We have engaged in a much shorter timeline compared to others and we know that this has created a bit of debate in the scientific community. I cannot compare one target year to another, but fusion is coming and it's coming sooner than the traditional roadmaps were foreseeing.

Why do we invest so much in the UK?

The UK has managed JET (The Joint European Torus) successfully over the years and has a lot of knowledge on fuel, the tritium cycle, materials and all the things that need to be done to make the technology a commercial reality. To do all of this, you need a supply chain and a collaboration of all these entities together. The UK has a very sound and important programme for this. We were very interested in the practicality and pragmatism that the UK has been bringing the fusion space at large.

In order to grow an industry on such a difficult technology, you need a stable, predictable environment; you need a regulatory system which is clear and different from fission. The UK has done all of this and this is valuable. As part of this, we are presenting the UK as a virtuous case of how you need to put everything together to make it possible for commercial fusion systems to develop. We are speaking to the UK Government in order to bring this experience to Italy, and aim for a fruitful collaboration of both countries at the international level.

What we need to do next

We do not want to reinvent the wheel. We believe it's really important to get over certain regulatory constraints. There's also going to be a lot of investment needed to get fusion to be a commercial reality. The effort that the UK is making and the role of UKAEA are very valuable. Cooperation between different parts of the community – public, private, and the supply chain – are fundamental to this, but it's still not enough. We need to sustain contributions from SMEs and technology providers. We also need to get more energy companies to be the end users and the developers of the systems that provide energy for the people. □

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The debate

After the presentations, the speakers responded to questions and comments from the audience on a range of topics, including: what may come first in terms of commercially viable fusion technology; the technology underpinning various projects across the globe; EuroAtom, and transparency with the public.

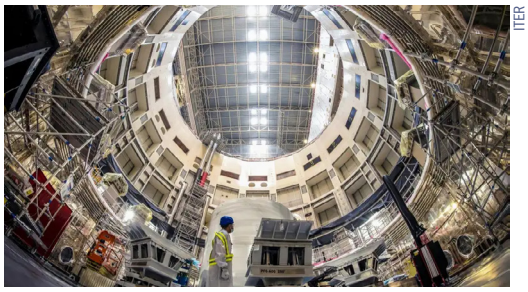
The urgent and essential nature of needing a low carbon, sustainable energy solution is so great that it is worth trying different and diverse approaches to fusion. Nobody knows which will be first or commercially viable in the longer term. It could well be that the first fusion power plant that turns on a light in a home will not be representative of the thing that ends up with dominant market position.

The UK has been operating JET which is a conventional tokomak, but we have also invested in spherical tokomaks and remain the world leaders in tokomaks. Conversely Germany is the world leader in accelerators and the US is a leader in inertial confinement. Different states have a thing that they dominate with, and valuing that diversity is a smart thing to do. We cannot do them all in one country, so it is a global endeavour. However, the underpinning technology of all of those approaches is largely common. So the UK strategy of having a power plant design programme is enabling the growth and development of suppliers in those key technologies which can be supplied to any varied of power plant. You enable an industry which can support any variant of approach to nuclear fusion.

Laser technology

One of the other things that the UK has a world lead in is the underpinning technology of high energy and high repetition rate lasers. We need to be incredibly careful to act now and commericialise this technology so that we maintain our world lead. STEP is a logical next step for the UK given our knowledge and heritage on the area. If we can build a thriving sector with a wide breadth then we have the ability to bring forward new technologies.

EuroAtom and ITER have been central in developing technology, skills and standards for the fusion sector and the UK's departure from the EuroAtom understandably brings concern for some. Europe is going through many changes and it's important to understand what Europe wants to do with fusion, and there is a feeling that it needs to evolve with organisation and timelines. The UK Government says that separating from Europe has enabled it to build some of the programmes that it is currently working on, but that it is still open to



ITER

international cooperation. The UK has also remained within the European grant-giving process and the ITER programme (above), which enables it to stay connected and linked with Europe. However, the exit from Euratom has made it challenging for academia to participate in ITER because the relationship is with the UK AEA rather than universities.

A participant from the audience commented that experts should be more transparent with the public on the amount of energy and resourced needed to produce high gain in nuclear fusion. Pannelists commented that getting to a sustainable, visible and commercial point where fusion becomes energy for homes is still a challenge. But like when gas overtook coal, everything in energy moves slowly. The physics works and now that the National Ignition Facility (NIF) has demonstrated ignition, this should open doors.

There is lots of spillover for investment in fusion. Many of the technologies developed within the nuclear fusion space can be used across the wider applications such as with tritium storage and hydrogen and robotic innovation. ☐

FURTHER INFORMATION

UK Atomic Energy Authority
www.gov.uk/government/organisations/uk-atomic-energy-authority

ITER
www.iter.org/

Joint European Torus
https://ccfe.ukaea.uk/programmes/joint-european-torus/

Euratom
https://en.wikipedia.org/wiki/Euratom

CONTEXT

The UK is a highly innovative nation, with a great reputation for small deep-tech startups, often emerging from the UK university sector. For the most promising of those organisations, seed funding can be found in the UK, but scaling up these companies, and sourcing the funds to enable that to happen, can be a real challenge. This limits the value to UK plc, as these companies have the potential to provide huge returns to the economy, but with longer timescales than startups in other sectors, with a need for patient capital investment.

On Wednesday 24th January, The Foundation for Science and Technology held an event to explore how big this problem is in comparison with key competitors and to look at the roles of universities, venture capital firms, UKRI, central government and the companies themselves.

Speakers included Amelia Armour, Partner for Early Stage Funds at Amadeus Capital Partners, Dr Simon Thomas FREng, Chief Executive Officer at Paragraf, Scott O'Brien, Chief Investment Officer at Innovate UK and Gus Wiseman, Deputy Director and Head of Investor Relations for the Department for Business and Trade.

A video recording, presentation slides and speaker audio from the event are available on the FST website at: **www.foundation.org.uk/Events/2024/Scaling-up-deep-technology-companies-in-the-UK-%E2%80%93-c**

The importance of scaling up from the seed stage

Amelia Armour

SUMMARY

- Deep-tech companies take longer to scale up
- Two stumbling blocks in the UK are talent and funding to actually make a scale-up happen
- Within Europe, the UK takes the greatest share of funding into deep-tech companies after France, Sweden and Germany. We have a vibrant 'seed stage' list of investors
- Because we do not have this developed ecosystem of scaling companies to a later stage, we do not have the outpouring of talent that then comes back into the more junior companies
- The UK ecosystem for growth of companies is growing but more can be done.

I work with Amadeus, which is an early-stage deep-tech investment fund and we've been around for 25 years. In that time we've invested in over 180 companies, have offices in Cambridge and London, and about 40% of our investments are in Cambridge spinouts.

The reason why I am so excited about deep tech in the UK is because of the strong research and technology development that we are seeing at the universities here.

We have four of the top 10 global universities in the UK, seven out of the top 10 in Europe. So we're creating lots of amazing ideas and that's brilliant at the very early stage. However, what we come across is the problem of taking these tech ideas and scaling those up to companies which have amazing products. Where we see the real difficulties here in the UK, versus maybe other countries are in two areas. One of them is talent and the other is in funding to actually make a scale-up happen.

Within Europe, the UK takes the greatest share of funding into deep tech companies after France, Sweden and Germany. And at the earliest stages, that's great. We have a vibrant 'seed stage' list of investors, we have angel investors, we have EIS investors. So per capita, we generate a significantly high number of start-up companies, but what we find with deep-tech companies is they take longer to scale. Compared to other technology companies – which do not have the strong IP breakthroughs – these companies take 25-40% longer between funding rounds to get to those next milestones. That means that they need to raise more funding to get from stage to stage. At the earliest stages, that's fine, but we have problems later on down the line in getting enough capital to really grow these companies to the size that we would like.

There are shoots and glimmers of things improving in the UK, and we're hopeful that some pension money will be released to support this asset class. We also see initiatives such as the Breakthrough Fund, which was set up by the British Business Bank a few years ago. This has £375m to invest in the types of companies

Amelia Armour joined Amadeus Capital Partners in 2009 and is a Partner in the Early Stage Fund, leading investments in deeptech companies focussed on AI & Cybersecurity, Photonics & Quantum, Digital Health & MedTech and Novel Materials. She is a Director on several boards including Xampla, who have developed plant-based materials to replace single-use plastics; and joined the UK Government's Semiconductor Advisory Panel in August 2023, established to deliver the National Semiconductor Strategy.

Because we do not have a developed ecosystem of scaling companies to a later stage, we do not have the talent to come back into more junior companies.

that we're supporting, but there's more that we could do there. Even at the seed stage, we could take larger funding rounds to help UK companies get through these early milestones much more quickly.

Then the second area which I think is important and where we could really do with more input in scaling these companies, is around talent. One example I can give is of an AI company I know. They are looking to grow their product function and really need to understand what the customer wants. They need to listen to the voice of those customers so that they can feed back into the product they're developing. They've hired multiple times in the UK, each time with failure. They have not been able to find a strong enough candidate to lead their product function from within the UK, so they've had to go to the US to hire that person. Because we do not have a developed ecosystem of scaling companies to a later stage, we do not have the outpouring of talent that then comes back into the more junior companies.

To give you a feel for the number of unicorns (start-up companies) that are in the UK versus the US – at the end of last year, there were just under 600 unicorns in the US, and just under 50 in the UK. Scale makes a real difference in attracting and retaining talent that can be used to support the junior companies.

In conclusion, I do think this ecosystem is really developing. We looked at the amount of investment coming into deep tech over the last 10 years, and it's now moved from 10% of total venture capital investment in the UK to 20%. Things are growing, but there's a lot more that can be done. □

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The four challenges of scaling up, and how to solve them

Simon Thomas

Simon Thomas is CEO of Paragraf, the company he founded in 2018. With a diverse background in physics, engineering and materials science, he spent nearly 20 years in the fields of compound semiconductor materials, devices, and applications. Paragraf is a global leader in producing graphene-based electronics at scale. These transform the worlds of magnetic sensing and biosensing in application spaces ranging across electrification of vehicles, quantum computing, medical diagnostics and renewable energy.

SUMMARY

- Early-stage investment in the UK is great and later stage is not so good. Could the investment risk for capital be lowered?
- Growing companies need great people, but there is a talent shortfall in the UK
- What if manufacturing sites were as easy to build as service-based infrastructure?
- Scaling business needs clarity, UK policy is often difficult to decode.

The UK is a great place to be. It's a fantastic fertile ground for the growth of innovation, the growth of new ideas and bringing new technologies into the world. The challenge we have is how we turn these great ideas and innovations into real value.

Just before I talk about the challenges, I want to give a flavour of what type of business Paragraf is so that there's context when I discuss the main challenges. Paragraf is a global, deep-technology business with three international sites and outsourced support across Asia. As a deep-technology business we do a lot of research and generate a lot of intellectual property. We are a hard-technology business who meaning we make and manufacture product and we are a materials technology business meaning that product is difficult. At the core of our scale-up challenge is the need for specialist skills, talent and sustained capital. It inherently takes longer with deep tech to get to a point where you can realise the value in a significant way. Additionally, suitable infrastructure and a supportive freedom to operate are important to move forward.

It's a difficult but exciting job to try and grow a company from the inception. We have been fortunate to have investors such as Amadeus (an early stage funder) stay with us for the whole of our journey which is fantastic, and that support has pushed us on. What I thought I'd focus on today are the four critical challenges that I believe if solved in the UK landscape, would benefit everybody. If all four of these happen, then we can maybe achieve a utopia.

1. Access to capital

In the UK, we are fantastic at funding early stage businesses, innovation and bringing it forward into fledgling companies. Venture capital funds like Amadeus have done a great job at bringing out

SHUTTERSTOCK/ CLARE LOUISE JACKSON

In its search for a site, Paragraf found landlords were giving priority to Amazon.

the innovations from universities and showing that they've got real value at that early stage. But as we get towards the later stages, as businesses start to grow and the requirement for scaling capital becomes prominent the availability of dedicated financial support drops off, and over the past few years this has got worse. In order to get the big value out of a deep-tech company (just as it starts to turn the corner of creating gross domestic product), it's imperative that we hold the bet and enable the company to cross the valley of death and thrive on the other side, through growth capital.

From Paragraf's perspective, we've had to scale up through a very capital-intensive roadmap, and every time I go out to fundraise it has two significant impacts. First, I have to spend a lot of time raising that capital, second, I am taken away from my day-to-day work as a CEO, the work of growing the business and creating value, there's a double whammy in terms of drain on resource and time resulting in a magnified effect on the business

In our experience there's only one thing that matters to investors – the risk. What is the inherent risk in the business that could lead them to losing their capital? The way we offset this is we demonstrate that we're not as risky a business to invest in as they may think. Unfortunately, scaling tech is a risky business to invest in. So, the question is, what if we could lower the investment risk for private capital? For example, we could look at Enterprise Investment Scheme (EIS) rules. We should look at different pools of capital that can come from the Government. Some of these challenges are being tackled at the moment, but there are still many open questions. For example, can we start using different monies that are invested in the UK ecosystem to fund scaling companies?

2. Access to talent

The UK has got a lot of growing businesses in innovative tech spaces where we are not the world leaders. We are the world leaders in innovative technology but not in growing the business. We just do not have the talent base that comes from many years of enterprise growth in specific technology fields. So how do we get that? Hiring talent in deep tech is a real challenge for scaling companies and this is my second biggest challenge at the moment.

I've hired three chief commercial officers but still have not got that right. We've got open job positions that we have not been able to fill for 12 months. Recently, somebody we really wanted to hire, a world expert in their field, someone who could have trained some of our younger staff internally and helped actively grow our talent base, went to a competitor in Germany because we could not get a visa from the UK government. It's absolutely absurd that we're handing an advantage to other countries, to other competitor companies, through our own Government's actions.

What would happen if the UK talent strategy was industry-led? If we want to grow industry in the UK, there needs to be a bigger industry input into how apprenticeships and internships work. How do we get courses into universities that focus on industry, as opposed to just focusing on the

Paragraf has found that the effects of the National Security and Investment Act are time-consuming and costly.

SHUTTERSTOCK/ WHITEMOCCA

subject? If we could do this, then we'd have a great talent base in the future.

3. Access to infrastructure

We are a country focussed on growing a service-based industry, and service-based businesses. We have lots of infrastructure for Amazon warehouses for example, but we have no infrastructure for growing manufacturing businesses. Paragraf travelled the whole country to find our ideal site. I can go down to Peterborough right now, talk to a landlord and ask, "Can we have this warehouse?" They'll say: "Yes, as long as Amazon turns it down first". This is crazy. So – what if manufacturing sites were as easy to build as service-based infrastructure? Regulation often gets in the way. As an example we had a builder wanting to provide a custom site for us, near where we are currently located. They said they could do it in three years, but in three years' time, we will not be here. Getting rules and regulations aligned with business and talking about how we can provide infrastructure is absolutely critical.

4. Policy in the UK

The way in which we set policy determines how we can get talent into the country. The way in which we obtain talent determines whether we can build the infrastructure.

The fourth challenge is one that is becoming more prominent for Paragraf: policy in the UK. We're in the semiconductor industry and I do not need to go into the background of what happened with the semiconductor strategy – the history is there for everyone to follow. Needless to say, the policy took far too long to formulate and launch and we still have a significant lack of clarity on it. Understanding policy for Paragraf is now costly. For example, understanding what the National Security and Investment Act means in practice; working out which countries we can operate in; understanding what the trade regulations are for graphene, and understanding where we can trade and where we cannot is really time-consuming and really costly, especially when our focus should be on growing our commercial base, not wondering how we can get our product into, or out of a country. But what if industry led the strategy for a cross-party agreement? We need to go across administrations and forget about how we want to run the country as different parties. We need to think about how we want to run it together as an underlying foundation to enable industry to move forward with strength. If we do not do that, we'll be asking the same question time and time again for the next 10, 15 or 20 years.

The way in which we set policy determines how we can get talent into the country. The way in which we obtain talent determines whether we can build the infrastructure, and the way that we obtain both of those things determines whether we can get capital. If we want inbound investment into this country, then let's have the Government make it clear to the rest of the world that we want business in this country. How do we do that? We build the foundations in policy. I truly believe that the UK can be absolutely fantastic in not just manufacturing, but in deep-tech exploitation. It's the exploitation point that delivers the real value of the ideas that have already happened five or 10 years ago in our research institutions and universities. □

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What Innovate UK can do to help businesses scale up

Scott O'Brien

SUMMARY

- Innovate UK is organising its business around products and services, technology domains and place. It has ambitions to refine customer-centric pathways towards growth through innovation – thinking beyond research and start-up and towards growth at scale
- Innovate UK offers more than just grants, including a scale-up programme of business support, connections across the innovation eco-system, infrastructure and finance.

One of the biggest needs we have identified is to go beyond the initial idea and its development, towards helping businesses scale up through their innovation. Traditionally, Innovate UK has been great at helping early-stage businesses create and nurture their ideas and innovation, but we increasingly recognise that we have to help those businesses grow beyond the need for our support and a reliance on public money to access private capital, get to market and scale effectively.

I'm really proud to represent Innovate UK because we are at the business-facing end of UK research and innovation. This pride comes from being part of an organisation that's currently supporting around 6,500 projects, that last year processed more than 4,500 applications. That volume of activity demonstrates the thriving creativity and sense of purpose that fuels our innovation system. It creates the momentum that's coming from the research base and leads to business-led innovation, which is really powerful.

But my excitement also comes from the shift we're beginning to go through at Innovate UK towards becoming more aware of and responsive to the needs of our innovators. Part of that is making Innovate UK more customer-centred, and that means thinking more about the innovator as we build our portfolio of products and services, balancing the important role we play in managing public money and delivering value for the taxpayer with the needs of innovators.

Let me focus in on the products that I think are particularly relevant to scaling businesses.

Innovate UK is not just about grants. Grants are a great way of fostering collaboration and de-risking some of the earliest stages of groundbreaking, cutting-edge and high-risk innovation. But they're not always the answer for businesses looking to achieve commercial growth and scale – they are not a substitute for genuine risk capital in a business.

Sometimes what the business needs at that point is guidance and a critical friend who provides constructive challenge. Innovate UK Business Growth has a dedicated scale-up offer, aimed at providing those things and our scale up directors are experienced business people with an innovation lens who work with individual businesses to support them as they mature.

We also have a pilot programme running in conjunction with the ScaleUp Institute, to help businesses understand the value of non-executives whose skills can round out their board and mature their governance. We are working to identify the skills needed in the innovation system, for example through our Workforce Foresighting Hub, so we can help businesses understand the skills needed in the future, while connecting the markets of the future with today's networks and experts through Innovate UK Business Connect.

Delivering the message

If at Innovate UK we can bring together the innovator, investors and prospective customers, it helps deliver the de-risking message successfully, and helps us to clarify the journey from idea to sales and growth. If you can see the customer, this will help you understand which markets provide the greatest opportunities and the business model needed to grasp them. In terms of investment, government can commit as much as it wants in terms of resource and capital, but whatever we do will always be less than the market can provide as a whole. So how do we bring investors in to support those businesses and how do we de-risk the great new technologies we see as critical to the future?

There are two programmes within my portfolio which look to enable those pathways: first, Investor Partnerships.

Scott O'Brien is Chief Investment Officer at Innovate UK. He joined in 2017 from the British Business Bank, initially to help create and pilot Innovate UK Innovation Loans, targeting innovators pursuing later stage R&D with a clear route to commercial success.

Innovate UK has been developing investor partnerships and working with firms such as the London Stock Exchange Group.

WIKIPEDIA COMMONS/GREN

Investor partnerships is a grant programme. The grant can be up to 70% for some industrial research. But unlike with a traditional grant programme, here we want to link our grant to a business with aligned investment from an investor partner. What we want them to do is to put an equal amount of capital into that business. So we put in £500,000, they put in £500,000, we put in £1 million, they put in £1 million. This brings foundational capital into the business, while we're looking after that really risky, difficult stuff on the innovation side. The investor's money goes into growing a sales team or building commercial function, building financial capability, or maturing the governance. Areas in which investors are expert already.

Investor partners

I'm pleased to say that we now have 115 investor partners signed up from the UK, Europe and beyond, including Amadeus Capital Partners, here today, and angel networks – through to people working in particular verticals such as life sciences or agriculture. The benefit of getting an investor in earlier is that you've got them on the hook, they understand your business, and you've got the benefit of their experience and insight into your business from an earlier stage. You've also got them on the hook for building syndicates for future rounds. So far this approach has leveraged £1bn in private investment.

The second programme is innovation loans. We can lend up to £2 million for later stage research and development (R&D), per project. One challenge for late-stage R&D is that the subsidy control rules mean that typically we can provide about 45% support. However, what we can do on innovation loans in exchange for a little bit of interest, and patient repayment terms is that we cover 100% of the costs. And we can do that quarterly in advance. You only have to pay half the interest during the period when you're doing the R&D and only once you get to market do we say okay, we'll start having the money back now, please. And non-dilutive capital at the right time can be helpful when you're building a sensible, balanced funding strategy.

Lastly, it is clear that the scale and impact of Innovate UK will be greater the more we can support current and future scale-ups, as well as spin-outs and start-ups. It's a shift for Innovate UK to lengthen its support pathways, but it's the direction we're heading in and we are doing so in a way which is connected to and in lockstep with our colleagues at British Business Bank and UK Infrastructure Bank. We're also looking beyond our fellow Government bodies, by doing joint work with the ScaleUp Institute and the London Stock Exchange Group.

Seeing UK businesses take our support, succeed and grow beyond the need for public money is absolutely the thing that drives me on and we will continue to grow the products and services we need to deliver on those opportunities. □

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Bringing global capital to the UK

Gus Wiseman

SUMMARY

- The global race for capital is going to get fiercer
- The UK's institutional investor market is not sufficient for our capital requirements
- There are reasons to be optimistic, with several global funds setting up UK presences since 2020
- International capital will complement the UK's Mansion House Reforms, which will unlock more investment for the UK innovation ecosystem.

We often hear a lot of people talk about Big Bang moments in history, but I think they miss out one of the first ones, which happened here in 1852. This was the creation of the first the world's first modern patent office which, in that decade, ushered in the first wave of international foreign investment. We had Siemens, Colt and Goodyear setting up in the UK. It is proof that as a nation, we've never shied away from exposing British industries to the rigours of international competition.

I work for the Department of Business and Trade and my job is very much about bringing skills and capital into the UK. As part of my role heading the Investor Relations team, I oversee our relationships with the international capital markets. I want to focus on how we're bringing global capital into the UK and making our innovation ambitions a reality.

My first observation is that the global race for capital is fierce and only going to get fiercer. The estimates of capital required to put us on a pathway to net zero are daunting and will stretch the capacity of the global capital funding market.

Geopolitical factors like the pursuit of net zero, regulation of AI, supply chain interruptions and more, are all creating a trend towards a more directive role for global governments. We have seen this with the introduction of the Inflation Reduction Act in the US and parallel initiatives in the EU and other nations. In that context, we as government and industry are going to need to get much better at collaborating if we're going to get the UK's message across.

In the medium term, things are looking fairly positive for global capital markets. Many of our source markets of capital, which come into the UK, are experiencing booms in their pension markets. For example, the Australian pension funds are forecast to double in size over the next 10 years because of member contributions and the performance of their underlying asset base. At the same time, those pension funds have fewer places to invest, because many of them are withdrawing or changing their allocations to emerging markets. All things being equal, the size of the pie and share of the pie for the UK should increase, which means more players in the UK, more liquidity in the UK, more money coming into the listing system and more money coming into the venture capital system. However, international capital comes with challenges – these are evident in the real estate market, where international capital is biased towards prime locations. An important part of Levelling Up is broadening the appetite of global capital for other regions and sectors where liquidity is lower.

To address these challenges, we should be creating the conditions for globally mobile capital to participate in the UK. A good example of that is happening now – at the Prime Minister's lead – is the UK being a regulation setter. At the AI summit at Bletchley last November, the UK was able to bring together actors from around the world. Even those who are not necessarily like-minded were able to come and set the momentum going for global agreements on AI. That's not the only place that we're trying to set the standards for regulation. We're doing it in areas like critical minerals, fusion energy, SMRs and quantum. This shows leadership for the UK, but it also shows the benefits of being a regulation setter, rather than a regulation taker.

We also need to take the UK message out to the global capital markets in a creative way. We're working with several Canadian, Australian and Asian Funds which are opening in the UK. We've seen many of the largest VC funds open in the UK in the last several years, bringing steadily more capital and investment skills to bear in the UK.

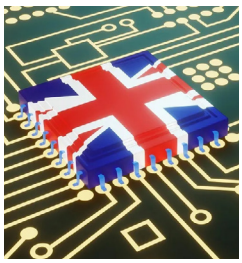
The rejoining of Horizon has attracted much coverage, but I'd also like point out the changes under way in our start-up ecosystem. There has been a revolution in the way that universities are approaching technology transfer. Equity expectations in line with global peer universities will help encourage more spinouts, bolstering the system further. The more that our universities seek to dominate a global niche, the more they'll be able to spin out firms who in turn, can dominate their global niches and grow. □

DOI: 10.53289/RJCV6000

Gus Wiseman is Deputy Director and Head of Investor Relations at the Department of Business and Trade. His team leads the UK's relationships with global institutional investors and venture capital funds, with a goal of bringing investment to the areas and sectors of the UK that need it most.

The debate

After the presentations, the speakers responded to questions and comments from the audience on a range of topics, including the barriers to promoting scale up in the UK, the difference between the UK and US, pension investments and global associations.



The event chair, David Willetts, noted that much of the formal presentation was in answer to the challenge set by CEO of Paragraf, Dr Simon Thomas, around the barriers to promoting scale-up in the UK. The audience responded to this, as well as the benefits of unlocking pension funds, how to get local investment, picking winners and the skills shortage.

The UK is really good at incubating lots of exciting small businesses and selling them off to the US very cheaply. The Mansion House reforms are an exciting prospect, but only if they can open up the City, stop investing in derivatives and start investing in fast-growing companies. We need a cadre of people that understand what is coming down the pipeline, and we need to work out what the sector needs and map it.

A cross-party approach to science and technology is key. An audience contributor disputed some comments from the panel on the UK's work to attract capital and said that one venture capital (VC) company, Sequoia Capital, is only coming to the UK due to our regulatory environment. They are not necessarily coming here to invest, and are instead investing across Europe. The UK needs to be wary of this.

If you look at the difference between the UK and the US in how they get their VC funds, 60% of these US funds come from pensions. In the UK and EU, it's currently only 10%. Part of the problem is unlocking pension money.

On steering pension companies to vary their investment of assets, one panellist said that instead of being focused on fees, they need to focus much more on upside returns. There needs to be some education of team members at pension companies into what these assets could deliver, and in what timeframe.

Global investors are looking at UK businesses. They are interested in scaling businesses, but expectations are different on what the business should be. There is usually a general, unsaid condition that you are going to go and be based in the investor's country at some point in time.

Global association helps corporates invest in start-ups as well as university venture funds, and corporates could be part of the solution. They have the balance sheets to help provide the funds. The largest venture funds in the world are corporates. UK corporates under-invest in local start-ups compared to investments in other countries.

The Government has been 'picking winners'. One example of this is the Quantum Strategy. A huge amount of money has gone into that. This may not mean necessarily mean picking companies, but picking at a macro level: picking policies and technologies which reflect the USPs and innovation strengths and assets of the UK. It is not possible for a country to pursue a globally competitive position in everything, but linking industry and Government together to make section decisions, is a good idea.

Investments are made too broadly across tech spheres, such as semi-conductors. We need a clear steer on how the money is deployed and made a success of. Otherwise, this feeds into inaction from corporates to invest into UK business as it's too tricky for them to know where to invest. □

FURTHER INFORMATION

Mansion House 2023
www.gov.uk/government/collections/mansion-house-2023

Sequoia Capital www.sequoiacap.com

National quantum strategy
www.gov.uk/government/publications/national-quantum-strategy

National semiconductor strategy
www.gov.uk/government/publications/national-semiconductor-strategy

From the climate crisis to terrorism, crises are expected to deepen and appear more frequently in the future. How do we prepare and grow from catastrophic events?

Investing in resilience is the key to surviving crises

David Ormand

Last year was the hottest since global records began. When winter came, it was one of the wettest on record, causing widespread flooding. Something that even Abu Dhabi, to the surprise of those living there, experienced. I have for some years been arguing[1] that we should expect more, and deeper, crises. Sadly, that forecast is being amply borne out by events, and not just over climate, as a result of serious cyberattacks and a compromised information space, technological disruption from advanced AI and quantum science and the risk of further pandemics, and all against the background of war in Europe, conflict in the Middle East, and civil wars and famines in Africa. Border security, energy security, supply chain security, materials security, health security, and food security are all now part of the national security conversation.

Growth from crisis

Of course, good things are happening at the same time. We have the benefit of more disease resistant crops, clean energy becoming more available, vaccines more quickly engineered and new horizons opening with big data exploitation and AI discovery of protein folding. We can also remind ourselves that serious crises have arisen for humankind in the past too, and the species has survived and multiplied, but I argue that today as citizens we are more vulnerable than ever to crisis. Global air transport shrinks distances, and climate change does not respect borders, yet decisions remain stubbornly national as we saw with Covid-19. We are highly vulnerable to major disruption in critical infrastructure of all types due to our growing dependence on complex digital networks, big data and always-on connectivity. And that is without the public realizing just how far the systems on which daily life depends are now digitized. Increasingly our lives will be steered by the outputs of advanced generative AI. It is becoming urgent to develop a consensus on the ethical framework to govern the incorporation of such systems into the processes that support our everyday life, and how best to communicate to users their inherent uncertainties.

It is, I believe, helpful to distinguish here between emergencies, crises and disasters. Even in the best regulated circumstances emergencies do arise – to governments, to communities, to businesses and to families. The public knows that emergencies happen all the time in business and certainly in government. The public rightly expects contingency plans to have been drawn up that can be adapted to circumstance and that there are emergency services trained to work together and ready to deploy. We can identify likely types of emergency, and prepare accordingly. Wise organizations have rehearsed plans for business continuity and have communications strategies ready to inform staff, customers, suppliers and investors when disruptions occur.

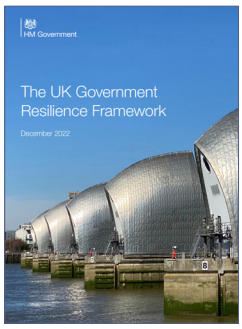
But crises are different in scale and intensity. They turn our world upside down. I use the rubber levers test. You pull the standard emergency responses levers but these do not produce the desired results on the ground. Problems multiply, new threats arise, opening the possibility of a slide into disaster. Some of the steps we take to try to control the situation seem to make matters worse. At least for a while, events seem out of control.

That out-of-control feeling can be deeply unsettling, especially for those used to being in charge and used to knowing what to do – and being used to being able to dictate how their day is to be spent and the priorities for attention. In crisis, it is the circumstances that dictate. For that reason, I have preferred not to use the term 'crisis management'. It is the crisis that is managing you. Being in crisis can therefore be deeply scary.

How well those in charge respond in crisis matters enormously to how things will turn out. In crisis, existing tensions are amplified and tempers fray, and some may try to take advantage of the situation. All this has been amply demonstrated by the evidence so far to the Covid-19 Inquiry. The complexities of any decent analysis of what to do in crisis certainly cannot be conveyed in hurried WhatsApp exchanges. We need processes

Professor Sir David Omand GCB is Visiting Professor War Studies Department at King's College London. He is a Cambridge University graduate in economics, has an honorary Doctorate from Birmingham University and has just completed a degree in Mathematics and Theoretical Physics with the Open University. He is a member of the editorial board of Intelligence and National Security. With his colleague Dr Michael Goodman, he is responsible for delivering training to government intelligence analysts and lectures regularly to BA and MA level classes in intelligence studies.

I prefer not to use the term 'crisis management'. It is the crisis that is managing you.



The UK national Resilience Framework document uses the word "resilience" no fewer than 556 times

that help to create a 'containing environment' for the heightened emotions that stress brings. It also reduces the risk of erratic judgements driven by personality clashes – or personal ambitions by those seeking to take advantage of the situation. Surviving crisis is a team sport.

Nations that take preparation for crisis seriously – and I would highlight the Nordic nations as good examples – put a significant effort into improving the state of national, organisational and personal resilience. Given the state of our world, 'resilience' has therefore a claim to be the word of the year in government and business. The UK national Resilience Framework document uses the word no fewer than 556 times[2]. The National Risk Register includes 61 references[3]. President Biden's recent 'National Security Memorandum on Critical Infrastructure Security and Resilience' has more than 50 references. The first Pentagon US Industrial Strategy has 21 resilience references about highlighting the urgent need to restore supply chain resilience. The new European Defence Industrial Strategy puts maintaining resilience alongside defence readiness and security as EU strategic objectives. NATO is committed to the development of National Resilience Plans (NRP). There are all indicators of a recognition that we are lacking something under the heading 'resilience' that would help.

Resilience is by origin an engineering term: the ability of a material to absorb energy when it is subjected to an external force but then able to release that energy after the impact. It is easy to explain why sea walls – a crucial part of national infrastructure subject to crashing waves in winter – need to be resilient. In simple cases, we could integrate the area under the stress-strain curve to derive a measure of the resilience of the material. In practice, however, absolute measures of the overall resilience of a complex non-linear system are not available – think of the disruption of the container ship blocking the Suez canal, or it could be jamming of a GPS network on which a maritime supply chain depends. Ideally, we should be demanding resilient network design so that the systems we all depend upon resume functioning after a short period of emergency readjustment. It is hard, in the current state of knowledge, to see how we might quantify for a Board seeking to allocate scarce investment the 'right' level of spending on organisational resilience or informational resilience (another concept that demands further research) against the threats and hazards of the future. 'Resilience' is therefore, at best, a metaphor and a broad one at that.

The best approach may be to identify at least the most glaring vulnerabilities in business continuity, keeping stocks to smooth out disruptions in supply, having the capacity to manufacture locally, and maintaining dormant capacity that can quickly be brought into use.

Some crises burst upon us without the possibility of much, if any, warning, such as Carrington events from solar activity or tsunamis from undersea earthquakes. But slow-burn crises are in many ways the hardest to deal with since the situation will have been allowed to worsen over months or possibly years. Crisis comes through failure to spot the problem early enough, so there is an obvious mitigation in improving our scanning of the international, environmental technological and social spheres to spot trouble brewing. But, as sadly happens, it may be that there were warning signs but they went unheeded. That can be because those providing the warnings were not sufficiently trusted, or their findings did not fit the prevailing political narrative, or the problem appeared too expensive to fix, or the time was simply not right to tackle such a problem. Examples, both macro and micro, abound.

Adaptive resilience

When trouble looms, good leaders quickly mobilise their top team and bring extra resource to bear to discover innovative ways through the situation. And they apply what has been called adaptive resilience to identify lessons contemporaneously, so that the organisation can emerge from the crisis experience stronger as well as wiser. We should therefore be more open about identifying generic vulnerabilities to a range of possible disruptions. The UK Government has already in its published Resilience Framework expanded the meaning of the resilience metaphor to cover the ability to anticipate, assess, prevent and mitigate upstream, as well as the ability to bounce back from crisis when it happens.

The lesson is I hope sinking in[4]: expect more frequent, and deeper, crises over the coming decade and spot them as early as possible, identify in advance our vulnerabilities (including our dependence on digital data, connectivity and data science) to major classes of disruption and invest in improving resilience accordingly, giving priority to measures that have a wide applicability. ❐

DOI: 10.53289/DAST9613

1. David Omand, *How to Survive a Crisis: Lessons in Resilience and Avoiding Disaster*, London: Penguin paperback, June 2024.
2. www.gov.uk/government/publications/the-uk-government-resilience-framework/the-uk-government-resilience-framework-html
3. www.gov.uk/government/publications/national-risk-register-2023
4. https://nationalpreparednesscommission.uk

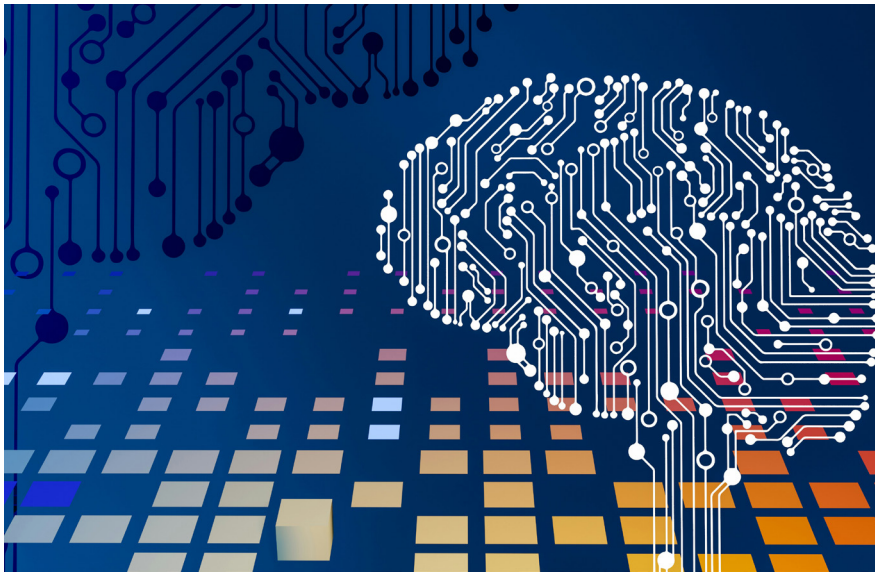
Forthcoming and recent events

Presentations and audio recordings from all meetings of the Foundation for Science and Technology are available at: **www.foundation.org.uk**

Empowerment and Ethics at the Edge: the Benefits and Risks of Edge Technologies

Wednesday 22nd May 2024

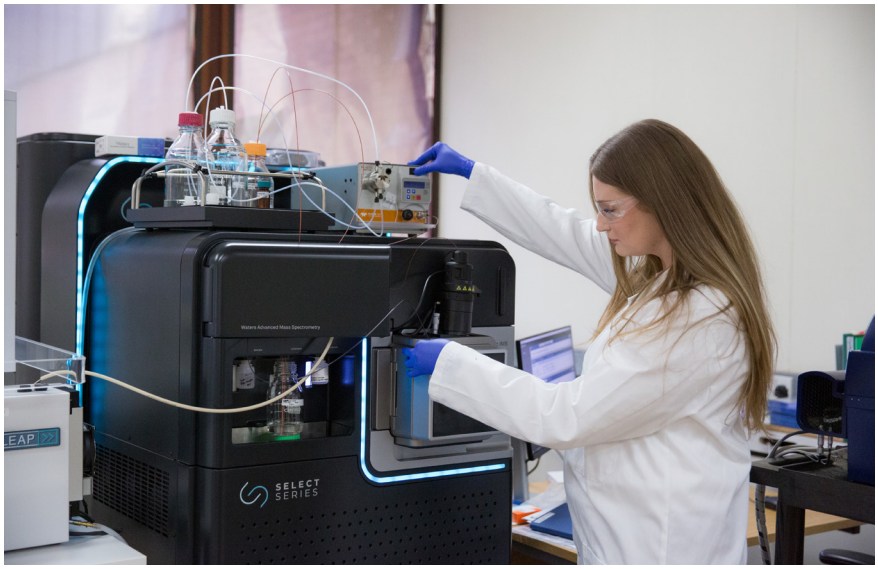
Joe Butler, Chief Technology Officer, Digital Catapult
Professor Payam Barnaghi, Chair in Machine Intelligence Applied to Medicine, Imperial College London
Dr Leonie Tanczer, Associate Professor in International Security and Emerging Technologies, University College London
Dr Peter Novitzky, Associate Professor at UCL; Ethics of Emerging Technologies at Avans University of Applied Sciences, the Netherlands



The Role of UK National Laboratories

Wednesday 12th June 2024

Sir Patrick Vallance, former Government Chief Scientific Adviser
Professor Steven Cowley, Director, Princeton Plasma Physics Laboratory
Dr Karen Hanghøj, Director, British Geological Survey
Dr Julian Braybrook, Director, National Laboratories at LGC, and UK Government Chemist



Safeguarding trust in science – the role of research integrity

Tuesday 9th July 2024

Professor Rachael Gooberman-Hill, Co-Chair, UK Committee on Research Integrity
Professor Andrew George, Co-Chair, UK Committee on Research Integrity
Cathy Alexander, Deputy Director for Science & Innovation, Systems& Capability, Government Office for Science
Professor Christopher Smith, Executive Chair, Arts & Humanities Research Council
Sarah Jenkins, Senior Director, Research Integrity & Publishing Ethics Centre of Expertise , Elsevier

Past events

The UK Fusion Programme
Wednesday 27 March 2024

John Staples, New Nuclear Strategy & Fusion Energy Director, Department for Energy Security & Net Zero
Professor Sir Ian Chapman, Chief Executive, UK Atomic Energy Authority
Dr Kate Lancaster, School of Physics, Engineering and Technology, University of York
Francesca Ferrazza, Head, Magnetic Fusion Initiatives, Eni

Can Artificial Intelligence be regulated and if so how?
28 February 2024

Stephen Almond, Executive Director, Regulatory Risk, Information Commissioner's Office
Professor Sana Khareghani, Professor of AI Practice, Kings College London
Dr Cosmina Dorobantu, Co-Director and Policy Fellow,, Public Policy Programme, The Alan Turing Institute
Professor Dame Wendy Hall DBE FRS FREng, Regius Professor of Computer Science, University of Southampton
John Gibson, Chief Commercial Officer, Faculty AI

Scaling up deep technology companies in the UK – challenges and solutions
24 January 2024

Amelia Armour, Partner, Early Stage Funds, Amadeus Capital Partners
Dr Simon Thomas FREng, Chief Executive Officer, Paragraf
Scott O'Brien, Chief Investment Officer, Innovate UK, UKRI
Gus Wiseman, Deputy Director, Head of Investor Relations, Department for Business and Trade

A Round Table on Artificial Intelligence
16 January 2024

Horizon Europe – making UK participation a success
6 December 2023

George Freeman MP, Former Minister for Science, Research and Innovation
Professor Maria Leptin, President, European Research Council
Professor Christopher Smith, Executive Chair of AHRC and UKRI International Champion
Professor Mary Ryan, Vice Provost (Research and Enterprise), Imperial College London

Risk and Resilience – Foundation Future Leaders Conference 2023
20 November 2023

Inventing a Better Britain - How does R&D fit into a new UK economic strategy?
November 15, 2023

Professor Dame Ottoline Leyser DBE FRS, Chief Executive , UKRI
Grant Fitzner, Chief Economist, Office for National Statistics
Professor Jonathan Haskel, Professor of Economics, Imperial College

Net Zero - UK and global progress
October 11, 2023

Lord Deben, Former Chair, Climate Change Committee
Professor Paul Monks, Chief Scientific Adviser, Department of Energy Security and Net Zero
Baroness Brown of Cambridge DBE FREng FRS, Chair of the Adaptation Committee, Committee on Climate Change and Chair, House of Lord Science and Technology Committee
Professor Jim Skea CBE, Chair, Intergovernmental Panel on Climate Change

Transforming Scottish Healthcare – The Role of Data and Technology
October 5, 2023

Professor Sarah Curtis FRSE, Honorary Professor, University of Edinburgh
Jonathan Cameron, Deputy Director of Digital Health and Care, Scottish Govt.
Professor Patricia Connolly, Deputy Associate Principal, Biomedical Engineering, University of Strathclyde
Professor Oliver Lemon, Co-academic lead, National Robotarium
Dr Ken Sutherland FRSE, President, Canon Medical Research Europe

The Emerging Shape of REF 2028
July 5, 2023

Professor Geraint Rees FMedSci, Vice-Provost for Research, Innovation and Global Engagement, University College London
The Rt Hon the Lord Willetts, Chair, The Foundation for Science and Technology
Dame Jessica Corner, Executive Chair, Research England
Dr Steven Hill, Director of Research, Research England
Sir Peter Gluckman, Chair FRAP IAG and President, International Science Council
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Professor James Wilsdon, Director, Research on Research Institute, University College London
Professor Louise Bracken, PVC for Research & Knowledge Exchange, Northumbria University
Diego Baptista, Head of Research Funding & Equity, Wellcome Trust
Professor Simon Hettrick, University of Southampton and Chair, The Hidden REF
Emma Todd, Director of Research Culture, University College London

Equity, Diversity and Inclusion in STEM
June 28, 2023

Dr Lilian Hunt, Equality, Diversity & Inclusion in Science and Health (EDIS) Lead, Wellcome Trust
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Kevin Coutinho, Pro-Director: Equality, Diversity and Inclusion, London School of Hygiene and Tropical Medicine & British Science Association Trustee

The use of AI in the early detection of disease
June 14, 2023

David Crosby, Head of Early Detection Research, Cancer Research UK
Mike Oldham, Director of Early Detection of Neurodegenerative Diseases, Alzheimer's Research UK
Jessica Morley, Oxford Internet Institute, University of Oxford
Tobias Rijken, Co-Founder and Chief Technology Officer, Kheiron Medical Technologies

The UK Semiconductor Strategy
May 24, 2023

Paul Scully MP, Minister for Tech and the Digital Economy, Department for Science, Innovation & Technology
Dr Andy Sellars, Strategic Development Director, Compound Semiconductor Applications Catapult
David Clark, Chief Technology Officer, Clas-SiC Wafer Fab
Dr Jalal Bagherli, Former CEO, Dialog Semiconductor

The Nurse Review of the Research, Development & Innovation Landscape
May 15, 2023

Sir Paul Nurse FRS FMedSci, Chair, the Research, Development & Innovation Landscape Review
Chi Onwurah MP, Labour Shadow Minister for Science, Research & Innovation
Dr Peter Thompson FREng FInstP FRSC CEng, Chief Executive, National Physical Laboratory
Vivienne Stern MBE, Chief Executive, Universities UK

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