Digital Future Index 2021–2022

The UK's trends index for advanced digital technologies

Report menu

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Dr Jeremy Silver

Chief Executive Officer, Digital Catapult

The pandemic has driven change in unprecedented ways in our society and the economy.

As a result, we have seen businesses moving to digitalise faster than ever — in order to cope with challenges and opportunities felt through remote working; health, safety and social distancing; changing consumer habits and shocks to supply chains. And all this is coinciding with increasing urgency in our need to address the challenges of the climate emergency. The Digital Future Index 2021–2022 is Digital Catapult's first barometer of where the UK currently sits in the global future of advanced digital technologies.

These groups of technologies are the fundamental building blocks to future economic growth and competitiveness around the world, spanning transformational capabilities such as artificial intelligence, immersive technologies such as virtual and augmented reality (VR and AR); blockchain and distributed ledger technologies (DLT); 5G, advanced digital networks and the internet of things (IoT). The Digital Future Index shows the UK ranked 3rd in the world for these technologies, behind only the US and China.

This places the UK in an excellent position as the world competes to adopt these sophisticated new capabilities such as spatial computing in the metaverse, advanced design in digital twins and process transformation through complex robotic and autonomous systems.

But there is still much more to be done — the distribution of innovative companies working with these technologies is imbalanced in terms of sector focus, geography and size with the gap between laggers and leaders too large. To tackle these challenges both private and public sectors in the UK would benefit from coming together in better collaboration in order to take increased ownership of the future of these technologies. We need to establish new approaches to enabling digital infrastructure and the advanced applications they support, to figure out together how these technologies can be applied to the sectors that are currently in danger of being left behind as well ensuring global market share in sectors where we lead. Industry and our community are still in the early stages of advanced digitalisation, but if we can get the first steps right, then UK businesses, individuals and society as a whole will benefit significantly in the future from the extraordinary power and capabilities of these new technologies.

Highlights

KEY STATISTICS

For the development and uptake of **advanced digital technologies,** the **UK ranks:**

1ST in Europe

3RD in the world

Measured across **125+ data point indicators** (spanning the six pillars of talent, innovation and commercial ventures, infrastructure, research, operating environment, and development). These technologies will underpin the next phase of digital transformation for global businesses.

The **total funding** for the UK **advanced digital technologies** market is an estimated:

£10.4bn

Split between **4,000 companies** working in:

From August 2020–August 2021, companies have received a total of **£2.46bn in investment,** with:

ARTIFICIAL INTELLIGENCE	**~£1.3bn**
IMMERSIVE TECHNOLOGIES	**~£180m**
BLOCKCHAIN	**~£481m**
INTERNET OF THINGS	**~£505m**

KEY STATISTICS

The **UK ranks: 16TH**

In **digital infrastructure and underpinning capabilities**

This includes:

- Number of supercomputers
- Hardware imports and exports
- 5G, mobile and internet network availability and average speeds

While this is largely on par with Germany, the UK is still significantly behind **China, South Korea** and the **United States.**

For the development of **5G progress,** the **UK ranks:**

2ND in Europe

7TH in the world

The UK may potentially improve in regards to underpinning infrastructure as 5G roll-out continues.

The broader roll out of digital infrastructure for the built environment, digital twins and metaverse applications will benefit from a focused UK strategy and investment into cyber physical infrastructure to stimulate further private investment. It will also benefit from the exploration of use cases and new capabilities across sectors.

KEY STATISTICS

The UK falls behind in **average funding per company across a range of advanced digital technologies:**

11TH in immersive technologies and IoT globally

While the UK is ranked 2nd globally for average funding per company for DLT, this average is still low at just £1.6m compared to the US at £8.9m.

The higher number of companies in the UK can mean this average is kept lower, but the UK and many other countries in the world are still significantly behind the US across these technology areas.

4.1% of advanced digital technology companies in the UK are generating revenues more than

$10m+ per annum

This is similar to a global average of ~3%, but significantly behind the US at 7.4%.

This indicates a lack of global scale in the market outside of the US for these technologies.

KEY STATISTICS

The UK has a comparatively strong AI ecosystem with an average funding of:

£4.8m per company (5th globally)

25.4% of **UK AI companies** are generating an estimated **$1m+ of revenue per annum.**

There is still some way to go to reach the same level of funding per company as the US (£8.8m). China is an order of magnitude higher, at £31m average total funding per company for AI.

However, it is yet to yield consistent revenue streams, with only 11.3% of its companies having estimated revenues of $1m+ per annum.

The distribution of advanced digital technology companies by sector shows **the UK is at risk of falling behind in the fourth industrial revolution.**

Low percentages of companies are focused on industrial applications in sectors such as:

MANUFACTURING

SUPPLY CHAINS

With an **average of 4%** of advanced digital technology companies having products and services targeted at either sector.

KEY STATISTICS

For the highest number of companies in the world, **the UK's digital ecosystem for innovation ranks:**

2ND for blockchain and DLT companies

2ND for immersive technology companies

3RD for IoT companies

2ND for AI companies

The **UK ranks: 4TH** (globally)

For **immersive technologies**

This includes: virtual, augmented, mixed reality and haptic technology interfaces that will underpin the future of spatial internet and metaverse capabilities.

While the UK is number one in Europe for these technologies, it has dropped behind the US, China and South Korea. Despite this, the UK has the 2nd highest number of immersive startups in the world, the third highest amount of investment into immersive companies with a total of **£592m** of total funding, but behind the US which has invested **£11.8bn** and China which has invested **£1.5bn.**

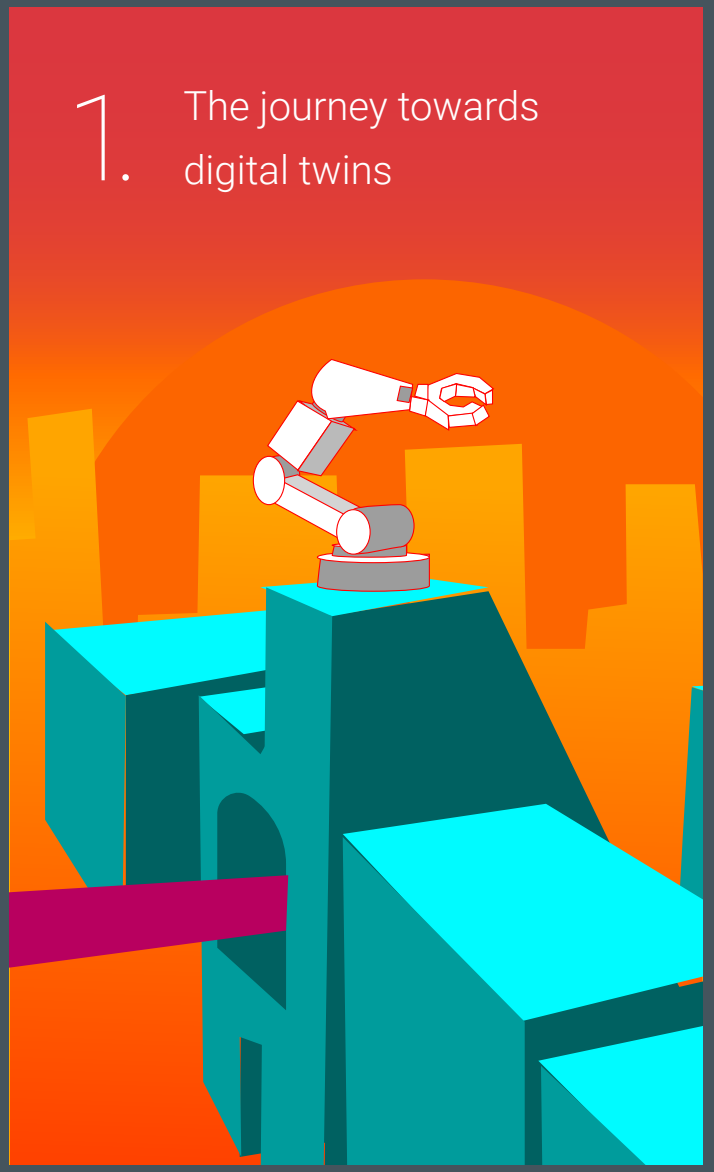
TOP TEN

Digital Future Index 2021

Country	AI	Immersive	Blockchain	IoT	Infrastructure	Weighted total score	Total ranking
United States	16.5	11.0	11.5	16.2	2.5	33.2	1
China	9.1	6.4	5.9	8.4	3.5	14.4	2
United Kingdom	6.4	4.8	5.2	6.8	2.0	10.5	3
South Korea	5.7	5.2	5.4	5.7	2.6	8.3	4
Japan	4.6	4.1	4.1	6.7	2.1	8.2	5
Israel	5.7	4.4	4.4	5.2	1.8	7.6	6
Canada	5.2	4.2	4.8	4.8	2.0	7.2	7
Germany	5.1	4.5	4.7	5.3	2.0	7.0	8
Australia	4.5	4.6	4.4	4.4	2.1	6.6	9
Singapore	4.8	3.9	4.6	4.4	2.3	6.52	10

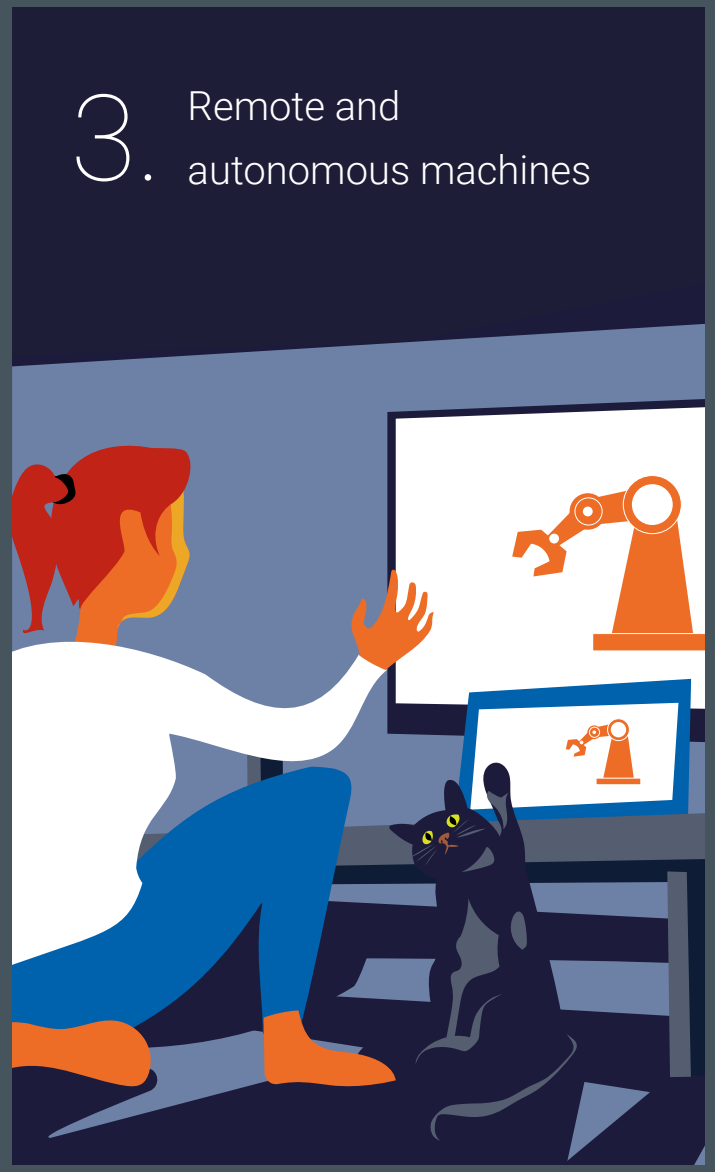
KEY TRENDS

1. The journey towards digital twins



2. The rise of the metaverse

3. Remote and autonomous machines



Context and trends

A new advanced digital future

2021 marks the starting line of a new advanced digital future. In 21/22 businesses will continue to see a rise in the importance of advanced digital technologies, with a particular focus on their convergence into complex cyber physical systems. This will build towards advanced digitalisation in businesses and sectors that have been most affected by the pandemic.

This report is an advanced digital technology index. It explores the data around advanced digitalisation, highlighting UK strengths and weaknesses alongside a range of trends that have been emerging over the past year.

Through 125+ datasets, alongside interviews with world leading innovative businesses, industry experts, technologists and researchers, this index provides insights into:

1. Where the UK and other countries have relative strengths and weaknesses around these technologies
2. Emerging trends focused on how these technologies are converging into new capabilities at a national, regional and business level

What are advanced digital technologies?

Advanced digital technologies provide businesses and consumers with game changing capabilities such as:

1. Intelligent and autonomous systems using artificial intelligence and machine learning (AI and ML)
2. Real time data and ultra reliable connectivity through advanced networks such as 5G and IoT
3. Advanced human machine interfaces and content through virtual, augmented, mixed reality, haptics, LED screens and games engines
4. Trusted multi-owner systems and smart contracts through distributed ledger technologies such as blockchain

These four digital technology groups are important in their own right, but even more so in their combination into complex cyber physical systems. These include digital twins, the metaverse and robotic and autonomous machines.

It is the convergence of these technologies that offers sector wide transformations at a scale that is unimaginable through current digital infrastructure, systems and applications.

The dawn of cyber physical technologies

To benefit from advanced digital technology adoption at scale across the economy and society, there is a need to consider how they work together as part of a complex cyber physical system and interconnected systems.

An example of a complex cyber physical system could be the use of physical environment data through devices such as the IoT (for example, sensors attached to a bit of machinery) connected via advanced networks such as 5G. This data can then be intelligently analysed and actioned often in real time. Through AI, shared and assured through DLT, it can enable autonomous robotic systems and new human machine interfaces through augmented, mixed reality or haptics.

Over the next three, five and ten years, the world will begin to see the benefits of the convergence of these technologies. It will bring the physical and digital world closer together in application areas such as; digital collaboration, design, operations, planning and consumer facing products and services — to name just a few. This could include an exact digital replica of a physical environment or thing, in the form of digital twins; a new extension of the world wide web in the form of the metaverse; or underpin and create the backbone for autonomous cars, robots and machines.

Through research, interviews and discussions with experts across industries, innovative startups and corporates — the Digital Future Index 2021 has identified three key trends for 2021–2022, as detailed on the next pages:

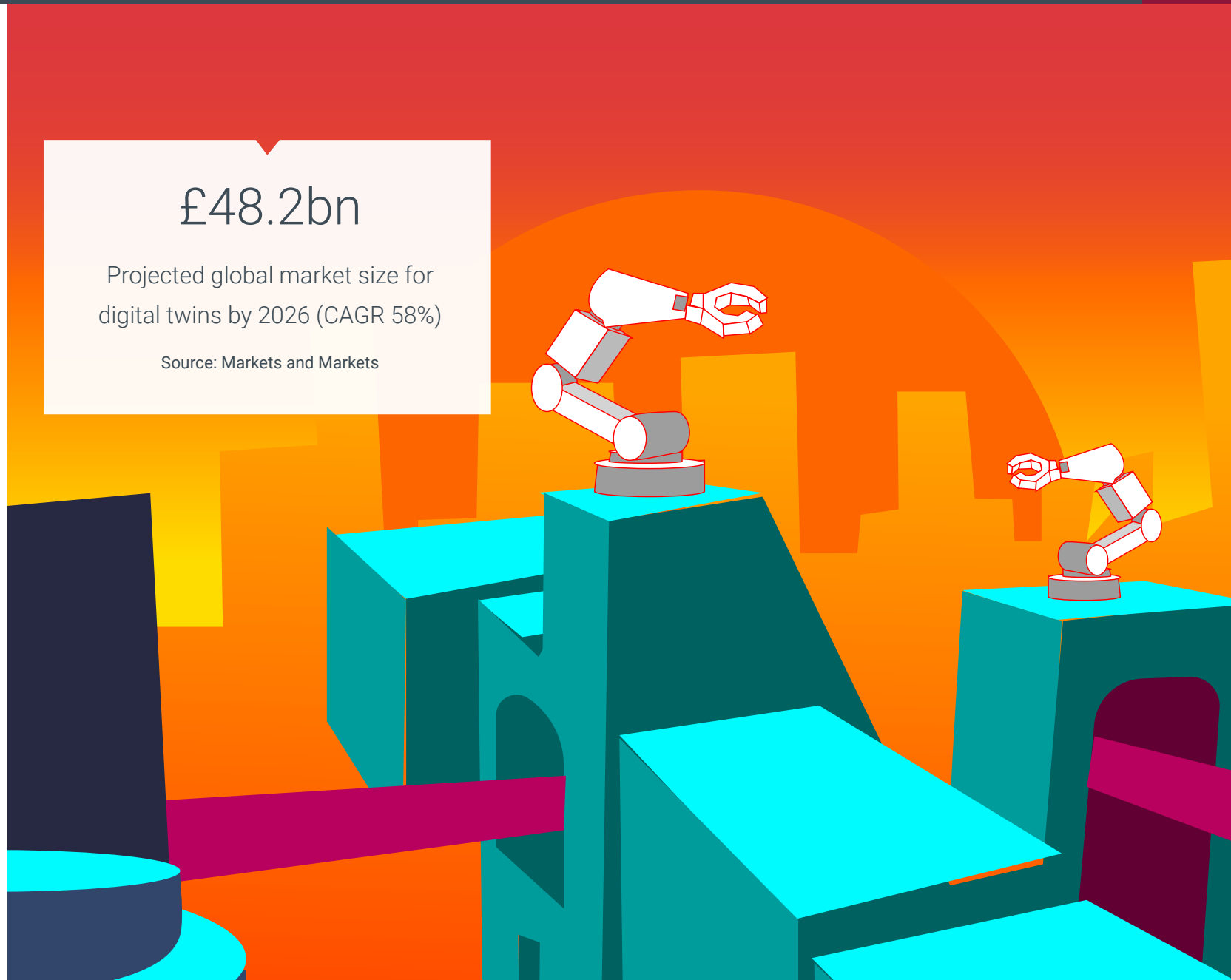
- **The journey towards digital twins**
- **The rise of the metaverse**
- **Remote and autonomous machines**

The impact of these technology trends are through new business models, new innovative use cases and applications. They do not exist in isolation, they exist in the context of economic recovery, resilience and growth, along with societal and sustainability impact goals.

Trend 1: The journey towards digital twins

Utilising a range of advanced digital technologies, a digital twin is a real time digital representation of a physical asset or process, that can be linked together by a live two way data model. These digital twins could be connected so that they can work together, utilising common digital and physical infrastructure including networks, tools, standards and platforms.

Connected digital twins will have an enabling effect on building resilience. They will allow companies, countries, global supply chains and sectors to manage risk, disruption, net zero goals and shocks such as the pandemic, more easily in the future. While more nascent, we are starting to see the foundations of digital twin applications across a range of areas. This could include interoperability between nodes of a supply chain, or advanced digital technology enabled data analytics and transparency.



Trend 1: The journey towards digital twins

Mark Enzer, OBE

CTO, Mott MacDonald

Head of UK National Digital Twin Programme, Centre for Digital Built Britain

Why are digital twins critical for the UK?

"The projected compound annual growth rate (CAGR) for the digital twin market clearly indicates that digital twins are taking off and that the market is not waiting for external stimulus. However, unless we address interoperability as a matter of urgency, the explosive growth of the market for isolated digital twins could be to the detriment of federating digital twins and integrating cyber physical infrastructure (CPI). Without interoperability, bespoke point-to-point data connections between digital twins will build friction into the system that will be hard to remove later. It's a potential market failure that is easy to spot, and the remedy of shared information management standards is similarly clear, but it will take concerted boundary-spanning leadership at government level to address it.

Within the built environment, the UK's Digital Twin Hub (DT Hub) has been a huge success. With more than two thousand individual members and more than one thousand separate organisations represented, the DT Hub is a vibrant community that concentrates the market leaders in a highly accessible platform. The community includes an array of suppliers that are delivering exciting products and services into the market. On the demand side, the most progressive owners and operators in sectors, such as energy, transport, water and telecoms, are starting to emerge as the key drivers of adoption in the built environment.

More than being a technology, connected digital twins are a means of integrating technologies to achieve a defined purpose — making better decisions faster. It's this integration of technologies in the service of 'information flow' that holds the promise: from the use of sensor technology, 5G and IoT to get data from the physical world into digital twins; through semantic solutions to integrate data from multiple sources and enable the federation of digital twins; through the use of modelling technology, AI and ML to generate insight and provide decision support; to immersive visualisation tools such as AR, VR and MR to facilitate human and digital twin interaction. All this is hugely exciting and has enormous potential value, but technical solutions alone will not be sufficient.

The development and adoption of cyber physical infrastructure requires socio-technical change on an industrial scale. Put simply: our complex physical infrastructure systems are massively interconnected, but our organisations operate in silos.

Therefore, we will need significant behavioural and cultural change to enable the low-friction information flow across organisational boundaries that cyber physical infrastructure requires. Nevertheless, the pandemic has demonstrated that rapid behavioural change is possible, especially in the huge pivot toward digitalisation, so it can be done."

Trend 1: The journey towards digital twins

Nathan Brown
Senior Policy Advisor,
CBI

What are UK businesses seeing in terms of the biggest trends for advanced digitalisation?

"The biggest trends the CBI has seen for 2021 have been around advanced AI and IoT systems. 40% of survey respondents to the CBI last year had already invested in AI technologies, with 31% planning to invest within the next five years. This demonstrates what we're seeing both anecdotally and from data, that there is significantly increased interest in, and that people see the transformative potential that it could have for their operations moving forward.

The biggest opportunity in supply chains is that of efficiency and transparency. CBI manufacturing members are keen to ensure that businesses throughout their supply chains can speak with confidence, knowledge and resources that help improve efficiency.

This is closely linked with sustainability and net zero goals. By ensuring these businesses have digital receipts and the ability to better track assets utilising technologies such as IoT, AI and blockchain, companies can track the origin and destination of products and components. This benefits both their efficiency needs and environmental interests."

Dame Wendy Hall
DBE, FRS, FREng
Regius Professor of Computer Science, Executive Director, Web Science Institute
University of Southampton

Why is cyber physical infrastructure vital to the UK?

"Driving the development of a digital twin ecosystem will require a coalition of the willing. Establishing interoperability standards will be essential for this as it was for the development of the world wide web.

Once standards have been established, everyone can work together to create interoperable cyber physical systems. I liken this time to where we were with the world wide web when it started, which is incredibly exciting.

Additionally, people often forget that a digital twin ecosystem is a socio-technical concept. Real-time data from people and organisations are essential to understanding how the physical and digital environments will come together. This will enable the evolution from small single digital twins to an all-encompassing digital fabric."

Trend 1: The journey towards digital twins

Anam Rahman
CEO,
Kavida AI

Digital twins and supply chain resilience

"The pandemic has shown the inherent vulnerabilities in global supply chains and the inadequacies of existing supply chain risk management. The external environment is changing too quickly for companies to use historical service level data as their sole supplier risk metric. Companies must take a holistic view of supply chain risk, down to the purchase order level.

Resiliency is a journey. Companies cannot change their supply chains overnight. In the immediate short term, resiliency means minimising response time to disruption threats, quantifying the impact of threats and getting full visibility over risk exposure. In the medium term, resiliency must be factored into operational decisions to optimise supply chains for both cost minimisation and resiliency maximisation such as, supplier selection and facility locations.

In the long term, companies are examining how to redesign their entire supply chain to reinforce their top line positioning, while optimising for trade offs. For example, if sustainability is your differentiator, how do you build a supply chain which optimises for cost minimisation, resiliency maximisation and carbon minimisation? There are complicated trade offs to manage. Our digital twins use data and simulations to answer these questions. Companies will be able to build, test and simulate their new supply chain on a digital version first before implementing in real life."

Professor Alan Norbury
Chief Technologist,
Siemens

Digital twins for Industry 4.0

"Industry 4.0 will involve the technical integration of cyber physical systems into manufacturing and logistics and the use of the IoT and services in industrial processes. This will have implications for value creation, business models, downstream services and work organisation.

Siemens believes Industry 4.0 will be key to integrating product and production life cycles. But users today can already benefit from foundation technologies such as industrial networks, sensors and software tools that enable the digital manufacturing enterprise. In the UK, Siemens adopted digital twins solutions (including its 3D cave) to optimise the factory environment: in the virtual environment, things can be tried out a number of times before being applied to the physical environment. This was particularly useful for the ventilator challenge: a consortium of UK industrial, technology and engineering businesses from across the aerospace, automotive and medical sectors set up to produce medical ventilators at the start of the COVID-19 crisis.

The pandemic highlighted that to make supply chains more autonomous and resilient, companies cannot rely on a single organisation for each component of the chain. Siemens is working to optimise its supply chain globally, and the UK needs to build its domestic capability and reduce its reliance on overseas production."

Trend 1: The journey towards digital twins

Professor Rab Scott
Chief Technology Officer, Advanced Manufacturing Research Centre, High Value Manufacturing Catapult

Jonathan Eyre
Technical Lead for Digital Twins and Advanced Visualisation, Advanced Manufacturing Research Centre, High Value Manufacturing Catapult

Digital twins for remote monitoring and optimisation in manufacturing

"The potential value that digital twins offers for manufacturing is huge. This comes from the impact on productivity that having digital twins of equipment and processes could offer with the ability to continually monitor and optimise the processes. But it also comes from the potential reduction in time to market of next generation products based on the insight derived from those out in service at the moment. The monitoring aspect alone, both from within a facility as well as remotely, delivers real-time actionable insights such as those generated by deploying supervisory digital twins.

Organisations have reported "improvement in workforce effectiveness by 25%, increased asset availability by up to 15% and reduced maintenance and inspection costs by 50%". (Industry 4.0 Demands a New Approach to Asset Management — September 2020). The ability to remotely improve or change performance through interactive digital twins has enabled social distancing to a level that wouldn't have been possible before the acceleration of many companies' digital transformation due to the pandemic.

The capability to plan maintenance proactively through predictive tools and to schedule downtime or replacements has enabled shorter site visits and thus reduced exposure to potential risk. These impacts are just the tip of the iceberg and the impact of digital twins in manufacturing will only increase going forwards."

Trend 2: The rise of the metaverse

As virtual, augmented, mixed reality and haptics grow in maturity, they are combining with advanced networks such as 5G and AI for spatial computing. As a consequence, we are beginning to see growing terms such as the metaverse or AR cloud becoming the biggest trend of the next decade — creating a new cyber physical internet. Rather than just fingers on screens, people will interact with data, information and content as it is layered over the physical world, making it digitally interactive and immersive.

This may be visual through headsets or mobile devices, but could also be built around spatial audio. It is the successor to the mobile internet, with many technology companies exploring and developing business capabilities in this space. This includes experimenting with what experiences work best, such as digital events in the game Fortnite or entirely new metaverse related platforms. This is also being played out through new advanced digital technology enabled content and media, such as combining LED screens, games engines and other deep technologies to create new approaches in entertainment through virtual production. It is also being explored for new business models that enable remote collaboration, training and operations.

£143bn

Projected global market size for spatial computing by 2026 (CAGR 41%)

Source: Zion Market Research

Trend 2: The rise of the metaverse

Roman Rappak
Co-Founder and CEO,
Overview Ark

What is the metaverse and why is it important?

"To steal the famous Gibson quote: "The metaverse is already here, it's just not very evenly distributed". The metaverse represents a paradigm shift in technologies that have shaped our world over the last 25 years. It could potentially shift the balance of power out of the hands of big tech firms and into the hands of creators. The metaverse could be a global, democratised open platform that will do more than simply change how we shop or go to school. It will shape the way we think about fundamental aspects of humanity, like value, physical space, property and reality itself.

The internet changed our perception of so many aspects of our lives in the space of the last 20 years — from money (Paypal) to music (Spotify), transport (Uber) to the hotel business (Airbnb) and the pandemic accelerated digital habits even further (Zoom and Clubhouse). However, these are just layers of tech replacing existing components within old structures. The metaverse represents all of these coming together, the crucial "interoperability" that is the switch that will change life forever — its not going to replace the internet, it will subsume it. We are at a transitional phase with technology, it's deeply fragmented, and we will look back on the chaos of different platforms, apps, devices and databases as a messy patchwork of awkward workarounds.

We jump between screens, use different platforms, apps, registering something in one database and waiting for a notification through an email. We have access to superhuman levels of information, can answer any question and witness events thousands of miles away, but we do all this through small screens encased in lumps of metal and plastic.

The irony is that more sophisticated tech will actually make us more human, that the metaverse, spatial computing, AR and gestural interfaces work so well because it is closer to our natural way of interacting with the world. Consequently, research into how quickly we learn in a 3D space, how our memory works when not looking at a screen or a page has shown incredible results, and something that is hugely valuable in an attention-based economy.

Our startup Overview Ark began building a 3D multiplayer virtual concert platform to help artists and venues bring their concerts to the metaverse, and even from the earliest events, the results were staggering. People formed profound relationships to the music, to the artists and with each other. They interacted in a much deeper way than if they had been watching a stream. These were real concerts, taking place in reality and in our platform. Fans formed friendships, memories, in one case buying a tshirt for their avatar and ordering a physical one to send to their home in the real world.

The metaverse is important because it is a link between artists, brands and institutions to the largest and most lucrative demographic in the world.

There are 2.8bn gamers already living in virtual worlds, but at the moment it is incredibly hard to connect your music, video, game or brand to them. This next phase in technology means that one of the 19.6bn hours gamers spend in virtual worlds might well be spent at your concert, or in your store. We believe that this has the potential to be the most powerful tool ever created, and it needs to be in the hands of artists and the talented people who work at labels and creative studios around the world."

Trend 2: The rise of the metaverse

Faisal Galaria
CEO,
Blippar

Why interoperability is key for the metaverse?

"At Blippar we've been building AR, one of the enabling pillars of the metaverse, since 2011. As such, we have been both a participant and had a ringside seat to observe the development of the metaverse, which in many ways still remains distant and some years away. However, in the past couple of years, the focus and pace of change has accelerated. Disparate ecosystems such as 5G, compatible hardware and the digital economy have started to coalesce, bringing the first manifestations of the metaverse tantalisingly within reach.

Perhaps the best way to imagine what this metaverse might look like is to look at the hugely successful game Fortnite which is played by over 350 million people (about four percent of the global population). While the number of players is in itself impressive, what is arguably even more impressive is the fact that it has allowed interoperability between hitherto competitors including iOS, Android, PC, Xbox and Nintendo. This allows seamless play traversing the different proprietary islands including payments, identity and social graphs. At Blippar we believe the world and the metaverse will be better with more creators — both bedroom developers and big agencies and brands. That's why we have developed no-code AR creation tools that non experts can use, as well as a platform for professional developers and creators to build and share AR experiences across platforms and devices."

Karl Woolley
Global Real-Time Director,
Framestore

Virtual production, driving growth for Framestore

"During the pandemic alone, Framestore's pre-production services team capacity increased from a handful, to over 100 people. Our team have been working on multiple TV shows and feature films making use of virtual production toolkits. This high level of growth has been catalysed by market conditions and virtual production's ability to effect a change in the way that the plethora of skilled filmmakers, such as DPs and Directors have been working traditionally for decades; a true paradigm shift.

LED walls and ICVFX have helped to improve acting performances, with actors and actresses being able to immerse themselves within a scene instead of standing in front of a green screen. This is just one highly visible benefit that LED wall ICVFX offers a production. Even as far back as 2011 when we pioneered this technique for Gravity, George Clooney and Sandra Bullock were able to perform more convincingly and in a shorter timeframe. We're now able to bring this benefit and a lot more to modern productions, such as 1899 — shot on the biggest LED volume in Europe."

Trend 2: The rise of the metaverse

Fiona Kilkelly
Head of Immersive,
StoryFutures Academy

Striking the balance of immersive technologies in the home

"Over the past year, we have found through surveys and engagements with immersive technology users and audiences that the space we use often determines what content virtual reality users engage with and the manner in which they will engage with it.

Our audience insights report indicated that 51% of immersive technology users were taking virtual tours during the pandemic. Home spaces became everything spaces, which brought to light the very real frictions of the consumption of content in the home, resulting in users feeling constrained in their space and the selection of less interactive content which did not require big movements and could be experienced in restricted conditions.

Whilst these indicate longer term challenges as we start to come out of lockdowns, alongside things like time being a key barrier to consumption of VR content, users have definitely indicated immersive technologies are here to stay, and will continue to value how immersive technologies can widen and can even shift perspectives on the real world, while opening up new ones."

Nancy Xu
Virtual Production Producer,
Epic Games

Virtual production before and after the pandemic

"During the pandemic it has been essential to use virtual production techniques to help get around travel restrictions. It allows for remote workers to collaborate together and reduces the stage crew size. For the post pandemic future, it will still be a more flexible way towards filmmaking, that lets you see the most complete image while shooting, so it's here to stay.

The pandemic made virtual production truly mainstream. This type of critical mass is what can drive the next important step — making the prices more affordable. When more stages are complete and up and running, and can amortise their costs across all of the productions booked to shoot there, that's the next milestone to allow more productions to use this method."

Ron Martin
Creative and Technical
Director, Unity

Why virtual production?

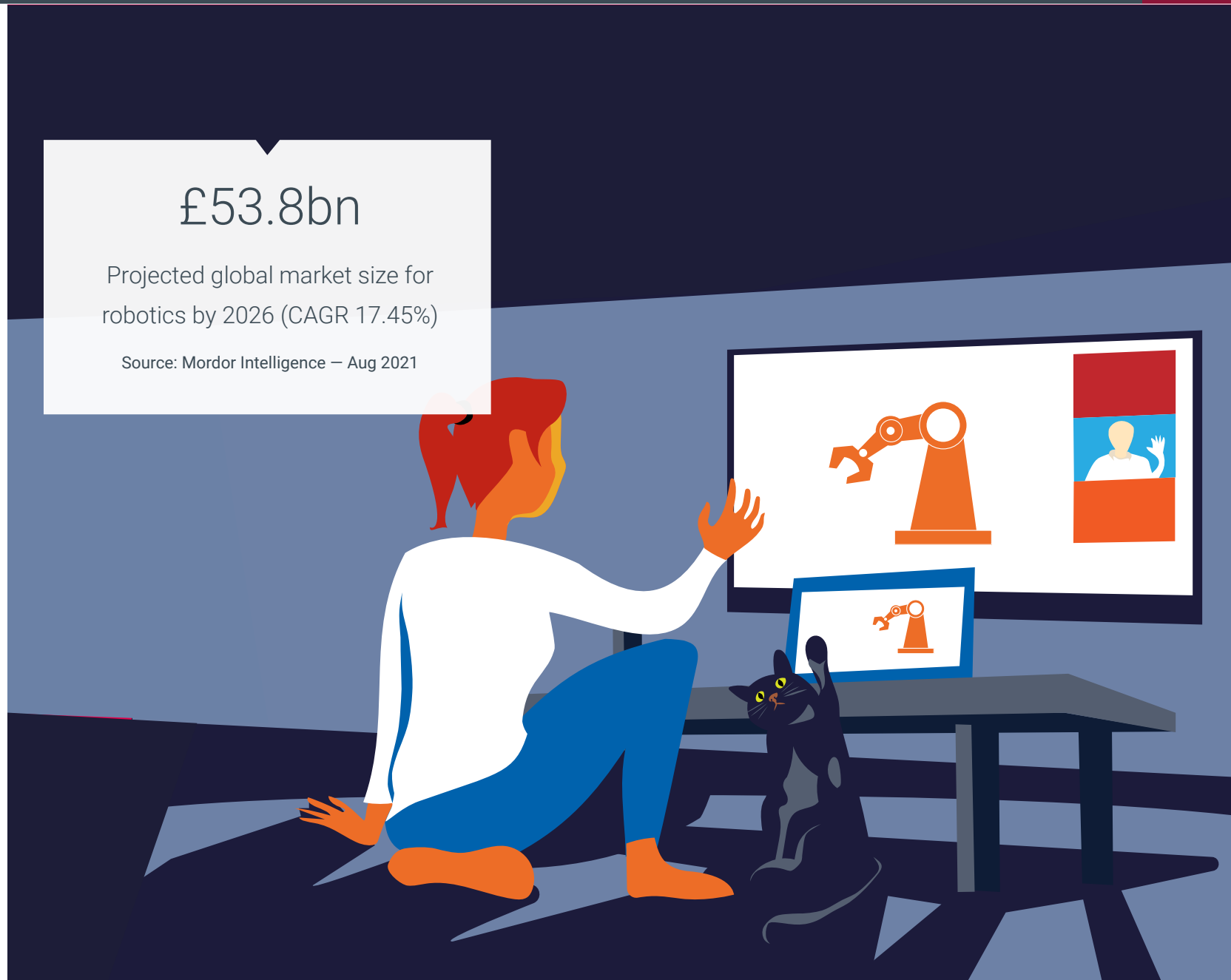
"Virtual production is changing the way stories are told. It is the most revolutionary advancement in technology since digital cameras. Being able to create a story prior to building sets, casting, costumes, or even location scouting, is a tremendous advantage. It doesn't replace those aspects, but it creates sustainability."

Trend 3: Remote and autonomous machines

As advanced networks, machine learning and new human machine interfaces such as haptic technologies and virtual reality converge — the value of robotics and autonomous machines is gathering pace. While the most well known example of this is autonomous vehicles, the pandemic has led to an increasing interest in advanced digital technology-enabled autonomous machines for other parts of the economy. This includes warehouses, waste management, construction, manufacturing and logistics.

With this increased demand comes a need for better accuracy, reliability and security for these machines — particularly if they are operated remotely.

Responsible adoption of these technologies in the context of the pandemic, climate change and national capabilities has heightened in 2021, as companies respond to changing global contexts, restrictions and business priorities.



Trend 3: Remote and autonomous machines

Charlie Alexander
Director of Product Strategy, Ultraleap

Haptics: Providing a touch-free advanced digital technology enabled world.

"The world is going through a paradigm shift in how people want to interact with the world around them. This became more evident during the pandemic as people became hesitant to touch public touchscreens and interfaces. This is likely to be a lasting effect. It has already driven a wave of innovation in industries that rely on touchscreens — quick-service restaurants, retail, ticketing kiosks — to the point where you no longer need to touch a surface to interact with the digital content.

Another key impact from the pandemic is the drive for remote working. Companies have been forced to embrace this, driving innovation in collaborative tools particularly in the VR and AR space. Natural controllerless interaction will be essential for this area going forward to allow for mass adoption — you're not going to want to walk around with controllers in your pocket in 2050! We foresee that in five years' time, buttons and touchscreens will be seen as old school tech. Hand tracking will be the interaction method of choice and our own integration into the Qualcomm Snapdragon XR2 platform is one of the things that will support and drive this change. In other areas, mid-air haptics will be enabling immersive interactions without the need for gloves or controllers, and become a key differentiator for automotive brands that want intuitive mid-air or gesture-based infotainment controls."

Fiacre O'Donnell
Director of Sustainability, Encirc

Advanced digital technologies for remote operations in hazardous environments.

"Encirc is continually striving to reduce the carbon footprint of glass bottle making, an extremely challenging undertaking for a company in an energy-intensive industry. To catalyse this process, Encirc set a challenge to pack 100% of the bottles made, something that would require some innovative thinking. One of the initial steps was the deployment of swabbing robots. Their role is to coat the bottle-making moulds with oil to prevent the glass from sticking to them. These robots provided consistency and repeatability, which improves output and releases the operators from repetitive, dangerous activity.

To further improve operator safety, VR headsets were introduced for hot end training. This facilitated the training of both new and existing operators in the running of hot end machines, the identification and rectification of defects and an ongoing refresher in safety procedures.

Now, we are starting to run a new project looking at the end-to-end technologies in glass manufacturing. This project will gather and analyse data to initially solve issues in real-time, with a future step of predictive analysis all contributing to the 100% objective. Looking to the future, Encirc is exploring the use of QR codes and blockchain technology, supporting customer demand, consumer interaction, brand loyalty and safety and the circular economy; making glass the smarter choice."

Trend 3: Remote and autonomous machines

Ambarish Mitra
Co-Founder,
Greyparrot

Waste, sustainability, efficiency and advanced digital tech

"Greyparrot is committed to tackling the mounting waste crisis by unlocking the financial value of waste to support our transition to a circular economy, where waste is recycled and reused in the most effective way. Greyparrot is automating an industry that is heavily relying on manual processes. Currently, there is little to no visibility on waste composition at each stage of the waste flow. This makes it impossible for waste managers at material recovery facilities (MRF) and packaged-goods producers to take informed actions on optimising processes to increase recycling rates.

This is why Greyparrot is using cutting edge AI waste recognition software deployed globally on moving conveyor belts in sorting facilities. It automates waste composition analysis to monitor, audit, and sort large waste flows at scale. Our solution provides waste analytics and new insights previously unavailable to waste managers, producers, and regulators. As a result, it increases recovery rates, reduces the cost of manual sampling, enhances product quality, and informs on the waste being generated end-to-end.

In 2020 we raised $3.5m seed investment and $650k government funding to support our product development efforts. We deployed our unit in over ten facilities through commercial pilots, focusing mainly on MRF and automated-sorting machinery suppliers, for example, robotics. This enables them to monitor in real-time 100% of waste flows and provide instant live-data down to granular composition information at product, material, and brand level, with more than 95% accuracy.

This allowed us to develop a commercial product that is able to scale to hundreds of facilities around the world later this year."

Trend 3: Remote and autonomous machines

Sophie Maxwell
Executive Director,
Connected Conservation
Foundation

Using advanced digital technologies in conservation for remote monitoring

Connected Conservation, supported by NTT and Cisco, is responsible for tackling poaching, providing education and creating employment through technology to help with wildlife conservation. Protected areas for conservation are vast, and it is impossible to provide connectivity to a whole reserve. As wildlife moves and poaching hotspots change, it is important to stay one step ahead.

To do this effectively we use various connected sensors, such as thermal cameras, to monitor wildlife, security threats and environmental indicators. We have developed a partnership with Axxis, which is providing subsidised cameras with capabilities to see up to two kilometres away and detect animals or people via heat signatures. This is particularly useful for looking at fence lines, borders and watering holes. People in the operations room receive that data in real-time and decide how to respond accordingly. These cameras are able to pan, tilt, zoom and move around freely and are coupled with AI, which can detect intention-behaviour to show the different signs of movement of a poacher or an elephant, and can raise an alarm - this is referred to as "object of interest detection". We have also recently agreed a five year partnership with Airbus Foundation and Microsoft to couple high-res satellite imagery with cutting edge AI and on-the-ground technology to strengthen the protection of wildlife and ecosystems across remote areas, uniting technology partners to help conservationists manage the natural systems that bring benefits to wildlife, people and our climate."

Chris White
Electrification and Global
Engineering Alignment Manager,
Ford Europe

Ford: Working with immersive tools for remote operations

"During the first few months of the pandemic, Ford participated in the ventilator challenge in the UK, scaling up the capabilities of a partner from eight ventilators a week to 80 ventilators a day through the use of international support. Restrictions on travel and the significant test requirement for medical equipment highlighted the need for technological tools that could allow remote training, testing and monitoring.

Using augmented reality equipment such as Hololens enabled us to do this on a greater scale, transforming the capability of being able to do remote sessions with engineers globally, whilst using 5G connectivity. As we increased the number of headsets being used in the company, we had continuous internal training for employees on how to set it up, how to run a meeting with it and other relevant information to enable a smooth integration into daily operations.

The integration of these technologies enables and improves remote working, particularly whilst integrating new methods of connectivity like 5G. This will allow manufacturers to understand supply chains better, know the exact locations of specific operations and the impact it will have in the future."

An advanced digital technology future

Advanced digital infrastructure

- 5G and advanced networks
- Artificial intelligence and machine learning
- Internet of things
- Distributed ledger technologies

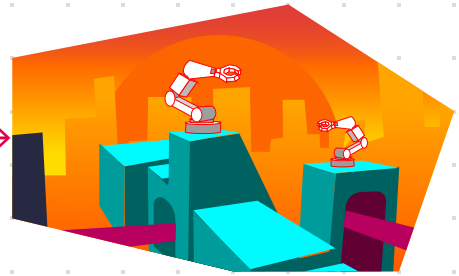
Advanced human machine interfaces

- Immersive technology (for example, AR or VR)
- Robotics and cobotics
- Haptics

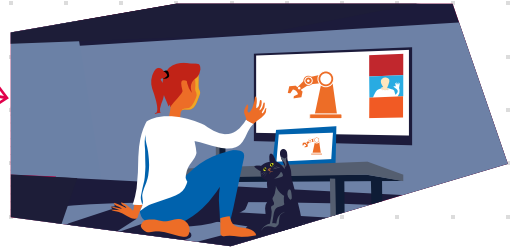
Applications

Metaverse

Digital twins



Remote and autonomous machines



The application of advanced digital technologies

Advanced digital technologies will drive a market worth hundreds of billions of pounds. Competition will be felt globally, transforming businesses, economies and societies.

This will span everything from localised and personalised manufacturing facilities, intelligent and transparent supply chains, smart cities, next-generation services, innovative healthcare, immersive entertainment, new methods of content distribution and beyond.

The UK will need to consider the geographical and sector distribution, scale, investment and underpinning infrastructure for advanced digital technology solutions. To be successful in a global race towards advanced digitalisation, countries will require out of the box strategic interventions, an openness to sharing and a cultural shift towards working with smaller innovative companies. The index data included in the following pages gives a sense of the direction and momentum for the UK in these areas. Further strategic consideration is required around how best to ensure the UK benefits from advanced digital technology innovation across sectors and regions.

Backdrop of a new world driven by pandemic recovery and the race to net zero.

In tandem with the growing interest and innovations taking place that use these technologies, there are also significant macro trends emerging that provide lenses through which these technologies will solve global challenges. This includes a growing and significant interest in how these technologies can be developed and applied in ways that tackle:

1. **The climate emergency**
   The world has seen an increased urgency to tackle challenges associated climate change, alongside businesses and governments working towards net zero emission targets

2. **The pandemic**
   As we move into a new normal and learn to live with requirements around safety and social distancing, remote working and travel restrictions, the pandemic has become a critical driver for advanced digitalisation

3. **Digital geopolitics**
   Including the balance of digital capabilities and influence between the US and China, alongside a gradual de-linking of the global supply chain and a rise in digital nationalism, to establish greater resilience through national and local capabilities

These drivers are stimulating an increased interest in these technologies, targeted at these macro challenges through system approaches, across supply chains, to tackle remote working challenges, social distancing and travel restrictions, and to help companies on the journey towards net zero.

Data and insights

Philip Young
Director for Policy, Research and Strategic Engagement, Digital Catapult

UK barriers and opportunities for advanced digitalisation

What the data says for the UK

The UK is in a position of strength for advanced digital technologies, sitting at third in the world in our Digital Future Index for 2021-2022, behind the US (1st) and China (2nd). This is largely due to our startup and innovation ecosystem that spans AI, IoT, blockchain, DLT and immersive technologies, and has strength in numbers that ensures we can remain globally competitive. We are leading in Europe, and have the second highest number of companies working with advanced digital technologies in the world, behind only the US.

London drives the supply-side business capabilities in the UK for these technologies, with an average of 63.6% of advanced digital technology companies being based in the capital. From Digital Catapult's perspective, the UK should look to leverage this startup ecosystem into industrial sectors, such as manufacturing and supply chains that underpin the UK economy. As the data indicates, these sectors are currently underserved by the existing focus of advanced digital technology companies.

Collaborative research and development, applied research, pilots and prototypes are important in stimulating technology supply-side interest across a wide range of industry sectors. This is particularly true where there are barriers to working together, such as culture, ready capital and understanding of the return on investment.

Innovation programmes can also help to encourage advanced digital technology startups and scaleups to pivot their products and services into new sectors and new markets. The UK can build for the future if it pinpoints capability gaps at the intersection where technology supply meets demand. This will drive economic growth, create new exportable products and services and help to achieve both industrial net zero and levelling up goals for our regions. The UK is not just a specialist in one area. Our strengths are across multiple technologies and their application. Our global position in immersive technologies, spatial computing and future complex cyber physical systems relies on our ability to leverage the strengths of the UK's small innovative startup companies.

This means helping them to scale and supporting them in applying their solutions in the areas of most economic need for the UK. The UK will also benefit by establishing and further investing into national capabilities for cyber physical infrastructure, which can leverage our growing momentum in 5G and advanced networks, our leadership in AI and our broader software engineering skills.

If we can do this while considering the interoperability and openness between systems and platforms, and integration of these technologies, we have the potential to become a real powerhouse in this space. The data indicates that the UK is on the right path, with recognised academic and innovation excellence when compared to the rest of the world — but it also suggests more can be done to leverage our strengths to the benefit of the wider UK economy, and help our most exciting innovative companies to grow.

Digital Future Index: Overall

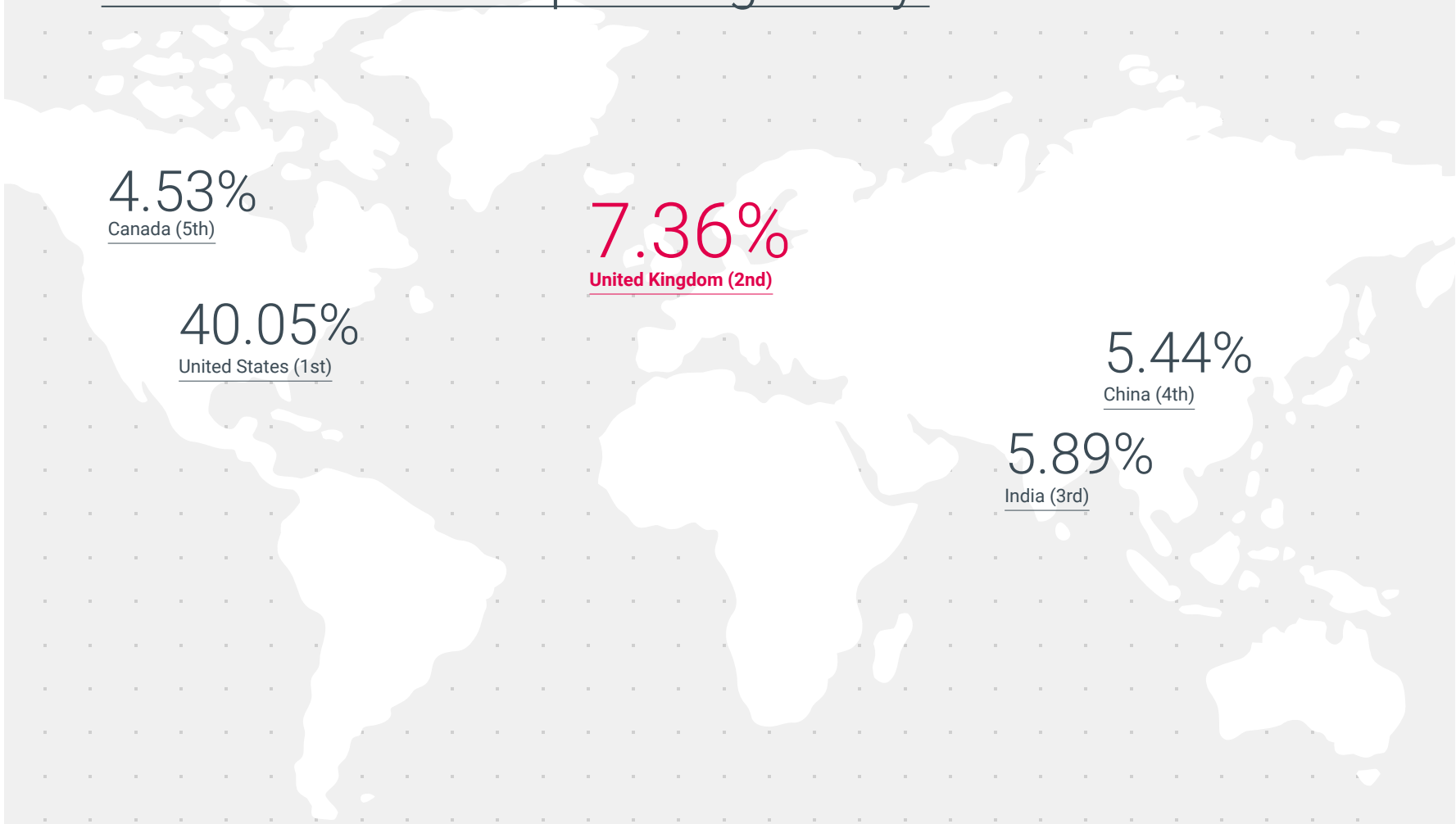
Country	AI	Immersive	Blockchain	IoT	Infrastructure	Weighted total score	Total ranking
United States	16.5	11.0	11.5	16.2	2.5	33.2	1
China	9.1	6.4	5.9	8.4	3.5	14.4	2
United Kingdom	**6.4**	**4.8**	**5.2**	**6.8**	**2.0**	**10.5**	**3**
South Korea	5.7	5.2	5.4	5.7	2.6	8.3	4
Japan	4.6	4.1	4.1	6.7	2.1	8.2	5
Israel	5.7	4.4	4.4	5.2	1.8	7.6	6
Canada	5.2	4.2	4.8	4.8	2.0	7.2	7
Germany	5.1	4.5	4.7	5.3	2.0	7.0	8
Australia	4.5	4.6	4.4	4.4	2.1	6.6	9
Singapore	4.8	3.9	4.6	4.4	2.3	6.52	10
Switzerland	4.8	4.3	4.4	4.6	2.1	6.4	11
France	4.6	3.9	4.1	4.6	1.9	5.9	12
Netherlands	4.6	4.2	4.4	4.6	2.1	5.7	13
Finland	4.1	3.8	3.8	4.7	2.0	5.7	14
India	3.5	2.6	2.8	3.5	1.5	5.3	15
Norway	4.0	3.6	3.7	4.3	2.1	5.1	16
Sweden	4.4	4.1	4.1	4.1	2.0	5.1	17
Denmark	4.3	4.0	4.0	4.1	2.1	5.0	18
Austria	3.9	3.6	3.9	4.0	1.9	4.7	19
Belgium	4.0	3.6	3.8	3.9	1.8	4.7	20
Spain	3.7	3.3	4.0	3.6	1.8	4.6	21
Estonia	3.6	3.0	3.2	3.3	1.9	4.4	22
Ireland	3.7	3.2	3.4	3.5	1.9	4.3	23
Italy	3.6	3.3	3.5	3.5	1.8	4.2	24
New Zealand	3.4	3.3	3.4	3.3	1.9	4.0	25
United Arab Emirates	3.4	3.0	3.2	3.1	2.4	3.9	26
Poland	3.2	3.0	3.2	3.2	1.8	3.8	27
Taiwan	2.9	2.9	2.9	2.8	1.9	3.8	28
Portugal	3.2	3.0	3.1	3.2	1.7	3.7	29
Brazil	2.9	2.6	2.8	3.0	1.7	3.6	30

Artificial intelligence

Total ranking:

1. United States (16.5)
2. China (9.1)
3. **United Kingdom (6.4)**
4. Israel (5.7)
5. South Korea (5.7)
6. Canada (5.2)
7. Germany (5.1)
8. Singapore (4.8)
9. Netherlands (4.6)
10. Japan (4.6)

% share of AI companies globally:



Artificial intelligence

AI companies total funding (since founded)	
United States	£71,275,424,980
China	£34,199,230,421
United Kingdom	**£7,191,208,778**
Israel	£3,518,616,483
Canada	£3,128,417,208
Japan	£2,454,630,363
Germany	£1,976,744,883
France	£1,760,761,868
Singapore	£1,212,220,223
India	£1,025,649,417

Average total funding per AI company	
China	£31,030,688
United States	£8,788,153
United Arab Emirates	£7,516,183
Taiwan	£4,867,693
United Kingdom	**£4,823,899**
Japan	£4,421,933
Israel	£4,385,121
Belgium	£3,539,902
Singapore	£3,501,677
Canada	£3,409,868

	% AI companies with estimated revenues $1m+ (per annum)	% AI companies with estimated revenues $10m+ (per annum)
United States	29.5%	6.3%
United Kingdom	**25.4%**	**3.3%**
Israel	19.3%	2.0%
China	11.3%	4.1%
South Korea	5.9%	1.5%

£225bn

Projected global AI market size by 2026 (CAGR 39.7%)

Source: Markets and Markets

£1.3bn

Investment into UK AI companies in 2020–2021

1,500+

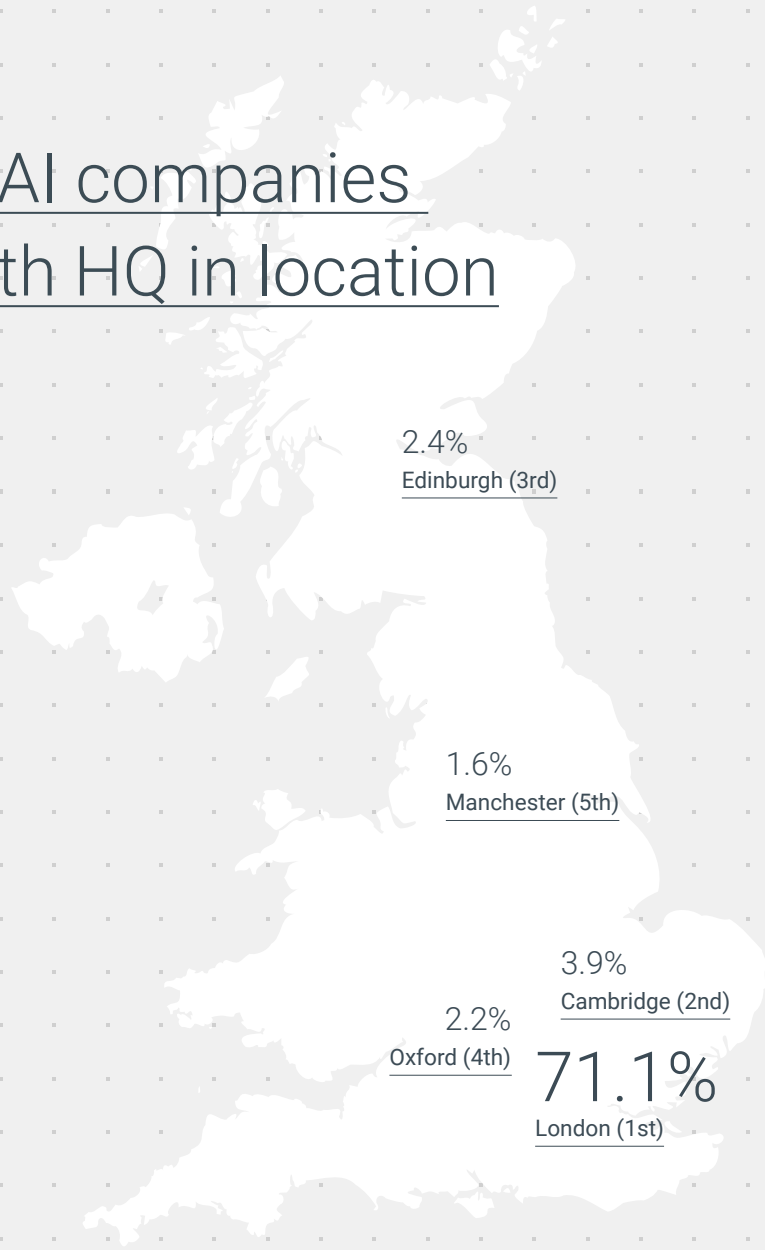
AI companies in the United Kingdom

Artificial intelligence

% of UK AI companies focused on sector

Manufacturing	3.7%
Transportation and supply chains	4.9%
Financial services	12.7%
Media and entertainment	7.7%
Healthcare	9.7%
Information technology	34.8%
Sales and marketing	8.5%
Commerce and shopping	7.1%
Professional services	11.9%
Education	7%
Community and lifestyle	1.9%
Advertising	3.4%

% AI companies with HQ in location



Spotlight 2021:
UK AI startups

Humain Studios

Kavida

Brarista

Bitfount

Climate X

Technology expert view:
Artificial intelligence

Dr Robert Elliott Smith
Head of Artificial Intelligence,
Digital Catapult

Artificial intelligence, explainability for complex cyber physical systems

Mark Twain purportedly said:
"History doesn't repeat itself,
but it rhymes."

In the mid-1970s, after many over-hyped promises, "The AI Winter" took hold. This decade-long period of AI's apparent deprecation did not mean that progress was abandoned. Instead, expert systems, the dominant form of AI at the time, were relabelled as decision support systems and such techniques continued to mature, eventually becoming vital but almost unnoticeable parts of mainstream computing.

Another AI Winter is unlikely, given the field's current momentum. However, with AI coming over the top of the hype curve, predictions of super-intelligent machines are likely to mature into a practical, mainstream AI that focuses on supporting people.

Several trends converge towards AI becoming more human-centric in the near-term future, including concerns over bias, privacy, and ethics, plus moves towards a net zero future. These coincidentally have similar technical implications for AI.

Today's massive deep learning ML models have done remarkable things. However, their intractability precludes human understanding, endangering their responsible and unbiased use. Their scale also makes their total environmental impact undesirable and impedes moving AI towards "the edge" of the computing ecosystem.

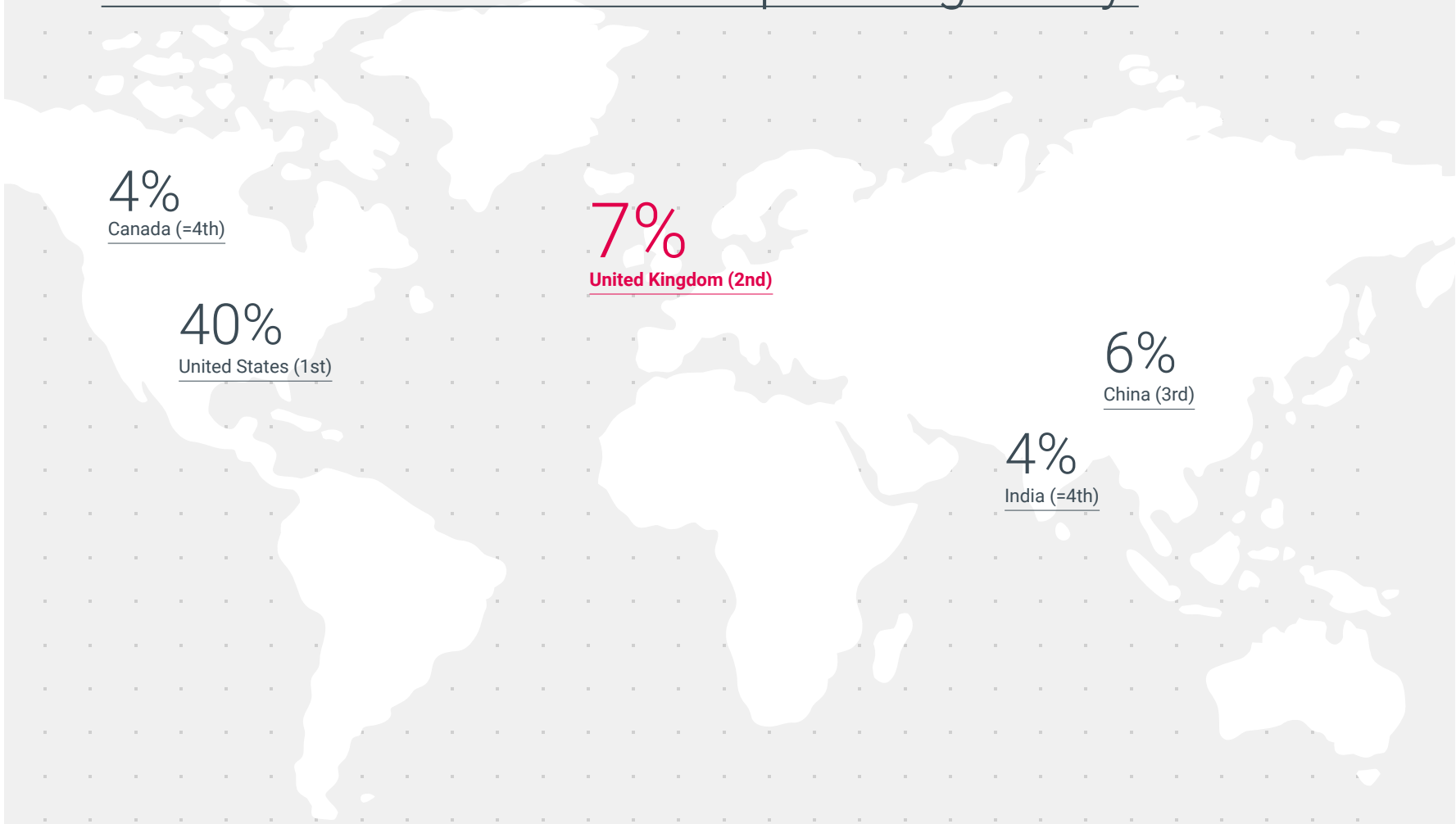
Edge computing is an essential cross-tech trend that will help preserve privacy by keeping data closer to the end-user. Likewise, digital twins are a cross-tech trend that will inform net zero computations and require edge computing and more economical models. Therefore, future trends include Explainable AI, Edge AI, and techniques that parse the complicated models that result from ML. In addition, after the pandemic made clear the importance of human work and interaction, developing better human-AI interaction will become a significant trend, including causal AI and advanced UI, UX and visualisation technologies. New tools may emerge in an AR-cloud metaverse to help reveal and clarify AI decision making in human workflows.

Immersive technologies

Total ranking:

1. United States (11.0)
2. China (6.4)
3. South Korea (5.2)
4. **United Kingdom (4.8)**
5. Australia (4.6)
6. Germany (4.5)
7. Israel (4.4)
8. Switzerland (4.3)
9. Canada (4.2)
10. Netherlands (4.2)

% share of immersive companies globally:



Immersive technologies

Immersive companies total funding (since founded)	
United States	£11,803,568,780
China	£1,573,564,517
United Kingdom	**£592,292,768**
Israel	£337,632,430
Switzerland	£329,449,339
Australia	£314,735,799
Japan	£248,390,821
Canada	£143,646,029
Sweden	£138,954,374
Finland	£94,459,552

Average total funding per immersive company	
Switzerland	£5,266,942
United States	£4,896,114
China	£4,521,698
Denmark	£3,094,371
Sweden	£2,459,494
Australia	£2,293,869
Israel	£2,003,960
Finland	£1,872,567
New Zealand	£1,720,706
Norway	£1,514,860
United Kingdom	**£1,391,129**

	% immersive companies with estimated revenues $1m+ (per annum)	% immersive companies with estimated revenues $10m+ (per annum)
United States	35.7%	12.5%
United Kingdom	**29.7%**	**6.1%**
Israel	16.8%	1.8%
China	10.3%	2%
South Korea	6.5%	1.2%

£91bn

Projected global extended reality market size by 2026 (CAGR 30.6%)

Source: Markets and Markets

1,000+

Immersive companies in the United Kingdom

£180m

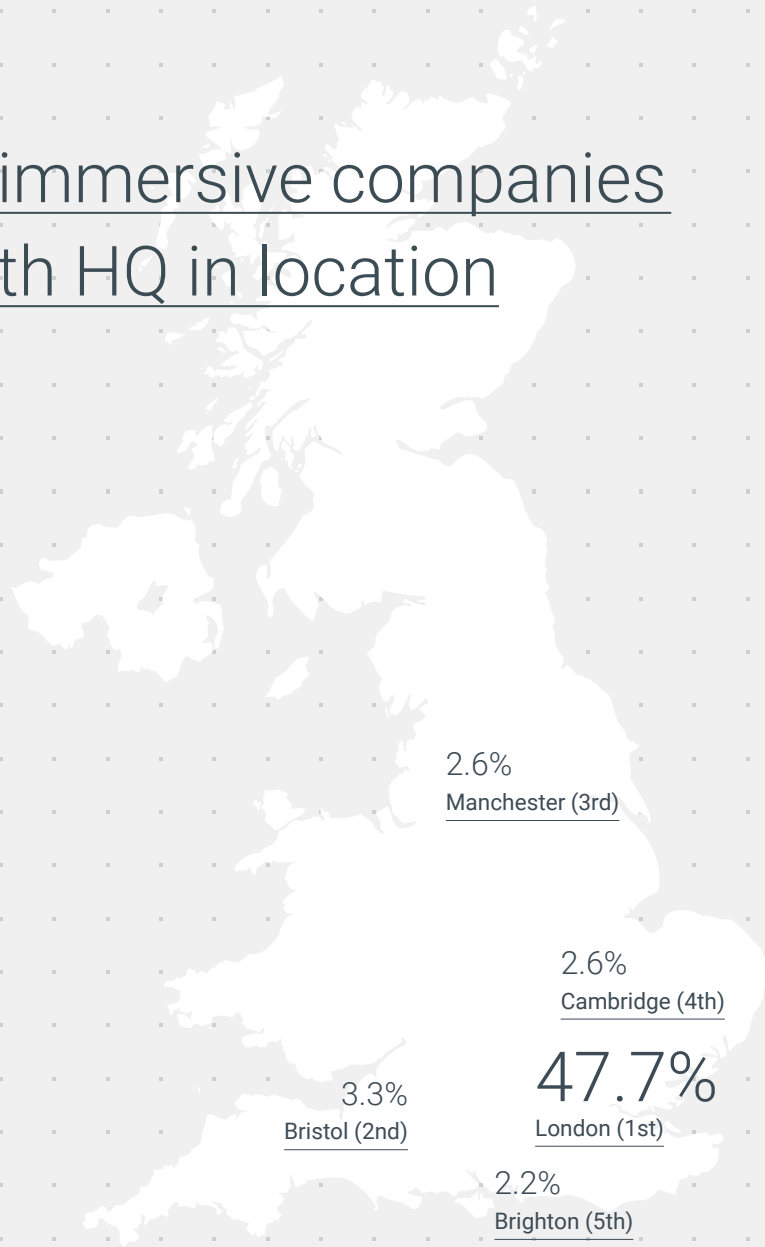
Investment in UK immersive companies in 2020–2021

Immersive technologies

% of UK immersive companies focused on sector

Manufacturing	7.7%
Transportation and supply chains	2.6%
Financial services	1.1%
Media and entertainment	25.7%
Healthcare	6.1%
Information technology	17.1%
Sales and marketing	13.6%
Commerce and shopping	5.4%
Professional services	3.7%
Education	7%
Community and lifestyle	3%
Advertising	8.8%

% immersive companies with HQ in location



Spotlight 2021:

UK immersive startups

Ultraleap

Universal Pixels

Blippar

Gravity Sketch

Beem

Technology expert view:
Immersive technologies

New human machine interfaces and content

Jessica Driscoll
Head of Immersive Technology,
Digital Catapult

The interest in immersive experiences has continued to grow, especially throughout the course of the pandemic, but it wasn't without stumbling blocks.

As VR necessitates human machine interfaces, the availability of hardware is an important part of the immersive puzzle. Immersive technology companies' biggest customers are not in the B2C millennial segment as many might have assumed. There has been a significant uptick in enterprise and manufacturing demand for a host of business and industrial uses.

Enterprise is still in the adoption phase, and these tools haven't been adopted at scale — yet. But there are a few trends that are already on their way to accelerate this adoption journey:

1. Hardware continues to get cheaper and deliver better user experiences, blurring the line between the physical and the virtual. We are also moving towards some controllerless interfaces, such as eye tracking, hand tracking and voice tracking.

2. Immersive platforms are enabling users to develop their own bespoke solutions at scale. For example, Immerse.io enables users to import or create content onto an immersive platform seamlessly, and integrate into an API system that is usable.

Looking forward at opportunities and trends for the next couple of years in immersive, we expect to see:

1. The creation of publishing tools for immersive applications — like Squarespace for websites, but for immersive content. This will significantly reduce the time it takes to get applications up and running and ready for sales.

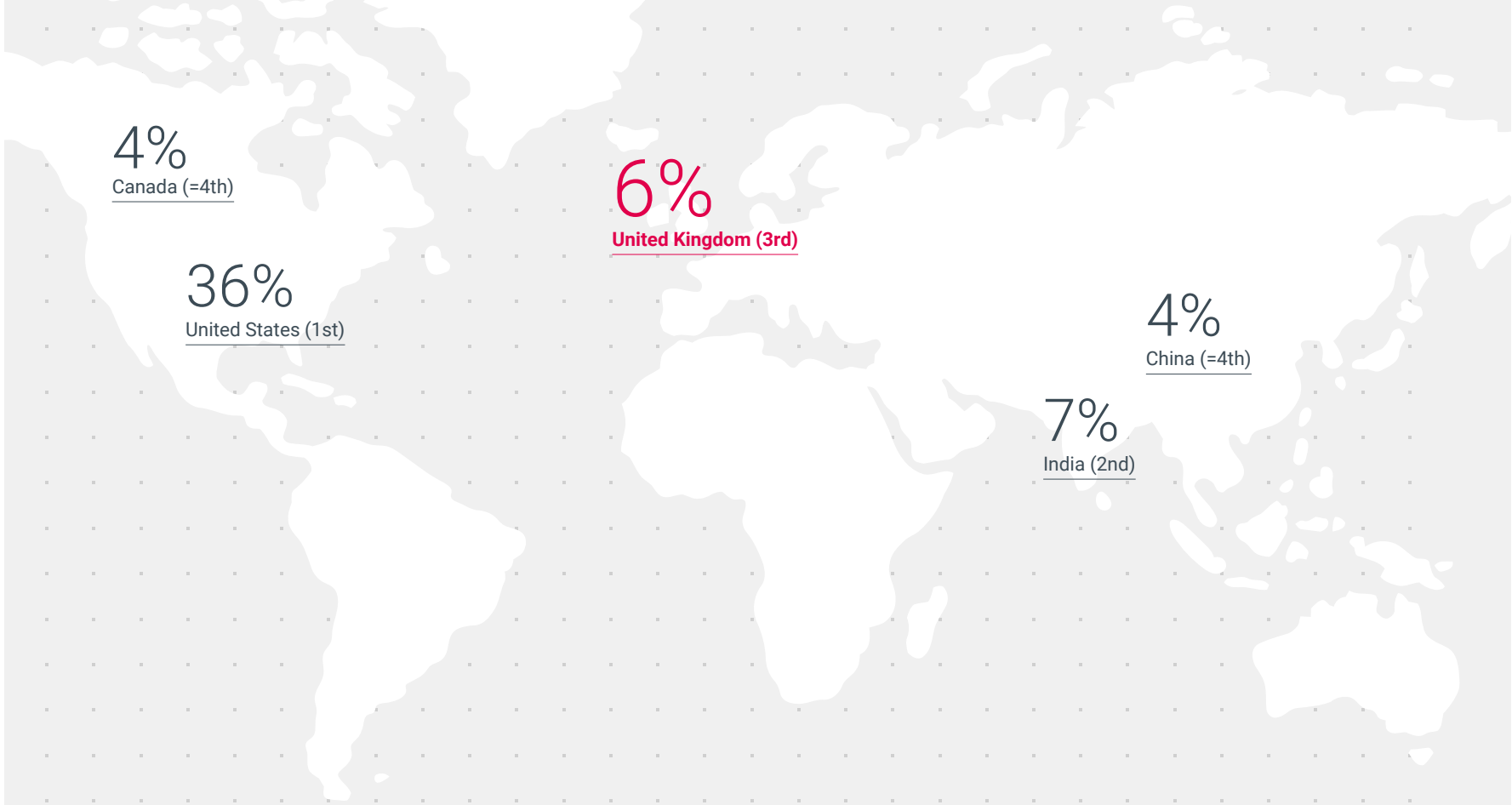
2. The journey to making VR as popular as Fortnite? One element of this is the social aspect of VR — if you can speak to people seamlessly over VR, with compelling voice application, this will reduce the barrier to entry for social applications in VR. This is starting to become a major priority for a number of companies, with the launch of Facebook's Metaverse applications the most recent example. We expect this will grow significantly over the next few years.

Internet of things technologies

Total ranking:

1. United States (16.2)
2. China (8.4)
3. **United Kingdom (6.8)**
5. Japan (6.7)
5. South Korea (5.7)
6. Germany (5.3)
7. Israel (5.2)
8. Canada (4.8)
9. Finland (4.7)
10. Netherlands (4.6)

% share of IoT companies globally:



Internet of things technologies

IoT companies total funding (since founded)	
United States	£15,658,715,622
China	£3,808,046,293
Japan	£2,416,214,573
United Kingdom	**£1,680,880,264**
Israel	£805,293,189
Finland	£790,697,712
France	£734,699,842
Germany	£636,071,326
Canada	£497,457,482
South Korea	£400,624,797

Average total funding per IoT company	
Finland	£9,005,108
China	£7,546,228
Norway	£5,054,868
Japan	£4,153,784
United States	£3,879,580
Malaysia	£3,243,689
Austria	£2,997,364
Switzerland	£2,717,686
Israel	£2,704,766
France	£2,647,128
United Kingdom	**£2,420,728**

	% IoT companies with estimated revenues $1m+ (per annum)	% IoT companies with estimated revenues $10m+ (per annum)
United States	35.4%	8.3%
United Kingdom	**27%**	**5.7%**
Israel	20.4%	2.7%
Japan	21.1%	6.6%
China	9.9%	4.3%

£947bn

Projected global IoT market size by 2026 (CAGR 27.6%)

Source: BCC

1,000+

IoT companies in the United Kingdom

£505m

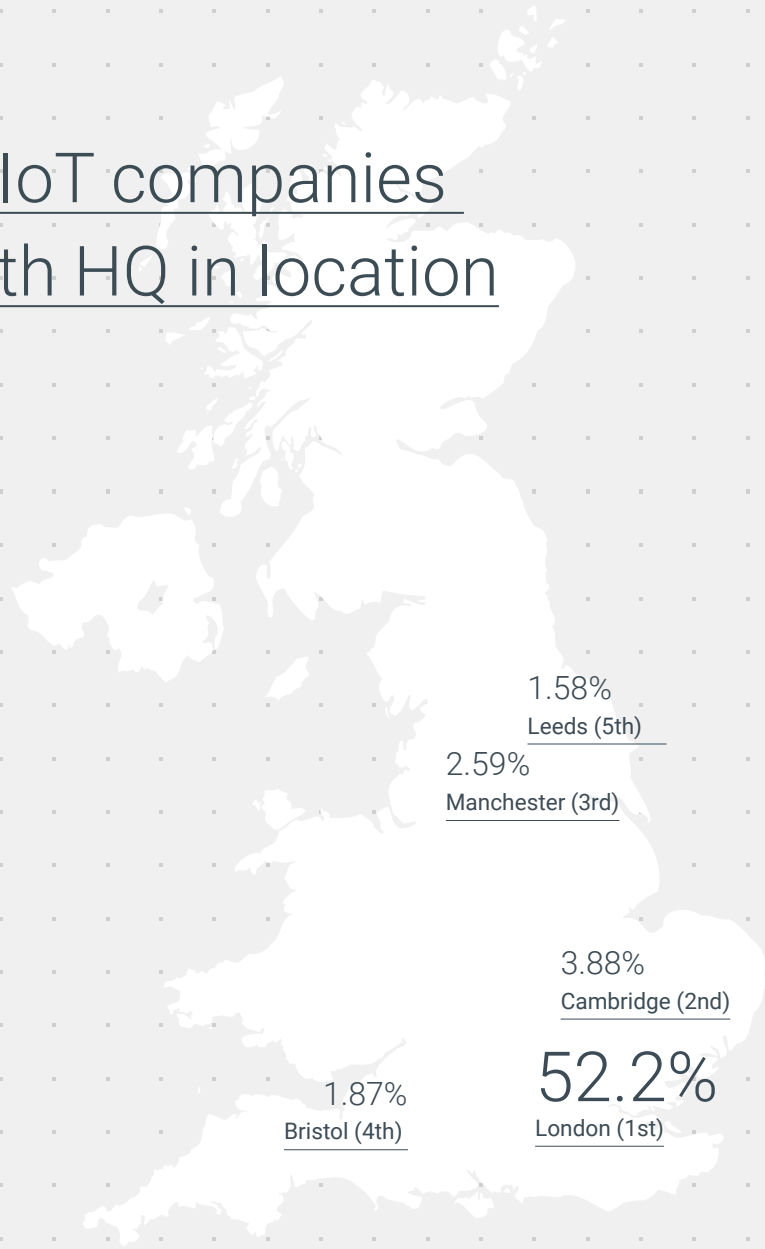
Investment in UK IoT companies in 2020–2021

Internet of things technologies

% of UK IoT companies focused on sector

Manufacturing	4.2%
Transportation and supply Chains	5.2%
Financial services	6.2%
Media and entertainment	12.6%
Healthcare	3.9%
Information technology	29%
Sales and marketing	12.1%
Commerce and shopping	9.9%
Professional services	7%
Education	2.7%
Community and lifestyle	5.3%
Advertising	8.3%

% IoT companies with HQ in location



Spotlight 2021:
UK IoT startups

Evrythng

See.Sense

IoT Solutions Group

Hark

Infogrid

Dr Munir Chowdhury
Head of IoT Technology,
Digital Catapult

Technology expert view:
Internet of things technologies

Internet of things as the backbone of new cyber physical system capabilities

What we recognise to be IoT is evolving. It is much more multidimensional and bigger than just about 'things', and involves how technologies, people and processes work together.

When we talk about IoT, it is usually thought about in the physical sense. But IoT has evolved into a broader business and cultural context it converges and infuses with other advanced and emerging technologies, such as AI or 5G. As this convergence matures, the question of where things like AI starts and IoT ends becomes less important, as the boundaries are blurred into areas such as edge devices and multi technology cyber physical systems. As a result, we are seeing players at the end of the chain trying to play upstream. Selling hardware is no longer as profitable as it used to be; it must have additional value through a system which enables data visualisation, interpretation and action.

From a business perspective, IoT is historically seen to be more experimental, where pilots have often not always gotten to the point of commercial maturity and scalability. But this must put into question if IoT was simply overhyped or misunderstood. Our belief is that it has been misunderstood, with businesses now looking at it from a different perspective. It's about structuring the business and culture; IoT is an essential part of the data requirements for businesses — it is an enabler rather than a driver.

More relevant and useful business use cases are being explored with regards to IoT. For example, IoT has been typically seen as a technology that lets you know where things are, or how well your things work. But we are now moving towards how IoT can enable wide scale operational efficiencies and remote management of businesses. Instead of, for example, sending a fleet of service engineers to check the functionality of equipment on a factory floor, we will begin to see the integration of IoT, wearables and immersive technologies. These will help engineers to manage maintenance from anywhere in the world — saving time and money, but also improving health and safety.

Finally, one of the biggest concerns for IoT has always been security. But as we move into the age of complex cyber physical systems, these concerns are becoming amplified. Especially as the number and location of devices, the types of connectivity and the sharing of data becomes more diverse (particularly if we are working from home more), with multiple points of failure rather than one.

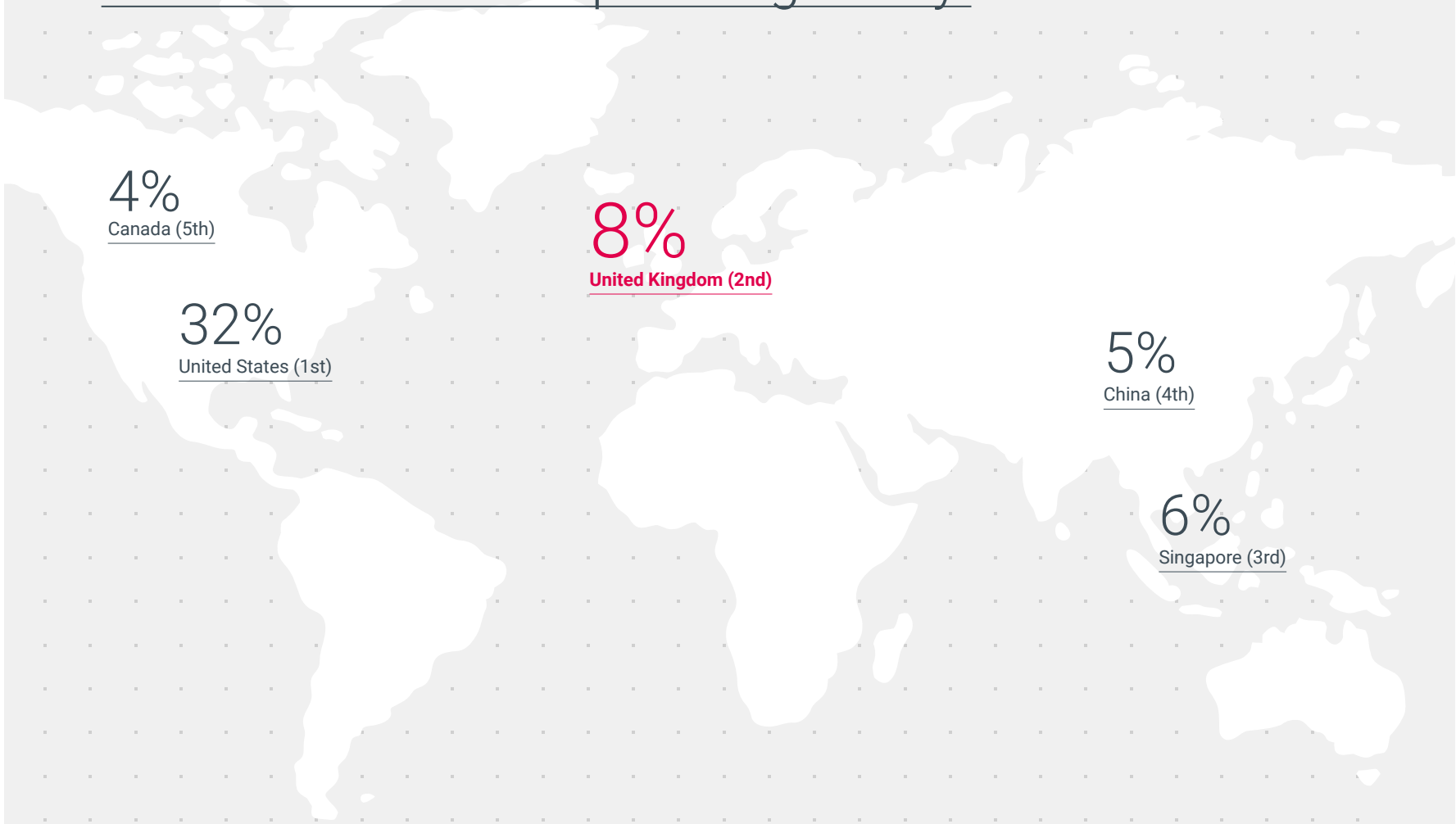
As we move into pandemic recovery and see the rise of these new work and technology dynamics play out, strategic alliances are becoming more and more crucial for the IoT community of developers and users. The UK needs to ensure it fosters, builds and leverages a strong ecosystem in a neutral way, to stimulate the adoption of IoT over the long term. By doing this, we can work together to ensure open standards, better accessibility and security and a shared responsibility for the technology for the future.

Distributed ledger technologies

Total ranking:

1. United States (11.5)
2. China (5.9)
3. South Korea (5.4)
3. **United Kingdom (5.2)**
5. Canada (4.8)
6. Germany (4.7)
7. Singapore (4.6)
8. Switzerland (4.4)
9. Netherlands (4.4)
10. Australia (4.4)

% share of DLT companies globally:



Distributed ledger technologies

DLT companies total funding (since founded)	
United States	£8,855,732,884
United Kingdom	**£1,620,649,243**
China	£1,536,393,787
Switzerland	£967,233,722
Singapore	£850,031,878
Canada	£829,715,846
France	£433,372,816
South Korea	£408,246,936
Israel	£294,472,668
Netherlands	£212,073,728

Average total funding per DLT company	
Austria	£7,741,177
China	£5,164,341
United States	£4,585,599
Switzerland	£4,502,837
France	£4,385,124
United Kingdom	**£3,448,558**
Israel	£3,435,361
Canada	£3,226,440
Singapore	£2,493,750
Estonia	£1,907,532

	% DLT companies with estimated revenues $1m+ (per annum)	% DLT companies with estimated revenues $10m+ (per annum)
United States	19.6%	3.3%
Israel	18.6%	2.3%
United Kingdom	**16%**	**2.3%**
South Korea	5%	1.3%
China	4.6%	1.3%

£41.3bn

Projected global IoT market size by 2026 (CAGR 56.9%)

Source: Research and Markets

450+

DLT or blockchain companies in the United Kingdom

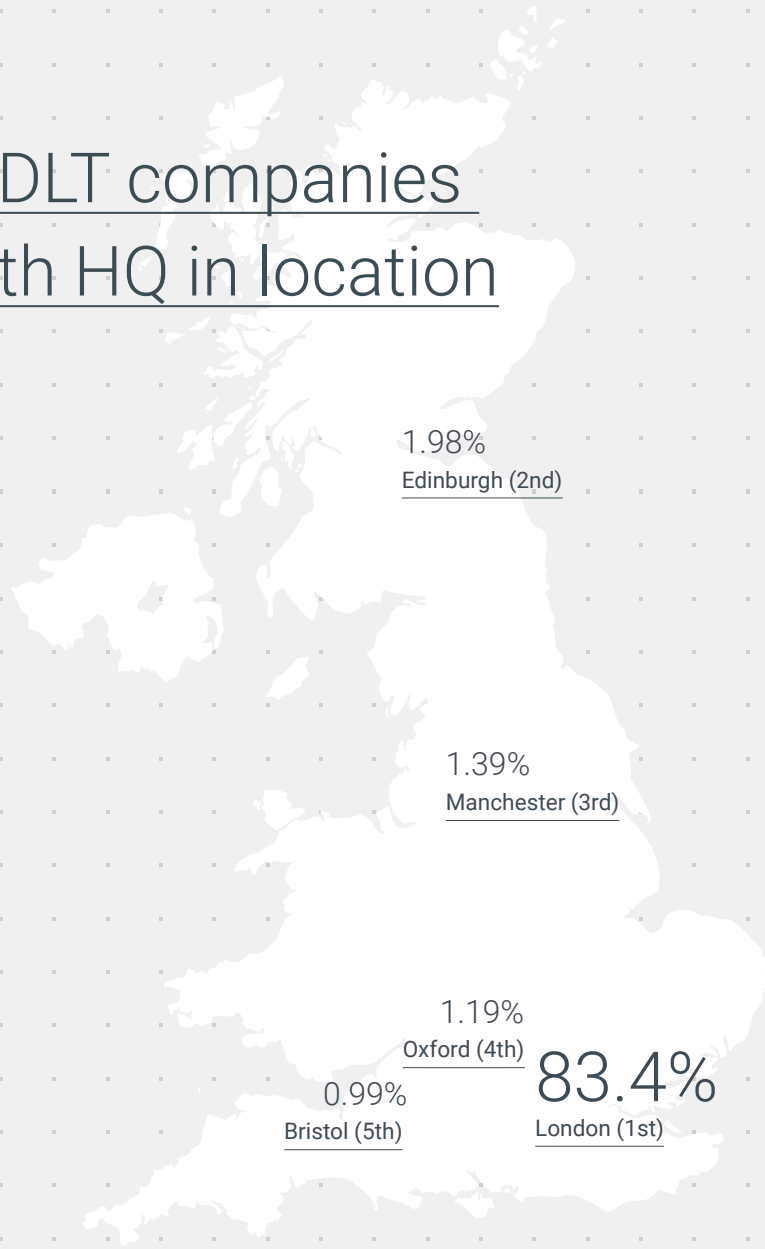
£481m

Investment in UK DLT companies in 2020–2021

Distributed ledger technologies

% of UK DLT companies focused on sector	
Manufacturing	0.6%
Transportation and supply chains	3.9%
Financial services	60.7%
Media and entertainment	7.9%
Healthcare	1.8%
Information technology	31.6%
Sales and marketing	6.3%
Commerce and shopping	10.3%
Professional services	9.9%
Education	1.6%
Community and lifestyle	2%
Advertising	3%

% DLT companies with HQ in location



Spotlight 2021:
UK DLT startups

Applied Blockchain

iov42

Tracr

Realm

Circulor

Dr Robert Learney
Head of Distributed Systems,
Digital Catapult

Technology expert view:
Distributed ledger technologies

Evolving trends for distributed ledger technologies

Over the next few years we expect to see a range of trends in our field evolve simultaneously — spanning the (1) further development of smart contracting, (2) credentialing; (3) supply chain management; and (4) financial applications.

Supply chain management is evolving to grow beyond the movement of physical goods into also caring about their provenance based upon trusted data, ensuring full traceability of items is grounded in digital evidence. For example, this might take the form of encrypting valuable data across the nodes of a supply network to ensure that an item (diamonds, wine, renewable energy) is what it purports to be, without leaking business-critical data to outside parties along the way.

Similar technology concepts also provide opportunities in the creative sector, including digital assets that are being bought and sold, such as avatars for computer games. Non-Fungible-tokens (NFTs) have started to enter public consciousness — blockchain provides digital scarcity and proof for born-digital assets.

What part NFTs will play in the future of the creative ecosystem is difficult to predict: could they take over the way we find, exchange and own art, music, and video in the future? Or will there be a fight back by traditional content industry gatekeepers?

In the past year, blockchain has been subjected to scrutiny around energy consumption and efficiency. Indeed, there are major planned updates to Ethereum, the widest used blockchain platform, changing the energy efficiency and improving its environmental credentials. The shift is from mining to staking, which should save a lot of energy and increase the number of transactions to become a much more useful network. More broadly, regarding the concerns on energy consumption, it is also important to consider that most groups that will use blockchain or DLT for their own internal operations are likely to use private blockchain deployments which are already energy efficient. Private blockchain networks are the model that Digital Catapult has been successfully piloting across industry.

Another significant trend in DLT is credentialing. Portable credentials between organisations are going to be very valuable: as long as you can trust the issuer and the digital signatures, you can then create better trust and efficiency between organisations.

Currently, verifying credentials can take a long time. Take universities for example — employers might phone up a university to check if their prospective employee attended during specific dates. This might take a week or more to get verified, wasting everyone's time and money. Instead, reading a blockchain entry to confirm a person holds a signed digital degree issued from a known university could reduce this check to seconds. These same principles apply to a host of jobs that require specific and specialist skills. For example, we are seeing interest in this technology specifically from the nuclear industry. Basing the future of trusted credentials on an unforgeable, decentralised network, underpinned by known and trusted actors, seems to make good business sense. But we must remain careful about what and when we should be verifying in a free society.

Digital infrastructure

Total ranking:

1.	China (3.5)	11.	Denmark (2.1)
2.	South Korea (2.6)	12.	Japan (2.1)
3.	United States (2.5)	13.	Switzerland (2.1)
4.	United Arab Emirates (2.4)	14.	Norway (2.1)
5.	Singapore (2.3)	15.	Sweden (2.0)
6.	Qatar (2.2)	**16.**	**United Kingdom (2.0)**
7.	Netherlands (2.1)	17.	Canada (2.0)
8.	Saudi Arabia (2.1)	18.	Germany (2.0)
9.	Kuwait (2.1)	19.	Bulgaria (2.0)
10.	Australia (2.1)	20.	Finland (2.0)

Total ranking for 5G progress
(5G coverage, spectrum availability, service provider launches, ecosystem and 5G take-up)
Source: OMDIA, 5G Progress Research, March 2020

1.	South Korea
2.	Switzerland
3.	Kuwait
4.	United States
5.	Qatar
6.	China
7.	**United Kingdom**
8.	Finland
9.	Japan
10.	Germany

Number of super computers per country

China (1)	214
United States (2)	113
Japan (3)	34
France (4)	18
Germany (5)	17
Netherlands (6)	15
Ireland (7)	14
United Kingdom (=8)	**12**
Canada (=8)	12
Italy (10)	6

5G geographical coverage (%)
Source: Umlaut UK 5G Audit Report, WM5G, 2020

Birmingham (1)	11.19
London (2)	10.76
Manchester (3)	10.53
Bristol (4)	5.12
Glasgow (5)	4.37

3.2bn
Projected global 5G connections by 2026 — up from 310m in 2021. Source: Juniper Research

169
Cities with 5G Coverage in the UK, GSMA, 2020

Technology expert view:
Digital infrastructure

How 5G and advanced digital technologies will enable future advanced digital infrastructure

Dr Dritan Kaleshi
Director of 5G Technologies,
Digital Catapult

There are a number of trends in advanced networks, 5G, 6G and advanced digital infrastructure which will enable cyber physical systems to thrive over the coming years.

For Digital Catapult, the key trends include:

Network softwarisation:
Softwarisation of networks allows greater flexibility in service creation and maintenance, and more adaptive networks with lower operational costs. This is an unstoppable trend as it will offer greater agility in how services can match to the needs of specific use cases in a more scalable, time efficient and cost effective way.

This is a key feature of 5G, and more broadly telecommunication systems: what previously required specialised hardware and significant work and time to configure and operate, can now be completed with commercial off the shelf components. It can then be overlaid with use case specific software that takes advantage of configured network services. The agility is already giving commercial benefit to operators, and will lower the cost of private networks too.

Edge computing in communications infrastructure:
The cloud computing era means that while consumers, for example, own the hardware (personal device or laptop), most usage is through centralised online services (Google Chrome, Netflix or Facebook, for example), which are powered by intelligent but largely centralised cloud services. Most of what can be done using cloud computing in this sense has been successfully deployed. What edge computing offers, however, is a focus in geographical distribution of computing. This means the computing will be done closer to the point of use, instead of in a remote data centre. In an industrial context, compute-intense solutions (for example quality inspection in a production or manufacturing line), are quicker and more secure to run, enabling functionality that cannot be delivered today without the right edge computing capabilities.

Intelligent network automation:
Networks have become very complex systems, with added challenges from the expectation of uninterrupted services and consistent quality. The good thing is that networks routinely generate a huge amount of operational data which is a prime asset for AI-enabled automated network operations. The automation of network operations is enabled by the previous two trends, as well as the increased investment in R&D in AI-enabled solutions that can directly solve most of the routing operations currently overseen by Network Operation Centres (NOC).

However, it is now possible to automate many activities by leveraging AI and machine learning to correlate alarms with meaningful insight from operational data. This will also ensure troubleshooting is quicker and more accurate, enabling businesses to enjoy huge time savings.

Finally, these three trends are leading to the emergence of advanced digital infrastructure (ADI) as a programmable service. This is the ability to offer converged compute and communication infrastructure as a set of libraries of network and compute services that companies and developers can pull together like lego-blocks, to create new digital products more easily.

The emergence of the ADI as a converged digital fabric, for the first time, will go way beyond our existing ability to create new software services from software component libraries (existing compute platform offering for data processing). Instead, it will move towards being able to build more complex cyber physical systems. ADI will help to connect devices that interact with the physical worlds (sensor and actuators), with the reconfigurable networks that allow them to dynamically interact with the data processing and decision making software (at the edge or in large data centres). This will create exciting new technology solutions, digital applications and platforms that will transform businesses and society across the world.

Methodology

Methodology

The Digital Future Index 2021–2022 report is constructed off the back of 40+ interviews, extensive secondary research into advanced digital technology companies, use cases, case studies and examples, and expert insights from across a range of technology areas. The engagement has spanned advanced digital technology startups and scaleups at various stages of growth and industry adopters of these technologies. It has spanned areas related to specific annual opportunities, challenges and themes that are relevant for businesses in the UK (for 21/22 this has predominantly focused on media and entertainment, remote working and living, and supply chains).

In addition to this extensive qualitative and quantitative research, we have also undertaken a data collection, consolidation and normalisation process across 125+ dataset variables that feed into our ranking of countries across the range of technologies we believe will underpin future economic and social activities on a global scale over the next ten years. This leverages proven methodologies for data curation through consultation and review of methodologies from the likes of Tortoise Media (in particular their AI Index).

Digital Future Global Index

The Digital Future Global Index has been constructed to provide a ranking of countries' capabilities across advanced digital technologies, weighted against their relative size and population. This ranking provides insights into the health, innovation and potential for a country as we move towards greater innovation and adoption of cyber physical systems and infrastructure.

The Digital Future Global Index is built from a range of dataset variables, with each variable being given a specific weighting (between zero to one) depending on its relevance, contribution and reliability to the advanced digital technology capacity of a country. The closer to one the weighting is, the better that variable's relevance, contribution and reliability is.

These weighted variables are then categorised into six 'pillars' and weighted a second time, depending on how important that pillar category is to building an advanced digital technology capability.

The six pillars are:

1. **Talent**
2. **Innovation and commercial ventures**
3. **Infrastructure**
4. **Research**
5. **Operating environment**
6. **Development**

Once this is done, all dataset values are added together and normalised to make the final score for a particular country.

Methodology

1. Talent

Advanced digital technologies are enabled by the people that implement and develop them. This is across the public and private sector, as well as researchers coming from universities and research institutions.

Talent is fundamental building block to the success of a country, and its ability to create economic and societal value through these technologies. This pillar underpins each of the technology areas for the index.

2. Infrastructure

Infrastructure is both a pillar and an assessment in its own right.

For cyber physical systems underpinned by advanced digital technologies, getting the infrastructure right is crucial to a country's ability to roll out, adopt and innovate successfully.

This includes considerations around existing mobile connectivity, next generation mobile connectivity such as 5G, as well as super computing capabilities and other underpinning data such as digital hardware imports and exports.

3. Research

Research often enables new use cases to emerge for these advanced digital technologies.

The ability for a national ecosystem to develop new research related to specific technologies, as well as their application into the real world, is critical for the future.

This includes considerations around the level of activity and ecosystem for research communities in a particular country, and how they share ideas and discoveries internationally and with the business community.

4. Operating environment

Advanced digital technologies benefit from a strong operating environment, including areas such as open data, privacy and cyber security.

This can be established through public information initiatives, knowledge sharing, innovation coordination and standards.

5. Development

Development includes indicators such as which sectors these technologies are being applied, levels of R&D investment per country, and patent data.

The number of patents filed and awarded for advanced digital technologies is an important indicator for bringing fundamental research to market and commercialisation. However, it must be considered in tandem with commercial ventures to ensure that new products and services are created.

6. Innovation and commercial ventures

Innovation is a crucial and often overlooked component to advanced digital technology adoption. This includes the ecosystem of startups and scaleups that build scalable products and services for other parts of the economy and society — and their ability to pivot into new markets.

It is often through these innovative companies that commercialisation becomes possible, with the ability to focus on use cases, business challenges and opportunities.

This pillar is weighted through the number of companies working with these technologies in each country, and an assessment of their size, scale of investment and ability to meet market demand.

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DETI

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Framestore

Greyparrot

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HTC VIVE

IBM

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Nesta

Overview Ark

Siccar

Siemens

Sonosphere

Southampton University

StoryFutures Academy

TechUK

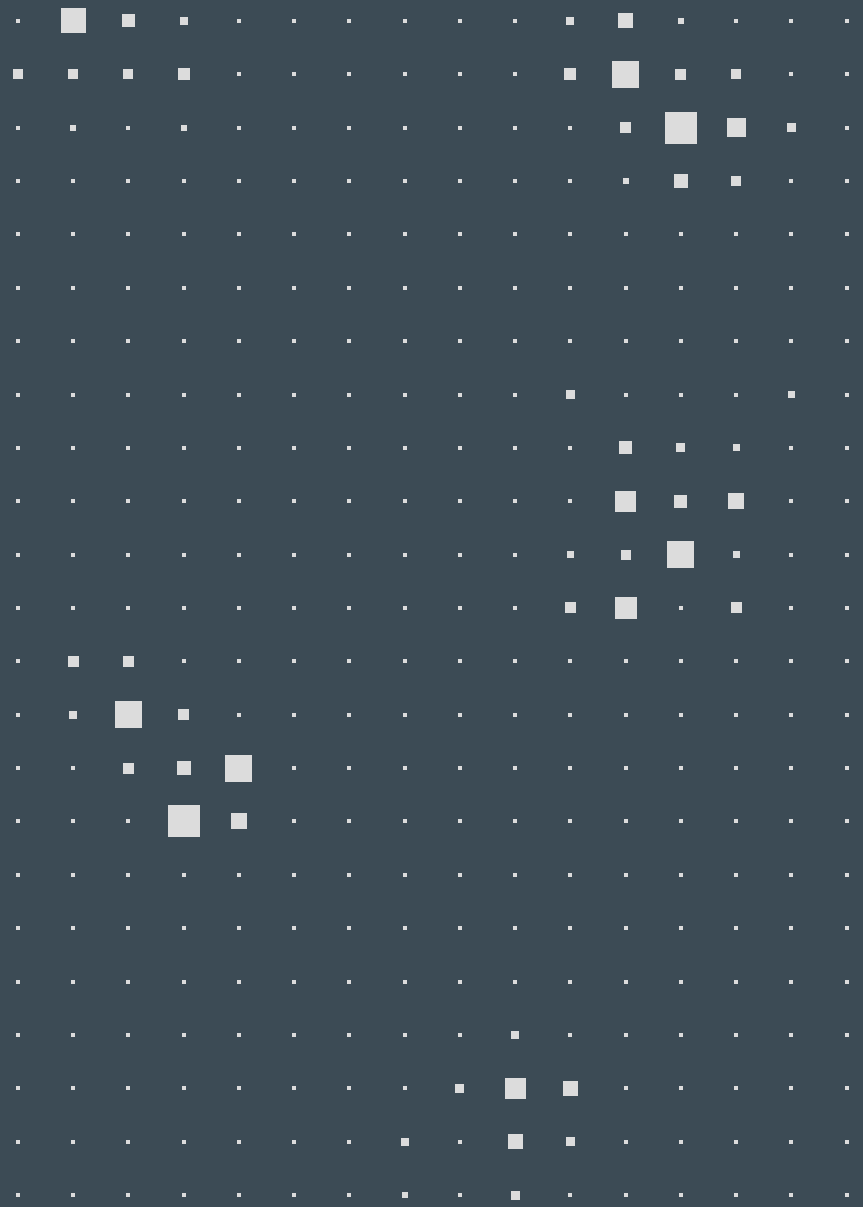
Ultraleap

Unity

Universal Pixels

University of Lincoln

Unreal



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What next?

Digital Catapult is keen to hear from businesses of all sizes in the UK and globally who are innovating with advanced digital technologies, or would like to better understand their benefits.

If you would like to understand how these trends may affect your organisation then please do get in touch:

digitalfuture@digicatapult.org.uk

About Digital Catapult:

Digital Catapult is the UK authority on advanced digital technology. Through collaboration and innovation, we accelerate industry adoption to drive growth and opportunity across the economy.

We bring together an expert and enterprising community of researchers, startups, scaleups and industry leaders to discover new ways to solve the big challenges limiting the UK's future potential. Through our specialist programmes and experimental facilities, we make sure that innovation thrives and the right solutions make it to the real world.

Our goal is to accelerate new possibilities in everything we do and for every business we partner with the journey – breaking down barriers, de-risking innovation, opening up markets and responsibly shaping the products, services and experiences of the future.

Digital Catapult is part of the Catapult Network that supports businesses in transforming great ideas into valuable products and services. We are a network of world-leading technology and innovation centres established by Innovate UK.

Visit **www.digicatapult.org.uk**
for more information.