Engineering and Physical Sciences Research Council

horizon

DIGITAL ECONOMY RESEARCH

IMPACT HIGHLIGHTS

2023

Contents

Foreword

In this brochure we highlight our achievements so far from the third iteration of Horizon as a Next Stage Digital Economy Centre funded by UKRI. Our focus has shifted from the collection and understanding of personal data to the challenge of ensuring that data-driven products can be trusted by consumers. Our research has been exploring how personal data can be used to co-create with users all manner of products for the digital economy that become more personalised and adaptive, and so deliver greater value to consumers and producers.

Professor Boriana Koleva

To deliver impact we have adopted a thematic, cross-sectorial approach by clustering key projects into three successive Campaigns each representing a different starting point for approaching future data-driven products: Consumables focusing on data driven consumer goods, Co-production exploring new media and experiences and Welfare focusing on products that actively promote personalised health and well-being. Specific Horizon projects within these campaigns emerge from user driven theme days and are required to be interdisciplinary and to involve external partners.

When this stage of the centre commenced in December 2020, the world was in the middle of the Covid-19 pandemic, which necessitated for us to adapt how we held project co-creation workshops, engaged with stakeholders and worked day to day. At the same time, we were also able to be responsive and address the challenges of the creative sector by starting with the Co-production campaign first and developing solutions for online and hybrid cultural events as highlighted in the Cultural impact section.

We have also completed two rounds of our Agile projects programme, which provides the opportunity for interdisciplinary teams across Horizon to propose and develop short translational research actions. We particularly encourage early career researchers to get involved and take on a leading role. Completed projects have enabled us to make use of the newly established Cobot Maker Space and link with the Trustworthy Autonomous Systems Hub, address challenges in relation to safety, privacy and trust online, promote sustainable living and draw generalisable results around Responsible Research and Innovation processes and practices.

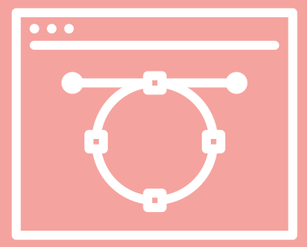
The training of interdisciplinary researchers has also been a key mission. We have embedded this in our approach to project creation and delivery and compliment it through the successful mechanism of Transitional Assistant Professors, which has enabled us to recruit five highly talented research fellows into the academic career track. You can read about their experiences in the Capacity building section.

Track Record

‘Trusted Data Driven Products’ award

We have developed
8 new open-source
software and technical products

Our researchers, partners
and students have delivered
114 publications featuring in
journals and conferences



10 new artistic and creative
products have been
released

40 new collaborations
and partnerships have
been established

39,500 people
have engaged with us
in over 195 activities

Impact Timeline

OUR journey

2021

Feb 2021

Submission of research evidence to Ada Lovelace call ‘Vaccine Passports and COVID Status Apps’

March 2021

Horizon Co-Investigator Sarah Sharples appointed as Transport Chief Scientific Advisor

April 2021

Round 1 Agile projects launch

Boriana Koleva presents Horizon at CHERISH-DE Festival of Ideas

June 2021

Co-Production Campaign launch

Nov 2021

Submission of research evidence to DCMS consultation ‘Data: a new direction’

2022

Jan 2022

Submission of research evidence to UK Parliament ‘The right to privacy: Digital Data’

ReEnTrust launch ‘Algorithms and Us’ video

Defence Against Dark Artefacts release board game tool

May 2022

Round 2 Agile projects launch

June 2022

Submission of research evidence to DCMS ‘Connected tech: smart or sinister?’

Aug 2022

Uncovering Consumer Consensus release video to assist business decision making in support of LUCID new software tool DECSYS

2022

Aug 2022

hoRRIzon launch RRI prompts and practice cards

Sept 2022

Derek McAuley elected to The Royal Academy of Engineering Fellowship

Nov 2022

Foundation of Responsible Digital Futures Group

Everything in Moderation receives funding for sister project Trends & Challenges: moderation of E2E encrypted communication in Zimbabwe

2023

Feb 2023

AIM release ‘Before We Disappear’

HomeZero and hoRRIzon participate in Festival of Science & Curiosity

April 2023

Pepi Barnard named as a Future Leader by the Foundation for Science & Technology

Consumer Products Campaign launch

Coronavirus Discourses and Domesticating Electric Vehicles Charging release reports of findings

June 2023

Boriana Koleva announced as Co-Investigator on Pro2 Network+ grant & Derek

McAuley announced as Chief Operation Officer on Responsible AI UK

Sept 2023

Round 3 Agile projects launch

RAiUK

Covid-19 threw the creative sector into a significant decline. Venues closed, jobs and revenue lost and the social experience of attending live entertainment and performances taken away from us due to repeated lock downs and social distancing measures. We recognised these challenges and introduced our Co-Production Campaign earlier than anticipated to support our creative partners and help them continue to engage with their audiences during and post pandemic.

In the heart of pandemic closures, at a time when live music was functionally impossible, Future Festivals began exploring what it would take to deliver online music festivals. Working with Oxfam, who were keen to take their performances online, we started by exploring what was possible with existing tools, running the **Oxjam**[1] Music Festival (redubbed Voxjam) twice in 2020 and 2021, uncovering challenges around virtual volunteering, the many roles necessary to deliver a shared experience, and elaborating what a unified system for delivering festivals might look like. From this early work we developed **Bubbles**[2], a multi-user 3D virtual-environment with live feeds as 'stages' set in a wider festival environment, where people could explore a virtual festival spatially together. Bubbles unique characteristic was to group visitors together into 'bubbles' inspired by the covid terminology, allowing audio/video communication with those in your 'bubble' while still maintaining awareness of the rest of the crowd. This allowed the experience to be scalable, while remaining manageable. Critically, performers could also use Bubbles to deliver their live shows instead of having to use separate streaming software, allowing for greater parity between performer and audience. We used the system to deliver Voxjam again in 2022 to a mixed audience of people in 'real' and 'virtual' venues.

Recognising that the technology behind Bubbles was applicable to a wider field than music festivals, we used it to deliver part of Nottingham University's Diversity Festival, providing a shared space with exhibits and talks around neurodiversity. We also worked in partnership with the National Holocaust Centre and Museum to deliver a system for school pupils to virtually visit a recreation of a 1930s German Jewish apartment, where a holocaust educator could talk to many classes simultaneously. The impact of Bubbles continues to grow with the system forming part of a new European research project called XTREME, which will see us further exploring the future of music in hybrid spaces.

Of course, online music and its audiences is only one part of how mixed reality affects and impacts our cultural day-to-day lives. We are increasingly seeing the use of mixed reality in live performances, from concerts taking place in Fortnite, to Abba's recent Abbatars. We see it in our museums, with exhibitions like our **Eye as Witness**[3], which invited visitors to "walk through" a photograph taken in the Second World War, into a recreation of its context – inviting speculation on the political purpose of the photograph. We see it in our shopping trips – from virtual changing room mirrors that show what you're going to look like in an outfit, to seeing how your next bookcase might fit against your own wall with the IKEA AR app. As businesses and creatives from diverse fields are embracing immersive technology and recognising that "mixed reality" means more than VR headsets, there is a need for showcasing the very best of what is possible. Horizon along with Nottingham's Mixed Reality Laboratory and our many creative partners has been a world-leader in that research.

Recognising the need to support Nottingham's businesses in understanding and exploiting immersive technology, we collaborated with Trent University, to run the Live Experiential and Digital Diversification for Nottingham (**LEADD:NG**)[4] Project, a £1.6M knowledge exchange initiative. LEADD:NG ended in July 2023 having supported 146 local businesses and delivering over 30 new product prototypes.

Emerging from the LEADD:NG project, we recognised the need for a new facility to explore and support mixed reality and virtual production. The result was a brand new, state of the art Virtual and Immersive Production (VIP) Studio[5] which opened in March 2023 at Kings Meadow Campus, a former TV studio. The **VIP Studio** is allowing us to explore the use of cutting-edge performance capture and performance delivery technologies using a range of state-of-the-art techniques and equipment, from large-scale live volumetric capture to holography. With a program of residencies and associate artists, the studio follows in Horizon's long-established tradition of offering artists the opportunity to bend the technology into incredible new shapes. We are excited to see where it goes over the next year and how the mix of creatives, technologists and scientists continue to shape the future of digital art from right here in Nottingham.

[1] https://www.nottingham.ac.uk/news/virtual-oxjam-creates-immersive-festival-fun

[2] https://youtu.be/-Pq_GIZ3HT0?si=yK1LLhQ8ZL-UpAVh

[3] https://www.nottingham.ac.uk/research/beacons-of-excellence/smart-products/engagement/eye-as-witness/index.aspx

[4] https://www.nottingham.ac.uk/Arts/Research/Multidisciplinary-research-and-knowledge-exchange/Live-Experiential-and-Digital-Diversification/Experiential-and-Digital-Diversification-Nottingham.aspx

[5] https://www.nottingham.ac.uk/clas/departments/culturalmediaandvisualstudies/research/vip-studio.aspx

Contributing towards influencing policy and driving change to improve UK regulation continues to be core to Horizon's impact agenda.

Our investigations around consumer trust and safety in the design, use and disposal of hybrid digital technologies, physical products and online services, built using our personal data, have resulted in submissions to UK Government initiatives, inquiries and calls, including: **Connected Tech: Smart of Sinister**[1], **The Right to Privacy: Digital Data**[2], **Data: A New Direction**[3], **Audience Protection Standards on Video-on-Demand Services**[4], **Draft Online Safety Bill**[5] . We discuss two specific strands of work around Digital Competition and Future Media.

Digital Competition

The foundation of a Digital Markets Unit (DMU) in 2021 was one of six recommendations in the Furman **Report**[6] 'Unlocking Digital Competition' commissioned by the Chancellor of the Exchequer and led by a panel of experts, including Horizon Co-Director Professor Derek McAuley. The remit of the DMU is to promote greater competition and innovation within digital markets, to protect consumers from the already excessive concentration in the marketplace and to create a more innovative landscape in which consumers have more choice and control over their data.

This activity was followed by a **consultation**[7] on 'A new pro-competition regime for digital markets'. Horizon researchers teamed up with colleagues from the Trustworthy Autonomous Systems (TAS) Hub to submit research evidence to the consultation, which resulted in a **report**[8] 'A new pro-competition regime for digital markets – government response to consultation'.

In June 2022 a policy **paper**[9] was published 'Digital regulation: driving growth and unlocking innovation'. The paper included a timeline of digital regulation activity and plans to introduce a new national data **strategy**[10] 'Transforming for a Digital Future' with a 'Data' theme along with other key areas such as AI, Cyber Security and Online Safety.

In April 2023 a new **Bill**[11] 'Digital Markets, Competition and Consumers Bill' was laid before Parliament to provide for the regulation of competition in digital markets, to amend the Competition Act 1998 and the Enterprise Act 2002, to make other provision about competition law and to make provision relating to the protection of consumer rights. A **Research Briefing**[12] published in May 2023 'Digital Markets, Competition and Consumers Bill 2022-23: Consumer Provisions' includes a section on reaction to the Bill.

[1] https://doi.org/10.25878/0kj7-hh45

[2] https://doi.org/10.17639/X2FE-4722

[3] https://doi.org/10.25878/gsc1-vz67

[4] https://doi.org/10.17639/KKAH-2D44

[5] https://doi.org/10.18742/pub01-060

[6] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/785547/unlocking_digital_competition_furman_review_web.pdf

[7] https://www.gov.uk/government/consultations/a-new-pro-competition-regime-for-digital-markets

[8] https://www.gov.uk/government/consultations/a-new-pro-competition-regime-for-digital-markets/outcome/a-new-pro-competition-regime-for-digital-markets-government-response-to-consultation

[9] https://www.gov.uk/government/publications/digital-regulation-driving-growth-and-unlocking-innovation/digital-regulation-driving-growth-and-unlocking-innovation

[10] https://digitalanddata.campaign.gov.uk/

[11] https://publications.parliament.uk/pa/bills/cbill/58-03/0350/220350.pdf

[12] https://researchbriefings.files.parliament.uk/documents/CBP-9796/CBP-9796.pdf

Future media

The UK has a rich history in the field of broadcasting, however changes have been taking place in the media and digital landscape due to the rapid innovation and diverse choices now available, which inadvertently influence audience viewing habits. In recognition of this, the UK Government introduced inquiries calling for evidence to ensure broadcasting regulation remains fit for the current climate.

Findings from our research investigating the challenges of using personal data in media experiences enabled us to contribute to two UK Government calls:

The future of Public Service Broadcasting (PSB) **inquiry**[13] was launched to look at the future of the PSB within the wider media and digital landscape, including funding, content and regulation; and to compare it with alternative subscription channels, streaming and Freeview services. Our research enabled us to submit comments around what a PSB should look like in the digital age and the challenges as media consumption turns ubiquitous, with services introducing customised and personalised recommendations. Following the inquiry, a **research briefing**[14] (section 11) was released, and a new audience-focused BBC operating **licence**[15] announced by Ofcom, to address the changing needs of viewers and listeners and the demand for greater public accountability.

The **consultation**[16] 'Audience protection standards on Video-on-Demand Services' considered whether audiences viewing on-demand content should receive the same or similar level of protections as they do whilst watching traditional television channels, and whether video-on-demand services should be brought within UK jurisdiction and regulated. Our research enabled us to contribute comments on the technical, social and ethical challenges presented by the use of audience personal data as media shifts from linear to on-demand. The UK Government issued a **response**[17] and carried out further work with Ofcom in the development of a regulatory framework to implement changes to video-on-demand regulation; along with this **guidance**[18].

Anna-Maria Piskopani

Anna-Maria is a legal scholar working on issues involving human rights in the digital ecosystems. She has experience as a legal expert in personal data protection and General Data Protection Regulation (GDPR) implementation and her research focuses on legal issues, such as privacy, secrecy of communications and copyright, raised by encrypted communications and Artificial Intelligence (AI) applications. Anna-Maria has worked on several projects, including Everything in Moderation, Open All Senses and hoRRIzon. In addition, she has prepared submissions of research evidence to UK Government consultations including: Data - a new direction, The right to privacy – digital data and Connected tech - smart or sinister. Anna-Maria also follows up the new regulatory initiatives both in national (Online safety bill, Data protection bill and Digital Markets, Competition and Consumers Bill) and international level (EU Digital Market Act and Digital Services Act).

[13] https://committees.parliament.uk/work/90/the-future-of-public-service-broadcasting/

[14] https://researchbriefings.files.parliament.uk/documents/CBP-9571/CBP-9571.pdf

[15] https://www.ofcom.org.uk/news-centre/2023/new-bbc-operating-licence-fit-for-digital-future

[16] https://www.gov.uk/government/consultations/audience-protection-standards-on-video-on-demand-services

[17] https://www.gov.uk/government/consultations/audience-protection-standards-on-video-on-demand-services/outcome/government-response-to-the-consultation-on-audience-protection-standards-on-video-on-demand-services

[18] https://www.ofcom.org.uk/tv-radio-and-on-demand/advice-for-consumers/television/video-on-demand

The Online Safety Bill has now been signed off by the Houses of Parliament (September 2023) and is soon to become law. Anticipating the bill coming into force, the biggest social media companies have already started to take action. Snapchat has started removing the accounts of underage users and TikTok has implemented stronger age verification.

An Office of National Statistics **report**[1] released in April 2021 states that an incredible 92% of adults in the UK were recent users of the internet in 2020.

As a society, we source, create and contribute information to communicate and connect with one another using a multitude of internet dependent online media streaming and social networking platforms, such as BBC Sounds, Spotify, Netflix, Apple Music, Facebook Meta and Snapchat. As we share our personal data and experiences with these online platforms, the content and speed of information exchange affects our opinions and influences our behaviours. We have been addressing some of the challenges in relation to safety, privacy and trust online.

Online harms is a term that refers to behaviour online which may hurt a person physically or emotionally. We have been investigating some of the trends and challenges for online communities, from public forums to end-to-end encrypted communication. **Everything in Moderation**[2] explored user perceptions, stakeholder concerns, and legal aspects of end-to-end encryption (E2EE).

E2EE is a system of communication used by the service providers of online platforms such as WhatsApp, Signal, Facebook Messenger and Telegram. It works by encrypting messages as they are sent and only decrypting them once they are received by the recipient. This means that only those sending and receiving messages can see their content, hence the service providers are unable to access the content of the messages its users send. With E2EE some of the traditional forms of moderating online content are not possible, such as automated detection of malicious content, the flagging of content and human moderators employed by the service providers. This means that responsibility for monitoring behaviour is left with the user of the platform rather than the service provider.

This is a timely project due to recent controversies in the **Online Safety Bill**[3]. The Bill has been in development for a long time and surrounded by debate, particularly concerning the perceived ambiguity about what measures service providers will be expected to take and how these can be enacted. An example being an amendment requiring a 'skilled person' to report to Ofcom before enacting powers to compel a service provider to scan messages. Some have pointed out that enabling any scanning of E2EE messages negates the use of E2EE. The Service Providers of WhatsApp rely on using E2EE to protect the privacy of users and to increase security. They have stated that they will not be able to operate in the UK under the potential new rules and would halt their service to UK users. Contrastingly other groups, such as Child Sexual Abuse Material (CSAM) campaigners are against the widescale introduction of E2EE, citing fears that it will stop authorities being able to police harm and abuse happening on these platforms.

We worked with the Internet Society to gather research evidence, useful to policy makers, around how service providers and users perceived moderation, their ability to deal with potentially harmful content and how these change with E2EE. In addition, we explored how the current and upcoming legal framework addresses moderation, harmful content, user behaviour and E2EE.

[1] https://www.ons.gov.uk/businessindustryandtrade/itandinternetindustry/bulletins/internetusers/2020
[2] https://www.horizon.ac.uk/project/everything-in-moderation/
[3] https://www.theguardian.com/technology/2023/apr/18/whatsapp-signal-unite-against-online-safety-bill-privacy-messaging-apps-safety-security-uk

Winning a Global Challenges Research Fund and Newton Fund Consolidation Award enabled us to carry out a **sister project**[4] with colleagues in the Harare Institute of Technology (HIT) in Zimbabwe. We hosted a visit from **Calvin Mugauri**[5] and organised a **competition**[6] for students at HIT, which involved identifying a challenge connected to the moderation of E2EE online communities. The funding also supported Calvin to interview professionals in Zimbabwe with expertise in social media and online moderation.

WhatsApp is by far the most used app in Zimbabwe, accounting for 44% of mobile app use. It is popular due to its affordability and accessibility and often used to facilitate economic participation and civic engagement.

For instance, it was widely used to circulate learning materials and support ongoing education during the COVID-19 pandemic whilst schools were closed. This wide extent of WhatsApp use presents significant moderation challenges and we have been comparing the UK/European landscape of E2EE use and moderation with the Zimbabwean one. Our work has highlighted the relevance of contextual factors. For instance, the popularity of WhatsApp in Zimbabwe appears to be driven more by connectivity issues and convenience than specific preference for an E2EE platform. Meanwhile, the legal requirement to register SIM cards in Zimbabwe combined with controversial incidents stemming from the politicisation of freedom of speech can undermine user confidence in the privacy of these spaces, despite their E2EE status. These findings open up exciting prospects for understanding the potential future of online communications across the globe.

In addition, we have been interested to find out about ‘unofficial’ versions of WhatsApp (such as GB WhatsApp) that are well known and popular amongst certain demographics in Zimbabwe and other countries, such as India. These unofficial versions include more features than official WhatsApp, however their E2EE status and security are difficult to determine.

[4] https://www.horizon.ac.uk/everything-in-moderation-sister-project-update/
[5] https://www.horizon.ac.uk/everything-in-moderation-sister-project-update/
[6] https://www.horizon.ac.uk/trends-and-challenges-for-the-moderation-of-end-to-end-encrypted-communication-in-zimbabwe/

The 2022 Ofcom Adults' media Use and Attitudes **Report**[1] states that 86% of internet users were familiar with a range of reasons why companies collect personal data online.

'Of this percentage, half felt information was used to target advertising, however only a small number recognised that data is used to build up consumer profiles to personalise online experiences.

Online service providers use recommender systems (AI algorithms associated with machine learning), to gain details about our personal preferences, based on what we watch, search for and listen to. These determine what and how much information we are exposed to in the digital space. Several of our projects have investigated the impact and influence of recommender systems.

New Forms of Public Value at the Edge[2] and **MIDAS**[3] were projects in partnership with BBC R&D which addressed challenges around digital identity, personal data control when sharing online accounts, such as Spotify, Netflix and the co-design and testing of a novel **recommender service**[4].

We have continued to work with the BBC who partnered with the European Broadcasting Union to explore the development of an open-source, adaptive, personalised podcast. To investigate how people felt about adopting this new type of online media service, **Adaptive Podcasts**[5] designed a prototype adaptive podcast which used personal data provided by listeners. Testing of the prototype will be carried out in collaboration with colleagues from the **Future Mundane project**[6].

Promoting Net Zero[7] explored how algorithms motivated by target advertising have perhaps unintended consequences and are applied to similar recommender systems used in search tools, news and media. We studied exacerbating opinion polarization in policy dissemination associated with the global race to achieve Net Zero - specifically focussing on public opinion towards mining. How does public opinion depend on recommended source of information? By recommending someone prejudiced on the topic, an article agreeing with their beliefs simply confirms their bias. Is there added value in providing diversity in the sources of information users are exposed to?

Recommender systems more generally could be designed to ensure a greater diversity of choice, but so far there is a little understanding of the problem and consequently no regulatory requirement or constraint. Our aim is to gauge the impact of poor content diversity constraints, investigate different mechanisms for imposing such constraints and provide regulatory guidance on ways to achieve this.

[1] https://www.ofcom.org.uk/__data/assets/pdf_file/0020/234362/adults-media-use-and-attitudes-report-2022.pdf
[2] https://www.horizon.ac.uk/project/new-forms-of-public-value-at-the-edge-designing-for-hdi-and-trust-in-media-iot-futures/
[3] https://www.horizon.ac.uk/minimal-intervention-distributed-account-system-midas/
[4] https://youtu.be/4QNxEXGwTnU
[5] https://www.horizon.ac.uk/project/adaptive-podcasts/
[6] https://imagination.lancaster.ac.uk/project/4313/
[7] https://www.horizon.ac.uk/project/promoting-net-zero/

Repairers told us

“The nice thing about it, is that it’s a pleasant community activity with like-minded people.”
- Electronics Repairer

“I like repairing older stuff that’s got some heritage.”
- General Repairer

‘Internet of Things’ (IoT) products, think for example energy meters, home security systems, smart televisions, washing machines and fridges, gather and exchange data via sensors and actuators through connectivity to the internet.

These products produce real time information about our activities and behaviours, along with the device itself, its status, use and functionality.

Smart products require us to sign up to service contracts, install apps, download and run software updates to continue to use them. These are some of the things that affect our choices and decisions about the purchases we make, in addition to consideration about product sustainability and their impact on the environment. Within the business-to-business (B2B) sector there has been a trend towards product-service models, which means the ownership of devices and the responsibility for repair in the event of a breakdown sits with the business that supplied it. However, this model is yet to be adopted to any significant levels within the consumer markets, which means the responsibility for care, repair and disposal sits with the consumer. With electronic waste (eWaste) levels already critical and increasing year on year, it is essential that improvements are made within this area, through supporting and encouraging repair as an option for consumers to extend the lifecycle of IoT products.

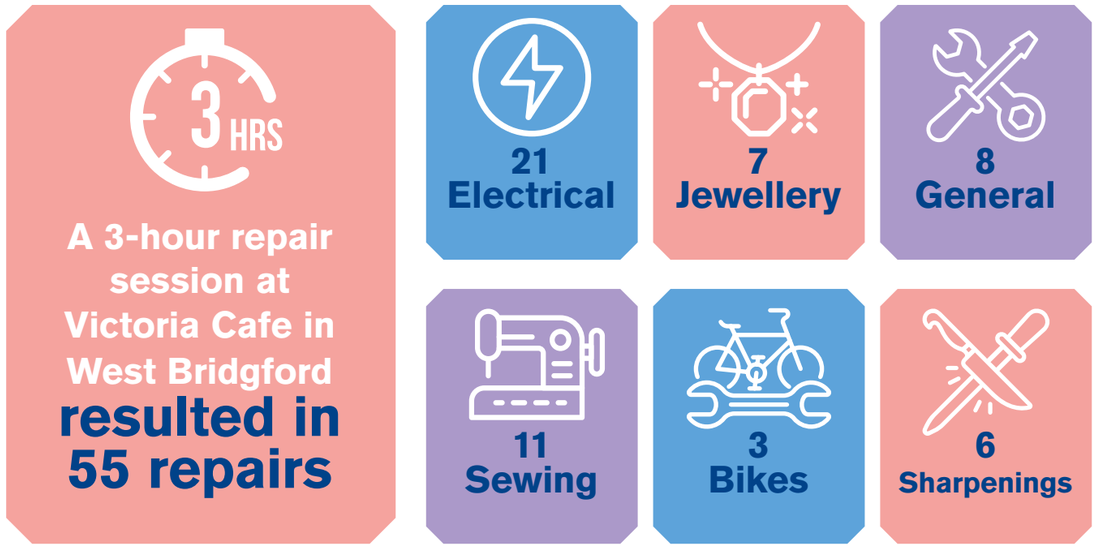
In a bid to increase a responsible approach to product design, consideration to reducing energy usage and eWaste and support consumer choice, the UK Government announced ‘Right to Repair’ **regulations**[1] in 2021. Fixing the Future: the Right to Repair and Equal-IoT is a **project**[2] exploring responsible smart product design and investigating what happens when these products break and require repair. The project has a vision of a digital economy with more repairable smart devices that respect citizens legal rights, provide long-term cybersecurity, minimise eWaste, and are supported by local community repairability networks, enabling digital inclusion and agency for citizens.

To achieve this future vision, it is essential to understand the various challenges that IoT products present to consumers and repairers. The multifaceted and embedded nature of IoT devices add complexity to repair, from the identification of the initial breakdown including; the decision to repair, diagnosis, realising the repair and post repair testing. In particular, the software and data elements of these devices mean that they may not fit into the current community repair setups that exist to support other non-connected products, such as food mixers and vacuum cleaners. To better understand these complexities, the Nottingham based Fixing the Future team are engaging with several local grassroots repair cafes.

The community-based repair movement has been gaining traction and popularity over the last few years motivated by sustainability and boosted by the Covid-19 pandemic, the climate and cost of living crisis in the UK. This repair culture plays a role in alleviating some of the inequalities in the technology markets of today’s societies. For example, by providing access to locally based repair, for the cost of a donation, addresses some of the access and socioeconomic barriers to repair. Our research into the repair cafe landscape has also highlighted positive social implications, as the community repair model brings people together and provides a sense of purpose to volunteers.

Our better understanding of these repair contexts and related processes will enable us to prototype and test technology-based interventions to assist consumers, repairers and other stakeholders in ensuring that Internet of Things products are repairable at a community level.

[1] https://researchbriefings.files.parliament.uk/documents/CBP-9302/CBP-9302.pdf
[2] https://www.horizon.ac.uk/project/the-right-to-repair-and-equal-iot/



Today's children are more exposed to climate damage than their parents and are the future voices to push for effective emissions reduction policies.

Encouraging families to have conversations about home emissions and their impact on climate change is important and supports raising awareness about how our individual behaviours and decisions can make a difference and influence change.

HOME:Zero[1] is a collaborative project between **Makers of Imaginary Worlds**[2], creative technologists and colleagues from the Mixed Reality Lab.

Following on from earlier work commissioned by Nesta and National Gallery X (The National Gallery and King's College London) HOME:Zero is a mixed reality installation which acts as a catalyst to stimulate conversations about the role of immersive installation. It was co-designed with Nottingham families to encourage us all to reimagine how we can make a sustainable difference starting at home. It uses digital media and a selection of National Gallery paintings to bring real-world issues about sustainability to the forefront of the visitors' mind.

HOME:Zero premiered at Lakeside Arts, a space that engages audiences in a rich cultural programme of events, including performances and exhibitions. MOIW were however keen to source different venues in which to display the installation, to attract a wider and more varied audience. One such venue, Strelley Library in Nottingham, with whom they had worked for the Festival of Science and Curiosity, proved a fantastic venue and attracted over 150 visitors!

HOME:Zero moved on to Mansfield Museum and with additional support from the Trustworthy Autonomous Systems (TAS) Hub **Creatives**[3] programme, continued to gather visitors' thoughts and experiences around engaging with this type of immersive installation. This helped provide a better understanding of how immersive interactive performances can help families and children to think about sustainable solutions in their homes. MOIW told us "It was a busy ten days with visits from several schools, home schoolers and families. In total 307 people visited us - 173 adults and 243 children. The children told us they enjoyed the interactive nature of HOME:Zero and were very enthusiastic about making and drawing pledges for a greener planet."

Taking the learnings from this work, HOME:Zero is undergoing further development and there are plans for a nationwide tour. In addition, the installation is being adapted for a three-screen tabletop **experience**[4] for Nottingham City Library's Connect Culture Project supported by Arts Council, England. The reuse of the digital asset into a new format means the work can reach many more children and families as it is scheduled to be at two libraries for at least one year.

[1] https://youtu.be/LEFTa8isi6E
[2] https://makersofimaginaryworlds.co.uk/
[3] https://tas.ac.uk/impact/tas-creatives/
[4] https://twitter.com/imaginarymakers/status/1663655880334639112

"It was awesome! I feel like it's a better world."

Twin brothers and members of the co-design team

"My son and I really enjoyed participating in the HOME:Zero project. We didn't know quite what to expect, but it was extremely enjoyable, fun and informative, and run by a fantastic team. It was amazing to see and hear the ideas of all those involved and how these were brought together to create the final installation which is amazing."

Parent on the co-design team

UK Research and Innovation (UKRI) and the Engineering & Physical Sciences Research Council (EPSRC) have articulated a strong commitment to Responsible Research and Innovation (RRI), recommending that researchers follow the AREA **framework**[1] (Anticipate, Reflect, Engage and Act).

However, we discovered from interviews carried out in **hoRRIzon 1.0**[2], that researchers often do not know what RRI means for them, or how to put it into practice. This was the the topic of our **paper**[3] 'Supporting responsible research and innovation within a university-based digital research programme'.

Horizon has championed the responsible use of personal data throughout its lifespan, in particular earlier research developed a set of Moral-IT **cards**[4] and we started to address the challenge of helping researchers to apply key ideas of RRI across all aspects of their work, during our **Services Campaign**[5].

To encourage our researchers to consider the bigger picture, long-term impacts and help them embed a culture of RRI into their work, we introduced a cross-cutting RRI team. Our team has subsequently connected with colleagues in **ORBIT**[6] and the Trustworthy Autonomous Systems (TAS) Hub, leading to the formation of a Responsible Digital Futures **Group**[7]. We have also created and promoted an increasing range of resources, tools and activities to help researchers and the wider audience engaging in research.

We developed **RRI cards**[8] in hoRRIzon 1.0, modified **versions**[9] during **hoRRIzon 2.0**[10], and took them out to over 20 events, supporting Undergraduate and PhD Students, Early Career Researchers, Youth Groups, Community Groups and the General Public; reaching over 200 people. As discussed in our **paper**[11] 'Responsible Research and Innovation (RRI) Prompts and Practice cards: a tool to Support Responsible Practice', the cards have been consistently well received, and activities using them have provoked reflection, discussion, critical thinking and helped to identify priorities for responsible innovation (RI) within several research projects. Researchers, academics and students fed back that they found cards useful, and that they helped them to think about aspects within their projects that they had not considered before, for example to anticipate risks of process and outcomes and plan accordingly.

We liaised with UKRI to maximize the impact and reach of the RRI cards. UKRI was impressed with how accessible we make the subject, clearly detailing the steps that need to be taken to consider RRI implications and action plans. We are delighted to be given this opportunity for wider impact and continue improving and adapting this playful RRI tool.

Additionally, in recognition of the complexity and importance of RRI, we introduced 'RRI reflections' as a standard agenda item within all Horizon project meetings. This RRI agenda item provides dedicated time for teams to reflect on responsibility issues arising from their study, identify and discuss actions that can be taken in connection to them.

However, we are finding that our resources and approach do not always connect with colleagues in other disciplines and institutions. So, in the next round of cross-cutting activities we will be looking at ways to translate our understandings of RRI, so that they have clearer relevance and value to a broad range of researchers and sectors.

[1] https://www.ukri.org/about-us/epsrc/our-policies-and-standards/framework-for-responsible-innovation/
[2] https://www.horizon.ac.uk/project/horrizon/
[3] 10.1016/j.jrt.2022.100045
[4] https://www.horizon.ac.uk/project/moralit-enabling-design-of-ethical-and-legal-it-systems/
[5] https://www.horizon.ac.uk/legacy/research-activities/services/
[6] https://www.orbit-rri.org/
[7] https://www.responsible-digital-futures.org/
[8] http://doi.org/10.17639/nott.7243
[9] https://rdmc.nottingham.ac.uk/handle/internal/10519
[10] https://dl.acm.org/doi/10.1145/3597512.3599721
[11] https://www.horizon.ac.uk/project/horrizon-2-0/

Example RI Prompts and Practice card fronts (version 3.0.7). The top row shows four examples of concept cards. Note these are colour coded according to the relevant RI activity (Anticipate, Reflect, Engage or Act), also indicated at the bottom with the "4Ps" (Purpose, Process, People or Product). The bottom row shows 3 exemplary instructions cards plus a "Can you agree" card example

Our Transitional Assistant Professor (TAP) scheme was introduced to attract talented research fellows into the academic career track, to provide them time and space to focus and develop their research portfolios, leadership skills and individual networks while transitioning over 4-5 years into the more balanced portfolio of assistant professor activities, including teaching and administrative duties.

Previous iterations of Horizon have supported the progression of ten TAPs from across Business, Computer Science, Engineering, Maths and Psychology. Since starting our EPSRC award 'Trusted Data Driven Products', five new TAPs have been appointed. We introduce them below.

In addition, we actively support and encourage our research fellows to step up to roles as Researcher Co-Investigators on projects and apply for other smaller funding opportunities which they can lead on as they arise. Evidence of such successes during post-doctoral study are increasingly important for those wishing to continue into an academic career path.


Georgina Nica-Avram

Georgiana's research has been uniquely placed, sitting between Marketing and Machine Learning. She has led work on complaint management, food insecurity and food mapping via Machine Learning, and recently contributed to research into nutrition and digital footprints.

Georgiana is passionate about empowering others and nurturing trans-disciplinary connections. She has led the University of Nottingham Business School's Analytics Specializations and Applications module and supervised masters' dissertations in the Marketing Department. She also contributed towards an Innovate UK Knowledge Transfer Partnership bid, has partnered with the Guy & St Thomas Foundation to generate the first food insecurity map for London and has secured funding to work on linking deprivation and nutrition in partnership with a major food retailer in the UK.


Helena Webb

Helena's research sits at the intersection of society and technology and explores the ways in which users interact with technologies in different kinds of setting, and how social action shapes and is shaped by innovation.

"Horizon's TAP programme has enabled me to gain more research independence by pursuing my own interests and I have benefitted from opportunities to develop my research skills and portfolio. The interdisciplinary focus of Horizon brings in researchers working from a range of backgrounds, and this presents opportunities to discover new ways of approaching research challenges and addressing research questions."

"I have joined several Horizon projects, such as the **Memory Machine**[1] and my interest in exploring behaviours and dynamics around online communication has enabled me to contribute towards the design and direction of the Everything in Moderation **project**[2]. I am particularly pleased to have been successful in gaining a Global Challenges Research Fund award which funded an Everything in Moderation **sister project**[3], conducted in collaboration with the Harare Institute of Technology in Zimbabwe. In addition to my own learning, I have also enjoyed supporting the learning of others. For instance, I have become involved in the Horizon Centre for Doctoral Training (CDT), supervising PhD students and teaching sessions within the Responsible Innovation module and Advanced Research Practice module."

"A final benefit of being a Horizon TAP is that is has helped me become part of the Trustworthy Autonomous Systems (TAS) network. I am part of the **TAS RRI Agile project**[4], was a member of the **TAS'23 Symposium**[5] organising committee and am leading a **TAS Pump Prime Project**[6]. Through these activities I have been able to expand my areas of focus."

[1] https://www.horizon.ac.uk/project/mema-3-0/
[2] https://www.horizon.ac.uk/project/everything-in-moderation/
[3] https://www.horizon.ac.uk/project/trends-and-challenges-moderation-of-e2e-encrypted-communication-in-zimbabwe/
[4] https://tas.ac.uk/research-projects-2022-23/tas-rri-responsible-research-and-innovation/
[5] https://symposium.tas.ac.uk
[6] https://tas.ac.uk/research-projects-2023-24/trustworthy-and-useful-tools-for-mobile-phone-extraction/

Horia Maior

Horia is interested in advancing the understanding of brain and physiological data in naturalistic study settings by developing new ways to process and analyse data.

"I am particularly keen to understand the relationship between system performance, user experience, workload and trust in the design of an interaction with trustworthy autonomous systems."

"The Horizon TAP programme has enabled me time to widen my network and I was delighted to be named as a **Future Leader**[1] by the Foundation for Science and Technology in 2022. This presented opportunities to meet with mid-career professionals and join useful discussions with senior figures from government, parliament, industry and third sector organisations."

"Leading Horizon's Open All Senses project presented an opportunity to apply for and receive funding to support the re-furbishment of a test bed museum gallery space at the Cobot Maker Space. During the project I collaborated with colleagues from the Trustworthy Autonomous Systems (TAS) Hub and this led to an invitation to help shape a new **initiative**[2] to showcase impact resulting from research carried out by Early Career Researchers working on TAS funded projects."

[1] https://www.foundation.org.uk/Future-Leaders

[2] https://tas.ac.uk/skills/early-career-researcher-awards/#:~:text=The%20inaugural%20TAS%20Early%20Career,%C2%A35k%20will%20be%20available.

Neelima's interests cover the socio-technical aspects of cutting-edge technologies, the sustainability of technology, Human Data Interaction, Human Computer Interaction (HCI) and edge computing. Her interdisciplinary research sits at the confluence of academia, industry, communities and policy, resulting in impact that spreads across these different layers of society.

"I started working at Horizon as a Research Fellow involved in projects around the data legibility, negotiability and agency in media experiences. Becoming a TAP has enabled me the opportunity to secure grants for new projects including the New Forms of Public Value at the Edge **project**[1] funded by **PETRAS**[2] (matched by the BBC). I presently lead the Human Computer Interaction and Human Design Interaction wing of the EPSRC funded Fixing the Future: Right to Repair and Equal IoT **project**[3] in collaboration with the Universities of Edinburgh, Lancaster and Napier."

Neelima Sailaja

[1] https://www.horizon.ac.uk/project/new-forms-of-public-value-at-the-edge-designing-for-hdi-and-trust-in-media-iot-futures/

[2] https://www.horizon.ac.uk/project/petras-2/

[3] https://www.horizon.ac.uk/project/the-right-to-repair-and-equal-iot/

Yordan Raykov

Yordan's work is largely inspired by his love for algorithms and responsible machine learning.

"During my time as a TAP, I have significantly benefited from the support, freedom and opportunities which I have been exposed to at Horizon. I have led the Promoting Net Zero project, which investigates the effect of algorithms inside search tools and news outlets on the formation of our opinion regarding political and societal topics, such as global warming and mining."

"The freedom and professional network provided by Horizon has allowed me to develop a longer-term independent research agenda, submit a fellowship bid and expand the impact of my work to application domains further away from my previous expertise."

"I have been working with university, industrial and clinical partners towards the design of new clinically approved digital outcome measures for long-term disorders, such as Parkinson's disease. I have extended my network and have started projects looking at how we can expand the capacity of digital outcome measures to improve our understanding of the impacts of Long Covid on patients. Partnering with University of Nottingham colleagues and Horizon partners, we are looking at ways digital outcomes can also support the design of closed-loop neuromodulation devices for both Parkinson's disease and Tourette's syndrome. Beyond wearables, I have had the opportunity to start a knowledge exchange Innovate UK funded partnership with Isogenica in Cambridge, in which we are building AI tools for discovery of cheaper and easier to manufacture anti-bodies."

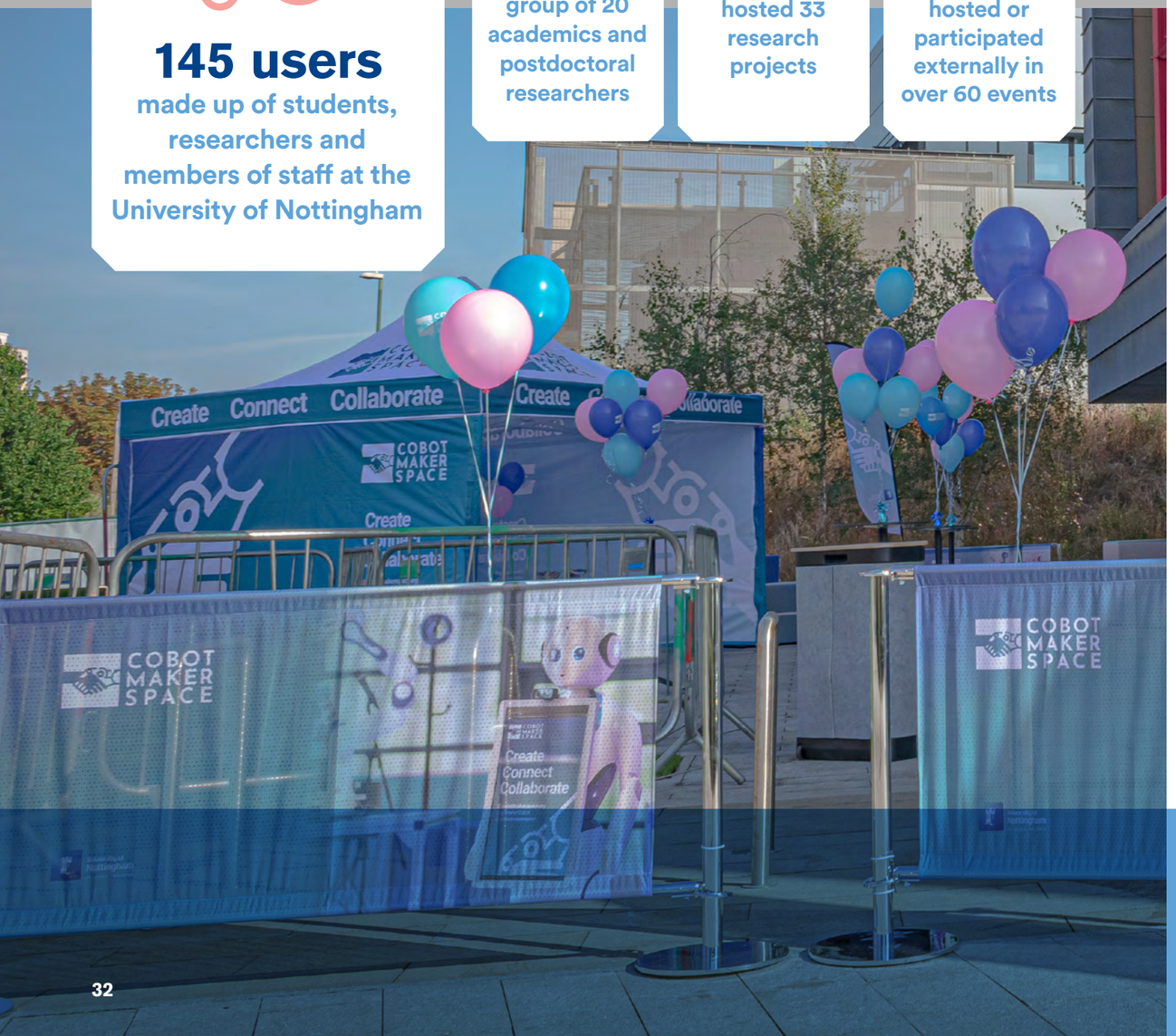
145 users

made up of students, researchers and members of staff at the University of Nottingham

supports a core group of 20 academics and postdoctoral researchers

hosted 33 research projects

Internally hosted or participated externally in over 60 events



COBOT MAKER SPACE

Launched in 2021, the Cobot Maker Space (**CMS**[1]) was created to help better understand how people interact and work with collaborative robots (cobots), and autonomous systems in the home, workplace and beyond.

The foundation of the maker space was an important commitment by the University of Nottingham to recognise Horizon's sustained track record for producing leading-edge, impactful research, examining how products, technologies and services of the future can be designed to deliver personalised and intuitive experiences.

The CMS provides a reconfigurable environment for research, knowledge exchange and engagement with stakeholders from academia, industry, government and the third sector. Kitted out with human-scale, mobile robots, sensors, cameras, physiological measurement systems, and compute capability, the CMS creates an ideal space for researchers specialising in sociotechnical research to explore the interface between people, robots and autonomous systems and personal data.

By design, the CMS has set out to provide an environment where collaboration elevates research quality through different disciplinary perspectives. The space has been successful in bringing together researchers from a broad range of disciplines, prompting new teams to form and embark on multi and interdisciplinary research - fundamental to Horizon's identity. Building on this community, colleagues from our extended network, including the Trustworthy Autonomous Systems (**TAS**[2]) Hub, Live, Experimental and Digital Diversification (**LEADD:NG**[3]) and the Cyber-physical Health and Assistive Robotics Technologies Research Group (**CHART**[4]), have used the space to meet, design, build and fine tune prototypes and to create bespoke everyday environments in which to carry out testing. In April 2022, the CMS was named as one of eight European Robotics League certified **testbeds**[5] for the recognised testing of tasks and functionality benchmarks.

Conceived as a facility for both research and engagement, the CMS provides a unique space to welcome visitors. Guests have included researchers from UK and international universities, including the **KTH Royal Institute of Technology in Sweden**[6], **Heriot Watt in Scotland**[7], **Bonn-Rhein-Sieg University of Applied Sciences in Germany**[8] and the **University of Florence, Italy**[9]. Our efforts to reach out to the wider audience have enabled us to attract several prestigious international research institutions, including the **Istituto Italiano di Tecnologia**[10], **Centre Inria Nancy**[11], **Idiap Research Institute**[12], **Technische Universität Wien**[13], **Johns Hopkins University**[14] and **The University of Texas**[15]. We have enjoyed hosting visitors from **UK Research and Innovation (UKRI)**[16], **Beko**[17], **Siemens**[18], **Makers of Imaginary Worlds (MOIW)**[19] and last year entertained a delegation from the **Department for Transport**[20], keen to understand the societal implications of addressing transport and infrastructures challenges with autonomous systems. Horizon research will be highly influential to these progressive conversations, as technologists and policy makers consider how to intuitively design, integrate and regulate new digital technologies and services.

Since its launch, the CMS has become a flexible backdrop for Horizon researchers and provides a pivot by which they investigate new opportunities for embedding digital economy research within other national research and innovation priorities; this includes the explosion in Artificial Intelligence (AI) development, personalised health and social care and new applications for next-generation robotics. This is particularly important against a landscape of evolution for the **EPSRC Digital Economy Theme**[21], as it transitions to an underpinning presence in other strategic priority areas.

1 https://cobotmakerspace.org/

2 https://tas.ac.uk/

3 https://www.nottingham.ac.uk/Arts/Research/Multidisciplinary-research-and-knowledge-exchange/Live-Experiential-and-Digital-Diversification/Experiential-and-Digital-Diversification-Nottingham.aspx

4 https://www.chartresearch.org/home

5 https://old.eu-robotics.net/robotics_league/consumer/certified-test-beds/certified-test-beds.html

6 https://www.kth.se/

7 https://www.hw.ac.uk/

8 https://www.h-brs.de/en

9 https://www.unifi.it/

10 https://www.iit.it/it/

11 https://www.inria.fr/fr/centre-inria-nancy-grand-est

12 https://www.idiap.ch/en

13 https://www.tuwien.at/

14 https://www.jhu.edu/

15 https://www.utexas.edu/

16 https://www.ukri.org/

17 https://www.beko.co.uk/

18 https://www.siemens.com/uk/en.html

19 https://makersofimaginaryworlds.co.uk/

20 https://www.gov.uk/government/organisations/department-for-transport

21 https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/digital-economy-theme/

What's next?

The UKRI Digital Economy (DE) Theme was introduced in 2008 in recognition of the fast-growing transformational impact of digital technologies at that time. Horizon has since established a well-regarded network and built a vast portfolio of digital economy research. Reflecting on our learnings and exploring how our work can shape future research agendas and initiatives has been a key area of focus for our programme 'Trusted Data Driven Products'.

As part of our legacy, we are proud that our expertise in the digital landscape has led to successful partnerships including with colleagues from the Trustworthy Autonomous Systems (TAS) Hub, the National Centre of Excellence for IoT Systems Cybersecurity (PETRAS), the Security, Privacy, Identify and Trust Engagement Network (SPRITE+), From Prototyping to Production of Digital Devices (Pro2+) and the Live, Experimental and Digital Diversification: Nottingham (LEADD:NG). Collaborating with these programmes has been key to the creation of the Cobot Maker Space and a Virtual Immersive Production studio at the University of Nottingham. These innovative spaces have been instrumental in attracting new academics and partners interested in artificial intelligence (AI), robotics and new immersive technologies, which align with the UKRI 2020-2025 strategic delivery plan, identifying new areas of priority: engineering net zero, Artificial Intelligence, digitalisation and data: driving value and security, transforming health and healthcare and quantum technologies.

Finally, I am delighted that my colleagues, Horizon founder and Co-Directors Professors Tom Rodden and Derek McAuley are part of a consortium awarded £31 million by UKRI EPSRC to deliver Responsible AI UK – an international research and innovation programme to explore the design, evaluation, regulation and operation of AI systems. This work will help to maintain and grow the UK's international position in the global AI market, attracting talent and incentivising private investment in the UK.

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