Fixing the Future: Cultivating A Capacity to Repair IoT Devices through Experiential Futures

Pilling, Matthew *[a]; Stead, Michael [a]; Coulton, Paul [a]; Macpherson-Pope, Thomas [b]

[a] Lancaster University, Lancaster, United Kingdom
[b] The Making Rooms, Blackburn, United Kingdom
* m.pilling@lancaster.ac.uk

As the global consumption of electronic devices continues to grow, so too does the volume of electronic waste (e-waste) that reaches landfill sites, which by 2030, is expected to reach 74.7M tonnes worldwide. This problem is exacerbated by the fact that across Europe less than 40% of e-waste is subject to sustainable recovery and further reinforced by the planned obsolescence of devices. An increasing amount of e-waste can be characterised as so-called 'smart' Internet of Things (IoT) devices. This paper firstly describes how our research engaged with industry and community stakeholders to explore their perceptions and behaviours relating to electronic devices, specifically their understanding relating to the repairability, maintenance, and longevity of IoT devices.

Secondly, we describe the key workshop findings, revealing the current attitudes and behaviours towards IoT repairability and the participants future expectations for repairable IoT. Thirdly, we introduce a mobile experiential research platform and describe how this has previously been used to introduce stakeholders to the notion of *Human Data Interaction* (HDI) and the highly detrimental impacts of IoT-AI data generation on the environment. We conclude by describing the creation of a new interactive physical-digital experience for the platform which is based on insights synthesized from our explorative workshops and highlights how we have embedded a rhetoric of repair and maintenance of smart devices and IoT systems to encourage the development /resurgence of repair cultures to reduce the production of IoT e-waste.

Keywords: Repairability; Internet of Things; Experiential Futures; Sustainability

1 Introduction

Due to the growing 'smartification' of contemporary society, Internet of Things (IoT) devices have become a central facet of our day-to-day lives, particularly within the modern home. This is exemplified by the ubiquity of such devices as, mobile phones, thermostats, wearables, and personal assistants such as Amazon *Alexa*. However, as the global consumption of IoT devices continues to grow, so too does the volume of electronic waste that reaches landfill sites, which by 2030 is expected to reach 74.7M tonnes worldwide. This problem is exacerbated by the fact that across Europe less than 40% of e-waste is subject to sustainable recovery and is further reinforced by planned obsolescence – devices are purposely designed to have short lifespans as they are intended to be replaced by newer models. The repairability of IoT is thus currently not a major consideration for designers and manufacturers (Cooper & Salvia, 2018; Perzanowski, 2022)

In 2021 the UK government introduced the Eco-design for Energy Related Products and Energy Information regulations (Conway, 2021), commonly referred to as the Right-to-Repair (R2R), in efforts to stymie electronic product obsolescence. Unfortunately, this current R2R only applies to a limited range of household products, such as dishwashers and refrigerators, and does not consider the growing environmental and social impacts that result through the unsustainable production, consumption, and disposal of billions of networked IoT devices (Stead & Coulton, 2022). Alongside government efforts, there has also been a rise in activist groups like RepairEU (2023) and The Restart Project (2023) who have long highlighted the damaging impacts of e-waste and campaigned on the benefits of product repair and reuse in efforts to curtail the Western trend of disposing of electronics in their entirety (Cooper, 2010). Whilst the introduction of new legislation for EU/UK citizens is a step forward in tackling planned obsolescence and can undoubtedly be viewed as a positive outcome for the R2R movement, in the long term, the efficacy of the new R2R law will ultimately be reliant on citizens and their communities themselves of this right by building a capacity to repair. This research uses an interactive experience to reveal and highlight the potential agency that citizens could have in this process with the aim of altering people's behaviour and attitude towards their perceptions of the life cycle of IoT devices.

2 Explorative Workshops

In late 2021, we launched a pilot research project called *The Repair Shop 2049* to explore how design approaches can be harnessed to better understand how citizens' might be empowered to increase IoT device R2R within their local communities. Rather than investigate the aforementioned challenges at a macro level, such as through a national framework, we instead wanted to focus on the micro level - a localized and situated context for the future of IoT device repairability as we considered this to be a more effective means of discovering the public's current attitudes towards the sustainability of their connected devices. To aid this endeavour, we partnered with a well-connected community makerspace, *The Making Rooms*, which afforded us the opportunity to directly engage with a wide range of key stakeholders including repairers, technologists, civic leaders and ordinary citizens. This collaboration, we agreed, would help us to start to assess the effectiveness of current R2R legislation amongst local communities, and in addition, enable us to consider the role that design can make in facilitating such social and environmental transitions – both in practical and theoretical terms.

Thus, to better understand the current perceptions and behaviours relating to IoT devices and their repairability, we ran two co-design workshops (Sanders & Stappers, 2014). The first was used to gauge informed perspectives regarding current Right to Repair legislation, with nine participants representing industry experts, academia and local government stakeholders. The second workshop had twelve participants, representing local repair professionals, repair enthusiasts, makers, community group members, and focused on the participants lived experiences of the existing Right to Repair framework. The design of these workshops and detailed analysis of *The Repair Shop 2049* findings have been discussed in a previous paper (M. Pilling et al., 2022), as such, here we will describe only the key findings, which we have used to inform our interactive experiential repair future design process that we introduce later in this paper.

2.1 Workshop One

The participants in workshop one were predominantly male and ranged in age from early twenties to late fifties and represented professionals working in the IoT industry, consumer rights organisations, waste management professionals and academic researchers. The prevailing sentiment of the first workshop was one of disappointment towards the current R2R, resulting in the emergence of three key themes. These were:

2.1.1 The Difficulties of Repair

There was no shortage of criticism levelled at the lack of existing networks and infrastructure available for repairing IoT. Participants persistently pointed out that very few manufacturers are supportive of the R2R and that these entities hold dominion over the transition to IoT repairability. This hegemony is demonstrated by the way manufacturers continue to release products that are not designed to afford effective and efficient repair and reuse. *Participant 7 from Workshop 1* opined that this design *and* policy flaw was increasingly to blame for IoT devices becoming inoperable (or so-called 'bricked') when they are no longer supported by the manufacturer and/or associated service platforms, regardless of whether the devices' hardware remains functional.

2.1.2 Changing Attitudes

Crucially, participants also countered the above criticisms with several optimistic contributions regarding our relationship with IoT technology and its impact on the environment. It was stressed that there has been a perceptible shift in greater consumer adoption of professionally refurbished products in recent years, noting how more and more consumers are deciding that they do not always need to purchase a brand-new device nor the latest 'throwaway gadget'. The participants collectively determined that the impetus for this shift is likely to be the result of increased public awareness surrounding the global challenges that modern societies currently face, principally climate change and the need for Global North countries in particular to transition to more sustainable ways of living. Participant 2 from Workshop 1 stressed that there has been a perceptible shift in greater consumer adoption of professionally refurbished products in recent years. They noted how more and more consumers are deciding that they do not always need to purchase a brand-new device nor the latest 'throwaway gadget'.

2.1.3 Opportunities for Education

The final key theme that emerged from the first workshop is the potential to improve *knowledge and education of repair*. Representatives of the local council explained that there are plans currently being drawn up by the local educational authority to improve schooling and run specific lessons regarding basic electronics repair and reuse/recycling processes. This led to further discussions around the capacity for introducing electronics repair and reuse as fundamental and applied skillsets across UK STEM subject curriculums (STEM stands for *science, technology, engineering,* and *mathematics* – these four subjects are considered critical, inter-related disciplines in the UK education system). Participants

5 and 9 from Workshop 1 explained that there were plans currently being drawn up by the local educational authority to improve schooling and run specific lessons regarding basic electronics repair and reuse/recycling processes.

2.2 Workshop Two

The participants in workshop two were once again predominantly male but this time represented an age range of young adults through to retirees. The participants were all users of the community makerspace, but their experience with IoT ranged from expert users and developers to newcomers and novices with the technology being discussed. The discussions that occurred during the second workshop were similarly critical of the practices of IoT device manufacturers and the insufficiencies of current repair infrastructures. However, the conversations were primarily centred on the unsustainable behaviour and ongoing attitudes of consumers. Having analysed the workshop's data, a second set of three key themes emerged.

2.2.1 Distrust in the System

The community participants displayed an evident 'distrust in the system' when discussing both IoT manufacturers' ongoing unsustainable practices, and the current lack of local IoT repair/recycling infrastructures. It was also suggested that manufacturers are unethical in their approach to the design of current IoT devices as there is little to no support for their long-term durability and repair. Participant 6 from Workshop 2 bemoaned that in previous generations, electronics and electrical goods used to be 'socially valuable' and actively repairing such products was part of everyday life. They felt that these repair practices, businesses, and mindsets have all but been eroded over recent decades as technology has become widespread, cheaper and therefore more disposable.

2.2.2 Public Awareness and Education

The term *friction* was introduced by the participants to describe the barriers faced by consumers when trying to handle and dispose of their e-waste in a sustainably appropriate manner. The participants' consensus was that there is a collective 'want to do the right thing' regarding the e-waste they were generating but it was often unclear what this positive move could or should be and how they might initiate such a shift. *Participant 4 from Workshop 2* believed that this was in large part a cultural problem – specifically a Western mindset – as in other parts of the world they have very different attitudes towards the economic and social benefits of repair, with devices' ongoing repairability being a major factor when making the decision to purchase a particular product or not. Improving public awareness and education was consequently raised as a method for better equipping UK citizens and local communities with basic knowledge for understanding both their repair rights under the legislation and how to discern if an IoT device is likely to be repairable or requires further investigation and support from expert repairers/repair services.

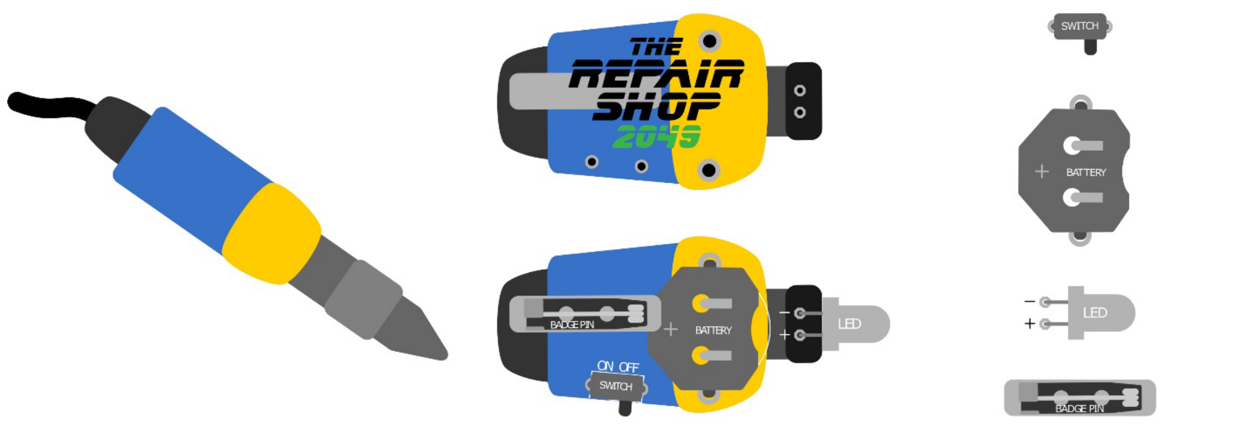
2.2.3 Local Solutions

Given the community-oriented pedigree of the participants, they were eager to highlight how to both 'localise' repair and reuse of IoT and emphasise that the solutions to do so were already present and correct within the community. A primary idea put forward was collecting e-waste from residents and/or refuse centres for refurbishment and materials and components recovery.

3 Physical Interactions

The above findings provided us with a range of long term challenges this research needs to address, however, we were also eager to produce some more immediate research interventions based on our data findings to ascertain if they resonated with a more general audience. Some of the most enthusiastic conversations occurred around education and skills, and how there is a want to do the right thing and an appetite for more repair, but there was perceived to be a lack of knowledge in this area regarding both the repair of electronics and the wider repair ecosystems that currently exist. As we had partnered with a local makerspace, the lack of skills and knowledge surrounding IoT device repair was considered to be an ideal starting point. It was therefore decided that we would design and manufacture a small electronic device that could be used to teach the rudimentary but necessary practical skills required for working with electronics. We therefore wanted to create a short and fun activity that would introduce absolute beginners to soldering and how to identify simple electronic components. This took the form of a functional LED badge that is supplied as a kit of parts, which can be quickly and easily assembled and soldered under the direction and supervision of makerspace technicians and volunteers. This has been successfully used at introductory electronics workshops which are regularly run by the makerspace and large external events that the makerspace has exhibiting at. The kit of parts comprises a PCB, switch, battery holder, cell battery and colour changing LED, as shown in Figure.1.

Whilst we do not presume that making this simple device will give people the knowledge or ability to tackle IoT device repair themselves, it does help to demystify electronics and show that they do have a greater agency when it comes to IoT device repair. These badges have proven to be highly effective at encouraging people to try out electronics and anecdotally there has been an enthusiasm from participants to develop further electronics skills.



Original Soldering Iron Diagram

Top: LED Pin Badge PCB
Bottom: Assembled LED Pin Badge

LED Pin Badge Components

Figure 1: The top diagram shows how the badge was developed and its constituent parts, the images below show the badges being assembled during an introductory electronics workshop.

4 Mobile Experiential Research Platform

The response to this small intervention has been overwhelmingly positive and encouraging, however, as the activity requires access to a soldering station, these badges are limited in their potential for outreach, beyond a makerspace or workshop environment. We therefore wanted an additional means of engaging with a large audience in a different environment. Fortunately for this research, we have access to a project called *The Future Mundane*, which developed a specially designed mobile experiential research platform. This too has been the focus of previous research papers (M. Pilling & Coulton, 2022), as such we will provide a brief overview of the project, which is necessary to understand our Research through Design approach (Durrant et al., 2017; Gaver, 2012) when designing an interactive physical-digital experience to promote the potential for repair of IoT devices.

The Future Mundane project presents an Experiential Future (EF)(Candy & Dunagan, 2017), the primary aim of which is to reveal that IoT, AI and data collection have become a central feature of our day-to-day lives, through the rising prevalence of what are oft described as smart products and services within our homes. Whilst computing power has been increasing over many years within such products with which we share our homes, to increase functionality and replace mechanical controls, it is the increasing "networkification" (Pierce & Disalvo, 2018) of these devices to facilitate new services that is fundamentally changing our relationships with them. To address this challenge, the term Human-Data Interaction (HDI) has been coined to describe this new area for research (Mortier et al., 2016) and guides the design of many of the experiences provided on the platform.

The creation of the mobile experiential research platform is a combination of breaching experiments (M. Pilling & Coulton, 2022) and *Design Fiction as World Building* approach (DFasWB) (Coulton et al., 2017), developed through the lens of *More-Than Human Centered Design* (MTHCD) in which considerations towards the values of non-human actants in these networks are also addressed. This research platform manifests as a teardrop caravan, chosen to maximise the audience that could be engaged with this research, beyond typical locations such as universities, museums, and exhibition spaces, as shown in Figure 2. The teardrop caravan houses a familiar representation of a (UK) living room (i.e., a sofa, TV, lamps, etc.) along with integrated smart devices and support for monitoring and capturing the experiences in an unobtrusive manner. Crucially, our worlding approach is used to disseminate our key research workshop findings to expand participants' knowledge of user legibility, negotiability, and agency towards smart devices and IoT systems. This also reflects a design choice which was taken as part of the design fiction as world building approach (Coulton et al., 2017), reflecting the mundane reality of how these technologies become part of our everyday lives.

The experience we describe in this paper relates to another project we have recently completed called the Edge of Reality (Stead et al., 2022) that was concerned with Human-Data Interaction and sought to make ongoing IoT-AI data operations more legible to users as well as empower them with levels of agency to negotiate how their data is managed, stored and shared between themselves and technology providers. This took the form of an interactive speculative game (Coulton et al., 2016) experience that revealed the carbon emissions ((F. Pilling et al., 2022)), the vast energy consuming infrastructure upon which they operate and the prodigious amounts of carbon emissions this produces, all of which actively contribute to climate change. By introducing the approach of More than Human Centred Design we explained that designers are able to make more robust considerations of the interdependent and independent perspectives of human and non-human (technological and ecological) actants that exist as part of today's networked design assemblages. The new repair experience that we describe here follows this same approach but instead focuses on improving peoples understanding of their lack of legibility, agency and negotiability in relation to managing the unsustainable impacts of their smart devices, specifically their current inability to repair data-driven IoT devices.

Figure 2: The Mobile experiential research platform is a customised teardrop trailer with a bespoke interior designed to look and feel like a living room, albeit it one from a near future with an increased number of electronic networked devices.

5 Interior Design

To sufficiently explain how a new digital/physical experience exploring the repairability of IoT devices will work within the existing setup, it is first necessary to describe the interior of this living room of the future and the devices that are integrated within. The primary design driver for the interior is the audience seating position, with all devices arranged in relation to this, as demonstrated in Fig.3. It was also necessary that the interior be flexible and adaptable to allow the integration of not only pre-identified electronic devices, but that it also provide the opportunity for additional new and emerging devices to be added for future iterations, adaptations to the experience or wholly new experiences. Due to this being a mobile platform it was also a necessity that everything be securely installed or fully integrated within the interior. It is important however that devices do not disappear from view, as suggested by 'ubiquitous computing' (*Mark Weiser*, 1991) but rather, and in stark contrast, that their behaviour, particularly in relation to data, are made legible without being overtly attention grabbing.

A typical experience begins with the participants seat themselves on the sofa in front of the television screen, as shown in Figure 4. The experience is then introduced using a voice user interface which seeks to gain consent from users to collect, process and store their data (the experience prints out a permission slip using the thermal printer which the audience must sign to proceed). Building on the work of Buchanan (1985), Bogost (2007) and Coulton (2015) we present the audience (player) with a procedural rhetoric, which is the practice of using interactive processes persuasively. As such each experience follow its own rhetorical path, for example in one experience a short drama is then played based on a profile generated by the system, during which time various IoT objects in the room begin to contribute to the immersion. For example, the windows become opaque, and the room's lighting adapts to each scene (the system 'knows' the outside weather and picks up a relevant colour gradient). When the lead character in the short drama is outdoors, the fan switches on, matching the wind blowing her hair. The music within the film is chosen dependent on the profile generated by the system, as is the chosen ending. The impact of particular data interactions which affect the drama do not immediately affect the media objects, which means that while each experience was uniquely tailored to the audience, they would not necessarily be able to see why or how.

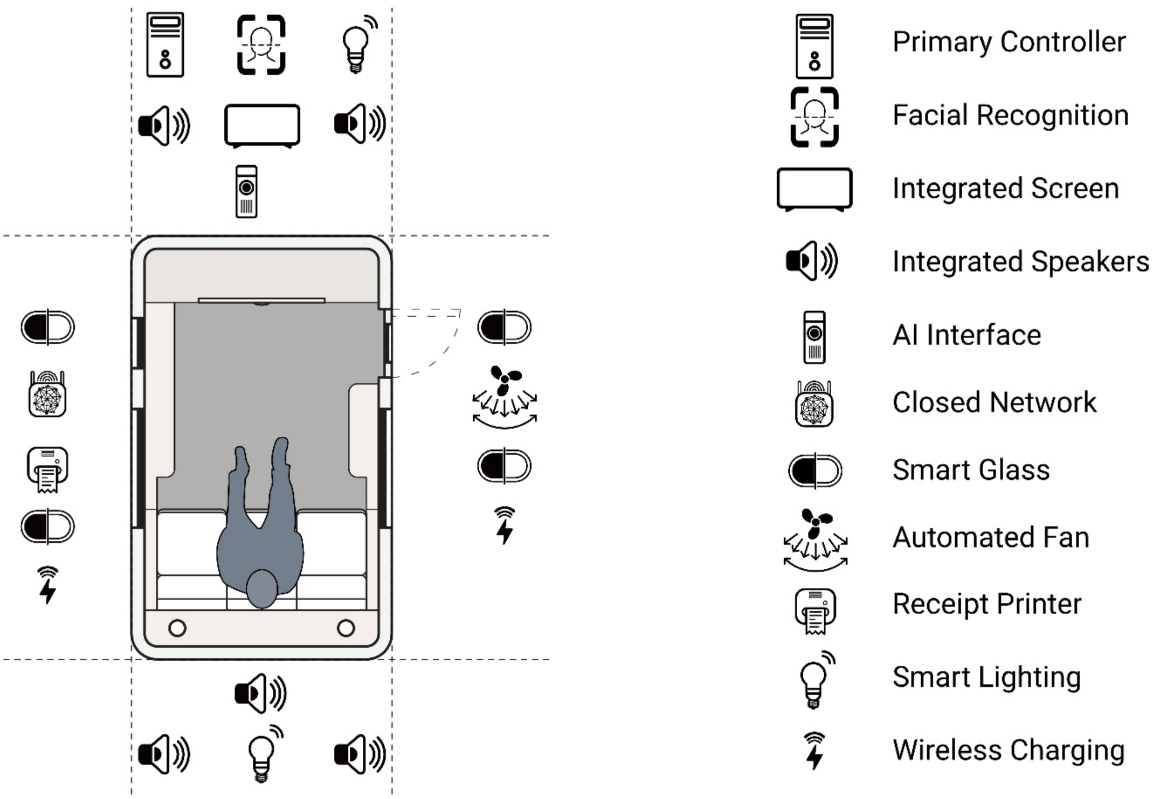


Figure 3: This diagram shows the interior plan of the caravan and indicates the location of each of the integrated devices that surround the viewer.

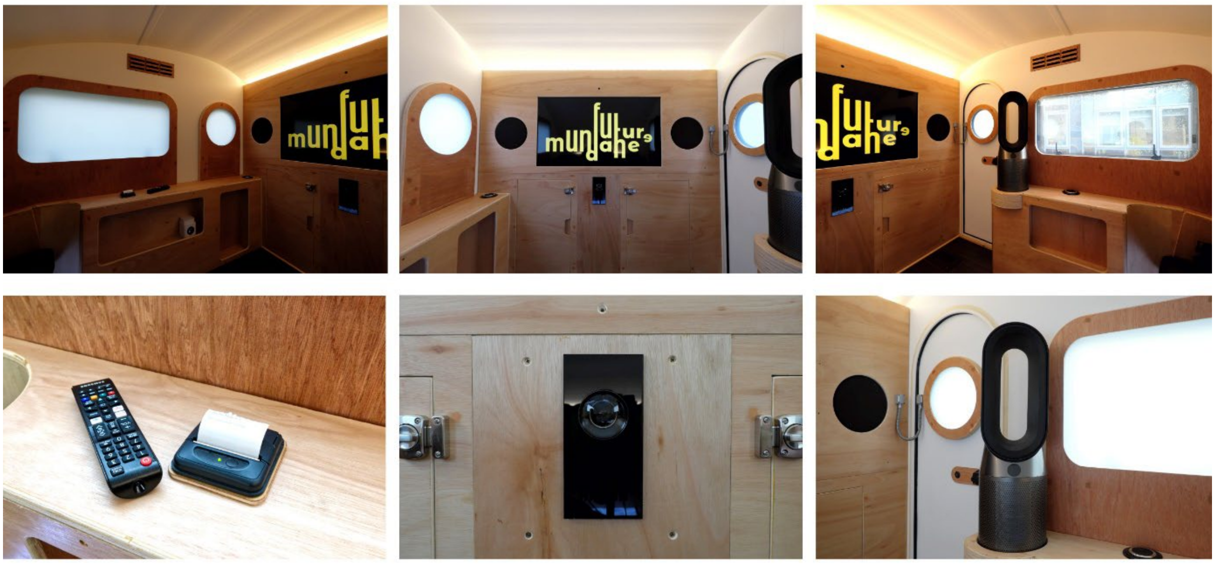


Figure 4: The top images show the audience view from a seated position inside the experience. The screen provides the primary focus for the experience, with additional interactive elements responding to both the short film being played on the screen and user interactions. The bottom images highlight some of the interactive elements that are integrated into the interior.

6 Fixing the Flux Capacitor

The repair experience makes use of all the existing connected devices and begins in a similar manner to the pre-existing experiences that have been described but differs in that the rhetoric embodied in the experience focuses on improving the participants' knowledge and agency towards the repair and extended use of physical smart devices and IoT systems. Blevis (2007) posits that sustainability can and should be a central focus of interaction design, which he refers to as Sustainable Interaction Design (SID), explaining that "design is defined as an act of choosing among or informing choices of future ways of being." This interactive experience addresses one of the main challenges of SID by promoting renewal & reuse and aligns with Stegall's (2006) claim that "the role of the designer in developing a sustainable society is not simply to create 'sustainable products,' but rather to envision products, processes, and services that encourage widespread sustainable behaviour." By drawing on the insights that were gleaned from *The Repair Shop 2049* workshops we were able to, to some degree, embody the notions of repairability and skills education into the experience. In the following sections we illustrate how this repair rhetoric is embodied in the experience we have designed.

The experience simulates a physical repair process for an integrated electronic device. This provides an opportunity to introduce members of the public to the possibilities of electronics repair in a safe and controlled way, by removing the potential harm caused by handling faulty components, such as batteries or power supplies. The users enter the caravan and once seated are introduced by the onboard AI voice that welcomes them to the living room of the future and are directed to make themselves comfortable. The voice then gives a brief overview of the main immersive devices that are installed in the space, such as activating the fan, the windows and lighting. After a short conversation with the viewer, they are asked if they are ready to begin, they are then directed to select a genre of film to watch as part of the experience, choosing from Action, Drama, Fantasy, Romance, Sci-Fi or Thriller. Once they have confirmed their choice the lighting and other environmental devices are activated to create the preprogramed conditions, intro music then begins to play, and the screen begins displaying the opening credits. Moments later however the video and audio begins to glitch and the surrounding smart devices begin to malfunction, at which point the onboard AI voice explains that they are experiencing technical difficulties and that they require the assistance of the users to try to diagnose and repair the faults. Users are then guided to locate a panel on the right-hand side of the interior (indicated in Fig.5) which they are then instructed to open. Within they find the caravans 'Flux Capacitor' (shown in Fig.6), a design which was chosen as a nod to the fictional device that powers the time machine vehicle in the sci-fi film series Back to The Future (Zemeckis & Gale, 1985). The user is told that the 'Flux Capacitor' is seemingly not operating as it should, but if they are willing, they can be guided through the process of identifying and then remedying the problem in order to get the experience back on track by manipulating the various components on the panel (listed in Fig.7). Though this interactive element to the experience is much more complex in appearance than the LED badge that we have discussed previously, the repair panel is presented in a playful manner and requires no specialist equipment or established knowledge.

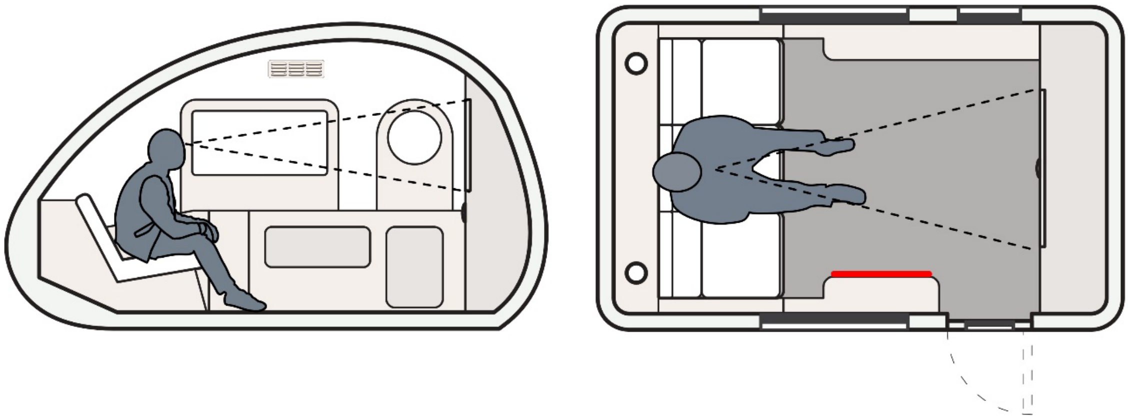


Figure 5: The interior of the caravan was designed to immerse the audience in an audio-visual experience, the red line highlights the location of the new 'Repair Panel' for the new experience.

The repair process comprises four stages, each representing a common activity in the diagnosis and repair of electronic devices, these are Fault Diagnosis, Parts Replacement, Electrical Testing and finally, System Reset. This demonstrates to those taking part in the experience that electronic devices can often be repaired rather than replaced. In stage one, Fault Diagnosis, the users are directed to activate the switches which are positioned along the bottom, in the sequence shown on the television screen. Each switch is used to represent a different aspect of the circuit and when each switch is depressed a sequence of lighting is activated on the 'Flux Capacitor' panel to indicate its current condition (shown in Fig.8). When the faulty circuit is activated, the lighting intermittently glows red to show the position of the fault on the panel. With this completed the users are then directed to press the 'Diagnosis Mode' key to indicate that this stage has been completed.

With the fault identified the users are then guided onto the second stage, Parts Replacement, whereby they are instructed to remove the three 'Control Crystals' which are presently slotted into the 'Flux Capacitor' (shown in Fig.9). Users are then directed to re-insert one of the 'Control Crystals' and set the corresponding rotary encoder to the required value by rotating the knob and tracking the progress on the integrated OLED screen. The same actions are then carried out for the remaining two 'Control

Crystals' and once again once complete the users are directed to press the 'Parts Replacement' key to indicate that this second stage has been completed.

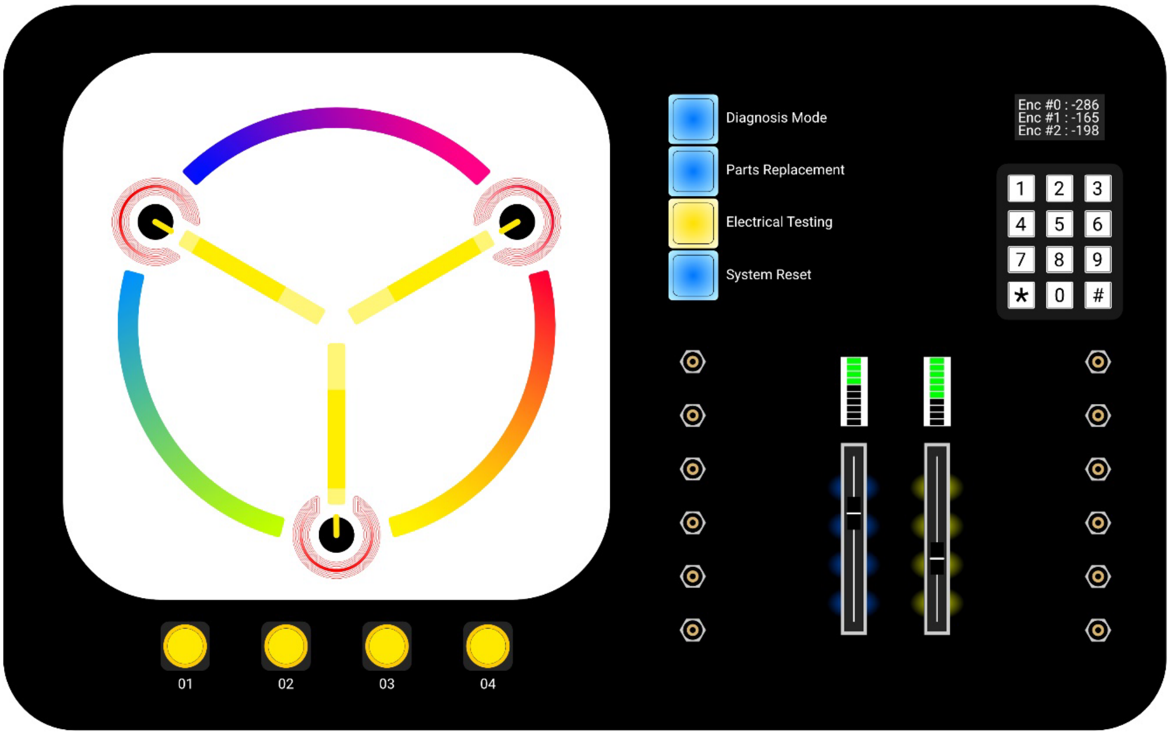


Figure 6: Once directed to do so the side panel is opened to reveal the faulty 'Flux Capacitor' that must be fixed in order to get the experience back on course. The onboard AI voice guides the user through the process, making use of the dials, switches, sliders and cables that are found within.

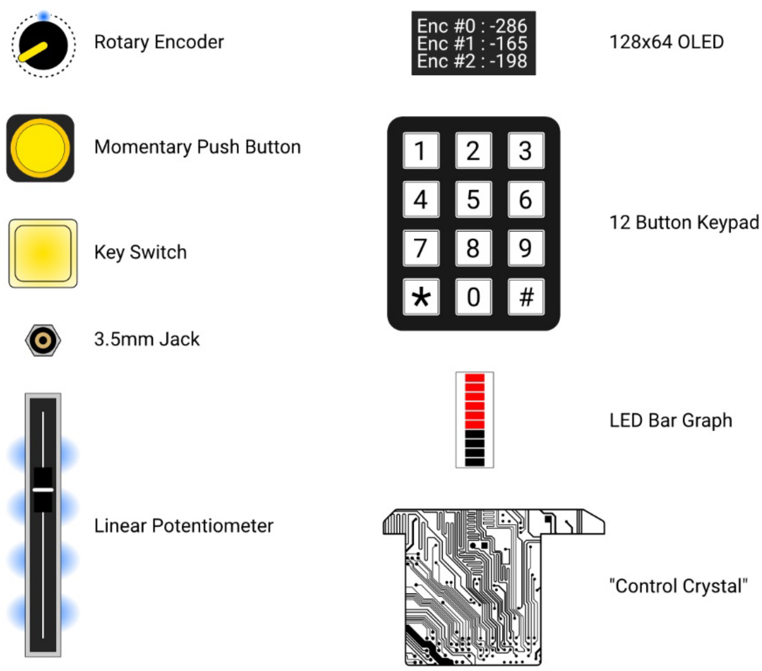


Figure 7: This legend identifies each of the components that makes up the 'Flux Capacitor' panel shown previously.

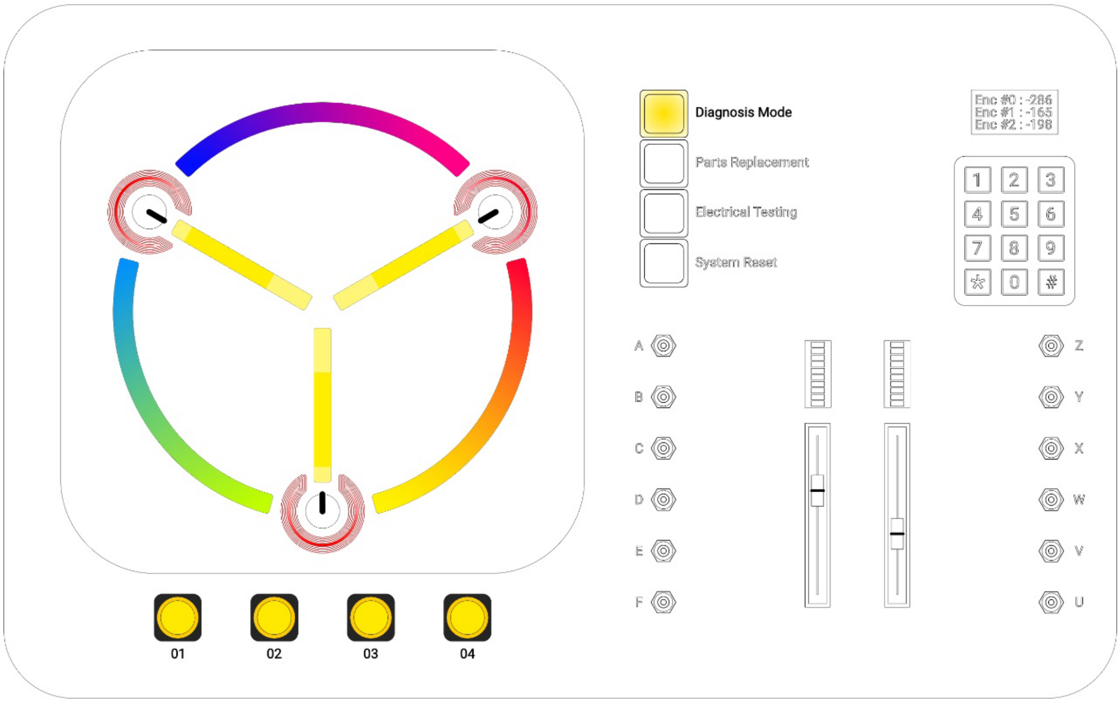


Figure 8: Stage 1 of the repair process involves putting the panel into 'Diagnosis Mode' and interacting with the components highlighted in colour.

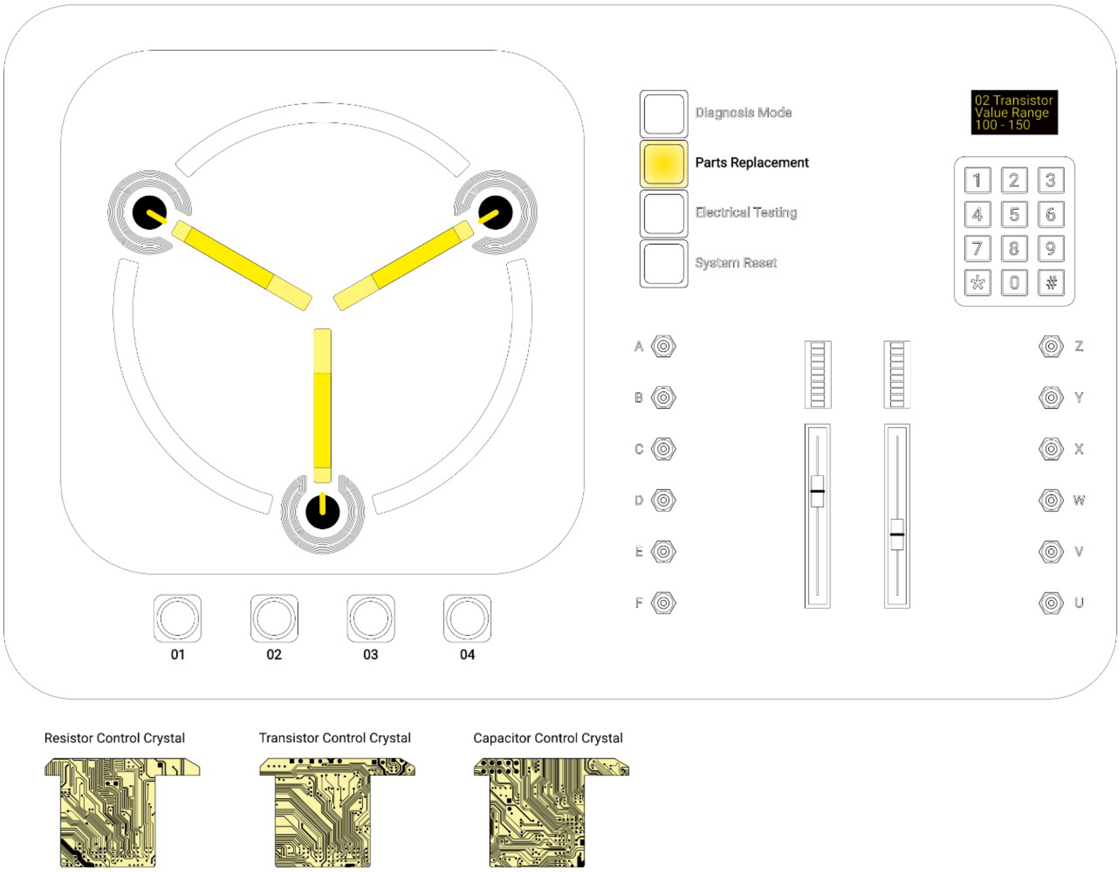


Figure 9: Stage 2 of the repair process involves putting the panel into 'Parts Replacement' mode and interacting with the components highlighted in colour.

It is now time for the third stage of the process which is ‘Electrical Testing’ which is necessary to ensure that the previous stages have been carried out correctly and that the problem has in fact been addressed. The users are first instructed to remove all the patch cables that are currently connected and then slide the two linear potentiometers to their lowest position, ensuring that the LED indicators are showing zero values (shown in Fig.10). Users are then instructed to slide each of the linear potentiometers up until they are positioned within the value range as shown on the OLED screen, which is aided by the LED indicators and the use of colour lighting to indicate when the correct position is being reached. With these values locked in the users are then instructed to plug in the patch cables in a specific order, such as A-V, C-Z etc, until each of the sockets has been connected. Once the final two sockets are connected the lighting on the ‘Flux Capacitor’ begins to pulse to show that the circuit is now operational. When this is completed, users are instructed to press the ‘Electrical Testing’ key to indicate that this third stage has been completed.

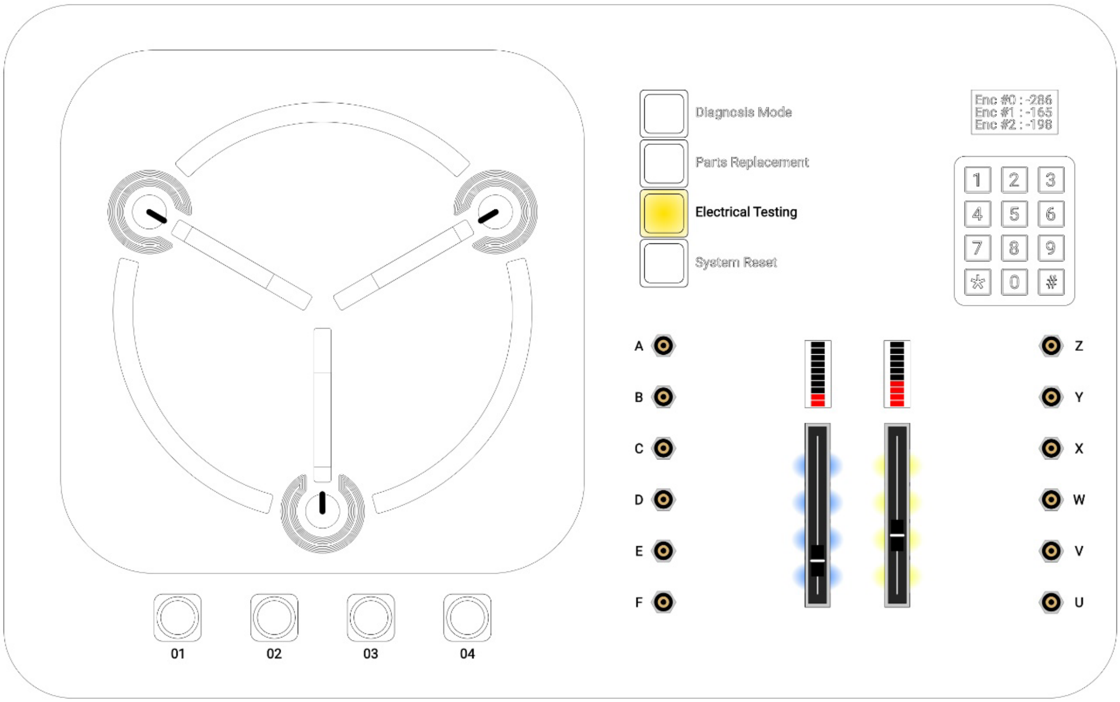


Figure 10: Stage 3 of the repair process involves putting the panel into ‘Electrical Testing’ mode and interacting with the components highlighted in colour.

The final stage is ‘System Reset’ which shuts down the control system to ensure that the changes have taken effect once restarted. To restart the control panel the users are given a 16-digit code to enter using the keypad, this is both shown on the television screen and read out to them by the onboard AI voice (as shown in Fig.11). Once this code has been keyed in correctly the control board begins to cycle through a boot up sequence, represented by different elements of the board lighting up to indicate that they are now back online. With all the components successfully back online, users are instructed to press the ‘System Reset’ key to indicate that fourth and final stage has been completed, they are then further instructed to close the panel and once again take a seat.

The lighting and other environmental devises are once again activated, in accordance with the user’s chosen genre of media, the screen flickers back to life just in time to see the end credits rolling. The audience is then informed that unfortunately they have just missed the short film but are thanked for fixing the experience in time for the next visitors, they are then kindly asked to exit through the gift shop, at which point the windows once again become transparent and the lighting returns to normal.

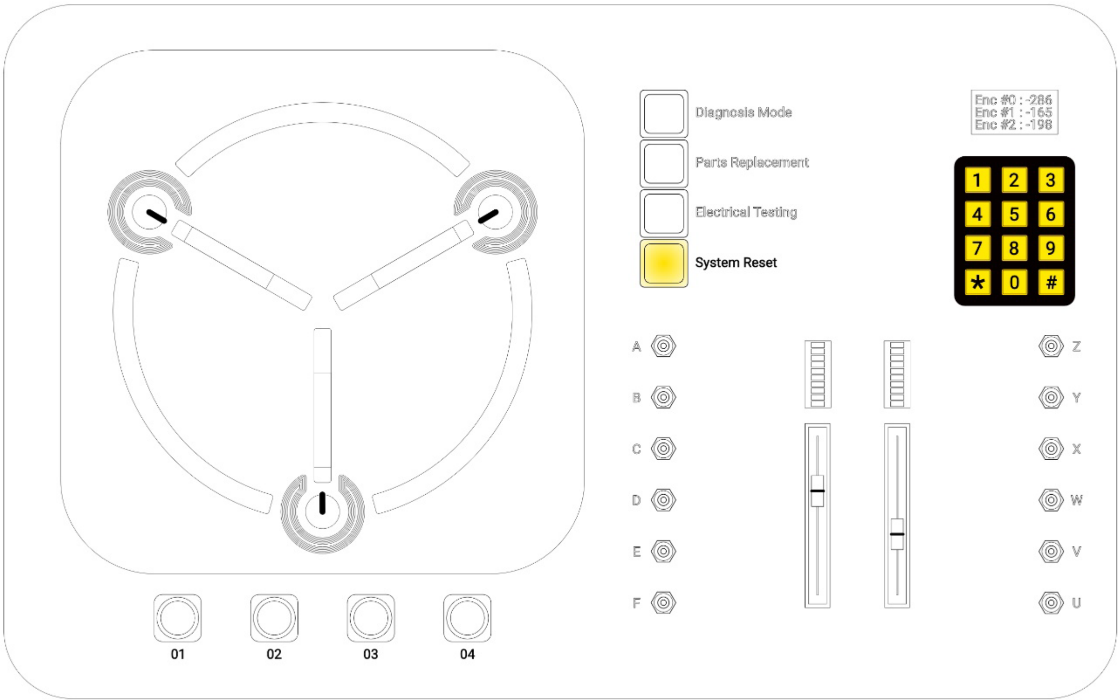


Figure 11: Stage 4 of the repair process involves putting the panel into 'System Reset' mode and interacting with the components highlighted in colour.

7 Conclusion

This paper has described the motivation for the design and development of an interactive physical-digital experience intended to raise public awareness of user agency regarding the repair of smart devices and IoT systems. This has been created in direct response to the findings of our early workshop sessions and represents our first steps in efforts to tackle the problems that the participants of the initial workshops highlighted. Primarily these being the throwaway electronic device culture that persists across society, the need for training in relation to IoT device repair, as well as improving access to knowledge and tools and raising public awareness around these issues, which were considered to be necessary if we are to transition from merely a right to repair towards having the capacity to repair. The other findings from these initial workshops will be used to inform longer term aims of this project, but we consider these two early interventions, the LED badge and Repair Panel, to be important steps in raising awareness around these issues as it has already been established that interactive technologies can be used to promote more sustainable behaviours and practices (Blevis, 2007). Building upon our previous research and design of interactive experiences (Stead et al., 2022) we consider that the immersive, interactive nature of the repair experience means audiences are, to a degree, diegetically (through narrative and storytelling) situated within mimesis – as if they are directly experiencing or 'living' the future world. Indeed, in the artificial (and intentionally players) world, players engage with a procedural rhetoric which explores and drives their experience to highlight that with the right knowledge and skills physically diagnosing and then repairing IoT-AI devices and systems can be a practical reality.

8 Future Work

The research presented here is the early manifestation of a much wider project exploring the future of repairability of smart devices. The initial workshops revealed a range of challenges that will need to be addressed by this research, and there will undoubtably be more as this research progresses. There are already plans for further work that will focus on the linking invention & disposing principle which seeks to ensure that the design of any new objects or systems is accompanied by an account of what will become of the of the objects or systems they are intended to replace. However, as stated at the beginning of this paper, ultimately the efficacy of the new R2R legislation and the success of research of this kind will be measured by the number of citizens and their communities availing themselves of this right. As such, this experience will be showcased at regional/national events to ensure that a wide and varied sets of participants can engage with the ideas it embodies. There will also be workshops designed to work around it and to gather feedback that will influence future iterations of the experience. Essentially, it is intended that this interactive experience and our wider research will successfully provide citizens and communities with an understanding of how a capacity to repair might be built for the increasingly prevalent smart devices they will purchase and use which will benefit both the planet and its inhabitants.

References

Blevis, E. (2007). Sustainable interaction design: Invention & disposal, renewal & reuse. *Conference on Human Factors in Computing Systems - Proceedings*, 503–512. https://doi.org/10.1145/1240624.1240705

Bogost, I. (2007). *Persuasive Games: The Expressive Power of Videogames*. MIT Press.

Buchanan, R. (1985). Declaration by Design: Rhetoric, Argument, and Demonstration in Design Practice. In *Design Issues* (Vol. 2, Issue 1).

Candy, S., & Dunagan, J. (2017). Designing an experiential scenario: The People Who Vanished. *Futures*, *86*, 136–153. https://doi.org/10.1016/j.futures.2016.05.006

Conway, L. (2021). *Right to Repair Regulations: Research Briefing Number 9302*.

Cooper, T. (2010). *Longer Lasting Products Alternatives To The Throwaway Society*. Routledge.

Cooper, T., & Salvia, G. (2018). *Fix it: barriers to repair and opportunities for change* (p. IN PRESS).

Coulton, P. (2015). *The role of game design in addressing behavioural change*.

Coulton, P., Burnett, D., & Gradinar, A. (2016, June 25). *Games as Speculative Design: Allowing Players to Consider Alternate Presents and Plausible Features*. https://doi.org/10.21606/drs.2016.15

Coulton, P., Lindley, J., Sturdee, M., & Stead, M. (2017). Design Fiction as World Building. *Research through Design 20171*, 1–16. https://doi.org/10.6084/m9.figshare.4746964.

Durrant, A., Elsden, C., Chatting, D., Green, D., Kirk, D., & Abacus, D. (2017). Abacus Datagraphy : A Speculative Enactment. *Proceedings of the 3nd Biennial Research*

Through Design Conference, *March*, 148–162. https://doi.org/10.6084/m9.figshare.4746961.Image
Gaver, W. (2012). What should we expect from research through design? *Conference on Human Factors in Computing Systems - Proceedings*, 937–946. https://doi.org/10.1145/2207676.2208538
Mark Weiser. (1991).
Mortier, R., Haddadi, H., Henderson, T., McAuley, D., Crowcroft, J., & Crabtree, A. (2016). Human-Data Interaction. In *The Encyclopedia of Human-Computer Interaction* (2nd ed.). Interaction Design Foundation.
Perzanowski, A. (2022). *The Right to Repair*. Cambridge University Press. https://doi.org/10.1017/9781108946926
Pierce, J., & Disalvo, C. (2018). Addressing Network Anxieties with Alternative Design Metaphors. *CHI2018*. https://doi.org/10.1145/10.1145/3173574.3174123
Pilling, F., Stead, M., & Gradinar, A. (2022). *The Prometheus Terminal: Worlding Games for the Adoption of Sustainable Datafication and Cybersecurity practices*.
Pilling, M., & Coulton, P. (2022, June 16). *Experiencing mundane AI futures*. https://doi.org/10.21606/drs.2022.283
Pilling, M., Stead, M., Gradinar, A., Remy, C., & Macpherson-Pope, T. (2022). *Preparing to Repair: Using Co-Design and Speculative Design Methods to Explore the Future of IoT Right-to-Repair with Citizens and Communities*.
Right to Repair Europe. (2023). https://repair.eu/
Stead, M., Coulton, P., Pilling, F., Gradinar, A., Pilling, M., & Forrester, I. (2022). More-than-Human-Data Interaction. *ACM International Conference Proceeding Series*, 62–74. https://doi.org/10.1145/3569219.3569344
Stegall, N. (2006). Designing for Sustainability: A Philosophy for Ecologically Intentional Design. In *Design Issues* (Vol. 22).
The Restart Project. (2023). https://therestartproject.org/
Zemeckis, R., & Gale, B. (1985). *Back to the Future*. Universal Pictures.

About the Authors:

Matthew Pilling: is a Senior Research Associate in the exploratory design-led research studio Imagination Lancaster. His research explores the role of design in futures thinking, with a particular focus on socio-technical imaginaries and futures visioning.

Michael Stead: is Lecturer in Sustainable Design Futures at Lancaster University. His current research focusses on how design can help society to better understand the socio-technical implications that data-driven technologies like IoT, AI and digital fabrication pose for achieving Circular Economy and Net Zero goals.

Paul Coulton: is the Chair of Speculative and Game Design in the open and exploratory design-led research studio Imagination Lancaster. He uses a research through design approach to create fictional representations of future worlds in which emerging technologies have become mundane.

Thomas Macpherson-Pope: is the director of The Making Rooms, a makerspace in Blackburn, dedicated to training individuals and organisations in creative

technologies. He has a background in educational electronics and searches for new sustainability concepts to bring to Blackburn.

Acknowledgement: This work was conducted in conjunction with colleagues at The Making Rooms Blackburn as part of the Fixing the Future: The Right to Repair and Equal-IoT research project which has been funded by the UKRI EPSRC Equitable Digital Society grant number EP/W024780/1.