A More-than-Human Right-to-Repair

Michael Stead,[a]* Paul Coulton[a]

[a]ImaginationLancaster, School of Design, Lancaster University, UK
*m.stead1@lancaster.ac.uk
https://doi.org/10.21606/drs.2022.718

Abstract: Whilst the recent introduction of the *Right-to-Repair* to European citizens is undoubtedly a step forward in tackling planned obsolescence, and the resultant deluge of electronic product waste – the efficacy of this new legislation is reliant on consumers availing themselves of this right. Given that repairing and maintaining devices will often require specialist knowledge and skills, it is difficult to assess how effective this right may prove to be in practice. To address this concern, we draw from the expanding infusion of *datafication* and *Artificial Intelligence* into everyday products and services via the *Internet of Things* to consider alternative futures whereby the *Right-to-Repair* is granted to the device itself. Building upon *More-than-Human-Centred Design* approaches, we explore the potential embodiment for such a perspective and present two *Speculative Designs* that concretise this consideration: the *Toaster for Life* and *The Three Rights of AI Things*.

Keywords: Right-to-Repair; More-Than-Human-Centred Design; Artificial Intelligence; Sustainability

1. Introduction

The introduction of EU legislation for the *Right-to-Repair* (R2R) (European Commission, 2020) has been hailed as a significant step forward in helping European countries address the 12013 kilotons of electronic waste (e-waste) being generated across the continent each year (Global E-waste Statistics Partnership, 2021). E-waste is the fastest growing waste stream in the world and primarily consists of discarded household consumer products and appliances – a growing number of which are networked or so-called 'smart' *Internet of Things* (IoT) devices (Stead, Gradinar & Coulton, 2020). Currently, less than 40% of the EU's e-waste is subject to any form of sustainable recovery, that is, 'post-lifespan' processes such as material recycling and the harvesting of reusable componentry (EC.Europa.EU, 2021). E-waste is consequently a significant contributor to the rise in harmful carbon emissions which are fuelling global climate change. Thus, the drive to develop new ways to extend and improve the lifespans of electronic devices feeds into wider societal efforts to keep global temperature increases to a maximum of 1.5 °C, as well as to meet ambitious *Net-Zero* decarbonisation targets by the year 2050 (IPCC, 2021).

2. A Restricted Right-to-Repair

Although *Apple* recently announced that it will make certain parts, tools, and manuals for its devices available to US consumers from early 2022 (Schroeder, 2021), the country's lawmakers have been hesitant to reform R2R policy (Kimball, 2021). This is because technology giants (including *Apple*) have long resisted new legislation, often by spending millions of dollars lobbying against such proposals. R2R legislation did however come into force across the EU in July 2021 (Schneider, 2021). Yet, the hyperbole surrounding the new policy is somewhat overblown. Although it requires manufacturers to begin to (re)design products for repairability, the law has been already criticised by many sustainability organisations and activists as it does not seek to ensure that spare parts and repair services will be affordable or that consumers will have access to the information they require to personally carry out repairs (Peake & Vallauri, 2021). Fundamentally, peoples' R2R their products will remain impeded as only 'authorised' third parties can carry out the work. This will likely increase inequalities for some groups – particularly in relation to the costs of repair and servicing.

The law's focus is also currently limited to washing machines, dishwashers, refrigerators and televisions (Which?, 2021) and does not account for the growing environmental and social impacts of billions of IoT products – it is estimated that by 2030 there will be over 25 billion active IoT physical devices worldwide (Statista, 2021). Although electronic product repair is a more regular occurrence in a number of *Global South* countries (Beniwal, 2020), the complex, physical-digital nature of the IoT is making it harder to maintain and repurpose these types of devices, which are now proliferating the *Global North.* R2R activist groups like *RepairEU* (2021) and *The Restart Project* (2021) are therefore striving to curtail the Western trend of disposing of redundant IoT devices in their entirety. Rooted in maker, hack and open-source communities, the movement aligns closely with *Circular Economy* thinking (Ellen MacArthur Foundation, 2021).

Despite such efforts, the R2R one's own IoT devices remains, for now at least, *a vision of the future*. To address this concern, we draw from the expanding infusion of *datafication* and *Artificial Intelligence* (AI) into everyday products and services via the IoT, to consider an alternative future whereby the R2R is granted to the devices themselves. Drawing from *More-than-Human Centred Design* approaches, we explore the rationale for such a perspective and present two *Speculative Designs* that illustrate and concretise this consideration: the *Toaster for Life* and *The Three Rights of AI Things.*

3. More-than-Human-Centred Design

To address R2R in the context of IoT products and systems, we must first acknowledge that the increasing 'networkification' (Pierce & DiSalvo, 2017) of computationally enabled devices fundamentally changes our relationships with them. This is because there is an increasing disparity for users – between what the devices "actually are and do and the ways in which they are presented as things for use" (Hauser, Redstrom, & Wiltse, 2021, p.1). The addition of networked services compounds this as it arguably leads to a shortening of the lifespan of such devices through *systemised obsolescence*, in that, while software for these products can (for a period at least) be upgraded via remote installation, we increasingly see their hardware rapidly rendered obsolete due to manufacturers' and service providers' constant drive to extend the functionality and data capture capabilities of these devices and services. Such redundancy increasingly contributes to the production of e-waste. These issues are amongst the reasons that a growing number of design researchers are arguing that substantial limitations stem from established anthropocentric framings of design, particularly those framings enacted in the approaches associated with *Human-Centred Design* (HCD) (Disalvo & Lukens, 2011; Forlano, 2017; Galloway, 2017). In HCD, the human (predominantly conceived as the user) and their perceived task are placed at the centre of the design process and resultant designed activity. This myopia leads to an obfuscation of the wider implications of performing the activity, such as the social impacts or environmental effects. With this in mind, we explore the need for adopting *More-than-Human-Centred Design* (MtHCD) approaches.

The origins of the term *More-than-Human* appears to originate in the field of *cultural geography* (Whatmore, 2006) where it has been employed to promote a shift from largely anthropocentric perspectives to one that acknowledges our relationships to and within complex ecological assemblages. As Coulton & Lindley (2019) argue, designers need to acknowledge humans are rarely the centre of things but rather we exist within complex interdependences of human and non-human actants which are emotionally, economically and morally independent of each other. This creates the need for MtHCD. Although attaching the *More-Than* prefix infers a criticism of HCD, this does not extend to the entirety of what HCD encompasses nor all HCD-informed projects. Rather, the aim is to shift focus from the individual actant to what might be considered a focus towards the 'common good', in that, an action by an individual is presented within the context of their membership of a community of numerous actants. Thus, in this paper, we utilise MtHCD to explore the role of technological non-human actants within networked design assemblages and how these interrelations in turn impact upon the biotic non-human actants – flora, fauna and climate – that exist within the said same assemblages.

The ubiquity and longevity of HCD is indicative of how it has been successfully leveraged to help design devices that are efficient, effortless, and edifying to use. A key factor in how HCD achieves this rests in its aim of reducing complexity (or conversely as it is oft interpreted, *increasing simplicity*). 'Simplicity', in HCD terms, echoes the Heideggerian notion of 'ready-to-hand' in that it suggests that the artefact being designed should fade into the background and become invisible (Heidegger, 2010). In essence, any complexity that remains should be that of the underlying task and not of the tool designed to achieve the task (Norman, 1998).

Although HCD's invoking of simplicity is well reasoned and, in the right circumstances, can produce desirable outcomes, it is also true that "if simplicity is treated dogmatically, it can import risk into design processes" (Coulton & Lindley, 2019, p.466). By obscuring the tangible, material affects that occur outside of the boundaries of the immediate task, design approaches that prioritise simplicity are increasingly problematic in relation to the evolving societal, economic and environmental challenges that today's cultures and communities now face. This problematising of HCD emphasises the need to develop MtHCD approaches which allow designers to make more robust considerations of the interdependent and independent perspectives of human and non-human (technological and biotic) actants that exist as part of today's networked design assemblages.

3.1 Object-Oriented Ontology

The *More-than-Human* approach we consider and advance in this paper is based on the contemporary presentations of *Object-Oriented* philosophies as put forward by scholars including Graham Harman (2018), Timothy Morton (2013), and Ian Bogost (2012). Our key argument is for the use of *Object-Oriented Ontology* (OOO) and principally its rejection of *correlationism* – the notion that human minds and bodies are not the only actants worth countenancing. Differently, through OOO, we adopt a *flat ontology* perspective where all human and non-human actants – people, objects and the natural world – are given equal footing within the design assemblage. Adoption of this equilibrious standpoint is beginning to present challenges for those designers and technologists whose approach is predicated upon the ubiquity and dogma of HCD which places the human-object relationship at the centre of the technological design process (Lindley, Akmal, & Coulton, 2020). Importantly, whilst we are problematising HCD, rather than a complete rejection of its principles, our argument is primarily against how HCD manifests itself in the creation, and consequently, use of many of our designed artefacts. We do this to promote encompassing socio-technical outcomes that curtail anthropogenic dominance and instead begin to support *the common good in relation to climate change and planetary sustainability*.

3.2 The Plurality of Futures

Rooted upon OOO, MtHCD allows us to consider an alternative to HCD. However, we are left with the consideration of the possible alternate futures that the adoption of a MtHCD approach could potentially lead to. Considering the future is generally seen as an integral part of all design practice and is often used to highlight the potential of emerging technologies (Berry, 1975). These promulgations are often put forward by technology corporations and are imbued with a rhetoric that these companies provide the gateway to efficient, desirable and benign technology driven futures. Yet, if we are to offer alternate futures that specifically address climate change and support planetary sustainability, we need to consider the current frameworks that facilitate the creation and negation of such potential futures. Crucially, we need to expand upon these framings to allow for a *plurality* of different perspectives. The dominant approach is to present futures as scenarios based on *qualifiers* – the most common qualifiers being *probable, plausible, possible*, and in some cases the addition of *preferable*. It is this framing which is presented through the much-hyped *Futures Cone* of Joseph Voros (2003). As these qualifications are subjective, they are open to interpretation but could be considered as: *possible* – might happen, *plausible* – could happen, and *probable* – likely to happen. The notion of 'preferable', which can occur within any of the qualifiers, has become increasingly contested as it is seen as often promoting the privileged vantages of the *Global North* (Prado & Oliveira, 2014; Mitrović, 2018) leading to the assertion that 'preferable' should be a question the designers ask of themselves within the design activity rather than an aim of the design (Coulton, Burnett, & Gradinar, 2016). Further, whilst 'possible' encompasses all potentialities when addressing particular challenges, it is 'plausible' and 'probable' which are most often utilized by designers, although for topics that cannot be easily defined and therefore many of its aspects could be considered as either 'plausible' or 'probable' dependent on your particular point of view. It has thus also been suggested to use 'plausible' to embrace both qualifiers to prevent discussions over the perceived differences in perceptions (Coulton, Burnett, & Gradinar, 2016).

Further, the *Futures Cone* is presented in a way that suggests a universally accepted consideration of the present, with no influence drawn from our perceived history or even how fictional representations of the world help to foster our particular *worldviews*. The cone therefore fails to acknowledge how these will combine to influence the futures presented (Gonzatto, van Amstel, Merkle, & Hartmann, 2013). We can also draw from the writings of Arturo Escobar in *Designs for the Pluriverse* (2018) to recognise how the differences in lived experiences of individuals and communities from around the world will also have significant implications for these factors. This inherent plurality results in an urgent requirement for practitioners to consider a wide range of *pasts, presents, and futures* when conducting their design processes:

> "[The] transition from the hegemony of modernity's one-world ontology to a pluriverse of socio-natural configurations." (Escobar, 2018, p.4).

To acknowledge this requirement and to further cement our previous discussion on the need for *More-than-Human* perspectives in design, in Figure 1, we offer an alternative to the *Futures Cone* that allows the consideration of a *plurality of futures* for both human and non-human actants.

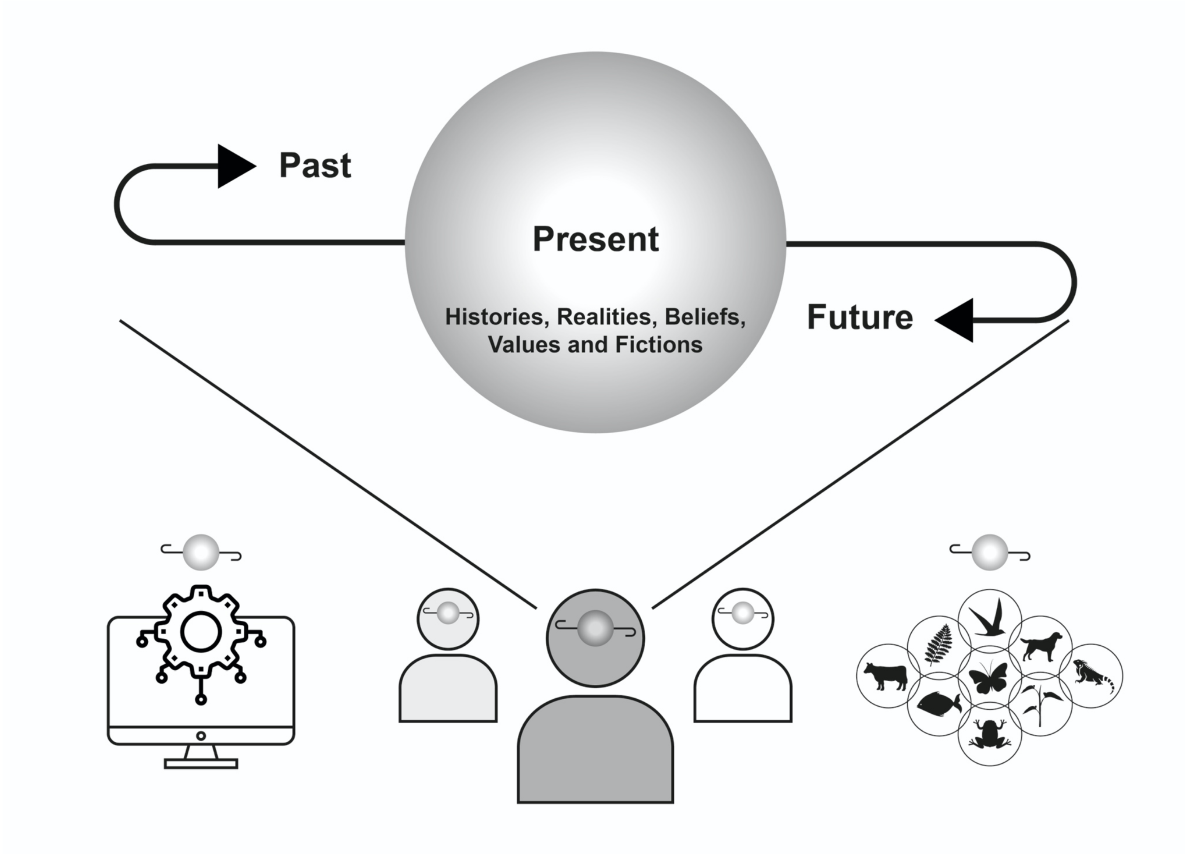

Figure 1 The plurality of More-than-Human futures (building upon Gonzatto, van Amstel, Merkle, & Hartmann, 2013).

3.3 Defuturing futures

Whilst *futuring* can help to highlight potential benefits of emerging technologies, it also operates in tandem with *defuturing*. As we noted, corporate visions regularly present futures which invoke a rhetoric that suggests that the products and services of the particular organisation are (or soon will be) the deliverers of these futures (Coulton & Lindley, 2017). In his book *Defuturing: A New Philosophy*, Tony Fry (2009) stresses the active role that designers play in creating unsustainable futures through the design and implementation of the products and services that we create. Fry asserts that because we materially consume large amounts of natural resources through our design activities, we are negating potential futures for both ourselves and for the other non-human actants with whom we share this planet. He argues we do this because:

> "Fundamentally, we act to defuture because we do not understand how the values, knowledge, worlds and things we create go on designing after we have designed and made them." (Fry, 2009, p.10).

Fry's observation embodies much of our previous argumentation, specifically the need to move towards *More-than-Human* approaches as well as emphasise that designers should broaden our perspectives when considering a particular design challenge. To this end, Fry suggests designers should seek to:

> “Disclose the bias and direction of that which is designed and how it is totally implicated in the world we conceptually constitute, materially produce, waste (rather than consume), occupy and use as an available material environment.” (Fry, 2009, p.10).

This means to broadening of design considerations is behind Coulton and Lindley’s (2019) introduction of *constellations* which seek to expose the independent and interdependent perspectives that exist throughout networked assemblages. We build upon this concept in Figure 2. Our *Defuturing Ontography* illustrates the *defuturing* potential of such human/non-human design assemblages and places particular emphasis on the impacts relating to the production, operation and disposal of our current IoT products and related services.

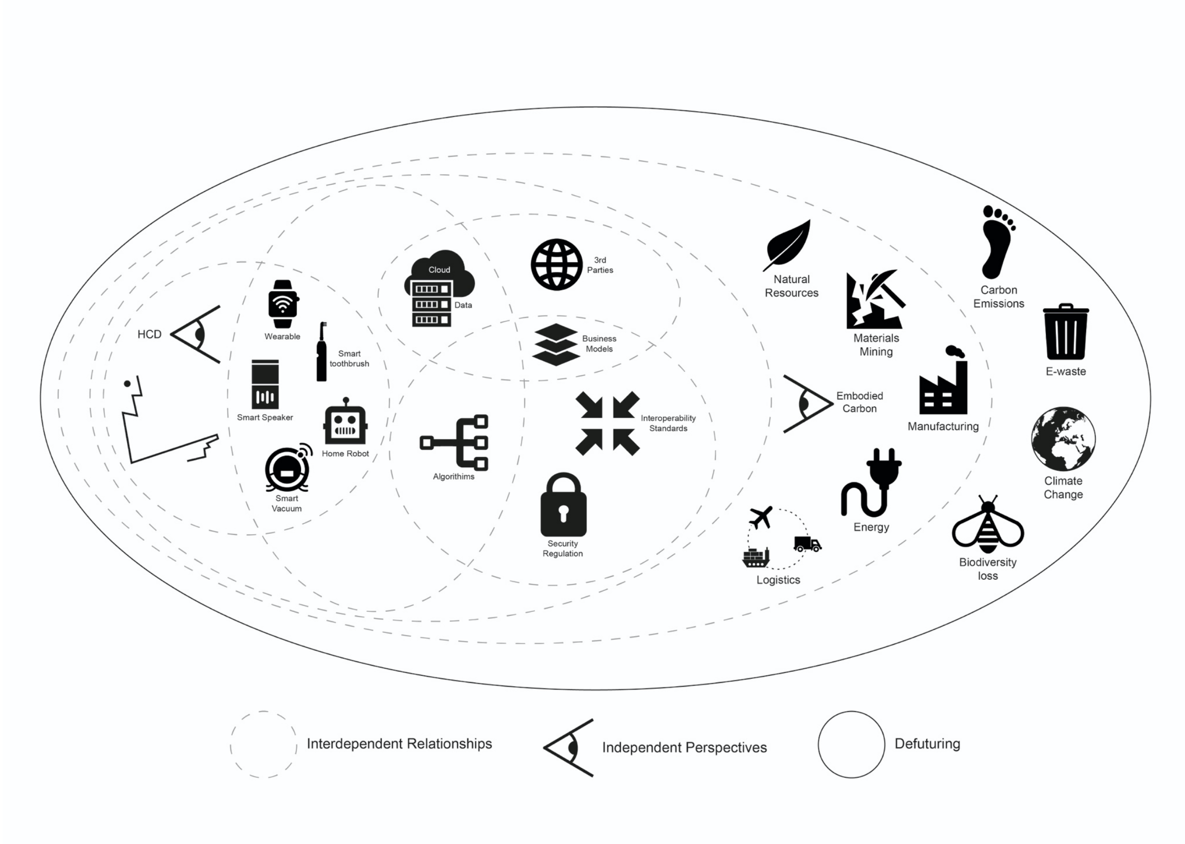

Figure 2 Defuturing Ontography (building upon Coulton & Lindley, 2019).

Significantly, whilst we have put forth both a rationale for MtHCD and a scaffold for how to approach futures in which it may be enacted, we are still left with the question of how MtHCD might be enacted directly *within design practice*. To address this, we will now consider how the approach might manifest in potential futures for R2R using the *Speculative Design* technique *Design Fiction as World Building*.

4. A More-than-Human Right-to-Repair

The application of *Design fiction* should not be seen as an attempt to predict the future or method for generating a specific 'product solution' but as a strategy for enabling more inclusive debate about how and why socio-technical futures are being designed and what they might mean. Importantly, the concept of *world building* is core to this research and as Coulton et al (2017) assert, collections of *Design Fiction* prototypes, when viewed together, scaffold a proximate fictional world in which new technologies can plausibly exist and then be more thoroughly considered - by practitioners and wider audiences alike. Accordingly, we embodied our *More-than-Human Right-to-Repair* (MtHR2R) visions as multiple prototypes which all exist within the same *Design Fiction* world. Given that *Design Fiction* prototypes are also free of commercial constraints such as usability, aesthetics and cost, our fictive devices are able to go beyond standard cycles of socio-technical innovation (Bleecker, 2009, Auger, 2013). This provides a lens to consider how a MtHR2R approach might manifest in potential sustainable futures which address *the common good in relation to planetary sustainability*.

4.2 A Toaster for Life?

The *Toaster for Life* (TfL) is a *Design Fiction* that embodies Sterling's (2005) concept of *spimes* which, when viewed simply, are a class of near future, sustainable, networked objects, designed to make the implicit impacts of a technological product's entire lifestyle more explicit to its potential users (Stead, 2016). The TfL (Figure 3) is designed to incorporate innate sustainable attributes including the ability to be repaired, upgraded, customised, recycled and tracked throughout its lifecycle. Whilst environmental sustainability is often framed within extreme visions of utopian or dystopian narratives that can disengage people from taking part in this important dialogue, we avoid this by situating the TfL as a mundane object that presents sustainability as what should be an 'everyday concern'.

In addition to providing the utility to toast bread, the device also affords self-repair and upgrades due to its modular design (Figure 4). Using sustainable design strategies *Design-for-Disassembly* (Chiodo 2005) and *Design-for-Recycling* (Gaustad, et al 2010) as reference, we have integrated accessible parts and efficient component separation into the toaster's design in an attempt to allow more effective repair and recycling by potential users. No glues, screws or hidden seals are featured. *Modularisation* is said to extend product lifecycles and reduce use of materials, energy, packaging and distribution emissions (Greenpeace, 2014). Upgrades to inner componentry would also be possible because the design would operate via modular open-source hardware and software. It is common for electronic/IoT device components to be soldered directly to printed circuit boards making them immovable without the correct equipment and expertise. In contrast, the TfL design incorporates solderless breadboards allowing components to be simply exchanged if they break and/or upgraded should new functionality become available.

Figure 3 TfL is a modular IoT toaster which possesses several key sustainable attributes.

The proposal further frames the product as inherently *trackable* due to the majority of its parts being fitted with nano RFID tags; a smaller but more powerful iteration of today's *radio frequency technology*. Data from each part would be stored on the attached tag. When tagged parts are within the required proximity, their data would be transmitted from their tag to the onboard micro-processor. The additional connectivity of the internet, logs details online about the toaster's current configuration of parts and state of operation. Unlike many of today's IoT products and services which capture data to be used for targeting users with advertising and further sales opportunities (Zuboff, 2014), here the collected data is instead used to support the sustainability of the device. The data would be used at different stages of the toaster's lifecycle, for example, at manufacture, points of distribution, during usage including for repair, and then finally at disposal.

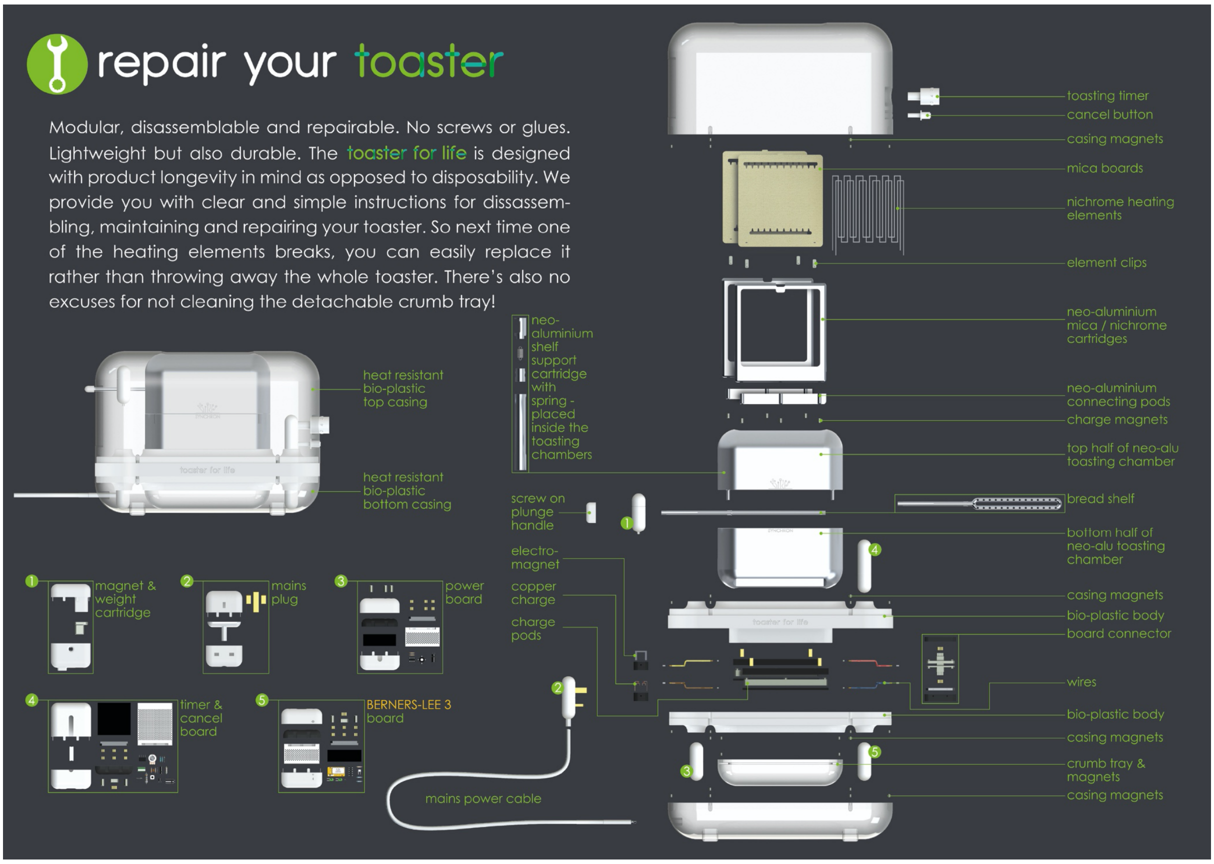

Figure 4 The TfL's design incorporates open-source hardware and software which facilitates ongoing self-repair and upgrades.

The TfL*'s* modular design also utilises 'eco-materials' to enable its users and manufacturer to reuse its individual parts. *Neo-aluminium* and heat resistant bio-plastics would be readily accessible for localised 3D printing and both materials could be efficiently and repeatedly recycled by users as well as enable device customisations (Figure 5). It is envisaged that *Synchron*, the environmentally conscious manufacturer of the TfL would likewise recycle and reuse their devices' components in the production of their future toasters or similar spime-like products.

Ultimately, in this *Design Fiction* world, the R2R is not considered as an isolated design requirement but rather is one part of a holistic design approach which underpins the creation of more sustainable data-driven *spime-like* IoT ecosystems (Stead, 2020). As such, the TfL embodies the independent *and* interdependent perspectives of MtHCD rather than that of HCD, as its digital networked attributes are situated within a larger human and non-human design assemblage.

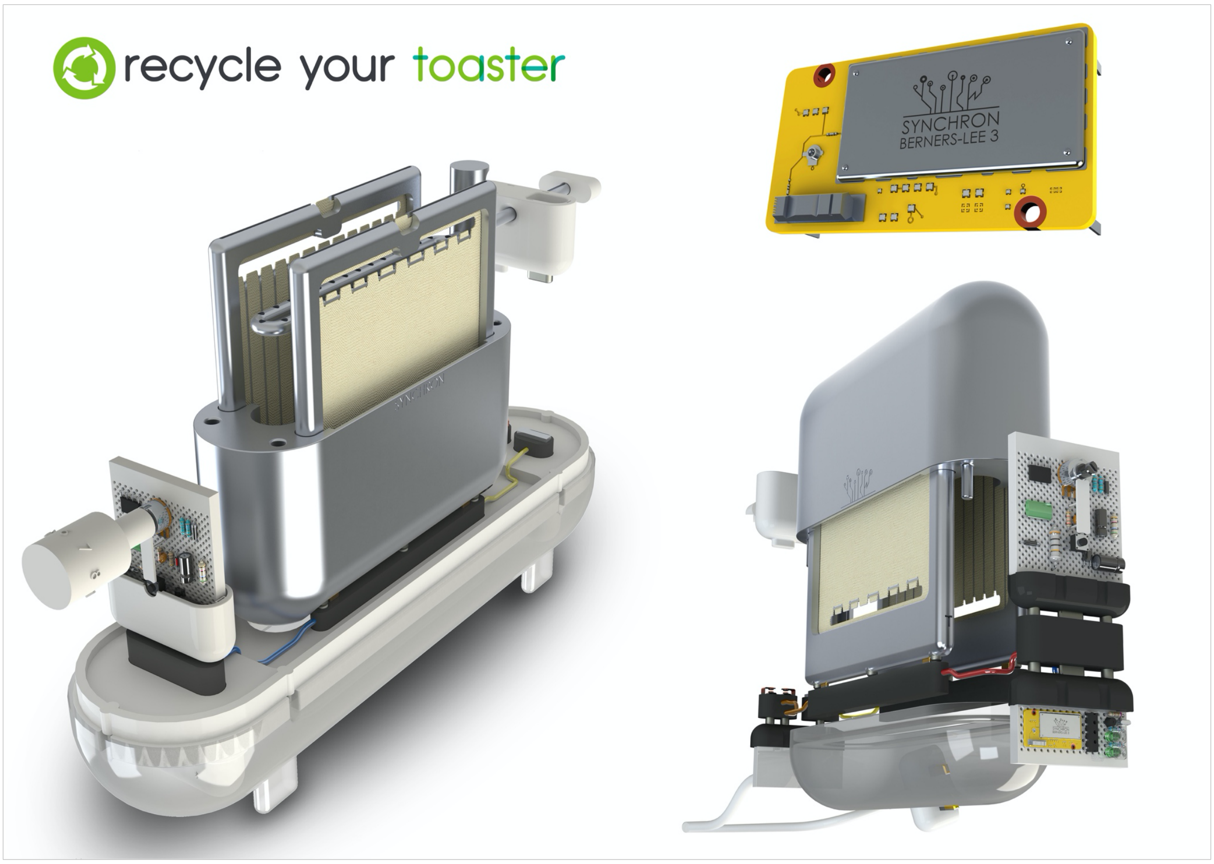

Figure 5 The toaster is manufactured from recyclable and customisable materials like Neo-aluminium and bio-plastics

4.2 The Three Rights of AI Things

Our second *Design Fiction* proposal further explores the role that IoT datafication and increasingly *Artificial Intelligence* (AI) could play in expanding MTHR2R practices and processes. Voice activated IoT devices like smart speakers have helped to make AI a facet of everyday life, particularly in the *Global North*. Popular AIs like *Amazon's Alexa* and *Google's Assistant* capture datasets from which they *learn* to make decisions on their users' behalf – "it is not the programmers anymore but the data itself that defines what to do next" (Alpaydin, 2016, p.11). From this perspective, *Machine Learning* (ML) is already granting *AI assisted* IoT devices a degree of *autonomy* and *agency* when it comes to making certain decisions that affect their users' lives. Moreover, it is posited that as the technology develops, it is likely that AI systems will begin to move beyond typical *machine-to-human* exchanges to more radical *machine-to-machine* interactions (Russell & Norvig, 2016). What if non-human actants like *Alexa* were granted the R2R their 'host' device's hardware and software?

To explore such questions and provoke new ones, we began to envision an alternative future whereby the R2R is directly granted to IoT devices themselves. We fused the concept of R2R with the notion of *AI Rights* – a term being used to denote how advanced AIs could one day be granted so-called *inalienable rights* like those presently afforded to humans (Gunkel, 2018). We were also inspired by Isaac Asimov's *Three Laws of Robotics* (Asimov, 1950) which continue to be influential across science fiction discourse as well as within real-world AI/robotics research, for example *Google's* (N.d.) AI framework. In our fictive future, *AI assisted Things* like *Toofy Peg* the Internet connected toothbrush (Figure 6) possess the autonomy to help societies to achieve *Net-Zero 2050* decarbonisation targets and *United Nations Sustainability Development Goals* (UN, 2021) by adhering to the following three rights:

1. *The First Right… An AI assisted Thing has the right to sustain its own existence as long as this action does not negatively impact upon Earth's sustainability.*
2. *The Second Right… An AI assisted Thing has the right to sustain the existence of fellow AI assisted Things as long as this action does not conflict with its First Right.*
3. *The Third Right… An AI assisted Thing has the right to end its existence as long as this action does not negatively impact upon Earth's sustainability and/or the existence of fellow AI assisted Things.*

Designed for children, the *Toofy Peg* toothbrush is a 'conversational AI' meaning that its user can directly engage with the device through voice and vice versa. *Toofy Peg's* principal function is to use ML to 'learn' its user's initial brushing habits and 'teach' them how to better clean their teeth. This functionality extends that of contemporary data-driven IoT devices like wearable fitness trackers which provide users with self-performance (and potentially self-improvement) data as well as the extrapolates our reliance upon AI as part of such products' operation. As we have noted, the need for continual reciprocity between a device's hardware and software is frequently unsustainable and often leads to *systemised obsolescence*, that is, where neither the material nor digital instantiation is able to continue to support each other's functional existence. We can see how *Toofy Peg's* design is more sustainable as it effectively aligns with key R2R legislation/practices.

Exemplifying *The First Right of AI Things,* the device's packaging highlights its inherent environmental credentials, particularly how its ability to carry out networked self-repair contributes to global sustainability agendas. This is reinforced by the inclusion of the *3 Rights* mark which affirms the product's compliance with the relevant EU R2R legislation. Similar to the present-day *CE mark,* this conformity means that the product may resultantly be sold and self-repaired anywhere in the *European Economic Area* (EEA). The device's packaging also states that the toothbrush uses *PRECOG* maintenance technology and that its hardware and software are also *interoperable* with other major providers including *Amazon*, *Meta* and *Google.*

Figure 6 The Toofy Peg AI assisted IoT toothbrush's packaging highlights the device's R2R credentials.

The lack of lack of *technological interoperability* (Brown, 2021) and its significance to R2R practices is further explored in Figure 7. Today's emergent fault/repair diagnostic systems use AI, sensor arrays and real-time telemetry data to identify maintenance issues and are mostly deployed in high-cost industrial settings (Stark, 2015) such as on factory floors and power stations and in transportation systems like airline and train networks. Termed *predictive maintenance,* some car manufacturers have recently begun to adopt these types of diagnostic systems. *Ford's Liive* service for example, monitors commercial fleets of *Ford* vehicles and can schedule "servicing at the most efficient time and... notifications when an action is identified that could help prevent a breakdown" (Ford, 2021). We go further and posit whether more advanced forms of MtH *predictive maintenance* could be incorporated into the design and functionality of low cost/high volume domestic IoT devices like the *Toofy Peg* toothbrush.

While the physical, material instantiation of the toothbrush is able to verbally 'tell' its user it requires maintenance, to facilitate the user in performing these reparations, the device directs them to the *Google gAIa* app interface. g*AIa* is a *PRECOG* maintenance subscription service which provides repair support for multiple AI assisted devices/systems. The *gAIa* app visualises a digital instantiation or *Digital Twin* of the user's *Toofy Peg* toothbrush. Like *predictive maintenance, Digital Twins* are currently being employed for high -cost applications such as in architectural *Building Information Modelling* practices (Gerrish, 2017), as opposed to everyday consumer devices. The *Toofy Peg* twin details the material device's fault and provides users with real-time interactive guidance regards how to carry out the repairs. This interoperability between various devices and systems helps to illustrate *The Second Right.*

Figure 8 conveys *The Third Right.* The *Toofy Peg* toothbrush is a *model 9000* and its manufacturer, *Oral-B*, is planning to release a significant OS update during the summer. This will leave the toothbrush unsupported and therefore make it obsolete. Given that there is no hardware repair nor software upgrade available that can resolve this issue, the device makes the decision to provide its owners with a *Last Right* script. This details all its material and digital elements, as well as a *Self-obsolescence Date*. Knowing many of its materials and parts can be reused in the production of new devices, the toothbrush hopes that, following its self-obsolescence, the script will help its owners to disassemble and upcycle the majority of its hardware in a sustainable manner, rather than allowing it to reach landfill. This fluid interdependency between the toothbrush's material and digital instantiations means that the device, like the TfL, possesses attributes akin to a *spime-like* product which also enables it to embody the key MtHCD principles that we put forward.

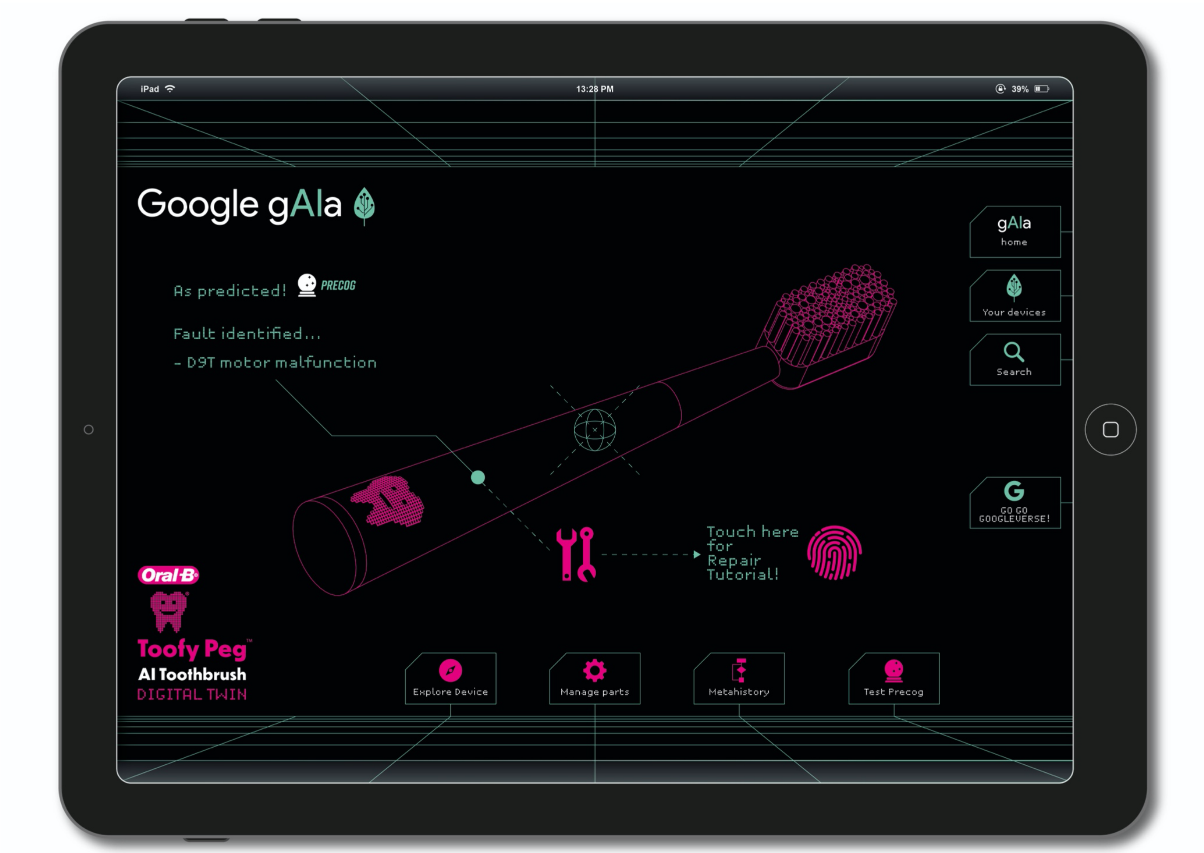

Figure 7 Google's gAIa app visualises a Digital Twin of the user's Toofy Peg and provides real-time interactive guidance regards repairing the device's fault.

Figure 8 The Toofy Peg's 'Last Right' Script.

6. More-than-Human Defuturing

Both *The Three Rights* and TfL proposals envision a future world which is inhabited by environmentally responsible technologies. They purposefully resist the temptation of echoing the tired dystopian trope of the *singularity* – that sufficiently advanced AIs will one day pose an existential threat to humanity (Vinge, 1993). Alternatively, these designs could be seen to embody the stance of *Bright Green Environmentalism* which is "less about the problems and limitations we need to overcome than highlighting the 'tools, models, and ideas' that already exist to overcome them. It forgoes the bleakness of protest and dissent for the energizing confidence of constructive solutions" (Robertson, 2007, para. 9). *Bright Green* advocates the convergence of technological innovation, social responsibility, and radical design processes to shape positive and practicable sustainable futures. Alex Steffan (2006) adopted the terminology to distinguish the stance from what he deems to be 'dark green' approaches, principally ones which emphasise obdurate strategies based on de-industrialisation, population control, anti-consumerism and degrowth. He states that "we can't build what we can't imagine… the fact that we haven't compellingly imagined a thriving, dynamic, sustainable world is a major reason we don't already live in one." (Steffen, cited in Rinde, 2016, para. 9)

The *Bright Green* approach invokes Marshall McLuhan's (1967, p.75) famous statement "we look at the present through a rear-view mirror. We march backwards into the future." Steffan's and McLuhan's perspectives both further highlight the need for designers and technologists to thoroughly consider a plurality of pasts, presents and futures as part of our practices (Figure 1, p.6). In doing so, the theorists also echo Escobar's (2018) notion of the *pluriverse* and reinforce the inherent complexity and uncertainty of designing for sustainable futures. We live in a deeply heterogeneous world where 'sustainability' means different things to different people in different contexts. One community's vision of a sustainable future might present unsustainable challenges for others. Western designers and technologists in particular must start to evaluate the *defuturing* impacts of their work – even if they are trying to design a product or service that they intend to be 'sustainable', it will likely have unintended consequences. The environmental scholar Elizabeth Kolbert (2021) notes this paradox by describing efforts to implement sustainable technologies and practices as "people trying to solve problems created by people trying to solve problems." Design's unsustainable ripple effects will be keenly felt by fellow human *and* non-human actants across networked assemblages and subsequently *defuture* other potential futures.

Like MtHCD, *The Three Rights* and TfL proposals also illustrate the notion of *defuturing*. We have noted that by negating means for repair and upgrades, most IoT devices are unsustainable. Yet, our prototypes demonstrate that future iterations of the IoT could potentially provide opportunities for extending the lifecycle of consumer devices, such as by incorporating modular, geo-trackable componentry. AI related innovations like *predictive maintenance* and *Digital Twins* add further currency to these proposals. There is, however, a caveat that comes with adopting data-driven technologies: these systems are themselves having a growing planetary impact. Our digital interactions and processes are collectively creating zettabytes of data every year. Invisible to the naked eye, such datafication is often considered to be immaterial and innocuous (Stead et al, 2020). However, the generation, processing and storage of data across vast networks like *The Cloud* – a proxy for millions of globally dispersed data centres, is actually consuming fossil fuel derived energy and releasing carbon emissions at environmentally detrimental levels (Freitag et al, 2021). To this end, in Figure 9, we build upon Auger's (2013) 'Speculative Trajectories' diagram and highlight the *defuturing* potential that new socio-technical developments like the TfL and *Toofy Peg* toothbrush could pose, particularly their ability to instigate *alternate presents* and *lost futures*.

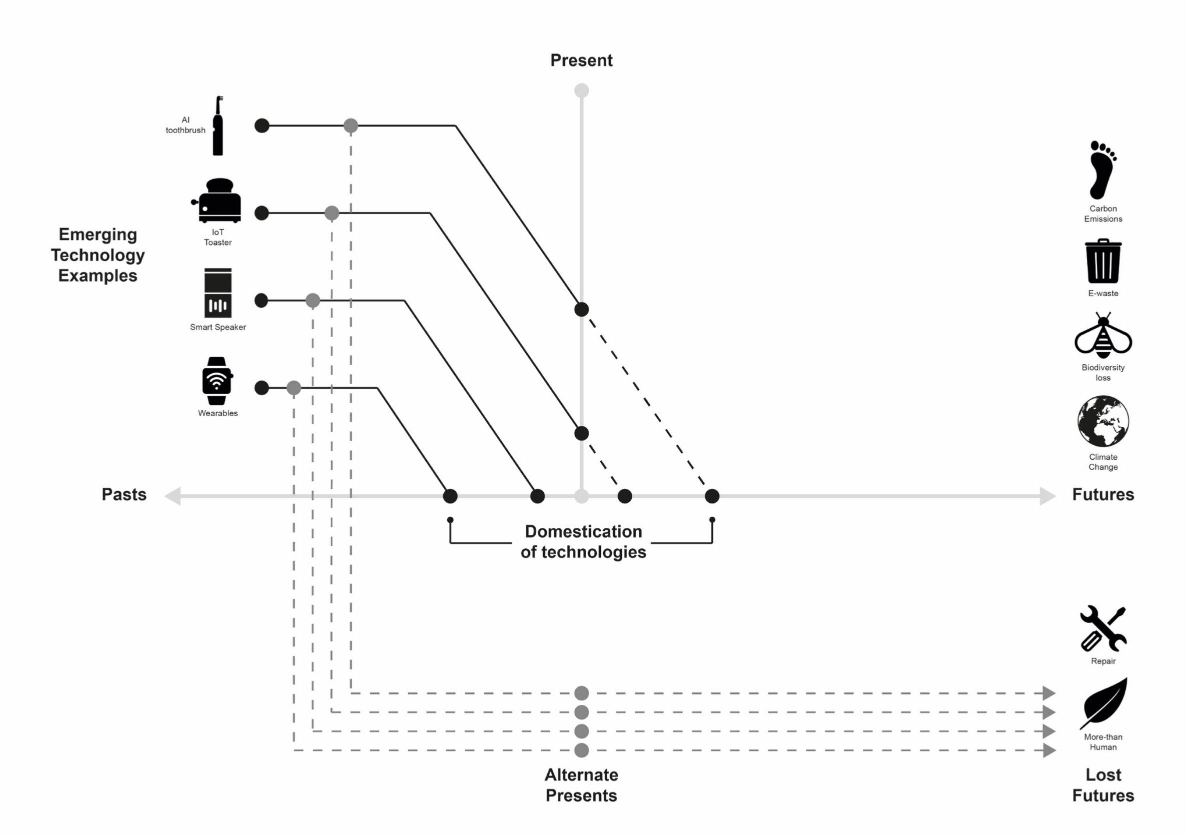

Figure 9 MtH Alternate Presents and Lost Futures (building upon Auger, 2013).

7. Conclusions

As Knowles et al (2018) attest, sustainability-focussed *Design Fiction* proposals such as the ones described in this paper can help increase environmental consciousness across a broad range of audiences – from academia, through industry, to wider publics. The primary goal of *The Three Rights* and TfL proposals is to raise awareness, provoke debate and perhaps even begin to shift perceptions regards the adoption of R2R legislation and its implications for facilitating sustainable IoT-AI. Whilst it is designers who help to limit the repair of electronic device hardware and software and drive obsolescence, the natural fluidity and reflexivity of design as a discipline means that it can also be reoriented to challenge its own unsustainable status quo. To this end, we see *Speculative Design* in the form of *Design Fiction*, as a key mediator in the sustainable evolution of data-driven device design. Our future work aims to continue to both highlight and cement this approach, particularly through the lens of MtHR2R.

Reflecting upon our design process, building the future world helped us to contemplate peoples' lack of autonomy and agency more thoroughly to legitimately repair today's data-driven devices and systems. We believe that if more designers were to engage in such a critically focussed practice, they will be better placed to consider both the present and future impacts of IoT-AI. Resultantly, perhaps we could collectively change the R2R IoT devices and systems from a *vision of the future* into a *present-day reality.*

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Acknowledgements: This research has been supported by the *Beyond Imagination* project funded through *Research England's Expanding Excellence in England* (E3) programme.

About the Authors:

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* at Lancaster University's open and exploratory design-led research studio *ImaginationLancaster*. He uses a *Research through Design* approach to create fictional representations of future worlds in which emerging technologies have become mundane.